PERSPECTIVES ON BIODIVERSITY OF INDIA

Volume II

Part 1

Editors
A. Bijukumar, N. S. Pradeep,
K. G. Ajit Kumar & P. G. Rajendran

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BIODIVERSITY DOCUMENTATION AND TAXONOMY
AGROBIODIVERSITY AND FOOD SECURITY

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Preface

Biodiversity is the foundation for life and for the essential services provided by ecosystems and it underpins peoples' livelihoods and sustainable development in a variety of sectors. According to the UN Secretariat of the Convention on Biological Diversity (CBD), biodiversity is essential to sustaining the living networks and systems that provide us with health, wealth, food, fuel and the vital services our lives depend upon. The Convention, of which India is a signatory, covers all ecosystems, species and genetic resources, linking traditional conservation efforts to economic goal of using biological resources sustainably, and setting principles for the fair and equitable sharing of the benefits from use of genetic resources.

There is a growing recognition that humankind, as Albert Einstein observed, "cannot solve problems in the same way of thinking that led to their creation." A new way of thinking, a paradigm shift is required to keep the web of life in tact so that it can continue to provide the essential raw materials for sustainable development. United Nations declared the period 2011 – 2020 to be "the United Nations Decade on Biodiversity, with a view to contributing to the implementation of the Strategic Plan for Biodiversity for the period 2011-2020". The Decade is intended to be a vehicle to support and promote implementation of the objectives of this synergistic Strategic Plan for Biodiversity and the Aichi Biodiversity Targets, and to mainstream biodiversity issues into broader development planning and in the economic sectors.

Indian Biodiversity Congress (IBC) is the largest get together of scientists, conservationists, environmentalists, civil society groups and local communities in India, a platform to discuss the current status of biodiversity in India and an inclusive colloquium to forward strategies and policies to conserve the rich biodiversity heritage of the country. The third IBC held at Chennai had the focal theme "Biodiversity for Poverty Eradication". The event was a phenomenal success and the papers presented in the Seminar are now compiled in the form of second volume of "Perspectives of Biodiversity" Volume II.

The papers are presented in this volume under various heads such as Biodiversity documentation and Taxonomy (49 papers), Agrobiodiversity and Food Security (22 papers), Diversity of Medicinal Plants and Sustainable Utilization (8 papers), Biotechnology for Biodiversity (11 papers),Biotechnology for Development (15 papers), Climate Change and and Biodiversity (5 papers), Biodiversity Laws and Intellectual Property Rights (4 Papers), Cultural, Spiritual and Linguistic Values of Biodiversity (2 papers), and Biodiversity Education (4 papers). We welcome comments from the readers and I congratulate CISSA for brining out this volume rich in diversity of topics.

New Delhi
12 June 2016

Vandana Shiva

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DIVERSITY AND DISTRIBUTION OF ENDEMIC AND EXOTIC EARTHWORMS FROM WESTERN GHATS REGION OF THE CENTRAL KERALA, INDIA

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ABSTRACT

The degree of endemism depends on the geological history, current climate of the region, temperature, moisture, pH and various other environmental factors; whereas the distribution of exotics is influenced by human trade and migrations. For determining the endemic earthworms, both the native and exotic worms were identified and categorized and the index for endemism was calculated. The systemic enumeration of the endemic species collected from different geographical localities with special emphasis on the unique locality was made. It is remarkable that more than half of the species presently reported from Kerala is endemic to Kerala. The central Kerala harbours more than 80 % endemic species and the highest endemism is observed in Thrissur district. The members of the family Megascolecidae seem to be quite fit for the local climatic and edaphic factors.

Key words: Endemism, exotics, natives, peregrines, earthworms

1. INTRODUCTION

Invasions of natural communities by non-indigenous species (exotics) threaten native biodiversity and are currently rated as one of the most important global-scale environmental problems. Although wide environmental tolerance is often characteristic of exotics, their ability to survive in a new region once introduced is influenced by the local climate and ecology (Lee, 1985 and 1987). Based on the distribution and dispersion mechanism, earthworms in an area may consist of both native and exotic species. The native species naturally occurs in a restricted geographical area and become endemic. The exotic species is a species introduced to a particular geographical area from distant places by agents including human being. The exotics compete with the indigenous species for food, habitat and shelter and some many cause demolition of indigenous species and degradation of physiochemical characteristics of the soil ecosystem.

Many native species are in danger of extinction or have already disappeared in Amazonia due to the colonization by exotic species of earthworms (Lavelle and Lapied, 2003). Michaelsen (1903) first used the word 'peregrine' to describe the distribution of some earthworm species that are dispersed over a wide range of geographically remote localities, whereas the other species that are not spread over other areas to any great extent have been termed 'endemic' species. In addition to endemic species, there are native peregrines and exotic peregrines that exist in a geographical area (Suthar, 2011). A taxon is endemic to an area if it occurs there and nowhere else.

The present study illustrates the current status of endemic earthworm species diversity and their distribution patterns in different localities in central Kerala. For determining the endemic earthworms it is necessary to find out both the native and exotic earthworms inhabiting the same geographical area. The present attempt is also to find out whether there is any influence of climatic factors, on the endemism of earthworms of different localities in central Kerala and to find out whether there is any relation between species richness and endemism.

2. MATERIALS AND METHOD

2.1. Field sampling

The sampled areas were restricted to central Kerala. The central zone comprises three districts Ernakulam, Thrissur and Palakad. The earthworms were collected by digging soil and hand sorting.

From each district at least 12 random samples were taken four times every year by trimonthly sampling. The earthworms were identified using traditional updated taxonomic keys. For determining the endemic earthworms, the native and exotic worms were identified and categorized.

2.2 Determination of Endemism

1.Native species were determined from the data generated during the present survey and from the existing literature and present survey.

2.Endemism of earthworm fauna in the geographical area studied is estimated from the fractional number of native species out of the total number of species reported for a geographical area (Tsai et al. 2000). Index for endemism is expressed as the product of this fractional number and one hundred (100).

3.The index of endemism is equal to:

$$\left[\frac{\text{Total Native species in a geograhical area} - \text{native peregrines}}{\text{Native species} + \text{Exotic species}}\right] \times 100$$

3. RESULTS

The present survey conducted during 2010-2013 resulted in the identification of 31 species of earthworms. The systemic enumeration of the endemic species collected from three different districts of Kerala with special emphasis on the unique locality was made.

3.1 Native and Exotic Species

The findings of this study revealed that out of the 31 identified species from different areas along the central Kerala, 87% are native species and 12% are exotic species. Among those identified, Megascolex konkanenesis, Lampito mauritii (both natives) and Pontoscolex corethrurus (exotic) were three species common across all the soil types and habitats. Out of the 27 native species of earthworms from the Kerala state, the Ernakulam District represents the highest percentage of natives in which 92.85% natives and 7.1% exotics. However, the highest number of native species is harboured by Thrissur (17) followed by Ernakulam (13) and Palakad (11).

3.2 Endemism

It is remarkable that more than half of the species presently reported from Kerala is endemic to Kerala. Among the 31 species recovered from the study site, 13 species are endemic to central Kerala. Endemism of each study site was calculated by observing the native and exotic species. The endemism and species richness are not correlated in central Kerala. The highest endemism is observed in Thrissur district. The native peregrines recorded from the state include, Megascolex cochinensis, M. konkanensis, M. sylvicola, M. insignis, Lampito mauritii, Perionyx excavatus, P. sansibaricus, P. saltans, Dichogaster annae, Glyphidrilus annandalei, Drawida uniqua and D. ghatensis. Of these Megascolex cochinensis, M. konkanensis, M. sylvicola, M. insignis, Perionyx saltans, Drawida uniqua and D. ghatensis are only reported from India and thus considered as endemic to India.

The central Kerala harbours more than 40 % endemic species. The highest endemism was noticed in Thrissur (57.8%) followed by Palakad (42.9%) and Ernakulam (35.7%). The 13 endemic species identified from the central Kerala are Drawida chalakudiana, D. parambikulamana, D. brunnea, D. ghatensis, Megascolex konkanensis var. longus, M. cochinensis , M. houletti, M. travancorensis var. mannarkadensis, nov., M. imperatrix var. anthikadensis, nov., Dichogaster vellanikkarae, sp. nov, Dashiella sp, Progizzardus varadiamensis sp. nov., and Woodwardiella hastata. The Mergaleff species richness index (M) is high in Thrissur (14.581) followed by Ernakulam (4.186) and Palakad (4.157)

The climatic factors considered were the soil moisture, soil pH, soil temperature. From the Principal component analysis it is found that temperature is the first principal component among the edaphic factors of the soil controlling the distribution and abundance of earthworms in all districts of the Kerala state followed by the moisture (M) and pH.

Soil temperature and soil pH are not considered as major limiting factors for the endemicity of earthworm in Kerala. In Ernakulam district, the mean soil moisture content was 18.68 % and soil temperature was 28.8°C where a very high endemicity was noticed. It was also noted that in Palakad district the mean soil moisture content is very low (8.5%) and represented high soil temperature (28.3°C) when compared to other parts of the Kerala other parts of the study area. However, the district represented 42.9% endemism. The palakad district is inhabited by two new sub species and one new species (Megascolex travancorensis var. mannarkadensis, nov. and Dichogaster bolaui var. vijai, nov., Dichogaster vellanikkarae, sp. nov and Dashiella species) of earthworms that may resist intensive drought.

It was also found that the endemism and species richness are not correlated in Central Kerala. The endemism was more pronounced in Thrissur (57.8%). The high level of endemism reported in some parts of the Kerala state may reasonably be attributed to high level of moisture in the areas under consideration. It may be due to rich surface-water bodies, watershed development, and man-made dams which have been supporting biodiversity in this area. In fact, Suthar (2011) reported that the moisture is the main soil physiochemical factor that control earthworm distribution. But in the case of endemism, there are other factors also to be considered. In Palakad district the moisture content is very low when compared to other parts of the Kerala. However, the district represented 42.9% endemism. Lee (1985) and Tripathi and Bhardwaj (2004) explained the development of meronephric excretory system in earthworms for moisture conservation. The Palakad district accommodates four new species (including new sub species) of earthworm that may resist intensive drought. Of the 4 taxa described from the region, including new subspecies, three species (Dashiella sp., Dichogaster vellanikkarae, sp. nov and Dichogaster bolaui var. vijai, nov.) are coming under the family Octochaetidae. They appear to be better adapted to withstand drought conditions as they have meroic nephridial system. This helps them to excrete urine into the gut for conservation of water in their bodies.

The results suggest that members of the family Megascolecidae dominate the list of earthworm fauna of this region. The members of the family Megascolecidae seem to be quite fit for the local climatic and edaphic factors. The occurrence of higher number of native species in the soil of Kerala indicates that the native species are more resistant to local variations in climatic conditions. In the present study Pontoscolex corethrurus belonging to the family Glossoscolecidae is the only exotic worm common across all the soil types and habitats in Kerala. The present study throws light on the high level of endemism that exists in Kerala, a sensitive eco region forming part of one of the world's eight hottest 'hot spots'. There may be species that combine small geographic ranges with narrow habitat tolerance and low population densities and so most vulnerable to extinction.

Table 1.1: The distribution of native and exotic species of three districts of central Kerala

(1 - Ernakulam; 2 - Thrissur; 3 - Palakad; '+' means native species and '–' means exotic species; 'N' means native and 'E' means exotic; blank space- the particular species not reported from the study area)

	1		2		3	
Species	N	E	N	E	N	E
Drawida barwelli						-
Drawida brunnea			+			
Drawida bullata						
Drawida chalakudiana	+					
Drawida fakir					+	
Drawida ghatensis	+					
Drawida japonica						
Drawida parambikulamana	+					
Drawida travancorensis var. oommeni, nov						

Drawida uniqua					+	
Woodwardiella hastata	+		+			
Woodwardiella uzeli						-
Notoscolex t. tenmalai						
Notoscolex trincomaliensis				-		
Megascolex cochinensis	+		+		+	
Megascolex imperatrix var. anthikadensis, nov			+			
Megascolex insignis						
Megascolex konkanensis	+		+		+	
Megascolex konkanensis var. longus			+			
Megascolex sylvicola	+					
Megascolex t. travancorensis			+		+	
Megascolex travancorensis var. mannarkadensis, nov.					+	
Megascolex sp			+			
Megascolex trivandranus						
Lampito mauritii	+		+		+	
Lampito mauritii var. zeylandicus						
Lampito sp						
Amynthas corticis						
Amynthas gracilis						
Amynthas sp						
Metaphire houlleti var. munnarensis, nov	+		+			
Perionyx excavatus	+		+			
Perionyx foveatus var. nairii, nov						
Perionyx saltans						
Perionyx sansibaricus	+		+			
Travoscolides chengannures						
Dichogaster affinis						
Dichogaster bolaui var. vijai, nov					+	
Dichogaster travancorensis			+			
Dichogaster annae			+			
Dichogaster vellanikkarae, sp. nov			+		+	
Dashiella sp.					+	
Gordiodrilus travancorensis			+			
Pickfordia sp.						
Pontoscolex corethrurus		-		-		-
Glyphidrilus annandalei	+				+	
Progizzardus varadiamensis sp. nov	+		+			
Eudrilus eugeniae						
Sparganophilus sp						

Eisenia fetida						
Total N/E	13	1	17	2	11	3
Combined Total (N+E)	14		19		14	
Native (%)	92.85		89.5		78.6	
Endemism (%)	35.7%		57.8%		42.9%	

Table 1.2: Systemic enumeration of endemic species recovered from Central Kerala

Family	Genus	Endemic Species	Author/Year	Unique Locality	Total No. of species	Locality
				Present report	with same Locality	Previous report
Moniligastridae	Drawida	D. brunnea	Stephenson, 1915			erstwhile cochin, Kerala
				Thrissur	19	
		D. chalakudiana	Stephenson, 1915	Ernakulam	14	Erstwhile Cochin, Kerala
		D. ghatensis	Michaelsen, 1910	Ernakulam	14	Kollam, Kottayam,Erstwhile
		D. parambikula-mana	Stephenson, 1915	Ernakulam	14	Erstwhile Cochin, Kerala
Megascolecidae	Woodwardi-ella	W. hastata	Stephenson, 1915			Erstwhile Cochin, Kerala
				Ernakulam	14	
				Thrissur	19	
	Megascolex	M. cochinensis	Stephenson, 1915	Ernakulam	14	TamilNadu
		M. imperatrix var. munnarensis, nov	2012	Thrissur	19	new sub species
				Thrissur	19	
				Ernakulam	14	
				Palakad	14	
		M.konkanensis var. longus	Stephenson, 1915	Thrissur	19	Erstwhile Cochin, Kerala
				Thrissur	19	
				Palakad	14	
		M. travancoren-sis var. man-narkadensis, nov	2012	Palakad	14	new sub species
	Metaphire	M.houlleti var. munnarensis, nov	2012	Ernakulam	14	new sub species
				Thrissur	19	
				Palakad	14	
				Thrissur	19	
	Dichogaster	D. vellanikkarae, sp. nov	2012	Thrissur	19	new species
	Dashiella	Dashiella sp.	2012	Palakad	14	new species
				Thrissur	19	

Acanthodrilidae						
	Progizzardus	P.varadiamensis sp. nov.	Nair, 2010	Ernakulam	14	new species
				Thrissur	19	

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ECONOMICS OF KERALA HOMEGARDENS- EVIDENCE FROM SOUTHERN KERALA

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ABSTRACT

Kerala Homegardens present a traditional agroforestry system designed to meet the household food, fodder, fuel wood and timber requirement and generate supplementary income through the sale of surplus. The study area included Southern Kerala covering a sample size of 208 homegardens using multi-stage stratified random sampling technique. Livestock, rubber and tapioca in Thiruvananthapuram; rubber, livestock, pepper and coconut in Kollam; livestock, coconut, arecanut and pepper in Alappuzha and rubber, livestock and coconut in Pathanamthitta contributed largely to annual homegarden income. The role of intermediaries in the marketing of homegarden produces was widely welcomed by the homegarden farmers.

1. INTRODUCTION

Homegarden is one of the oldest forms of agro-ecosystems present throughout the world. It plays an important role in the economic as well as socio-cultural functions of rural societies. It is a major, unique and very much developed agricultural production system in Kerala, where it forms the basic farming system in all agro-ecological zones. Marketing of homegarden produces is of great importance requiring a special status as an integral part of production owing to the availabilities of wide varieties of cherished products from homegardens. Moreover, it is virtually impossible to produce these treasured varieties of horticultural produces especially fruits and vegetables in any other system than that of homegarden system. Owing to its highly perishable nature especially horticultural products, marketing decides the net realizable income from the cultivators.

Marketing activities includes the functioning of various agencies mainly classified as producer, intermediaries and consumer who have an individualistic view towards marketing and are concerned with profit alone. Besides, unnecessary attachment of large number of intermediaries results in producers' small share in consumer rupee (Lepcha et al., 1993). Next, being perishable in nature they have to be sold at the earliest opportunity. Majority of Kerala homegardens are relatively smaller holdings, hence farmers do not possess withholding capacity until a favourable price emerges in the market. Besides, they do not have any bargaining power of deriving the best of their revenue. This situation is further aggravated by the less quantum of marketable produce from homegardens, which ultimately provides traders with an opportunity to exploit the homegarden farmers.

It is a pre requisite for the welfare and well-being of the farming community in general and homegarden farmers who possess the major land holding in Kerala, that an efficient marketing system be ensured so that it pays rich dividend to the producers and safeguards the interest of the consumer.

Hence, an attempt has been made to know the contribution of major and dominant homegarden components towards annual homegarden income, and the homegarden farmer's perception on the need of intermediary in the marketing of homegarden produces.

2. METHODOLOGY

The study was conducted in the southern zone of Kerala comprising Thiruvananthapuram, Kollam, Alappuzha and Pathanamthitta districts covering a sample size of 208 homegardens using multi-stage stratified random sampling technique representing the three major agro climatic zones viz. lowland (problem zone), highland and midland. The economics of homegardens was worked out under two major subheads.

3.1 The economic contribution of major and dominant homegarden components towards annual homegarden income

Based on the dominance (numerical and economical dominance) of crops and other components a theoretical perspective of the contributing components to the homegarden economy was arrived. The actual amount in rupees received by the homegarden respondent annually from those dominant components was arrived at and subjected to statistical analysis using multiple linear regression model. The results obtained will describe the contributing crops with the extent of contribution to the annual homegarden income.

3.2 The need for intermediary in marketing the homegarden produces as perceived by the homegarden farmers

Intermediaries are operationally defined as the connecting link between the producer and consumer with an individualistic view and profit motive.

In the present study, the homegarden respondents were asked to respond whether the respondents felt a need for intermediaries in marketing the homegarden produces. The response category 'Yes' or 'No' from the homegarden respondents was awarded with a score of 'One' and 'Zero' respectively. The frequency was worked out and it was expressed as percentage.

3. RESULTS

The economics of homegardens was studied with a view to assess the contribution of homegarden components towards homegarden income, the marketing channels identified for the contributing homegarden components and the homegarden farmers perception on the need of middleman in the marketing of homegarden produces. These are presented in detail under the following subheads.

3.1.1 The economic contribution of major and dominant homegarden components towards annual homegarden income in Thiruvananthapuram district

Though ten dominant crops were identified, it became imperative to make a fair assessment of the more dominant of the identified dominance in terms of numerical and economical dominance, which had a natural relationship. All structural dominance identified need not necessarily be an overall dominant species. The data of multiple linear regression analysis for each district to identify the most economically contributing crops towards homegarden income are presented from Tables 1 to 4. The homegarden components like livestock and poultry, aquaculture, sericulture, apiculture etc. were also considered as contributing components to the homegarden of which livestock was identified as a dominantly contributing component to the annual homegarden income that was included for the economic analysis.

The results of linear regression analysis between homegarden income and their contributing components (crop and livestock) in Thiruvananthapuram district are presented in Table 1.

A high R^2 value of 0.852 with highly significant 'F' value (30.956) indicated that more than 85.20 per cent of the variation in the homegarden income could be explained from the eight variables of the selected components (crop and livestock) contributing to the homegarden income.

Table 1 revealed that only three homegarden components out of eight were significantly contributing to the annual homegarden income. They were income from livestock, rubber and tapioca.

The results indicated that an increase of three units of livestock, rubber and tapioca would increase one unit of homegarden income independently.

Hence, it is inferred that out of eight major and dominant components of homegarden, three components viz., livestock, rubber and tapioca were significantly contributing to the annual homegarden income in Thiruvananthapuram district.

3.1.2 The economic contribution of major and dominant homegarden components towards annual homegarden income in Kollam district

The results of multiple regression analysis between homegarden income of the respondents and the contributing major and dominant homegarden components in Kollam are presented in Table 2.

A careful perusal of the Table shows that a high R^2 value of 0.939 with highly significant F value

(70.932) indicated that more than 93.9 per cent of the variation in homegarden income of the homegarden farmers could be explained by the different crop/farm components taken together and independently.

The results indicated that an increase in two units of annual homegarden income could be achieved with three units increase of rubber and two units of livestock, three units of coconut and five units of pepper could increase one unit of annual homegarden income.

Hence, it was inferred that out of eight components four components were significantly contributing to the annual homegarden income in Kollam district. They were rubber, livestock, coconut and pepper.

3.1.3 The economic contribution of major and dominant homegarden components towards annual homegarden income in Alappuzha district

The results of multiple regression analysis between annual homegarden income of farmers and their major and dominant homegarden components are presented in Table 3.

A high R^2 value of 0.905 with a significant high ‘F’ value (59.648) indicated that more the 90.5 per cent of the variation in the annual homegarden income could be explained by the selected homegarden income.

Table revealed that except three crop components (pepper, vegetables and banana) in Alappuzha district, all other components were seen to contribute to the homegarden income. They were livestock, coconut, tapioca, arecanut and pepper.

The results indicated that an increase in two units of annual homegarden income could be achieved through a corresponding increase in three units of livestock, five units of coconut, nine units of tapioca and ten units of arecanut in the homegardens respectively and independently.

Hence, it was inferred that four out of seven major and dominant homegarden components viz., livestock, coconut, tapioca and arecanut were significantly contributing to the annual homegarden income in Alappuzha district.

3.1.4 The economic contribution of major and dominant homegarden components towards annual homegarden income in Pathanamthitta district

The results of multiple regression analysis between annual homegarden income and their contributing factors (crop components) are presented in Table 4. A very high R^2 value (0.964) with a significantly high F value indicated that more than 96.4 per cent of the variation in the homegarden income could be explained by the selected crops together. Table revealed that three components out of seven components namely rubber, livestock and coconut were the major components contributing to the annual homegarden income.

The results indicated that an increase in two units of annual homegarden income could be achieved through a corresponding increase in two units of rubber, four units of livestock and six units of coconut respectively and independently.

Hence it was inferred that out of the seven major and dominant components in homegardens of Pathanamthitta district, three components viz., rubber, livestock and coconut were contributing to the annual homegarden income.

3.2 The need for intermediary in marketing the homegarden produces as perceived by the homegarden farmers

Marketing of surplus of homegarden products obtained from crop component and animal husbandry components contribute to the main or additional income generated by the homegarden farmers. Marketing activities includes the function of main agencies like producer, middle- man and consumer. The results of the usefulness or role of intermediary as perceived by the homegardens farmers are presented in Table 5.

The table points out to very interesting results. More than half the respondents (54.33%) felt that intermediary were useful and essential in the marketing of homegarden produce. However, 45.67 per cent felt that intermediary should be avoided from the marketing activities.

A district wise analysis showed that the respondents from Thiruvananthapuram, Alappuzha and Kollam preferred to have intermediary for marketing their produce. Homegarden farmers from Thiruvananthapuram ranked first with more than two third of the homegarden farmers (69.23%) feeling the need for intermediary followed by 59.62 per cent of Alappuzha homegardens and 55.77 per cent of Kollam homegarden respondents. The homegardens of Pathanamthitta district showed a conspicuous difference to that of the respondents from the other three districts of study wherein more than two third of the homegarden respondents (67.31%) felt that there was no need for intermediaries in the marketing of their homegarden produce.

Hence it was inferred that except in case of Pathanamthitta district majority of the respondents from other district preferred and liked the use of middle man in the marketing of homegarden produces.

Table 1: The contribution of major and dominant homegarden components towards annual homegarden income in Thiruvananthapuram district

Sl. No.	Crops	Standard Error	Standardised coefficient 'ß'	t
1	Arecanut	3.164	-0.030	0.219
2	Banana	1.505	0.352	1.101
3	Coconut	0.856	0.124	0.428
4	Livestock	0.224	0.351	5.710**
5	Pepper	0.581	0.159	1.892
6	Rubber	0.124	0.315	5.161**
7	Tapioca	0.411	0.333	2.307*
8	Vegetables	1.792	0.058	0.454

R^2 - 0.852 F - 30.956** Adj R^2 - 0.825

Table 2: The contribution of major and dominant homegarden components towards annual homegarden income in Kollam district

Sl. No.	Crops	Standard Error	Standardised coefficient 'ß'	t
1	Arecanut	0.860	-0.023	0.470
2	Banana	0.747	0.077	1.251
3	Coconut	0.217	0.318	6.004**
4	Livestock	0.088	0.554	12.837**
5	Pepper	0.201	0.219	4.732**
6	Rubber	0.056	0.762	17.547**
7	Tapioca	0.653	0.096	1.482
8	Vegetables	1.277	0.043	0.883

R^2 - 0.939 F - 70.932** Adj R^2 - 0.926

Table 3: The contribution of major and dominant homegarden components towards annual homegarden income in Alappuzha district

Sl. No.	Crops	Standard Error	Standardised coefficient 'ß'	t
1	Arecanut	0.360	0.217	3.988**
2	Banana	0.727	0.013	0.221
3	Coconut	0.125	0.463	7.595**
4	Livestock	0.074	0.624	12.427**
5	Pepper	0.620	0.060	1.273
6	Tapioca	1.234	0.223	4.427**
7	Vegetable	0.051	0.081	1.623

R^2 - 0.905 F - 59.648** Adj R^2 - 0.890

Table 4: The contribution of major and dominant homegarden components towards annual homegarden income in Pathanamthitta district

Sl. No.	Crops	Standard Error	Standardised coefficient 'ß'	t
1	Arecanut	1.322	0.024	0.515
2	Banana	0.596	0.045	1.323
3	Coconut	0.217	0.316	8.741**
4	Livestock	0.052	0.570	19.386**
5	Pepper	0.721	0.058	1.156
6	Rubber	0.037	0.847	27.415**
7	Tapioca	0.645	0.047	1.691

R^2 - 0.969 F - 197.440** Adj R^2 - 0.964

Table 5: The need for middleman in marketing the homegarden produces as perceived by the homegarden farmers

Response	TVM		KLM		APY		PTA		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Yes	36	69.23	29	55.77	31	59.62	17	32.69	113	54.33
No	16	30.77	23	44.23	21	40.38	35	67.31	95	45.67

TVM- Thiruvananthapuram, KLM- Kollam, APY- Alappuzha, PTA- Pathanamthitta

4. DISCUSSION

The discussions on the results for the economics of homegardens are presented under the following subheads:

4.1 The economic contribution of major and dominant homegarden components towards annual homegarden income

The results of economic analysis with respect to different contributing components towards annual homegarden income reveals that live stock was uniformly perceived to be contributing in nature to the homegardens of all the districts.

There could be several reasons for this. The primary means for inclusion of livestock unit in a homegarden was because they provide all advantages inherent in a mixed farming system. The livestock system not only ensures enterprise diversification but also augment homegarden income by the sale of surplus milk, besides contributing to the homegarden farmers requirements. In this context one has to view the homegarden as a complete, self-reliant unit with respect to the individual requirements of the homegarden farmer.

Apart from the provision of food and nutritional security to the members of farm family, the livestock components facilitate a high degree of organic recycling between the various systems and minimize the inputs like manures. These results conform to the earlier findings of Salam et al. 1991 and Soemarwoto (1986).

Whether intentional or not, inclusion of livestock in majorities of homegardens was due to its efficiency not only economically and ecologically but also biologically. The easiness to selling products like milk or meat after consumption requirements locally might be another reason for having a livestock unit in the homegardens.

Thus the present study on the major and dominant crop components that were found to contribute economically to homegardens were rubber, coconut, tapioca, pepper and arecanut. However, this does not mean that other crops are not contributing. They contribute to the total income but in lesser proportion. The results clearly reveal that rubber (if present) was the most remunerative of the crop components in homegardens. The occurrence of rubber was predominantly in Pathanamthitta and Kollam districts in this study. The fewer occurrences in other two districts were primarily due to the geographical and land utility constraints for rubber crop in homegardens.

The occurrence and maintenance of rubber in homegardens was due to manifold reasons. The major reason being that the rubber owned land might have been gifted to the generations or as a result of sub division and fragmentation in true economic terms. Since rubber being a profitable perennial crop with regular returns, the household farmers have domesticated the crop with utmost care as they function as the main source of livelihood. Another reason for rubber to be a major crop in the homegardens of Pathanamthitta was due to the congenial conditions prevailing for rubber. The efficient extension activities and technologies such as subsidy for replanting and quality planting material from sources such as “Rubber Board” was another reason for the homegarden farmer’s scientific adoption and better productivity. The efficient contribution was mainly with right and timely advisory service and credit supply as evident from the results of our study of the rubber growers, which was not the case for other crops. The present remunerative price situations were another motivating factor for more number of homegardens switching to this crop. This again has to be explained in terms of various associations at definite internal effects on homegardens.

Coconut base crop was seen in almost all the districts but with less dominance in Pathanamthitta. It was proved to be of income contributing nature with respect to regular returns. In many of the homegardens, though coconut was a neglected crop with reference to management as revealed in the study but proved to be a major source of income. Besides, the products of coconut like leaf, leaf peduncle, inflorescence, spathe, dried husk of coconut and coconut shells catered to the fuel and economic requirements of the household.

The contribution of tapioca to the annual homegarden income was also revealed from the result of the study. High profit coupled with minimal attention on management aspects and input was a valid reason for the predominance of this crop. The findings are in agreement to the results of Salam and Sreekumar (1990).

Another major reason as revealed in the study is that this crop was a major crop not only from the dietary habits, but also from the point of consumer preference. The stem and processed tuber also serve as a food for livestock at all times particularly lean periods.

Pepper was a contributing crop to the annual homegarden income. It was generated because it is a high value crop. A less quantity obtained can fetch more prices. Shehna et al. (1992) reported that spices occurred in every eight out of ten homesteads surveyed and the most common spice component identified was pepper, which was observed in 58 per cent of the homesteads studied. A major reason for the high occurrence can be traced to many multi purpose tree species occurrence in the homegarden, which served as live standards for pepper thus making it a numerically dominant and contributing crop in Kerala homegardens.

The culinary habit of the tract is another reason. Most of the people of Kerala prefer spicy food. Again the spices from Kerala have a premium and find a ready market. When it comes to sale, it serves as a buffer security to homegarden. The crop with its superficial feeding habits fits the spatial and temporal land use making it an ideal component of the crop mix pattern of Kerala homegardens.

The results also revealed that arecanut was also contributing to the annual homegarden income especially in case of Alappuzha district. Arecanut predominantly existed in homegardens and it occurred in association with other tree crops in coconut dominant multi tier cropping systems. This is because Alappuzha is predominantly coastal and other crops fail to come up to its potential best in the sandy tract. Vegetables are now adding to the fortune of the farmer very recently. Only further studies can make it a major player among the crops.

Even though the aforesaid crop components were found out to be more contributing in nature for homegardens, tree crops like mango, jack, cashew, tamarind, teak, mahogany and many other fruit crops were widely grown in the homegardens for meeting the various requirements. They contributed more to the homegarden self-reliance. The contributing nature of the aforesaid components have been attained due to the synergistic interaction among the different components (be it crop, livestock or poultry) in the homegardens making it a sustainable one from all aspects of the requirement of households. Thus the homegardens, which, were originally expected to the function of food security, has now undergone a radical change where a prioritization with income generation has been the prime concern. This is mainly because higher income gives the homegarden farmers better access of his entire requirement plus a surplus savings. This is contrary of the reports of Fernandes and Nair (1986).

4.2 The need for intermediary in marketing the homegarden produces as perceived by the homegarden farmers

The result of the study revealed that intermediaries were necessary for marketing of homegarden products except in the case of Pathanamthitta district. Pathanamthitta homegardens having predominantly a rubber dominant cropping system, coupled with a strong and efficient market system with adequate extension and advisory support from agencies like rubber board, societies and NGO's. This was the reason for their dislike in having intermediaries in the marketing activities of homegarden produces.

On the contrary, majority of homegarden respondents of Thiruvananthapuram, Kollam and Alappuzha felt that intermediaries were useful and necessary in the marketing of homegarden products. This was primarily attributed to the varying diversity and species composition in the homegardens where animal husbandry components with many crop components contributed to homegarden with different products but in less quantity. In short, there was surplus of products but not enough for direct marketing. Hence, it became essential that some agencies who could market the products be involved in the marketing activities. Since there was no organised or regulated structure for the purpose, the homegarden respondents had to rely on the intermediaries to get their products marketed forgoing some of the actual profit they intend from the products which was often taken by the middlemen as commission. The results of the study are contradictory to the findings of Lepcha et al. (1993) and Babu (1995).

Also, homegardens are rich with horticultural components where there is a predominance of fruits and vegetables. It being perishable in nature, they have to be sold at the earliest opportunity. A majority of the homegarden farmers are small farmers, hence do not posses withholding capacity till a favourable price emerges in the market. Due to its less quantity, they do not have a bargaining power to derive the best of their resource. This particular situation obviously made the homegarden farmers feel the essentiality and usefulness of intermediaries in marketing their homegarden products.

5. CONCLUSION

The economics of homegardens with respect to extent of contribution of major components (crop and livestock) towards annual homegarden income, it was found that livestock, rubber and tapioca were significantly related to annual homegarden income in Thiruvananthapuram whereas in case of Kollam it was rubber, livestock, coconut and pepper. In case of Alappuzha it was livestock, coconut, arecanut and pepper whereas for Pathanamthitta it was rubber, livestock and coconut. The marketing channels identified in the study proved that intermediaries in various forms had a role in marketing the homegarden products.

Notes

The extent of contribution of major components to the annual homegarden income was worked out for enabling better interventional planning for the homegarden farmers by way of incorporating these components to homegardens of similar agroclimatic conditions. The major components in homegarden was worked out using measure of dominance index. A methodology was derived for the purpose. The dominance of crops in the homegardens was measured in terms of structural dominance, numerical dominance and economical dominance.

The measure of structural dominance was arrived at by observing promptly the pattern of canopy (configuration) formation, the height of plants, a perception of the root spread of plants and rating it in a 'seven point' scale with 'one' for a crop species with a highly dominating structure over the surrounding individual plants and 'seven' for the least dominating one in the homegardens.

The numerical dominance of a crop is the scale value assigned to that crop in accordance with the numerical strength of the individual plants belonging to the crops species. A seven point scale with 'one' assigned for the crop with maximum dominance stand and seven for the one with a minimum stand or scarcely distributed stand in the homegarden.

The economic dominance was worked out using the similar procedures by assigning a rank 'one' in the seven point scale for the most remunerative crops and subsequently the other ranks of two, three, four, five, six and seven for the lesser remunerative crops in the order.

By careful evaluation of these three types of dominance, the major component contributing to the annual homegerden income was established.

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INDIAN DIVERSITY OF ASCIDIANS – A REVIEW

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ABSTRACTS

Ascidians (Chordata: Ascidiacea) represent research opportunities in the fields of evolution, ecology, natural and supplementary products. This review article provides an introspective to the Indian biodiversity of the Class Ascidiacea, focusing taxonomy, distribution and abundance patterns. Earlier studies on the ascidians of India were sporadic and limited with only about 450 species recorded over the last 99 years. The number of species and families is found in the order Aplousobranchia, Phlebobranchia and Stolidobranchia. Family Didemnidae contribute the highest diversity of species with more than 183 within each group. This account of diversity is indeed shortened as the ascidians fauna in many areas around the Indian coast is comparatively poorly identified.

Key words: Ascidians, diversity, taxonomy, Indian coast

1. INTRODUCTION

Ascidians (Phylum Chordata, Class Ascidiacea), or sea squirts, are the largest and most diverse class of the sub-phylum Tunicata (also known as Urochordata). Tunicates are included with the chordates because of their three important characters. The first character is the presence of a notochord either in the larval or in the adult stage. The same characters are found in ascidians also. In the adult ascidians, the notochord is absent, but it is found in the tail of the tadpole larvae, stretching to its full length. The second character of the chordate is the tubular nerve cord placed dorsal to the notochord. In ascidians, the nerve tube is placed above the notochord in the tail of the larvae and the anterior end of the nerve cord is dilated into a brain vesicle situated in the trunk region. The third chordate character is the presence of gills having perforations of the pharyngeal wall. In the lower chordates, food capture and respiration take place when water passes through these opening. In the adult ascidians, the gill openings are placed in a series of rows on a massive bag, the branchial sac, which leads to the intestine.

Ascidians can be divided in to three main types based on their growth forms: solitary ascidians are single discrete individuals that can only reproduce sexually, species may have separate sexes but many are hermaphroditic, meanings that they produce both sperm and eggs. Social ascidians include species where genetically identical individual or clones that are vascular connected to each other in some way. Each "zooid "or discrete unit has on inhalant and exhalant siphons. In compound or colonial ascidians, individual zooids are integrated in a gelatinous matrix to the oxygen of sharing a common exhalant siphon with neighbouring zooids these species often look like blobs, but are actually hundreds or thousands of genetically identified individuals (Fig. 1).

Both, solitary and colonial tunicates have sac-like bodies and feed by filtering water. Water is drawn in through an inhalant siphon and expelled through an exhalant siphon. The siphons are visible on the larger solitary tunicates, which will sometimes expel water when touched, hence the nickname "sea squirts." Colonial tunicates are much smaller and live embedded in a common "tunic"; their siphons are difficult to see without a microscope. A colony is formed when a larva attaches to substrate and undergoes metamorphosis to become an adult tunicate, called a zooid. The first zooid then replicates itself asexually through a process called budding, creating additional zooids. All of the zooids are connected via the living tissue of tunic, which may be translucent and gelatinous or thick and leathery. While the individual zooids are small, colonies can be quite large. In some tunicate species, zooids are arranged in patterns, such as clusters in the shape of flowers or stars.

Some species are known to be rapid colonizers on artificial substrates such as marina floats, pilings, buoys, and boat bottoms in protected harbours, where there is reduced wave action and enhanced nutrients from anthropogenic activities (Naranjo et al., 1996; Oren and Benayahu, 1998; Lambert and Lambert, 1998, 2003). Eggs and sperms are produced in the colonial species and brood their young ones and release mature larvae into the water column (Millar, 1971; Kott, 1985). In temperate and cold seas, breeding is usually seasonal and restricted to the warmer season (Millar, 1952, 1954, 1971; Becerro and Turon, 1992), but in tropical waters it may continue throughout the year (Goodbody, 1961; Millar, 1971, 1974; Van Duyl et al., 1981; Stoner, 1990). Since the larval stage is relatively short (6–24 h), (Berrill, 1950), it is believed that the primary mode of invasion is by the transport of adult forms overgrowing boat hulls or other fouled surfaces (Lambert and Lambert, 1998; Lambert, 2002).

The ascidians inhabit exclusively in marine environments which are unable to survive in low salinity areas. In rare instances some ascidians are able to accumulate in lower salinities. Cnemidocarpa zenkevichi is found in the brackish water bays of the Knox coast in the Antarctic where there is a fresh water runoff in summer (Dell, 1972). Ciona intestinalis which occurs in high salinities in different seas of the world is reported to survive and reproduce in the waters around southern Scandinavia in salinities varying from 8 to 11ppt (Dybern, 1967) and live in Suez where salinity can reach up to 41ppt. Aim of the present paper is to provide a systematic review of the class Ascidiacea, describing the main regions of highest biodiversity; discussing the risks of invasive species, and summarizing the current trends in ascidians India distribution patterns.

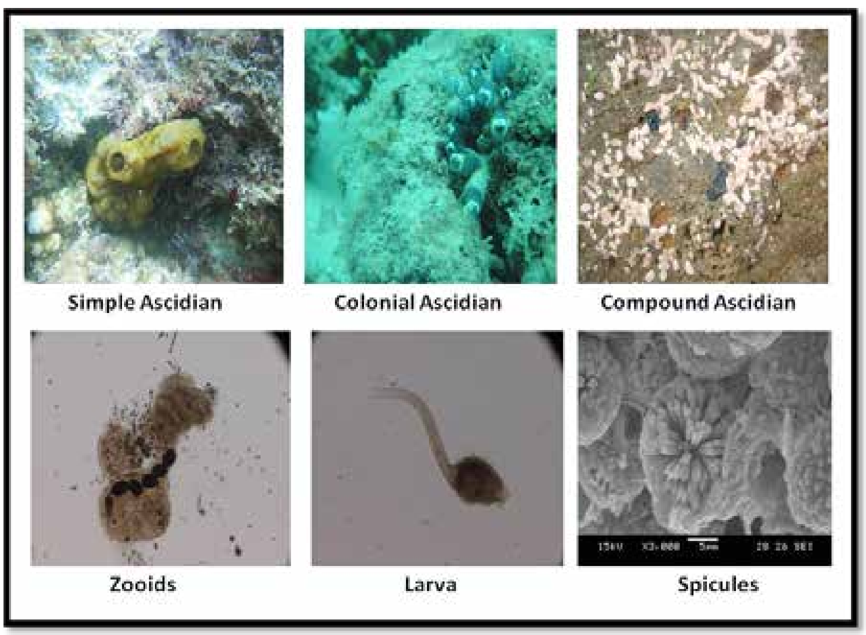

Fig 1. Ascidian, distinguishing taxonomic character.

1.1 Distribution of Ascidians in Indian waters

Work on Ascidians in Indian waters begin in 1915, Oka (1915) descripted the tunicate (simple ascidians) in the collection of Indian museum. Gravely (1927) surveyed littoral ascidians along the Krusadai Island of the Gulf of Mannar Biosphere Reserve. Das (1936) reported monascidian characterstics of Herdmania sp. in the Indian Zoological Memoirs Series. Similarly Das (1945) also accounted collection of monascidians from Madras coast. Sebastian (1952, 1954 and 1955) recorded many new species of Polyclinum indicum, Perophora listeriindica synascidians along the Madras coast of India. Further Sebastian (1956) observated two new fouling organisms such as Symplegma viride and Symplegma viride stolonica) from the Indian waters. Sebastian (1959) made structural studies of Herdmania ennurensis. Das (1936, a) reported fouling ascidian characteristics on fishing vessels in the Kerala coast of India. Sebastian and Kurian (1981) explored the diversity of Indian ascidian species.

Renganathan (1981a, 1981b, 1983a, 1983b, 1983c, 1984a, 1984b 1984c, 1984d, 1984e 1985, 1986a, 1986b and 1986c) studied the spatial occurrence of colonial and simple ascidians species from the Tuticorin coastal region of India. He also recorded new species of ascidians such as Didemnum psammatode Botrylloides chevalense, Aplidium multiplicatum, Styela bicolour, Microcosmus curvus, Eudistoma viride, Ecteinascidia garstangi, Perophora formosana, Pyura lanka, Symplegma brakenhielmi, Eudistoma lakshmiani and Molgula martensli from Gulf of Mannar region. In addition,Renganathan (1982a, 1982b) identified a new genus of colonial ascidian such as Lissoclinum fragile. Krishna et al. (1989) investigated on the occurrence of four species of ascidians new to Indian waters.

Meenakshi (1997) recorded rare simple ascidian species of Rhodosoma turcicum from Gulf of Mannar area. Meenakshi (1998a, 1998b, 1999a, 1999b, 2000a, 2000b, 2002, 2004a, 2004b, 2005, 2006a, 2006b and 2006c) made intensive survey of ascidian species along the Gulf of Mannar and she identified several new records on species distribution. It includes Distaplia nathensis, Eusynstyela tincta, Phallusia nigra, Polyclinidae, Phallusia polytrema, Ecteinascidia sluiteri, Eceinascidia venue, Eudistoma kaverium, Polycarpa maniensis, Polycarpa scatterat, Polycarpa aurita and Pyura spinosa in the Indian waters. Further, Meenakshi and Renganathan (1998) reported on the occurrence of a simple ascidian, Ascidia sydneiensis Stimpson, 1885 from Tuticorin coast of India.

Abdul Jaffar Ali (2004) deliberated comparative study on ecology of Phallusia nigra (Savigny, 1816) between Tuticorin (South east coast) and Vizhinjam (South west coast) of India. Abdul Jaffar Ali and Sivakumar (2007) observed the occurrence of ascidians in Vizhinjam Bay, Southwest coast of India. Tamilselvi (2008) described significances on ecological diversity of different ascidian species in Tuticorin coastal water. Karthikeyan (2010) identified 23 species of ascidians from Palk Bay and 44 species of ascidians were recorded in the Gulf of Mannar, India by Ananthan (2012). The database on Indian records of ascidians taxonomic literature and systematic were reviled for India ascidians distribution patterns.

Works on Ascidians in Indian waters begin in 1915 and over the 99 years completed (Fig. 2). The highest number of ascidian species is found in the Bay of Bengal, with inventory numbers such as 359 species from Gulf of Mannar, 25 species from the Palk Bay region, 41 species from South Coast and 25 species from Andaman & Nicobar Islands. The ascidian fauna along the coasts of Gulf of Mannar was studied extensively, resulting in records of 359 species from Gulf of Mannar (Fig. 3) (Table. 1).

Fig2. Ascidian India distribution

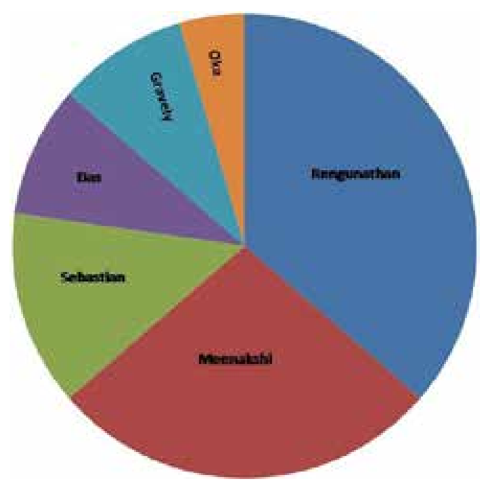

Fig 3 Author contributions. Percentage of species described per taxonomic authority.

Table 1. Ascidian regional species richness.

S.No	Area	Number of Species
1	Madras Coast	25
2	Gulf of Mannar	350
3	Palk Bay	22
4	Southwest Coast	23
5	Mumbai Coast	5
6	Andaman & Nicobar Islands	25

1.2. Records of non-indigenous ascidians

Most of the ascidians have blooming characteristics of new habitats during the favorable environmental conditions (Lambert, 2002; 2003). These blooming phenomenons can make damage to the coastal installation such as boat jetties and harbors (Spanier and Galil, 1991). Further it also displaces the local ascidian species and affects community structure (Rilov et al., 2004; Blum et al., 2007). The above said phenomenons take place during the cargo ships hull. It is vital source of introduction of non-native species and these new species affects the huge economical loss of local aquaculture species (Whitlatch et al., 1995). However, little information are exists in the presence and distribution of alien and native cryptogenic ascidians. Some information is available on the impact of ascidians as marine fouling species (Nair et al., 1988, Maruthamuthu et al., 1990 and Venkat et al., 1995) but these ascidians are not categorized into either alien or native species. Styela bicolor, Phallusia nigra and Eusynstyela tincta could have been translocated into Indian waters from other parts of the world and also between coastal locations of India (Anil et al., 2002).

Based on the review of the literature, 22 non-indigenous species of ascidians in India which include 10 simple and 12 colonial ascidians. In the past decade, many aquatic invasive species are introduced into Indian coastal waters resulting in alteration of ecosystem at various levels (Table. 2).

Table 2. Documented locations of non-indigenous ascidians (Tamilselvi et al., 2011).

Species	Introduced sites
1. Ascidia sydneiensis	Indo-Pacific and Atlantic ocean, Sub Antarctic region, East South America
2. A. gemmata	Indo-West Pacific
3. Phallusia nigra	Panama, USA, Indo-Pacific, Atlantic and the Mediterranean
4. P. arabica	Indo West Pacific and North east Atlantic
5. P. polytrema	Indo-West Pacific Region, East South America, Pan tropical throughout the Caribbean
6. Herdmania pallida	Atlantic Ocean, Indo-West Pacific and the Mediterranean: Sub Antarctic region.
7. Microcosmus curvus	Pacific ocean
8. M. squamiger	Indo-Pacific, Southwest Atlantic and the Mediterranean Sea,: Sub Antarctic region
9. M. exasperatus	Indo-West Pacific, Atlantic Ocean and the Mediterranean: East Africa, Sub-antarctic, southeast America
10. Perophora formosana	Indo-West Pacific and Atlantic Ocean
11. Eusynstyela tincta	Atlantic Ocean and Indo West Pacific: East South America
12. Styela canopus	Indo Pacific, Atlantic Ocean and the Mediterranean: South and South east America

13. Symplegma oceania	Indo-West Pacific
14. S. viride Herdman	Atlantic Ocean, Indo West Pacific and the Mediterranean: Sub Antarctic East South America
15. Botrylloides magnicoecum	Indo-West Pacific and Western Central Atlantic
16. B. leachii	Northeast Atlantic, Indo West Pacific and Mediterranean and Black sea: Australia and Europe
17. Didemnum psammatodes	Indo-West Pacific and Eastern Atlantic:Subantarctic region, Malaya and West Africa
18. Lissoclinum fragile	Indo-Pacific and Western central Atlantic
19. Trididemnum clinides	Indo-West Pacific
20. T. savignii	Indo-Pacific and Western Central Atlantic
21. E. viride	Western Central Pacific and Indian Ocean
22. A.multiplicatum	Indo-West Pacific

2. DISCUSSION

The biodiversity of class Ascidiacea described 2815 species from overall world based on review of the literature and the species registered in the online World Register of Marine Species. The class Ascidiacea has been the object of much scientific interest in the last decade (Pourquie´, 2001). The biodiversity of the Ascidian fauna of India is largely unknown and little information is available on the group as a whole. It is speculated that a large number species are still undescribed. Even though India where only in Tamil Nadu few works on ascidians has been done, resulting in very low number of described ascidian species and generally lacking of data. The majority of the described ascidian species are attributed to only few taxonomic experts. The ascidians represent vast opportunities for research in the fields of evolution and development, physiology, natural products, and marine bioinvasion. Ascidians are producers of amino acid derived secondary metabolites. Investigations of taxonomically diverse ascidians could reveal a variety of pharmacologically potent natural products. Most of the microorganisms which cause infectious diseases in man are rapidly developing resistance towards traditional antibiotics. Yet, there are many areas around India that are relatively poorly known, and the available data should be updated and revised. Many more species are yet to be discovered, contributing to our knowledge of this unique group.

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A SURVEY ON THE MICRO ALGAL DIVERSITY OF THE LAKE INSIDE THE GOVERNMENT ZOOLOGICAL GARDEN, THIRUVANANTHAPURAM, KERALA.

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ABSTRACT

Species diversity is a key concept in ecology. In this study phytoplankton diversity of the lake inside Thiruvananthapuram Zoological Garden has been carried out. Eight diversity indices have been derived using the PAST software program. They include Dominance index, Evenness, Simpson's index, Shannon and Wiener index, Menhinich's and Margalef richness index, Equitability index, Fisher's index and Berger Parker dominance index. Diversity indices are important in understanding the distribution of planktonic algae in fresh water bodies. A total of 88 algal species have been identified which is the first report of them from this area. Chlorophycean members observed were dominant throughout the study period. The plankton study is a very useful tool for the assessment of water quality, trophic status and pollution level. The Shannon- Wiener diversity index was most useful in indicating the trophic status which in this case depicted a moderate level of pollution of this lake.

Key Words: Diversity Indices, PAST, Plankton, Water Quality, Trophic Status.

1. INTRODUCTION

Phytoplankton are free floating unicellular, filamentous and colonial eutrophic organisms that grow in aquatic environments whose movement is more or less dependent upon water currents (Millman et al., 2005). These micro flora acts as primary producers as well as the basis of food chain, source of protein, bio purifier and bio indicators of the aquatic ecosystems of which diverse array of the life depends (Monika & Patralekh, 2004; Ariyadej et al., 2004). They are considered as an important component of aquatic flora, play a key role in maintaining equilibrium between abiotic and biotic components of aquatic ecosystem (Pandey et al., 2004). In general, different planktonic species can tolerate different ranges of temperature as well as light and nutrient limitation. These tolerant levels determine th dominance of different species within different sea sons (Akbay et al., 1999). Further, these entities ca tolerate wide range of pollution in the aquatic en vironment. Therefore, in this study, phytoplankto ecology is of special importance because they pla a dynamic role in trapping solar energy and als reflects the average ecological condition (Kotut e al., 1998). Keeping these in view, the present stud was undertaken to evaluate phytoplankton species diversity indices which indicates the quality of water in the lake of Thiruvananthapuram Zoological Garden.

2. MATERIALS AND METHODS

Thiruvananthapuram Zoo is one of the oldest in the country which is located at the heart of the city, is at 8.5117293°N 76.9550014°E. It was established as an annexe to the Museum in 1857 by the erstwhile Maharaja of Travancore in order to attract more visitors. This Zoo was originally set up for recreational purpose only. But with more and more loss of forest and wildlife in the process of human development, the goal of the Zoo changed from recreation to conservation. The lake is extended over 7693.93 sq.m, often named as the 'The lungs of the city'. About 60 species of resident water birds like Pond Herons, Oriental Darter and Cormorants are some of them associated with the lake. A sketch of the lake showing the sampling sites is shown in Fig 1.

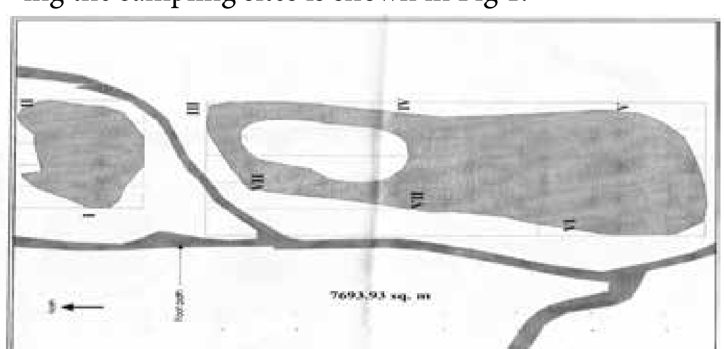

Fig.1 Sketch of the Thiruvananthapuram Zoo Lake

Water samples were collected at monthly interval from the selected sites of the water body using phytoplankton net and fixed in 4% formaldehyde, with the help of relevant literatures they were identified (Prescott, 1978). A total of 88 algal species belonging to Chlorophyceae, Cyanophyceae, Bacillariophyceae and Euglenophyceae were recorded. The data were subjected to a software program PAST (Hammer et al., 2001) which generates eight diversity indices. The formula designed for various index are described below.

Dominance Index=1-J, J is evenness of relative diversity (H'/Hmax) where absolute evenness =1.00. The Shannon Weiner Index (H') assumes all species are represented, sample randomized'= Σpi in pi; pi=proportion of the ith species and in natural logarithm. The Simpson's Diversity Index (D) (1949) is calculated as Ds= Σ (ni(ni-1/N(n- 1) where Ds=Bias corrected from Simpson Index ,n1 is number of individuals of species 1,N=total number of species in community. As diversity increases index value gets smaller. Menhinick's index Dmm (Whittaker, 1977) is expressed as Dmm=S/ N, where N is the number of individuals in the sample and S the species number. Margalef's Index (1968) is expressed as D=(S-1)/In N. It is calculated as the species number (S) minus 1 divided by the logarithm of the total number of individuals (N).The Shannon's equitability Index(EH)=H/Hmax=H/In S (Lloyd and Ghelard, 1964). Equitability assumes a value between 0 and 1 with the value of 1 being complete evenness. The Fisher α index is a parametric index of diversity which assumes that the abundance of species follows the log series distribution and is expressed as ax, ax2/2, ax3/3……axn/n The Berger-Parker Dominance Index is a simple measure of the numerical importance of the most abundant species and is expressed a d=Nmax/N. N max is the number of individuals in the most abundant species and N is the total number of individuals in the sample. A reciprocal of the Index 1/d is often used so that and increase in the value of the index accompanies an increase in diversity and a reduction in dominance.

3. RESULTS AND DISCUSSIONS

The validity of comparing diversities in various samples can be criticized because of arbitrary choice of the diversity index. It is better to try a number of diversity indices in order to make sure that the diversity ordering is robust (Shankar P Hosmani, 2010).

The abundance of phytoplankton in the lakes under study cannot be exactly pointed out since the physico chemical parameters were not considered in this study. However the diversity and diversity indices of phytoplankton are discussed. Chlorophycean members (503) were found dominant throughout the study period. Pediastrum duplex, P. tetras, Scenedesmus acunae, S. dimorphus and S. protuberens were the common Chlorophycean members. Chlorophyceae dominance has been attributed to eutrophic nature of the lake (Bhat et al. , 2012). Cyanophycean and Euglenophycean members were represented low. Zafar (1967) attributed the occurrence of Euglenaceae to be inversely related to Cyanophyceae. Bhat et al. (2012) opined that Euglenophyceae members show higher tolerance to organically polluted areas; Palmer (1969) inferred that Euglenophyceae members can be used as biological indicator of organic pollution. The results of the abundance of phytoplankton in the lake are presented in Table 1

The Dominance index in the present study indicates that the pre-monsoon period has the highest phytoplankton dominance (0.4534) and post-monsoon with lower value of dominance (0.3213). The Simpsons index is used to quantify the biodiversity of habitats. It takes into account the number of species and the abundance of the species. The greater the index value the greater the sample diversity. In the present study the value ranges from 0.5465-0.6787 and shows it is not evenly distributed. The various diversity indices values are shown in Table 2.

Shannon and Weiner index (1949) represents entropy. It is a diversity index taking into account the number of individuals as well as the number of taxa. It varies from 0 for communities with only single taxa to high values for community with many taxa each with few individuals. This index can also determine the pollution status of a water body. Normal values range from 0 to 4. This index

Table.1. Abundance of Microalgae in Thiruvananthapuram Zoo Lake

Material	Pre-monsoon	Monsoon	Post- monsoon
CHLOROPHYCEAE			
Ankistrodesmus falcatus	+	+ +	+
Coelastrum indicum	+	-	-
Coelastrum microporum	+	-	-
Chlorococcum sp	+	-	-
Chlorogonium sp	+	+	-
Closterim acerosum	+++	++	-
Closterium aciculare	+++	++	-
Closterium angustatum	+++	++	-
Closterium calosporum	+++	+ +	-
Cosmarium sp	+ +	+	+
Crucigenia quadrata	+++	+++	+
Crucigenia tetrapedis	++	-	+
Dactylocopsosis sp	+	-	-
Desmodesmus armatus var. subglobosa	++	+	-
Desmodesmus armatus var. spinosus	++	+	-
Dictyosphaerium ehrenbergianum	+	+	-
Dictyosphaerium pulchellum	+	+	-
Didymocystis planktoria	+	+	-
Docidium bacculum	+	-	-
Euastrum sp	+	-	+
Eudorina elegans	+++	+	-
Kirchneriella lunaris	+ ++	+	+
Kirchneriella rotunda	+++	+	-
Microsterias sp	+	+	+
Monoraphidium minutum	-	-	+
Nannochloris sp	+	-	-
Onchonema filiformis	+	-	-
Oocystis crassa	+	-	-

Ourococcus sp	+	-	-
Pandorina sp	+	-	-
Pediastrum duplex	+++	++	+
Pediastrum tetras			
Planktosphaeria gelatinosa	+++	++	+
Scenedesmus acunae			
Scenedesmus acuminatus	+++	++	+
Scenedesmus dimorphus			
Scenedesmus disciformis	+++	++	+
Scenedesmus obliques			
Scenedesmus protuberens			
Scenedesmus quadricauda	++	+	+
Schroederia setigeria			
Sorastrum spinulosum			
Staurodesmus mucrinatum	+++	++	+
Tetradesmus sp			
Tetrahedron sp	+	+	+
Tetrallentos sp			
Tetrastrum sp			
CYANOPHYCEAE	++	+	+
Anabaena spiroides			
Aphanocapsa sp	+++	++	+
Chrococcus turgidium			
Merismopedia elegans			
Merismopedia glauca	++	+	+
Microcystis aeroginosa			
Oscillatoria subbervis			
BACILLARIOPHYCEAE	++	+	+
Achnanthes sp			
Amphora angusta			

(+++ Abundant; ++ Present; + Rare; -Absent) is a combination of species present and the evenness of the species. Examining the diversity in the range of polluted and unpolluted ecosystems, Wilham and Dorris (1968) concluded that the values of the index greater than 3 indicate clean water, values in the range of 1 to 3 are characterized by moderate pollution and values less than 1 are characterized as heavily polluted. Moderate pollution can be inferred in this study for the Thiruvananthapuram Zoo Lake.

Both the Menhinick's and Margalef's indices measure richness of species in an ecosystem.

Menhinick's index was low in pre-monsoon (0.454) and reached a high value of 0.9036 in the post-monsoon period.

The Shannon Equitability index is a measures of the evenness with which individuals are divided among the taxa present. The explanation for this index is that, for a given richness (total number of species in a community, S), Simpson's diversity index increases as diversity increases and for a given equitability Simpson's index increases as richness of species increase. Taking Simpson's index and expressing it as a proportion of the maximum value can also calculate equitability. Equitability takes a value between 0 and 1, with 1 being complete evenness. The diversity index could be assumed if individuals in a community were completely evenly distributed. The index when applied to the present study indicates that individuals of the community in lake are not evenly distributed with values ranging from 0.7425 to 0.9030.

Fisher's á index (1943) is a mathematical calculation for determining diversity within a population. It represented the first attempt to describe mathematically the relationship between the number of species and the number of individuals of those species. The index values are shown in Table.2. Berger-Parker dominance index (1970) is the number of individuals in the dominant taxa divided by number of individuals (n). It is the largest species proportion of all species in a community. This index is most strongly influenced by evenness of the indices (Shannon and Weiner, 1949). Its reciprocal value is an index of diversity. In the present study it indicates that individuals of the community in all lakes are not completely evenly distributed. The values are high in pre-monsoon (0.6329) and least in post-monsoon (0.4410).

Various diversity measures have potential applications in aquatic ecosystems, mainly in conservation. It is often understood that species rich communities are better than species poor communities. Secondly, in environmental monitoring it is assumed that the adverse effects of pollution will be reflected in the reduction of diversity or change in the composition of species abundance. Both these factors involve diversity as an index of a good ecosystem (Shankar P Hosmani, 2010). Rosenberg (1976) and Patrick (1973) are of the opinion that enriched or polluted ecosystems display a reduction in diversity. Shannon and Wiener index is widely adopted in pollution monitoring. Platt et al. (1984) used the Simpson's index in bio-monitoring. Stoermer (1984) discussed the role of phytoplankton species and assemblage as bio-indicators. Simple species richness and dominance measures are invariably informative. There is considerable evidence that conservation strategies may be improved if information on species abundance patterns is taken into account.

Table.2. Diversity Indices of Microalgae in the Thiruvananthapuram Zoo Lake

	Pre-Monsoon	Monsoon	Post-Monsoon
Total Individuals	484	255	128
Dominance	0.4534	0.3868	0.3213
Simpson's	0.5465	0.6131	0.6787
Shannon Wiener	1.0292	1.1235	1.252
Evenness	0.7003	0.7802	0.8779
Berger Parker	0.6329	0.5473	0.4410
Menhinick	0.454	0.7316	0.9036
Margalef	0.7344	0.8842	1.102
Equitability	0.7425	0.8166	0.9030
Fisher	0.9663	1.2541	1.5863

4. CONCLUSION

Calculating the diversity indices during this period may indicate a negative inference. According to the indices, Lake has low dominance of species in post-monsoon unlike various studies which reported and support post-monsoon period as the highest species rich time. That may be due to the increased number of fish population associated with the Lake which actually does not have a stronger predator and it needs further study. From the Shannon Wiener diversity index it can be inferred that the water quality of the lake is moderately and organically polluted. From the study it is concluded that the Thiruvananthapuram Zoo Lake needs more care in quality parameters to check pollution for a healthy environment of the Zoo animals and to enjoy the zoo tourism. Therefore, the lake has to be preserved for its intended use, a sustainable and aesthetic management planning is necessary for the conservation of this water body.

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MICROBIAL BIODIVERSITY IN WESTERN GHATS OF MAHARASHTRA

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ABSTRACT

The samples were collected from the rhizosphere and bulk soil of Euphobiaceae panchaganiensis, Persicaria glabra, Strobilanthes callosus from Kas plateau, Satara; Abutilon sp. from Ambeghat, Kolhapur; and the bulk soil from Amboli and Sindhudurg of Western ghats of Maharashtra. Total 20 Actinomycetes, 14 Pseudomonas and 8 endophytes were isolated and studied for their biodiversity with respect to enzyme activity viz., xylanase, amylase, pectinase, cellulase, gelatinase, protease, lipase, laccase, chitinase and esterase. The plant growth promoting traits viz., ammonia production; production of plant growth hormones Indole Acetic Acid, Gibberellins and Cytokinins; acetoin production; hydrogen cyanide production; solubilization of minerals viz. phosphorus, zinc and potassium and siderophore production were also studied. The Pseudomonas and actinomycetes isolated from Western ghats of Maharashtra indicated biodiversity with respect to enzyme activity and plant growth promoting traits which will be important from the agriculture point of view.

Key words: Biodiversity, Western Ghats, indole acetic acid, gibberellins, hydrogen cyanide

1. INTRODUCTION

The microbial world is the largest unexplored reservoir of biodiversity on the earth. It is an important frontier in biology under intensive investigations. The exploration of microbial diversity has been spurred by the fact that microbes are essential for life as they perform numerous functions essential for the biosphere which include nutrient recycling and environmental detoxification (Bhardwaj and Garg, 2012). The management and exploitation of microbial diversity plays an important role in sustainable development with the industrial and commercial applications of microbial diversity worth millions of rupees (Bhardwaj and Garg, 2012). However, despite the obvious economic value of microbial diversity, microorganisms have been largely ignored in debates on the conservation and management of global diversity. There is, therefore, an urgent need to persuade the policy-maker to be more concerned about the conservation, management and exploitation of microbial diversity.

The biological diversity of the Indian subcontinent is one of the richest in the world owing to its vast geographic area, varied topography, climate, and the concurrence of several bio geographical regions and Western Ghats is one of the 34 global hotspots of biodiversity (Myers et al., 2000). Its varied climate and diverse topography create a wide array of habitats which support unique set of microbial species. About 500 plants mainly the medicinal plants from the Western ghats are reported to show the presence of microbial biodiversity (Naik et al., 2008).

In recent years, research has indicated the earth contains microbiological diversity that has the potential for remarkable scientific, social, and economic impact. In spite of these recent research activities, microbiological biodiversity remains largely undiscovered, and an understanding of its global distribution and temporal variability remains elusive. There is a need to integrate microbiological data with environmental parameters, ecological data, and geographical location in order to improve the understanding of the spatial and temporal patterns of microbial diversity and the relationship between population structure and function. Such knowledge can be used to assess the effect on ecosystems of environmental stress and perturbations like pollution, agricultural exploitation and global changes. The measure of microbial biodiversity describes the qualitative variation among the organisms in a community (Logeswaran et al., 2014).

Among various ranges of organisms in Western ghats, microorganisms are a vast array of novel and unidentified microbes, which can be explored for potential applications. The present work describes the study of microbial biodiversity from Western Ghats of Maharashtra with respect to enzyme activity and plant growth promoting traits.

2. MATERIALS AND METHODS

2.1Sampling

The samples were collected from the rhizosphere and bulk soil of Euphobiaceae panchaganiensis; Persicaria glabra; Strobilanthes callosus; Abutilon sp. of Western ghats of Maharashtra. The rhizosphere soil was collected by uprooting and removing soil adhering to roots of Euphobiaceae panchaganiensis, Persicaria glabra, Strobilanthes callosus from Kas plateau, Satara; Abutilon sp. from Ambeghat, Kolhapur; and the bulk soil from Amboli and Sindhudurg of Western ghats of Maharashtra. The latitude, longitude and altitude of each location was measured by Global Positioning System (GPS). The location map of study area of Kas plateau, Satara is represented in Figure 1. The soil samples and their locations is represented in Table 1. The rhizosphere soil and bulk soil samples were collected using hand-held scoops in the sterile labeled bags. The samples were stored at 4 ^{0}C until analysis. Each soil sample was dried in oven at 60 ^{0}C for 3 hr, passed through 0.8 mm sieve and preserved in polycarbonate bags for further studies.

Table.1: Soil samples and their locations.

Sr. No.	Location	Soil sample	Sample Code	Latitude/longitude	Altitude
1	Kas, Satara	Rhizosphere	E.P.R.1	N17 43.634 E73 49.186	4037
2		Bulk	E.P.B.1		
3		Rhizosphere	E.P.R.2	N17 43.627 E73 49.185	4041
4		Bulk	E.P.B.2		
5		Rhizosphere	S.C.R	N17 44.132 E73 48.786	4052
6		Bulk	S.C.B		
7		Bulk	S.L.B	N17 44.172 E73 48.832	4055
8		Rhizosphere	P.G.R		
9	Ambeghat, Kolhapur	Bulk	K.D.1	N16 37.069 E73 51.897	2124
10		Bulk	K.D.2		
11		Rhizosphere	A.P.R	N16 37.069 E73 51.917	2139
12		Bulk	A.P.B		
13	Amboli, Sindhudurg	Bulk	R.A	N16 16.008 E74 12.534	-

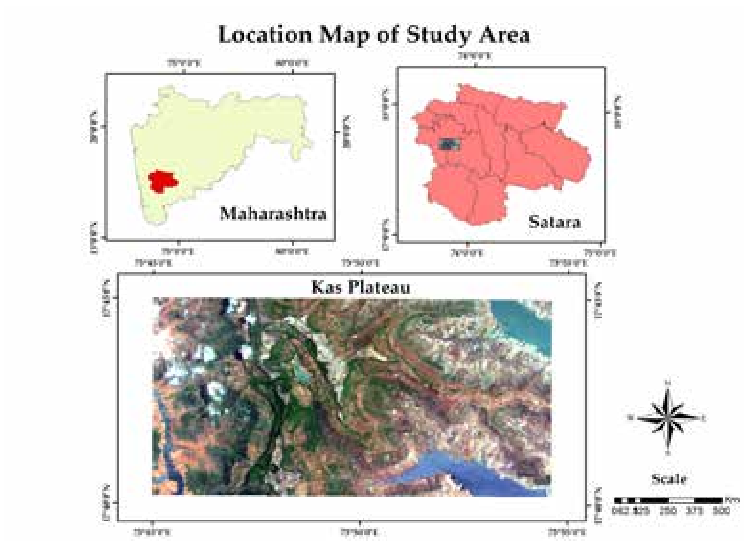

Figure 1: Location map of study area of Kas plateau, Satara.

2.2.Isolation of microbial population and actinomycetes from rhizosphere and bulk soil samples

One gram of each soil sample was suspended in 9 mL sterile saline, shaken and allowed to settle for 5 min. Dilutions ranging from10^2 to10^6 were made and 0.1 mL of each dilution was spread on nutrient agar (NA) (gL^{-1}: peptone-10, yeast extract-3, NaCl-5, p^H-7.2, agar-30, DW-1000 mL). For the actinomycetes isolation, the samples were spread on starch casein agar (SCA) media (HiMedia, Mumbai, India) of pH 6.5 and 8.5. The plates were incubated at 28 and 37 ^{0}C. The isolated colonies obtained were further streaked on cetrimide and King's B agar media (HiMedia, Mumbai, India) for Pseudomonas and the plates were incubated at 37 ^{0}C for 2-3 days.

2.3. Study of microbial biodiversity for enzyme activity

The isolates were studied for their biodiversity with respect to enzyme activity viz., xylanase and cellulase on minimal media (gL^{-1}:NH_4Cl-3, NaCl-3, K_2HPO_4-0.4, sodium citrate-3, glucose-10, p^H-7.0, agar-30, distilled water (DW)-1000 mL) supplemented with 1 % xylan and carboxylmethyl cellulose (CMC) respectively, amylase and gelatinase on NA supplemented with 1 % soluble starch and gelatin respectively, protease on skimmed milk agar media (milk-100 mL, sterile NA-200 mL. Sterilize the milk by autoclaving it and add to sterile NA, agar 20 g), pectinase on pectin agar media (KH_2PO_4-4.2, pectin-5, yeast extract-1, Na_2HPO_4-6, $MgSO_4.7H_2O$-2, $FeSO_4.7H_2O$-0.001, $(NH_4)_2SO_4$-2, $CaCl_2$-0.001, agar-30, DW-1000 mL), esterase on the media described by Sierra (Sierra, 1957) (gL^{-1}: peptone-6.5, $CaCl_2.2H_2O$-0.065, NaCl-3.2, agar-30, DW-1000 mL) supplemented with Tween 80 (1 % v/v), lipase on Tauson media (K_2HPO_4-1, $NaNO_3$-2, KCl-0.5, $MgSO_4.7H_2O$-0.5, $FeSO_4.7H_2O$-0.001, agar-30, DW-1000 mL), supplemented with 1 % tributyrin, laccase on glucose yeast extract peptone media (glucose-1, peptone-0.5, pH-6.0, agar-30, DW- 1000 mL) supplemented with 0.005 % -naphthol and chitinase on colloidal chitin agar media (Hsu and Lockwood, 1975). The plates were incubated at 37 ^{0}C for 3 days and checked for the zone of clearance around the colony. For the enzymes viz., xylanase, cellulase, amylase, pectinase and chitinase, the plates were flooded with Gram's iodine (I_2) regent (I_2-1 g, KI-3 g, DW- 300 mL) and gelatinase with acidic $HgCl_2$ reagent ($HgCl_2$- 100 mg, HCl- 5 mL) to observe the zone of clearance. The laccase enzyme was detected by observing the change in color of the medium from clear to blue.

2.4. Study of microbial biodiversity for plant growth promoting traits

The plant growth promoting traits viz., ammonia (NH_3) production; production of plant growth hormones Indole Acetic Acid (IAA), gibberellins and cytokinins; acetoin production; hydrogen cyanide (HCN) production; solubilization of minerals viz., phosphorus, zinc and potassium and siderophore production were studied. NH_3 production was done using Nessler's reagent (Solution 1 [gL^{-1}]: HgI_2-50, KI-40, DW- 1000 mL and Solution 2 [gL^{-1}]: NaOH-200, DW- 1000 mL) (Cappuccino and Sherman, 1992); plant hormones viz., IAA by spectrophotometric method using Salkowasky reagent ($FeCl_3$-2.02, H_2SO_4-300 mL, DW-300 mL) (Brick et al., 1991), gibberellins by spectrophotometric method using ethanolic sulphuric acid reagent (C_2H_5OH-90 mL, H_2SO_4-1 mL) (Holbrook et al., 1961) and cytokinins using bromophenol blue reagent (bromophenol blue- 0.10 g, 20 % C_2H_5OH- 100 mL) (Tien et al., 1979); acetoin production using Barritt's reagent (KOH- 40 %, -naphthol- 5 % in absolute alcohol) (Houdt et al., 2006); HCN production was detected by Bakker and Schipper's method (Bakker and Schippers, 1987). The phosphate solubilization detection was done on Pikovskaya's agar medium (gL^{-1}: glucose-10, $(NH_4)_2SO_4$-0.5, NaCl-0.2, $MgSO_4.7H_2O$-0.1, KCl-0.2, $MnSO_4$-trace, $FeSO_4.7H_2O$-trace, yeast extract-0.5, agar-30, DW-1000 mL) containing 0.5 % (w/v) tricalcium phosphate [$Ca_3(PO_4)_2$] and the zone of clearance around the colony and colony diameter were measured. (El-Azouni, 2008).The quantitative estimation for phosphate solubilization was carried according to the method of Briggs (1924). The zinc solubilization was detected on Pikovskaya's agar containing 0.15 % (w/v) zinc oxide (ZnO) and zinc sulphide (ZnS) instead of 0.5 % (w/v) [$Ca_3(PO_4)_2$] and supplemented with 6 % D-glucose (El-Azouni, 2008), while potassium solubilization was detected on Aleksandrov agar medium (gL^{-1}: glucose-5, $MgSO_4.7H_2O$-0.5, $FeCl_3$-0.005, $CaCO_3$-0.1, $CaPO_4$-0.2, pH- 7.0, agar-30, DW- 1000 mL) containing 0.2 % (w/v) potassium aluminum silicate (Hu et al., 2006). The siderophores detection was done on Chromeazurol S (CAS) media (Schwyn and Neilands, 1987) by the agar well diffusion method. A color change from blue to purple around the well indicated the presence of a catechol-type siderophore, from blue to orange indicated the presence of a hydroxamate-type siderophore and from blue to a light yellow indicated a carboxylate-type of siderophore (Perez-Miranda et al., 2007).

3. RESULTS AND DISCUSSION

3.1. Microbial diversity from Western ghats of Maharashtra

Total 42 isolates were obtained from the rhizosphere and bulk soil of Euphobiaceae panchaganiensis, Persicaria glabra, Strobilanthes callosus from Kas plateau, Satara; Abutilon sp. from Ambeghat, Kolhapur; and the bulk soil from Amboli and Sindhudurg of Western ghats of Maharashtra. From these, 20 isolates belonged to the genera of Actinomycetes, 14 isolates belonged to the genus Pseudomonas and 8 isolates were found to be endophytes.

3.2 Microbial diversity with respect to enzyme activity

Among the Pseudomonas isolates, the xylanase and pectinase activity was seen by isolate P12 with diameter of zone of clearance 1.70 and 2.10 cm respectively. The amylase activity was shown by isolate P13 with diameter of zone of clearance 2.50 cm (Table 2). None of the isolates showed cellulase, gelatinase, protease, esterase, lipase, laccase and chitinase activity (Table 2).

In case of the actinomycetes, fifteen isolates showed xylanase and amylase activity. Only four isolates showed pectinase activity with highest pectinase activity by isolate EPB with diameter of zone of clearance 2.50 cm. Cellulase and esterase activity was shown by eight isolates, with highest cellulase activity by isolate 127 with diameter of zone of clearance 2.20 cm and esterase activity by isolate KD2 with diameter of zone of clearance 3.25 cm (Table 3). The two isolates viz., 127 and EPB showed lipase activity, while the protease activity by only one isolate. The chitinase activity was shown by fourteen isolates with the highest activity by isolate EP plant soil with diameter of zone of clearance 4.25 cm (Table 3).

Table 2: Biodiversity with respect to enzyme activity of Pseudomonas isolates.

Isolates	Xylanase	Amylase	Pectinase	Cellulase	Gelatinase	Protease	Esterase	Lipase	Laccase	Chitinase
AP2	-	-	-	-	-	-	-	-	-	-
P12	+(1.70±0.00)	-	+(2.10±0.28)	-	-	-	-	-	-	-
P14	-	-	-	-	-	-	-	-	-	-
AP1	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-
KR2	-	-	-	-	-	-	-	-	-	-
KR1A	-	-	-	-	-	-	-	-	-	-
J2	-	-	-	-	-	-	-	-	-	-
P10	-	-	-	-	-	-	-	-	-	-
P9	-	-	-	-	-	-	-	-	-	-
AP1B	-	-	-	-	-	-	-	-	-	-
EPR2	-	-	-	-	-	-	-	-	-	-
P13	-	+(2.50±0.00)	-	-	-	-	-	-	-	-
P2	-	-	-	-	-	-	-	-	-	-

No enzyme activity. Fig in bracket indicate diameter of zone of clearance (cm). Each data point represents average of duplicate ± SD.

3.3. Microbial diversity with respect to plant growth promoting traits

All the isolates, except P13 and P2 did not show NH_3 production. The twelve isolates showed IAA production with highest IAA production by the isolate AP1B which was 15.50 µg/ml (Table 4). The gibberellin production was shown only by isolate AP2 which was 1.80 µg/ml and cytokinin by isolate AP1B. None of the isolates showed acetoin and siderophore production. The three isolates viz., AP2, AP1 and 1 showed HCN production, while phosphate solubilization was shown by five isolates viz., P14, KR2, KR1A, J2 and EPR2 with maximum phosphate solubilization by isolate EPR2 which was 0.90 µg/ml (Table 4). None of the isolates solubilized zinc and potassium.

The five isolates viz., Junewadi, EPR soil, EP plant soil, SC pH 6.5 and EPB showed NH_3 production (Table 5). The IAA production was shown by seven isolates with highest IAA production by the isolates SC pH 8.5 and ab which was 7.50 µg/ml respectively and gibberellins production was shown by ten isolates with highest gibberellins production by isolate KL which was 2.13 µg/ml (Table 5). The cytokinin was shown by six isolates viz., EP plant soil, J2, SCB, EPB, KD2 and SC pH 8.5. None of the isolates showed acetoin and HCN production and did not solubilize phosphate, zinc and potassium.

The four isolates viz., EPB, KD2, KD2 pH 8.5 and KL showed siderophore production which were hydroxamate-type siderophore.

The Pseudomonas isolates from Western ghats of Maharashtra will help to pave the way to identify the novel bioactive compounds.

The rhizosphere actinomycetes population in plants chosen from different ecosystems and different altitudes of Western ghats showed that Euphobiaceae panchaganiensis has highest actinomycetes population when compared to Strobilanthes callosus and Persicaria glabra at Kas plateau, Satara. Also, the density of actinomycetes in rhizosphere of Abutilon sp. at Ambeghat, Kolhapur was observed to be highest as compared to rhizosphere of Strobilanthes callosus and Persicaria glabra at Kas plateau, Satara.

Soil microorganisms are rich known to be rich sources of novel compounds; to date about 1000 natural products are reported to be derived from soil microbes (Adams et al., 2003). The Pseudomonas and actinomycetes isolated from the Western ghats of Maharashtra indicated biodiversity with respect to enzyme activity and plant growth promoting traits. The study indicated that Western ghats soil samples are rich sources of Pseudomonas, actinomycetes and endophytes with enzyme activity and plant growth promoting traits and hence can be used as potential plant growth promoting rhizobacteria. This can be very useful in the field of agriculture. There is a report on bacterial species of 21 different genera (Proteobacteria (58 %), Firmicutes (26 %), Actinobacteria (13 %) and Bacteroidetes (3 %) isolated from water samples of Western ghats region of India, with abundance of microbial diversity of ecosystem (Ruckmani and Chakrabarti, 2011). Also there is a report on actinomycetes diversity in Eastern ghats (Yercaud Hills) of Southern India for secondary metabolite production (Nithya and Ponmurugan, 2012). Table 4: Biodiversity with respect to plant growth promoting traits of Pseudomonas isolates.

4. CONCLUSIONS

The study of biodiversity will give access to new organisms and allow the selection of isolates useful; for agricultural applications. The microbial biodiversity will help to screen the culture bank for the ability to produce biomolecules of commercial agricultural value which can be mass multiplied and process developed for the industrial purpose. The microbial biodiversity of Pseudomonas and actinomycetes studied will help to explore their role in antibacterial properties and also for the exploitation of novel bioactive compounds viz., antibiotics, enzymes and other pharmaceutical products. The diverse environment of Western ghats of Maharashtra will provide sufficient diversity to explore the place for various microorganisms for bioprospecting.

Table 3: Biodiversity with respect to enzyme activity of Actinomycetes isolates.

Isolates	Xylanase	Amylase	Pectinase	Cellulase	Gelatinase	Protease	Esterase	Lipase	Laccase	Chitinase
127	+(2.25±0.07)	+(2.10±0.14)	-	+(2.20±0.14)	-	-	-	+(1.00±0.00)	-	+(3.00±0.00)
Junewadi	+(1.70±0.00)	+ (2.30±0.00)	-	+ (1.60±0.00)	-	-	-	-	-	+(3.40±0.14)
128	+(2.15±0.21)	+ (0.85±0.07)	-	+ (1.15±0.21)	-	-	-	-	-	-
EPR soil	+(1.65±0.21)	+ (1.55±0.07)	-	+ (2.00±0.00)	-	-	-	-	-	+(3.55±0.07)
EP plant soil	+(1.60±0.00)	-	-	+(1.40±0.14)	-	-	+(2.15±0.21)	-	-	+(4.25±0.07)
J2	+(2.00±0.00)	-	-	+(1.40±0.14)	-	-	-	-	-	+(1.35±0.07)
SC 285	+(1.10±0.14)	+(1.70±0.00)	-	+(1.50±0.00)	-	-	+(2.40±0.14)	-	-	+(1.20±0.00)
SC; pH 6.5	+(1.20±0.28)	+ (2.40±0.14)	-	+ (1.80±0.00)	-	-	-	-	-	+(2.35±0.07)
EPPY	+(0.95±0.07)	+(1.50±0.00)	+(2.30±0.14)	-	-	-	-	-	-	+(2.50±0.00)
EPB2	+(1.10±0.14)	+(1.60±0.00)	+(1.05±0.07)	-	-	-	+(2.20±0.28)	-	-	+(1.80±0.00)
SCB	+(1.05±0.07)	+(2.50±0.00)	+(1.30±0.00)	-	-	-	+(1.90±0.00)	-	-	+(1.50±0.00)
EPB	+(2.05±0.07)	+ (3.00±0.00)	+ (2.50±0.00)	-		-	+(2.30±0.14)	+(1.10±0.00)	-	+(2.85±0.21)
KD2	+(1.90±0.00)	+(2.60±0.00)	-	-		-	+(3.25±0.35)	-	-	+(3.00±0.00)
KD2;pH 8.5	+(2.00±0.00)	+(2.40±0.14)	-	-		-	+(2.15±0.49)	-	-	+(3.00±0.00)
KL	+(2.30±0.00)	+(2.50±0.00)	-	-		-	+(2.45±0.35)	-	-	+(3.00±0.00)
SC; pH 8.5	-	+(1.40±0.14)	-	-	-	-	-	-	-	-
ab	-	-	-	-	-	-	-	-	-	-
R10G	-	-	-	-	-	+(1.80±0.00)	-	-	-	-
EPBAZ	-	+(1.10±0.14)	-	-	-	-	-	-	-	-
Kasarwadi	-	-	-	-	-	-	-	-	-	-

-: No enzyme activity. Fig in bracket indicate diameter of zone of clearance (cm). Each data point represents average of duplicate ± SD.

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Table 4:

Isolates	NH_3 production	IAA (µg/ml)	Acetoin production	HCN production	Phosphate solubilization (µg/ml)	Zn solubilization	K solubilization	Siderophore production	Gibberellins (µg/ml)
AP2	+	5.50±0.00	-	+	-	-	-	-	1.80±0.00
P12	+	12.00±0.00	-	-	-	-	-	-	-
P14	+	9.00±0.00	-	-	0.24±0.04	-	-	-	-
AP1	+	5.50±0.00	-	+	-	-	-	-	-
1	+	5.00±0.00	-	+	-	-	-	-	-
KR2	+	13.50±0.00	-	-	0.28±0.04	-	-	-	-
KR1A	+	8.50±0.00	-	-	0.26±0.02	-	-	-	-
J2	+	11.00±0.70	-	-	0.53±0.02	-	-	-	-
P10	+	-	-	-	-	-	-	-	-
P9	+	8.50±0.00	-	-	-	-	-	-	-
AP1B	+	15.50±0.00	-	-	-	-	-	-	-
EPR2	+	10.00±0.70	-	-	0.90±0.02	-	-	-	-
P13	-	-	-	-	-	-	-	-	-
P2	-	-	-	-	-	-	-	-	-

+: Positive, -: Negative. NH_3: Ammonia, IAA: Indole Acetic Acid, HCN: Hydrogen cyanide, Zn: Zinc, K: Potassium. Each data point represents average of duplicate ± SD.

Table 5: Biodiversity with respect to plant growth promoting traits of Actinomycetes isolates.

Isolates	NH_3 production	IAA (µg/ml)	Acetoin production	HCN production	Phosphate solubilization (µg/ml)	Zn solubilization	K solubilization	Siderophore production	Gibberellins (µg/ml)
127	-	-	-	-	-	-	-	-	-
Junewadi	++	5.50±0.70	-	-	-	-	-	-	1.46±0.23
128	-	-	-	-	-	-	-	-	-
EPR soil	+	-	-	-	-	-	-	-	-
EP plant soil	+	-	-	-	-	-	-	-	1.20±0.20
J2	-	-	-	-	-	-	-	-	-
SC 285	-	-	-	-	-	-	-	-	-
SC; pH 6.5	+	-	-	-	-	-	-	-	-
EPPY	-	5.50±0.00	-	-	-	-	-	-	-
EPB2	-	-	-	-	-	-	-	-	-
SCB	-	4.50±0.00	-	-	-	-	-	-	1.80±0.00
EPB	+	-	-	-	-	-	-	+	2.00±0.00
KD2	-	-	-	-	-	-	-	+	-
KD2; pH 8.5	-	-	-	-	-	-	-	+	1.53±0.11
KL	-	-	-	-	-	-	-	+	2.13±0.41
SC; pH 8.5	-	7.50±0.00	-	-	-	-	-	-	1.40±0.23
ab	-	7.50±0.00	-	-	-	-	-	-	1.53±0.11
R10G	-	5.50±0.00	-	-	-	-	-	-	1.66±0.23
EPBAZ	-	5.50±0.00	-	-	-	-	-	-	1.80±0.00
Kasarwadi	-	-	-	-	-	-	-	-	-

+: Positive, -: Negative. NH_3: Ammonia, IAA: Indole Acetic Acid, HCN: Hydrogen cyanide, Zn: Zinc, K: Potassium. Each data point represents average of duplicate ± S

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SEAGRASS MEADOWS AND ASSOCIATES IN PUDUKOTTAI COAST OF PALK BAY, SOUTHEASTERN INDIA

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ABSTRACT

Seagrasses are marine flowering plants with global distribution that form extensive meadows and are amongst the most productive ecosystems on earth. A detailed under water survey of seagrass medows and associates was carry-out in 4 locations (Muthukuda, Kottaipatinam, Manalmelkudi, and Kattumavadi) in Pudukottai coast of Palk Bay during August 2014 to October 2014 to study the seagrass cover, species diversity, seagrass shoot density and associated macroalgal and faunal density. A total of 7 species of seagrasses were recorded, namely Thalassia hemprichii, Halophila ovalis Halophila stipulacea, Cymodocea serrulata, Halodule pinifolia, Enhalus acoroides and Syringodium isoetifolium. Mean seagrass shoot density was found to be 235.35 no/m^2 and maximum shoot density were recorded with 299.45 no/m^2.at Muthukuda. In total, 31 macro algal species were observed in seagrass meadows of Pudukoattai coast, belongs to the family cholorophyceae, Phaeophyceae and Rhodophyceae. Mean macro algal density was found to be 18.17 no/m^{-2}. Chlrophyceae group was dominant in all study locations and maximum density was observed in Muthukuda with10.34 no/m^{-2}. Seagrass meadows represented fair faunal community and the four major groups encountered were molluscs, sponges, echinoderms and sea anemones. In pudukottai coast, mean macro faunal density was found to be 12.08 no/ 5 m^2 and among them, bivalve was dominant with 3.05 no/ 5 m^2 followed by gastropod with 2.87 no/ 5 m^2. The study reveals that seagrass meadows are dynamic ecosystem which provides shelter to a wide range of macro algae and associated macrofauna and continuous monitoring is essential to study the trend and pattern of assemblages.

Key words: macro algae, macro fauna, shoot density, species diversity, Palk Bay

1. INTRODUCTION

Sea grass ecosystem is one of the most widespread coastal vegetation types when compared to coral and mangrove ecosystems (Nobi et al., 2010). Seagrasses a unique group of flowering plants that have adapted to exist fully submersed in the sea profoundly influence the physical, chemical, and biological environments in coastal waters, acting as ecological engineers (Wright and Jones 2006) and providing numerous important ecological services to the marine environment (Costanza et al., 1997). Forming extensive meadows, they support high levels of biodiversity, stabilize sediments and trap heavy metals and nutrient rich runoff, thereby improving the water quality for large numbers of associated coral reef communities. They are important nursery habitats for fishes and feeding grounds for endangered species such as turtles and dugongs, the latter for who the presence of seagrass is highly correlated with its ability to survive. Additionally, seagrass rhizome systems bind and stabilize bottom sediments and provide habitats for hundreds of infaunal organisms. (D'Souza et al., 2013). Seagrasses alter water flow, nutrient cycling, and food web structure (Hemminga and Duarte, 2000).

Seagrass meadows produce a variety of goods (finfish and shellfish, sediment) and provide ecological services (maintenance of biodiversity, water-quality control, shore-line protection) that are directly used or beneficial to humans. The presence and abundance of seagrasses, can be considered, therefore, as indicators of the overall environmental quality of the coastal zone. Hence their long-term maintenance could be a surrogate target of coastal management strategies aiming at preserving or improving the environmental quality of the coastal zone.

Seagrass flora of India is represented by 6 genera and 14 species, Gulf of Mannar and Palk Bay harbour the maximum species followed by Andaman and Nicobar and Lakshadweep islands (kannan et al., 1999). Indian seagrass habitats are mainly limited to mud flats and sandy regions. It extend from the lower inter tidal zone to a depth of 10-15 m along the open shores and in the lagoons around the islands (Jagtap, 1991, Ramamurthy et al., 1992).

Unfortunately, seagrass of these regions significantly decline in their coverage and density. (Thangaradjou et al., 2008) Globally, there has decrease in seagrass abundance and associated organisms, mainly due to anthropogenic activities (Kemp, 2000).Seagrass ecosystem in the tropics and particularly in India has always been given with low priority in research by the scientific communities and environmentalists (Jagtap, 1996).

The sea grass one of the important producer in the marine environment from extensive meadows supporting high biodiversity, serves as feeding and nursery habitat. Hence it is essential to monitor the status of the sea grass in the marine environment so the present study was aim to study the seagrass cover, species diversity, seagrass shoot density and associated macroalgal and faunal density from the four fishing villages of Puthukottai coastal waters.

2. MATERIALS AND METHOD

Pudukottai is the coastal province in south eastern coast india, situated in (Lat 9^0 52'N to10^0 7'N and Long 79^0 7'E to 79 ^{0} 14'E), the length of the coast lines about 42.6km. A detailed under water survey of seagrass medows and associates was carryout in 4 locations (Muthukuda, Kottaipatinam, Manalmelkudi, and Kattumavadi) in Pudukottai coast of Palk Bay during August 2014 to October 2014.

100 M transects were made on the sea grass meadows and the transects were seperated from each other by a reasonable distance (50 -100M), and were parallel to each other and perpendicular to the shore using English et al. (1997) method. In each transects a Quadrate (50 cm × 50 cm) was laid at 5m regular intervals. Each quadrate were divided into 25 squares (10 cm × 10 cm) in order to calculate the percentage cover of seagrass species through visual estimation method (Saito and Atobe, 1970).At least 2-4 replicates of quadrats were laid depending on the abundance of the seagrass. Individual shoots were also counted randomly at selected qudrats. Each sea grass species are collected and sorted taxonomical order for further identification (English et al., 1997). The shoot density was averaged along each transect. Sea grass associated Macroalgal and macro faunal density were also observed from randomly placed qudatrs (1x1 m). Macro algal and macro faunal species level identification done by using standard manuals.

3. RESULTS

Overall percentage cover of sea grasses in Pudukottai coast of Palk Bay as 39.40%. Highest seagrass coverage was recorded in kattumavadi coast with 43.82% and lowest was recorded in muthukuda with 33.60%. A total of seven species of seagrasses were recorded at pudukottai coastal waters, namely Thalassia hemprichii, Halophila ovalis, Halophila stipulacea, Cymadocea serrulata, Halodule pinifolia, Enhalus acroroides and Syringodium isoetifolium.

Among the seven species Syringodium isoetifulium was the dominant species with 38.60 % followed by Cymadocea serrulata and Thalassia hemprichii with 35.10 % and 16.16 % respectively. Minimum percentage cover occupied by Enhalus acoroides with 0.66 %. (Fig .1)

Fig. 3.1: Map showing Muthukuda, Kottaipatinam, Manalmelkudi, and Kattumavadi

3.1 Shoot density:

In puthukottai coast, mean seagrass shoot density was found to be 235.35 no/m^2 and maximum shoot density were recorded with 299.45 no/m^{2}at Muthukuda and lowest Shoot density was recorded with 208.01 no/m^2.at kaattumadi. Overall Syringodium isoetifolium was found to be highest shoot density as 76.04 no/m^2 while as Halophila stipulacea was the lowest density were recorded as 4.48 no/m^2. Average shoot density of seagrass species is given in the Fig 2 and 3.

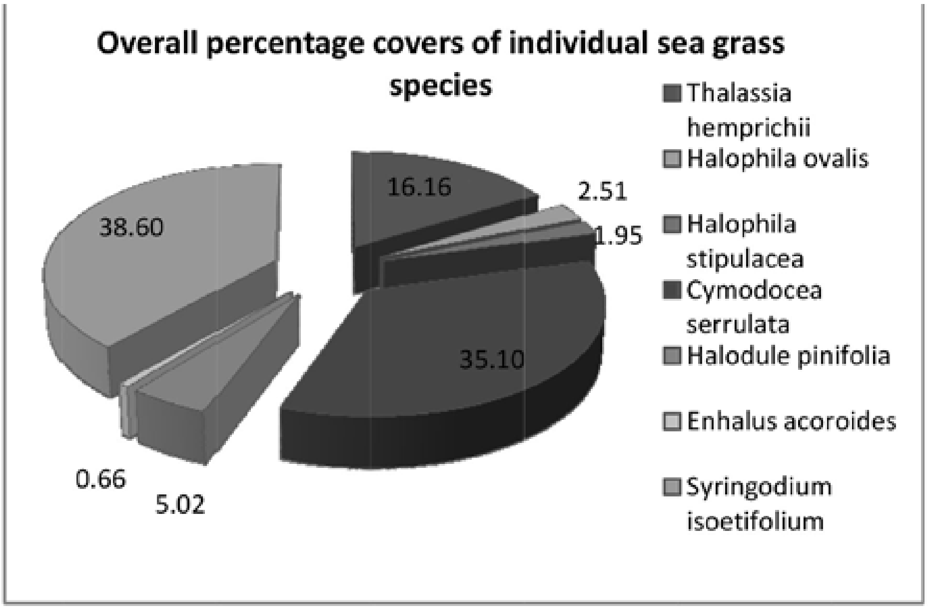

Fig. 2: Overall percentage covers of individual sea grass species:

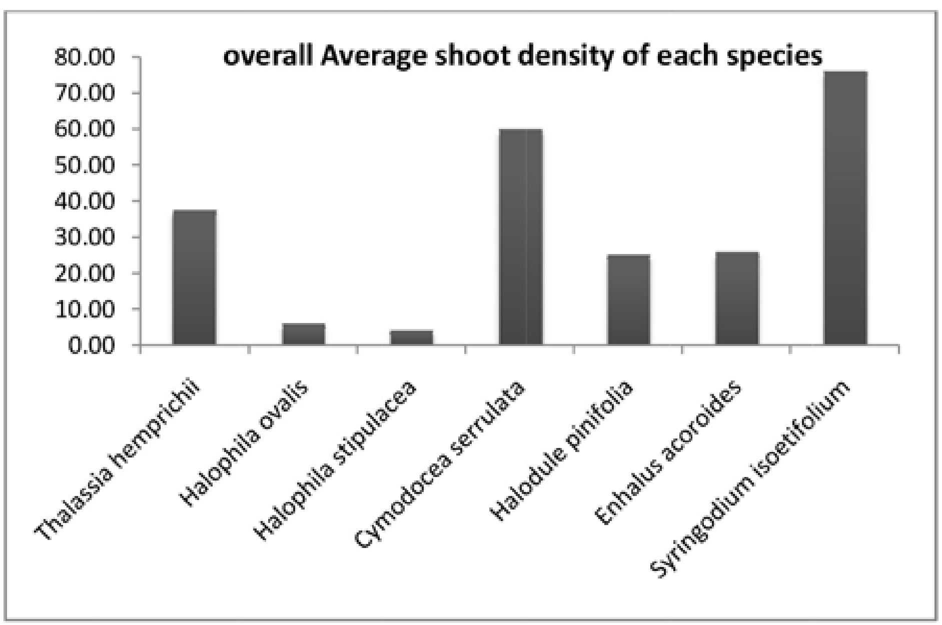

Fig 3: Overall Average shoot density of each species (number of shoots (m^2)

3.2 Macro algal diversity and density:
A total of 31 seaweed species were documented from the Pudukottai coast. The Chlorophyta prevailed with 12 species followed by Rhodophyta (11 species) and Phaeophyta (8 species). Detailed seagrass meadows associated seaweed species list are given in Table 1. Among these four stations, maximum species were documented in Muthukuda coast as 31 and minimum 24 species were recorded in Kattumavadi coast (Table 2).

In puthukottai coast, mean macro algal density was found to be 18.17 no/m^{-2}. Chlrophyceae group was dominant in all study locations and maximum density was observed in Muthukuda with 10.34 no/m^{-2}. phaeophyaaceae group was present in lowest level 3.27 no/m^{-2} in kottaipatinam. In pudukottai coast, highest Macoalgal density was found to be 21.78 no/ 5 m^{2} at Muthukuda followed by Manalmelkudi with 19.67 no/ 5 m^{2}. Lowest Macro algal density were recorded in kattumavadi at 14.65 no/ 5 m^{2} (Fig .4).

Table 1: List of marine algae recorded at four localities of pudukottai coast palkbay.

S.NO	Name of Algae	Muthukuda	Kottaipatinam	Manalmelkudi	Kattumavadi
	cholorophyaceae				
1	Ulva compressa	+	+	+	+
2	Ulva lactuca	+	+	+	+
3	Chaetomorpha linum	+	+	+	_
4	Caulerpa racemosa	+	+	+	_
5	Caulerpa peltata	+	+	+	+
6	Caulerpa scalpelliformis	+	+	+	+
7	Halimeda opuntia	+	+	+	+
8	codiun elongatum	+	+	+	+
9	Enteromporpho tubulsoa	+	+	+	+
10	clsdosphora fascicularis	+	+	+	+
11	cladosphora prolifrra	+	_	+	_
12	Valoniopsis pachynema	+	_	_	_
	rhodophyaceae				
13	Hydropuntia edulis	+	+	+	+
14	Gracilaria corticata	+	+	+	+
15	Gracilaria foliifera	+	+	+	+
16	Gracilaria fergusonii	+	+	+	+
17	Gracilariaverucosa	+	+	+	+
18	Sarconema filiforme	+	_	+	+
19	Hypnea valentiae	+	+	+	+
20	Amphiroa sp	+	+	+	+
21	Acanthophora muscoides	+	+	+	_
22	Asparagopsis taxiformis	+	+	+	+
23	Gelidiella indica	+	_	+	+

	phaeophyceae				
24	Dictyota bartayresiana	+	+	+	+
25	Dictyota ciliata	+	+	+	+
26	Padina pavonica	+	+	–	+
27	Padina tetrastomatica	+	–	+	–
28	Sargassum duplicatum	+	+	+	+
29	Sargassum linearifolium	+	+	+	+
30	Sargassum wightii	+	+	+	+
31	Colpomenia sinuosa	+	–	+	–

Table 2: The total number of genera and species of marine algae occurring in each station.

		Chororophyta		Phaeophyta		Rhodophyta	
S.No	locality	genera	species	genera	species	genera	species
1	Muthukuda	8	12	4	8	8	11
2	Kottaipatinam	7	10	4	6	6	9
3	Manalmelkudi	7	11	4	7	8	11
4	Kattumavadi	6	8	3	6	7	10

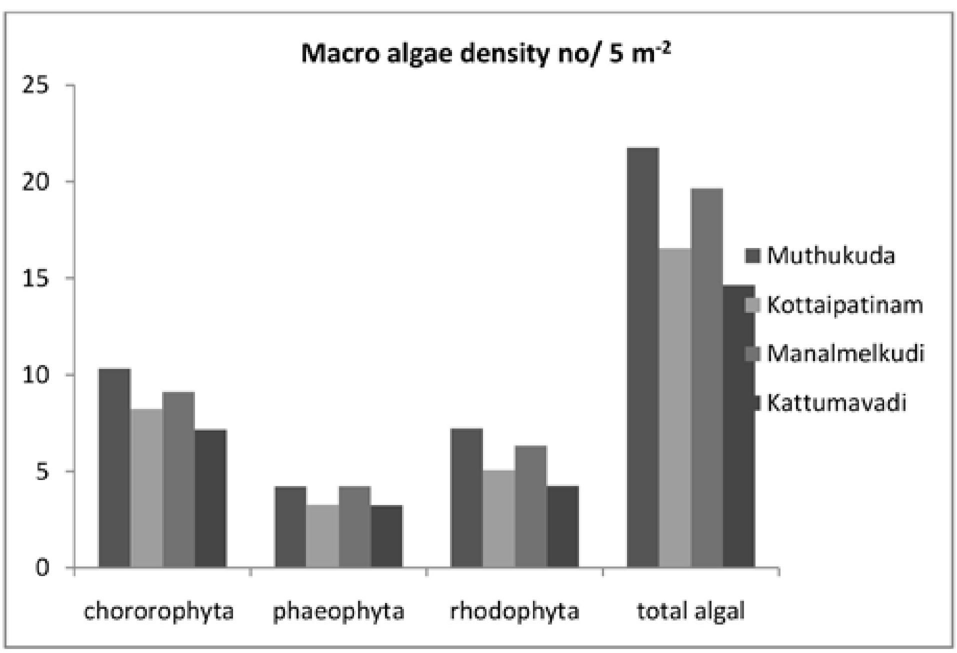

Fig 4: Macro algae density no/ 5 m^2 four localities of pudukottai coast palkbay.

3.3. Macro fauna density:

In pudukottai coast, mean macro faunal density was found to be 12.08 no/ 5 m^2 and among them, bivalve was dominant group with 3.05 no/ 5 m^2 followed by gastropod with 2.87 no/ 5 m^2 respectively. Highest macrofaunal density was occurred in kottaipatinam as 12.97 no/5 m^2 followed by kattumadai as 12.57 no/5 m^2. Lowest macrofaunal density was occurred in Manalmelkudi as 11.14 no/5 m^2 (Fig 5).

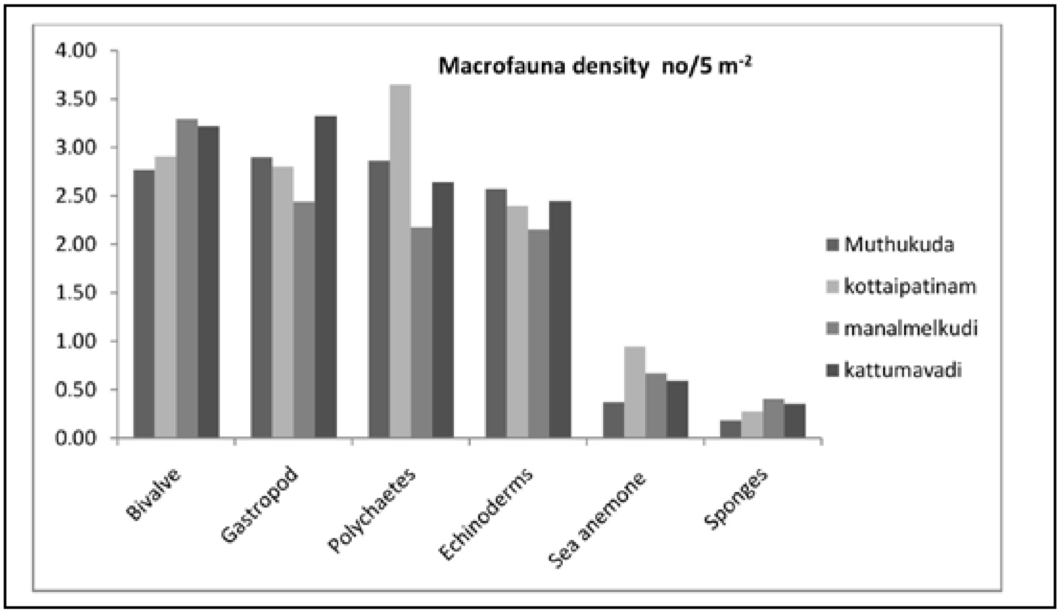

Fig 5: Macro fauna density no/ 5 m^2 four localities of pudukottai coast palkbay.

4. DISCUSSION

Seagrass meadows are highly productive ecosystems that provide important ecological functions and economic services (Sheppard et al., 1992; Duarte, 2002; Duffy, 2006). Ecologically, seagrass ecosystems provide food sources and function as nursery grounds for threatened species such as turtles and dugongs (Price et al., 1993; Preen, 2004). They can also improve water quality by stabilizing loose sediment and by filtering some pollutants out of the water (Duffy, 2006). Seagrasses are known to be important contributors to regional food webs (e.g. Heck et al., 2008).

Sea grasses of India consist of 14 species belonging to seven genera; among the 14 the pudukottai coasta area is having 7 species. Spatial variation of seagrass species in these study indicated that various physicochemical and geomorphological characteristics have role in the distribution of seagrass as noted by Coles et al. (1987). The seagrass beds at the study sites in the pudukottai coast of palkbay comprised of seven species. In the study sites (Muthukuda, Kottaipatinam, Manalmelkudi, and Kattumavadi), Among all the species Syringodium isoetifolium is the dominant species, this species occupies 38.60 % Cymodocea serrulata following behind (35.10%). Cymodocea serrulata occur one third part of total seagrass present in the pudukottai coatal area. Cymodocea serrulata is seen as intermediate genera that can survive a moderate level of disturbance. Cymodocea serrulata is a runner and possess more root density and also drop-off all its leaves during seasonal changes.

Overall percentage of sea grasses 16.15 % of thallasia recorded in pudukottai coastal area, Thallasia Growth and nitrogen responses to clipping exhibit a considerable variation among sea grass species. It has been reported that the growth and nitrogen response of Thalassia hemprichii appeared to be unaffected by herbivore pressure, while other species get affected (Teresa Alcoverro, 2005). It has also been reported that nutrient concentrations are generally low in reef habitats; however intermittent sources of nutrients are added by seasonal runoff reaching the reef (Gabric and Bell, 1993). Tight nutrient recycling strategies of Thalassis hemprichii, by location of nitrogen in rhizomes when leaves are shed due to desiccation stress, aids in survival in the nutrient poor reef habitat (Stapel et al., 1997).

Halophila and Halodule are described as ephemeral species with rapid turnover and high seed set, well adapted to high disturbance and high rates of grazing (Walker et al., 1999).Halodule pinifolia species were found in exceeding low abundance (5.02%). Halophia ovalis had the least coverage in the site (at 2.51%). Halophila stipulacea was only distributed in the depth region of the shoreward and absent seaward side because these are alive under low light circumstance as suggested by Longstaff and Dennison (1999). Halophila stipulacea was the least the species (1.95%) recorded in the shoreward side in Muthukuda, Kottaipatinam, and Manalmelkudi. It's absent in the kattumadi. Previous studies indicate (Japtap, 1996) that species of Halodule and Halophila occurred in higher frequencies in the intertidal and shallow seagrass beds of the Gulf of Mannar, whereas Cymodocea serrulataand Thalassia hemprichii showed greater frequencies in the depth range of 3 – 5m and 7 – 8m respectively. This contrasted with the results of the present study in that it was observed that Cymodocea serrulata was consistently present in all seagrass beds regardless of depth or distance from shore of the seagrass bed.

Enhalus acoroides are endemic to the region which possess rich amount of clay toasted silt soil (Thangaradjou and Kannan, 2005).Enhalus acoroides were observed dominantly in shoreward side of Muthukuda at (2.65%) because of which this region possess rich amount of clay toasted silt soil. Its absent in other three study sites such as Kottaipatinam, Manalmelkudi, and Kattumavadi.

The shot density of seagrass was higher in the shoreward side due to known light and nutrient. According to Short et al. (1993) the overall reduction in the total seagrass weight could be due to insufficient light and also the effects of decreased light have reduction in shoot density, number of leaves per shoot, and growth rate. The shoot density and diversity of seagrass were less in seaward side this indicated that, the rising of depth and reduced light penetration affect the shoot density. In Muthukuda record at mean highest shoot density 299.45 no/m^2 followed by manalmelkudi at 217.98 no/m^2. Lowest shoot density recorded in kattumavadi at 208.01 no/m^2 followed by kottaipatinam at 215.99 no/m^2.

The seaweeds were identified using the taxonomic keys provided by Umamaheswara Rao (1987), Desikachary et al. (1990, 1998) and Krishnamurthy (1999), and the nomenclature was updated using Appeltans et al. (2012). Seagrasses are the widely dispersed group of plants comprising relatively few species and are often overlooked due their submerged environment (Short et al., 2007). Seagrass play an important ecological role in coastal ecosystems due to their habitat value for many organisms In total, 31 macro algal species were observed in seagrass meadows of Pudukoattai coast, belongs to the family cholorophyceae, Phaeophyceae and Rhodophyceae.

In a recent review, Thomsen et al., (2012) found that mass macroalgae have stronger affect on seagrasses than a small quantity of macroalgae. The negative effects of macroalgae depend on the environmental variables in the region, impacting on the management of seagrass ecosystems subject to high nutrient loadings (Hessing-Lewis et al., 2011). In Muthukuda recorded at a highest algal density and highest macroalgae noted but seagrass coverage was very low. Likewise in Kattumavadi macroalgal density was very low but seagrass coverage was high. So There is a inter relationship between macroalgae and seagrass Therefore, it is necessary to study the effect of macroalgae on seagrass ecosystem to further understand the causes and mechanisms of seagrass decline. The direct effects of macroalgae on seagrass ecosystems include the competition for space or resources (Druehl, 1973; Williams, 1990; Fourqurean et al., 1995; Ceccherlli and Cinelli, 1997). Multer (1988) found that high biomass of macroalgae appears under the conditions of low and moderate seagrass shoot density, indirectly demonstrating the competitive relationship between seagrasses and macroalgae. Competition between seagrasses may have more effects than competition between seagrass and other species at high densities of seagrass (Rose and Dawes, 1999).

Seagrass habitats support greater macro-fauna species diversity, abundance and biomass than adjacent unvegetated habitats (Coles and McCain, 1990; Ansari et al., 1991; Al-Khayat, 2007). Seagrass meadows are highly productive coastal habitats of great ecological and socio-economic importance (Larkum et al., 2006, McLeod et al., 2011). In pudukottai coast, mean macro faunal density was found to be 12.08 no/5 m^2 and among them, bivalve was dominant with 3.05 no/ 5 m^2 followed by gastropod with 2.87 no/ 5 m^2. Highest mean macro faunal density was recorded to be 12.97 no/5 m^2 at kottaipatinam followed by kattumavadi at 12.57 no/5 m^2. Lowest mean macrofaunal density was recorded in mananlmelkudi at 11.14 no/5 m^2 followed by muthukuda at 11.65 no/5 m^2.Seagrass coverage dominant area in kottaipatinam record at high macrofaunal density. Loss of seagrass habitats also affects associated organisms.

This study revealed that percentage of seagrass was moderate at shoreward side whereas seagrass percentage and distribution was low in seaward side. In palkBay also lot of turtles and marine mammals were seen very often few decades back, but nowadays it is very rare to see them. Because of the destructive fishing activities and adverse natural calamities sea grasses have not been treated well in this part of the world for few decades. Fishermen use the bottom trawling nets in the sea grass area for fishing which directly damages the health of a sea grass meadow. This dangerous fishing not only affects the sea grass community but also destroys a wide variety of epiphytes inhabiting the sea grasses along with them. The increasing water temperature is also being a big threat to the sea grass community.

5. CONCLUSION

The present study revealed that on comparing both shoreward and seaward side, the shoreward have more seagrass percentage, shoot density and seagrass associated flora and fauna because in the shoreward side of pudukottai coast of palkbay region which possess more salinity and more temperature, less waves, less currents, less depth, sandy-clay substrate, light, nutrient and less sedimentation which favour the growth of seagrass. This study was to compare the diversity, and abundance of macroalgae and macrofauna associated with seagrass. Therefore, it is necessary to study the effect of macroalgae on seagrass ecosystem to further understand the causes and mechanisms of seagrass decline. Additionally, conducting ecological baseline studies, and monitoring programs are essential parts of any effort to conserve seagrass ecosystems in pudukottai coast of palkbay. These studies should not be limited to seagrasses, but also extended to investigate other primary producers such as algae and secondary consumers including macro benthic and fish assemblages, and their interactions (Walker et al., 2001), which could increase the national and international conservational benefits of these habitats.

6. ACKNOWLEDGEMENTS

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Costanza, R., Ralph D'arge., Rudolf De Groot., Stephen Farber., Monica Grasso., Bruce Han-

Syringodium isoetifolium

Thalassia hemprichii

Cymodocea serrulata

halohila ovalis

Enhalus acoroides

Seagrass associated with macro algae:

Caulerpa sp.,

Ulva sp.,

Seagrass with associated macrofauna:

seagrass associated mollusks

seagrass associated Ascidians

seagrass associated seaanemone

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RARE, ENDANGERED AND THREATENED (RET) TREES OF KUDUKKATHU-PARA, AN ECOLOGICALLY SENSITIVE AREA (ESA) IN SOUTHERN WESTERN GHATS, KOLLAM DISTRICT, KERALA STATE

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ABSTRACT

The Western Ghats forest of Kerala is gifted with a vast spectrum of ecological habitats hosting a wide variety of plant species including many endemics and endangered ones. Alarming decline of habitats, ecosystems and species has caused fragmentation of habitats and population that push many endemics to live in isolated refugia and become unviable in the long run. The study documents 135 trees in Kudukkathupara, one of the three Ecologically Sensitive Areas (ESA) in Kollam district. Over 40% of the trees are under different degree of RET status. There are 38 endemics, 22 under different RET status and 15 with viviparous nature. Visibly low density of the 9 vulnerable, 2 endangered, 1 critically endangered, 3 lower risk near threatened and 5 rare and threatened species warrants immediate conservation strategies. Though regional attempts to conserve a few medicinal and horticulture plants exist, comprehensive measures for regeneration and restoration of RET trees are scarce.

Key words: Kudukkathupara, RET, ESA, recalcitrant, regeneration, restorationq

1. INTRODUCTION

Covering an estimated area of 159,000 sq. km, the Western Ghats is an area of exceptional biological diversity and conservation interest, and is "one of the major Tropical Evergreen Forest regions in India" (Rodgers and Panwar, 1988). As the zone has already lost a large part of its original forest cover, it must rank as a region of great conservation concern. The small remaining extent of natural forest, coupled with exceptional biological richness and ever increasing levels of threat are factors which necessitate major conservation inputs. It has received attention recently due to controversy over the conservation initiatives suggested by Gadgil Committee Report.

The Southern Western Ghats of Kerala region, a treasure house for medicinal and other economical plants has been identified as one of the hottest of hotspots of the world for biodiversity conservation. Unfortunately vegetation in general and endemic plants in particular of this region is facing severe threat and endangerment due to various physical and physiological reasons, especially for extraction pressures. Due to the increase in anthropogenic pressure on forest as well as the riverine ecosystem, the habitat specific species are under severe threat. Recalcitrant trees and medicinal herbs are the immediate casualties of these changes Apart from the above reasons, river sand mining, natural calamities and climate change also contribute the loss of valuable germplasm resources (Ramesh, 2000). Some studies in this respect include validation and documentation of rare endemic and threatened (RET) plants from Nilgiri, Kanuvai and Madukkarai forests of southern Western Ghats has been done by Prabhukumar et al. (2012).

Each biodiversity hotspot needs to be closely monitored for its genetic resources and inventory of each sensitive region be prepared. Validation will pave way to devise conservative measures for ecological components and their conservation can help exploit them for future generation. Under this background, the current project is an attempt to study the conservation assessment of rare, endemic and threatened species (RET) at Kudukkathupara and Ecological Sensitive Area (ESA) in Channappetta village, Alayamon panchayat, Kollam district Kerala.

No record of research for the identification of plants or animal diversity of this ESA is available so far. The current study carried out in August September 2014 has the following objectives.

2. OBJECTIVES

1. To understand the diversity of the trees of Kudukkathupara ESA, understand their vernacular names,scientific names, family and nativity

2. To identify the endemicity of the trees identified in the ESA

3. To assess the RET status of trees in the ESA

4. To identify the recalcitrant trees and attempt to suggest their regeneration and restoration measures

5. Attempt to make a biodiversity register of the trees of the ESA

3. MATERIALS AND METHODS

3.1. Study area

Kudukkathupara falls in Channappetta village of Alayamon Panchayat in Pathanapuram taluk, Kollam district in Kerala state (Fig 1). Alayamon is located 49 KM towards East from District head quarters Kollam, 8 KM from Anchal and 51 KM from State capital Thiruvananthapuram. Due to exceptionally rich biodiversity and ecologically sensitiveness it is included in the proposed Ecologically Sensitive Area (ESA) demarcated for special conservative status in Oommen V Oommen report (KSREC, 2012).

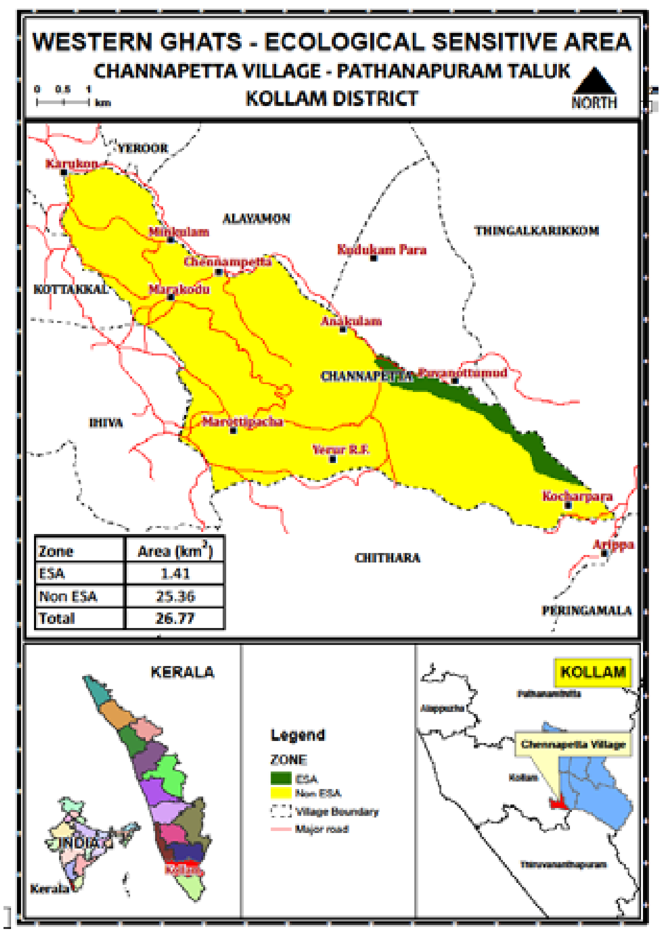

Fig.1: Location map of the study area

The study area has been included in the Ecotourism Development Project of Kerala government (Eco-Tourism Development Centre (ETDC), 2013) where the development activities are initiated.

Direct observation and information collection from local knowledgeable persons was followed by validation and finalization of information with the help of experts from scientists of JNTBGRI and State Biodiversity Board. Reference of standard text (Sasidharan, 2004) and internet was made for information seeking.

4. RESULTS

Endemic tress recorded from the study area, their scientific name and RET status are given in Table 1-3. A total of 135 species have been enumerated in the document where in 23 species have been categorised in endemic, 16 under RET group and 15 under recalcitrant groups.

Table 1: Endemic trees of Southern Western Ghats recorded from the study area

S.No.	Local name	Scientific name	Status
1	Vathakollimaram	Syzygium Travancorica	Rare and Threatened
2	Chunnambumaram	Croton malabaricus	
3	Charu	Semecarpus auriculata	Lower risk near threatened
4	Melamthelli	Goniothalamus cardiopetalus	
5	Not known	Antistrophe seratifolia	Vulnerable
6	Malamcheru	Holigarna beddomei	Vulnerable
7	Cheru	Holigarna arnottiana	
8	Kudanaru	Ochreinuclea missionalis	Vulnerable
9	Parappakku	Betindica condopanna	Vulnerable
10	Karamavu	Apollonias arnottiana	
11	Muttamaram	Ardisia pauciflora	
12	Nagamaram	Beilschmelia wigttia	Rare and Threatened
13	Not known	Aralia malabarica	Vulnerable
14	Kundalappala	Tabernamontana heyneana	Lower risk near threatened
15	Malampuli	Dialium travancoricum	Critically endangered
16	Nedunaari	Polyalthiya fragrans	
17	Not known	Canthiyum neilgherrense	Vulnerable
18	Kallankaimaram	Atuna travancorica	Endangered
19	Vellappyne	Vateria indica	
20	Not known	Atlantia recemooasa	
21	Kambakam	Hopea parviflora	
22	Anjili	Artocarpus hirsutus	
23	Malavirinji	Actinodaphne malabarica	Rare and Threatened
24	Not known	Cryptocarya beddomi	
25	Njaval	Syzygium densiflorum	Vulnerable
26	Koori	Cynometra travancorica	Endangered
27	Not known	Phaeanthus malabaricus	Lower risk near threatened

Table 2: Endemic trees of Western Ghats recorded from the study area

S. No.	Local name	Scientific name	Status
1	Kattumarotti	Hydnocarpus alpina	
2	Madakka/Mottal	Xanthophyllum arnottianum	
3	Moothasari	Vepris binocularis	Rare and Threatened
4	Karakil	Aglaia barberi	Rare and Threatened
5	Nirkurunda	Blepharistemma seratum	Vulnerable
6	Marotti	Hydnocarpus pentandra	
7	Kattupunna	Calophyllum polyanthum	
8	Chorappyne	Knema attenuata	
9	Cherupunna	Callophyllum apetalum	

Other vulnerable trees: Anisochelus argenteusi, Cholavenga (Bischofia javanica), Kulamavu (Buchanaria lanceolota).

Table 3: Major families of endemic trees in the study area

S. No.	Family	No. of species	No. of endemic and RET species
1	Euphorbiaceae	12	2
2	Lauraceae	8	5
3	Anacardiaceae	8	4
4	Rubiaceae	7	2
5	Annonaceae	6	3
6	Combretaceae	6	Nil
7	Caesalpiniaceae	6	3
8	Fabaceae	5	Nil
9	Meliaceae	5	2
10	Rutaceae	5	3
11	Sapotaceae	5	Nil
12	Clusiaceae	4	2
13	Apocyanaceae	4	1
14	Flacourtiaceae	4	2
15	Mimosaceae	4	1
16	Moraceae	4	Nil
17	Aeraceae	2	1
18	Dipterocarpaceae	2	1
19-49	Others	39	54
Total		135	23endemic+16RET+15 recalcitrant species

5. DISCUSSION

There are 135 tree species identified from the region in which 23 endemic, 16 RET and 15 recalcitrant species are present. From Western Ghats, 159 endemic tree species have been reported (ENVIS, 2011). Earlier study conducted by French Institute of Pondicherry on Endemic Tree Species of Western Ghats also noted similar figure (Endemic Tree Species of Western Ghats, (2009). Notwithstanding our inability to find out all endemic tree species from this ESA, or there is considerable loss of plant germplasm. The later can be true to an extent since a considerable portion of the forest has been destroyed for Acacia and Eucalyptus plantation and the invasion of these fast growers might have adversely affected the propagation of the endemic species.

However all the RET species identified are in very low visible density (density need to find out by quantifying each species). 2 endangered plants, 3 lower risk near threatened, 2 threatened and 9 vulnerable trees are observed during the study. This indicates that many of the inhabitants of Kudukkathupara ESA are under RET status. No scientific documentation has so far ascertained the biological wealth of this region without which any intervention will not be eco-friendly.

In light of the localised change in climate change and extraction pressure, many important trees seem losing their niche. Special conservative measures need to be adopted for them. Two endangered, 3 lower risk near threatened, 5 rare and threatened, 1 critically endangered and 11 vulnerable trees are found during the study period. This indicates that many of the trees in Kudukkathupara ESA are under RET status. No scientific documentation has so far ascertained the biological wealth of this region without which any intervention will not be eco-friendly.

In view of the localised change in climate and increased extraction pressure, many important genetic resources seem losing. Special conservation measures need to be adopted for regeneration and restoration of these species.

5.1. Conservation of recalcitrant trees

Since the seeds of recalcitrant trees loss viability in dry conditions resultant of climate change, many endemic tree species face extinction worldwide. In order to contain the loss of viable germplasm resources, concerted effort need to be taken. Research at the Department of Forest Ecology of KFRI focuses around developing strategies for in situ as well as ex situ conservation of rare, endangered and threatened (RET) species besides monitoring of the impacts of climate change and vegetation process in the natural forests and human modified landscapes in Western Ghats (Muralidharan, 2001). The study facilitated to understand the RET plants so far recorded in the state with literature available on each species (Chandrasekharan et al., 2007). They (2007) also studied the anthropogenic pressure on structure and composition of a shola forest in Kerala. Cryopreservation and micropropagation of plants was also undertaken by different workers on the establishment of a Seed and Pollen Cryobank for ex situ conservation and sustainable utilization of Orchids of Western Ghats(Ganesan et al., 2001).Measures of cryopreservation for seed storage is done for Knema attenuata (Kunhikannan et al, 2004, and Vinayachandra and Chandrashekar, 2011).This shows that though great efforts have beentaken elsewhere in the region to conserve the recalcitrant germplasm the same is not attempted for this ESA yet. For long term conservation scientific multiplication of seedlings and their propagation should be taken up. Local rural people may be involved with the project for recalcitrant tree conservation so that they will turn to conserve them in future.

Knema attenuata conservation by cryopreservation is suggested by Kunjikkannan (2011). Conservation measures for Lagerstroma microcarpa, Holigarna arnottiana, Hydnocarpa alpina, Vateria indica, Myristica malabarica, Semecarpus auriculata, Hopea parviflora, Calophyllum inophyllum need to be devised.

5.2. Trees which need conservation measures for Long term use

Tree species like Lagerstromia microcarpa, Holigarna arnottiana,Hydnocarpus alpina, Vateria indica, Myristica malabarica, Knemaattenuata,Seme carpusauriculata, Hopea parviflora, Calophyllum apetalum, Calophyllum inophyllum,Ochrenauclea missionals, Wrightia tinctoria, Gmelina arborea, Holigarna arnottiana, Semecarpus nacardium, Terminalia chebula, Terminalia bellerica, Terminalia paniculata, Aegle marmelos, Cinnamomum verum etc. should be conserved for long term use.

6. CONCLUSION

- There are two endangered plants, 3 lower risk near threatened, 2 threatened and 9 vulnerable trees in Kudukkathupara ESA
- Over 40% of the trees recorded from Kudukkathupra ESA are under different degree of RET status
- No scientific documentation has so far ascertained the biological wealth of this region. The study estimated the diversity of the trees of Kudukkathupara ESA. The study identified 135 tree species in which 23 are endemic, 16 are RET and 15 are recalcitrant. The ESA shows high endemism with 2 endangered species, 3 lower risk near threatened, 5 rare and threatened,1 critically endangered and 11 vulnerable trees. Outstandingly over 40% of trees recorded from Kudukkathupara ESA are under different degree of RET status. The status of recalcitrant trees at the rate of 15 shows the urgency of regeneration and restoration measures. Various methods for the conservation includes cryopreservation for Knema attenuate, seed banking for Hydnocarpus pentandra, Actinodaphne malabarica etc, in vitro by tissue culture and meristem culture for Calophyllum apettalum etc. The study helped in the preparation of a biodiversity register and also identified trees highlighting all their possible uses and traditional knowledge

The study suggests close monitoring RET trees so that they are protected from tourists and encroachers. It is suggested to have establish close linkage with R&D institutions like JNTBGRI for micro propagation of valuable RET species in the ESA. Appropriate schemes may be prepared for linking rural people around ESA for restoration and regeneration of RET species as a means to their livelihood support

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ETHNOBOTANICAL STUDIES OF IRULAR TRIBES IN THIRUPORUR, KANCHIPURAM DISTRICT, EASTERN GHATS, INDIA

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ABSTRACT

India is one of the richest floristic diversity zones having 16 agroclimatic centres of the world. India has a wealth of biological resources and is home to a large number of different ethnic and cultural groups, many of which have developed their own customs, religious rites, taboos, folktales, songs, medicinal practices, distinct health care systems. Plants have been associated with the health of mankind from prehistoric times for relieving suffering and curing ailments. The knowledge acquired by forest dwellers, folk healers, vaidyas in understanding the properties of roots, stems, leaves, flowers and fruits of these plants have immense value in traditional folk medicines. The purpose of this study is to enumerate the list of plants used by the irular tribe in Thiruporur, Kanchipuram district, Eastern Ghats. A total of 45 species were enumerated. Diseases like fever, jaundice, mouth ulcer, headache, cold, toothache, constipation, fungal disease, sexual debility, eye disease, piles and skin problems were treated using the locally available plants. Life style disorders like diabetes and hypertension were also treated. Apart from these diseases plants were also used as cardio tonic, liver tonic, blood purifier, wound healer, antidote for insect and scorpion bite. Medicines to increase lactation, removal of lice from hair were also made from the available plants. Plants exhibiting aphrodisiac, stimulant, and diuretic properties were also effectively used. The result of the present study provides the list of medicinal plants that are used by irulars to cure various ailments which can be utilised by common public and pharmaceutical companies for a healthy living.

Key words: Ethnobotany, irular, medicinal plants, thiruporur, Eastern Ghats

1. INTRODUCTION

India is one of the richest floristic diversity zones having 16 agroclimatic centres of the world. India has a wealth of biological resources and is home to a large number of different ethnic and cultural groups, many of which have developed their own customs, religious rites, taboos, folktales, songs, medicinal practices, distinct health care systems. Plants have been associated with the health of mankind from prehistoric times for relieving suffering and curing ailments. Medicinal plants are very important as according to the World Health Organization (WHO), over 80% of the world's population (4.3 billion people) relies on traditional plant-based medicines as their primary form of health care (Bannerman et al., 1983). Traditional/indigenous communities have depended on plants to meet their basic needs over centuries and people around the world use between 50,000 to 80,000 flowering plants as medicinal herbs (IUCN Species Survival Commission, 2007). Biodiversity plays important role in functioning of the ecosystem; hence there is an urgent need to study on the conservation of biodiversity in and around the tribal settlements would help in sustainable development giving more emphasis to the indigenous people (Ramachandran et al., 2009). The knowledge acquired by forest dwellers, folk healers, vaidyas in understanding the properties of roots, stems, leaves, flowers and fruits of these plants have immense value in traditional folk medicines. The purpose of this study is to enumerate the list of plants used by the irular tribe in Thiruporur, Kanchipuram district, Eastern Ghats.

2. MATERIALS AND METHODS

Study on ethnobotanical observation was made in Thiruporur, Kanchipuram district in Eastern Ghats. Kanchipuram district is situated on the northern East Coast of Tamil Nadu and is adjacent by Bay of Bengal and Chennai city and is bounded in the west by Vellore and Thiruvannamalai district, in the north by Thiruvallur district and Chennai district, in the south by Villuppuram district in the east by Bay of Bengal. It lies between 11° 00' to 12° 00' North latitudes and 77° 28' to 78° 50' East longitudes. The district has a total geographical area of 4, 43,210 hectares and coastline of 57 Kms. There are only a few hills of considerable elevation in the district. The southern part of Maduranthakam taluk contains small hills. Ethnobotanical data were collected according to the methodology suggested by Jain (1981). Data were collected through interviews, various direct observations at different study sites and discussion with tribals. The informants were aged between 40-90 years. The specimens were collected and identified with the help of Flora of Presidency of Madras (Gamble, 1915- 1936) and The Flora of Tamilnadu Carnatic (Matthew, 1983). The nomenclature was checked by using Sasidharan (2004). The voucher specimens were deposited in the Herbarium at Department of Botany, Bharathiar University.

3. RESULTS AND DISCUSSION

A total of 45 species belonging to 35 families were identified (Table 1) for medicinal uses during this investigation. The largest number of plants used medicinally belongs to the family Apocynaceae and Caesalpiniaceae with 3spp, followed by Acanthaceae, Asteraceae, Malvaceae, Poaceae, Rutaceae and Solanaceae with 2 spp each, remaining 27 families constitute one species each. Whole plant, parts like bark, flower, fruit, latex, leaf, rhizome, root, seed, and stem were used as medicine.

Diseases like fever, jaundice, mouth ulcer, headache, cold, tootache, constipation, fungal disease, sexual debility, eye disease, piles and skin problems were treated using the locally available plants. Life style disorders like diabetes and hypertension were also treated. Apart from these diseases plants were also used as cardio tonic, liver tonic, blood purifier, wound healer, antidote for insect and scorpion bite. Medicines to increase lactation, removal of lice from hair were also made from the available plants. Plants exhibiting aphrodisiac, stimulant, and diuretic properties were also effectively used. The result of the present study provides the list of medicinal plants that are used by irulars to cure various ailments which can be utilised by common public and pharmaceutical companies for a healthy living. Also further research on the medicinal plants mentioned in this study might provide some potential leads to fulfill the needs of search for bioactive compounds and the discovery of new drugs to fight various diseases.

Table.1: List of plants used by irular tribes as medicine

S.No	Botanical name	Family	Part used	Disease
1	Abrus precatorius L.	Papilionaceae	Seed	Roasted seedpowder - abortifacient
2	Acacia catechu (L.f.) Willd.	Mimosaceae	Leaf	Teeth ache, Head ache
3	Acalypha indica L.	Euphorbiaceae	Leaf	Antidote for insect bites
4	Achyranthes aspera L.	Amaranthaceae	Leaf	Boils, wound healing, fungal diseases on foot
5	Acorus calamus L.	Acoraceae	Root	Scorpion sting, to kill lice
6	Aegle marmelos (L.) Corr.	Rutaceae	Fruit	Constipation
7	Alstonia scholaris (L.) R. Br.	Apocynaceae	Latex	Post delivery fever
8	Andrographis paniculata (Burm. f.) Nees	Acanthaceae	Whole plant	Fever
9	Annona squamosa L.	Annonaceae	Seed	Removal of lice
10	Asparagus racemosus Willd.	Liliaceae	Root	Lactation in women, general weakness

11	Azadirachta indica A. Juss.	Meliaceae	Leaf	Fever, skin problems, insect repellant
12	Boerhaavia diffusa L.	Nyctaginaceae	Root	Jaundice
13	Cardiospermum halicacabum L.	Sapindaceae	Leaf	Joint pain
14	Carissa spinarum L.	Apocynaceae	Root	Antidote for insect bites
15	Cassia auriculata L.	Caesalpiniaceae	Flower	Diabetes
16	Cassia fistula L.	Caesalpiniaceae	Fruit pulp	Piles
17	Cassia occidentalis L.	Caesalpiniaceae	Leaf	Constipation
18	Centella asiatica (L.) Urban	Apiaceae	Leaf	Hypertension
19	Cleome viscosa L.	Cleomaceae	Leaf	Headache
20	Curculigo orchioides Gaertn.	Hypoxidaceae	Rhizome	Weakness
21	Cynodon dactylon (L.) Pers.	Poaceae	Leaf	Wound healing
22	Eclipta prostrata L.	Asteraceae	Leaf	Juice cure swelling of cattle ears
23	Ficus religiosa L.	Moraceae	Seed	Sexual debility
24	Gloriosa superba L.	Colchicaceae	Whole plant	Abortion
25	Helicteres isora L.	Malvaceae	Root	Diabetes
26	Hemidesmus indicus (L.) Schult.	Asclepiadaceae	Root	Tonic and blood purifier
27	Hibiscus rosa-sinensis L.	Malvaceae	Flower	Cardiac tonic
28	Hybanthus enneaspermus (L.) F.Muell.	Violaceae	Root	Cardiac tonic
29	Justicia adhatoda L.	Acanthaceae	Leaf	Cough
30	Moringa oleifera Lam.	Moringaceae	Fruit	Stimulant
31	Murraya koenigii (L.) Spreng.	Rutaceae	Leaf	Hypertension
32	Nyctanthes arbor-tristis L.	Oleaceae	Leaf	Burns
33	Ocimum tenuiflorum L.	Lamiaceae	Leaf	Cold
34	Oxalis corniculata L.	Oxalidaceae	Whole plant	Cold, Liver tonic
35	Piper longum L.	Piperaceae	Dried fruit	Liver tonic
36	Psidium gujava	Myrtaceae	Leaf	Tooth ache
37	Sesamum indicum L.	Pedaliaceae	Seed	Oil- hair tonic
38	Solanum nigrum L.	Solanaceae	Leaf	Mouth ulcer
39	Solanum surattense Burm.f.	Solanaceae	Leaf	Asthma
40	Tabernaemontana divaricata (L.)R. Br.ex. Roem. &Schult	Apocynaceae	Flower	Eye disease
41	Tinospora cordifolia (Willd.) Hk.f. & Th.	Menispermaceae	Stem	Fever
42	Tribulus terrestris L.	Zygophyllaceae	Whole plant	Aphrodisiac
43	Tridax procumbens L.	Asteraceae	Leaf	Wound healing
44	Vetiveria zizanioides (L.) Nash	Poaceae	Root	Blood purifier
45	Ziziphus mauritiana Lam	Rhamnaceae	Bark	Diarrhoea

4. CONCLUSION

The survey indicated that the study area has plenty of medicinal plants to treat a wide spectrum of human ailments. Traditional knowledge of plants in many tribal communities is changing because of rapid industrialization, urbanization, socio-economic and cultural changes. Exploration of medicinal plants is essential from the view point of documentation of indigenous and traditional knowledge, which consequently helps in formulation of potential raw materials in modern pharmaceutical industry for further availability and for the greater benefit of mankind.

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MAMMALIAN DIVERSITY IN HOSUR AND DHARMAPURI FOREST DIVISIONS, EASTERN GHATS, SOUTHERN INDIA

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ABSTRACT

Despite a significant number of studies on the distribution and biogeography of vertebrate taxa in the past two decades, much of these were from Protected Area (PA) networks, which constitute just 5% of forest cover in India. The PA network may or may not support all wide-ranging species or have all the micro/major habitats of a landscape within, which is required to support the large assemblage of species diversity found in the region. Much of the larger forest areas encompassed by territorial forest divisions, with no detailed data on biodiversity, are subjected to a wide range of anthropogenic pressures including threats from large-scale developmental projects. Thus, knowledge about the diversity of wildlife species in the territorial forest divisions is also vital for planning the conservation of the regional biodiversity. We documented the mammalian species of Hosur Territorial Forest Division (FD) and its contiguous habitats in the Dharmapuri FD, located in Eastern Ghats of southern India, between June 2009 and April 2010. The study area being close to Bangalore, the 'Electronic Hub of India', its developmental activities could potentially affect forests and biodiversity of the adjoining areas. The study used rapid survey, camera trapping, and Ad-hoc or opportunistic sampling methods.

Key words: Mammalian diversity, eastern ghats, endangered and endemic species

1. INTRODUCTION

Out of 5488 species of mammalian fauna found across the globe (IUCN Red List 2008), India harbours 417 species (Nameer 2008), with bulk of them found in high rainfall regions of Himalayas and Western Ghats. The low rainfall areas of Eastern Ghats are known to support very few of them. Although mammalian taxa is the most advanced among animal kingdom and has been studied or surveyed for longer period than any other taxa, yet documentation of mammalian diversity is not much in semi-arid zones of Eastern Ghats, as compared Western Ghats. Further, systematic checklist of species at forest division level does not exist even for the advanced and more easily comprehendible taxa like mammal. Past efforts were mostly biased towards Protected Area (PA) networks, which include Wildlife Sanctuary and National Park, only limited studies have been carried out in territorial forest divisions, which is also known to support endangered species of fauna and flora. The territorial forest divisions have compromised value for biodiversity conservation, as they are legally open to human activities unlike the PAs, yet as a first step, baseline data on check list various taxa and their distribution, and as a second step, fine tuned ecological data on species of concern if any, are vital for effective conservation planning and management. While a minimum of 20% of Indian large mammals face extinction crisis, and several have even disappeared from >90% of traditional ranges (Madhusudan & Mishra 2003), the need for basic data on distribution, abundance and habitat requirements of mammalian species occurring in areas with high anthropogenic pressure are crucial for regional conservation planning. This study was carried out to document the diversity of mammalian fauna and their distribution in Hosur and its contiguous habitats in Dharmapuri Forest Divisions in the Eastern Ghats.

2. MATERIALS AND METHODS

2.1. Study Area

The study was carried out in Hosur, and its adjoining contiguous habitat in Dharmapuri Forest Divisions between June 2009 and April 2010. The area falls under Eastern Ghats, which represent the isolated hills of the Deccan Plateau (Mani 1974) and one of the biologically richest Biogeographic Zones of India (Rodgers et al. 2002). The study extended over eight territorial Forest Ranges, which include six Forest Ranges from Hosur Forest Division viz. Anchetty, Denkanikotta, Hosur, Jawalagiri, Rayakottai, and Urigam and two Forest Ranges viz. Hokenakkal and Pennagaram that are adjoining contiguous habitat to Hosur Forest Division, from Dharmapuri Forest Division (Figure 1) were surveyed. In 1886, the government notified these as Reserve Forests (Subaiah 1982). There are proposals more recently to declare this area as a sanctuary. It lies between the latitudes 12.15° to 12.69° N and longitudes of 78.01° to 77.47°, located in the Eastern Ghats. The area receives a mean annual rainfall of 800mm from both southwest (May–August) and northeast monsoons, with a higher quantum from the later one. The vegetation of the area represents tropical dry thorn, dry deciduous and mixed deciduous and a few patches of lowland dry evergreen forests, a patch of high altitude (1395m: Guttirayan Hill) montane evergreen forest and a large tract (65km) of riparian habitat along the Cauvery river (Champion and Seth 1968). The Cauvery River, the largest perennial river in southern India, flows between Karnataka and Tamil Nadu on the southern side of the study area. Some of its large tributaries such as Pennaiyar and Chinnar are also perennial and the smaller ones are semi-perennial flowing through the forest of the study area, notably on the Hosur plateau. The area has a few Hindu religious temples (Madhesvaran and Dhabakuli Appan), situated along the Cauvery River that attract a large number of pilgrimages every year, that could potentially affect the riparian habitats along Cauvery river. Besides, the area being a territorial forest division, where conservation does not receive the top priority to reduce the human dependency on forest, unlike the PAs, the forest habitats are subjected to intensive anthropogenic pressure (Kumar 1994) due to extensive cattle grazing, and fire wood collection and large-scale extraction of minor forest produces such as fruits (Tamarindus indica, Phyllanthus emblica), nuts (Pugamia pinnata, Terminalia chebula, Sapindus indicus), common greenshield lichen (Flavoparmelia caperata), honey, and fishing in Cauvery river.

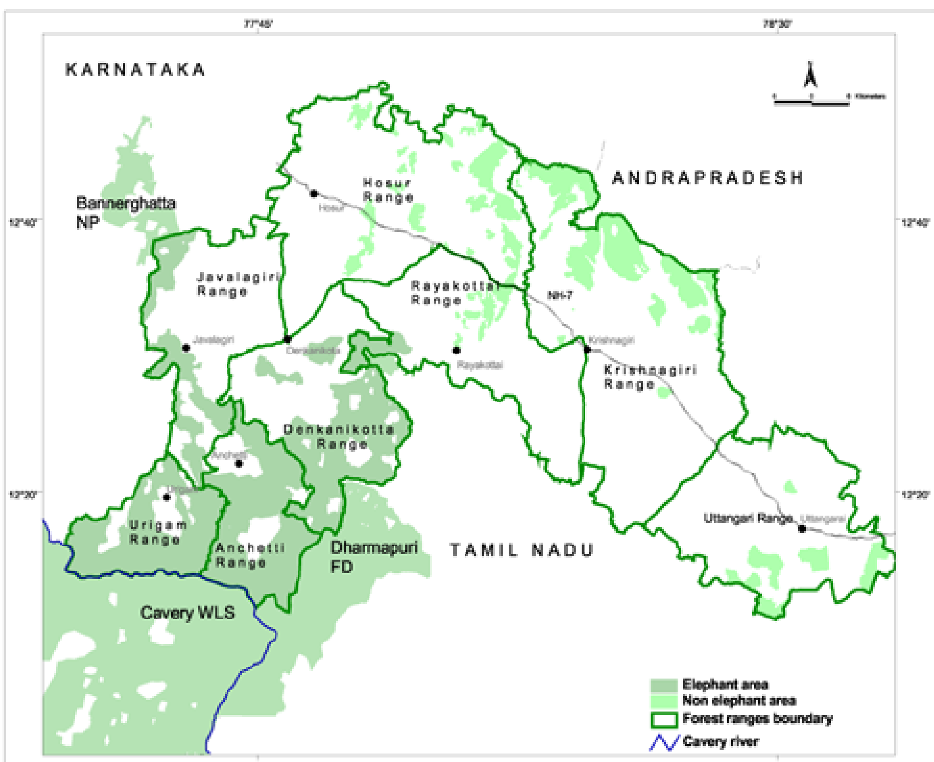

Fig.1: Map showing Hosur Forest Division and its adjoining contiguous area in Dharmapuri Forest Division, in Tamil Nadu and Bannarghatta National Park and Cauvery Wildlife Sanctuary in Karnataka

The area endowed with diverse fauna; viz. Asian elephant (Elaphas maximus indicus), Indian gaur (Bos gaurus), sambar (Rusa unicolor), spotter deer (Axis axis) and Indian hare (Lepus nigricollis), carnivores such as leopard (Panthera pardus), wild dog (Cuon alpinus), jungle cat (Felis chaus), common mongoose (Herpestes edwardsi) and omnivores like sloth bear (Melursus ursinus) wild boar (Sus scrofa), Indian porcupine (Hystrix indica) and jackal (Canis aureus). In addition, the area is also known to have Indian Pangolin (Manis crassicaudata) and Bonnet macaque (Macaca radiata) (Mani 2007)

2.2. Mammalian documentation

The mammalian species inventory was carried out using four different methods: (1) A rapid ground survey, (2) Camera trap and (3) Ad-hoc or opportunistic sampling, while on other field surveys.

2.3. Rapid survey:

The survey following block count method documented the mammalian diversity using a team volunteers and forest department staff. The rapid survey used both direct sighting and indirect evidences such as the droppings, pug/hoof/pad marks, and feeding signs were mainly used to identify presence or absence of mammal species. The survey teams (consist minimum two volunteers and a forest staff) were briefed using a power point or oral presentation, about the survey goal, area of survey, methods, and variables to be observed and recorded. After briefing, the survey teams were provided with necessary data sheets, digital camera, resource materials such a list of mammal species of the area (prepared from working plan), book on field guide to mammals, and pictures showing their indirect evidences and dropped at the survey block. The forest department field staff familiar with the sampling areas, who are part of the survey teams, were asked to perambulate the areas where probability of sighting wild animals is high within the survey block along with their team members. The team covered the survey block on foot during morning time between 07:00 and 11:00 hrs and evening between 15:00 and 18:00 hrs. Within each team, the documentation of direct sightings was recorded by one volunteer, while the second volunteer recoded the indirect evidences, verifying the resource materials supplied, apart from consulting the forest staff. At every direct sighting or indirect evidences of mammal species, the subject was first photographed (when possible), and recorded the species name, number individuals, the sighting location and microhabitat in the data sheets supplied.

2.4. Camera trap sampling:

This method was employed especially to document the lesser known and nonvolant small mammals and used during the two months (March–April 2010). Hence, the area coverage by the camera traps was not as wide as compared to the other methods. Therefore, the list of mammalian species especially the lesser known small carnivores and nonvolant small mammals compiled in this study could be considered as a minimum.

2.5. Ad-hoc or opportunistic sampling:

In addition to the rapid survey and camera trapping, documentation of mammalian fauna was carried out following ad-hoc or opportunistic sampling method while on field surveys for vegetation sampling, assessment of other vertebrate fauna, human-elephant conflict, and socio-economic condition of the human population in the study area. Both direct sighting and indirect evidences were taken into account.

3. RESULTS AND DISCUSSION

3.1. Mammalian diversity

Overall using all the four different methods, the survey documented a minimum of 35 mammalian species belonging to 10 orders (Table 1) in the Hosur forest division and its adjoining contiguous habitats in the Dharmapuri forest division during the period June 2009 and April 2010. The 35 species include two endangered species—the Asian elephant and Wild dog—five vulnerable (four-horned antelope Tetracerous quadricornis, Indian gaur Bos gaurus, Sambar deer Rusa unicolor, Smooth coated otter Lutrogale perspicillata and Sloth bear Melursus ursinus) and two near threatened (Leopard Panthera pardus and Grizzled giant squirrel Ratufa macroura) species. Among the 10 orders mammalian species recorded, carnivora represented the highest number of species (n = 11), followed by artiodactyla and rodentia with each of them representing seven different species. The other orders of mammalian fauna found in the area include, primates (with three different species), chiroptera (with two different species), and proboscidea, logomorpha, pholidata, insectivora, and scandentia (with each of them representing one species).

Table 1: List of mammalian fauna recorded in Hosur and Dharmapuri Forest Divisions, Tamil Nadu between June 2009 and April 2010

Order and Common Name	Scientific Name	IUCN status	Distribution (in Forest Range/s)
Insectivora			
House shrews	Suncus murinus	LC	A, D, J & U
Scandentia			
Madras tree shrew	Anathana elliotti	LC	A, J & U
Chiroptera			
Indian flying fox	Pteropus giganteus	LC	D
Indian pipistrelles	Pipistrellus coromandra	LC	U
Primates			
Bonnet macaque	Macaca radiata	LC	All ranges studied
Common langur	Semnopithecus entellus	LC	A & U
Slender loris	Loris lyddekeriannus	LC	D & U
Carnivora			
Jackal	Canis aureus	LC	A, D, J & U
Jungle cat	Felis chaus	LC	D
Leopard*	Panthera pardus	NT	A, D, R & U
Ruddy mongoose	Herpestes smithii	LC	U
Small Indian mongoose	Herpestes javanicus	LC	A
Stripe necked mongoose	Herpestes vitticollis	LC	A
Smooth-coated otter	Lutrogale perspicillata	VU	A, Hok & U
Sloth bear*	Melursus ursinus	VU	A, D & U
Common palm civet	Paradoxurus hermaphroditus	LC	D
Small Indian civet	Viverra civettina	LC	A, D , Hok & U
Wild dog	Cuon alpinus	EN	A, D & U
Proboscidea			
Asian elephant*	Elephas maximus	EN	All ranges studied
Artiodactyla			
Four-horned antelope*	Tetracerus quadricornis	VU	A & U
Indian gaur*	Bos gaurus	VU	A, D, J, Hok & U
Sambar	Rusa unicolor	VU	D, Hok & U
Spotted deer	Axis axis	LC	A, D, J, Hok, P, R & U
Wild boar	Sus scrofa	LC	All ranges studied
Mouse deer*	Moschiola meminna	LC	D
Barking deer	Muntiacus muntjak	LC	D
Pholidota			
Indian pangolin*	Manis crassicaudata	LC	D
Rodentia			
Indian porcupine	Hystrix indica	LC	D & U
House rat	Rattus rattus	LC	D
India gerbil	Tatera indica	LC	D
Lesser bandicoot	Bandicota bengalensis	LC	A, D, J & U
Little Indian field mouse	Mus booduga	LC	D
Grizzled giant squirrels*	Ratufa macroura	NT	A & U
Three striped palm squirrel	Funambulus palmarum	LC	All ranges studied
Logomorpha			
Black-naped hare	Lepus nigricollis	LC	All ranges studied

Note: * Schedule I Part I species of Indian Wildlife Act (1972); IUCN Status: EN: Endangered, LC: Least Concerned, NT: Near Threatened, VU: Vulnerable. Forest Range/s: A: Anchetty, D: Denkanikotta, J: Jawalagiri, R: Royakotta, U: Urigam, Hos: Hosur, P: Pennagaram and Hok: Hokenakkal.

3.2. Distribution pattern

The species such as wild boar (Sus scrofa), bonnet macaque (Macaca radiata), black-napped hare (Lepus nigricollis) and Asian elephant were widely distributed in all the forest ranges of the study area. In contrast, species like the four-horned antelope (T. quadricornis), grizzled giant squirrel (Ratufa macroura), barking deer (Muntiacus muntjak), mouse deer (Moschiola meminna) and smooth-coated otter (L. perspicillata) were restricted in their distribution due to the habitat specific nature. Distribution of the remaining species of mammals have not been recorded in all the ranges, which is likely be due to their low-density coupled with inadequate effort by the short term study.

3.3. Grizzled giant squirrel sighting records:

The documentation of the grizzled giant squirrel by the present study is the first scientific information on the existence of this species in the study area. Joshua (1992), who did a detailed ecological study on the species in another population further south in Tamil Nadu, mentioned that the collection of skins of R. macroura by Bombay Natural History Society during 1920–30 indicates that in the past the species occurred in places such as Dharmapuri and Salem Attur in the Eastern Ghats. Nevertheless, no published data is yet available on the existence of the species in this Forest Division, except Baskaran et al. 2011, who made detailed documentation based on the survey carried out in 2009-10. The species is distributed in isolated populations with less than 500 mature individuals in India, unlike the large contiguous population in Sri Lanka. Its numbers are declining significantly due to habitat loss and hunting throughout much of its range (Joshua and Johnsingh 1992, Molur et al. 2005). The species is listed as near threatened in IUCN (2010), placed in Appendix II of CITES to regulate the international trade in this species, and under the schedule I (part I) of the Indian Wildlife Act (1972 & 1991).

3.4. Distribution of Madras Tree shrew:

The species is also known as southern Indian tree shrew, an endemic species to India. It was earlier placed under Insectivora, but based on a recent molecular study (Schmitz et al. 2000) classified under a new order Scandentia. The species was sighted on three occasions during the last one year and records of this species represent the first report of the sighting of this species in Hosur Forest Division. The species earlier known to exist in Wynad, Kerala (George 1989), Garhwa Forest, Bihar (Gupta 1996), Wardha River Basin, Maharashtira (Pradhan 1997), Bori Wildlife Sanctuary, Madhya Pradesh (Shrivastava 1995), Yercaud Hills, Tamil Nadu (Karthikeyan 1992, 2001) and very recently at BRT Wildlife Sanctuary, Karnataka (Srinivasan et al. 2009).

Among the eight different ranges that were surveyed in the Hosur and Dharamapuri Forest Divisions, Denkanikotta, Urigam and Anchatti have supported the highest number of mammalian species, besides harbouring more number of endangered, vulnerable and near-threatened species (Fig. 2) indicating their importance for conservation of mammalian diversity. The forest ranges such as Hokenakkal and Pennagaram that belong to Dharmapuri Forest Division, are also likely to be similar to Denkanikotta, Urigam and Anchatti in mammalian species richness. Nevertheless, these ranges were found to have lesser number of mammalian species, which is more likely be due to inadequate sampling effort in these ranges as compared to the forest ranges in Hosur Division.

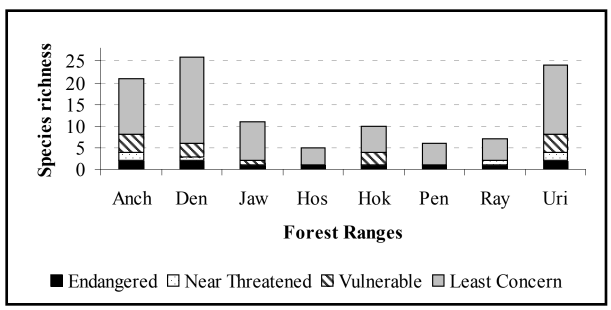

Figure 2: Mammalian species richness recorded in different Forest Ranges of Hosur Forest Division and its adjoining contiguous area in Dharmapuri Forest Division between June 2009 and April 2010

Note: Anch: Anchatty, Den: Denkanikotta, Jaw: Jawalagiri, Hos: Hosur, Hok: Hokenekkal, Pen: Pennagaram, Ray: Rayakotta, Uri: Urigam.

Number of mammalian species recorded in the study should be considered the minimum, as it was short term assessment. Although number of mammalian species recorded in the study area is considerable (n = 35), the abundance of each species was very low, so that the study was unable to obtain adequate sample size to estimate the population density of large mammals like elephants, gaur, sambar, chital and common langur using line transect direct sighting method. The reason for the low abundance could be due to poor habitat quality. Mammalian species especially the large mammals, given their larger body mass, unique habitat requirements, and associated life-history traits, are more prone to extinction (Brashares 2003, Michalski and Peres 2005). Further, the evolutionary and life-history strategies that render the large mammals more susceptible to extinction also make them vulnerable to a wide range of anthropogenic threats (Madhusudan and Mishra 2003, Morrison et al. 2007). The natural habitats in Hosur Forest Division is well known to experience severe anthropogenic pressure since the 19th century. Large forest tract from this division was brought under British rule through treaties with Tippu Sultan in 1792. The tract was well known for sandalwood (Santalum album) production and was brought under strict protection during Tippu's regime. Subsequently, when the forest passed on to the East India Company had undergone relentless exploitation for about 180 years. The construction of railways and its demand for sleepers recklessly denuded the forest. In 1859–60 alone 2,45,743 railway sleepers were extracted (Harikrishnan 1970). There have been indiscriminate thefts of timber from these areas by railway contractors in 1865. In 1886, the area was notified as Reserve Forest (Subaiah 1982). Nevertheless, the forest continues to experience large-scale destruction through exploitation of bamboo (Babusa arundinacea), fuel wood (Canthium dicoccum, Atalantia monophylla, Ixora parviflora and Albizzia amara), selective felling of timber resources (Hardwickia binata, Tectona grandis and Pterocarpus marsupium), sandalwood, and minor forest produces mostly fruits and nuts from tamarind (Tamarindus indica) thanikai (Terminalia belerica), soapnut (Sapindus emarginatus) and thagaravarai (Cassia tora) including honey collection. The forest pastures of the plateau deteriorated by unlimited grazing of cattle and there were not less than 36 cattle pens, with each one of them rearing as many as 1500 cattle, placed right inside the forest. Available statistics shows several thousand cattle (up to 99,772) were licensed to graze inside the forest annually between 1959 and 1969 and incidences of illegal goat browsing, mainly on the northern sides of the division, increased over the years (Harikrishnan 1970).

In addition to the above, large number of villages located in around the study area posses a tremendous pressure on the natural habitats of the study area. The major sources of revenue for the people living in and around the plateau are cultivation, livestock grazing, minor forest produce collection, and fuel woodcutting. As many as 1200 people were given gun licenses to protect crops. The division, being a territorial forest, all the denuding factors (except selective felling of timber and sandalwood extraction) continue to degrade the plateau resulting in extensive loss of natural resources available to wild animals especially to the large mammals. The degradation of habitats brought about by grazing and fuel wood cutting opens up spaces that facilitate the proliferation of weeds like Lantana and Eupatorium. These weeds suppress the growth of grass and other natural vegetation, which in turn results in reduced food resources to herbivorous mammals as reported elsewhere (Baskaran et al. 2011). From the above discussion, it is quite evident that the degree of anthropogenic pressure exerted on the habitats is the most likely reason for the observed low density of mammalian species in the study area. The study area was known to support species Tiger, Hyaena and Blackbuck, whose signs were unrecorded during the present study indicating that they are most likely extinct locally. If the anthropogenic pressure on the natural habitats continues, the area will lose more number of species.

3.5. Management Recommendations

Despite all the negative effect on the natural habitats, the study area still contains potential habitats, which can support a wide verity of mammalian species including endangered, near threatened and vulnerable species as reported in the study. The natural habitats in the southern part of the Hosur Forest Division located along the Cauvery River i.e. Urigam, Anchetty, and parts of Denkanikotta with its contiguity to Hokenakkal and Pennagaram in Tamil Nadu and Cauvery Wildlife Sanctuary in Karnataka state are the vital areas. In Karnataka side the Cauvery riparian habitats stretch is already protected as a Cauvery Wildlife Sanctuary. While in Tamil Nadu side, the riparian habitat stretch, being still remains as territorial forest status, though in the past there was a proposal to upgrade these area into a Wildlife Sanctuary. These areas with less human settlements, and habitat fragmentation (Baskaran and Venkatesh, 2009) and perennial water source of Cauvery River need to be upgraded into a Wildlife Sanctuary or declared as an Ecological Sensitive Area to regulate the developmental activities and promote the conservation efforts.

Although small populations of grizzled giant squirrels with isolated individuals are neither demographically nor genetically viable, the species is found more often in small numbers (Davidar 1989, Karthikeyan et al. 1992, Kumara and Singh 2006, Kumar et al. 2007), with restricted distribution mostly to riverine habitats, which is generally patchy in nature. The long riparian habitat available along the Cauvery River is a potential sites for the species, and hence measures such as (a) restoration of habitat and maintenance of canopy continuity (through afforestation of preferred tree species like Tamarindus indica and Mangifera indica), (b) stop auctioning the Tamarindus indica fruits on large scale for commercial purpose by Forest Department, (c) reducing anthropogenic pressure along the riverine habitats (through strict management action against the cattle pens that are along the gallery forest of Cauvery River), (d) Establishing artificial canopy contiguity (bridge) to connect northern bank with southern bank riverine habitat and (e) translocation of a few individuals of R. macroura from larger populations to this habitat would not only enhance their long-term survival, otherwise on the brink of local extinction, but will also ensure the availability of the largest riverine habitats for this habitat specialist. Needless to say that such efforts in gallery forests would also enhance the conservation status of the other habitat specialists like otter and generalists like Asian elephant, as the Cauvery River is the vital source of water during summer.

4. ACKNOWLEDGEMENTS

We are thankful to the Tamil Nadu Forest Department, especially Mr. Sundarajan IFS former Chief Wildlife Warden Tamil Nadu, and Mr. V. Ganesan IFS, former District Forest Officer, Hosur Forest Division for permitting this study and Asian Nature Conservation Foundation (ANCF), Bangalore for financial support. We also extend our sincere thanks to the members of Kenneth Anderson Nature Society, Bangalore Mr. K.G. Avinash, GIS Expert, ANCF in producing the maps.

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DIVERSITY OF BUTTERFLY SPECIES (LEPIDOPTERA: RHOPALOCERA) IN LOYOLA COLLEGE CAMPUS, CHENNAI, TAMILNADU, INDIA

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ABSTRACT

The diversity of butterfly fauna was carried out in the lush green 88 acre campus of Loyola College. A total of 47 species distributed in 34 genera and 5 families were recorded. The families include Nymphalidae, Lycaenidae, Hesperidae, Pieridae and Papilionidae with Nymphalidae and Lycaenidae being the most dominating families with 27% of butterfly species recorded in each followed by the family Pieridae (19%), Hesperidae (8%) and Papilionidae (8%). The frequently encountered species include Danaus chrysippus, Catopsillia pyranthe, Papilio demoleus, Tirumala limiaceae, Eupolea core Acraea terpsicore, Papilio polytes and Graphium doson. The abundance of butterfly species was estimated every month during the study period of 6 months (February to July) and the number of species was found to be higher in the month of July and the highest number of the species, Common crow (Eupolea core) and Blue tiger (Tirumala limiace) was recorded during this period.

Key words: Butterfly fauna, diversity, Loyola College.

1. INTRODUCTION

Butterflies, one of the most plant dependent groups of insects are excellent indicators of the environmental quality. About 1500 species of butterflies are found in India. Butterflies are known to exhibit high host plant specificity and thus serve as valuable indicators when there is a drastic change in the terrestrial biotope. They are beneficial as pollinators, silk producers, indicators of environmental quality, and respected for their visual value (Kunte, 2000). They are among the most interesting groups of insects (Pajni et al., 2006) and have been referred to as flagships and honorary birds. Among the invertebrate animals, they are one of the best studied groups (Varshney et al., 1993) and are considered accurate indicators of environmental quality. They have been a source of inspiration to designers, poets and writers. India harbours about 1501 species of butterflies; 285 species are found in Southern India (Thomas, 1996), of which 45 species are endemic to southern India. The earliest scientific records on the butterflies of Western Ghats dates back to the 18th century records by Linnaeus, Fabricius and Cramer (Gaonkar, 1996). Since then there have been many studies on butterflies from different parts of southern India (Fergusson, 1891) including the Western Ghats (Arun, 2002). Many species have become rare in the recent past due to various anthropogenic activities. Therefore, the present study is an attempt to explore the existing diversity of butterflies in Loyola College.

2. MATERIALS AND METHODS

2.1. Study Area

The study area, Loyola College is situated in the heart of Chennai city at Nungambakkam, Chennai, Tamil Nadu (Fig.1a). It lies between 13.0620° N latitude and 80.2340° E longitude and the campus is located in 88 acres of lush green vegetation .The study was carried out from February 2014 to July 2014 following line transect methods (Pollard et al., 1975 and Pollard, 1977) modified as per the Kunte (1997). The number of species and the number of individuals in each species was recorded during the survey which was carried out during the day from 7 a.m. to 12 noon. Data were collected by walking along the transect lines and butterflies encountered within the range of the transect belt were recorded (Fig 1.b). The road joining various departments and institutes like ERI, LIBA, LICET was chosen as the transect. The transect was walked at a slow, constant pace and all butterflies were counted in an imaginary box 2.5m to each side and 5m in front and above as shown in figure 2.The butterfly species were identified directly in the field conditions using the keys of Evans (1932), Wynter-Blyth (1957), Haribal (1992) and Kunte (2000) or in difficult cases, following capture or photography. Collection was restricted to those specimens that could not be identified directly. The diversity of butterflies was calculated by using Simpson's, Menhinick and Margalef's diversity indices as per (Khan et al., 2004; Simpson, 1949; Zar, 2006).

Fig 1.a: Map showing the study area (Loyola College, Chennai, Tamil Nad

Fig 1.b: The transect route used for the study

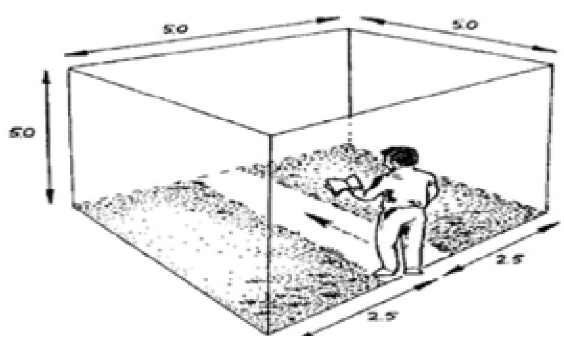


Fig 2: Imaginary box assumed while counting butterfly species in the transect route

2.2. Measurement of diversity

The diversity index was calculated by using the Shannon- Weiner diversity index (1949).

Diversity index= H= -∑ Pi In Pi

Where Pi = S/N

S = number of individuals of one species

N = total number of individuals in the sample

In = natural logarithm

Measurement of species richness

Margalef index was used as a simple measure of species richness (Margalef, 1958).

Margalef's index= (S-1)/In N

S = number of individuals of one species

N = total number of individuals in the sample

In = natural logarithm

Measurement of evenness

For calculating the evenness of species, the Pielou's Evenness Index (e) was used (Pielou, 1966).

e = H/ In S

H= Shannon- Weiner diversity index

S= total number of species in the sample

3. RESULT

In the present field study, 47 species of butterflies distributed in 34 genera and 5 families were recorded (Table.1). The families include Nymphalidae (Plate 1), Lycaenidae (Plate 2), Hesperidae (Plate 3), Pieridae (Plate 4) and Papilionidae (Plate 5). Nymphalidae and Lycaenidae were found to be the dominant families with 27% of butterfly species recorded in each. The family Pieridae comes next in the order with 19% of butterfly species being recorded during the study period of 6 months. The family Pieridae is followed by two families Hesperidae (8%) and Papilionidae (8%). The family wise abundance of butterflies has been illustrated in Figure 3. The frequently traceable species include Danaus chrysippus, Catopsilliapyranthe, Papiliodemoleus, Tirumala limiaceae, Eupolea core, Acraea terpsicore, Papilio polytes, Graphium doson. The status of butterfly species i.e., its abundance was estimated every month during the study period (Table 2 and 3) as common if it is found frequently and in large number, occasional if its presence is infrequent and rare if it not occurring very often. The number of species was found to be in the month of July. The butterfly status has been graphically represented in Figure 4. The diversity indices used were Simpson's diversity index, Shannon- Weiner index, Margalef's index, Menhinick's index. All the values obtained from these indices showed that the whole area is rich in butterfly abundance.

Table 1: Diversity Indices

S.No	Month	Simpson's diversity index	Simpson's index of diversity	Simpson's reciprocal index	Shannon Weiner index	Margalef's index	Menhinick's index
1.	February	0.07	0.93	14.2	2.8	4.7	2.4
2.	March	0.07	0.93	14.2	2.3	5.3	2.5
3.	April	0.09	0.91	11.1	2.9	4.8	1.72
4.	May	0.1	0.9	10.0	2.5	4.0	1.1
5.	June	0,024	0.97	41.6	2.7	4.64	1.9
6.	July	0.006	0.99	166.6	2.9	5.75	1.5

The diversity indices used are Simpson's diversity index, Shannon Weiner index, Margalef's index, Menhinick's index. All the values obtained from these indices proved that the whole area is rich in butterflies. With regard to the Simpson's index (Figure 5), 0 represents infinite diversity and 1, no diversity, i.e., the bigger the value of D, the lower the diversity and the D value was found to be lowest in July month which proves that the diversity was at its peak during the month. The Simpson's index of diversity (Figure 6) ranges between 0 and 1 which proves that the greater the value, the greater the sample diversity. The Simpson's Reciprocal index (Figure 7) starts with 1 as the lowest possible figure which also proves that the greater the value, the greater the sample diversity. The Shannon Weiner index is a measure of the average degree of uncertainty in predicting to what species an individual chosen at random from a collection of S species and N individuals will belong. The greater the value of H, greater the evenness of species distributed. The Margalef index (R_1) and the Menhinick index(R_2) explains the relationship between the number of species (S) recorded and the number of individuals (n) recorded and they will vary with samples containing different n values i.e., as n increases, (R_1) and (R_2) decreases.

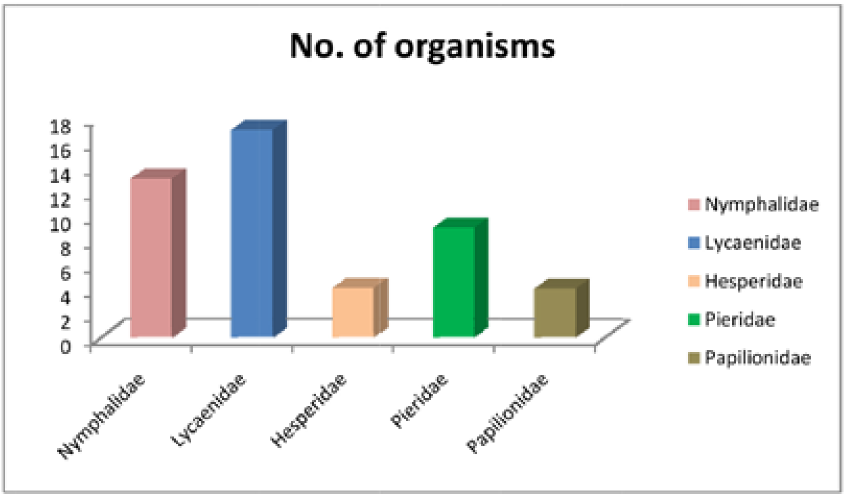


Fig 3: Family wise abundance of butterflies during the study period

S.No.	Common name	Scientific name	Family
1.	Babul blue	Azanus ubaldus	Lycaenidae
2.	Blue tiger	Tirumala limiace	Nymphalidae
3.	Brown king crow	Eupolea klugii	Nymphalidae
4.	Common banded awl	Hasora chromus	Hesperidae
5.	Common Castor	Ariadne merione	Nymphalidae
6.	Common crow	Euploea core	Nymphalidae
7.	Common emigrant	Catopsilia pomona	Pieridae
8.	Common Gull	Cepora neriss	Pieridae
9.	Common Jay	Graphium doson	Papilionidae
10.	Common Leopard	Phalanta phalantha	Nymphalidae
11.	Common Mormon	Papilio polytes	Papilionidae
12.	Common Pierrot	Castalius rosimon	Lycaenidae
13.	Common Sunbeam	Curetis thetis	Lycaenidae
14.	Striped tiger	Danaus genutia	Nymphalidae
15.	Dark Blue tiger	Tirumala septentrionis	Nymphalidae
16.	Dark grass blue	Zizeeria knysna	Lycaenidae
17.	Double banded crow	Eupolea sylvester	Nymphalidae
18.	Forget-me-not	Catochrysops strabo	Lycaenidae
19.	Gram Blue	Euchrysops cnejus	Lycaenidae

20.	Grass Yellow	Eurema hecabe	Pieridae
21.	Great eggfly	Hypolimnas bolina	Nymphalidae
22.	Indian Cupid	Everes lacturnus	Lycaenidae
23.	Indian skipper	Spialia galba	Hesperiidae
24.	Blue Pansy	Junonia orithya	Nymphalidae
25.	Large Salmon Arab	Colotisf austa	Pieridae
26.	Lemon Pansy	Junonia lemonias	Nymphalidae
27.	Lesser grass blue	Zizina otis	Lycaenidae
28.	Lesser Gull	Cepora nadina	Pieridae
29.	Lime blue	Chilades lajus	Lycaenidae
30.	Lime Butterfly	Papilio demoleus	Papilionidae
31.	Mottled emigrant	Catopsilia pyranthe	Pieridae
32.	Plain tiger	Danaus chrysippus	Nymphalidae
33.	Plains Cupid	Chilades pandava	Lycaenidae
34.	Rice swift	Borbo cinnara	Hesperidae
35.	Small Orange-Tip	Colotis etrida	Pieridae
36.	Small salmon arab	Colotis amata	Pieridae
37.	Spot swordtail	Graphium nomius	Papilionidae
38.	Tawny coster	Acraeat erpsicore	Nymphalidae
39.	Tiny grass blue	Zizula hylax	Lycaenidae
40.	Zebra Blue	Leptotes plinius	Lycaenidae
41.	Common Jezebel	Delias eucharis	Pieridae
42.	Dark Cerulean	Jamides bochus	Lycaenidae
43.	Common Grass Dart	Taractrocera maevius	Hesperiidae
44.	Yellow Pansy	Junonia hierta	Nymphalidae
45.	Peacock Pansy	Junonia almana	Nymphalidae
46.	Chocolate Pansy	Junonia iphita	Nymphalidae
47.	Common evening brown	Melanitis leda	Nymphalidae

Table 2: Butterflies recorded during the study period

Table 3: Status of Butterflies of Loyola College

S.No	Common name	Scientific name	FEB	MAR	APR	MAY	JUN	JUL
1.	Babul blue	Azanus ubaldus	R	R	R	R	O	R
2.	Blue tiger	Tirumala limiace	C	C	C	C	C	O
3.	Brown king crow	Eupolea klugii	R	R	R	R	O	R
4.	Common banded awl	Hasora chromus	O	O	O	O	O	O
5.	Common Castor	Ariadne merione	O	O	O	R	O	O
6.	Common crow	Euploea core	C	C	C	C	C	O
7.	Common emigrant	Catopsilia pomona	C	C	C	C	O	O
8.	Common Gull	Cepora neriss	R	O	O	O	C	O
9.	Common Jay	Graphium doson	C	C	C	O	O	R
10.	Common Leopard	Phalanta phalantha	O	O	O	O	O	O

11.	Common Mormon	Papilio polytes	O	O	O	O	C	C
12.	Common Pierrot	Castalius rosimon	O	O	O	R	R	R
13.	Common Sunbeam	Curetis thetis	O	O	R	R	R	R
14.	Striped tiger	Danaus genutia	O	O	R	R	R	R
15.	Dark Blue tiger	Tirumala septentrionis	O	O	O	O	R	R
16.	Dark grass blue	Zizeeria knysna	O	O	O	O	R	R
17.	Double banded crow	Eupolea sylvester	R	R	R	O	R	R
18.	Forget-me-not	Catochrysops strabo	R	R	R	R	O	R
19.	Gram Blue	Euchrysops cnejus	O	O	O	O	O	O
20.	Grass Yellow	Eurema hecabe	O	O	O	O	C	C
21.	Great eggfly	Hypolimnas bolina	O	O	O	O	C	O
22.	Indian Cupid	Everes lacturnus	O	O	O	O	O	O
23.	Indian skipper	Spialia galba	O	O	O	O	R	R
24.	Blue Pansy	Junonia orithya	R	R	R	R	C	C
25.	Large Salmon Arab	Colotisf austa	R	R	R	R	R	R
26.	Lemon Pansy	Junonia lemonias	R	O	O	O	C	C
27.	Lesser grass blue	Zizina otis	R	R	R	R	O	O
28.	Lesser Gull	Cepora nadina	R	R	R	R	O	O
29.	Lime blue	Chilades lajus	R	O	R	R	R	R
30.	Lime Butterfly	Papilio demoleus	O	O	O	O	C	C
31.	Mottled emigrant	Catopsilia pyranthe	C	C	C	O	O	O
32.	Plain tiger	Danaus chrysippus	C	C	C	C	O	O
33.	Plains Cupid	Chilades pandava	C	C	C	O	C	C
34.	Rice swift	Borbo cinnara	O	O	O	O	O	O
35.	Small Orange-Tip	Colotis etrida	O	R	R	R	R	R
36.	Small salmon arab	Colotis amata	R	R	R	R	R	R
37.	Spot swordtail	Graphium nomius	R	R	R	R	C	O
38.	Tawny coster	Acraeat erpsicore	C	C	C	O	C	C
39.	Tiny grass blue	Zizula hylax	O	O	O	O	R	R
40.	Zebra Blue	Leptotes plinius	O	R	R	O	R	R
41.	Common Jezebel	Delias eucharis	R	R	R	R	R	R
42.	Dark Cerulean	Jamides bochus	O	O	O	O	O	R
43.	Common Grass Dart	Taractrocera maevius	R	O	O	R	R	O
44.	Yellow Pansy	Junonia hierta	R	R	R	R	O	C
45.	Peacock Pansy	Junonia almana	R			R	O	O
46.	Chocolate Pansy	Junonia iphita	R			R	R	O
47.	Common evening brown	Melanitis leda	R			R	R	O

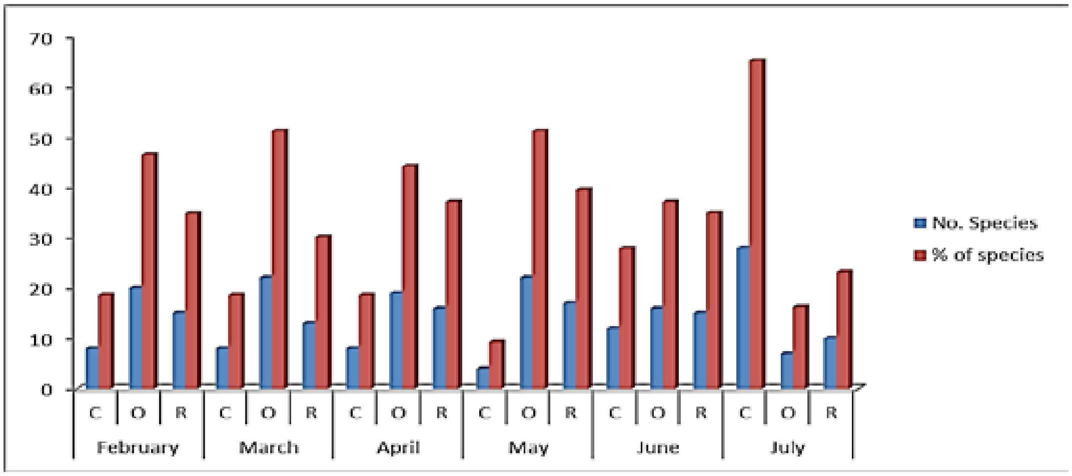
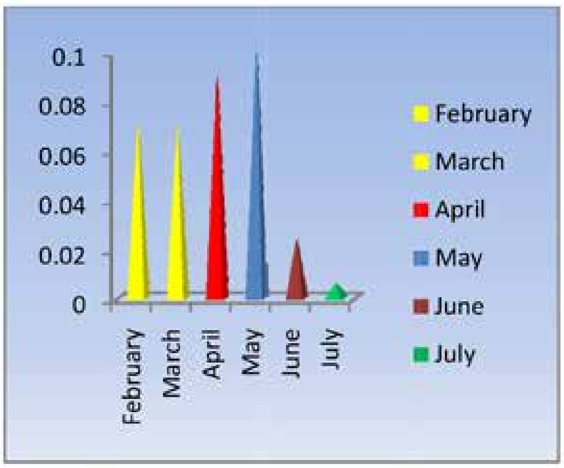


Figure 4: Monthly status of Butterflies in the study area during the study period



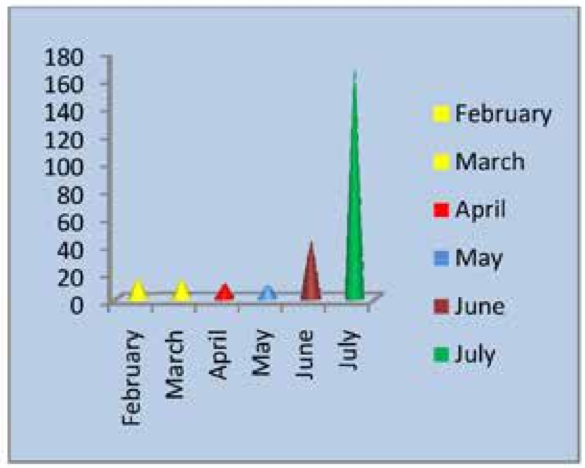
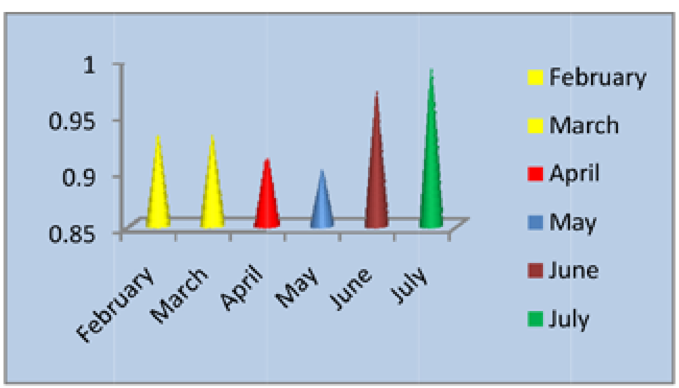


Fig 5: Simpson's diversity index Figure 6: Simpson's reciprocal index



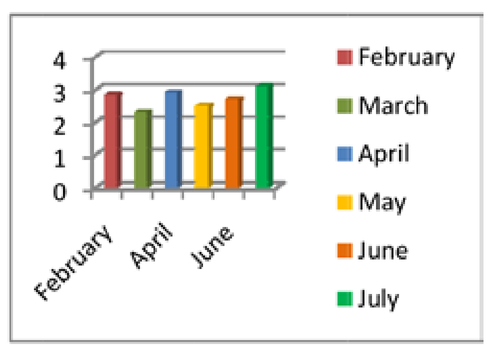


Figure 7: Simpson's index of diversity Fig. 8: Shannon Weiner Index

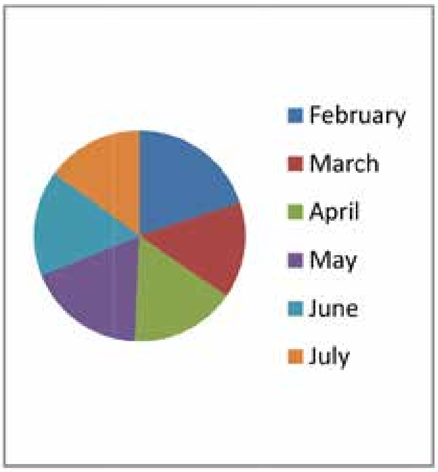


Fig. 9: Pielou's evenness index

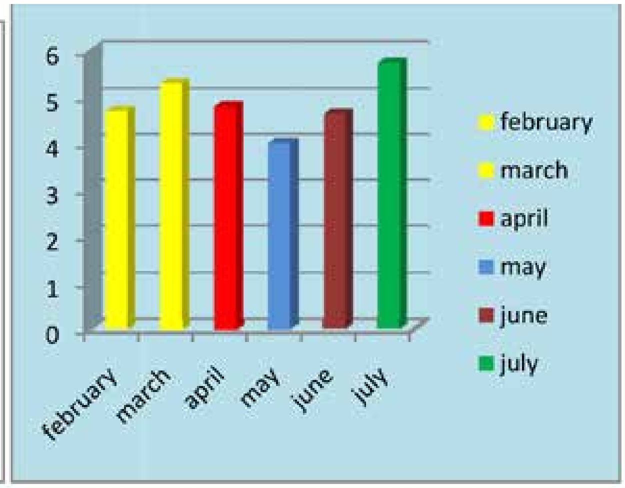


Fig 10: Margalef index (R_1)

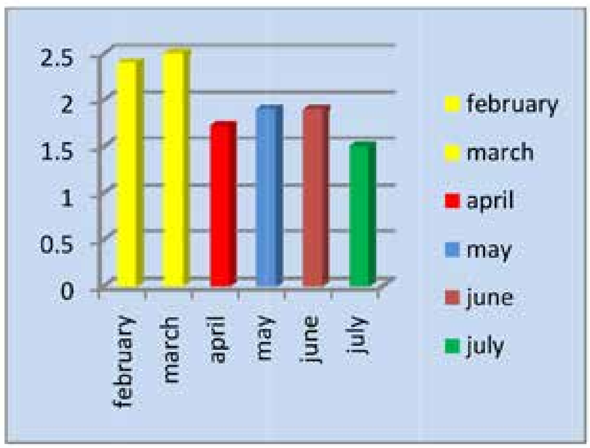
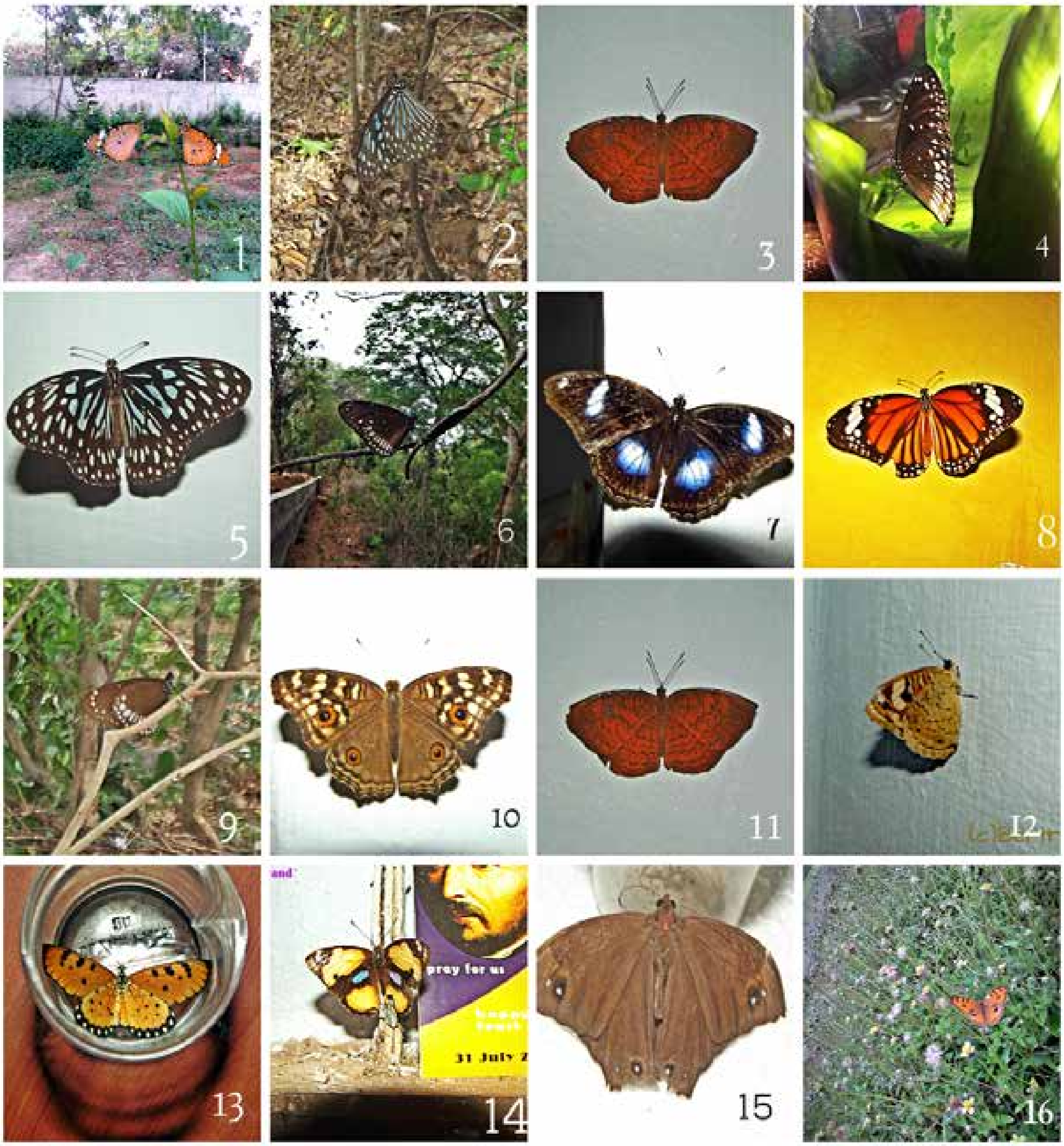


Fig 11: Menhinick index (R_2)

4. DISCUSSION

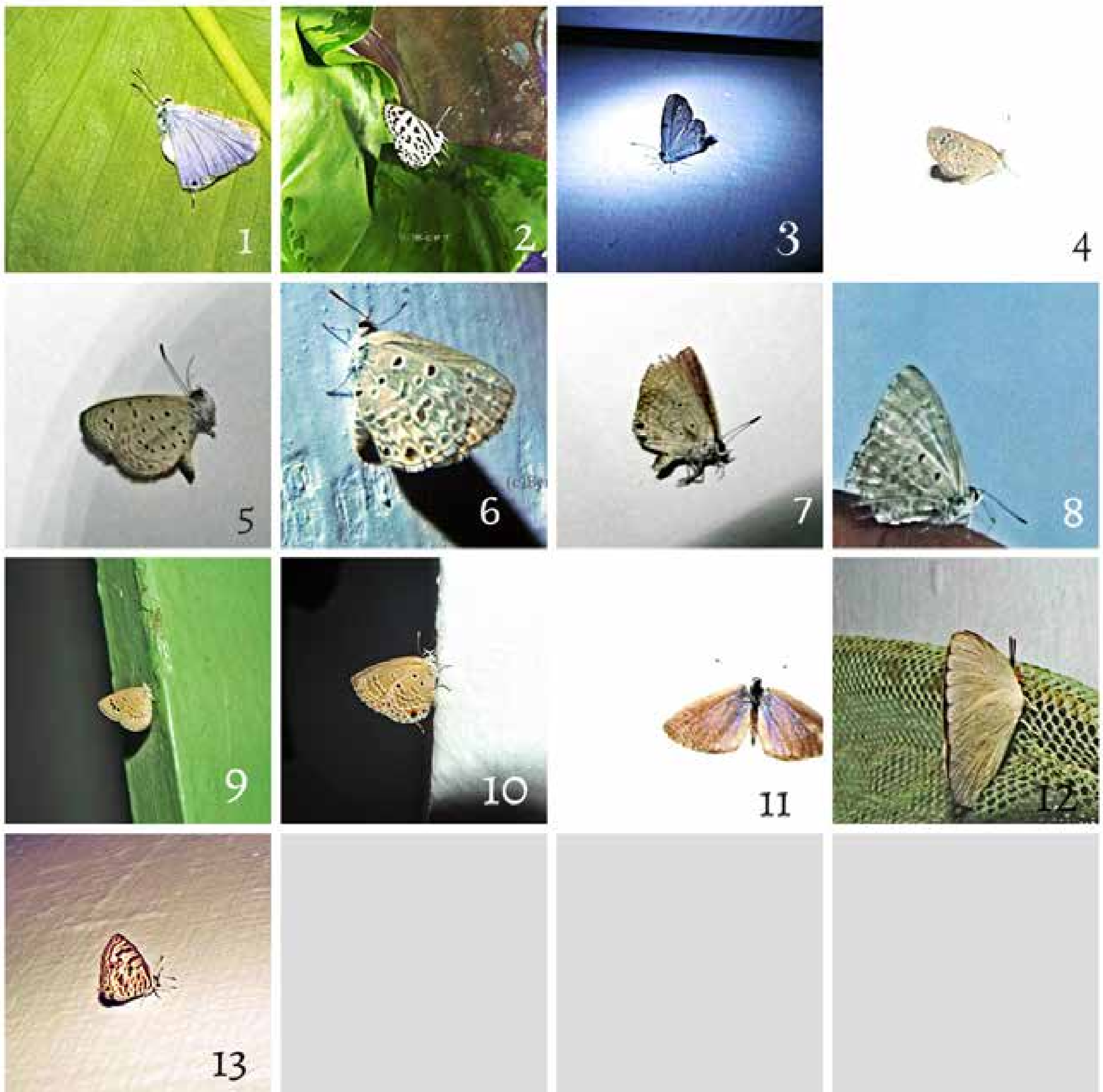
During the transect sampling, a total of 1335 individuals belonging to 47 species of 34 genera and 5 families were recorded. Nymphalidae and Lycaenidae were found to be the dominant families during the study period of 6 months. The study reveals increase in richness and abundance during the month of July which received monsoon showers. Monthly changes faced by different species may include changes in ambient temperature and day-length, differential availability of secure resting places, nectar plants for adults and larval host plants, and a different set of predators and predation risk. In the Virudhanagar district of Tamil Nadu, Shobana et al., (2012), reported 53 species of butterflies which coincided with the present study in terms of the similarity in the species level which proves the omnipresence of the organisms. A similar work was carried out at Kalpakkam, Chennai by Ramesh et al., (2010) wherein 55 species were recorded and the finding proves the uniform presence of butterflies over a wide area in a particular time of the year. The differences in composition and patterns of abundance among assemblages suggest that the butterfly community is shaped by various factors such as food, breeding habitat, competition among co-existing species, climate, vegetation and disturbance level (Spitzer et al., 1997). The present

Plate 1: Butterflies of Lycaenidae family recorded during the study



1.Danaus chrysippus (Plain Tiger); 2. Tirumala limiace (Blue Tiger); 3. Ariadne merione (Common Caster); 4. Euploea core (Common crow); 5. Tirumala septentrionis (Dark Blue Tiger); 6. Eupolea Sylvester (Double banded crow); 7. Hypolimnas bolina (Great eggfly); 8. Danaus genutia (Striped Tiger); 9. Eupolea klugii (Brown king crow); 10. Junonia lemonias (Lemon Pansy); 11. Phalanta phalantha (Common Leopard); 12. Junonia orithya (Blue Pansy); 13. Acraea terpsicore (Tawny coster); 14. .Junonia hierta (Yellow pansy); 15. Melanitis leda (Common evening brown); 16. Junonia almanac (Peacock pansy)

Plate 1: Butterflies of Nymphalidae family recorded during the study



1. Azanus ubaldus (Babul blue); 2. Castalius rosimon (Common Pierrot); 3. Everes lacturnus (Indian Cupid); 4. Zizeeria knysna (Dark grass blue); 5. Zizula hylax (Tiny grass blue); 6. Chilades lajus (Lime blue) ; 7. Euchrysops cnejus (Gram Blue); 8. Catochrysops strabo (Forget-me-not); 9. Zizina otis (Lesser grass blue); 10. Chilades pandava (Plains Cupid); 11. Jamides bochus (Dark Cerulean); 12. Curetis thetis (Common Sunbeam); 13.. Leptotes plinius (Zebra Blue).

Plate 2: Butterflies of Lycaenidae family recorded during the study

1. Colotis amata (Small salmon arab) ; 2. Colotis etrida (Small Orange-Tip); 3. Catopsilia pomona (Common emigrant); 4. Cepora nadina (Lesser Gull); 5. Delias eucharis (Common Jezebel); 6. Catopsilia pyranthe (Mottled emigrant); 7. Colotis fausta (Large Salmon Arab) ; 8. Eurema hecabe (Grass Yellow); 9. Cepora neriss (Common Gull)

Plate 3: Butterflies of Pieridae family recorded during the study

Hasora chromus (Common banded awl); 2. Taractrocera maevius (Common Grass Dart);3. Spialia galba (Indian skipper); 4. Borbo cinnara (Rice swift)

Plate 4: Butterflies of Hesperidae family recorded during the study

.1. Papilio demoleus (Lime Butterfly); 2. Graphium doson (Common Jay); 3. Graphium nomius (Spot swordtail); 4. Papilio polytes (Common Mormon)

Plate 5: Butterflies of Papilionidae family recorded during the study

information is useful for planning and implementation of conservation measures in urban ecosystem. Hence the study on diversity of butterflies will greatly aid in formulating conservation measures.

5. CONCLUSION

The present study being an effort in exploring the butterfly wealth of this institution was observed and it was found that the area possesses a unique and diverse butterfly fauna. The highest abundance was seen at areas with less human disturbance, less vehicular movement, dense vegetation, etc. However, it cannot be assessed whether the butterfly wealth of the area is increasing or decreasing. Being a renowned educational institution, it was observed that the area is under tremendous anthropogenic pressure and with the increase in infrastructure facilities and the increase in number of student intake every year which peaks the floating population to thousands, the area will be put under more pressure and stress which could have deleterious effects on the environment in the years to come. Hence to address these external challenges, research in the area needs to be undertaken. Since butterflies are regarded as indicator taxa, the butterfly fauna of the area needs to be continuously monitored so that any changes in the environment which may occur in future can be identified and appropriate measures can be taken to counter them.

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A PRELIMINARY MACROBENTHIC STUDY OF WORLD WAR II ERA WRECKS ALONG THE COAST OF SOUTH ANDAMAN

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ABSTRACT

During the early months of 2014, a preliminary study was carried out to understand the diverse macrofaunal habitat resting in the outer surface of shipwreck SS Inchkeith (SSI) and HMIS Sophie Marie (HMIS) both of World War II era, which now lay silent at a depth of 15 and 33 meters along the coast of South Andaman. They also act as a successful artificial reef as well as a popular dive site. The faunal inventory compiled consisted of more than 60 Taxa, Some being common to both, belonged to the Phyla Porifera, Cnidaria, Annelida, Arthropoda, Mollusca, Echinodermata and Prochordata. The organisms were identified to the lowest possible taxa with the help of relevant bibliography and pictorial identification books. The sponge Chelonaplysilla erecta (Row, 1911) obtained from the second wreck is a new occurrence to the islands. This scientific study immediately reflects the importance of wrecks as an artificial reef and their capability to inhabit rich biodiverse environments which can be considered for conservation, and also points out the need to conduct such studies in the Andaman and Nicobar Islands where a number of shipwrecks known as well as unknown lie untouched.

Key words: Artificial reef, conservation, macrofauna, biodiverse, new occurrence.

1. INTRODUCTION

The Andaman and Nicobar archipelago, which lies in the southeast corner of the Bay of Bengal consist of about 572 pristine islands, islets and rocky outcrops (Venkataraman and Raghunathan et al. (2012), these islands are regarded as one of the biodiversity hotspots of India, with a staggering record of 6440 marine species of which, 843 are considered endemic (ZSI, 2009), but when it comes to artificial reef like shipwrecks the amount of information present is less. A number of shipwrecks are reported from these islands during and after the World War II. These wrecks have now become artificial reef supporting a wide range of the flora and fauna as a result it attracts a large number of scuba divers from around the world, as observed by Dowling & Nichole, (2001) and Lira et al.(2010). Although the wrecks surveyed during the study are popular dive sites, no published scientific studies have been conducted in these areas.

Artificial reef is a concept that specifies a number of activities which primary purpose is to construct a marine ecosystem for the outgrowth of new habitats (Seaman, 2000; Lira & Farrapiera et al., 2010), they can exist in different shapes like blocks of concrete (Bombace et al., 1994; Clark & Edwards, 1994), various types of petroleum platforms, tires with different size (Bull & Kendall, 1994; Rajamani, 1996), planes, submarines and shipwrecks (Zintzen et al., 2006). Artificial reefs are known to offer shelter from predation and strong currents; they too behave as a substrate for sessile communities, feeding ground for different fishes and act as a nursery habitat for the juvenile fishes (Rajamani, 1996; Amaral et al., 2010). Thus the fauna associated with artificial reefs such as shipwrecks cannot be ignored (Amaral & Farrarpiera et al. 2010). Reviewing most of the literatures, it was found that studies related to macrofauna of shipwrecks in the Andaman Island had hardly been addressed, which itself propelled us to initiate this study. The only scientific study regarding the fish assemblages at shipwrecks in Andaman was conducted by Mohan (2013 unpublished).The main objective of this study was to document the diversity associated macrofauna that were growing on the outer surface of shipwrecks in Andaman Islands. Fishes, which were observed during the study have also been documented to illustrate the fish diversity of the study sites

1.1.Sampling Methods And Analysis

The shipwreck SS Inchkeith sank as a scrap on 2nd

March, it can be actually considered as a post war wreck since it broke down in 1955. It is located at (12°00'23.69" N, 92°46'08.34"E) (Mohan 2013; Unpublished) about 0.23 nautical miles (0.44km) from the nearest coast of South Andaman at a depth of 15m and the other wreck known as HMIS Sophie Marie sank on 19th march 1942 at (11°28'38.02"N, 92°42'12.20"E) about 0.36 nautical miles (0.66km) from the nearest coast of Chidiatapu (South Andaman) at a depth of 33m. Both the wrecks are at a distance of approximately 32.17 nautical miles (59.58km) (Google earth ever. 4.3). The previous one is a British cargo ship about 115 meters in length, It was fairly in good condition and seemed to be covered by sediments in certain areas while the later one was an Indian royal navy minesweeper about 70m in length. The wreck was damaged in between but the hull and the propeller remains fairly intact. Both ships were built from steel. Selection of the wrecks were done on the basis of size, condition, location (Out of Navigation routes) and age (more than 10 years) (Leewis et al., 2000; Zintzen et al., 2006; Zintzen et al., 2007). Although the movement of current was not studied scientifically, smooth slow current was felt in certain areas of the wreck SSI since it was located in an open ocean, HMIS suffers 1-2 knots of currents during spring and neap periods as reported by frequent divers. It seems to be located in a sheltered bay leading to the Macphearson strait.

The random quadrat method was adopted to study the shipwrecks, a photographic record of each quadrat was taken for lab analysis. Samples were collected with the help of scuba equipments and were preserved with 70% ethanol or 10% formalin (depending on the taxa) in the lab. Decompression diving was conducted in the second shipwreck to extend the sampling time. Specimens were identified with the help of proper bibliography and photo identification handbooks. An 8mp Olympus camera, with model number uTough-8010 was used to take photos. The most prominent organisms observed in the wreck were also noted.Water transparency was recorded with the help of a Secchi disk. A total of 10 m^2 was studied from both the wrecks and the quantitative statistical analysis was conducted with the help of PRIMER software.

2. RESULTS

The benthic macrofauna found in both the wrecks gave a consolidated amount of 61 taxa. 40 species were recorded from the wreck SSI and 33 species were recorded from the wreck HMIS with 12 species being common in both. A list of species is presented in Table 1.

Table 1: Invertebrates found in (SSI) and (HMIS) during the study (New Record *)

Species List	SSI	HMIS	Species List	SSI	HMIS
Ircinia sp.	+	+	Dipsastraea matthaii	+	-
Stylissa sp.	+	-	Cyphastrea sp.	+	-
Spirastrella sp.	+	+	Paracyathus cf stokesii	-	+
Haliclona sp.	+	-	Acropora sp.	+	-
Haliclona (reniera)	-	+	Favites sp.	+	+
Chelonaplysilla erecta *	-	+	Platygyra sp.	-	+
Dactylospongia sp.	-	+	Porites sp.	+	-
Hyrtios sp.	-	+	Physogyra sp.	-	+
Iotrochota baculifera	-	+	Tubastrea micranthus	+	+
Unidentified corals	+	+	Tubastrea aurea	+	+
Leptoseris hawaiiensis	+	+	Dendrophyllia robusta	+	+
Echinopora sp.	+	+	Dendrophyllia sp.	+	+
Heteractis magnifica	+	-	Turbinaria sp.	+	-
Dendronephthya sp.	+	-	Gorgonia sp.	+	-

Cirrhipathes anguina	+	-	Pennatulaceae sp.	-	+
Didemnum sp.	-	+	Aglaophenia sp.	+	+
Perophora sp.	-	+	Capillaster sp.	+	-
Atriolum robustum	+	-	Stephanometra indica	+	-
Ropalea sp.	+	+	Macrorhynchia philippina	+	-
Phallusia sp.	+	-	Clypeaster sp.	-	+
Unidentified Amphinomidae	-	+			
Unidentified Sabellidae	+	-	Fishes observed (Overall)		
Unidentified Nemertia	-	+	Plectorhinchus ceylonensis		
Spirobranchus sp.	+	-	Plectorhincus multivittatum		
Chicoreus bourguignati	-	+	Platax teira		
Acrosterigma maculosum	-	+	Siganus javus		
Semiricinula konkanensis	+	-	Heniochus acuminatus		
Peristernia cf	+	-	Epinephalus sp.		
Mauritia arabica	+	-	Lutjanus sp.		
Pylopaguropsis sp.	-	+	Helcogramma striata		
Phyllidiella pustulosa	-	+	Pterois volitans		
Phyllidia varicosa	+	-	Scorpaenopsis oxycephala		
Hyotissa hyotis	+	-	Pterocaesio sp.		
Spondylus sp.	-	+	Amphiprion ocellaris		
Octopus sp.	+	-			
Diadema setosum	+	-			
Echinothrix calamaris	+	-			
Himerometra robustipinna	+	-			
Culcita novaeguineae	+	-			
Colobometra sp.	-	+			
Amphimetra sp.	-	+			

2.1. Faunal Assemblage in SS Inchkeith:

SS Inchkeith which was located at a depth of 15 meters had a highly biodiverse reef ecosystem (Fig 1). It sustained a wide range of fauna and was overlaid by sediments in certain regions. A number of patches of tunicates (Ascidiaceae) Atrolium robustum were observed with a total of 354 individuals overall. In terms of Cnidarians both hard corals and soft corals were abundant. Scleractina observed in SSI included typical reef species like Favia matthaii, Cyphastrea sp., Acropora sp., Favites sp., Leptoseris hawaiiensis, Echinopora sp. and Porites infested with polychaete Spirobranchus sp. Tube corals were also observed growing on the complex areas of the wreck surface surface which included Tubastrea micranthus, Tubastrea aurea and Dendrophylla sp. Other cnidarians include soft coral Dendronephthya sp., black coral Cirrhipathes anguina, sessile colonial Gorgonian sp., hydrozoans Macrorhynchia philippina and sea anemone Heteractis magnifica, with Amphiprion ocellaris. In terms of phylum Mollusca, gastropods Semiricinula konkanensis, Peristernia cf, Mauritia Arabica, Phyllidia varicosa (nudibranchia), Hyotissa hyotis (Bivalvia), Octopus sp. (Cephalopoda) were observed. It should be mentioned that a single patch of Hyotissa hyotis containing around nine individuals were seen covering a small area of the shipwreck. Sponges which belong to the phylum Porifera were visualized in high numbers. Ircinia sp. Spirastrella sp. Haliclona sp. Stylissa sp. was the mainly observed genera in the area. Echinoderms like Diadema setosum, Echinothrix diadema were seen inhabiting in the crevices of the wreck surfaces whereas Himerometra robustipinna, Culcita novaeguineae, Capillaster sp., Stephanometra indica remained completely exposed.

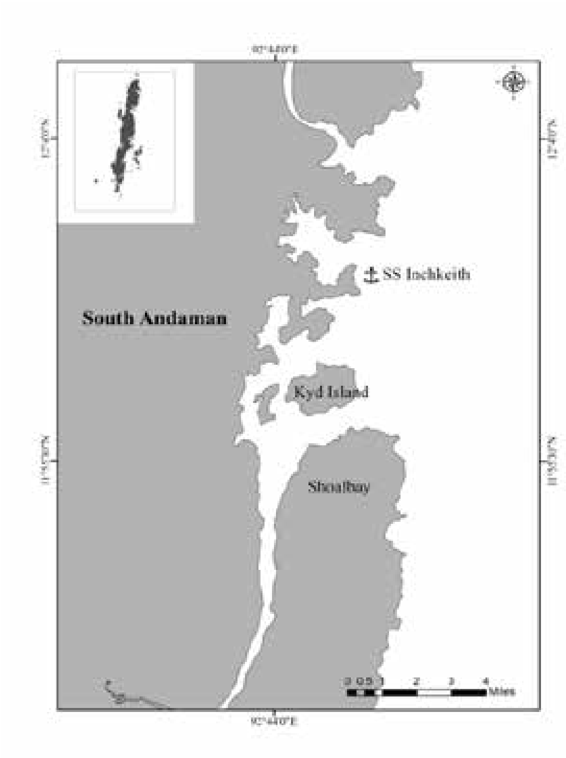


Fig 1: Location of SS Inchkeith

2.2. Faunal Assemblages in HMIS Sophie Marie:

HMIS Sophie Marie was the second study site, a shipwreck which lies at a depth of approximately 33 meters with a low light condition, 16 meters of water transparency was recorded with a Secchi disk (Fig 2). The fauna observed in this region were somewhat less diverse and low in abundance. Similar to SSI profusion of tunics (Ascidiaceae) were observed at this wreck site also. A number of 251 individuals of Pereophora sp. and 210 individuals of Didemnum sp. were observed in the study area. The growth and recruitment of corals in this wreck was somewhat different. Luxuriant growth of tube corals like Tubastrea micranthus were recorded during the study, but the other typical Scleractina like Favites sp. Platygyra sp. Physogyra sp. Echinopora sp. Leptoseris hawaiiensis , although they were present their abundance was pretty low. Soft corals were also absent from this wreck. An interesting fact observed in this area was the rich growth of coral, Paracyathus cf stokesii, a number of 24 individuals of this species were observed on this wreck. Sponges in this wreck were very much dominated, Iotrochota baculifera was observed in many places, and other sponges include Haliclona (reniera), Dactylospongia sp., Hyrtios sp., Spirastrella sp., Ircinia sp. The sponge Chelonaplysilla erecta was recorded for the first time from this island. In terms of Molluscans a lone carnivorous muricid Chicoreus bourguignati was present, interestingly the same species were also recorded from a small wreck named M.V Mars, which lie near Havelock islands at a depth of 16 meters during a non scientific survey. Phyllidiella pustulosa (Nudibranchia) and an empty shell of Acrosterigma maculosum (Bivalvia) were some of the other mollusc observed.

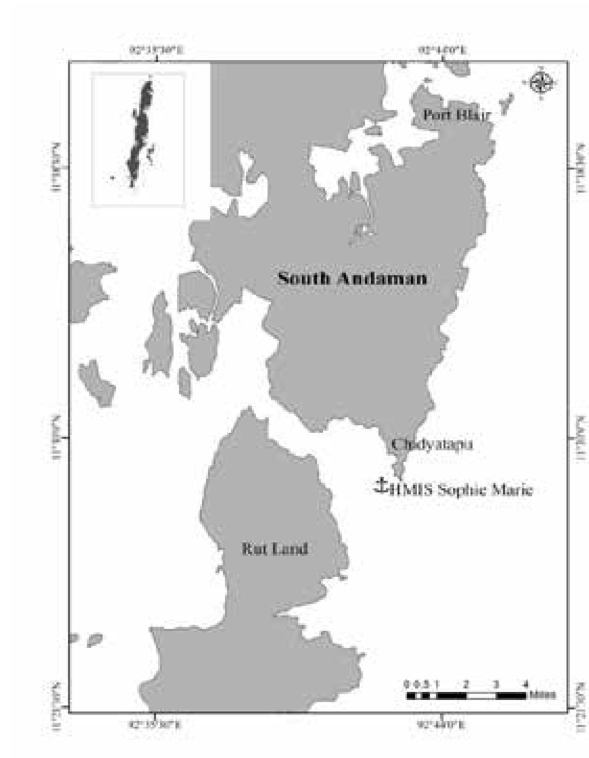


Fig 2: Location of HMIS Sophie Marie

2.3. Comparative Statistical Analysis between the two wrecks:

Comparative study has shown that difference between the depths and light has affected the community in both the wrecks. SSI, which was placed at a depth of 15 meters had good visibility and light penetration when compared to HMIS. As expected statistical analysis showed that species richness, diversity and evenness were all high in SSI (Table 2).

Table 2: Statistical Analysis: (Quantitative data)

Shipwrecks	Margalef's Richness (d)	Pielou's evenness (J')	Shanon-Weiner Diversity (H'(loge))
SS Inchkeith	2.3566	0.6576	1.5092
HMIS Sophie Marie	1.996	0.5546	1.30796

3. DISCUSSIONS

When compared with studies done in other parts of the world, the number of Taxa recorded seems satisfactory enough. 57 taxa were recorded during a yearlong study from two wrecks in the Brazilian coast (Amaral & Farrarpiera et al., 2010), a total of 93 species were investigated from five wrecks in South Carolina and Georgia (USA) located at a depth of 22-31 meters and only 11 taxa were recorded from James clunies wreck located at Mar Del Plata (Argentina) at a depth of 10 meters which was 50 years old. (Genzano et al., 2007). 90 species were recorded from nine shipwrecks during two month long study along the Belgian coast (Zintzen et al.2007). A total of 127 species was reported from 21 Dutch shipwrecks during a five year study (Leewis et al.2000). Comparing with studies in India, Artificial reefs (not shipwreck) along the Tamil nadu coast have yielded 137 taxa from study duration of 2 years (CMFRI Final Report, 2009)

With only 5 metre^2 studied from each wreck in a short span of time, it can be assumed that if any species accumulation curve is constructed then the list will be much intense if further sampling is continued (Zintzen et al., 2006). Active filter feeders like tunics, preference and bivalves comprised of about 75.6% of the SS Inchkeith fauna where current velocity remains often low because since it is located in an open ocean condition with the coast of South Andaman on the western side. Almost similar results have been found by studies conducted in Adriatic Sea where active suspension feeders contributed 55% of the total fauna in areas where current conditions were less (Gabriele et al., 1999). It has even been mentioned that low current conditions creates competition between active filter feeders (de Kluijver & Leewis, 1994) and since the inner part of SSI was not studied it may be quite relevant that those areas will also sustain good numbers of active filter feeders as pointed by Zintzen et al.during his study on Birkenfel and Borrasque shipwrecks on the coast of Belgium.

Infestation of Polychaetes on Porites sp. is a common scenario among the coral reefs in the Andaman and Nicobar Islands, During a study conducted by Roj & Sreeraj et al.in 2008 high tourism areas like North Bay, Aberdeen jetty and Havelock jetty showed high infestation of feather duster and christmas tree worms. They concluded that in areas with anthropogenic stress one metre transect revealed about 80-120 polychaetes. Although infestation on Porites was observed in SSI, direct comparison is not possible since transect method was not applied in our study but qualitative data from photographic observations clearly shows the presence of 65 to 75 polychaetes on a single massive Porites leaving an impression that although the numbers were less as suggested by Roj & Sreeraj, SSI has a high risk of being exposed to anthropogenic stress in the near future since it is a famous wreck diving site and it lies about two hours speed boat ride from Havelock jetty. The absence of such infestations from HMIS is clearly due to the low amounts of light penetration and less number of coral growth on its surface.

Sponges were observed frequently in both the wreck surfaces, and they are known to be widespread in artificial reefs (Perkol-Finkel & Benayahu, 2005).

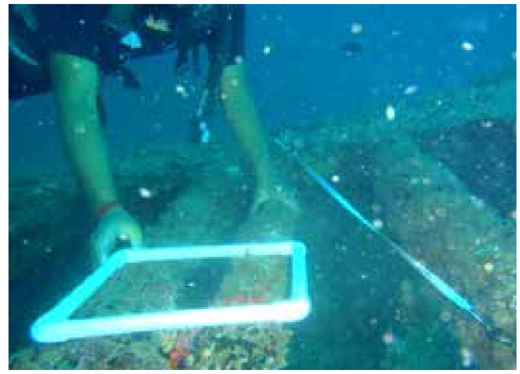
Sponges are seen only during the later stage of a community succession because they are slow growing and long living (Bailey-Brock 1989; Boaventura et al., 2006.) and their growth completely depends on their specific requirements for food, light and current (Carballo et al., 1996), however once recruited they can show dominance (Walker et al., 2007).

The effect of macroalgae on a reef may it be natural or artificial can be immense, they are documented to offer food to a bunch of reef organisms (Castro & Huber, 2008). The growth of macroalgae Halimeda on the SSI surface and the abundance of sea urchins which are mainly algal feeders, a conclusion can be reached that algal presence was infact quite common in that area.The sediment dominated area in certain parts of the wreck can also be referable to the presence of Halimeda sp., because they are known to release great amounts of $CaCO_3$ in the form of skeletal material with a shell like structure and these skeletal materials are known to be a major part of reef sediment in the tropics (Colin & Arneson, 1995). The absence of macro algae in HMIS can be compared with the study conducted by Zintzen et al. 2006, where he found low macroalgal growth at a depth of 42 meters, in fact he also found carnivorous/scavenger dominant community.

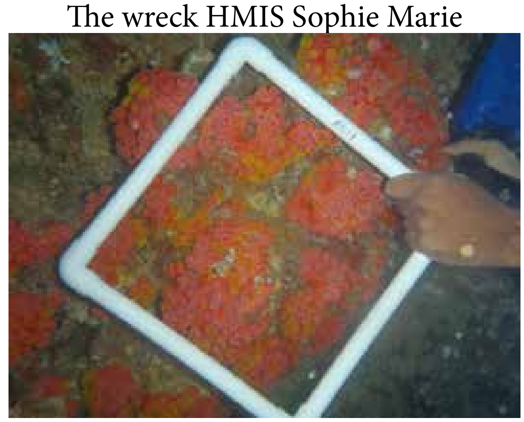
The presence of corals on both the wrecks was different in sense of diversity and numerical abundance. The high occurrence of Tubastrea micranthus from HMIS was similar to the study conducted on 119 years old steel shipwreck Kingston AR, in the gulf, where the vertical region of the wreck was highly dominated by the same. (Perkol-Finkel & Shashar et al., 2006).

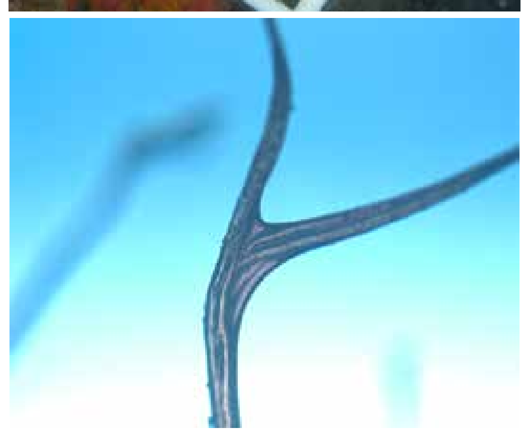
4. CONCLUSION

This preliminary study revealed a total of 61 taxa representing various diverse phyla. This scientific study immediately reflects the importance of wrecks as an artificial reef and their capability to inhabit rich biodiverse environments. Detailed faunal accounts of each ship wreck site and their species composition can be considered for marine species conservation, and points out the need to conduct such studies in the Andaman and Nicobar Islands where a number of shipwrecks known as well as unknown lie unexplored.



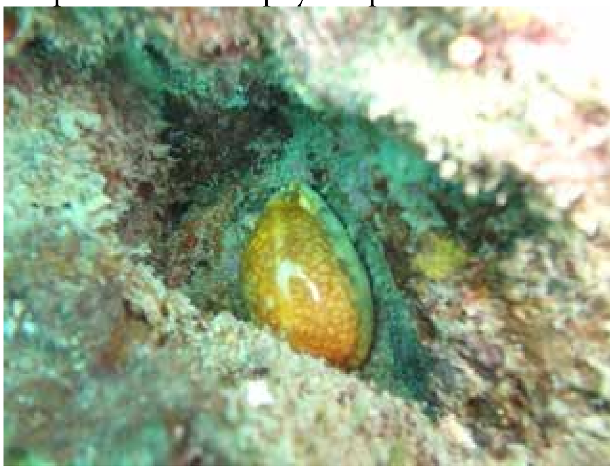
Random quadrat sampling in HMI
The wreck HMIS Sophie Marie





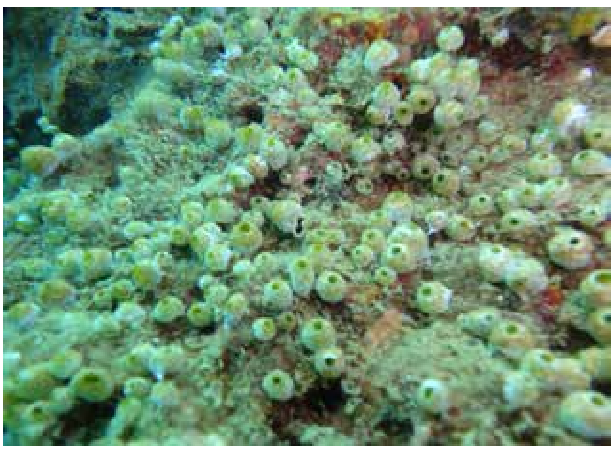
A patch of Dendrophyllia sp. on HMIS

C.erecta under microscope



Mauritia Arabica as seen in SSI

E.calamaris as seen in crevices(SSI)



Profusion of A.robustum in SSI

H.hyotis patch in SSI surface

Octopus sp. in SS Inchkeith

Halimeda sp. and Macrorhynchia philippina

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STATUS OF PATCH REEF RESOURCE DIVERSITY IN PERIYAPAR, TUTICORIN COAST OF GULF OF MANNAR, SOUTHEASTERN INDIA

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ABSTRACT

Coral reefs are known for rich biodiversity, productivity and scenic beauty. The reefs in the Gulf of Mannar are important to the lives and livelihoods of thousands of coastal people in the area. The present underwater study was conducted at Periyapar, Tuticorin coast of Gulf of Mannar. The Periyapar slope is located (N 08^0 44.288 E 78^0 19.019) 17 km away from Vaan Island and 11 km away from V.O. Chidambaranar Port. The depth at Periyapar site is about 16 m and the total area is about 220 sq.m. A systematic assessment was carried out to study the diversity and status of corals, mortality index and relative abundance. Line intercept transect (LIT) method was followed for the assessment. A total of 8 coral species belonging to 4 families and 4 genera were recorded and the percentage of live coral was 16. Rocks and abiotic factors were dominant with 32.4%5 and 40.9 % respectively. Soft corals were observed in little amount with 2.54 % and others were 8.11%. No seagrasses were recorded. The fish abundance was fair as many schools of fish were observed. In total, 95 no/50m^2 fishes were observed. The common observed fish species wereLutjanus sp., Parupeneus sp., Odonus sp., Pomacentrus sp., Amphiprion sp., Scarus sp. and Sargocentron sp. Among the bottom macro fauna, echinoderms were high with 2.15 no/5m^2.The results indicate that Periyaparsupports a considerable diversity of marine animals including coral species.

Key words: Periyapar, gulf of mannar, assessment, corals.

1. INTRODUCTION

Corals are small, sedentary marine animals that occur in dense colonies in warm shallow waters of oceans.Coral reefs are formed by the skeleton remains of many generations of stony corals.Coral reefs are sometimes referred to as 'tropical rainforests of the deep' since they are one of the most diverse, productive, and beautiful marine ecosystems in the world. The extraordinary diversity of reefs makes them biologically important and, like rainforests, they have provided valuable scientific insights into the nature of underwater ecology.The coral reef ecosystem is a diverse collection of species that interact with each other and the physical environment. The numerous species residing and depending on coral reefs represent a bank contains the genetic diversity necessary for adaptation to changes in the environment.

India has four major coral reef areas, the Andaman and Nicobar Islands, the Gulf of Kachchh, the Lakshadweep islands, and the Palk Bay and Gulf of Mannar area. The Gulf of Mannar (GoM) is located in Tamil Nadu, on the mainland southeast coast of India. Coral reefs in the area have developed around a chain of 21 uninhabited islands in four groups that lie along the 140 km coastal stretch between Rameswaram and Tuticorin, at an average distance of 8-10 km from the mainland. Narrow fringing reefs are mostly located at a distance of 100 to 350 m from the islands, and patch reefs up to 1-2 km long and 50m wide rise from depths of 2 m to 9 m. Pillai (1986) provided a comprehensive account of the coral fauna of GoM, describing 94 species in 37 genera, the most common being Acropora spp. Montipora spp. and Porites spp. Patterson et al. (2004) updated the checklist of corals of GoM adding 10 new records, to 104 species. A survey of the entire GoM conducted between 2003 and 2005 further updated the list of corals to 117 species (Patterson et al., 2007).

Apart from the Island areas, exploration on resources in GoM is very limited. New coral patches in slightly deeper areas occur in GoM which are yet to be explored. The present study carried out to assess the biodiversity in Periapar area, a distinct coral patch which occurs at Tuticorin coast, Gulf of mannar. Periyapar slope is located (N 08^0 44.288 E 78^0 19.019) 17 kilometers away from Vaan Island and 11 kilometers away from Tuticorin Port. Depth of the area was around 16 m. Total area was about 220 sq.m. Bottom was mostly hard sandy in nature with scattered boulders.

2. MATERIALS AND METHODS

Line Intercept Transect (LIT) method was used to assess the sessile benthic community of the area (English et al., 1997). A total of six 20 m transectswere laid randomly on the reef. Each change of life-form category along the tape measures was recorded on data sheets, using scuba diving. The percentage cover of each life form category was calculated following the method of English et al. (1997). Two scuba divers were employed for fish visual census and belt transect method (English et al., 1997) was used. To minimize diver impacts, each census commenced 15 minutes after the tape is laid out. The diversity and abundance of fishes wererecorded by swimming along each transect within a 50 x 10 m corridor, identifying the species that are found near or at visible distance of each transect. Density of benthic macro fauna was assessed using 1 X 1 m quadrates (English et al., 1997).

2.1. Coral Categories

Coral Categories are represented in table 1.

Table 1: Coral Categories

CATEGORIES	CODE	NOTES / REMARKS
Dead Coral	DC	recently dead, white to dirty white
Dead Coral with Algae	DCA	this coral is standing, skeletal structure can still be seen
Acropora Branching	ACB	at least 2° branching, e.g. Acropora palmate, A.formosa
Encrusting	ACE	usually the base-plate of immature Acropora forms, e.g. A. palifera and A. cuneata
Sub massive	ACS	robust with knob or wedge-like form e.g. A. Palifera
Digitate	ACD	no least 2° branching, typically includes A. humilis, A. digitifera and A. gemmifera
Tabular	ACT	horizontal flattened plates e.g. A. hyacinthus
Non–Acropora Branching	CB	at least 2° branching e.g. Seriatoporahystrix
Encrusting	CE	major portion attached to substratum as a laminar plate e.g. Poritesvaughani, Montiporaundata
Foliose	CF	Coral attached at one or more points, leaf-like, or plate-like appearance e.g. Merulinaampliata, Montiporaaequituberculata
Submassive	CS	tends to form small columns, knobs, or wedges e.g. Porites lichen, Psammocoradigitata
Mushroom	CMR	solitary, free-living corals of the Fungia
Heliopora	CHL	blue coral
Millepora	CME	fire coral
Tubipora	CTU	organ-pipe coral, Tubipora musica
Other Fauna:		
Soft Coral	SC	soft bodied coral
Sponge	SP	
Zoanthids	ZO	examples are Platythoa, Protopalythoa
Others	OT	Ascidians, anemones, gorgonians, giant clams
Algal Assemblage	AA	consists of more than one species
Coralline Algae	CA	
Halimeda	HA	

Macroalgae	MA	weedy/fleshy browns, reds, etc.
Turf Algae	TA	lush filamentous algae, often found inside damselfish territories
Abiotic Sand	S	
Rubble	R	unconsolidated coral fragments
Silt	SI	
Water	WA	fissures deeper than 50 cm
Rock	RCK	
Other	DDD	Missing data

3. RESULTS

In Periapar slope, in the benthic community structure, percentage of live corals was 16. Rocks and abiotic factors were dominant with 32.45 and 40.9% respectively. Soft corals were also found in little amount with 2.54% and others were 8.11% (Fig 1). Among the coral life form categories CE was dominant followed by CF with 6.1 and 4.85% respectively and the other life form categories found were CM, CB and ACB with 4.25, 0.52 and 0.28% respectively (Fig 2). Turbinariaspp, and Goniastreaspp. were dominant with 4.1% and 3.2 % respectively followed by Favitesspp. with 1.8% (Fig 3). Encrusting and massive types of corals were noticed predominantly. Many holes were observed in the rocky bottoms which are inhabited by trigger fish. Coral reef recruitment study revealed that recruits of Turbinariaspp. were dominant followed by Goniastreaspp. with the densities of 0.75 and 0.35% no.m^{-2} respectively (fig 4). No seagrasses were found in this site.

Fish abundance was fair in this site as many schools of fish were seen. Totally 95 no/50m^{-2} fishes were observed in this site with the maximum abundance of the genus Odonus with 22 no/50m^{-2} followed by Parupeneuswith 19 no/50m^{-2}. All kinds of fishes including herbivore, carnivore, omnivore, piscivore, planktivore and corallivore were observed (table 2). Among the bottom macrofauna, echinoderms were high with 2.15 no/5 m^{-2} followed by sponges with 1.63 no/5 m^{-2} and the other major categories observed were sea anemones (0.86 no/5 m^{-2}), bivalves (0.33 no/5 m^{-2}), gastropods (0.74 no/5 m^{-2}) and ascidians (0.21 no/5 m^{-2}) (Fig 5).

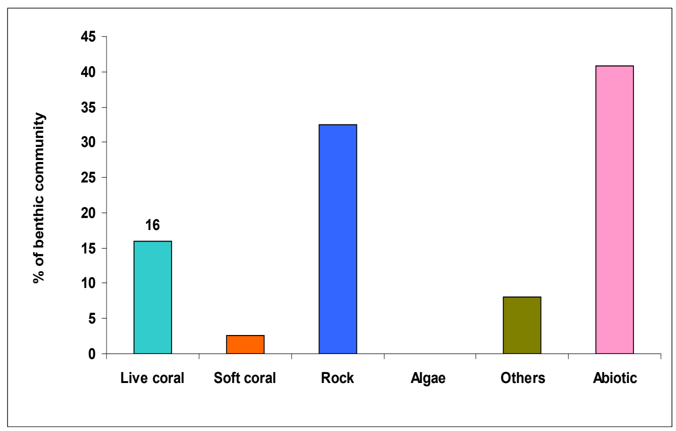

Fig: 1: Percentage of benthic community in Periapar

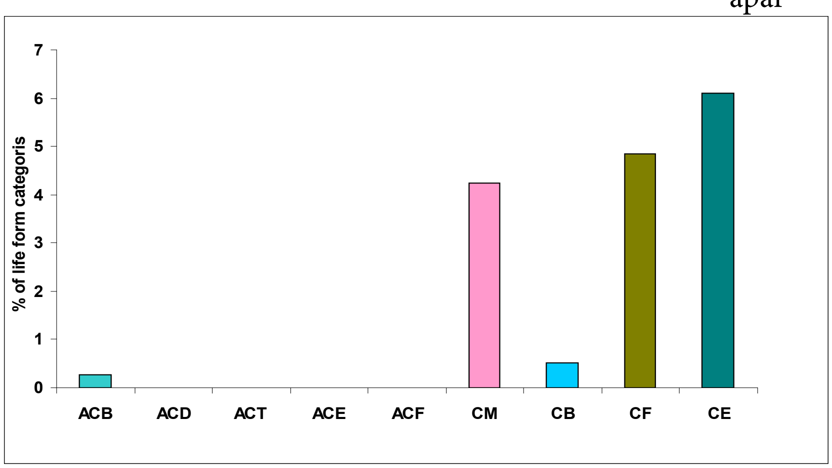

Fig 2: percentage of coral life forms in Periapar

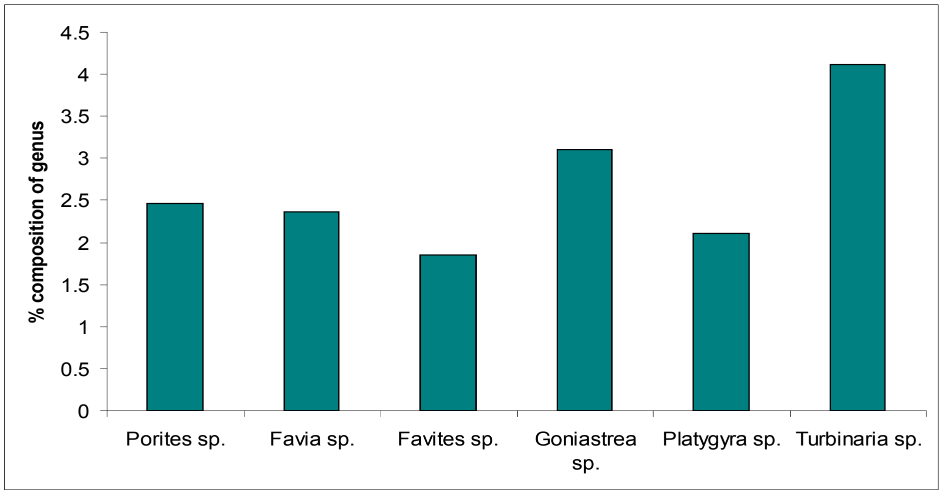

Fig 3: Percentage composition of coral genus

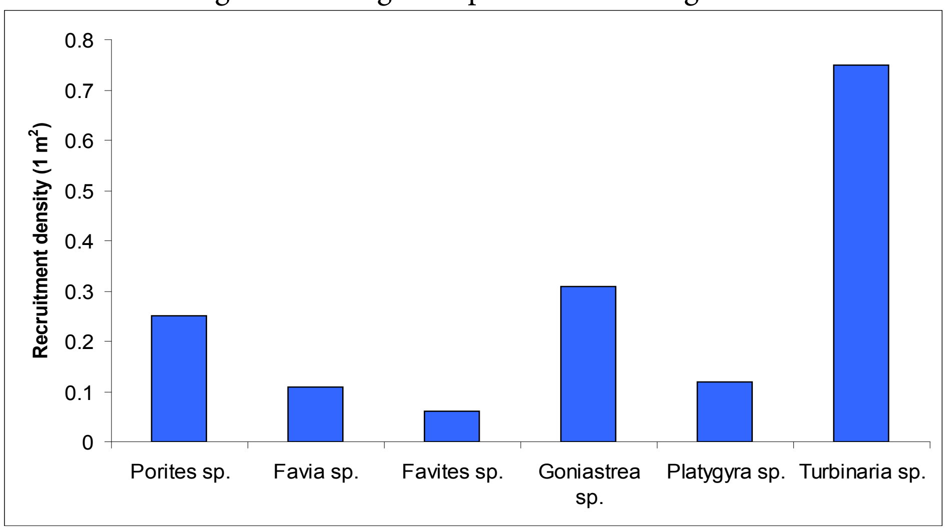

Fig 4: Coral recruitment density

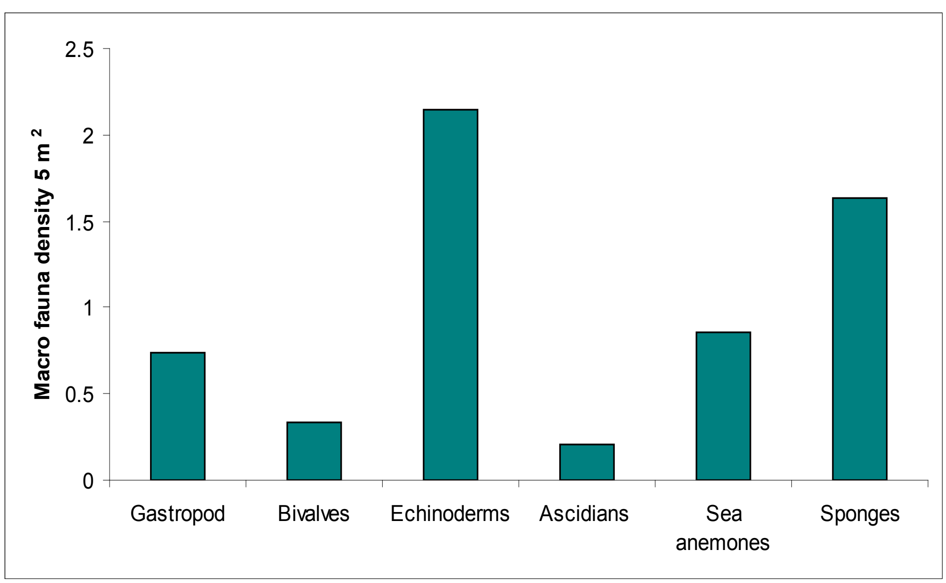

Figure 5: Macro fauna density

Table 2: Fish Species List

N	No.per 50 m [2]
Lutjanussp	17
Parupeneus sp.	19
Odonus sp.	22
Pomacentrus sp.	12
Amphiprion sp.	13
Scarus sp.	8
Sargocentron sp.	4
Total no. of fishes	95

4. DISCUSSION

There are numerous reports on the coral reefs and associated resources of the Gulf of Mannar (Pillai, 1971, 1972, 1977, 1986, 1994 and 1996), but which are mostly about the corals around the islands. This study adds to the pool of knowledge on the reefs of the Gulf of Mannar, in view of increasing stress on this ecosystem and in support of conservation and management efforts by state and federal governments and other organizations. The study found fringing and patch reef common in all islands of the Gulf of Mannar. Keezhakkarai group has the highest percentage of healthy live coral cover, followed by Mandapam, Vembar and Tuticorin groups. The dominant coral species in Gulf of Mannar are Acroporacytherea , A. formosa , A. nobilis , Montiporadigitata , and Porites sp., while Echinopora lamellose and Pocilloporadamicornis are commonly present in Keelakarai and Mandapam groups respectively. Recruit density, predominantly Pocillopora sp., Montipora sp., and Acroporasp, have increased by about 10-15% in each island since the Indian Ocean tsunami in 2004. Coral diversity has been highly affected by coral mining, which has also led to change in habitat and abundance of reef associated species. However, in spite of being so vital for the local population, reef fish communities in the Gulf of Mannar are the least studied part of the ecosystem. Reef fishes are strongly influenced by the structure of their habitat, with more complex coral reefs generally supporting more fish (e.g. Sedberry and Certer, 1993; Nagelkerken et al., 2000 and Mateo & Tobias, 2001). Results presented herein indicate higher reef fish species richness in areas with high cover of live coral, as well as areas with dead standing coral with algal growth. This shows that habitat variables play a substantial role in the enhancement of fish diversity. Fish-habitat correlations from various regions (Caribbean, Southeast Asia and Great Barrier Reef) show significant relationship between structural complexity and reef fish diversity (Risk, 1972; Luckhurst & Luckhurst 1978; Carpenter et al., 1981; McCormick, 1994). Distribution patterns of reef fishes have been related to available shelter and food (Williams, 1991; Sheppard et al., 1992, Ohman, et al., 1993). Refuges may positively influence prey abundance (Hixon and Beets, 1993) and the smaller reef fishes rely on branching corals for protection (Sale, 1972). Herbivores feed primarily on filamentous algae that grow with a high turnover rate mainly in the shallows between coral colonies and among coral branches (Borowitzka,, 1981; Scott and Russ, 1987; Choat 1991).

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SEXUAL REPRODUCTION OF HARD CORALS IN GULF OF MANNAR – A SIGN OF REEF RECOVERY

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ABSTRACT

Coral reefs constitute one of the most valuable natural resources to humanity and play an essential role in sustaining life in the sea. Reefs serve as a source of livelihood and protection to people and coast. Since being in the Indo-Pacific realm, Gulf of Mannar (GoM) is bestowed with coral reefs and associated rich biodiversity. After a profound degradation due to coral mining and other factors, corals in GoM have started recovering since 2005 onwards. This recovery can primarily be attributed to the complete halt of coral mining, successful sexual reproduction followed by coral recruitment. Coral spawning is a rare phenomenon since it happens in a particular time of the year at night. Monitoring on coral reproduction in GoM has been carried out regularly since 2006. With the experimentation on acroporan corals, it has been found that corals in GoM spawn during March every year. Reproductive season is observed to be between January and March every year as visible gametes are being witnessed during this period in different locations of GoM. Single gametogenic cycle was found among the acroporans and the gametes are released in a particular night during March. Multi-specific synchronous spawning was recorded among the acroporans and elevation of temperature by mid March in Gulf of Mannar being the decisive factor in spawning. Coral recruitment through sexual reproduction plays important role in the reef recovery in GoM, though the reef areas are stressed due to both several non-climatic (anthropogenic) and climatic impacts.

Key words: Coral reefs, Gulf of Mannar, coral reproduction, coral spawning, acroporans

1. INTRODUCTION

Coral reefs are a striking, complex, and important feature of the marine environment. Reefs are geologic formations constructed from the accumulated skeletons of limestone-secreting animals and plants. Coral reefs have the highest biodiversity of any marine ecosystem, and they provide important ecosystem services and direct economic benefits to the large and growing human populations in low-latitude coastal zones (Buddemeier et al., 2004). They constitute one of the most valuable natural resources to humanity and play an essential role in sustaining life in the sea and serve as a source of food and protection to people and coast. They can be justifiably compared to tropical rainforests (Connell, 1978; Thomas, 2001) as they are most productive, complex and diverse (Brown, 1986; Van der Land, 1989a,b; Tomascik et al., 1997).

Knowledge of coral reproductive biology and the associated processes of dispersal and recruitment is an essential prerequisite for ecological studies of coral populations and communities. Research on these topics, particularly on sexual reproduction, has increased greatly during last two decades. These studies have revealed an extraordinary diversity in reproductive patterns among corals and have transformed scientific understanding of their reproductive biology (Harrison and Wallace, 1990). Corals reproduce both sexually and asexually and both are important to restore a degraded reef area. Sexual reproduction involves the process of gametogenesis, which may require from a few weeks for sperm, to over 10 months for eggs. Spawning and subsequent fertilization of eggs by sperm results in small, presumably genetically unique, dispersive propagules (planula larvae) which may settle, metamorphose and develop into primary polyps (Richmond and Hunter, 1990). Scleractinian corals lack obvious secondary sexual characters; thus, gonads serve as the only guide to sexual patterns among corals. Although cnidarians have no true organs, sites of gamete development are generally referred to as gonads (Chapman, 1974). Coral spawning was first described on the Great Barrier Reef (GBR), (Harrison et al., 1984), and on reefs along the coast of Western Australia (Simpson, 1991; Babcock et al., 1994) and in many places around the world since then. Temperature, photoperiod, and nocturnal illumination all appear to be important in providing temporal cues which may allow synchrony within populations (Kojis and Quinn, 1981; Jokiel et al., 1985; Willis et al., 1985; Hunter, 1989).

Following larval development and dispersal, coral planulae must settle, metamorphose and grow to form the next generation (Wallace, l983). Settlement of coral larvae is normally initiated when competent planulae encounter solid substrata which are deemed suitable for attachment and metamorphosis (Harrison and Wallace, 1990). Reproductive success may best be measured by recruitment. Recruitment of both sexual and asexual propagules is mediated by biotic factors, such as predation and competition, and by abiotic factors such as environmental variability and disturbance. The complex community dynamics of coral reefs includes the influence of disturbances on community structure and population dynamics. Within ecological communities, the abundance of juvenile stages provides insight into the future diversity and abundance of corals in an area and into the community's long-term response to disturbance (Connell, 1978).

India has four major reef areas (Gulf of Mannar and Palk Bay, Gulf of Kachchh, Lakshadweep and Andaman and Nicobar Islands) and the total reef area in India is estimated to be 2,375 sq km (Pillai, 1994). All major coral reef areas in India are under threat from human activities (Arthur, 2000; Rajasuriya, et al., 2004). The reefs in the Gulf of Mannar (GoM) are developed around the 21 uninhabited islands that lie along the 140 km stretch between Tuticorin and Rameswaram of Tamilnadu, Southeast coast of India. The large areas of reefs along the GoM are generally in poor condition due to a number of destructive activities by coastal people who depend on fishery resources of reef areas for their livelihood (Edward et al., 2007). Degradation in the GoM has been heavy for the past few decades; over 32 km^2 of coral reef has already been degraded around the 21 islands. However, coral mining was completely stopped in GoM since 2005 (after the 2004 Indian Ocean tsunami) since it made a change in the minds of fishermen, who attributed protection of their villages from the tsunami to the presence of coral reefs and islands and also enforcement measures (Edward et al., 2008).

Though extensive research works have been carried out on GoM corals, sexual reproduction of corals has been neglected as it requires tedious sampling protocol including scuba diving at night. The present work provides information about the works carried out regarding coral reproduction and recruitment in GoM and the resulting coral recovery.

2. MATERIALS AND METHODS

Acroporan corals were selected for the reproduction study as they are widespread and abundant in GoM. Acroporans are colonial, encrusting, ramose or rarely sub-massive. Acropora forms the most dominant reef building genus with about 250 species has been described in literature so far. Detailed study was carried out in Tuticorin coast at 5 sites, mainland Punnakayal patch reef; Vaan Island; Koswari Island; Kariyachalli Island and Harbour breakwater area since 2006. However, periodical monitoring was extended to Rameswaram in the south and Kanniyakumari in the North of GoM. Monitoring was done also on restored corals in Vaan Island. Baird et al. (2002) was followed for sampling which involves scuba diving. The reproductive state of acroporans can be gauged easily by breaking off a branch below the expected sterile zone (Wallace, 1985) and noting the presence or absence of eggs. Mature eggs in acroporans are pigmented (usually red, pink or orange in colour) and large enough to be visible to the naked eye (Wallace, 1985; Guest et al., 2002). It has been proved that colonies that contain visible, pigmented eggs are likely to spawn on or shortly after the subsequent full moon; colonies with eggs that are visible but un-pigmented (white) are likely to spawn within 1 to 3 months; and colonies with no visible eggs have either just spawned or are unlikely to spawn for at least three months (Harrison et al., 1984; Baird et al., 2002).

Detailed study on gametogenic cycle was carried out in three species which are Acropora intermedia, A. nobilis and A. cytherea from natural and transplanted colonies. The timing of spawning was monitored using scuba at night. Frequent dives were made after the sunset every day when matured gametes were seen frequently in the coral colonies. Starting from 6 pm dives were made with an interval of 30 minutes to investigate the spawning during these suspected nights. Vaan Island was concentrated for the spawning observation because of its proximity to the shore and relatively good coral cover. Restored corals were also included in the spawning monitoring to investigate whether they involve in the spawning as the natural corals do. Photographs were taken using underwater digital camera when the spawning was observed. Regular monitoring on the status of corals was carried out using Line Intercept Transect (LIT) method and overall coral recruit density was collected using 1x1 m quadrates (English et al., 1997).

3. RESULTS

A typical pattern of reproduction was observed in GoM which is uniform from the south to north of GoM. Single reproductive season (January to March) was observed among the acroporans which culminates in March every year (Raj and Edward, 2010). In Acropora, visible but immature gametes were seen from January every year and the percentage of immature gametes increase in the next month (February) and they get coloration and maturity during March and spawn in the same month (Fig 1). Starting from April to December all the coral colonies were empty to the naked eyes in all study sites during the entire study period. Throughout the GoM the trend was the same and in other genera such as Montipora and Turbinaria, gametes were observed during this season. However, massive corals are still invisible in terms of reproductive pattern in GoM. All the three experimented species, Acropora intermedia, A. nobilis and A. cytherea had a single annual cycle of gametogenesis. Patterns of oogenesis and spermatogenesis were almost similar between the three species with gametes reaching maturity during March every year. No significant difference was found between the natural and restored corals both in the oogenesis and spermatogenesis (Raj et al., 2014a).

Synchronous mult-ispecific spawning has been observed in GoM as the acroporans were found to expel their reproductive products in a particular night at a particular time during March every year (Raj and Edward, 2010). Spawning synchrony was observed in GoM as the very next day after the spawning night all Acropora colonies were seen empty indicating that spawning had happened. Spawning was observed during March but the exact date of spawning differed from year to year. Spawning was first observed in Acropora cytherea on 24th of March 2006 which was 10 days after the full moon. During 2007, spawning was observed on 28th of March which was 5 days before the full moon. In 2008, spawning was noticed on 8th and 9th March 2008. In 2009, spawning was observed even earlier than 2008 on 3rd of March which was seven days before full moon (Raj and Edward, 2010). In south GoM, spawning slicks were observed during March 2013 near Kudankulam area indicating the spawning synchrony between south and north of GoM (Raj et al., 2014b). Sudden elevation of sea surface temperature was found to be the deciding factor on the timing of coral spawning (Raj and Edward, 2010).

Coral cover in GoM was on an increasing trend since 2003 until 2009 when an increase from 36.98 to 42.85% was recorded. However, a sharp decline was witnessed during 2010 because of the mortality caused by persistent coral bleaching (Edward et al., 2012) which reduced the coral cover from 42.85 to 33.2% during 2010. But after 2010 mortality, corals in GoM again started recovering gradually and increased to 37.31% during 2011, to 37.79% during 2012 and to 38.26% during 2013. Coral recruit density also increased gradually from 2003 to 2009 from 0.65 to 0.8 no.m^{-2} before facing a dent during 2010 bleaching mortality which reduced the recruit density to 0.64 no.m^{-2}. However, subsequent recruits through coral sexual reproduction increased the recruit density to 0.69 no.m^{-2} during 2011, to 0.74 no.m^{-2} during 2012 and to 0.77 no.m^{-2} during 2013.

4. DISCUSSION

The dominant view prior to the early 1980s was that corals brood their larvae and release planulae periodically throughout the year (Harrison and Wallace, 1990). Coral spawning was first described on the Great Barrier Reef (GBR), (Harrison et al.,

Fig. 1: Visible gametes in Acropora Formosa

Fig. 2: Coral spawning in GoM

Fig.

3: Coral spawning slicks in GoM

Fig. 4: New coral recruits on dead coral substratum in GoM

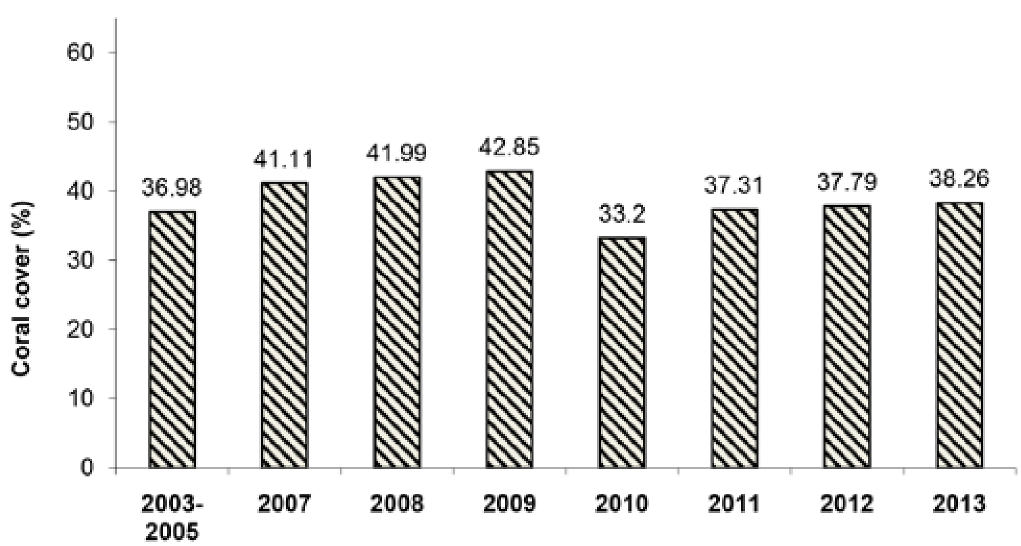

Fig. 5: Status of live coral covers in GoM from 2003 to 2013

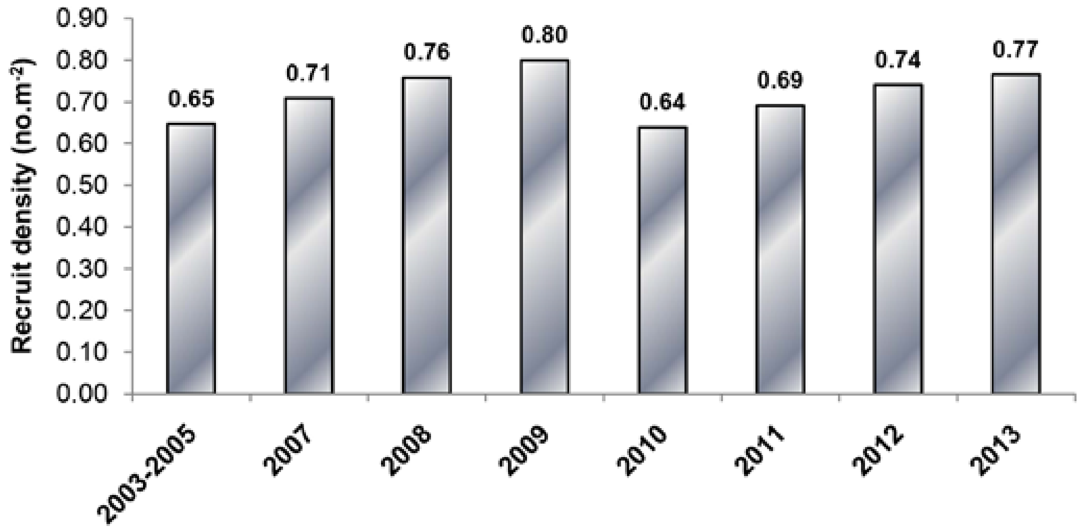

Fig. 6: Status of recruit density in GoM from 2003 to 2013

1984), and on reefs along the coast of Western Australia (Simpson, 1991; Babcock et al., 1994). Since then, similar spawning has been reported from other coral reef areas such as Red sea, Japan, Taiwan, Singapore and Kenya (Shlesinger and Loya, 1985; Heyward et al., 1987; Hayashibara et al., 1993; Dai et al., 1992; Guest et al., 2005; Manghubai, 2007). Studies on coral reproduction were not carried out in GoM before 2006 and coral spawning was never reported before 2006 in any Indian reef. Tedious sampling protocol which involves night scuba diving was presumably the reason. However, Raj and Edward (2010; 2014a) provided detailed baseline information about the reproductive behaviours of GoM corals, especially about the timing of coral spawning which happens during March every year in GoM. It is to be noted that the timing of spawning season is similar across south and north of GoM as spawning slicks were witnessed during March near Kudankulam in south GoM (Raj et al., 2014b). Further, it is interesting that spawning slicks were observed in Lakshadweep islands also during March 2013(The Hindu, 2013).

When spawning slicks were first observed in Lakshadweep islands, it was flashed as a rare phenomenon (The Hindu, 2013) across the country. In spite of the rarity and significant seasonality, coral reproduction is completed only when the coral larvae attach themselves on a hard substrate to grow as coral colonies after their free swimming period. Recruitment to reef habitats is dependent on the ability of the coral larva to find a suitable place to settle and metamorphose (Harrison and Wallace, 1990). Reef recovery will largely be dependent on the supply of larvae when mortality has been severe. However, recruitment processes are subject to high levels of natural variability (Hughes et al., 1999). In GoM, mining of corals for several decades degraded the reef and made the substratum unstable. It was estimated that the exploitation of corals was about 60,000 cubic meters (about 25,000 metric tons) per annum from Palk Bay and GoM together (Mahadevan and Nayar, 1972). Two of the 21 Islands of GoM (Vilanguchalli Island from Tuticorin group and Poovarasanpatti Island from Keelakarai group) have already submerged and coral mining is probably responsible for the submersion (Edward et al., 2008).

However, coral mining was completely stopped in GoM since 2005 (after the 2004 Indian Ocean tsunami) because of the combined efforts of awareness creation and enforcement measures (Edward et al., 2008). Since coral mining was stopped, the substratum remains largely undisturbed with dead reefs which paved way for the coral larvae to attach themselves and grow. Consequently, live coral cover and coral recruit density kept on increasing until 2010. A significant dent though occurred during 2010 when a severe mortality happened because of persistent coral bleaching (Edward et al., 2012). Despite the decline in 2010, corals started recovering again and increasing in biomass through successful coral reproduction and successive recruitment. An increase of live coral cover from 33.2 to 38.26% was recorded between 2010 and 2013 in GoM and an increase of recruit density from 0.64 to 0.77 no.m^{-2} was also recorded.

Sexual reproduction is often critical in recovery processes, especially in coral communities that have suffered extensive mortality (Glynn et al., 2000). It is obvious from this study that after the widespread degradation, coral recovery is happening in GoM through sexual coral reproduction and recruitment. However, climate change, coral algal phase-shift and destructive fishing practices are threatening the survival of existing corals. Proper management is needed to curb the threats and allow the corals to recover. Since it has been proved that restored corals also actively participate in sexual reproduction, extensive fragment transplantation could also be done to increase the coral biomass and consequently the livelihood of the dependant fishermen.

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PHENOTYPICAL KEY TO THE IDENTIFICATION OF CROTALARIA SPECIES ASSOCIATED WITH SOME GRASSLANDS IN GUJARAT

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ABSTRACT

Crotalaria belonging to Fabaceae is commonly known as rattlepods or rattlebox. Crotalaria species are worldwide in distribution and most of the species are known from Africa. Crotalaria species are economically important as ornamentals and medicinally. Some of the species are important food plants. Crotolaria juncea is well known for the fibers obtained from it which is utilized in pulp and paper industry. In the present study vegetative characters of the seedlings of 6 Crotalaria species growing in the Baria and Godhra grasslands of Gujarat have been evaluated. Seedling characters have been evaluated from both field grown and under laboratory conditions. Characteristic features were found to be same. The seedling vegetative features distinctly differed from the mature plant. Crotolaria mysorensis and Crotolaria juncea has linear to lanceolate type of leaf, but Crotolaria juncea has a smooth texture while Crotolaria mysorensis has hairy texture with an acute leaf tip. Crotalaria linifolia has an ovate to obovate leaf shape. Crotolaria notonii and Crotolaria orixensis have palmate compound leaf. Crotolaria notonii has a retuse leaf tip and Crotolaria orixensis has an acute leaf tip. On the basis of the diagnostic features a key to the identification of the seedlings of the six species have been prepared.

Key words: Seedling, vegetative characters, crotalaria.

1. INTRODUCTION

The family Leguminosae is one of the largest and easiest to identify. The fruit is a 'Legume' gives this family its original name. Legume is a plant with seeds in a pod that splits into two distinct halves. They are the important component of pastures (Cosgrove and Undersander, 2003). They increase the yield and quality of pastures and provide nitrogen to grasses through fixation of atmospheric nitrogen.

Crotolaria is a genus of herbaceous plants and woody shrubs in the family Fabaceae. The name derives from the Greek word "κροταλον" meaning castanet. Around 600 or more species of Crotolaria are described worldwide and mostly from the tropics and at least 500 species are known from Africa (The plant list, 2010).

Seed and seedling traits vary strongly across the tropical forest biome to cope with the variations in the distribution and amount of rainfall, light, temperature and soil nutrient regimes (Fenner, 1987). Seedlings are very helpful for the different studies related to Genetics, Physiology, Ecology and Biochemical analysis. A seedling is helpful in assessing the natural regeneration of an ecosystem and is of great importance to the forest planners. Recognition of plants by their vegetative characters is essential in the development of a sound pasture-improvement program. The best time to identify the legume seedling is in the 3-4 leaf stage. At this time vegetative characteristics are easily seen. The legume seedlings differ in characters like type of leaf, number of leaflets, venation of leaf, presence or absence of petiole, margin of the leaf, presence or absence of pulvinous base, stipels, pubescence, etc. The leaves are often flat, thin and approximately horizontally expanded. Leaf can be acicular, liguliform, scatelliform. Phyllotaxy is an important characteristic feature. The leaves can be opposite, alternate or whorled. Leaves are stipulate or without stipules (Henning, 1930). The surface of the blade can be plicate, flat, crispate, etc. The external surface of seedling organs may contain some hairs, glands, scales, prickles, etc. A spine and a tendril can also be present which may serve as a diagnostic feature of identification. The main purpose of this study was to identify the seedling in the field so that unwanted species can be removed at the seedling stage itself.

In the present study, Crotolaria species collected from the Baria and Godhara grasslands of Guajrat and their vegetative characters in seedling stage has been evaluated.

2. MATERIAL & METHODS

The seedling study was carried out both in field and in laboratory.

(1) In field: Seedlings of grasses were collected as the new emergents. The collected seedlings and their different parts were photographed by Digital camera in the field itself. Total 10-15 samples for each species were collected from the field and observed for distinctive features.

(2) In laboratory: Total 45-50 seeds were grown in earthern pots and seedlings were raised till the emergence of four to five leaves. Randomly selected seedlings were evaluated for their characteristic features and photographed by Digital camera (DSC-T20). All observations were made on seedlings < 20-25 days old. Characteristic features of seedlings raised in the pots were critically observed and compared with those collected from the field.

The information included in the morphological data was used to prepare a morphological key. The morphological features were grouped and a dichotomous key was constructed on the basis of the most conspicuous morphological features observed in the field collected samples. The features were critically observed and compared with the laboratory raised seedling features.

3. RESULT & DISCUSSION

A seedling differs in its morphological features from the mature plant. The seedlings differ in the different features of root, stem, leaf lamina, leaf tip, stipules/stiples etc. These features vary from the mature flowering plant to some extent (Fishel, 2004).

All the characteristic features of studied seedling plants are given in Table 1 and their photographs are given in Figs. 1—6.

All the studied species have thin and taproot system. The main feature by which the species can be divided is the type of leaf i.e. One in which the species have simple leaf and the other one in which the species have a compound leaf. All the studied species have thin tap root and free lateral type of stipules. Among the studied species, C. notonii (Fig. 4A) and C. orixensis (Fig. 5A) have compound leaf while other four species have simple type of leaf. Most of the species shows acute type of leaf tip. C. notonii have retuse type of leaftip (Fig. 4H) while C. orixensis have acute type of leaftip (Fig. 5H). Among the other four species, C. juncea have smooth stem (Fig. 1C) while other three species have hairy stem. C. linifolia have cirrhose type of leaf tip (Fig. 2H) and C. mysorensis (Fig. 3H) and C. retusa (Fig. 6H) have acute leaftip. Seeds of all the studied species are bean/kidney shaped (Figs. 1-6, A inset). C. orixensis have rough surface while others have smooth surface. The colour of fresh mature seeds varies from Greenish to black to brown. The lengths of the seeds vary from 1.5mm to 2.9 mm. The breadth of the seeds vary from 1.4 mm to 3.0 mm. The thicknesses of the seeds vary from 0.3 mm to 1.1 mm (Gandhi et al., 2011).

A: Habit, Inset (seed), B: Root, C: Stem, D: Dorsal surface of leaf, E: Ventral surface of leaf, F: Petiole (arrow), G: Presence of hairs on stem and leaf, H: Leaf tip, I: Stipules and stiples (Fig 1-6)

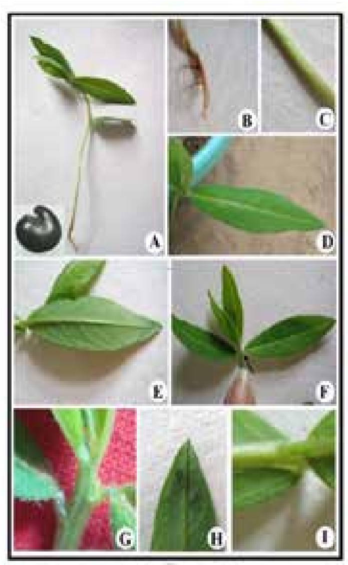


Fig. 1

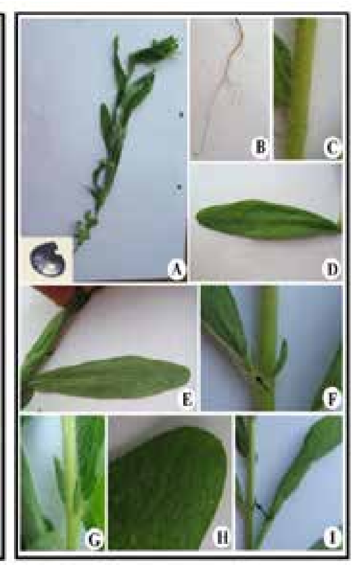
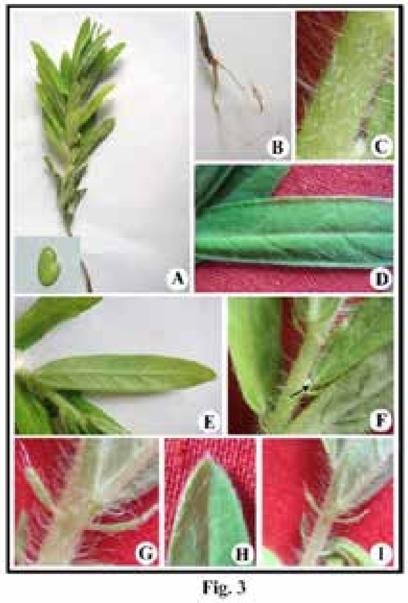


Fig. 2

Fig. 1: Crotalaria juncea Fig. 2: Crotalaria linifolia



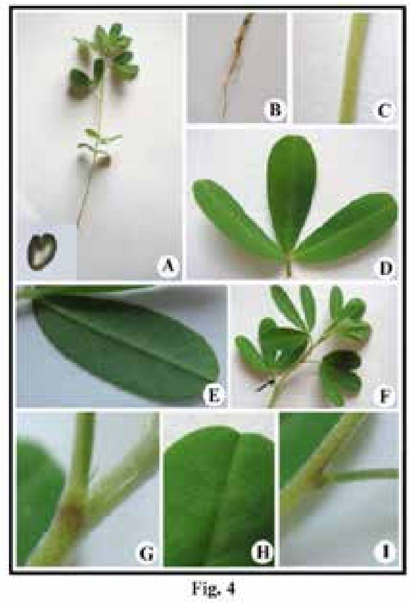
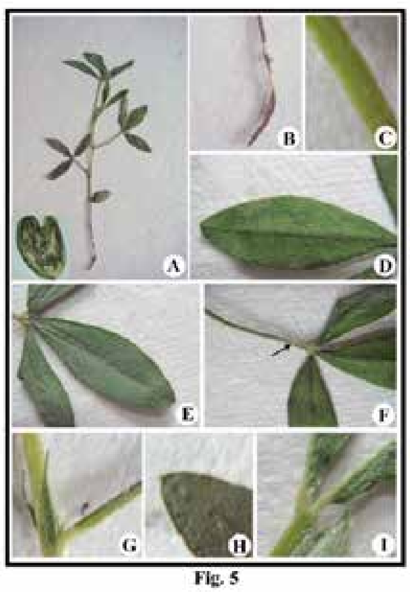


Fig. 3: Crotalaria mysorensis   Fig. 4: Crotalaria notonii



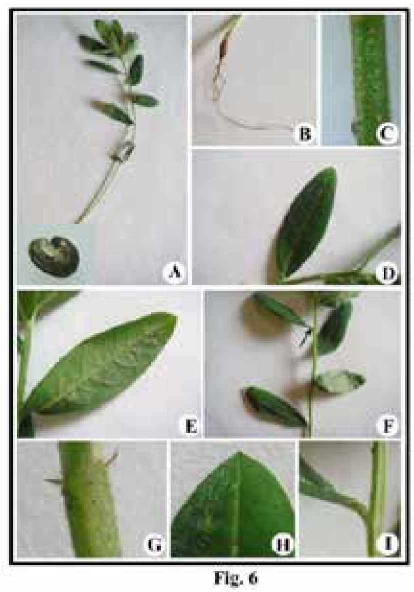


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Fig. 5: Crotalaria orixensis   Fig. 6: Crotalaria retusa

4. CONCLUSION

Characteristic features of seedling helps to identify the plant at a very young stage itself. This facilitates uprooting of unwanted plants at regular intervals from the field thereby helping in maintaining the productivity of the valuable plants and improve its vegetative as well as reproductive output.

5. ACKNOWLEDGEMENTS

We are thankful to Head, Department of Botany, Faculty of Science, The Maharaja University of Baroda, Vadodara, Gujarat, India for providing us the facilities required for the present work. We are also thankful to The Conservator of Forests, Working Plan Circle, Forest Department, Vadodara, Gujarat state for providing financial support for the present study.

Table 1: Characteristic features of seedlings

Sr. No.	Botanical name	Stem	Leaf/Leaflets	Leaf tip	Stipules/ Stiples
1.	Crotalaria linifolia L. f.	Hairy, very long hairs present on the surface	Simple, alternate, obovate to oblong, hairy surface, sessile to subsessile	Cirrhose	Free lateral, leafy, hairy
2.	Crotolaria juncea L.	Smooth	Simple, linear to lanceolate, glabrous, margin hairy, subsessile	Acute	Free lateral, small
3.	Crotolaria mysorensis Roth.	Hairy, long hairs with bulbous base	Simple, lanceolate, hairy, subsessile, margin hairy	Acute	Free lateral, leafy, hairy
4.	Crotolaria notonii W. & A. Prodr.	Hairy, very short hairs	Palmate compound, trifoliate,3-leaflets, all are equal, obovate, glabrous	Retuse	Freelateral, membranous, linear
5.	Crotolaria orixensis Rottler ex Willd.	Hairy	Palmate compound, 3-leaflets, obovate to oblong, hairy	Acute	Free lateral, leafy, hairy, linear
6.	Crotolaria retusa L.	Hairy, hairs with bulbose base	Simple, obovate to oblong, hairy, subsessile	Acute	Free lateral, small,n thin

Based on the characteristic features a diagnostic key to the identification of the studied species has been prepared as follows:

1. Simple leaf……………………………………………………………………..……..2
1. Compound leaf……………………………………..……………………………..…5
2. Smooth stem…………………..……………………………………………...….C. juncea
2. Hairy stem……………………………………………………….……………………3
3. Cirrhose leaf tip…………………………………………………………….….C. linifolia
3. Acute leaf tip…………………………………………………..………...……….4
4. Stipules leafy and hairy………………………………………………...………..C. mysorensis
4. Stipules thin and smooth……………………………………………………...…...C. retusa
5. Retuse leaf tip………………………………………………………...………...C. notonii
5. Acute leaf tip………………………………………………………..…..C. orixensis

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PHOTOSYNTHETIC AND RESPIRATORY CHARACTERISTICS OF TOLERANCE TO STRESS INDUCED BY DESICCATION IN CREPIDOMANES INTRAMARGINALE (HOOKER & GREVILLE) COPELAND.

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ABSTRACT

Plants may be classified into desiccation sensitive and tolerant depending on their adaptations for living in habitats. Ferns which grow in sunny habitats have been shown to possess characteristic differences in terms of morphology, anatomical structure and physiological activities when compared to those growing in shade. The present study focuses tolerance mechanism of Crepidomanes intramarginale induced by desiccation. The fern showed remarkable variations in total chlorophyll content from 1 day to 16 d of desiccation. The protein and protohaem content was increased during different periods of desiccation. The higher soluble protein content in the sun ferns probably reflects the higher concentration of ribulose bisphosphate carboxylase (RUBISCO). Although the concentration of RUBISCO was not determined here, it has been reported that high RUBISCO activity is associated with high photosynthetic rates observed in leaves at light saturation. The greater protohaem content is probably due to the greater photosynthetic cytochrome content found in this fern. This in turn possibly explains the higher photochemical activities observed in the chloroplasts isolated from the desiccated fronds. Measurements of the ***in vitro*** photochemical activities of the photosystems **I** and **II** in isolated chloroplasts by means of an oxygen electrode showed higher rates. As determined by spectrophotometric analysis, the photosynthetic cytochrome content from isolated chloroplasts was also greater. Cytochromes *f*, *b* 559_{HP}, *b* 559_{LP} and *b* 563 were present in greater amounts in chloroplasts isolated from 16 d desiccated ferns. The results indicate that the ferns have physiological characteristics favoring greater capacity for photosynthesis. Mitochondria isolated from the desiccated ferns showed faster rates of electron transport using exogenous NADH as substrate. The greater rate of electron transport observed in the ferns is probably a result of the greater quantity of redox components present in their mitochondria.

Key words: Crepidomanes intramarginale, photosynthesis, respiration, desiccation.

1. INTRODUCTION

Plants have to face different types of abiotic stresses in their natural environment; drought stress or water stress is one among them that affects the normal physiological functions in plants. Thus plants can be classified into desiccation sensitive and desiccation tolerant depending on their adaptations fo living in habitats. Desiccation induces oxidative stress via ROS cycle in the plants. Basically plants record their environment & respond with adaptation mechanisms. The present study focuses tolerance mechanism of Crepidomanes intramarginale induced by desiccation and also followed by rehydration. Crepidomanes intramarginale belongs to the family Hymenophyllaceae of Pteridophyta. They are popularly known as filmy ferns because

of their semitransparent, glabrous fronds. And rhizomes are long creeping and wiry.

2. MATERIALS AND METHODS

1.1. Plant material

Crepidomanes intramarginale was collected from the lower floor of Kallar near Ponmudi hills, Thiruvananthapuram, Kerala, India. The identification was confirmed by referring with the voucher sample at Department of Botany, University of Calicut.

Fresh C. intramarginale was fully hydrated and equilibrated in a controlled environment chamber for 48 h at 20°C and at a radiant flux intensity 75 µM /m^2/ s. The samples were desiccated in a desiccator over polyethylene glycol (PEG) in a controlled environment chamber using the same light and temperature regimes as described above. The selected species were subjected to five different desiccation regimes (a) 1 d (b) 4 d (c) 8 d (d) 12 d and 16 d. After the desiccation exposure a set of desiccated samples were subjected to rehydration for 30 min. The samples were divided into two groups: desiccated and desiccated subsequently rehydrated. Control plants were maintained in an optimal water conditions in each case during the whole experimental period.

1.2. Total Pigments

Total chlorophyll was estimated by the methods of Vicas et al. (2010). For the extraction of pigments, 1 g of fresh leaves was homogenized with 80% acetone. The homogenate were centrifuged at 12000 rpm, for 10 min at 4ºC. The supernatant were separated and the pigment content was determined by measuring the absorbance at 663.6 nm, 663.8 nm and 665.2 nm for chlorophyll a and 652.0 nm, 646.6 nm and 646.8nm for chlorophyll b using spectrophotometer. Carotenoids were estimated by the method of Vicas et al. (2010). An aliquot of 0.5mL extract was taken from each step of purification and mixed with 4.5 mL of 80% acetone and the optical density was measured at 480, 645, 652 and 663 nm and calculated the the total carotenoids

1.3. Estimation of soluble proteins

The soluble proteins were estimated by using the method of Lowry et al. (1951). The finely chopped leaf tissues were ground in extraction buffer (0.1M phosphate buffer, pH. 7) and centrifuged at 10,000 rpm for 10min. The protein in the supernatant was precipitated with 10% TCA. The precipitate was collected by centrifugation and dissolved in 0.1N NaOH and made upto a known volume. Aliquots were pipetted out and made upto 1 mL using 0.1N NaOH. 5 mL of reagent C was prepared by mixing 50mL of reagent A and 1 mL of reagent B (Reagent A is 2% Na_2CO_4 in 1% potassium sodium tartarate). 0.5 mL diluted folins reagent was added (0.1N NaOH and folins reagent in 1:1 ratio) and mixed well. The absorbance was read at 670 nm after 30 min using a proper blank and the amount of protein was calculated.

1.4. Protohaem extraction from plant tissue

The tissue sample is homogenized in 80% acetone to remove pigments and lipids. Protohaem is then extracted from the tissue residue with 2% HCL in acetone and quantitatively transferred into diethyl ether. After evaporation of the ether, the residue is dissolved in alkaline pyridine and the Protohaem concentration is estimated from a dithionite- reduced – minus- ferricyanide- oxidized spectrum.

1.5. Isolation of Chloroplast

Chloroplasts were isolated from the leaves using the sucrose gradient method. Young leaves where collected and kept in dark for 72h at 4^{o}C in order to decrease the starch level stored in the leaves. Leaves were homogenized in 400 ml of ice- cold isolation buffer for 30s. The homogenate was filtered into centrifuge bottles using two layers of Miracloth by softly squeezing the cloth. The homogenate was centrifuged at 200g for 15 min at 4^{o}C. The nucleus pellet and cell wall debris were discarded. The supernatant included chloroplasts suspended in it. The supernatant was centrifuged at higher centrifugal force (2000g) for 20 min at 4^{o}C and the resulting chloroplast pellet showed some contamination. The pellet was resuspended in 7ml of ice-cold wash buffer using a soft paintbrush. The homogenate was gently loaded into 6 tubes containing sucrose step gradient consisting of 18 ml of 52% sucrose and overlaid with 7 ml of 30% sucrose. Step gradients were centrifuged at 3500g for 60 min at 4^{o}C. The band from the 30-52% interface containing chloroplasts was collected, diluted twice with 200 ml of wash buffer and centrifuged at 1500g for 15 min at $4^{o}C$ to gain the purified chloroplast pellet.

1.6. Isolation of Mitochondria

The fresh tissue is gently homogenized to disrupt the cells and release the contents and the mitochondria are pelleted by differential centrifugation. Further purification is carried out by sucrose gradient centrifugation.

1.7. Electron Carrier Proteins

The thylakoid membrane contains four spectroscopically distinguishable cytochromes: cytochrome f with an a -band at 554 nm and a midpoint potential of + 0.36 at pH 7, cytochrome b_6 (alternate name b– 563) with an a -band at 563 nm and a mid-point potential below - 0.1V, cytochrome b– 559_{HP} (high potential form) with an a -band at 559 nm and a mid-point potential (+ 0.37V) close to that of cytochrome f and cytochrome b – 559^{LP} (low potential form) with an a -band at 559 nm and a mid-point potential of 0.06V. The thylakoid cytochromes are not extracted by aqueous solvents. Cytochrome is extracted into ammoniacal ethanol (Bendall et al. 1971), but the b cytochromes are tightly associated with the thylakoid membranes and are released on extraction of the membranes with detergent.

1.8. Assay of photochemical and respiratory activites

Activities of photosystems I and II in chloroplasts were assayed at $25^{o}C$ at saturating irradiance using a Hansatech oxygen electrode according to the method described by Plesnicar & bendall (1973). Photosystems II activity was assayed as the rate of light- dependent oxygen evolution observed in the presence of potassium ferricyanide as the electron acceptor in a reaction mixture rendered anaerobic by pre-flushing with nitrogen.

Photosystem I activity was assayed as the rate of light-dependent oxygen uptake in the presence of 3,4 dichlorophenyl-1,1-dimethyl urea & ascorbate plus tetramethyl-p-phenylenediamine as the electron donor and methyl viologen as the electron acceptor, the reaction mixture was rendered aerobic by pre-flushing with air.

Respiratory activity was assayed with the Hansatech oxygen electrode in a buffer medium containing 02 m sucrose, 10 mM KH_2P0_4, pH 72, 10 mM KC1, 5 mM $MgCl_2$, aerated prior to use. To 20 ml of the reaction buffer contained in the electrode vessel, 100 to 500 µl of the mitochondrial extract was added. The rate of oxygen uptake was monitored after each addition of 25 µl 20 raw NADH, 25 µl cytochrome c (l0 mg/ ml), 50 mM 100 mM ascorbate, 50 µl 100 mM tetramethyl phenylene diamine (TMPD) and finally 20 µl 50 mM KCN. The activity was determined as the rate of oxygen uptake in the presence of NADH and cytochrome c and was expressed as µmmol 0_2 consumed/ mg protein h^{-1}.

3. RESULTS AND DISCUSSION

Initially fresh weight per unit leaf area, chlorophyll content and chlorophyll a / b ratio were evaluated from 24h to 16^{th} day after desiccation and also followed by rehydration (Table 1). The fresh weight showed a marginal decline from the initial day to the final day. Similarly the chlorophyll content and the same are reflected with chlorophyll a / b ratio; whereas rehydration regained the control values. The soluble protein content showed an increase compared to control suggesting the formation of desiccation tolerant protein (Fig 1). Similarly protohaem a compex red organic pigment containing iron and other atoms to which o_2 binds; also showed a marginal increase during desiccation (Fig 2). Both chlorophyll and protohaem are believed to share a common pathway (Castelfranco & Beale, 1983). Furthermore, protohaem makes up the prosthetic group of cytochromes which participate in electron transfer activities of the chloroplasts and mitochondria. The photochemical activity showed an increase when compared with the control suggesting the active phase of the plant in terms of photochemical activity (Fig 3). The data was supported by protoheam and chlorophyll content. Further the Photosystem I activity was measured it showed a steady state under different irradiance treatments against duration. An increase was noticed when compared with the control and regained the original value during rehydration (Table 2). The Photosystem II activity was measured as the ratio of Fv/Fo interms of o_2 evolution (Table 3). It showed a marginal decrease when compared to the control and interestingly regained the original value during rehydration suggesting that the fern is still viable. Similarly the cytochrome content such as b559HB showed an increase but not drastically meanwhile, b559LP and b563 showed al level similar to control during different periods of desiccation suggesting the tolerance nature of the plant against desiccation (Fig 4). The respiratory efficiency showed a more or less similar trend to that of control interms of electron donor NADH as well as the artificial donor ASC/TMPD suggesting the unaffected nature of the respiratory system in the species (Fig 5).

Table 1: Analysis of fresh weight, chlorophyll content and chlorophyll a / b ratio

Fresh weight per unit leaf area (gdm-2)		Chlorophyll content (mg/g)	Chlorophyll a/b ratio
Control	1.45	2.1	2.4
1d	1.31	1.90	2.1
4d	1.20	1.77	1.9
8d	1.14	1.68	1.72
12d	1.10	1.62	1.6
16d	0.98	1.57	1.48
Rehydration	1.45	1.98	2.25

Table 2: The activity of Photosystem I under different irradiance treatment.

Irradiance	Control	1d	4d	8d	12d	16d	Rehydra-tion
10	4 ±0.02	5 ±0.01	5 ±0.01	5 ±0.01	5 ±0.01	5 ±0.01	4 ±0.02
20	24 ±0.32	24.8 ±0.02	24.8 ±0.02	24.8 ±0.02	24.8 ±0.02	24.8 ±0.02	24 ±0.32
30	32 ±0.43	33 ±0.11	33 ±0.11	33 ±0.11	33 ±0.11	33 ±0.11	32 ±0.43
40	33 ±0.12	34.2 ±0.01	34.2 ±0.01	34.2 ±0.01	34.2 ±0.01	34.2 ±0.01	33 ±0.12
50	33 ±0.01	34.5 ±0.25	34.5 ±0.25	34.5 ±0.25	34.5 ±0.25	34.5 ±0.25	33 ±0.01
60	34 ±0.12	35 ±0.23	35 ±0.23	35 ±0.23	35 ±0.23	35 ±0.23	34 ±0.12
70	34 ±0.32	35 ±0.32	35 ±0.32	35 ±0.32	35 ±0.32	35 ±0.32	34 ±0.32
80	35 ±0.24	36.2 ±0.12	36.2 ±0.12	36.2 ±0.12	36.2 ±0.12	36.2 ±0.12	35 ±0.24
90	35 ±0.10	36.3 ±0.11	36.3 ±0.11	36.3 ±0.11	36.3 ±0.11	36.3 ±0.11	35 ±0.10
100	35 ±0.13	36.3 ±0.11	36.3 ±0.11	36.3 ±0.11	36.3 ±0.11	36.3 ±0.11	35 ±0.32

Table 3: The activity of Photosystem II interms of o_2 evolution.

control	1 d	4 d	8 d	12 d	16 d	rehydration
95	73	70	65	60	59	92

4. CONCLUSION

The filmy fern showed desiccation tolerance efficiency in terms of chlorophyll content, chlorophyll protein, chlorophyll a/b ratio, protohaem, cytochrome content, and photochemical activity and also the efficiency of respiratory system suggesting the inbuilt capacity of the plant to defend dryness.

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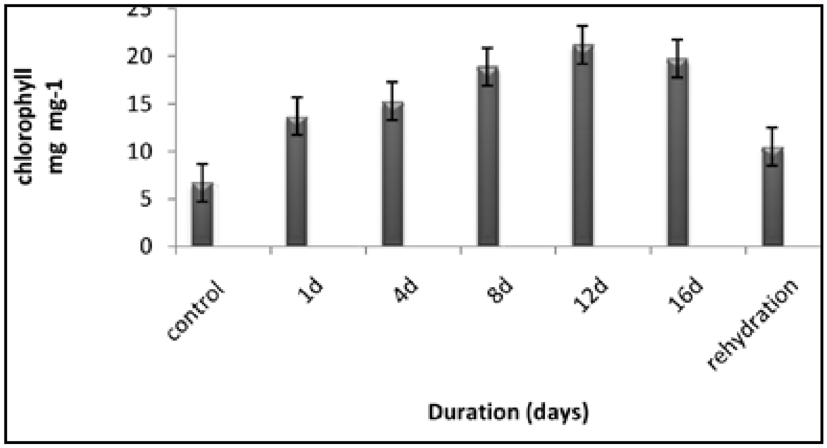

Figure 1: The ratio of soluble protein formed during desiccation

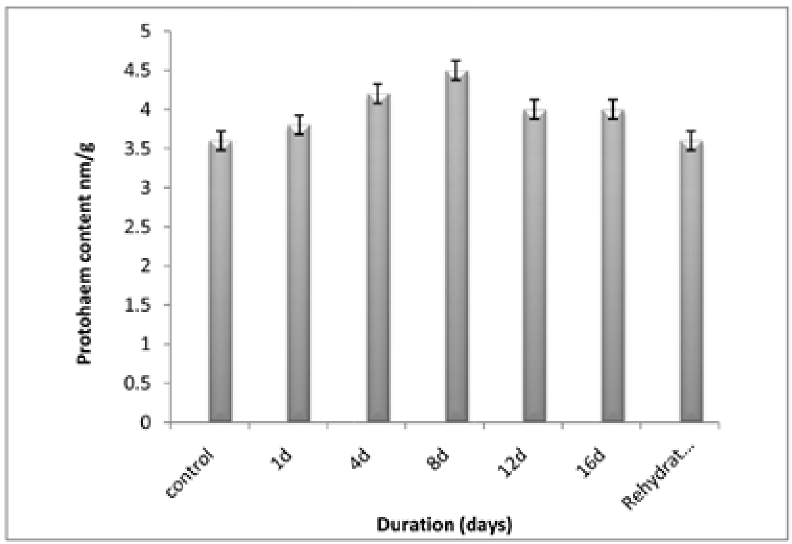

Figure 2: Increase in protohaem content during desiccation

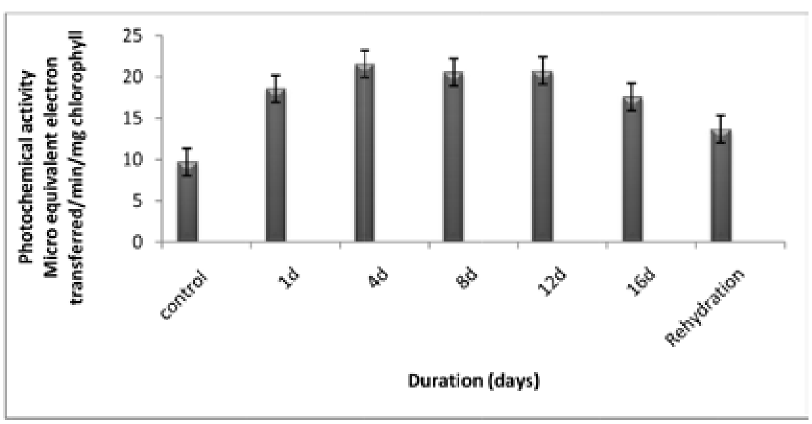

Figure 3: The photochemical chemical activity of the plant during desiccation

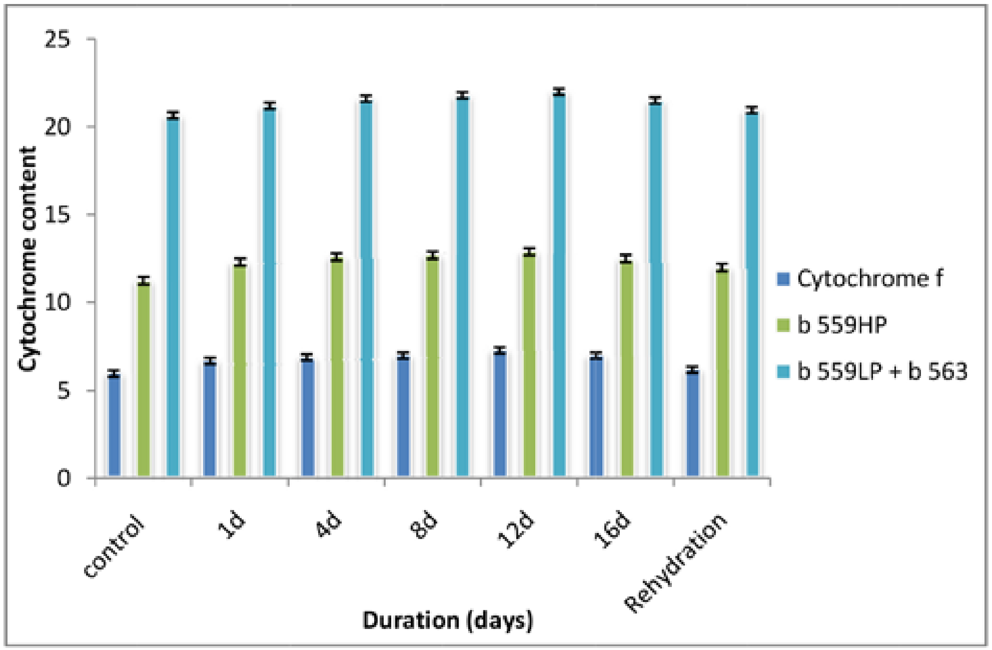

Figure 4: Cytochrome content during different periods of desiccation.

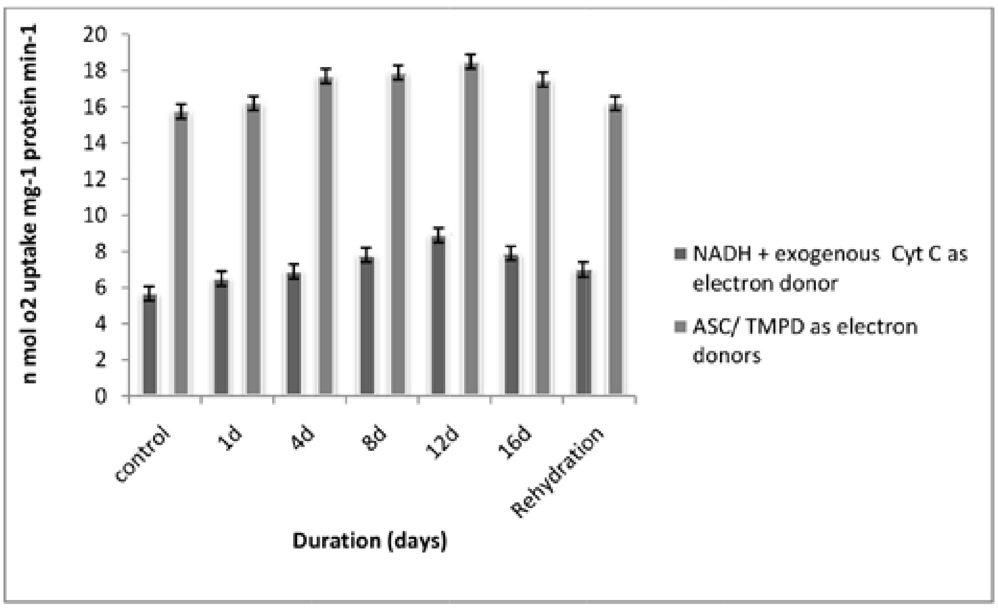

Figure 5: The respiratory efficiency of the fern during desiccation

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SOIL AND DRIFTWOOD ASSOCIATED MARINE FUNGI OF PUNNAKAYAL MANGROVE - DIVERSITY, GROWTH AND EXTRACELLULAR ENZYME PRODUCTION

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ABSTRACT

Marine mycology is one of the major emerging areas of research in tropics. It is gaining importance not only due to taxonomic and ecological perspective, but also for its unique metabolites, biochemical and enzymes from the sea. Mangrove forests are the hot spots of biodiversity and also for marine fungi. Punnakayal estuary is the only estuary situated in Tuticorin district, South east coast of India. Avicennia sp is the most dominant mangrove in this area. In this study the soil and drift wood associated marine fungal diversity and their growth abilities in different culture media and extracellular enzyme production were studied in different seasons during 2011-12. Altogether 20 fungal species under 8 genera were isolated from soil. Among them, 13 species were of Aspergillus genera. In total, 62 species of fungi under 33 genera were recorded from the drift wood samples. After identification, pure culture of 14 dominant drift woods associated and 11 soils associated fungal species were grown on different fungal culture media and the results showed that all the species grew well on SWPDA medium. Screening of extracellular enzyme (amylase, protease, cellulase, pectinolytic and lipase) production by the selected 25 dominant fungal species was carried out. Among them, 14 drift woods associated marine fungi showed good response in cellulase, pectinase and lipase activity; whereas 11 soil associated marine fungi showed good amylase, laccase and proteinase activity. The results support that the occurrence of manglicolous marine fungi of Punnakayal mangrove facilitates recognition of individual colonies that produce specific extracellular enzymes. Study also shows that it would be useful for surveys of pure cultures for the detection of enzyme production variants which could possibly be used to differentiate fungal taxa chemo taxonomically.

Key words: Fungal diversity, mangrove, optimization, extracellular enzyme

1. INTRODUCTION

Biodiversity in extreme habitats attract great attention among researchers because the study of these systems can increase our understanding of the relationship between organisms and their environment and unraveling the mechanisms of their adaptation to extreme conditions (Oren, 1999). Microbial diversity represents the largest untapped reservoir of biodiversity for potential discovery of new biotechnological products, including new pharmaceuticals, new enzymes, new chemicals or new organisms that carry out novel process. Mangrove forests are the hot spots of biodiversity and also for marine fungi (Rani and Paneerselvam, 2009). Mangrove trees are able to grow at salinities ranging from full sea water to fresh water, thus a different fungal flora can be expected within this salinity gradient (Kohlmeyer, 1969). Mangroves provide a unique niche to different microbes which play various roles in nutrient recycling as well as various environmental activities. Mangrove species diversity is well known for animals and plants, but poorly known for other organisms such as fungi. Fungi are cosmopolitan in oceans and estuaries and occur commonly on decomposing organic matter such as drift and intertidal wood. The true fungi belongs to the kingdom of Eukaryota has 11 phyla, 103 orders, 484 families and 4979 genera (Hawsworth et al., 1995). These fungi play an important role in the nutritive cycle and support the mangrove ecosystem. Hyde et al. (2000) highlighted the first reports of marine fungi until 1846; however, interest in marine mycology only increased worldwide with Barghoorn and Linder (1944). Fungi secrete digestive enzymes outside their bodies and absorb the nutrients and also produce valuable source of chemicals, antibiotics and enzymes. The majority of manglicolous fungi is omnivores and occurs mostly on dead cellulosic substrates all around the tropics. A wide range of enzymes are excreted by fungi and play an important role in the breakdown of organic materials and many of these enzymes now produced commercially.

In natural marine environments many substrata are good sources for marine fungi detection. Among that the most studied have been on plant detritus (Koch and Petersen, 1996). Among the plant detritus, intertidal driftwood are one of the important and interesting objects for fungal diversity study, as they are unknown origin of plant species and drift to any part of the coast by wind, wave action and water movement. They are exposed to sunlight and atmosphere at a frequent interval due to the tidal variations. Mangrove sediment soils are also another good resource for fungi providing an end number of enzymes that finds their use in industrial processes (Prakash and Sivakumar, 2013).

Literature revealed that a few studies have been undertaken to assess the fungal diversity from different Indian mangroves like Pichavaram in Tamil Nadu (Sivakumar and Kathiresan, 1990), Muthupattai in Tamil Nadu (Rani and Pannerselvam, 2009). But the information of the fungi on mangroves of Punnakayal in Tuticorin district remained unexplored. Punnakayal estuary (N' 80 38. 266 E' 780 07. 317) is the only estuary of Tuticorin region in Gulf of Mannar Marine biosphere reserve. The total estimated mangrove area is around 7 sq.km out of which 3 sq.km is denuded and 1 sq.km restoration has been attempted which is rich in Avicennia species. Besides species composition, biotechnologically important microbes for the enzyme production have not been revealed from this area. Hence, in this study attempt has been made to assess the microbial diversity from the soil and drift wood in the mangrove forest ecosystem to understand the diversity of fungi. The identification of dominant species and their growth was assessed in different culture media at different season and some biotechnologically important fungi for the enzyme production were also isolated.

2. MATERIALS AND METHODS

2.1.Collection of samples and isolation

The soil and drift wood samples were collected from Punnakayal mangrove during pre monsoon, summer, post monsoon and monsoon seasons. The sediment soil samples were collected by sterile scrapping. The collected samples were stored in clean plastic containers and it was brought to the laboratory. The fungal colonies were isolated from soil using potato dextrose agar with the supplementation of 50% sterile sea water at 28°C in petri plates (Azevedo et al., 2010).

The naturally occurring different wood substrates such as, driftwood and intertidal woods found in the estuary were collected in sterile polythene bags and brought to the laboratory for further processing. In the laboratory the surface fouling organisms were gently scraped off and washed by exposing under running tap water and the samples were again washed with sterile seawater. Then the surface of the wood piece was scrapped with the help of a new blade and particles were used for plating technique using Potato dextrose agar. The remaining wood pieces were incubated with 50% sterilized distilled water in order to maintain the moisture condition at room temperature for seven days. After incubation, all the wood samples were examined under dissection microscope for the observation of ascocarps, basidiocarps and conidia. The fungal cultures were then transferred, sub cultured and pure cultures were maintained.

The incubated plates were observed for the development of fungi from 3rd day onwards. The number of colonies in each plate were counted and compared with the control. The data obtained were used for calculating the frequency of occurrence. In addition to this, cultural characters like color and structure of the colonies were also observed and fungi were enumerated. All the isolated fungal cultures were sub cultured in test tubes containing agar medium and fungal culture collection being maintained as a stock culture. The semi permanent slides of the isolated fungi were stained using Lactophenol Cotton Blue Staining method (Dring, 1976) and sealed with DPX mountant. The fungal species were photographed using photo micrographic instrument (Nikon AFX II Microscope fitted with Nikon FX-35 camera, Tokyo, Japan).

2.2. Identification

All these strains were identified by noting the colour and morphology like hyphal structure, spore size, shapes and spore bearing structures. They were compared with the standard works of Manual of soil fungi (Gilman, 1995), Marine Mycology - The Higher Fungi (Kohlmeyer and Kohlmeyer, 1979), and the publication (Kohlmeyer and Kohlmeyer, 1992), Hypomycetes (Subramanian, 1971), Manual of Penicillia (Raper and Thom 1949), Manual of Aspergillus (Raper and Fennell 1965), Dematiaceous Hypomycetes (Ellis, 1976) and Soil fungi (Domsch et al., 1980).

2.3. Quantitative analysis

Number of species is referred as species diversity. Population is expressed in terms of colony forming unit (CFU) per wood sample with the dilution factor. In order to assess the dominance of individual species in each season, percentage contribution was worked out as follows.

Density = Total number of individuals of the species / Total number of sampling studied ×100

% contribution = No. of colonies of fungus in a sample / Total number of colonies of all the species in a sample × 100

Frequency occurrence was calculated as follows in order to identify their existence in the drift wood collected during different seasons.

% frequency = Number of wood samples in which a particular fungus occurred / Total number of wood samples examined × 100

Based on the frequency occurrence, the fungi were grouped as rare (0-25% frequency), occasional (26-50% frequency), frequency (51-75% frequency) and common (76-100% frequency) species. The diversity of fungi in the mangrove samples of four sampling seasons were assessed on the basis of diversity indices.

Simpson Index D' =	1	
	∑ (Pi)2	

Shannon Index	H' = - ∑ Pi * In Pi

Where Pi is the Proportion of individuals of that species; i contribute to the total (Magurran, 1988). The Shannon Evenness, J, was expressed by:

Shannon Evenness J' =	H' H' Max

Where H mark is the maximum value of density for the number of species present (Pielou, 1975).

2.4.Analysis of physico-chemical characteristics of the soil

The collected soil samples debris were removed, suspended in distilled water (1: 2 w/v) and allowed to settle down. The pH of the suspension was assessed using a pH meter (Hanna pH 213, 0 to 14). Electrical conductivity of the soil was determined in the filtrate of the water extract using Conductivity Bridge as described by Jackson (1973). Cation exchange capacity (CEC) of the soil was determined by using 1 N ammonium acetate solution as described by Jackson (1973). Organic carbon content was determined by adopting chromic acid wet digestion method as described by Walkley and Black (1934) and available nitrogen was estimated by alkaline permanganate method of Subbiah and Asija (1956) Available phosphorus was assessed by Brayl method of Bray and Kutz (1945). Potassium was extracted from soil with neutral 1N ammonium acetate (1:5) and the potassium content of the extract was determined by using flame photo meter (Standfold and English, 1949), calcium (Neutral 1 N NH_4 OAC extractable 1:5) was extracted with neutral 1 N ammonium acetate and the calcium in the extract was determined by Versenate method (Jackson, 1973). Available micronutrients such as Zn, Cu and Mn were determined by Versenate method (Jackson, 1973). Available micronutrients such as Zn, Cu and Mn were determined in the diethylene triamine pentaacetic extract of soil using Atomic Absorption spectrometer (Linday and Norvell, 1978). Other nutrients such as magnesium, sodium and iron were analyzed following the method of Barnes (1959) and Muthuvel and Udyasoorian (1999).

2.5. Effect of different media on the growth rate of some isolated fungi

After identification, the dominant fungal species of pure culture were prepared by single spore isolation technique (Raghukumar and Bhat, 1994). The isolated culture was maintained as stock culture in potato dextrose (PDA) agar slants. They were grown at 30°C for 5 days and stored at 4°C for regular sub culturing. The growing margin of the colony was cut with the help of a sterilized cork borer and the inoculum was transferred to Petri plates containing different media, such as, SWPDA (Sea water potato dextrose agar), SWMEA (Sea water malt extract agar), SWRBA (Sea water Rose Bengal Agar), SWCMA (Sea water corn meal agar), SWYEA (Seawater Yeast extract agar), SWYPGA (Sea water yeast peptone glucose agar) and SWCDA (Sea water Czapek- Dox agar). The plates were incubated at room temperature (28 ± 2°C) for a period of five days. The radial growth of fungi (colony diameter) was measured using a centimeter scale.

2.6. Extracellular enzyme production

A survey for extracellular enzyme by fungi using the qualitative techniques helps to screen a large number of fungi in a relatively short time. Among the total isolates dominant species were screened for extracellular enzymes. Screening of fungal extracellular enzymes typically involved growth on specific indicative media as mentioned by Hankin and Ananostakis (1975). The functional role of extracellular enzymes by fungal isolates was assessed by growing them on PDA for 6 -7 days and placing 5 mm mycelia plugs on the selective solid media with the dissolved substrates. After incubation for 3 -7 days at room temperature, the zone of enzyme activity surrounding the fungal colony was measured.

2.7. Amylolytic activity

The Glucose Yeast extract peptone agar (GYP) culture medium (glucose-1g, yeast extract-0.1g, peptone-0.5g, agar-16g, distilled water-1L) with 2% soluble starch (pH 6.0) was prepared and poured into Petri plates and inoculated with a pure culture at the center using pinpoint inoculation of the test fungus from actively growing margin. Inoculated plates were incubated for 3 - 7 days, after that the plates were flooded with 1% iodine solution in 2% potassium iodide. Yellow zone around the fungal colony indicated amylolytic activity.

2.8. Cellulase activity

The Glucose yeast extract peptone agar medium containing 0.5% Carboxy-methylcellulose was used. After 3 - 5 days of fungal colony growth, the plates were flooded with 0.2% aqueous Congo red solution and distained with 1 M NaCl for 15 minutes. Appearance of yellow areas around the fungal colony in an otherwise red medium indicated cellulose activity.

2.9. Lipolytic activity

For lipase activity, the fungi were grown on peptone agar medium (Peptone-10g, Nacl-5g, $CaCl_2$ $2H_2O$-0.1g, agar-16g, distilled water-1 L, pH-6.0) supplemented with Tween-20 separately sterilized and 1% was added to the medium. At the end of the incubation period, a visible precipitate around the colony due to the formation of calcium salts of the Lauric acid liberated by the enzyme indicated positive lipase activity.

2.10. Pectinolytic activity

Pectinolytic activity was determined by growing the fungi in Pectin Agar medium (Pectine-5g, yeast extract-1g, agar-15g, pH 5.0 in 1 L distilled water). After the incubation period, the plates were flooded with 1% aqueous solution of hexa decyltrimethyl ammonium bromide. A clear zone formed around the fungal colony indicated pectinolytic activity.

2.11. Proteolytic activity

Glucose yeast extract peptone agar medium with 0.4% gelatin (pH 6.0) was used. 8% of gelatin solution in water was sterilized separately and GYP medium was added at the rate of 5 ml per 100 ml of medium. After incubation degradation of the gelatin was seen as clear zone around the colonies. The plate was then flooded with saturated aqueous ammonium sulphate, which resulted in formation of a precipitate. This made the agar opaque and enhanced the clear zone around the fungal colony.

2.12. Laccase activity

Glucose yeast extract peptone agar medium with 0.05g 1-napthol L^{-1}, pH 6.0 was used. As the fungus grows the colourless medium turns blue due to oxidation of 1-napthol by Laccase.

3. RESULTS AND DISCUSSION

The mangrove soil of Punnakayal mangrove area is generally clayey, rich in nutrients. Hence, the soil characteristics were analyzed and the results were represented in Table 1. Soil samples pH were alkaline in nature during the entire period of study. It was in the range of 7.9 to 8.8 during post monsoon season in 2011 and monsoon season of 2012. Alkaline nature is the characteristic feature of marine soils (Nadimuthu, 1998) and brackish environs (Subramanian and Raghukumar, 1974). In the present study, EC recorded in the range of 1.07 to 1.29 dsm^{-1}. This was comparatively lower than the marine and brackish water sediments of Madras coast (Subramanian and Ragukumar, 1974) and mangroves of Andaman island (Chaudhuri et al., 2009). Since Punnakayal did experience the complete inundation of seawater, the EC value was low and this might be due to the dilution of seawater by the heavy flow of freshwater of the perennial river Thamirabarani, which traverse along the coast and subsequent rainfall. Likewise, Cation exchange capacity (CEC) in the soils was also low which was in the range of 8.15 to 9.4 (c.mol proton + /kg), when compared to the salt affected soils of Elhussinia plane, Sharkia Governorate, Egypt, that was in the range of 31 to 54.8 (c.mol proton +/kg), (Elbodiny et al., 2008) and 189 and 275 mmol kg^{-1} in the soil samples of Andaman's (Chaudhuri et al., 2009). Organic carbon content is considered to be the factor responsible to influence the population of any of the heterotrophic microorganisms. It showed variations in the range of 0.07 to 0.18% in all the sampling stations. These values are comparatively less than that of the river sediments (Lakshmi et al., 2002) and various biotopes in the Muthupettai mangroves (Kanimozhi, 2008). Nitrogen is an important nutrient for the growth of plants. The nitrogen content fluctuated from 0.012 to 0.020% during different seasons which is also less than other marine environs. The biological origin of nitrogen in the study areas seem to be hardly possible and thus the lesser amount of nitrogen is recorded in the present study. This may be the reason for the record of less amount of phosphate in the present study. Available potassium was in the range of 0.014 to 0.056 ppm in the soils analysed in the present study which was well within the range of 1.6% from Shenzhen (Tam and Wong, 1997), Fujian 2.07% (Lin et al., 1987) in Hain mangroves 0.42 – 1.19% (Liao, 1990) and mangroves of Andaman's (0.81 – 125%) (Chaudhuri et al., 2009). As that of major and minor elements, Zn, Fe, Cu, Mn, Ca, Mg and Na were recorded is less than other marine habitats such as mangroves (Chaudhuri et al., 2009) and estuaries (Elbordiny et al., 2008). The values recorded in the present investigation are also in accordance with the said trends. The concentrations of different elements were in the order of Ca > Mg > Fe >Mn> Na > Zn > Cu.

In the present investigation totally 20 species belonging to 8 genera were identified from the soil samples of Punnakayal mangroves in different seasons are represented in Table 2 and fungal community structure, density and percentage contribution are represented in Table 3.The genus Aspergillus was constituted by maximum 13 species followed by other genera like Trichoderma, Absidia, Botrytis, Drechslera ellsii, Helminthosporium oryzae, Nuurospora crassa and Fusarium which were represented by one species each. All these fungal species were reported earlier from soils and a variety of substrates in the terrestrial environment (Gilman, 1995). Great majority of them were also reported from oceans and estuaries (Johnson and Sparrow, 1961) as facultative forms to marine habitats. In the present study 20 species were recorded and this indicates that the fungal diversity in the coastal environs vary greatly. Such variations are spelled within the mangrove soils of Punnakayal estuarine ecosystem. At this study area, the species diversity was narrow in the range from 38 to 71 in all the seasons. The minimum were recorded in the soils collected during monsoon season of 2012 and post monsoon season of 2012 and the maximum were recorded in the soils collected during summer season of 2011 and post monsoon season of 2012. The maximum percentage contribution of 9.17% was found with Aspergillus chevalieri. Bulk amount of Aspergillus was noted in estuarine soil and it was contributed by 67.56%. The dominance of different species of Aspergillus in coastal - marine soils was reported as unique feature but different investigations have identified different species of Aspergillus as dominant one in different regions which was reported by Upadhyay et al., (1978); Prabhu et al., (1991); Nadimuthu (1998).

Species richness and diversity of fungi at mangrove soil at different seasons of 2011 were determined using Simpson and Shannon indices were presented in Table. 4. Both the Simpson and Shannon indices were highest at summer season (9625.82; 2.60 and 0.99). Species richness and diversity of fungi in summer season was in conformity with the diversity studies of Maria and Sridhar (2002). The species richness and diversity of fungi at four different seasons were determined by Simpson and Shannon indices and both the indices were highest at pre monsoon season and represented by 11928.92. Shannon and Shannon evenness was also highest at the same season while it was least at monsoon season.

In the present investigation totally 62 fungal species belonging to 33 genera were encountered including 46 species of Deuteromycetes followed by 14 species of Ascomycetes and one species of Trichomycetes and Basidiomycetes each. Fungal hyphae are commonly found on decomposing mangrove leaves, wood and from mangrove communities and over a hundred species of fungi were identified by many researches. Hyde (1990) listed 120 species from 29 mangrove forests around the world. In the present study abundance of fungi belonging to Deuteromycetes were high followed by Ascomycetes, Trichomycetes and Basidiomycetes. The abundance of the group of fungi on marine substrates has been reported by Hyde and Jones (1988); Rani and Paneerselvam (2009) and Immaculate et al. (2012). Dominant occurrence of Deuteromycetes as facultative marine forms which was already reported by these workers also coincided with the present study. Among the 62 species recorded in the present investigation, the genus Aspergillus, Alternaria, Lignicola and Penicillium showed broad spectrum range, represented by 19 and 3 species respectively. Dominant occurrence of Aspergillus was reported from various marine soils. Evidently Madhanraj et al. (2010) reported that Aspergillus was dominant genera among the 24 fungal species isolated from entire Tamil Nadu coast. In the present study 50% occurrence of all those species observed in the study area. The percentage occurrence as an expression of the frequency of collections of fungi gives an indication of the more common fungi within the mangrove ecosystems (Alias et al., 1995). The pattern of distribution has been categorized into common, frequent, occasional and rare. The common occurrence of A. terreus and A. niger was reported in the sites from Madras coast by Subramanian and Raghukumar (1974). In the present study A. terreus found as rare species but A. niger found as commonly available species in drift wood during all the seasons. Prabhakaran et al., (1987) reported thirty one fungal isolates from soil and 27 species from decaying mangroves and seven species from floating plants with the dominance of Aspergillus followed by Penicillium, Fusarium and Trichoderma in mangalvan mangrove ecosystem. Sixty seven fungal species were recorded from the intertidal wood samples with the dominance of Lulworthia species and forty eight fungal species were identified from dead parts of Rhizophora mucronata prop roots (Poonyth et al., 2001). In the present study Lulworthia species were observed from drift wood samples in the season of pre monsoon and monsoon season were recorded as an occasionally observed species. There is no previous record in the drift wood associated species from Punnakayal mangrove. Therefore this is new information about the diversity of fungi in Punnakayal mangrove. Substrate availability and climate change are the delimiting factors for the geographical distribution of fungi (Bobout et al., 1987; Ananda et al., 1998), and it has been rightly suggested that examination of more substratum is needed to understand the complete biodiversity status of marine fungi of India. The species richness and diversity of fungi at mangrove driftwood at different seasons were determined using Simpson and Shannon indices. Simpson index (D') was highest at summer and both Shannon index (H') and Shannon evenness (J') was highest at post monsoon season.

Based on the biodiversity study, 11 dominant soil fungi and 14 drift wood associated fungi were selected for the further growth study. Requirement of nutrient and other physical, chemical environment vary greatly among the marine fungi which in turn affects the distribution of the fungi. Growth of the different fungal species was measured by radial growth. The radial growth 0.5 cm of the culture plug of the dominant soil and drift wood fungus were studied for a period of 5 days at 24 hours intervals. All the fungal species showed fast growth in SWPDA medium. Byrne and Jones (1975b) stressed the need for the analysis of fungi under laboratory so as to understand their distribution and successful colonization on different substratum. Saravanan (2002) reported the growth (8 mm) of fungus on sea water corn meal agar medium and poor growth rate was observed in Sea water Czapek-Dox agar medium (SWCDA) with 5 mm on 5th day. Hyde and Jones (1987) stated a number of culture media so far been described was suitable for isolation and culture of different marine fungi. Further, it is stated that seawater potato dextrose agar as a best medium besides the other media described so far, as this statement in line with the present study.

Vinod et al. (2014) reported fungi isolated from mangrove habitats are known to be potential candidates for production of various industrially important enzymes and bio-active secondary metabolites. A wide range of enzymes are excreted by fungi and play an important role in the breakdown of organic materials and many of these enzymes now produced commercially. Qualitative screening of degrading enzymes in marine fungi was reported by Rohrmann and Molitoris (1992). Screening the fungal resources of mangroves for enzymes and their application is the major goal of this study to accomplish environment friendly technological development. In the present study extracellular enzyme production from the dominant soil and driftwood associated marine fungi was studied. The assays on solid media may be made semi quantitative by measuring the diameter of the zone formation in the agar and relating this zone size to the colony size. In this manner, the enzymatic activity of variants' of the same species may be determined. However, such a relationship may not be valid when different species are compared with each other. The term enzyme production is intended here to mean both synthesis of the enzyme by the fungus and activity of the enzyme in the medium after it produced. In the present study soil associated fungi shows good amylase, proteinase and laccase activity, whereas driftwood associated fungi produced good cellulase, pectinase and lipase activity. The production of these enzymes also varied from 3-8 days of incubation. The maximum production of amylase was from the isolates of soil strains such as A.flavus (4.2 mm), Botrytis cinerea (4.2 mm), Trichoderma koeningii (4.9 mm) exhibited maximum amylolyic activity, however the isolates of drift wood fungi showed maximum amylolytic productivity 2.9 mm in Lignicola tropica and remaining strains were weak producers of the amylase enzyme. Maximum amylotytic activity (5 mm) were observed by Venkatesagowda et al., (2012) in Rhizopus stolonifer and Lasiodiplodia theobromae followed by Aspergillus niger and Penicillium variotii, while other isolates produced moderate-to-low amylolytic activity. High level of amylase activity was produced by Aspergillus niger, A.ocharaceous, A.terreus, Halocyphina villosa isolated from mangrove driftwood of Muthupet mangrove, Tamil Nadu (Immaculate et al., 2011).

There are many microbes capable of producing cellulose enzyme but a fungus only produces significant quantities of enzyme (Kumara and Khan, 2012). Cellulases are widely used in the food, feed, textile and pulp industries (Nakari and Pentilla, 1996). Cellulolytic activity was prominent in drift wood associated marine fungi of Lignicola tropica (4.4 mm) followed by 4.3 mm in Trichoderma koeninji, 4.0 mm in Aspergillus flavus. The production of cellulose was not significant from isolates of other soil associated fungi. Similar result was reported by Maria et al., (2005) from mangrove angiosperm isolates. However, 100% cellulolytic activity was reported by Gessner (1980), in leaf inhibiting salt marsh fungi and 66% by Choi et al. (2005) from isolates of Brucea javanica. In our study Aspergillus candidus, A. fumigatus, A. ruber, A. unguis, Botrytis cinerea isolated from soil was negative for cellulase. Venkatesagowda et al., (2012) reported Aspergillus versicolor and Cladosporium species from mangrove produced good cellulase activity which was consistent with our results. Xia-liming and Cen-prilin (1999) reported cellulase production from Trichoderma resei was good and this coincided with the present study in T. koeninji produced good cellulose activity. Kathiresan and Manivannan (2006) reported Trichoderma sps isolated from mangrove environment able to produce high cellulase enzyme and this statement agreed with our results. Trichoderma species is a potential cellulolytic organism and widely distributed fungal species having ability to produce bio-control agents and plant growth promoting factors.

Pectic enzymes are induced in the presence of pectic substances by both pathogenic and endophytic fungi. Microbial pectinases are important in the phytopathologic process, plant microbe symbiosis and in the decomposition of dead plant material (Bezerra et al., 2012). Degradation of host tissue by phyto pathogens generally begins with the production of pectinolytic enzymes, which are the major enzymes involved in plant attack (Hoondal et al., 2002). In our study maximum pectinase activity was observed in A. flavus isolated from drift wood followed by A.luchensis, Aigialus species, Cladosporium species were the significant producers of pectinase activity. Fungal species isolated from soil also exhibited moderate pectinase activity. Venkatesagowda et al. (2012) reported high proteolytic activity of endophytic C.gloeosporioides followed by A.niger, Penicillium citrinum and Pestalotiopsis palmarum.

Among the tested organisms, maximum extracellular protease activity was observed in fungal species isolated from the sediment soil especially it was high in A. awamori (3.9 mm) followed by A. unguis (3.8 mm), F.solani (3.5 mm), A. chevalieri (3.4 mm), A. ruber (3.3 mm), Botrytis cinerea (3.2 mm) also produced significant amount of protease. A. luchensis isolated from drift wood produced moderate (1.9 mm) protease activity. Lipases were also produced by mangrove fungi of south east India such as Acremonium sp, Alternaria chlamydosporus, Alternaria sp., Aspergillus sp., Fusarium sp. The high lipase activity suggests their ability to use fats as energy source (Maria et al., 2005). The isolates of drift wood fungi such as Aigialus species, A.versicolor and Aspergillus flavus and Rhizophila marina was the maximum producer of lipase activity followed by isolates from the soil such as Aspergillus ruber, Trichoderma koeningii, Aspergillus chevalieri produced moderate activity. Panuthai et al. (2012) found 100% lipase production among healthy leaf of Croton oblongifolius and among them F.oxysporum was the potential isolate, whereas in our study F. solani showed negative result for lipolytic activity. Colen et al. (2006) found C. glosporioides as the best producer of alkaline lipase which was able to hydrolase wide range of oils.

Laccase can be used for application in several bioprocesses, such as bio pulping, bio bleaching, bioremediation, food technological uses and treatment of industrial waste water (Robinson et al., 2001). Soil isolated fungi was significantly highest producer of laccase enzyme followed by Aspergillus candidus (3.5 mm), A. awamori (2.9 mm), 2.7 mm for A. luchuensis, Fusarium solani, Trichoderma koeningii. Very few species of isolates in the present study were able to produce laccase, similar to the results on marine fungi (Raghukumar et al., 1994; Bucher et al., 2004). However Maria et al. (2005) reported none of the isolated endophytic fungi were able to produce laccase. In the present study also sediment soil isolated fungi poorly produced the enzyme laccase.

Table 1: Physico-chemical characteristics of soil of Punnakayal mangrove during different seasons

Parameters	2011				2012			
	Post monsoon	Summer	Pre monsoon	Monsoon	Post monsoon	Summer	Pre monsoon	Monsoon
pH	8.0	7.9	8.8	8.1	8.7	8.2	8.4	8.3
E C (dSm^{-1})	1.07	1.29	1.09	1.22	1.18	1.16	1.27	1.19
C E C (c.mol proton^{+}/kg)	8.62	8.41	9.4	8.47	8.57	8.61	8.3	8.15
Organic Carbon (%)	0.07	0.18	0.10	0.08	0.11	0.14	0.12	0.16
Available Nitrogen (%)	0.017	0.019	0.020	0.015	0.017	0.016	0.014	0.012
Available phosphorus (%)	0.003	0.002	0.004	0.002	0.005	0.001	0.002	0.004
Available potassium (ppm)	0.052	0.014	0.023	0.056	0.023	0.034	0.047	0.041
Available Zinc (ppm)	0.55	0.44	0.51	0.53	0.52	0.54	0.41	0.42
Available Iron (ppm)	2.91	2.01	2.18	2.43	2.71	2.67	2.71	2.78
Available copper (ppm)	0.34	0.19	0.17	0.14	0.24	0.27	0.21	0.31

Available manganese (ppm)	1.50	1.42	1.31	1.41	1.33	1.29	1.22	1.32
Calcium (mg/kg)	4.3	4	5.1	5.7	4.1	5.6	5.6	4.1
Magnesium (mg/kg)	3.9	3.7	3.9	3.1	4.2	3.3	3.7	3.2
Sodium (mg/kg)	1.22	1.73	1.04	0.99	0.91	1.41	1.32	1.02
Potassium (mg/kg)	0.03	0.08	0.01	0.02	0.02	0.03	0.04	0.06
TFC	61	71	46	58	45	47	59	38

EC - Electrical conductivity, CEC - Cation Exchange Capacity

Table 2: Isolation of fungi from the soil of Punnakayal mangrove

Fungal isolates from sediment soil	Taxonomy
Absidia glauca	Zygomycetes
Aspergillus awamori	Deuteromycetes
A. candidus	Deuteromycetes
A. chevalieri	Deuteromycetes
A. flavipes	Deuteromycetes
A. flavus	Deuteromycetes
A. fumigatus	Deuteromycetes
A. luchuensis	Deuteromycetes
A. nidulans	Deuteromycetes
A. ruber	Deuteromycetes
A. sacchari	Deuteromycetes
A. terricola	Deuteromycetes
A. unguis	Deuteromycetes
A. variecolor	Deuteromycetes
Bortrytis cinerea	Ascomyccetes
Drechslera ellisii	Ascomyccetes
F. solani	Deutromycetes
Helminthosporium oryzae	Deutromycetes
Trichoderma koeningii	Deutromycetes
Neurospora crassa	Ascomyccetes

4. CONCLUSION

Mangrove ecosystems provide shelter and nurturing sites for many marine microorganisms. Due to the presence of rich source of nutrients mangroves are called the homeland of microbes. These surveys strengthen the mycogeographic and mycodiversity studies. In addition, this information helps to monitor the status of marine and marine influenced ecosystems. Fungal colonization of mangrove and intertidal woody litter was assessed by plating and damp incubation techniques extent of salinity, kind of substrates and position of intertidal region, nature of floor, pH and oceanic region affect the occurrence and diversity of marine fungi in the mangrove ecosystem. Hence it could be concluded that there is no uniformity in the diversity of marine fungi and their distribution in different seasons. The major advantage of using microorganisms for the production of enzymes is the eco-

Table 3: Total colonies, mean density (CFU/g) and percentage contribution of fungi in Punnakayal mangrove

Name of the organism	2011								2012								Total number of colonies	% contribution
	Po M		Summer		Pr M		Monsoon		Po M		Summer		Pr M		Monsoon			
	TNC	MD	TNC	MD	TNC	MD	TNC	MD	TNC	MD	TNC	MD	TNC	MD	TNC	MD		
Absidia glauca	7	2.33	-	-	4	1.33	-	-	2	0.66	-	-	3	1	-	-	16	3.76
Aspergillus awamori	5	1.66	5	1.66	-	-	7	2.33	-	-	4	1.33	2	0.66	-	-	23	5.41
A. candidus	-	-	4	1.33	-	-	10	3.33	4	1.33	-	-	8	2.66	2	0.66	28	6.58
A. chevalieri	4	1.33	7	2.33	7	2.33	3	1	-	-	6	2	5	1.66	7	2.33	39	9.17
A. flavipes	6	2	-	-	-	-	-	-	-	-	7	2.33	1	0.33	-	-	14	3.29
A. flavus	7	2.33	4	1.33	8	2.66	4	1.33	-	-	2	0.66	-	-	-	-	25	5.88
A. fumigatus	3	1	5	1.66	-	-	7	2.33	7	2.33	1	0.33	3	1	-	-	26	6.11
A. luchuensis	-	-	8	2.66	3	1	-	-	8	2.66	5	1.66	5	1.66	-	-	29	6.82
A. nidulans	-	-	4	1.33	1	0.33	-	-	-	-	-	-	2	0.66	8	2.66	15	3.52
A. ruber	1	0.33	-	-	5	1.66	8	2.66	4	1.33	7	2.33	4	1.33	4	1.33	33	7.76
A. sacchari	3	1	5	1.66	-	-	3	1	-	-	-	-	4	1.33	-	-	15	3.52
A. terricola	-	-	8	2.66	-	-	1	0.33	-	-	-	-	-	-	1	0.33	10	2.35
A. unguis	4	1.33	-	-	3	1	2	0.66	6	2	8	2.66	-	-	-	-	23	5.41
A. variecolor	-	-	3	1	4	1.33	-	-	7	2.33	-	-	5	1.66	-	-	19	4.47
Bortrytis cinerea	3	1	1	0.33	-	-	2	0.66	-	-	-	-	7	2.33	7	2.33	20	4.70
Drechslera ellisii	2	0.66	2	0.66	8	2.66	-	-	-	-	1	0.33	3	1	-	-	16	3.76
F. solani	7	2.33	4	1.33	-	-	4	2.33	4	1.33	-	-	4	1.33	-	-	23	5.41
Helminthosporium oryzae	-	-	3	1	3	1	-	-	-	-	4	1.33	-	-	3	1	13	3.05
Trichoderma koeningii	4	1.33	8	2.66	-	-	7	1.33	3	1	-	-	1	0.33	1	0.33	21	5.64
Neurospora crassa	5	1.66	-	-	-	-	-	-	-	-	2	0.66	2	0.66	5	1.66	14	3.29
Total	61	20.3	71	23.7	46	15.3	58	19.3	45	15	47	15.6	59	19.6	38	12.7	425	

TNC – Total Number of colonies, MD – Mean density

Table 4: Species richness, diversity and evenness of fungi recovered from soil in different seasons during 2011

Sampling seasons	Species recovered	Species richness Simpson (D')	Diversity indices Shannon (H')	Shannon Evenness (J')
Post monsoon	14	7218.13	2.54	0.97
Summer	15	9625.82	2.60	0.99
Pre monsoon	10	3279.78	2.18	0.83
Monsoon	12	6506.22	2.32	0.88

nomical bulk production capacity and the fact that microbes are easy to manipulate to obtain enzymes of desired characteristics. The variety of physico-chemical factors is being thoroughly investigated so that the spectrum of applications of enzymes is meaningful and effective. The search for diverse endophytic fungi for novel enzymes will sure remain a mainstream area of research.

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DIVERSITY AND RICHNESS OF WATERBIRDS IN SELECT WETLANDS OF TAMIL NADU

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ABSTRACT

An attempt was made to assess the waterbird diversity and richness in select wetlands of Tamil Nadu. This study using total count method obtained the diversity and richness of birds from 41 wetlands located in 14 districts of Tamil Nadu between March and September 2012. The diversity (Shannon Wiener Index) and species richness was computed using Diversity and Richness Software 2.65. Nineteen out of forty one wetlands surveyed are part of the Important Bird Areas in Tamil Nadu. In total, thirty eight species of waterbirds were observed during survey. The dominant species of resident waterbirds were Little Egret, Little Cormorant and Indian Pond Heron. Most of the species recorded were largely from four locations, namely Karaivetti Bird Sanctuary in Perambalur, Udayamarthandapuram Bird Sanctuary in Thiruvarur, Vedanthangal Bird Sanctuary in Kancheepuram, Pichavaram Mangroves and Veeranam lake in Cuddalore. Out of the 41 wetlands studied, the highest diversity (H 2.38) was recorded in Manakudi Tank in Kanyakumari district followed by Big tank in Ramanathapuram district, while the lowest was observed in Manikakulam tank in Thirunelveli district. Due to lack of bird species, diversity index could not be calculated for the remaining 11 wetlands. The observed results are discussed in the light of timely availability of water, safe habitats and food sources for both adults and nestlings along with essential nesting and roosting sites in and around the wetlands.

Key words: Diversity, occurrence, richness, waterbirds, wetlands

1. INTRODUCTION

India has wide diversity of wetland microhabitats of both inland (mainly freshwater) and coastal (saline water) areas and hence there is a wide variation and diversity of wetland birds (Vijayan et al., 2004). The east coast of India, especially the Tamil Nadu region, is of major significance for waterbirds because many extensive wetlands are found here (Thiyagesan and Nagarajan, 1995). These wetlands are especially important as wintering areas for waterbirds. Also, an appreciable number of bird species migrate annually from breeding sites in arctic Siberia via India to wintering grounds in Australia (Sampath and Krishnamurthy, 1989 & 1990) and these areas are critical for the continuance of migration and, ultimately, for the survival of many waterfowls (Sridharan, 2003; Islam and Rahmani, 2004; Rahmani and Islam, 2008).

The attractions of birding areas increase when its avifaunal density, richness and diversity increase and these are the important measures to assess the avian diversity (Nagarajan and Thiyagesan, 1996; Pandiyan, 2006). Waterbirds are the most conspicuous components which serve as an excellent indicator of wetland ecosystem (Hancock and Kushlan, 1984). Many species of waterbird in India face significant threats to the long-term stability of their populations and habitats due to the destruction of freshwater wetlands, destruction and degradation of coastal ecosystems, depletion of the forage base in fresh water, and marine ecosystems, contaminants, sea level rise and various conflicts with human land and resource use. For some species, these threats have resulted in a decline in number (Gopi and Pandev, 2011; Jakubas, 2011 and Urfi, 2011). The successful conservation of waterbirds will depend on an improved understanding of their ecological requirements (Nagarajan and Thiyagesan, 1996). Insights on wetlands and wetland birds are important for understanding long-term trends and eventually for their conservation. Therefore the present investigation is carried out to assess the diversity and richness of waterbirds in select wetlands in Tamil Nadu.

2. MATERIALS AND METHODS

Field surveys were conducted in Tamil Nadu to collect data on the diversity and richness of waterbirds. During the survey the abundance of waterbirds was estimated by total count method as has been employed by several workers for wetland birds (Weller. 1975; Shah et al., 1983 and Sivasubramanian. 1992). A pair of binoculars (Nikon 8 x 42) was used for counting birds and a standard field guides (Ali and Ripley, 1987, Grimmett et al., 1999) was used for identifying birds. The bird survey was carried after two hours of sunshine, and normally from 06.00 to 09.00 am. Care was taken to avoid double count by watching the birds' direction of flight and landing in case they are disturbed by predators or people. The diversity (Shannon Wiener Index; Shannon and Wiener, 1949) and species richness was computed using Diversity and Richness Software 2.65.

3. RESULTS

3.1. Diversity of waterbirds in Tamil Nadu

Shannon Wiener Index was estimated to know the diversity of wetland birds in various districts in Tamil Nadu and the results are given in table 1. Among the 14 districts surveyed, Cuddalore had the highest diversity (H′ 2.33) followed by Thiruvarur (H′ 2.26) and Ramanathapuram (H′ 2.18), whereas Tutucorin (H′ 1.08) had the least. Virudhunagar district did not have any birds due to lack of water during the survey. Diversity Index was also estimated in various wetlands in Tamil Nadu. Among the 41 wetlands studied, the highest diversity was recorded in Manakudi Tank (H′ 2.38) in Kanyakumari district followed by Big Tank (H′ 2.17) in Ramanathapuram district and Karaivetti Bird Sanctuary (H′ 2.06) in Perambalur district, while the lowest diversity was observed in Manikakulam Tank (H′ 0.65) in Thirunelveli district. Due to lack of birds diversity index could not be calculated for remaining 11 wetlands (Table 2).

Table 1: Diversity of waterbirds in various districts of Tamil Nadu between March and September 2007

S. No.	District	Shannon Wiener Diversity (H')	Variance H
1	Thiruvallur	1.45	0.000
2	Thiruvarur	2.26	0.001
3	Erode	1.69	0.001
4	Cuddalore	2.33	0.000
5	Kancheepuram	1.77	0.001
6	Perambalur	2.06	0.000
7	Nagapattinam	1.59	0.003
8	Madurai	1.47	0.002
9	Sivagangai	1.71	0.004
10	Ramanatha-puram	2.18	0.002
11	Thirunelveli	2.05	0.002
12	Tutucorin	1.08	0.032
13	Virudhunagar	0.00	0.000
14	Kanyakumari	2.09	0.001

1.1. Richness of waterbirds in Tamil Nadu

During the surveys, 35 species of wetland birds were recorded in Tamil Nadu. Among the districts studied, Cuddalore district had the highest richness with 29 species followed by Kanyakumari district with 28 species and Perambalur district with 22 species, while no bird was found in any of the wetlands surveyed in Virudhunagar district due to lack of water (Figure 1). Richness among the wetlands studied, was the highest in Karaivetti Bird Sanctuary with 22 species followed by Udhayamarthandapuram Bird Sanctuary, Vedanthangal Bird Sanctaury and Pichavaram Mangrove with 16 species each. While Veeranam Lake, Suchidram Tank and Manakudi Tank had an abundance of 14 species, four wetlands had just three species. The re-

Table 2: Diversity of waterbirds in various wetlands in Tamil Nadu between March and September 2007

S. No.	Sample	H'	Variance H
1	Aringer Anna Zoological Park	1.61	0.00
2	Ariyakulam Tank	1.58	0.01
3	Avalpoondarai Lake	1.04	0.00
4	Big Tank	2.17	0.00
5	Chitrankudi Bird Sanctuary	0.00	0.00
6	Guindy National Park	1.16	0.01
7	Kanjirankulam Bird Sanctuary	0.94	0.04
8	Karaivetti Bird Sanctuary	2.06	0.00
9	Karikili Bird Sanctuary	1.33	0.02
10	Kelaselvanoor Bird Sanctuary	0.00	0.00
11	Koonthankulam Bird Sanctuary	1.86	0.02
12	Kunnathur Wetland	0.00	0.00
13	Manakudi Tank	2.38	0.00
14	Manikakulam Tank	0.65	0.00
15	Melaselvanoor Bird Sanctuary	0.00	0.00
16	Moondradaippu Tank	0.00	0.00
17	Muthupet Mangrove	1.96	0.00
18	Nagarcoil-Municipal Park	0.00	0.00
19	Nainaarkulam Tank	1.52	0.00
20	Periya Kollukudi Tank	0.00	0.00
21	Pitchavaram Mangrove	1.99	0.00
22	Point Calimere Wildlife Sanctuary	1.59	0.00
23	Poolam Tank	0.00	0.00
24	Pudhukiramam Wetland	0.88	0.01
25	Sakarakottai Tank	0.00	0.00
26	Sankarapandipuram Tank	0.78	0.01
27	Suchidram Wetland	1.96	0.00
28	Theroor Wetland	0.82	0.00
29	Thirupudaimaruthur Reserve	0.66	0.02
30	Udhayamarthandapuram Bird Sanctuary	1.71	0.00
31	Uthirakasakulam Tank	1.64	0.01
32	Vaduvoor Bird Sanctuary	0.77	0.00
33	Vallanadu Black Buck Sanctuary	1.08	0.03
34	Vandiyur Wetland	1.47	0.00
35	Vedanthangal Bird Sanctuary	1.74	0.00
36	Veerakasamuthirakulam Tank	0.00	0.00
37	Veeranam Lake	1.93	0.00
38	Vellode Bird Sanctuary	1.48	0.00
39	Vembanoor Wetland	1.62	0.01
40	Vettangudi Bird Sanctuary	1.71	0.00
41	Watrap Tank	0.00	0.00

maining 11 wetlands did not have any birds probably due to lack of water during the survey (Figure 2). Most of the species recorded were largely from six locations, namely Karaivetti Bird Sanctuary in Perambalur, Pichavaram Mangroves in Cuddalore, Vedanthangal Bird Sanctuary in Kancheepuram, Koonthankulam Bird Sanctuary in Thirunelveli, Vettangudi Bird Sanctuary in Sivagangai and Udayamarthandapuram Bird Sanctuary in Thiruvarur district.

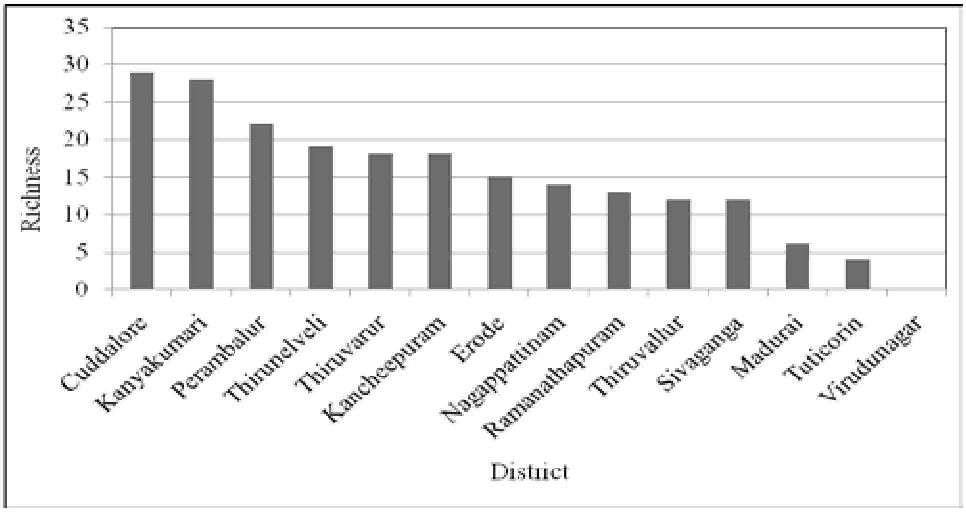

Figure 1: Species richness in different districts of Tamil Nadu during March- September 2007

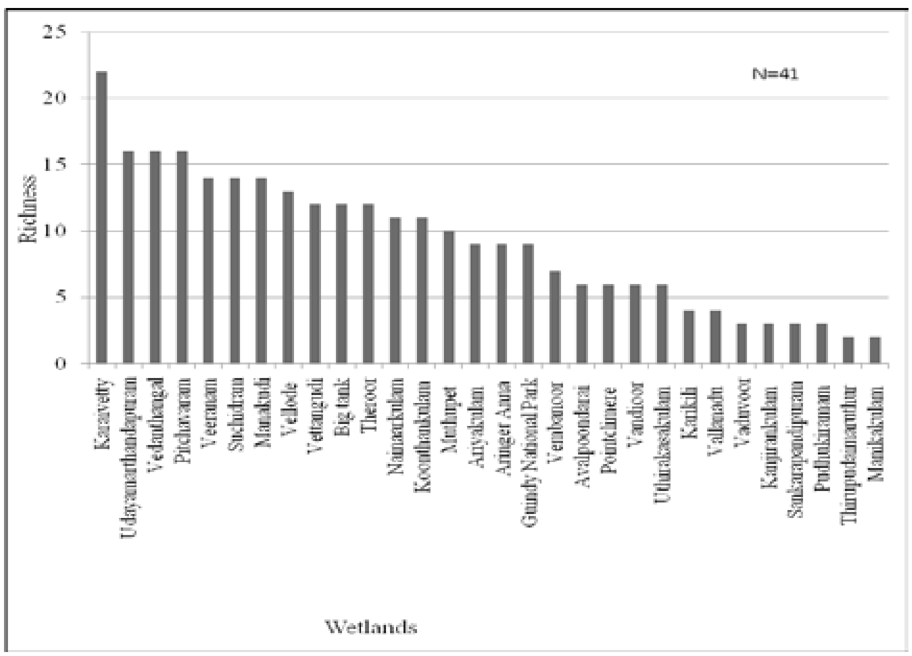

Figure 2: Species richness in different heronries of Tamil Nadu during March- September 2007

4. DISCUSSION

Diversity index recorded in the present study is comparable to the diversity index (1.59 to 2.66 H') reported by Guptha et al. (2011) in various wetlands of Tamil Nadu. The highest diversity of birds was recorded in Manakudi Tank, Big Tank and Karaivetti Bird Sanctuary, which are well maintained and protected IBAs in Tamil Nadu, whereas the lowest bird diversity was observed in Manikakulam Tank, which is in human disturbed area. Variations in diversity among various locations studied were observed. This might be due to differing habitat conditions for roosting/ nesting/ feeding and availability of food as reported by several researchers in India (Sampath and Krishnamoorthy, 1989; Sivasubramanian, 1992; Sridharan, 2003 and Guptha et al., 2011).

Diversity of wetland birds recorded in the present study coincides with the number of breeding sites and other wetlands. Although Cuddalore district had fewer wetlands, Veeranam Lake and Pichavaram mangrove were the two important IBS sites, which attracted more diversity of birds. Similarly Kanyakumari district had several wetlands that offer better breeding and foraging opportunities to the resident and migratory waterbirds correspondingly (Vijayan et al., 2004). Among the 13 wetlands in these districts, seven have been previously declared as Important Bird Area (Islam and Rahmani, 2004) and also protected by Tamil Nadu Forest Department. Furthermore, Kanyakumari district has 2633 freshwater ponds which irrigate around 55,000 hectares of fertile land. Therefore, these districts had a rich array of floral and faunal diversity including birds (Sathia Geetha, 2010). Virudhunagar and Tuticorin districts do not appear to support bird life due to scarcity of wetlands and water. Further, felling of nesting trees was also noticed in these sites.

Species richness recorded in the present study is almost similar to what Guptha et al. (2011) had reported in various wetlands in Coimbatore, Tiruchirappalli, Perambalur, Thiruvarur, Kanyakumari, Nagapattinam, Cuddalore and Thanjavur districts in Tamil Nadu. They had reported 47 species of wetland birds in Tamil Nadu. Of which, Perambalur had 31 species followed by Cuddalore with 27 species. Thiruvarur and Thanjavur districts had 14 and 13 species respectively. Guptha et al., (2011) had documented the species richness in various wetlands, namely Suchindram (27 species.), Theroor (25 species.), Vembanoor (15 species), Vaduvoor (24 species), Veeranam (17 species), Karaivetti (31 species) and Udhayamarthandapuram (22 species). The number of species observed in the present study is slightly varied from the previous observation. The slight variation in species richness from that of the present study could be due to the nomadic activities of waterbirds to the neighboring wetlands and agricultural fields as reported by Subramanya (2005). According to Weller (1999), wetlands are the most important habitats to waterbirds for their feeding, roosting and breeding. Therefore, it is obvious that water logged areas such as ponds, lakes, reservoirs, tanks and rivers are the prime factor determining the distribution of wetland dependent birds including nesting birds in Tamil Nadu.

5. CONCLUSION

From the aforementioned results it could be made out that the availability of water, safe habitat and food sources for both adults and nestlings and essential nesting/roosting sites in and around the lakes are important for the occurrence and abundance of aquatic bird populations. As water depth, quality and trophic structure are the important habitat characteristics that influence the abundance and diversity of aquatic birds in wetlands, the proper and regular maintenance of these, would further increases the aquatic bird populations. Other factors, such as water depth and water quality could also influence the abundance and diversity of aquatic birds. The results of this study will help to conserve waterbird populations in Tamil Nadu.

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A PIONEERING STUDY ON THE SPIDER (ARACHNIDA: ARANEAE) FAUNA OF KUMARAKOM BIRD SANCTUARY IN THE VEMBANAD RAMSAR SITE, KERALA

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ABSTRACT

Biodiversity is a term encompassing the variety of organisms at all levels, from genetic variants belonging to the same species, to species diversity and including the variety of species within a region. In situ conservation methods including maintenance of protected areas such as Wildlife Sanctuaries, National Parks and Biosphere reserves play an important role in the conservation of Biodiversity. Kerala state has many such protected areas. Kumarakom Bird Sanctuary,a region of vembanadramsar site, situated in Kottayam district of Kerala is green patch of land with potential as a protected area. Kumarakom Bird Sanctuary, a lush patch of land is situated in the eastern coast of Lake Vembanad in Kottayam district of Kerala. Spiders were collected for one year from November, 2007 to November, 2008; bimonthly. The specimens collected were analyzed to study the general population trend and the guild structure. The seventy four species in 51 genera belonging to 19 families clearly indicate a high diversity of spiders distributed in the study area. Of these, Salticidae was the dominant family with 18 species. The spiders collected during the study were classified into 7 ecological guilds based on their foraging mode. They are orb weavers (31%), stalkers (30%), Space web builders (14%), foliage runners (9%), ground runners (8%), ambushers (5%), and sheet web builders (3%). The major achievement in this study is after a century, it is found that Fecenia travancoria Pocock (1899) is recognized as the synonym of Fecenia protensa Thorell (1891) (Araneae: Psechridae).

Key words: Biodiversity, salticidae, population, dominance, guild.

1. INTRODUCTION

Kumarakom Bird Sanctuary (KBS) (9°37’46.97”N& 76°25’25.56”E/ 44 ft alt) a green patch of land with mangrove forests criss-crossed with channels connected to the nearby backwater which is famous for its wetland vegetation and birdlife. This area that encompasses the Kerala Tourism Development Corporation (KTDC) Complex is 90.199 acres (36.4869 hectares) in extent and forms a part of the Baker Estate. The Kumarakom Bird sanctuary is situated at Kavanattinkara in Kottayam District of Keralaon the western side of the Kumarakom -Vechoor road on the southern banks of the river Kavanar, a branch of the Meenachil river system. This area is known for its avian fauna which includes a variety of local resident birds and a number of migratory birds. Many of them use this place as the breeding ground.

Among the seventeen species of Mammals identified from the Kumarakom Bird Sanctuary, Smooth-coated Otter (Lutrogaleperspicillata) is the most important species. KBS forms the largest heronry in Kerala, based on number as well as species diversity. It is found that two globally near threatened bird species like Darter (Anhinga melanogaster) and Black headed Ibis (Threskiornismelanocephalus) are breeding in this heronry. Prof. K.K.Neelakantan, well – known ornithologist reported about 3000 to 4000 Night Herons in breeding, in the two marshy areas of the north-western part of the Estate. Out of 483 species all over Kerala, a total of 88 species of birds under 33 families and 14 orders are recognized from KBS. Water birds belonging to five families, namely Anhingidae, Phalcrocoracidae, Ardeidae, Threskiornithidae and Rallidae under two orders – Ciconiiformesand Gruiformes, are found to breed in the Bird sanctuary.

Mangroves have got a crucial role to supporting the ecosystem with a number of wetland medicinal plants. Among the longest mangrove belt (ten species of mangroves) of Kerala, eight species were recorded from the Kumarakom Tourist Complex namely Avicenniaofficinalis. Bruguiera gymnorrhiza, Rhizophora apiculata, Rhizophora mucronata, Sonneratia caseolaris and Kandelia candel. Of these, three are found only at Kumarakom.

KBS hosts a large colony of Indian Flying Fox of more than 5000 individuals. Five species of bats are identified from this area. Fifty species of minor vertebrates, representing 10 orders and 29 families are reported from the sanctuary. The number of species of fishes, amphibians and reptiles are 34, 5, and 14 respectively.About 45 species of butterfly and 40 species of Dragonflies and Damselflies are recorded from the Kumarakom Bird sanctuary. Almost all faunal groups such as birds, bats, fishes, amphibians, reptiles, butterflies, dragonflies etc. of this area have been investigated by researchers. But still the spider fauna of this area are remaining unexplored. So this is a pioneering attempt to explore the spider diversity distributed in Kumarakom bird sanctuary.

2. MATERIALS AND METHODS

The investigation was carried out for a period of one year from November, 2007 to November, 2008. Spiders were collected twice in a month in sessions starting early in the morning (8.00 am) up to the noon (12.30 pm). An all out search method was used for collecting the spiders. For a systematic collection, the entire place of the sanctuary was divided into six areas and the plants were thoroughly examined for the possible spiders. Collection was conducted mainly by handpicking and beating methods. Spiders from height above were mainly collected by beating method in which vegetation was shaken with hands or beaten with a one meter long stick and catching the falling spiders on an inverted umbrella held below and transferring them to collection bottles.

Ground dwelling spiders were searched exploring leaf litter, under surface of logs, rocks, and plant surfaces below knee. Specimens collected were transported to the laboratory. Small specimens were photographed with the help of a stereo zoom camera attached microscope (Leica-MS5). Comparatively large specimens were photographed in the field itself before collection. Specimens were preserved in 75% alcohol with proper labeling of locality, date, and other notes of importance for further studies. Preserved specimens were examined under a stereo zoom microscope (Leica-MS5) in the laboratory for taxonomic identification. Spiders were identified up to species level with the help of available literature.

Ecological characteristics relating to foraging manner, nature of web, prey species, microhabitat use, site tenacity and daily activity pattern at family level were subjected to guild classification. Output of the analysis was organized into graphical form. The spider guild classification was composed according to the families collected during the study. Designation of spider guild was based on the ecological characteristic known for the family.

3. RESULTS

A total of 74 spider species coming under 51 genera under 19 families were collected from the study site. Of the 19 families sampled, the family Salticidae was found rich in number of species. This family was represented by 18 species. The next dominated family was Aranedae, possessed 13 species. Theridiidae and Tetragnathidae were the others with higher diversity having 10 and 7 species respectively. A total of 4 species were reported from Lycosidae and Oxyopidae. Family Miturgidae possessed 3 species. The families like, Linyphiidae, Pisauridae and Sparassidae were with 2 species each. The remaining families such asClubionidae, Corinnidae,Hersilidae, Nephilidae, Oonopidae, Psechridae, Scytodidae, Thomisidae, Uloboridae having only one species (Fig.1). This study revealed that spider fauna in the study area is qualitatively rich.

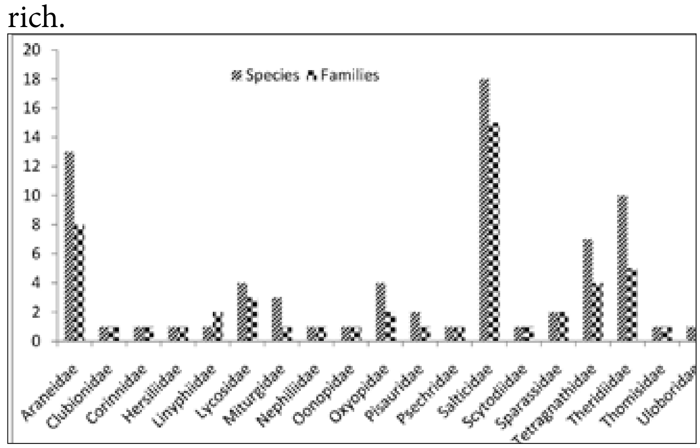

Figure 1: Number of genera and species of each

families collected from Kumarakom BS

Spider population of the study area represents the population trend taking 5 dominant species of these spiders viz, Argiopepulchella (Family: Araneidae), Cyrtophoracirticola(Family: Araneidae), Clubionadrassodes (Family: Clubionidae), Leucaugepondae(Family: Tetragnathidae), Tetragnatha mandibulata (Family: Tetragnathidae) (Fig. 2).

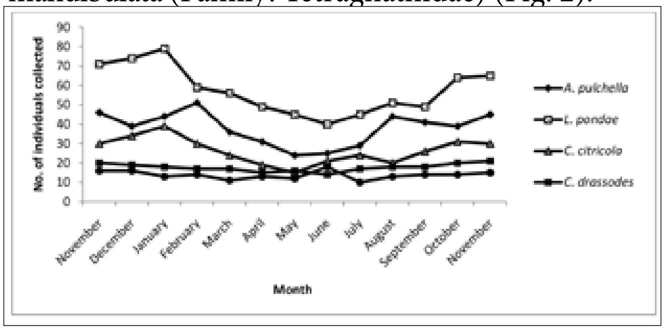

Figure 2: Population fluctuation of 5 dominant species of spiders in Kumarakom BS

The spiders collected during the study were classified into 7 ecological guilds based on the foraging mode of the spiders (Fig. 3). Among the 19 families of spiders collected, majority of families (31%) belong to "orb weavers" category. The second dominant guild constituted the "stalkers" (30%). Space web builders (14%), foliage runners (9%), ground runners (8%), ambushers (5%), and sheet web builders (3%) are the other ecological guilds.

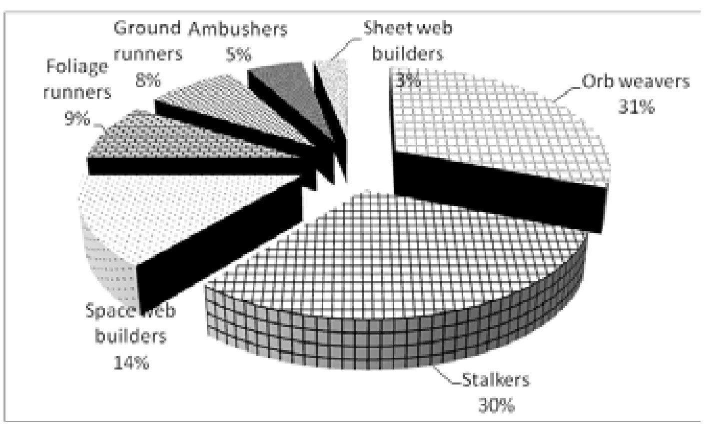

Figure 3: Guild structure of spiders collected from Kumarakom BS

4. DISCUSSION

The study revealed that KBS is qualitatively rich in spiders with 74 species of spiders belonging to 51 genera coming under 19 families. It indicates that 60 families identified so far from Kerala, nearly 32% families were recognized from KBS. Diversity generally increases when a greater variety of habitat types were present. The study area is endowed with different types of habitats such as grassland, mangroves, coconut plantation, rubber trees and shrubs. This may be the reason for the species richness. Riechert and Lockley (1984) also noted this trend among spider populations.

5. CONCLUSION

Kerala, God's own country, is blessed with a rich flora and fauna mainly owing to the presence of green patch of lands like Kumarakom. The study reveals that region harbors a rich spider diversity which indicates the region is less polluted as these creatures are highly sensitive to various pollutants. So it is our duty to protect this ecologically unique bionetwork at any cost.

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AN APPRAISAL OF THE FISHING ACTIVITIES OF THE ARTISANAL FISHERMEN AND ITS IMPACT ON FISHERIES IN THE THRISSUR DISTRICT OF KERALA

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ABSTRACT

Fishing in the past was an occupation for subsistence. Sixty years back the craft and gear in use was the dug out canoes and simple nylon nets. Locally prevalent kadakkodys (sea courts) were the traditional fisheries management institutions in Thrissur district of Kerala. Fishermen were literally enslaved by the feudal style of functioning of the kadakkodys. Poverty and bankruptcy were the condition of majority of the fishermen then. State intervention led to local self governing systems to take charge of the management of the artisanal fisheries sector in this area. This system was found to be more democratic and organized. The present study adopted the Institutional Analysis and Development (IAD) framework conceived by Ostrom et al. (1994) to analyse the fisheries, fishermen and institutional arrangements in the artisanal fisheries sector. The active fishermen in the Azhikode to Chettuva region of Thrissur district were interviewed and their opinions and attitudes were taken note of. It was found that though the technological advancement has led to improved versions of craft and gear it resulted in increased fishing pressure in the sea leading to the depletion and disappearance of many varieties of fishes impacting biodiversity. Most of the fishermen were found to be well aware of the consequences of the destructive practices of fishing followed by them. It was also found out that the government intervention has enabled the artisanal fishermen to some extent to become owners of craft and gear. Even then most of the fishermen are in poverty due to the debt traps set by the tharakans (middle men). Other finding of the study is that though the artisanal fishermen as a professional group were not organized, when pertinent problems which adversely affect fishing and fisheries arise they unite to solve the issue and then disperse. The study recommends that the government and fishermen must act in compliance to preserve the biodiversity and at the same time maintain a sustainable livelihood for the fishermen.

Key words: Artisanal fishing, fisheries management, institutions, biodiversity

1. INTRODUCTION

Fishing in the past was a caste related profession. Fishermen were hunters in the sea and fishing was an occupation for subsistence. There were no sophisticated fishing crafts, no hard and fast rules regarding fishing methods pursued or the size of fishes to be caught. The fishing effort was less in those days and a variety of fishes were available in the sea. In Kerala the fisheries management institutions in the past were the 'kadakkodis'. Kadakkodis were the local village sea courts that were institutions managed by the elderly fishing folk. They were mediators in many issues related to fishing. They performed both marine fisheries management and other social functions. Local self governing systems delivered a variety of useful services for the management of traditional fisheries in many countries (Townsend, et al., 2008). These community organisations regulated member's access to various fishing grounds, monitored the concurrent operations of multiple gears and resolved fishing conflicts among gear groups (Thomson and Gray, 2009). The kadakkody in the Thrissur region was headed by a chief who was called the kadakkody achhan. He was financially sound and was the decision maker for all the matters related to fishing. He provided finance to the fishermen for the purchase of boat and so the major chunk of the catch has to be returned to him as loan repayment. The active fishermen were financially enslaved to him. Thus the artisanal fishermen in the past were in poverty, facing hardship at sea as well at home. Motorization in fishing operations came in the eighties. Technological advancement, state interventions and broader thinking led local self governance in fisheries sector to take a better shape. With the influence of democratic set up in the society, such informal organizations came to an end. A study was made into the present fishing operations carried out by the artisanal fishermen in the Thrissur district of Kerala and its impact in the fisheries biodiversity of that region. Also an attempt was made to study the effect of financial aid from the local self governing management systems in uplifting the status fishermen.

2. MATERIALS AND METHODS

The study adopted the Institutional Analysis and Development (IAD) framework developed by Ostrom et al. (1994). Basic Components of the IAD Framework is shown in Fig 1.

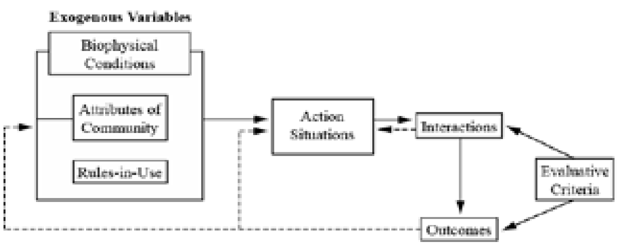

Fig 1: Basic Components of the IAD Framework. Aframework for institutional analysis. Adapted from E. Ostrom (2005:15)

In the IAD framework factors affecting local organizations of natural resource management are summarised as physical and technical characteristics of resource system, characteristics of the group of users and institutional arrangements. Physical and technical characteristic conditions included production inputs and technology and under the characteristics of the group of users, the socio-cultural profiles of local fishing communities and their rule systems were considered. The institutional arrangement included the sources of finance. The Azhikode to Chettuva area that belong to the coastal waters of Thrissur district was selected for the study. The active fishermen of different age groups were interviewed and their opinions and attitudes were taken note of.

3. RESULTS

The following are the results of the studies

3.1. Physical and technical characteristics of resource system

The fishing grounds at about 15 km off Thrissur coast are rocky and form a good habitat for a variety of marine fishes thus reflecting rich biodiversity. Pelagic fishing constituted about 80% of the fishing. Artisanal fishermen undertake fishing based on traditional knowledge on fish behaviour and migration. The coast is known for the occurrence of 'chagara' during the monsoon months preferably in the June-October season. According to the fishermen many varieties of fish such as adaval, valli sravu, kilivaranda, moodukuthy para, kurumanugu vellachooda and chuvappan manugu vanished from the coastal waters in the recent years. At present catch of mullan, kannathi, veloori, parava and palav are showing a depleting trend. On the contrary they are now getting kera, big vatta, maachan akoli which they were not getting previously. High value shrimp species such as Indian white shrimp, tiger shrimp, brown shrimp as well as sardine, mackerel, pomfret are caught. Catches are landed in the shore areas of different villages including the fishing harbour at Azhikode. The fishing area selected for the study purpose had large 'chappa's numbering about 7 for curing and drying fishes which have become almost dysfunctional now. There are several beach-landing centres in the Azhikode-Chettuva area for artisanal fishing. They are involved in fishing with dug out canoes such as deppa vallom, muri vallom/ mooduvetty, vanchi and vallom with inboard engine. Previously they were using chala vala of 38 mm mesh size and ayala vala of 56mm mesh size, now majority of fishing is by the use of ring seines and gill nets. Fishermen are also found to be using chooda vala with a mesh size of 10mm for catching small fishes. Pair trawling along coastal waters is being practiced in this area. Through the years there has been change in the size of the craft and power of the engine. At the time of kadakkody the concept of fishing was related to vanchi (dug out canoes). Later fishermen started using 2HP, 5 HP, 8HP engines. With the coming of inboard engine fishermen started using Indian model engine Asok Leyland with a towing speed of 8 nautical miles per hour. Formerly there was 65 feet craft with 148 HP engine, then came 77ft craft with 180 HP engine and as of now the craft size has come up to 118 ft with 420 HP engine. Some of them are found to use

Chinese made inboard engine with a speed of 15 nautical miles.

3.2.Characteristics of the group of users and their rules in use

Formerly fishing was a caste related profession but now fishing has become a seasonal profession and people belonging to other caste also are going for fishing. Seventy five years back there was a 'Matsya pravarthana sanghadana' which was formed to resist the atrocities against the fishermen by the land lords of that time. Gradually the party was politicized and it led to its collapse. The prevalent families that functioned in kadakkody have now seen to have left the scene. Majority of the fishermen households belong to the Araya community and the rest by Muslim community. With the coming of goverment intervention in fisheries sector in the form of Matsyafed in the eighties fishermen became owners of craft and gear. Fishermen became self reliant and started to form associations when they faced problems. When there was a ban on traditional boats from fishing in the monsoon period traditional fishermen formed a 'Swathanthra Matsyathozhilali Union' in 2006. By their legal involvement they got the permission for fishing in all season. They could also bring policies with regard to production of fish. One important policy formed by the union was that for a vallom with inboard engine, one carrier boat alone should be allocated. According to the new policy formulated it was decided that the carrier boat can go several times but the vallom could go only once in a day. This helped to reduce the abundance of fish in the shore and thereby control the price of fish. This union was active for two years and then collapsed due to political reasons. Problems related to catch is solved by the fishermen in the fishing ground itself nowadays.

3.3. Institutional arrangements

In the present scenario, of the total 68 vallom operating from Azhikode to Chettuva region in the Thrissur district of Kerala except 6 vallom all others are registered under different fishermen welfare co-operative societies. There are 5 clusters of fishermen welfare co-operative societies in Thrissur district. Under each cluster there are 4 fishermen welfare co-operative societies. The welfare societies have several schemes for assisting fishermen such as those concerned with auction, fishing equipment purchase loan, fishing boat purchase etc. The fishermen welfare societies are a support to the fishermen. For example, a fishing boat with Chinese engine costs about 75 lakhs of rupees. Seventeen lakhs is given as loan through fishermen welfare co-operative society, another 10 lakhs from Matsyafed on pledging the property and three lakhs from society's own fund. Other than the assistance from fishermen welfare co-operative societies the money sources prevalent in this sector are the tharakans (middle men) and the local moneylenders. According to the fishermen in a year they are getting only 100 days of fishing. Within that period they may receive good catch only for 60 days and they may have to spend another 30 days to rectify the damages of the gear. Tharakan takes 16% interest for the amount given as loan. One percent of the catch has also to be given to tharakan. From the rest of the amount deducting the operating cost 60% goes to the workers and only 40% to the owner. This situation leads to the bankruptcy of fishermen. In the Nattika-Valapad region, there is a 'Kodiyanpuzha kadapuram devasom committee' based on 2 temples in the region consisting of 1500 fishermen from the Nattika and Valapad Panchayat. They meet once in a month. The problems related with fishing are handled by the 'Rakshadhikari committee'. Fishermen contribute 1 ½% of the catch to the temple. 1/3 rd of the contribution is utilized for insurance project. The committee lends upto 2 lakhs rupees at 1 ½ % interest to its members. This is done to free these fishermen from the hands of money lenders.

4. DISCUSSION

Fishing in the past was a profession for subsistence for a particular sect of people. Since technology was not developed the fishing operations were not affecting the fisheries adversely. There were many varieties of fishes in the past. The only fishery management system was the kadakkody. The autocratic functioning of kadakkody gave the fishermen a low profile in the society. With the fishermen going after increasing the size of boats and hiking the engine power the cost of operation has risen very high with less or no beneficial returns. Kerala Government intervention in the form of Matsyafed (The Kerala State Co-operative Federation for Fisheries Development Ltd.) helped the fishermen to get timely assistance for replacement of their fishing inputs and working capital assistance through primary co-operatives for strengthening beach level auction (Nair, 1989). This has helped them to some extend to become owners of craft and gears. The functioning of the society in turn depends on the timely utilization and refunding of the loans and schemes offered. Even then the majority of the fishermen are in the economic traps of tharakans. The temple centered committee of fishermen in the Nattika Valapad region is a good move by them to free them from the exorbitant interest rate for the loan set by the tharakan. Motorization helped the artisanal fishermen to go further deep into the sea. In the older time fishermen were using 2HP engines. Through the years there has been change in the size of the craft and power of the engine used. Now they prefer to use 620 HP Japan made engine and the cost of one such engine alone comes to about 30 lakhs. The fishermen are not concerned about mismatch between the engine power and catch value involved. Artisanal fishermen started practicing unscientific methods of fishing using pair trawlers in the coastal waters. It was seen that majority of the active fishermen are well aware of the destructive effect of pair trawling in the coastal waters but most of them are silent on the matter, blaming the government for not controlling such operations. On probing about the situation it was seen that the government officials are afraid to interfere in the matter due to the rebellious reactions from the fishermen involved. They also blame the loss of biodiversity to the operations of mechanized fishing vessels and foreign chartered vessels charging that these vessels are engaged in the unlawful fishing in the coastal waters during night time. A ray of hope in this situation is the emergence of a group of fishermen who are well aware of the long standing effects of the destructive fishing practices. They have started to act overtly by not allowing boats with fish juveniles to land in the beach landing centres. Such mass movement towards responsible fishing is what is required for sustaining the fisheries and conserving the biodiversity. With the coming of technological advancement there came a revolutionary change in the craft and gear that is being used. Both the mechanized as well as motorized sectors began to operate in full swing. The fishing effort increased disproportionately to the resource potential in the sea. All these resulted in the loss of many varieties of fishes and shrimps. More and more awareness programme has to be organized to educate the fishermen about the consequences of irresponsible fishing methods which will affect their very existence in the fishing industry. From the government side, more force has to be entrusted with the duty of monitoring the fishing activities in the coastal waters and to strictly enforce the punishment for those not complying with the rules and regulations that are set by the fisheries department. There should be strict measures against fishing by those boats that are not registered. By this way a control could be made on the fishing effort in the sea. Fishermen as well as government should stand equally strong in policy and spirit to sustain the fisheries in this region.

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DIVERSITY OF ANTS IN THE COASTAL AGRO- HORTI ECOSYSTEMS OF KARAIKAL DISTRICT, U.T. OF PUDUCHERRY, INDIA.

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ABSTRACT

An investigation was carried out to study the diversity of ants in the coastal Agro-Horti ecosystems of Karaikal district. U. T of Puducherry. Ants were collected in four locations of Karaikal district viz., East and West farms of PAJANCOA and RI, Thirumalairayan pattinam, Thiruvettakudy, and Ambagarathoor. The study indicated that a total of eighteen species of ants viz., Camponotus sericeus (Fabricius), Crematogaster spp., Paratrechinica longicornis (Latreille), Solenopsis geminata (Fabricius), Tapinoma melanocephalum (Fabricius), Tetraponera rufonigra Jerdon, Camponotus compressus Fabricius, Oecophylla smaragdina (Fabricius), Monomorium criniceps Mayr, Monomorium pharaonis (Linnaeus), Myrmicaria brunnea Saunders, Leptogenys processionalis Jerdon, Tetraponera allaborans (Walker), Polyrhachis rastellata Latreille, Aenictus ceylonicus (Mayr), Crematogaster subnuda Mayr. Meranoplus bicolor Guérin-Méneville and Pheidole watsoni Forel were recorded. Among them, seventeen species of ants except Pheidole watsoni were recorded in horticultural ecosystem, but a total of ten species were recorded in agricultural ecosystem. PAJANCOA & RI recorded fifteen species of ants out of eighteen species. A total of seven species of ants were recorded in Thiruvettakudi, Karaikal. The four species of ants, Camponotus compressus, C. sericeus, Aenictus ceylonicus and Crematogaster subnuda were recorded in Thirumalairayan pattinam. Ambagarathur registered C. sericeus, C. compressus, Meranoplus bicolor and Pheidole watsoni species of ants. The two species of ants C. compressus, and C. sericeus were dominant and common in agricultural ecosystem, whereas Oecophylla smaragdina and Tetraponera rufonigra were the dominant species in hroticultural ecosystem. C. compressus, C. sericeus, and P. watsoni were recorded in the agricultural fields of East farm, while other species of ants were recorded in the orchard of West farm of PAJANCOA AND RI, Karaikal.

Key words: Species of ants, different locations, agriculture, horticulture etc..

1. INTRODUCTION

Ants occupy a great variety of habitats in the worldwide. They are eusocial insects with effective chemical communication among them. Their abundance and varied ecological roles make them influential in agricultural ecosystems around the world (Holldobler and Wilson, 1990). Ants originated 145 -168 million years ago and were witness to the extinction of dinosaurs. Since their origin, ants have evolved to become the most dominant creatures in terrestrial ecosystem (Agosti et al., 1997). They constitute 25% of the total animal weight in the tropics. Because of their great adaptability, these creatures have occupied every possible niche or habitat found on land. India is one of the world's most biodiverse regions. The ant fauna includes 12 of the 22 known subfamilies. The current species list includes approximately 600 species from 80 genera and will continue to increase in number as researchers begin to systematically explore the diverse habitats of ants across the region. Ants in India occupy a variety of habitats such as leaf litter, trees, soil, and dead logs, while tramp species prefer human-modified habitats.

The diversity of ants in coastal agricultural and horticultural ecosystems has not studied so far in the Karaikal district of Puducherry. Hence, the present investigation was taken up to study the diversity of ants by surveying them in various locations of the district.

2. MATERIALS AND METHODS

2.1. Weather condition of the study area

The study area is located in coastal area. It has an altitude of 4 m MSL. It has 10°55 N latitude and 79°52 E. It receives water from the mattur dam for kharif and rabi rice crops. The average rain fall of the study area was 1394.25 mm during 2010. It receives rainfall in north east monsoon and south west monsoon. The minimum and maximum temperatures of the study area were 24.5^{o} C and 32.7^{o}C during 2010 and 20.40 ^{o}C and 32.60 ^{o}C during 2011.

2.2. Collection of ants

An aspirator was used to collect the ants over the surface of soil, leaf litters, branches, stems and leaves of trees and plants. The collected individuals were transferred to a potassium cyanide killing bottle to kill them. After killing them, card mounting was done for identification. This was a process by which ants were glued down to the apex of a small triangular strip of paper, in the region between the fore and middle coxae or between the middle and hind coxae ventrally. Finally one pin was pushed through the base of the card and put labels (dry preservation). Rest of the individuals was stored in glass vials containing 70 per cent alcohol (wet preservation) (Agosti et al., 2000). Card mounted individuals were placed in an insect box. Inside the insect box paradichlorobenzene pellets in paper covers with holes were placed, since card mounted ant specimens should be protected from museum pests. All the vials invariably were contained small labels giving details of the locality, date of collection, name of the collector and all other possible information about the species' habitat. Survey was conducted once in a week in different locations of Agri-horticultural fields in the East and West farms of PAJANCOA and RI, Thirumalairayan pattinam, Thiruvettakudy, and Ambagarathoor villages of Karaikal district from November 2010 to April 2011. The collected individuals of ants were identified based on the available taxonomic keys.

3. RESULTS

The study indicated that a total of eighteen species of ants were recorded in the coastal agricultural and horticultural fields of Karaikal district (Table 1). More species of ants were recorded in the West farm of PAJANCOA & RI, Karaikal and horticultural fields of Thiruvettakudi. Among them, two species of ants viz., Camponotus compressus, and C. sericeus were dominant and common in agricultural ecosystem, where as Oecophylla smaragdina and Tetraponera rufonigra were the dominant species in horticultural ecosystem. Among the eighteen species of ants, seventeen species of ants except Pheidole watsoni were recorded in horticultural ecosystem, but a total of ten species were recorded in agricultural ecosystem (Fig 1).

Ants were collected in four sites of Karaikal district. PAJANCOA & RI recorded fifteen species of ants out of eighteen species (Fig.2). C. compressus, C. sericeus, and P. watsoni were recorded in the agricultural fields of East farm, while other species of ants were recorded in the orchard of West farm (Table 2). A total of seven species of ants were recorded in Thiruvettakudi, Karaikal. The four species of ants, C. sericeus, C. compressus, Aenictus ceylonicus and Crematogaster subnuda were recorded in Thirumalairayan pattinam. Ambagarathur registered C. sericeus, C. compressus, Meranoplus bicolor and P. watsoni species of ants.

T. rufonigra was present and recorded on horticultural trees viz., pala (Manilchara exantha) almond (Prunus dulcis), tamarind (Tamarindus indicus), ber (Zizyphus mauritiana), pencil tree (Acacia hotosersia), golden shower (Cassia fistula) and bamboo (Bambusa bambos), where they collected larvae, caterpillars and sucking insects. It was aggressive species found in horticultural ecosystem.

Tetraponera allaborans was collected below the wet leaf litters (Jack leaves) and individuals had movements in wet place of soil. They were moving in between the layer of wet leaf litter to collect foods.

O. smaragdina was recorded on mango (Mangiferae indica), sapota, guava (Psidium gujava), almond (P.dulcis), neem (Azadirachta indica) and pongam (Millettia pinnata) trees especially at East and West farms of PAJANCOA and Thiruvettakudi. They collected caterpillars,termites, dead larvae and insects and nymphs of bugs present on the trees. It was the dominant species among the weaver ants. They constructed more number of nests on mango followed by almond, guava and sapota.

C. compressus and C. sericeus were noticed on mounds present close to the base of pungam and mango trees. They were residing inside the mounds and had movement over the bark and branches of casurina, pongam, ball badmiton (Parkia biglandulosa) trees, rain trees (Samanea saman), golden showers (C.fistula) and neem to collect honey dew secreted by the sucking pests and honey dew in inflorescences. C. compressus and C. sericeus were recorded on castor (Ricinus communis), green gram (Vigna radiata), black gram (Vigna mungo), cow pea (Vigna sinensis), beans (Phaseolus vulgaris), ground nut (Arachis hypogaea), sunflower (Helianthus anus), cotton (Gossypium hirsutum), sesame (Sesamum indicum), sunnhemp (Crotalaria juncea), daincha (Sesbania grandiflora) where they had frequent movement towards inflorescences in order to obtain nectar. In rice ecosystem they moved towards the population of brown planthopper to collect honey dew.

Aenictus ceylonicus was recorded below leaf litter. They were commonly seen foraging underneath leaf litter in moist soil. They had movement underneath the moist leaf litter for foraging.

Paratrechinica longicornis was registered on orchard trees. They feed on dead insects and honey dew excreted by sucking insects. Polyrhachis rastellata was recorded on the stem of mango trees. They had habit of constructing nest by spinning a thin silky web between two or three leaves.

Monomorium criniceps was noticed on the surface of dried soil below tamarind trees in the coastal area (sea shore) of Thiruvettakkudi. They will collect seeds of grasses.

M. Pharaonis was recorded on grasses below the orchard crops. Myrmicaria brunnea was recorded below the dried soils of fruit trees where they had collected honey of sucking insects and dead insects. Solenopsis geminata was observed on soil surface of fruit trees. C. subnuda was recorded on desi badam tree. They were moving to collect honey dew excreted by cow bugs, aphids and other sucking pests. Meranoplus bicolor was registered on banana, desi badam and citrus trees. P. watsoni was recorded on dried soil adjacent to grasses.

Table.1: Diversity of ants in coastal Agro- Horti ecosystems of Karaikal district, U.T. of Puducherry, India

Sl.No.	Species of ants	Agrl.Ecosyst.	Hor.Ecosyst.
1.	Golden backed ant, Camponotus sericeus (Fabricius)	++	+
2.	Black acrobat ant, Crematogaster spp.	-	+
3.	Black crazy ant, Paratrechinica longicornis (Latreille)	+	+
4.	Common red fire ant, Solenopsis geminata (Fabricius)	+	+
5.	Odour ant, Tapinoma melanocephalum (Fabricius)	-	+
6.	Arboreal bicoloured ant, Tetraponera rufonigra Jerdon	+	++
7.	Common godzilla ant, Camponotus compressus Fabricius	++	+
8.	Weaver ant, Oecophylla smaragdina (Fabricius)	-	++
9.	Spineless harvester ant, Monomorium criniceps Mayr	+	+
10.	Pharaoh ant, Monomorium pharaonis (Linnaeus)	+	+
11.	Short-legged Hunchback ant, Myrmicaria brunnea Saunders	+	+
12.	Procession ant, Leptogenys processionalis Jerdon	-	+
13.	Polished leaf-border ant, Tetraponera allaborans (Walker)	-	+
14.	Shiny four star ant, Polyrhachis rastellata Latreille	-	+
15.	Lesser army ant, Aenictus ceylonicus (Mayr)	-	+
16.	Common broad acrobat ant, Crematogaster subnuda Mayr.	-	+
17.	Silky shield ant, Meranoplus bicolor Guérin-Méneville	+	+
18.	Spiny harvester ant, Pheidole watsoni Forel	+	-

++ more abundant, + present, - absent

Table 2: Diversity of ants in the different locations of Karaikal district, U.T.of Puducherry, India.

Sl.No.	Species of ants	PAJANCOA	Thiruvettakudy	T.R. pattinam	Ambagara Thur.
1.	Golden backed ant, Camponotus sericeus (Fabricius)	+	+	+	+
2.	Black acrobat ant, Crematogaster spp.	+	-	-	-
3.	Black crazy ant, Paratrechinica longicornis (Latreille)	+	-	-	-
4.	Common red fire ant, Solenopsis geminata (Fabricius)	+	-	-	-
5.	Odour ant, Tapinoma melanocephalum (Fabricius)	+	-	-	-
6.	Arboreal bicoloured ant, Tetraponera rufonigra Jerdon	+	-	-	-
7.	Common godzilla ant, Camponotus compressus Fabricius	+	+	+	+
8.	Weaver ant, Oecophylla smaragdina (Fabricius)	+	+	-	-
9.	Spineless harvester ant, Monomorium criniceps Mayr	-	+	-	-
10.	Pharaoh ant, Monomorium pharaonis (Linnaeus)	-	+	-	-
11.	Short-legged Hunchback ant, Myrmicaria brunnea Saunders	-	+	-	-
12.	Procession ant, Leptogenys processionalis Jerdon	+	-	-	-
13.	Polished leaf-border ant, Tetraponera allaborans (Walker)	+	-	-	-
14.	Shiny four star ant, Polyrhachis rastellata Latreille	+	+	-	-
15.	Lesser army ant, Aenictus ceylonicus (Mayr)	+	-	+	-
16.	Common broad acrobat ant, Crematogaster subnuda Mayr	+	-	+	-
17.	Silky shield ant, Meranoplus bicolor Guérin-Méneville	+	-	-	+
18.	Spiny harvester ant, Pheidole watsoni Forel	+	-	-	+
	Total	15	7	4	4

+ Present, - absent

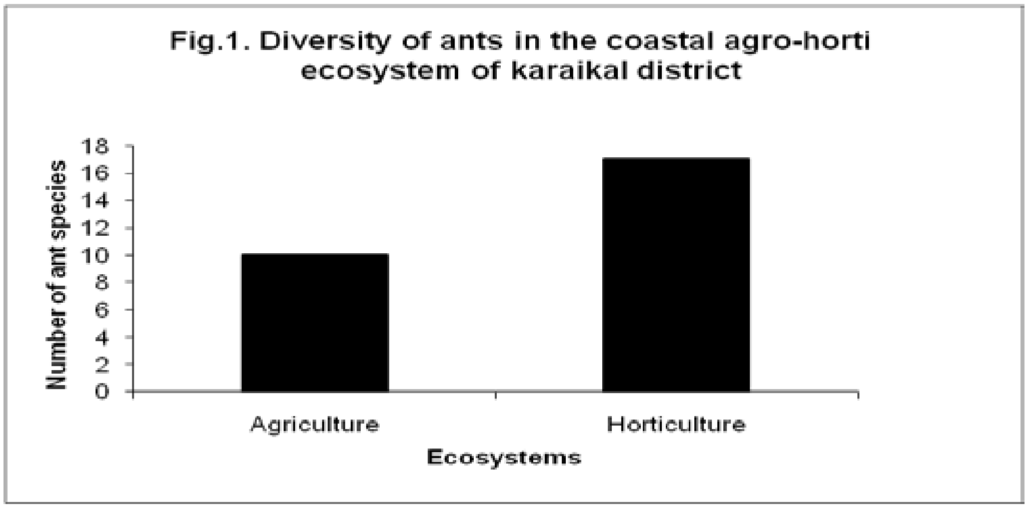

Fig 1: Diversity of ants in the cosatal agro-horti ecosystem in karaikal district.

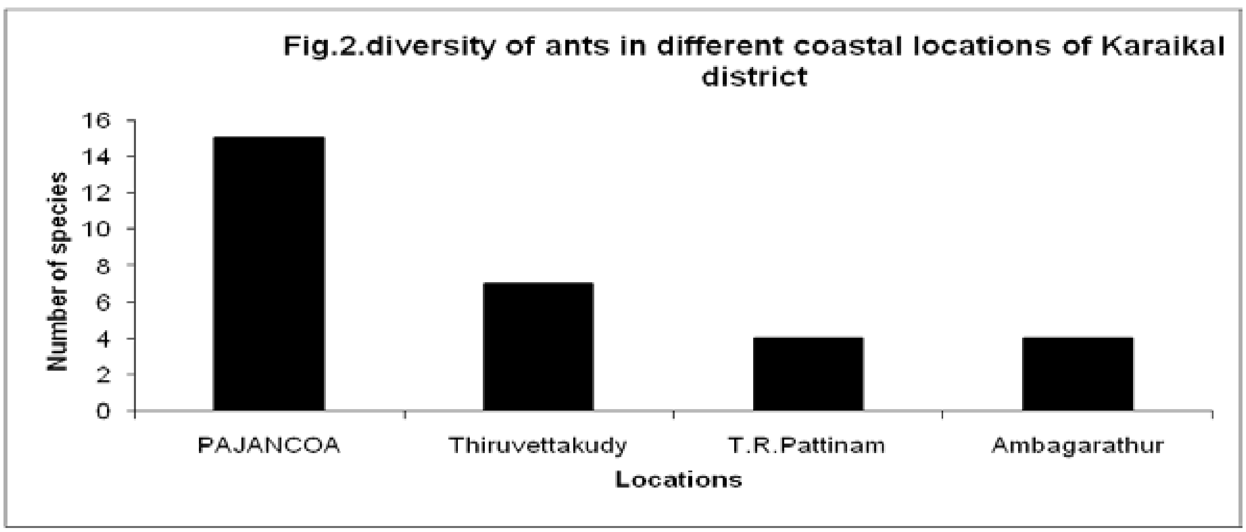

Fig 2: Diversity of ants in different coastla locations of Karaikal district

4. DISCUSSION

Studies were undertaken to know the diversity of ants in the coastal agricultural and horticultural ecosystems of karaikal district, U.T. of Puducherry, since no check-list of ants in the coatal agro-horti ecosystem of Karaikal district was recorded yet.

A total of eighteen species of ants were recorded in the coastal agricultural and horticultural ecosystems of Karaikal district. The diversity of ants was found to be more in the orchard (west farm) of PAJACOA &RI and horticultural fields of Thiruvettakudi, where mango, sapota, citrus, jack, Desi badam, cashew, casurina, rose, Hibiscus, and tamarind were found. This indicated that availability of resources namely larvae, honey secreted by hoppers, mealy bugs, aphids and scale insects and nectars in infloroscences, were more on these trees and plants in these locations. The present statement is true in view of Risch et al. (1983) stated that the diversifying agroecosystem enhances species of ants and other natural enemies and results in agronomic benefits. The Resource Abundance Hypothesis predicts that plants, which offer more resources, have the potential to support more species and greater abundances of insect herbivores (Teragushi et al., 1981; Hunter and Wilmer, 1989; Ohgushi, 1992; Hunter, 1992).

The two species of ants C. compressus, and C. sericeus were present everywhere in agricultural ecosystem. This was the cause that they collected honey dew excreted by sucking insects (mealy bugs, aphids, cow bugs and BPH) and floral nectars on sunflower, green gram, black gram, cowpea, castor, coconut, maize and rice. The above statement is in consonance with the statement of Marques et al. (2000), who stated that plants offered greater quantity of resources, especially flowers had greater species richness and abundance of insects.

Among them, C. compressus, C. sericeus and O. smaragdina were the dominant and common species of ants, since they had more abundance than other species of ants. They had more stability when they had extreme climatic conditions. Risch (1981) stated that stability is usually defined so that it represents low fluctuations in populations over time. Hurd et al. (1971) stated that the stability as the dominance of populations crashes in a community and the abundance of one species is to have little effect on the other species in a stable ecosystem.

O. smaragdina was found to be the dominant species of ants in horticultural ecosystem, because they had more numbers of nests in the leaves of desi badam, mango, neem, sapota and guava trees. The reason for the dominance of this species of ant is in conformity with the observations of Teragushi et al. (1981) and Hunter (1992) that the plant resource could support its abundance. Narendra and Sunilkumar (2004) stated that O. smaragdina will collect larvae, caterpillars and other sucking insects causing damaging on horticultural trees, so number of weaver ant nest is found to be more.

T. rufonigra was present on pala (Manilchara exantha) almond, tamarind, ber, pencil tree, golden shower and bamboo where they collected larvae, caterpillars, termites and sucking insects present on these trees. The reason might be the availability of favourable habitat on these trees, Narendra and Sunilkumar (2004) stated that the arboreal bicoloured ant, T. rufonigra are very aggressive and extremely territorial.

Other species of ants were recorded in isolated places of coastal agro – horti ecosystem. This indicated that the occurrence of these specialist species of ants decided the favourable habit and habitat of location. Ohgushi (1992) explained that rare species of insects occur in a particular place of ecosystem.

Hunter and Wilmer (1989) proposed that the dominant species of ants has little effect on the rare species of insect. This is true in our study that M. bicolor, P. watsoni, C. subnuda, and A. ceylonicus were recorded with less individuals.

Summary

The study concluded that in coastal horticultural ecosystem a total of seventeen species of ants were recorded out of 18 species and a total of ten species were recorded in coastal agricultural ecosystem. C. compressus & C. sericeus were the dominant species in agricultural ecosystem, where as O. smaragdina, T. rufonigra were dominant in horticultural ecosystem.

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STUDY ON REEF FISH DIVERSITY,DISTRIBUTION AND ECOLOGY AT MULLI ISLAND ,GULF OF MANNAR , SOUTH EASTERN INDIA

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1. ABSTRACT

Reef fishes are an important component of marine biodiversity and include species that provide both top down control of reef ecosystems through tropic cascades .This study represents the qualitative census of the reef fish diversity, distribution and ecology of coral reefs in the vicinity of Mulli Island, Gulf of Mannar, Southeast coast of India. Observational data of fish species sightings were collected during September 2013. Four reef sites were fixed for visual census data collection. Belt transect method was used with low observer bias, detailing fish assemblages from the reef zones of the area. Fish density, species diversity, health and biological indicator fishes, percentage cover of habitat structure and fish assemblages were estimated. A total of about 29 species of 21 genera from 18 families were recorded. Abudefduf saxitalis was recorded the highest density with 86 no/ 50 m^2 among the 29 species. The Shannon diversity of reef fishes with highest value was observed in Site -1 as 1.41. Seven species of fishes were observed as biological and health indicators of Montipora sp and Acropora sp. Highest percentage of fish aggregation was observed on Acropora branching forms with 48.82%. Fish density of this island is relatively low due to high levels of aquarium fish trade, trap fishing and other disturbances to reef ecosystem. Improved management of these protected areas coupled with strict enforcement will be the key to protect the reef fish diversity in Mulli Island.

Key words: Reef fishes, Mulli Island. belt transect, shannon diversity.

2. INTRODUCTION

Biodiversity is an important factor in all healthy ecosystems. Coral reef ecosystems support an incredibly diverse community of fish species. Coral reef fish are fish which live in close proximity to coral reefs. They are incredibly diverse, and sometimes hundreds of different species will be found in a very small area of healthy reef. As a result, coral reef fish are considered to be the most diverse assemblage of vertebrates on Earth (Sale & Peter, 2002) As coral reefs are in decline due to a combination of factors such as climate change and over fishing, the species which are being supported by the reef are at risk. In particular, coral reef fish communities have been shown to be in decline. Coral reef fish biodiversity is important for the health and sustainability of the coral reef ecosystem and for the ability for coral reef ecosystems to be able to provide ecosystem services. It has been shown that biodiversity is declining in many ecosystems throughout the world at alarming rates (Singh, 2002). Coral reef are one of the most biologically diverse ecosystems on Earth, and are often compared with the better known tropical rain forest ecosystems, as they both exhibit immense diversity and ecological complexity (Connell, 1978). The extinction of coral reefs would potentially lead to a loss of global biodiversity at a catastrophic scale (Carpenter et al., 2008).

Gulf of Mannar has been known for its rich biodiversity, especially for its coral reefs. The coastal area covering 560 sq. km between Rameswaram and Tuticorin including 21 islands in the Gulf of Mannar were declared as Marine National Park in 1986 by the Government of Tamil Nadu for the purpose of protecting marine wild life and its environment. The Gulf of Mannar Marine Biosphere was declared in 1989 by the Government of India, covering 10,500 sq.km areas between Rameswaram and Kanniyakumari. Reefs in the Gulf of Mannar are developed around the 21 uninhabited islands which are located between latitude 8°47' N and 9°15'N and longitude 78°12'E and 79°14'E and the average distance of these islands from mainland is about 8 km. Pillai (1986) provided a comprehensive account of coral fauna of the Gulf of Mannar and the diversity includes 94 species of 37 genera with most common being Acropora sp., Montipora sp. and Porites sp. and Edward et al. (2007), updated the species list to 117 species of 40 genera. Coral reefs and associated reef fishes of Gulf of Mannar have been damaged severely due to the rampant coral mining which was happening until 2004 (Mahadevan and Nayar 1972). Destructive fishing methods such as trap fishing, near-shore trawling, sedimentation and pollution are causing considerable damage to the coral reefs, threatening the reef fisheries of the Gulf of Mannar (James, 1994; Bakus et al., 2000).

Understanding of the diversity of reef fishes in reef ecosystem is important not only ecologically but economically also. At this juncture, the present study has been taken up with the intentions to assess the reef fish diversity of Mulli island in the Gulf of Mannar.

3. MATERIALS AND METHODS

2.1. Study sites

The assessment of reef fish was carried out in Mulli island of Gulf of Mannar (Fig1). Mulli Island covers an area of 10.20 ha. and it is 9km from Kilakarai. This island is completely covered with tall shrubs and bushes with a swamp. The northern side of the island is studded with massive corals. Eastern side with low fringing reef continues up to 3m depth. The south reef is 1.25km from shore and it extends upto the western side. Observational data of fish species sightings were collected over the course of a year September 2012 and November 2013 at 4 sites (N9 11.492 E78 57.973, N9 11.368 E78 58.261, N9 11.131 E78 57.724, N9 11.023 E78 58.350)

Fig. 1. Map showing Tuticorin group of islands

2.2. Fish assessment - Visual census

The belt transect method (English et al., 1997) was used for visual survey of fishes which involves scuba diving. 50 m transects were laid for the assessment and the number of transects differed from each Island according to the size of the reef. 17 transects were laid totally. To minimize diver impacts, each fish census commenced 15 minutes after the tape is laid out. The fishes were recorded by swimming along each transect within a 50 x 10 m corridor, identifying the species that are found near or at visible distance of each transect. The divers swam slowly and randomly searching for fish species in a dive which lasts for 15 minutes. Diversity, density and size class of the observed fishes were noted in underwater slates. Underwater photographs were taken using Nikon AW100 under water digital camera. Reef fish identification was carried out using fish base identification keys Fish base. 2005 and Reef fish Identification Tropical Pacific Manual (Gerald et al., 2003).

Species diversity was statistically assessed using the Shannon diversity index (H') in natural log. Species richness (S') and evenness (J') were also calculated using statistical software Biodiversity Pro (ver.2).

4. RESULTS

3.1. Fish status:

A total of 29 species of reef fishes belonging to 21 genera from 18 families were recorded in Mulli Island during the study period. Following are the 18 families recorded in the present study, Acanthuridae (2 species), Balistidae (1 species), Carangidae (1 species), Chaetodontidae (2 species), Haemulidae (2 species), Holocentridae (1 species), Labridae (2 species), Lutjanidae (3 species), Pomacanthidae (1 species), Pomacentridae (4 species), Scaridae (1 species), Serranidae (2 species), Gobiidae (1 species), Siganidae (2 species) Mullidae (1 species), Nemipteridae (1 species), Pempheridae (1 species), Leiognathidae (1 species). Details are given in the table 1.

In this island, overall density was about 1610 no/ 50 m^2. Among the four sites most diverse in reef fishes with total density 567 in site-1 and lowest fish density was observed at site 4 with 242 while as sites 2 and 3 were having total density of 423 and 378 no/ 50 m^2 respectively (Fig 2). Densities of each species in each sites are given in the table 1. Abudeduf saxitalis followed by Paraupeneus indicus and Lutjanus decussates were the dominant fish species found with the densities of 86, 85 and 84 no/50 m^2 respectively.

Table 1: Fish abundance and Relative abundance (RA) and Frequency of appearance (FA) in Mulli Island

S.No	Species	Family	Site 1	Site 2	Site 3	Site 4	Total Density	FA	RA
1	Acanthurus mata	Acanthuridae	0	11	8	4	23	1.43	75
2	Acanthurus lineatus	Acanthuridae	23	15	16	12	66	4.10	100
3	Balistoides viridescens	Balistidae	21	16	15	10	62	3.85	100
4	Gnathodon speciosus	Carangidae	24	18	0	0	42	2.61	50
5	Chaetodon octofasciatus	Chaetodontidae	22	20	15	12	69	4.29	100
6	Chaetodon decussatus	Chaetodontidae	20	19	16	8	63	3.91	100
7	Plectrohinchus orientalis	Haemulidae	24	20	20	9	73	4.53	100
8	Diagramma pictum	Haemulidae	28	0	19	14	61	3.79	75
9	Sargocentron rubrum	Holocentridae	0	15	18	10	43	2.67	75
10	Bathygobius laddi	Gobiidae	19	12	0	12	43	2.67	75
11	Thalassoma lunare	Labridae	17	10	22	14	63	3.91	100
12	Thalassoma purpureum	Labridae	19	12	15	9	55	3.42	100
13	Lutjanus decussatus	Lutjanidae	26	24	20	14	84	5.28	100
14	Lutjanus lutjanus	Lutjanidae	23	15	18	10	66	4.10	100
15	Lutjanus malabaricus	Lutjanidae	16	13	16	0	45	2.80	75
16	Leiognathus sp.	Leiognathidae	28	24	18	14	84	5.22	100
17	Paraupeneus indicus	Mullidae	30	22	18	15	85	5.71	100
18	Pempheris vanicolensis	Pempheridae	24	18	0	0	42	2.61	50
19	Pomacanthus imperator	Pomacanthidae	21	15	11	7	54	3.35	100
20	Amphiprion sebae	Pomacentridae	8	0	4	0	12	0.75	50
21	Dascyllus sp	Pomacentridae	15	11	8	4	38	2.36	100
22	Amphiprion clarkii	Pomacentridae	13	8	0	0	21	1.30	50
23	Abudeduf saxitalis	Pomacentridae	28	24	19	15	86	5.34	100
24	Scarus ghibbus	Scaridae	22	17	20	8	67	4.16	100
25	Epinephelus malabaricus	Serranidae	17	11	16	5	49	3.04	100
26	Epinephelus formosa	Serranidae	25	20	20	14	79	4.91	100
27	Siganus canaliculatus	Siganidae	12	8	6	2	28	1.74	100
28	Siganus lineatus	Siganidae	15	10	8	10	43	2.67	100
29	Scolopsis vosmeri	Nemipteridae	20	15	12	9	56	3.48	100

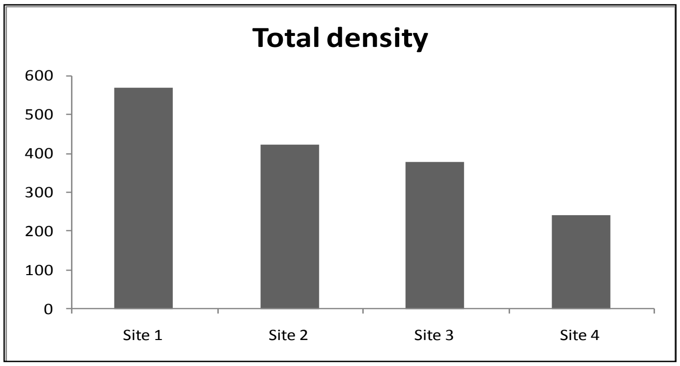

Fig 2: Total density results

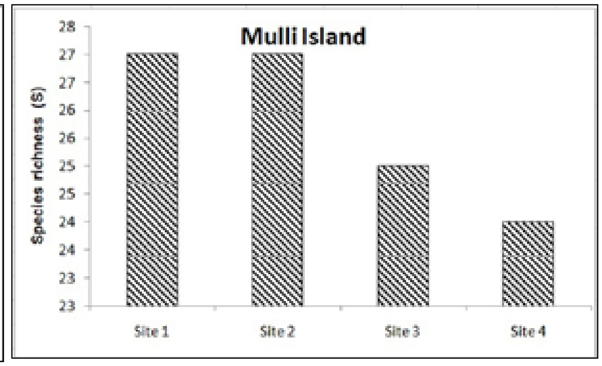

Fig 5: Species richness of reef fishes

2.3. Diversity index

In Mulli Island, the Shannon diversity of reef fishes with highest value was observed in site 1 as 1.41, and the lowest value was observed in site 4 as 1.33. Analysis of Species richness of reef fishes in this island revealed highest value in site 1 and 2 as 27, and lowest value appeared to be as 24 in site 4. Evenness of the reef fish assessment revealed the highest value at Site 1, and 2 as 0.99 and the lowest value was observed at site 3and 4 as 0.98 (Fig.3-5).

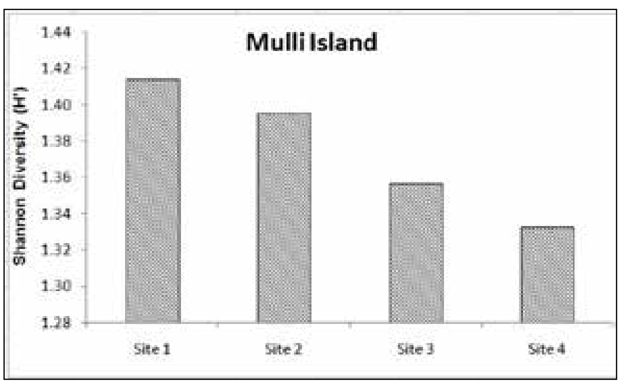

Fig 3: Shannon diversity of reef fishes

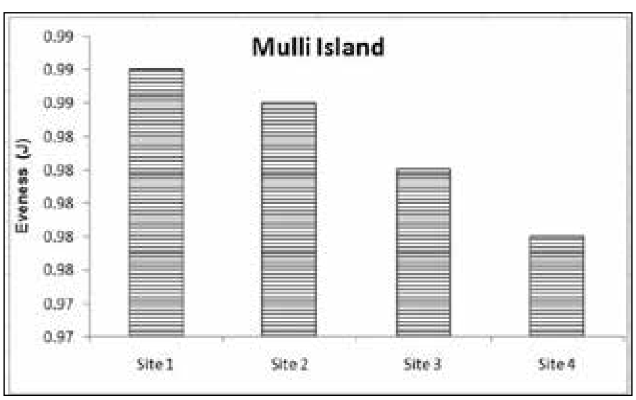

Fig 4: Evenness of the reef fishes

2.4. Health and biological indicator fishes

From the Study, 7 species of fishes were observed as biological and health indicators of 2 coral genera. Visual assessment of Coral and fish community structure in this island revealed that, the fish species Chaetodon octofasciatus, Scarus gibbus and Plectrohinchus orientalis were found dominantly associated to the coral species Acropora sp. and Montipora sp (Table 2).

Table 2: Health and biological indicator fish list

Mulli island	Coral genera
Family - Chaetodontidae	Acropora sp
Chaetodon octofasciatus	
Chaetodon decussatus	
Family - Serranidae	Acropora sp
Epinepheleus formosa	
Family- Scaridae	Montipora sp and Acropora sp
Scarus gibbus	
Family-Haemulidae	Acropora sp
Plectrohinchus orientalis	
Family-Labridae	
Thalassoma lunare	
Thalassoma purpureum	

2.5. Habitat structure and fish assemblages

Habitat structure has been determined by visual assessment of reef fish aggregations in different benthic substratum. The study revealed that the Acropora branching coral forms were observed with higher fish aggregation ranges about 48.82 %

followed by coral massive forms with 42.80%, followed by Dead coral with algae, dead coral and rubbles with 5.53, 1.49 and 1.37% respectively (Fig. 6).

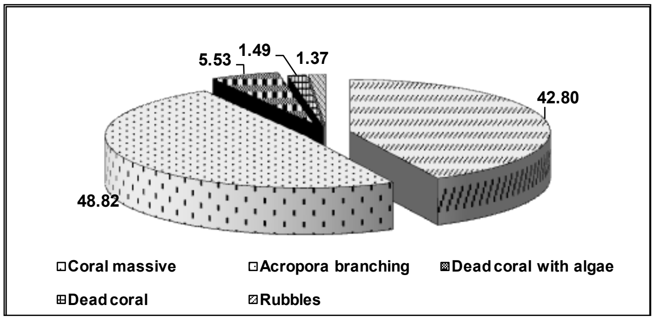

Fig. 6: Coral Structural complexity for fish aagregation in Mulli Island

5. DISCUSSION

There are numerous reports on the coral reefs and reef associated resources of Gulf of Mannar, however predominantly from the Mandapam coast and on taxonomic aspects (Pillai, 1971, 1972, 1977, 1994 and 1996), and more comprehensive baseline information on the area has been lacking. However, in spite of being so vital for the local population, reef fish communities in the Gulf of Mannar are the least studied part of the ecosystem. This study indicates the quantitative assessment of reef fish diversity in Mulli Island and the study was aimed on density, species diversity, health and biological indicator fishes, percentage cover of habitat structure and fish assemblages. In the current study, about 29 species from 18 families were reported; this evidences the average habitat complexity with low diversity of reef fishes in this island. Reef fishes are strongly influenced by the structure of their habitat, with more complex coral reefs generally supporting more fish (Sedberry and Carter, 1993; Nagelkerken et al., 2000; and Mateo & Tobias, 2001). Pereira 2000 reported about 94 reef-associated fishes known to occur in Mozambican coral and rocky reefs and this is a first accountancy of the high fish diversity of Mozambican reefs assessed. Fowler 1981 reported a total of 334 species over the year of sampling in Madagascar, Western Indian Ocean and the total species numbers are considerably higher than those found in this study. Results from a literature review also indicate that remarkably little is known about diversity of these coral reef fishes.

Shannon diversity, Pleiou's Eveness and Richness of reef fish diversity in this island was analysed with range of 1.33 to 1.41, 0.98 to 0.99, and 24 to 27 respectively. Results presented herein indicates higher reef fish species richness in areas with high live coral cover, as well as areas with less coral cover indicates less fish diversity. This shows that habitat variables play a substantial role in the enhancement of fish diversity. Fish-habitat correlations from various regions (Caribbean, Southeast Asia and Great Barrier Reef) show significant relationship between structural complexity and reef fish diversity (Risk, 1972; Luckhurst & Luckhurst 1978; Carpenter et al., 1981; McCormick, 1994). Total number of fishes was highest in Site 1 with 567, whereas least was observed with range of 242 in site 2. According to Harmelin –Vivien (1979), observed carnivore levels on a healthy reef are usually between 60-80%, depending on the geographic location. Habitat structure has been determined by visual assessment of reef fish aggregations in different benthic substratum. The fish species that belong to family Chaetodontidae, which is generally used as bioindicators of health of the coral and habitat disturbances, were also represented in good number on the reef (Roberts and Ormond, 1987).

Coral Structural complexity study revealed that the Acropora branching coral forms were observed with higher fish aggregation ranges about 48.82 % followed by coral massive forms with 42.80%. This proves that the distribution patterns of reef fishes have been related to available shelter and food (Williams 1991, Sheppard et al., 1992, Ohman et al., 1993). Refuges may positively influence prey abundance (Hixon and Beets, 1993) and the smaller reef fishes rely on branching corals for protection (Sale, 1972).

The findings of the current study proves the complex coral habitat structures and reef fish diversity – Species richness and abundance of Mulli Island may be in declination with influence of anthropogenic activities and climate change and special attention is needed for the management and conservation of these precious ecosystems in Gulf of

Mannar

6. ACKNOWLEDGEMENT

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INTERFAMILIAL AFFINITY IN SILURIFORMES OF WESTERN GHATS BASED ON MITOCHONDRIAL 16 SRRNA AND CO1 GENES.

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ABSTRACT

The devastating species diversity and the extensive biogeographical allocation of catfishes (order- Siluriformes) with 3023 species under 38 extant families make them third most diverse vertebrate order. Asia including the sub-continent India is a home to 14 families and the Western Ghats, the biodiversity hotspot, to nine families with 52 species. Recently one of the challenging and intriguing problems in ichthyology is the higher level systematics of order Siluriformes which seems to be the most complex among Ostariophysians. There are two major schemes for Silurian systematics-Nelson's classification based on morphological characters and Sullivan's taxonomic or phylogenetic scheme supported on molecular data. A few literatures on the freshwater catfishes of India are obtainable as in the form of checklists as well as books focusing morphological variations and molecular research works particularly concentrating the populational or species level systematics. Better perceptive of higher level systematics including inter familial relationships can be made by exploring information gathered on traditional morphological as well as through recent molecular analytical techniques. Sequences of Mitochondrial genes have much informative potential in phylogenic studies. The present study is simply an initiative approach to investigate interfamilial relationship of catfish families in India at molecular level. The partial sequencing of approximately 600 base fragments of mitochondrial 16 S rRNA genes and Cytochrome C oxidase subunit 1 genes of 11 representative species from 7families inhabiting the water realms of Western Ghats were done. The families selected for the study were Heteropnuestidae, Bagridae, Pangasidae, Siluridae, Ariidae, Sisoridae, Horabagridae. The total genomic DNA from the tissue samples of fin clips of live specimens were extracted by using salting out protocol of Miller and amplified using specific primers of Ward et al.,2005 and sequenced in the sequencing facility in MWG Biotech, Banglore. The sequences were edited using BIOEDIT sequence Alignment Version 7.0.5.2 and aligned using CLUSTAL X. The phylogenies were computed by pair wise geneic distance based methods like Neighbor Joining (NJ) and Maximum Parsimony (MP) tree. For estimating genetic divergence among the selected species Kimura Two parameter method was adopted using software program MEGA version 3.1. The NJ and MP trees obtained demonstrate- the monophyly of the fresh water families, the occurrence of two close affinity groups i.e one with the families Horabagridae, Bagridae, Pangasidae and the other with Heteropnuestuidae, Sisoridae and Siluridae, a separate cluster for marine family Aridae and clustering of members at intra generic level as in Horabagridae or Heteropnuestidae. The 16SrRNA and CO1 display very similar pattern of heterogeneity and species structuring patterns. This study reveals that the mitochondrial gene sequences contain sufficient phylogenic signals that will be useful for both species identification and revealing interfamilial affinities in Siluriformes of Western Ghats.

Key words: Catfishes, cytochrome c oxidase, systematics, horabagridae, heteropnuestuidae

1. INTRODUCTON

Teleostan fishes include about 28000 species which is nearly 51% of the 54,711 recognized extant vertebrate species (Nelson, 2006). Within Teleostei, Ostariophysi is the second largest super order with five orders Gonorynchiformes, Cypriniformes, Characiformes, Siluriformes and Gymnotiformes comprising about the 93% of the fresh water fishes (Berra, 2001). The order Siluriformes, known by the English common name of catfishes, form a well diagnosed natural group of primarily freshwater fishes constituting 1/3 of the global freshwater fish fauna (Briggs, 1979). The enormous ecological and evolutionary diversity of the group as well as the restriction of most of the members to fresh water has made this group a focus of research in evolution and biogeography. As of 2007, there are about 38 extant catfish families, and about 3,023 extant species have been described, which makes the catfish order the third most diverse vertebrate order (Sullivan et al., 2006; Ferraris, 2007) representing an important component of the global fish fauna. When considering the biogeographical allocation, the Neotropical Region dominates with Siluriformes followed by the Ethiopian, Oriental, Nearctic and Palearctic regions respectively. Asia, including the subcontinent of India is home to a wide variety of catfishes. Of the 38 Siluriform families 14 (Cranoglanididae, Siluridae, Schilbeidae, Clariidae, Akysidae, Amblycipitidae, Heteropneustidae, Parakysidae, Chacidae, Pangasiidae, Ariidae, Sisoridae, Horabagridae and Bagridae) are found in the Indian region: Bangladesh, India, Myanmar, Nepal, Pakistan and Sri Lanka, represented by 52 genera (Jayaram, 2007). Freshwater catfishes of the Western Ghats are represented by 8 families and about 52 species. Family Bagridae comprise most of the species (20) followed by Sisoridae (14), Schilbeidae (7), Siluridae (6), Clariidae (4), Heteropneustidae (2), Horabagridae (2) and Pangasidae (1) respectively. Of the 52 species of Siluroid reported from Western Ghats region, 30 species within seven families are found in the streams and rivers of Kerala (Jayaram2007). Seven species are endemic to rivers originating from the Kerala part of Western Ghats embracing the sole genera Horabagrus.

Knowledge of historical biogeography and phylogeny of Siluriformes in Indian region is seriously limited. Information about the interrelationship at generic level based only on morphology or numerical taxonomy are dealt by Day (1865 & 1871) Hora (1941) and Jayaram (1968) in their account on fresh water fishes. Misra (1976) published a detailed account on the catfish fauna of India and adjacent countries. Jayaram (1954), Jayaram (1977) and Jayaram & Sanyal (2003) contributed to the knowledge of Indian catfishes through their systematic revisions especially on the family Bagridae and Tachysuridae. Later the contributions on Indian Siluroid taxonomy were done by Menon (1999) through his "Checklist of the freshwater fishes of India". The recent, up-to-date and exclusive literature on freshwater catfishes of India is done by Jayaram (2006) through his book "Catfishes of India". In the phylogenetics or systematics at higher level taxa of Siluriformes by de Pinna (1993), Hardman (2005) and Sullivan et al. (2006) have included almost all families appearing universally with a representation of fewer native species found in India. De Pinna (1993) analyzed 239 morphological characters from 400 catfish species representing 33 families. The work of Hardman (2005) has concentrated to resolve the phylogenic position of the family Ictaluridae in relation to its sister taxa, Mo's (1991) study focused on the relationships among bagrid catfishes as inferred from 126 morphological characters drawn from 214 species in 30 families. The exclusive molecular phylogenic work of Sullivan et al. (2006) based on rag gene have been subject to many criticisms and arouse questions on the taxonomic status of many families of the Asian region. The phylogenic assumptions at different level of taxa such as interfamilial relationships, evolutionary and biogeographical distribution of Siluriform members found in Western Ghats have not been available in many works. Thus further research is needed to ascertain the systematic positions and status of the catfish families or genera and clarify taxonomic ambiguity regarding the Siluriformes found in Western Ghats.

The objective of the work is to obtain molecular information about at least a representative species of each Siluriform family present in Western Ghats. The major conservation uses of mt DNA are resolving taxonomic uncertainties, defining management units, and helping to understand important aspects of species biology. By sequencing the mitochondrial genes - 16S rRNA and Cytochrome Oxidase Subunit One (CO1) genes of 11 species, documentation of the results and using bioinformatic tools, the study aims to reveal the interfamilial affinity of Westen Ghats Siluriformes. With the help of most advanced and reliable techniques of molecular biology, genetics the work aim to resolve taxonomic controversy regarding the members of family Horabagridae and Heteropnuestidae.

2. MATERIALS AND METHODS

2.1. Collection of samples, DNA Isolation:

Fin clips of 11 representative species as of 7 families (table.1) were collected from the Western Ghats water realms were preserved in 75–95% ethanol. The total genomic DNA were salted out as per Miller et al., 1988 protocol in 50mM Tris-HCl-pH8.0 20mM

EDTA-pH8.0, 2%SDS, Proteinase-K (20mg/ml)-6M NaCl at 55^{0}C. DNA samples were analyzed on 0.7% Agarose Gel (containing Ethidium Bromide) Electrophoresis.

Table 1: Details of the species collected for the study:

Name of the Species	Family	Area of collection	Code used
Horabagrus brachysoma	Horabagridae	Pampa	H B
Horabagrus nigricollaris		Vettilappara,Chalakkudy	HN
Heteropnuesteus fossilis	Heteropnuestidae	Pampa	HF
Heteropnuesteus microps		Thamarabharani	HM
Mystus occulatus	Bagridae (Schillbidae)	Chalakkudy	MO
Psuedotropius mitchelli		Periyar	PM
Glyptothorax annandeili	Sisoridae	Chalakkudy	BT
Ompok malabaricus	Siiluridae	Achenkovil	OM
Wallago attu		Chalakudy	WA
Arius arius	Ariidae	Vembanad Lake	AM
Pangasius suchi	Pangasidae	Aquarium Shop, Cochin	PS

2.2. PCR amplification and Sequencing

Approximately 600 base fragments of the mitochondrial 16S rRNA and Cytochrome c Oxidase subunit 1 (COI) genes were amplified from samples using 1µl of the DNA extract as a template and available primers for 16S rRNA gene (Palumbi et al.,1991) and COI (Ward et al., 2005) in BIORAD I Cycler i-Q5 Real time PCR.. The amplifications were performed in 25µl reactions containing 1x assay buffer (100mM Tris, 500mM KCl, 0.1% gelatin, pH 9.0) with 1.5mM $MgCl_2$ (Genei, Bangalore, India), 10 p moles/µL of primer mix, 10 mM dNTPs (Genei, Bangalore, India), 1.5 U Taq DNA polymerase and 20 ng of template DNA..Initially denaturation was performed at 95^{o}C for 5 minutes followed by 29 cycles (denaturation at 94^{o}C for 45 seconds, annealing at 50^{o}C (for 16S) or 54^{o}C (for COI) for 30 seconds and 72^o C for 45 seconds a final extension at 72^o C for 5 minutes. The PCR products and 100bp DNA ladder (Genei, Bangalore, India) were electrophoresed on a 1.5% agarose gel (in 1 X TBE) for 30 minutes. The gel was then visualized under a UV transilluminator and documented by the unit BIORAD, USA. The remaining PCR product was cleaned using GeNei™ Quick PCR purification kit (Genei, Bangalore, India) and then sent to the sequencing facility in MWG Oligotech, India.

2.3. Data analysis

The DNA sequences of the selected species were edited using BIOEDIT (Hall, 1999) and aligned using CLUSTAL X as implemented in BIOEDIT sequence alignment editor version 7.0.5.2 and were used to estimate genetic divergence values and for constructing phylogenic trees (Neighbor Joining 'NJ' and Maximum Parsimony 'MP') using MEGA 3.1 (Kumar et al., 2004). The extent of sequence difference between individuals was calculated by averaging pair wise comparisons of sequence difference along all individuals. Pairwise evolutionary distances among the haplotypes were determined by the Kimura-2-Parameter (K2P) method (Kimura, 1980) using the software program MEGA version 3.1 (Kumar et al., 2004). The data set was bootstrapped 1000 times to estimate the internal stability of the tree nodes.

3. RESULT

3.1. Quantification and Purity of DNA

During spectrophotometric analysis at wavelength 260nm and 280nm, the Optical Density ratio appeared between 1.7 and 1.9 indicating the purity of DNA without contamination of protein and RNA. A total of 513 base pairs of aligned sequences of 16S rRNA gene and 560 nucleotides of COI were used for analysis in 11 Siluriform species from seven different families. 16S and CO1 Sequences representing 11 species were submitted to the nucleotide database of GenBank (www.ncbi.nlm.nih.gov) and got accession numbers (reference).In general, the nucleotide sequences were more variable in protein coding regions than in rRNA gene regions. Alignment of sequence was simple and unambiguous for both the genes. The NJ and MP analytical methods provided virtually identical trees and many clades were established with strong tree-support values (Fig.1-4). Nucleotide-sequence divergences were calculated using the Kimura-two-parameter (K2P) model, the best metric when distances are low (Nei and Kumar, 2000) as in this study. 'Indels' (insertions/deletions) or 'gaps' during aligning the sequences were treated as "fifth character". Kimura-2-parameter method was identified as the mutational model in the present study to accommodate higher rate of transitions that is generally observed in teleosts. The sequence data of Arius maculatus was used as out group. The phylogenic trees supported monophyly of the Siluriform species in relation to the out-group species used in this study. The plotted observations indicated that transitions continue to outnumber transversions, even in the comparisons between the ingroup and the outgroups in both cases (table 2 &3).

Table 2: Observed transition transversion ratio of mitochondrial genes]

Species code	16 S Gene					CO1 Gene				
	T	C	A	G	Total	T	C	A	G	Total
WA3	21.3	25.2	30.4	23.1	503	28.9	30.7	23.7	16.8	561
WA1	21.1	25.2	30.8	22.9	503	28.9	30.7	23.7	16.8	561
MO2	21.2	25.9	30.9	22.0	499	30.5	28.2	25.8	15.5	561
MO1	21.2	25.9	30.9	22.0	499	30.5	28.2	25.8	15.5	561
AM1	21.6	25.2	30.8	22.4	504	29.2	30.1	25.5	15.2	561
OM3	21.6	25.2	30.8	22.4	504	28.3	31.0	23.7	16.9	561
OM2	21.4	25.4	30.6	22.6	504	28.3	31.0	23.7	16.9	561
HM1	21.4	25.4	30.8	22.4	504	29.2	30.3	25.3	15.2	561
HF2	21.8	26.2	29.0	23.0	504	28.0	31.0	23.5	17.5	561
HN1	21.8	26.4	29.0	22.8	504	30.3	27.5	23.5	18.7	561
HN2	22.1	26.0	29.6	22.3	503	30.4	27.7	24.6	16.2	561
PM1	22.1	25.8	29.8	22.3	503	25.1	32.8	24.8	17.3	561
HB1	22.6	25.0	30.6	21.8	504	30.5	28.7	24.6	16.2	561
HB2	22.4	25.2	30.6	21.8	504	29.2	30.7	22.8	17.3	561
GA1	22.5	24.1	30.6	22.9	507	28.0	31.0	23.5	17.5	561
PS1	20.7	23.8	32.5	23.0	474	25.1	32.6	25.0	17.3	561
PS2	23.3	24.1	29.7	22.9	498	25.2	32.4	25.1	17.3	561
Avg.	21.8	25.3	30.3	22.7	501.9	28.9	30.0	24.3	16.7	561

Table 3: Maximum Composite Likelihood Estimate of the Pattern of Nucleotide Substitution.

	CO1 GENE				16 S GENE				
Base	A	T	C	G		A	T	C	G
A	-	5.1	4.6	14.92	A	-	3.27	3.5	9.79
T	4.41	-	13.48	2.91	T	4.44	-	24.79	3.27
C	4.41	14.95	-	2.91	C	4.44	23.18	-	3.27
G	22.62	5.1	4.6	-	G	13.27	3.27	3.5	-

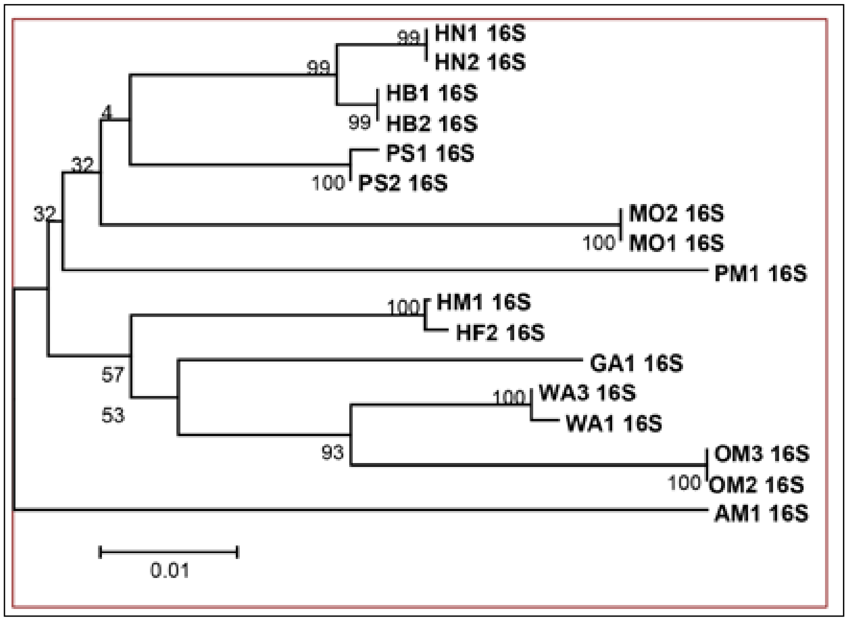

Fig 1: Maximum Parsimony tree for mitochondrial 16S gene o f Western Ghats Siluriformes

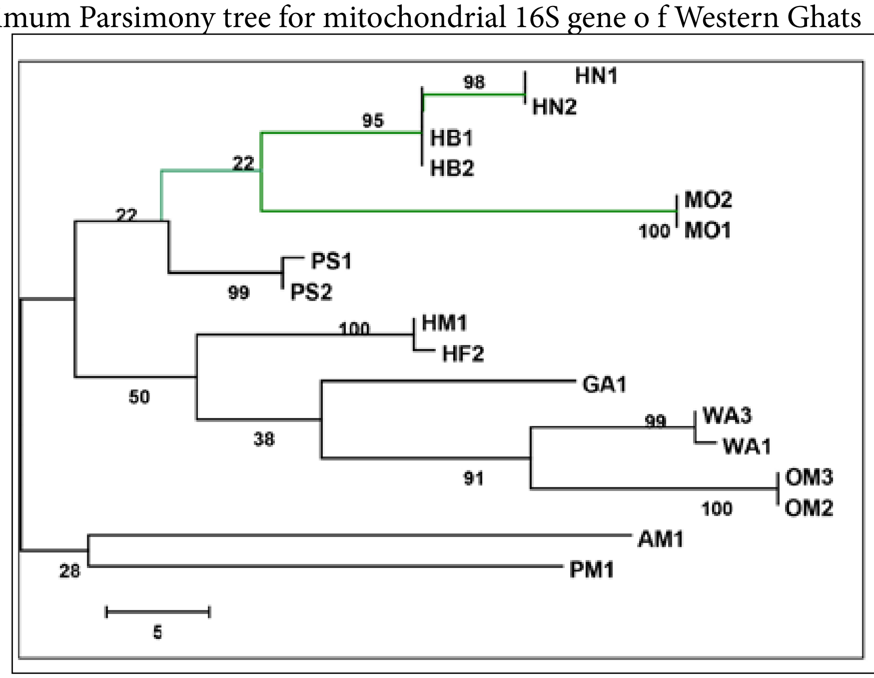

Fig 2: Neighbor Joining tree for mitochondrial 16S gene o f Western Ghats Siluriformes.

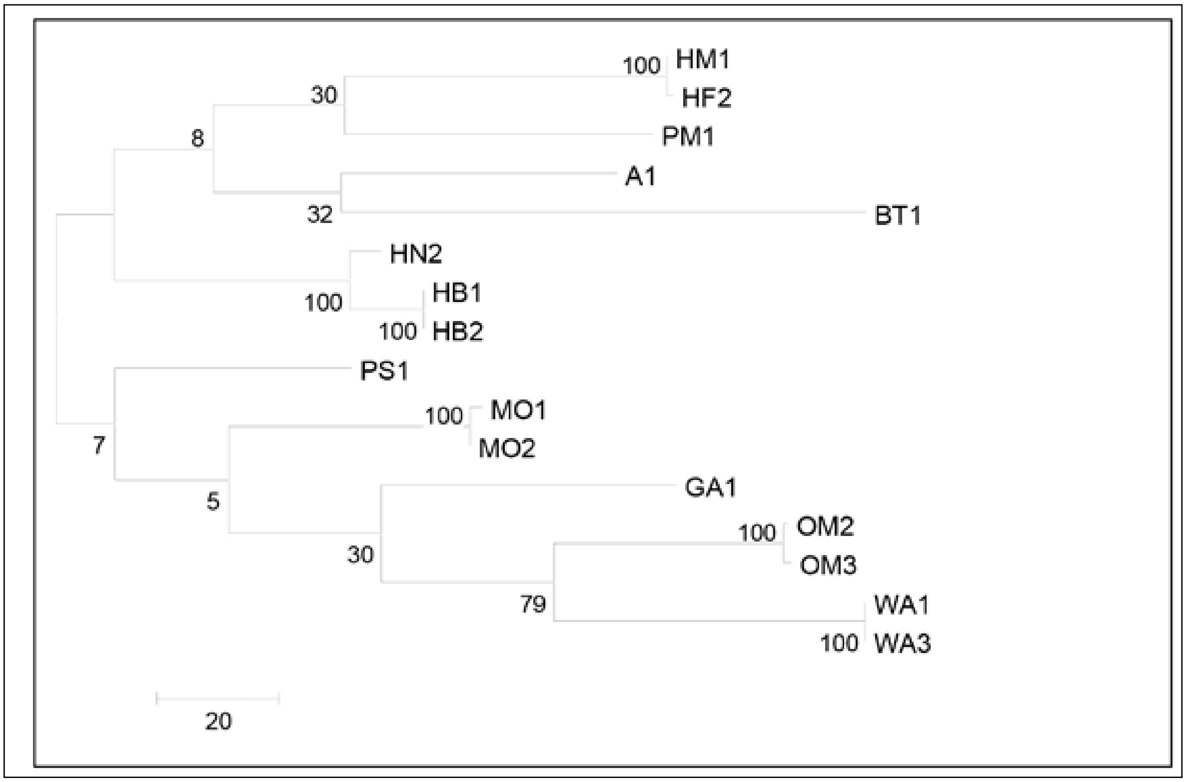

Fig 3: MP tree for CO1 gene of Western Ghats Siluriformes.

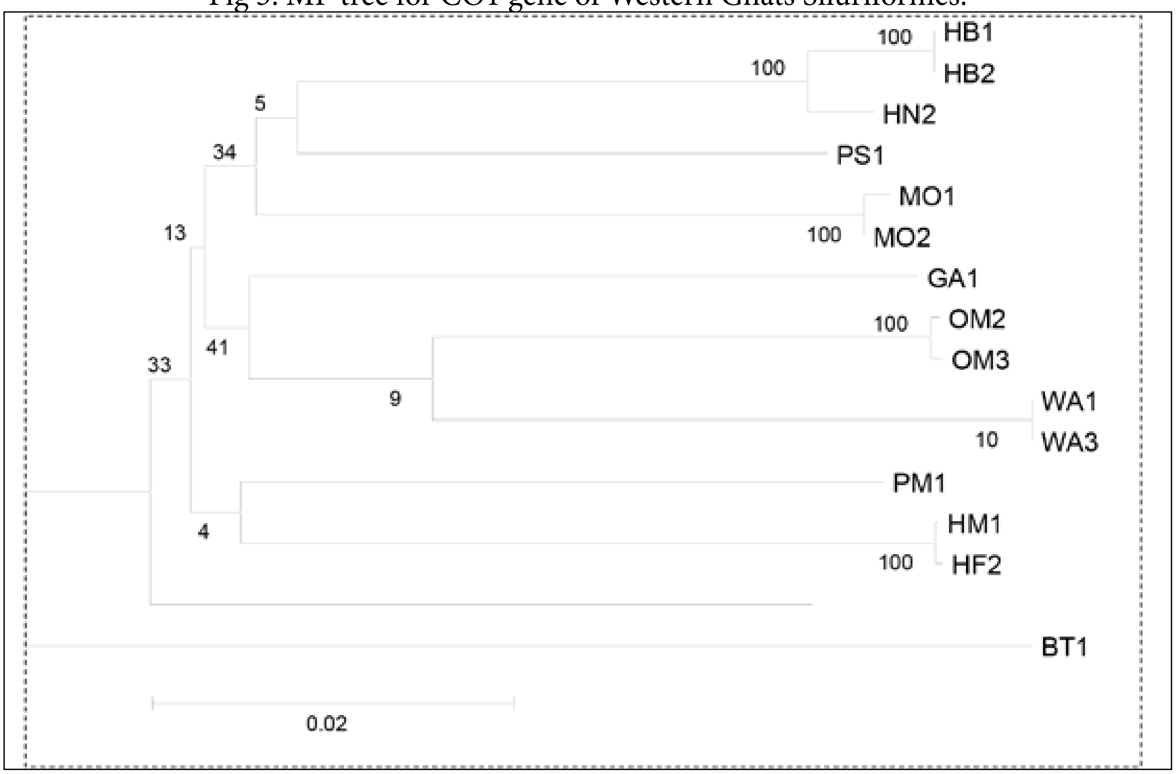

Fig 4: NJ tree for CO1 geneof Western Ghats Siluriformes

3.2. Sequencing of 16S rRNA gene

It produced an average of 550 nucleotide base pairs per taxon. Multiple alignments resulted in a consensus length of 535 sites including base pairs and gaps. This alignment consisted of 535 positions, of which 79 were parsimony informative. The average nucleotide composition (Table4) for 16S was 30.3% A, 21.8% T, 25.2% C, and 22.7% G. Observed transitions and transversions were plotted for all comparisons(table3,5) The MP (Fig.1) and NJ (Fig.2) trees revealed almost identical phylogenetic relationship among the species. Two major clusters were obtained with the first cluster formed by the families Horabagridae, Pangasidae and Bagridae. The second cluster was formed by Heteropnuestidae, Siluridae and Sisoridae. But in MP analysis, Pseudeutropius also forms a cluster with the out- group Ariidae.. In both the trees, these clusters were supported by high bootstrap values. The transition/ transversion rate ratios are $k_1 = 2.99$ (purines) and $k_2 = 7.08$ (pyrimidines). The overall transition/transversion bias was observed to be: R = 2.21 (Table 2)

Table 4: Primers used

Gene	Primer-sequence5'-3'
COI	16SAR-CGCCTGTTTATCAAAAACAT 16SBR-CCGGTCTGAACTCAGATCACGT
16S rRNA	FISH F1-TCAACCAACCACAAAGA-CATTGGCAC FISH F2-TCGACTAATCATAAAGATATCG-GCAC FISHR1-TAGACTTCTGGGTGGC-CAAAGAATCA FISH R2-ACTTCAGGGTGACCGAAGAAT-CAGAA

3.3. Result for COI Gene

Sequencing of the COI gene produced an average of 630 nucleotide base pairs per taxon. Multiple alignments resulted in a consensus length of 616 sites including base pairs and gaps. This alignment consisted of 616 positions, of which 200 were parsimony informative. The average nucleotide composition (Table 5.) was 24.3 % (A), 28.9% (T/U), 30.3% (C), and 16.7% (G). The transition/transversion rate ratios were $k_1 = 5.131$ (purines) and $k_2 = 2.93$ (pyrimidines). The overall transition/transversions bias observed was R = 1.74. Observed transitions and transversions were plotted for all comparisons (Table2). The average nucleotide composition at the first codon position was 36.5% (A), 29.6% (T/U), 25.0% (C), and 8.9% (G), at the second codon position it was 26.9% (A), 18.2% (T/U), 26.1% (C), and 28.7% (G), and at the third codon position it was 30.2% (A), 42.3% (T/U), 14.1% (C), and 13.5% (G). The MP (Fig.3) and NJ (Fig.4) trees revealed almost identical phylogenetic relationship among the families. In NJ tree, two major clusters were obtained with the first cluster formed by Horabagridae, Bagridae and Pangasidae, the second cluster was formed by Heteropnuestidae, Psueotropius, Sisoridae and Siluridae. In MP tree, two major clusters were obtained with the first cluster formed by Horabagridae, Bagridae, Pangasidae, Sisoridae and Siluridae The second cluster was formed by Heteropnuestidae and Psuedotropius. In both the trees, these clusters were supported by high bootstrap values.

Table 5: Transition transversion ratio for the COI gene

Domain	Ii	Si	Sv	R	TT	TC	TA	TG	CT	CC	CA	CG	AT	AC	AA	AG	GT	GC	GA	GG	TDI
1.avg 16 S	502.00	22.00	11.00	2.05	112.00	8.00	2.00	0.00	6.00	119.00	3.00	0.00	2.00	4.00	155.00	4.00	0.00	0.00	5.00	116.00	535.59
1.avg CO1	513	64	40	1.6	152	24	8	1	22	135	7 .0	2	9.00	7.00	134.00	8.00	3.00	3.00	11	91	616.8

4. DISCUSSION

Mitochondrial DNA is commonly used in population and phylogenetic studies due to its maternal mode of inheritance, relative lack of recombination, self-replicating nature and possess generally about 16-kb-long, circular DNA molecule that codes for 13 mitochondrial proteins, 22 mitochondrial tRNAs, and two mitochondrial specific ribosomal RNAs: the 12S and 16S rRNAs (Zuogang et al., 2006). From the evolutionary viewpoint, mtDNAs are "small genomes" that co-evolve at their own rate with the organism. The phylogenetic performance of the mtDNA as COI can be considered as the best individual genes for reconstructing higher-level relationships among major otophysan fish lineages. In the two globally popular taxonomic schemes of Siluriformes- Nelson in his book, Fishes of the world (2006) deals with a classification scheme based on extensive morphological data, principally including a large number of characters traditionally considered. Sullivan et al., 2006 dealt with a cladistic analysis of catfish higher-level phylogeny based on molecular data helping to clarify the interrelationships of catfish families. The many conflicting or incompletely resolved hypotheses of relationships based on morphology or molecules need testing with additional characters and species. The taxonomy of catfish is at fast flux due to classical as well as modern systematic researches from population level to higher level taxa, as well as description of new species and promontory activities of ACSI, Fish Base and ITIS. High levels of endemism are also observed with the ichthyofauna of the south Western Ghats, which includes several endemic genera as Horabagrus and Horaglanis. The proper understanding of the taxonomy and phylogeny is a key for devising proper conservation and management of these species. There are several taxonomic ambiguities regarding the phylogenic positions of many members as in the case of the Family Horabagridae and in the family Heteropnuestidae.

The NJ and MP diagrams for the selected representatives (fig1,2,3&4) visibly reflect monophyly in Western Ghats Siluriformes. A noticeable separate cluster for the out-group species in the marine family Arius and two prominent clusters consisting of three families each were observed in the identical trees produced by the analysis of two mitochondrial genes. First group was formed by Horabagridae, Bagridae and Pangasidae and the second by Heteropnuestidae, Sisoridae and Siluridae. The close relationship among the three families Horabagridae, Bagridae and Pangasiidae support Nelson's (2006) morphological scheme under the suborder Bagroidea rather than Asian continental clad concept of Sullivan et al., (2006). It is not in accordance with the concept of Sullivan- family Horabagridae consisting of three genera Horabagrus, Pseudeutropius and Platytropius. The phylogenetic postion of Pseudotropiius mitchellei seem to be problematic. Pseudeutropius had shown varying relationship with other groups. In NJ tree of 16 S it form cluster with the Horabagridae-Bagridae and Pangasiidae group and supporting itself as a Bagrid while in MP tree it group with the out group Arius, however this cluster shows only a very low bootstrap value of 10% which means the cluster is not a correct representation of the affinities but it is the best one in the present taxon sample. Both relationships can substantiate the Bagroidea concept of Nelson (2006). From the family Siluridae, for which only two species for comparison, Wallago attu and Ompok malabaricus each belonging to different and diverse genera, were available for analysis. They together formed a sub cluster indicating affinity but as different species with a genetic distance of 6.1 for 16 S gene and 3.9 for CO1 gene.

The family Horabagridae endemic to Western Ghats consists of single genera Horabagrus with two members H. brachysoma and H. nigriicollaris. This genus was placed in Bagridae earlier, shifted to Schelbidae (Tilak, 1964) and then got separate family status by Sullivan et al., 2006.In the phlogenetic trees, Horabagridae reflected its high affinity to Bagridae than any other groups. The K2 P distance between the two species H. brachysoma and H. nigricollaris for 16 S genes is 1.0 and that for CO1 gene is 1.1 which is well below the conventional threshold levels to be considered as a species. In a study by Muneer et al. (2011), RAPD and microsatellite methods reported a low degree of gene diversity and lack of genetic heterogeneity in both species of Horabagrus. Though Species-specific RAPD bands were found the heterozygosities observed were 0.463 and 0.443, respectively. The validity of the species H. nigricollaris has been challenging with relatively low genetic divergence and further research are needed for confirmation.The placement in the single cluster of the two species of Heteropneustus, the only genera of the family Heteropnuestidae, may be considered realistic, as these two clades do not represent diverse taxon. The validity of the species H. microps has been questioned and it was considered only as a junior synonym of

H. fossilis (Pethiyagoda and Bahir, 1998). As per the genetic distance (0.2 for 16 s and 0.1 for CO1) between the two species for both genes, H. microps may be considered as an invalid species.

5. CONCLUSION

The 16S and COI region of the mitochondrial genes of the catfish families contained sufficient genetic variation and phylogenetic signal to be useful in species identification and revealing familial affinity of Siluriformes. The management, conservation and rehabilitation through culture of fishes require exact systematic ranking. By analyzing genetic variation in the mitochondrial DNA as in the Heteropnustids and Horabagrids, this work demonstrates that species-specific sequence data has considerable potential for addressing systematic questions and taxonomic problems. The study opens opportunities for a cladistic or phylogenic approach to the documentation of Western Ghats Siluriformes. It also brings about the need for considering the biogeographic or evolutionary perspective of the native catfish fauna of Western Ghats during such further studies.

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A COMPARATIVE STUDY ON ANT DIVERSITY IN TWO DIFFERENT LOCALITIES OF MYSURU DISTRICT, KARNATAKA.

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ABSTRACT

The study examined the diversity and distribution of ants in Mysuru district, Karnataka, as there is no adequate information pertaining to ant diversity of this region is available. The present study was carried out during January to June 2013 at two different localities of Mysuru district viz; Nanjanagud town and Mysuru city. We have sampled ants by employing intensive all out search method. This result showed that a total of 3106 individuals were captured in the study area. The sampled specimens representing 41 species belonging to 20 genera and five subfamilies, of which 21 species were recorded in both study sites. The highest ant diversity was recorded in Mysuru with 34 species. The most diverse subfamily was myrmicinae (14 species), followed by formicinae (13species). The smallest number of species belonged to the pseudomyrmicinae (3species). Among the sampled genera, one which showed the highest number of species representation was Camponotus with 6 species and some genera viz; Tapinoma, Technomyrmex, Anoplolepis, Paratrechina, Oecophylla, Cataulacus, Meranoplus, Myrmicaria, Tetramorium, Platythyrea and Anochetus, are represented by lone species each. The present study also revealed that Mysuru has richest ant diversity compared to Nanjanagud.

Key words: Diversity, ant, study area, formicidae

1. INTRODUCTION

Ants are most dominant components of terrestrial ecosystem. They act as ecosystem engineers because they play very important role in the ecosystem by improving the soil and assisting in the decomposition process. (Suparaek watanasit) and are considered as good biological indicators due to mutualistic behavior with both flora and fauna. They are social insects and lead high level interactive lives assisting each other. They belong to the family Formicidae, included in superfamily Vesoidea of order Hymenoptera placed under class Insecta of phylum Arthropoda. There are about 15000 species of ants (Andrade, 2007); only 11,769 species have been described (Agosti, 2004). The family Formicidae contains 21 subfamilies, 283 genera and about 15000 living ant species of which 633 ant species belonging to 82 genera, 13 subfamilies are reported from India. About 226 species of ants belonging to 63 genera and 11 subfamilies are estimated from Karnataka state (Varghese, 2009). The main aim of the present study was to conduct survey, to document, to compare the ant species diversity in two different localities of Mysuru district and prepare a partial checklist of ants in the study area.

2. MATERIALS AND METHODS

The study was conducted in two different localities of Mysuru district of Karnataka viz, Nanjanagud town and Mysuru city (Fig 1).

2.1. Study area: 1

Mysuru is a city located between latitude $12^0\ 18^1$ N and longitude $76^0\ 42^1$ E. It is bounded by Mandya district to the northeast, Chamarajanagar district to the southeast, Kerala state to the south, Kodagu district to the west and Hassan district to the north. In study site 1, there are 3 categories of sampling sites are chosen namely Karanji Garden, Kukkarahally Lake and Manasagangothri Campus. The selected sites ensure that different habitats and levels of disturbances.

2.2. STUDY SITE: 2

Nanjangud is a town in Mysuru district in the Karnataka state. Nanjangud lies on the banks of the river Kapila (Kabini), 23 km from the city of Mysuru. Nanjangud is located at 15.12°N 76.68°E. It has an average elevation of 657 metres (2155 ft). It is bounded by Mysuru district to the north, T Narsipur taluk to the east, H D Kote taluk to the west and Gundlupet and Chamarajanagar taluks to the south. In study site 2, there are 3 categories of sampling sites are chosen namely Gandhi Park, RV park, and temple garden. The selected sites represent the different habitats and levels of disturbances.

Fig 1: Study Area

2.3. ANT SAMPLING METHOD

Ant field sampling was done during January to June 2013. We employed intensive all out search method.i.e. Manual collection by using a brush and forceps during daytime from 9 AM to 6 PM in every time. The collected specimens were then transferred into vials containing 70% ethyl alcohol. Then ants were brought to the laboratory of Department of Zoology, Maharani's Science College for labeling, preservation and identification. The information about the habitat, locality, date, time was also recorded at the time of collection.

2.4. ANT IDENTIFICATION

The collected ants were identified upto the genus level by using stereo microscope based on taxonomic keys prepared by Thresiamma Varghese.

3. RESULT AND DISCUSSION

The study provides informative comparisons of two different localities. A total of 3106 sampled specimens were captured in the study area. The 41 ant species are belonging to 20 genera and five subfamilies (Table 1). They are as follows, the Formicinae were represented by 13 species and 5 genera. The most species rich Formicinae genera were Camponotus with 6 species and Polyrhachis with 4 species. The Myrmicinae were represented with 14 species with and 8 genera, the Ponerinae by 9 species and 4 genera, the Pseudomyrmicinae by 3 species and 1 genus and the Dolichoderine by 2 species with 2 genera. The most speciose genus of these 5 subfamilies was Camponotus with 6 species followed by Polyrhachis, Crematogaster, Leptogenys with 4 species (Table 3).

The highest ant diversity was recorded in Mysuru with 34 species. There were 21 species recorded in both study sites. Among these species Camponotus compressus was high compare to other species and noticeably found in both study sites. Camponotus was dominant genera in all the sampling sites. The species of Oecophylla and crematogaster were dominant on tree trunk which nested on trees. The fig.2 & 3 shows detailed distribution of diversity of ants.

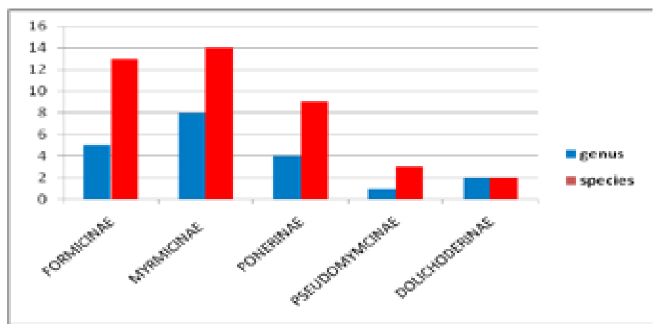

Fig 2: Diversity of ants representing Subfamily, genera with species

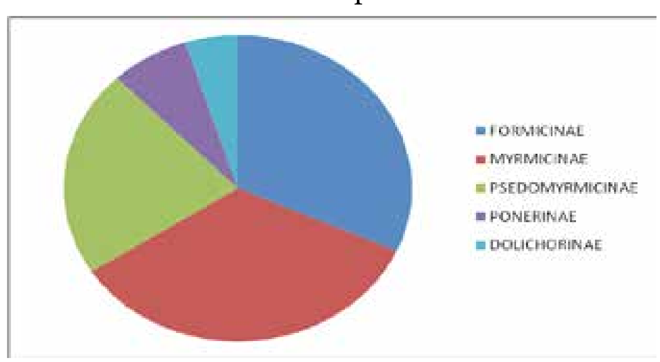

Fig 3: Subfamily wise distribution of ants with genera

A total 709 specimens were collected from Karanji garden, 668 specimens were collected from Manasa Gangothri Campus and 651 specimens were collected from Kukkarahally Lake. In Nanjanagud, a total 309 specimens were collected from Gandhi Park, 377 specimens were collected from RV Park and 392 specimens were collected from temple garden (Table 2).

Table 1: Checklist of ants with their ecological status of Mysuru district.

Sl.No	Scientific name	Common Name	Ecological Status
1	Anoplolepis gracilipes	Yellow crazy ant	Common
2	Camponotus compressus	Carpenter ant	Common
3	Camponotus sp.1		Common
4	Camponotus sp.2		Common
5	Camponotus sp.3		Common
6	Camponotus sericeus		Common
7	Camponotus irritans		Rare
8	Oecophylla smaragdina	Weaver ant	Common
9	Paratrechina longicornis	Black crazy ant	Rare
10	Polyrhachis sp.1	Spiny ant	Common
11	Polyrhachis sp.2		Common
12	Polyrhachis lacteipennis		Rare
13	Polyrhachis rastellata		Rare
14	Cataulacus taprobanae		Rare
15	Crematogaster ransonneti	Acrobat ant	Common
16	Crematogaster subnuda		Rare
17	Crematogaster sp.1		Rare
18	Crematogaster sp.2		Common
19	Meranoplus bicolor	Shield ant	Common
20	Monomorium pharaonis	Pharaoh ant	Common
21	Monomorium sp.		Common
22	Myrmicaria brunnea	Harvester ant	Rare
23	Pheidole sp.	Big headed ant	Rare
24	Pheidole watsoni		Rare
25	Solenopsis geminata	Fire ant or thief ant	Common
26	Solenopsis sp.1		Rare
27	Tetamoriun walshi		Rare
28	Anochetus sp.	Trap jaw ant	Common
29	Diacamma ceylonense	Queenless ant	Common
30	Diacamma indicus		Rare
31	Diacamma rugosum		Rare
32	Leptogenys sp.1	Long legged ant	Common
33	Leptogenys sp.2		Common
34	Leptogenys sp.3		Common
35	Leptogenys processionalis		Common
36	Platythyrea sagei		Rare
37	Tetraponera allaborans	Arboreal ant	Rare
38	Tetraponera sp.2		Common
39	Tetraponera rufonigra		Common
40	Tapinoma melanocephalum	Ghost ant	Common
41	Technomyrmex albipes	White footed ant	Common

Table 2: Comparison of ant diversity in Mysuru city and Nanjanagud town.

Sampling sites in Mysuru	No. of subfamilies	No. of genera	No. of species	No. of individual
Karanji Garden	5	17	19	709
Kukkarahally Lake	3	8	12	651
Manasagangothri Campus.	5	16	18	668
Sampling sites in Nanjangud	No. of subfamilies	No. of genera	No. of species	No. of individual
Gandhi park	4	9	14	309
Rv park	3	11	15	377
Temple garden	5	9	12	392

Table 3: Summary of ant species collected from six sampling sites.

Subfamilies	Genera	Species found
FORMICINAE	Camponotus Oecophylla Anoplolepis Polyrhachis Paratrechina	6 1 1 4 1
MYRMICINAE	Meranoplus Cataulacus Myrmicaria Pheidole Crematogaster Solenopsis Tetramoriun Monomorium	1 1 1 2 4 2 1 2
PONERINAE	Anochetus Leptogenys Diacamma Platythyrea	1 4 3 1
PSEUDOMYRMICINAE	Tetraponera	3
DOLICHODERINE	Tapinoma Technomyrmex	1 1
TOTAL	20	41

4. CONCLUSION

Ant diversity in in different localities of Mysuru and Nanjanagud have been analysed in this study. In comparison Mysuru city was composed of highest ant diversity when compared to Nanjanagud. A number of factors seem to be involved in the increased diversity. It includes food resources, nesting habitat etc. The reduction in ant diversity was due to disturbance. The disturbed localities show relatively lower diversity in their ant fauna than those which are less disturbed. Our results support the prediction that ant diversity is greater in undisturbed sites (Mysuru) than disturbed sites (Nanjanagud).

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BUTTERFLIES OF BHARATHIDASAN UNIVERSITY, TIRUCHIRAPPALLI, INDIA

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ABSTRACT

Insects are the most abundant creatures in the World ruling far more than 400 million years. Their role in equilibrium of ecological components is inevitable. Certain species present every corner of the earth from water to land and few pertained to some climatic and edaphic conditions. The diversity of insects varies to diverse ecosystems and they perform their role accordingly. Micro-ecosystems have their unique set of insect population. Butterflies are the colorful insects present widely through terrestrial ecosystems. Butterflies' role in insect-mediated pollination is recognized over the years. The present work intends to document the butterfly population inside the Bharathidasan University campus. Only avian and plant diversity of this campus were documented and published. Butterflies were observed randomly inside the campus, documented virtually using photographs and later identified with their morphological features. Standard text references were used to identify the species. Till then, there were 37 species of butterflies belonging to all the 5 families of order Lepidoptera. It showed 11.6% of Butterfly diversity present in Tamil Nadu level. To this account 14 species of Nymphalidae, 10 species of Pieridae, 7 species of Lycaenidae and 3 species of each Hesperiidae and Papilionidae were observed in the University campus. IUCN Red List of Threatened Species showed that only 4 out of 37 butterflies found in this region assessed for their population ecology. This signified the diversity of the campus, which required further observations on diversity, seasonal variation etc. Further observation will append more to this documentation and which will substantiate the diversity need to be protected inside the campus.

Key words: insects; IUCN red list; Lepidoptera; population ecology; conservation.

1. INTRODUCTION

The insects are the creatures for centuries dominating the Earth in terms of numbers. The role played by insects cannot be underestimated, as several of them served as 'keystone species'. Insects have been placed under phylum Arthropoda, majorly constitutes the classes Insecta and Arachnida. The Insecta class includes 31 orders. Butterflies along with moths fall under the order Lepidoptera. They have been classified under superfamily Papilionoidea and Hesperioidea. The Papilionoidea includes five families namely Papilionidae (Swallowtails and Bird wings), Pieridae (Whites and Yellows), Nymphalidae (Brush-footed), Riodinidae (metalmark) and Lycaenidae (Blues). The Hesperioidea represents Hesperiidae family.

Butterflies are colored, winged insects which fascinates several researchers in the past. The diversity varies with different climatic conditions. India is one among 17 'mega diverse' countries, having Butterflies of all six families. The number of species observed in India varies 1502 (Sing, 2011) to 1800 (Kunte et al., 2014). The southern state, Tamil Nadu constitutes 319 species to this account (Wikipedia, 2014).

2. MATERIALS AND METHODS

2.1. Study Area and Tools

This study is pertinent to main campus of Bharathidasan University, situated at Palkalaiperur, about 15 Kms from Tiruchirappalli City. It sprawls about 500 acres of land in Tiruchirappalli-Pudukkottai Highway (NH 210). The campus is having good infrastructure including Admin Block, Central Library, Informatics, Departments along with significant area with green cover. Though most area is covered with Eucalyptus and Wattle plantation, still other diverse plants inhabit sparsely. It also has a perennial water body as a pond with about 25 acres in addition to many seasonal puddles.

2.2. IUCN Threat Status

International Union for Conservation of Nature and Natural Resources (IUCN) is the global body which is working towards the conservation of species. It works through The IUCN Species Programme working with the IUCN Species Survival Commission (SSC) in order to assess the status of the species, even sub populations and thus promote conservation strategies worldwide. The IUCN Red List of Threatened Species™ is the well recognized as global objective or approach towards the conservation of plants and animals.

3. RESULTS AND DISCUSSION

3.1. Distribution of Butterfly species

The preliminary investigation of butterfly diversity reveals a total of 37 species (Fig. 1). These belong to 5 families of butterflies namely, Hesperiidae, Lycaenidae, Nymphalidae, Papiliniodae and Pieridae (Tables 1 and 2). Though it represents only half the number of families present in Western Ghats, which reported 9 families by Ambrose et al., 2005, still it is good diversity considering the small study area. Even then Tamil Nadu is reported to have only five families of butterflies by the investigators.

In Tamil Nadu, 77 skipper butterflies of Hesperiidae have been reported, whereas in the study area only 3 species of skippers were observed at this instance. This may be due to handling the study in less scientific manner or the restricted time scale took for this purpose. There were 7 Lycaenidae species found which is comparatively less (7.2%) to Tamil Nadu scale. The state had been reported to have 97 species.

There were 14.9% of Nymphalidae species and 15.8% of Papilionidae species butterflies observed during this study. Tamil Nadu is reported to have 94 and 19 species of Nymphalidae and Papilionidae respectively. Pieridae is the one family having higher number of butterfliy species to the Tamil Nadu scale which is 31.3%. During the study period, 10 out of 32 Pieridae species were observed in Tamil Nadu.

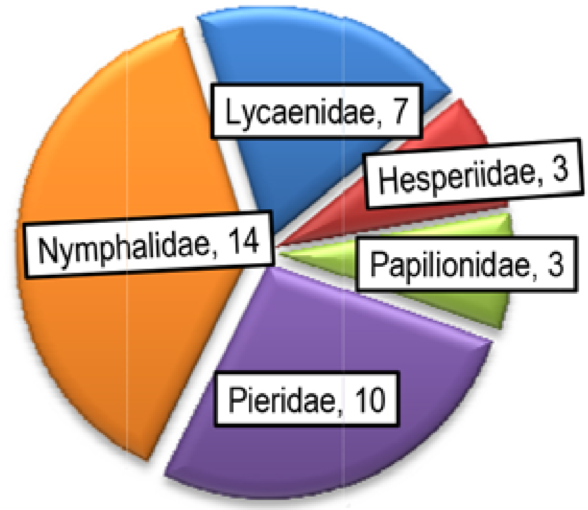

Fig 1: Distribution of Butterfly species inside Bharathidasan University Campus

Table 1: Butterfly diversity of Bharathidasan University

	IUCN Status	Scientific Name	Common Name
Hesperiidae			
	NL	Hasora chromus	Common Banded Awl
	NL	Parnara bada	Common Straight Swift
	NL	Spialia galba	Indian Skipper
Lycaenidae			
	NL	Azanus ubaldus	Bright Babul Blue
	NL	Castalius rosimon	Common Pierrot
	NL	Curetis thetis	Indian Sunbeam
	NL	Chilades parrhasius	Small Cupid
	LC	Jamides caerulea	Common Cerulean
	NL	Tarucus nara	Rounded Pierrot
	NL	Zizula hylax	Tiny Grass Blue
Nymphalidae			
	NL	Acraea violae	Tawny Coster
	NL	Byblia ilithyia	Joker

	NL	Tirumala limniace	Blue Tiger
	NL	Tirumala septentrionis	Dark Blue Tiger
	NL	Danaus chrysippus	Plain Tiger
	NL	Danaus genutia	Striped Tiger
	LC	Euploea core	Common Crow
	NL	Hypolimnas bolina	Great Eggfly
	NL	Junonia almanac	Peacock Pansy
	LC	Junonia hierta	Yellow Pansy
	NL	Junonia lemonias	Lemon Pansy
	NL	Junonia orithya	Blue Pansy
	NL	Melanitis leda	Common Evening Brown
	NL	Mycalesis perseus	Common Bush Brown
Papilionidae			
	NL	Chilasa clytia	Common Mime
	NL	Pachliopta hector	Crimson Rose
	NL	Papilio demoleus	Lime Butterfly
Pieridae			
	NL	Belenois aurota	Pioneer
	NL	Catopsilia pomona	Common Emigrant
	NL	Catopsilia pyranthe	Mottled Emigrant
	NL	Colias fieldii	Dark Clouded Yellow
	NL	Colotis danae	Crimson Tip
	NL	Delias eucharis	Common Jezebel
	LC	Eurema brigitta	Small Grass Yellow
	NL	Eurema blanda	Three-spot Grass Yellow
	NL	Eurema laeta	Spotless Grass yellow
	NL	Ixias marianne	White Orange Tip

Table 2: Butterfly species distribution in comparison with Tamil Nadu and Indian Scale

Families	India	Tamil Nadu	B D U Campus	% to TN scale
Papilionidae	107	19	03	15.8
Pieridae	109	32	10	31.3
Nymphalidae	522	94	14	14.9
Lycaenidae	443	97	07	07.2
Hesperiidae	321	77	03	03.9
Total	1502	319	37	11.6

3.2. IUCN Threat Status

There were total of 37 butterfly species observed inside the Bharathidasan University campus in the specified period. Fig 2 shows that out of 36 butterflies observed, only 4 species have been assessed by the IUCN, listed as Least Concern (LC). The species listed under this LC category encounters no major threats and no specific conservation strategies need to be adopted under the circumstances. Accordingly these 4 butterflies namely, common cerulean, common crow, yellow pansy and small yellow grass need not to be taken care of for conservation at the current status.

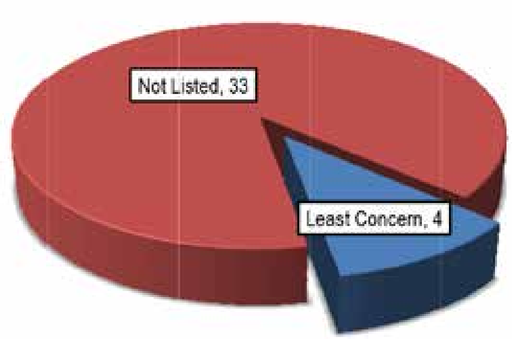

Fig 2: IUCN Threat status of Bharathidasan University Butterfly species

It is to be noted that the remaining 33 species of butterflies observed in the campus have not been assessed for its population status, range, distribution, habitat, ecology and conservation strategies by IUCN. But all the species have been mentioned in IUCN Red List of Threatened Species as listed in Catalogue of Life (COL), which is an online database of known plant and animal species. It has a checklist of more than 1.5 million species of organisms.

4. CONCLUSION

The study area is restricted to a small range and restrains about 11.6% of butterflies found in Tamil Nadu. Further investigation at the regional level would undeniably count more to this number. IUCN Red List of Threatened Species shows that only 4 out of 36 butterflies found in this region assessed for their population ecology. This signifies that, the present investigation needs to be taken further with a wide study area and scientific approach in order to have holistic approach towards the population status and conservation strategies for threatened species if any.

5. ACKNOWLEDGEMENT

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ROLE OF BIODIVERSITY IN ENVIRONMENTAL IMPACT ASSESSMENT: A LEGAL POLICY CONSIDERATION

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ABSTRACT

Developmental activities can have major impacts on the environment by degrading quality of air, soil and waterways thus altering landscape and destroying biodiversity and habitat. Environmental Impact Assessment (EIA) is a tool that assists in the anticipation and minimization of the adverse effects of development. Biodiversity is to be assessed quantitatively with proper scientific, ecological and statistical methods and are to be carried out not only before project implementation but also during operational phase periodically as applicable. In addition to these assessments, it is suggested that the project proponent has to assess the Green Belt quantification in the project area by applying Carbon dioxide absorption and Oxygen release Budget Accounting based on CO_2 emission from industrial activity and quantum of absorption by plants.

This paper deals about the role of Biodiversity in EIA projects and the need of the legally bound policy consideration on, 1. "Comprehensive Periodic quantitative analysis of Biodiversity components by project proponents" 2. "CO_2 Emission from industrial process and absorption by plants-Budget Accounting Statement system", to implement effectively the biodiversity issues in EIA projects and subsequent monitoring and maintenance.

Key words: EIA, bio diversity, environmental clearance, co2 emission

1. INTRODUCTION

Development can have major impacts on the environment by degrading soils and waterways, altering landscape and destroying biodiversity and habitat. Other problems associated with development and human activity include land use conflicts, human and animal conflicts, water management and environmental pollution. In addition to harming the environment, these impacts can and do have significant economic costs and negatively affect human health. Environmental Impact Assessment (EIA) is a tool that assists in the anticipation and minimization of the adverse effects of development. Undertaken in the early stages of project planning and design, EIA seeks to help shape development in a manner that best suits the local environment and is most responsive to human needs.

The concept of EIA arose from the pollution and degradation of natural resources caused by rapid population growth, industrialization, agricultural development and technical progress. EIA recognizes that natural resources are incapable of absorbing the unchecked demands of modern society. There is a growing concern in our country and at global level that many forms of development activities cause damage to the environment. This has been aggravated by lack of awareness and inadequate information amongst the public on the consequences of their interaction with the environment.

1.1. Environmental Legal Framework

Recognizing the importance of natural resources and the environment in general, the Government India has put in place wide range of policy, institutional and legislative framework to address the major causes of environmental degradation and negative impacts on ecosystems emanating from industrial and economic development programmes. It is now accepted that development projects must be economically viable, socially acceptable and environmentally sound. It is a condition of the Indian Government to conduct Environmental Impact Assessment on development Projects. EIA assesses the impacts of a proposed project before commencement of implementation. In addition to helping formulate proper development policy, EIA provides for public participation in the decision making process in respect of a given proposed project. EIA serves the following purposes: i) Integration of environmental issues into planning and decision making processes; ii) Anticipation, minimization and mitigation of environmental damage and recommendation of alternatives; iii) Public participation in decision making and environmental conservation. The steps included in and EIA are contained in the Environmental Impact Assessment Notification dated 14th September, 2006(Gazette of India, GOI, 2006) issued under sub-rule (3) of Rule 5 of the Environment (Protection) Rules, 1986 Environmental Impact Assessment project/study report prepared and submitted to the Central or State level Environmental Appraisal Committee for further processing to get clearance .

1.2. Biodiversity Concept

The concept of diversity arises quite naturally in various subject areas. Intuitively, diversity is related to the apportionment of some quantities into a number of well- defined categories, which may take the form of resources, investment, time, energy, abundance, etc, according to the problem under study.

Biodiversity encompasses the variety of life at all levels of organization, from genetic diversity within a species to diversity within entire regions or ecosystems. Biodiversity is increasingly recognized as critical to human life, but many species are more threatened than ever by urbanization, global deforestation, and climate change.

The Environmental Impact Assessment (EIA), Notification 2006 categorically specified the need of assessing impact on biological components (flora & fauna) for proposed project activities. In practice, most of the cases, this assessment is carried out with scanty data like list of flora and fauna only. It is to be assessed quantitatively with proper scientific, ecological and statistical methods.

This paper deals about the role of Biodiversity in EIA projects and subsequent measures to be taken by project proponent to maintain the biodiversity without deterioration and also how the CO_2 Emission from industrial process and absorption by plants - Budget system will help in reducing CO_2 release into the atmosphere.

2. METHODOLOGY

Biodiversity is to be assessed quantitatively with proper scientific, ecological and statistical methods like Quadrant sampling, enumeration of species list and count, mapping of vegetation etc. Further the data generated is to be analysed statistically for estimation of Frequency, Abundance, Dominance, Importance Value Index (IVI), Diversity Index, Dominance Index, Inter Specific Association, Phytosociological aspects etc. These assessments are to be carried out not only before project implementation but also during operational phase periodically in around the project site as applicable. The significance of defining and measuring ecological diversity by means of well-behaved indexes is to be considered in the easement studies. Any diversity measure is a function of the species abundances in the community

The formula for calculation of various indices is given as described by Misra (1968) is given below:

$$\text{\% frequency} = \frac{\text{No. of sampling unit in which the species occurred}}{\text{Total No. of units studied}} \times 100$$

$$\text{Abundance} = \frac{\text{Total No. of individuals}}{\text{No. of Quadrats of occurrence}}$$

$$\text{Density} = \frac{\text{Total No. of individuals}}{\text{No. of Quadrats studied}}$$

$$\text{RelativeFrequency} = \frac{\text{No. of occurrence of the species}}{\text{No. of occurrence of all species}} \times 100$$

$$\text{Relative Density} = \frac{\text{No. of individuals of the species}}{\text{No. of individuals of all species}} \times 100$$

$$\text{Relative Dominance} = \frac{\text{Total basal area of the species}}{\text{Total basal area of all the species}} \times 100$$

Importance Value Index (IVI) = Relative Frequency + Relative Density + Relative Dominance

The change in IVI in course o period will indicate improvement or deterioration of bio diversity. The changes either positive or negative on biodiversity components during the course of operation are to be considered with due care for corrective measures. According necessary measures are to be taken to restore the diversity indices in order to maintain the ecological balance

In addition to these assessments, the project proponent has to assess the Green Belt quantification in the project area by applying Carbon dioxide absorption and Oxygen release Budget Accounting based on CO_2 emission from industrial activity and quantum of absorption by plants. The industry has to ensure complete absorption of CO_2 arising from process by plants either within the factory premises or elsewhere in social forestry scheme. This CO2 budgeting is to be assessed once in year and an annual statement is to be submitted to regulatory authorities.

3. CONCLUSION

The need of legally bound policy consideration on, 1. "Comprehensive Periodic Analysis of Biodiversity components by project proponents" 2. "CO_2 Emission from industrial process and absorption by plants-Budget Accounting Statement system", to implement effectively the biodiversity issues in EIA projects and subsequent monitoring and maintenance is suggested. .

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PLANT DIVERSITY IN THE SACRED GROVES OF KOVILPATTI, TAMILNADU

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ABSTRACT

Sacred groves and sacred plants are important in ecological conservation and tradition. Sacred trees are examples for ex-situ conservation. The sacred groves are shelter for several medicinal plants of great value not only for primary health care of the village communities, but also important in modern pharmacopoeia. In the present investigation, sacred groves survey was made in and around Kovilpatti with regard to enthobotanical and enthomedicinal characteristics of sacred plants. The highest species diversity was noticed in the sacred groves of Krishnan kovil and Sri Anuman kovil. The lowest species diversity was noticed in the sacred groves of Murugan kovil, Shenbaga Valliamman kovil, Pillayar kovil, Arulmigu Vetrivinayagar kovil, Dekshina Vinayagar kovil and Karupasami kovil. The predominant species in the sacred groves is Azadiracta indica. Tamarindus indica is the co-dominant species.

Key words: Sacred groves, sacred plants, kovilpatti

1. INTRODUCTION

'A sacred grove is an area of "natural" vegetation preserved through local taboos and sanctions that entail spiritual and ecological values' (UNESCO, 1996). These fragments of natural forest vegetation represent a long tradition of environmental conservation based on sound ecological principles. Being repositories of rich biodiversity sacred groves often represent climax vegetation of the area and harbour a number of rare and endangered floral and faunal elements. These relatively less studied regions are recently threatened by agriculture and other human activities. Studies on the changes in animal communities and factors governing them in habitat fragments are a major thrust area of research, which is crucial for effective conservation and management programmes (Sandhyarani et al., 2003). Sacred groves can be used as indicators for potential natural vegetation (Schaff, 1998) and are vital for well being of the society (Islam et al., 1998). Sacred groves are the religious practice of conserving biodiversity with strong beliefs, customs and taboos and are treasure house of rare and endemic species. Everything within these groves is under the protection of the reigning deity of the grove and the removal of any material, even dead wood or twig is a taboo (Gadgil and Vartak, 1976). The sacred groves found in different regions of India possess rich diversity of medicinal plants and provide suitable habitat for their sustainable, natural regeneration. (Ved et al., 2001; Boraiah et al., 2003; Airi et al., 2000). Protection of a large number of medicinal plants in sacred forests of different parts of India is well documented by earlier studies (Vartak et al., 1987, Bhakat and Pandit, 2004). It is also observed that more than 35,000 plant species are being used around the world for medicinal purposes (Sukumaran, 2010). Hence an attempt has been made to study the plant diversity in the sacred groves of Kovilpatti in Tamilnadu.

2. MATERIALS AND METHODS

2.1. Study Area

In the present investigation an attempt was made towards the survey on enthomedicinal plants and traditional system of medicine in and around Kovilpatti. In this study, Kovilpatti town and its neighboring areas namely Odappatti, Illuppaiurani, Kalugumalai, Moopanpatti, Keela Iral, Kayathar and Vilathikulam were taken. Kovilpatti is situated in Tuticorin District. It has many match factories, and few fireworks and spinning mills. Humid and hot climatic conditions are present throughout the year. Kovilpatti is experiencing a growth in the industrial front; still it holds that traditional and cultural heritage. A good number of temples are testimony to this fact. Kovilpatti lies in 90 36'N latitude and 78 51'E longitude with an altitude of MSL + 112.

2.1. Sacred Grove Survey

Field survey on medicinal plants was carried out in a Sacred groves and Plains of Kovilpatti town and neighbouring area (Illuppaiurani, Odappati, Kayathar, Keela Iral, Kalugumalai, Vilathikulam and Moopanpatti) (Fig.1) during the period from January 2007 to July 2007.

Fig. 1 Map showing the study area

Fig 1: Study Area Map

3. RESULTS AND DISCUSSION

3.1. Sacred Groves – Conservation Spot of Rare and Endangered species

Sacred groves are the most important ecological conservation tradition. The centre has been working on the creation of a National Policy on Sacred groves and sacred trees on behalf of the Ministry of Environment and Forests, government undertaking steps to protect and conserve forest in association with the local people through their programme (NAEB Report, 1997). The scientific community has the occasion to protect this reserved forest with technological advancements it is enjoying. So the sacred groves and sacred trees are the repository of our rural biodiversity. The sacred groves are shelter to several medicinal plants of great value not only for the primary health care of the village communities, but also important in modern pharmacopoeia. Indian society comprises of several cultures, each with its own set of traditional methods of conserving nature and its creations. The Mundas and Santhals of Bihar worship mahua (Bassia latifolia) and kadamba (Anthocaphalus cadamba) trees and tribals of Orissa and Bihar worship the tamarind (Tamarindus indica) and mango (Mangifera indica) trees during weddings. Banyan trees are also considered as sacred in India (Sudhakar et al., 2005).

In India, many trees are worshiped in the temple and are associated either with the village, temple or the deity. Tree worship is found in ancient societies worldwide. Ever since prehistoric period, tree worship is continued to be a part of Indian culture. People in TamilNadu considered the tree associated with deity as sacred and worthy of worship. In the present investigation, explorations were made with regard to the ethnobotanical, ethnomedical characteristics of sacred plants in Kovilpatti, Illupaiurani. Vilathikulam, Kayathar, Odappatti, Moopanpatti, Keela Iral and Kalugumalai. Field visits were made during the period from January 2007 to July 2007. Maru and Patel (2013) reported 37 plant species belonging to 26 families documenting of sacred groves and sacred plants of Jhalod and surrounding areas in Dahod District of Gujarat in India.

Sacred groves surveyed in and around Kovilpatti are tabulated in Table 1 and 2. In Kovilpatti, sixteen sacred groves were identified (Plate I & II). The highest species diversity was noticed in the sacred grove of Krishnan Kovil and Sri Anuman Kovil. The lowest species diversity was noticed in the sacred groves of Murugan Kovil, Shenbagavalliamman kovil, Pillayar Kovil, Arulmigu vetrivinayahar kovil, Dekshnina vinayagar kovil, Karaupasami kovil. The predominant species in the sacred groves is Azadiracta indica. Tamarindus indica is the codominant species.

Table 1: Sacred groves and its distribution in and around Kovilpatti

Sl. No.	Name of the Temple and Locality	Components of the sacred grove	Number of species
1	Arulmigu Vetrivinayahar Thriukovil Kovilpatti	Azadirachta indica A.Juss	1
2	Dekshina Vinayahar Kovil -Kovilpatti	Azadirachta indica A.Juss	1
3	Karuppasami Kovil Kovilpatti	Azadirachta indica A.Juss Mangifera indica Linn.	2
4	Sri Palaniandavar Kovil Kovilpatti	Azadirachta indica A.Juss Aegle marmelos (L.) Correa	2
5	Mukkarai Pillayar Kovil Kovilpatti	Azadirachta indica A.Juss Aegle marmelos (L.) Correa Ficus bengalensis	3
6	Kaliamman Kovil Kovilpatti	Azadirachta indica A.Juss Ficus religiosa Linn.	2
7	Erratai Vinayahar Kovil Kovilpatti	Ficus religiosa Linn.	1
8	Jothivinayahar Kovil Kovilpatti	Azadirachta indica A.Juss Ficus religiosa Linn.	2

Table 2: Sacred groves and its distribution in and around Kovilpatti

Sl.No.	Name of the Temple and Locality	Components of the sacred grove	Number of species
1	Murugan kovil - Kovilpatti	Azadirachta indica A.Juss	1
2	Shenbagavalliamman kovil Kovilpatti	Carrisa carandus Linn.	1
3	Krishnankovil - Kovilpatti	Tamarindus indica Linn. Cocos nucifera Linn. Musa paradisiaca Linn. Azadirachta indica A.Juss Vinca rosea Linn.	5
4	Sri Anuman kovil - Kovilpatti	Calotropis gigantean L.Dry Ocimum sanctum Linn. Azadirachta indica A.Juss. Nerium oleander Linn.	4
5	Pillayarkovil - Kovilpatti	Mangifera indica Linn. Cocos nucifera Linn. Ficus religiosa Linn.	3
6	Pillayarkovil - Kovilpatti	Azadirachta indica A.Juss.	1
7	Pillayarkovil - Kovilpatti	Azadirachta indica A.Juss.	1
8	Pillayarkovil - Kovilpatti	Azadirachta indica A.Juss. Ficus religiosa Linn.	2


Mukkarai Pillayar Kovil


Jothi Vinayakar Kovil


Palani Andawar Kovil


Arulmigu Vettivinayahar Thirukovil


Karuppasami Kovil


Dekshina Vinayakar Kovil


Kaliamman Kovil


Erattai Vinayakar Kovil

Plate I: Sacred groves distribution in and Kovilpatti.

PLATE II

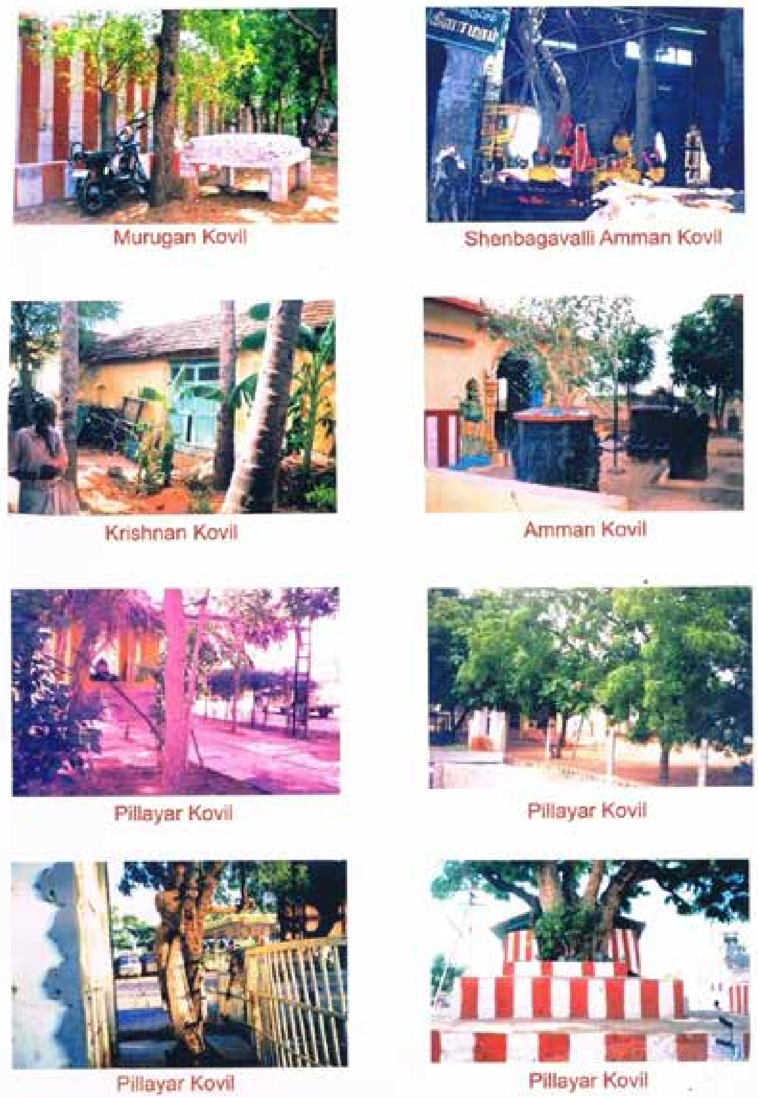

Plate II: Sacred groves distribution in and Kovilpatti.

Sacred groves and their distribution of dominant species in Illupaiurani and Vilathikulam are presented in Table 3. In Illuppaiurani and Vilathikulam region, seven sacred groves were identified (Plate III). The highest species diversity was observed in the sacred grove of Karupasami Kovil and Sastha kovil. The lowest species diversity was noticed in the sacred groves of Balavinayagar kovil and Arasamarathu Pillayar Koil. The dominant species recorded in the above said sacred groves are Nerium indicum, Ocimum sanctum and Azadirachta indica.

Sacred groves and their species diversity distribution in Kovilpatti, Odappatti, Moopanpatti, Keela Iral and Kalugumalai are presented in the Table 4. In these regions, nine sacred groves were recorded (Plate IV). The highest species diversity was observed in Ganesapillayar Kovil, Sadaiappar Sivanalayam, and Sangili Bhudhathar Kovil sacred groves. The lowest species diversity was noticed in the sacred groves of Akilandaeswari Kovil, Vannivinnayagar Kovil and Murugankovil. The dominant species found in the above said sacred groves are Ocimum sanctum, Musa paradisiaca, Nerium oleander and Azadirachta indica.

Table 3: Sacred groves and its distribution in Illuppaiurani and Vilathikulam

Sl.No.	Name of the Temple and Locality	Components of the sacred grove	Number of species
1	Kaliamman Kovil - Illuppaiurani	Azadirachta indica A.Juss Pongamiaglabra (L) Pierre Emblica Officinalsi Gaertn.	3
2	Sasthakovil - Illuppaiurani	Aegle marmelos (L) Correa Mangifera indica Linn.Tamarindus indica Linn. Morinda tintoria Roxb .	4
3	Karuppasamy Kovil - Illuppaiurani	Ficus bengalensis. Linn. Azadirachta india A.Juss. Mangifera indica Linn.Tamarindus indica Linn. Ocimum sanctum. Linn.	5
4	Bala Vinayahar Kovil -Illuppaiurani	Nerium oleander Linn.	1
5	Madasamy Kovil - Illuppaiurani	Ficus bengalensis Linn. Tamarindus indica Acacia Aarabica (Wild)	3
6	Arasamarathu Pillayar Kovil -Vilathikulam	Ficus religiosa Linn.	1
7	Meenakshi Sundareswaran Kovil -Vilathikulam	Cocos nucifera Linn. Azadirachta indica A.Juss.	2

number of land requirements and agricultural development increase, reducing these pockets of biodiversity to small pockets of trees and plants (Amirhtalingam, 1998). According to Nanditha Krishna and Javathi Prabhakaran (1997) the most important ecological conservation tradition was the sacred grove, protected forest area in the village, and they also reported that the sacred groves, being the home of the local flora and fauna, represent a mini biosphere reserve, making them an essential part of the conservation process.

The Sthalavrikshas once placed a major role in local ecology and celebrates our biological heritage. Propagation of sthalavrikshas in temples, will contribute to the conservation of our floral diversity. The sacred plants found in the sacred groves are presented in Table 1 to 4. As stated earlier, sacred groves are nothing but a group of vegetation containing a mini ecosystem of diversified flora and fauna (Oliver King et al., 1997). In the ancient Tamil geographical location, different patches of sacred groves were recognized based on their composition (Krishnamurthy, 1998). According to Krishnamurthy (1998), sacred groves or nandavanas can be classified into five different types as follows:

- The first category of nandavanas is exclusively floral gardens containing various types flowers yielding plants.
- The second category on nandavanas contains exclusively fruit bearing trees and plants such as Mango, Jack fruit, Citrus etc.,
- The third category of nandavanas contains combination of both floral and fruit gardens.
- The fourth category of nandavanas contains a single plant species cultivated throughout the garden.
- The fifth category of nandavanas is entire by forest fragments maintained as groves and such nandavanas are very common in "Mullai" and "Kurinji" ecosystem of ancient Tamil word, although they were known in other ecosystem as well as medieval South India.

Sri Anuman Kovil have a first category of nandavanas i.e. exclusively floral garden with various types of flower yielding plants. Mangifera indica, (Mango) has associated with Pillayar Kovil, Karuppasamy Kovil. Sastha Kovil as a part of sacred grove. These trees are also associated with floral plants like

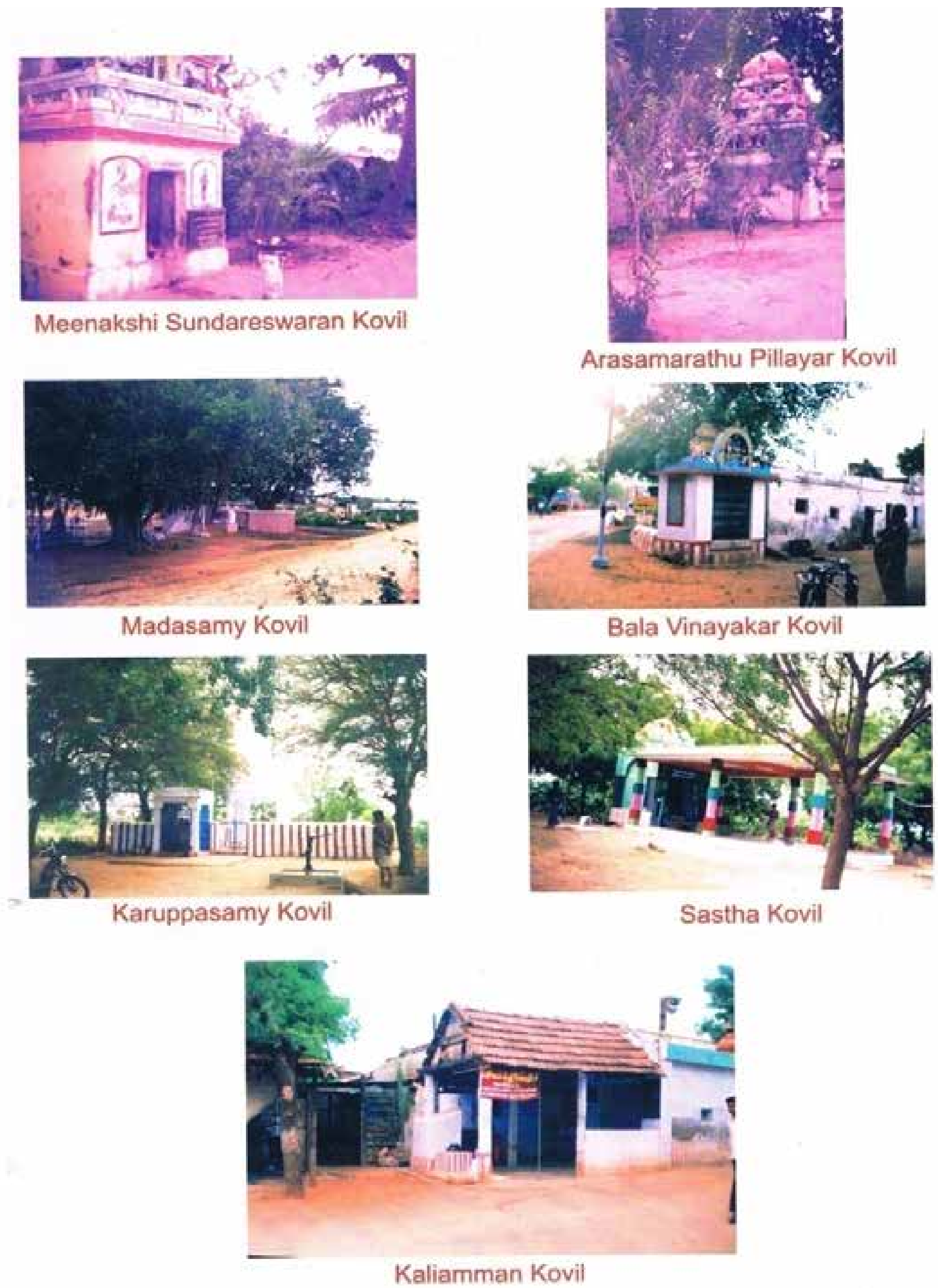

Plate III: Sacred groves distribution in Illuppaiurani and Vilathikulam area.

Plate IV: Sacred groves distribution in Kayathar, Odappatti, Moopanpatti, Keela Iral and Kalugumalai area.

Many sacred groves are also important archaeological sites with evidences of Paleolithic or Neolithic cultures. While Sacred groves are found all over the country, they are gradually shrinking in size and

Azadirachta indica, Moninda tinctoria. According to Krishnamurthy's classification this is the third category of nandavanas containing combination of both floral and fruit gardens.

Pongamia galbra has been preserved as a sacred grove in Kaliamman and Ganesha Pillayar Kovil. This tree is also associated with other flowering plants like Ficus Bengalensis, Emblica officinalis. According to Krishnamurthy's classification this is the first category of nandavanas containing floral plants with various types of flower yielding plants.

In the present investigation there is no second, fourth and fifth category of nandavanas in Krishnamurthy's classification. Carrisa carandus, is conserved as a Sthualavrisksh in the Shenbagavalliamman temple in Kovilpatti. Indian Oleander and Nerium Oleander are conserved as sacred trees in Kayathar Sangili Bhaudhatharkovil and Kovilpatti Sri Anuman kovil. According to Amirthalingam (1998), those 3 temples of Tamil nadu are also having this tree as a sacred tree. This plant is poisonous but if administrated carefully fresh leaf juice is used as eye drops to reduce swelling and also improve the eye sight (Bor and Rajzada, 1990). Oliver king et al. (1997) also pointed out that sacred groves are perfect system of in-situ conservation strategy wherein entire ecosystem is conserved and protected. Sacred plants are not only conserved out of fear and reverence, but some plants in groves and trees has its own medicinal and botanical value too.

Table 4: Sacred groves and its distribution in Kayathar, Odapatti, Moopanpatti, KeelaIral and Kalugumalai

Sl.No.	Name of the Temple and Locality	Components of the sacred grove	Number of species
1	Pechiyamman kovil - Kayathar	Cocos nucifera Linn. Carica papaya Linn.	2
2	Sadayappar Sivalayam - Kayathar	Cocos nucifera Linn. Azadirachta indica A.Juss Musa paradisiaca Linn. Tamarindus indica Linn.	4
3	Ganesapillayar kovil - Kayathar	Cocos nucifera Linn. Jasminum sambac Linn. Ficus bengalensis Linn. Pongamea glabra (L) Pierre Ocimum sanctum	5
4	Akilandaeswari kovil - Kayathar	Ficus bengalensis Linn.	1
5	Sangili Bhudhathar kovil	Tamarindus indica Linn. Nerium Oleander Linn. Azadirachta indica A.Juss. Cocos nucifera Linn.	4
6	Nageswari Kovil - Kayathar	Azadirachta indica A.Juss. Ficus religlosa Linn.	2
7	Vannivinayahar Kovil - Odappatti	Azadirachta indica A.Juss.	1
8	Maharaja Kovil - Moopanpatti	Azadirachta indica A.Juss. Ficus religiosa Linn.	2
9	Sri Pandhirakaliamman Kovil -Keela Iral	Azadirachta indica A.Juss. Tamarindus indica Linn. Ficus bengalensis Linn.	3
10	Murugan Kovil - Kalugumalai	Azadirachta indica A.Juss.	1

Prominent live examples of traditional forms of biodiversity conservation still exist and in practice, which include the philosophy of sacred groves, sacred species and sacred landscape. The evidences suggest that sacred grove concept of biodiversity conservation had adopted by various indigenous communities worldwide, such as, aboriginals of Australia, Caucasus Mountains community, ancient Slavic people, German tribes (Torakev, 1989), Greek and Romans, Kikuyu of Africa (Hughes, 1990), and Mbeere tribe of East Africa (Gowda, 2006). Before the spread of Christianity and Islam the sacred groves covered much of the Middle East and Europe. The sacred grove concept is still relevant and exists today, especially in many parts of Asia, Africa and Mexico (Gadgil et al., 1993). In India, over 13,720 sacred groves have been enlisted (Malhotra et al., 2001) that exist across diverse topography and climatic conditions from down south to north however; the actual number is thought to be much larger (Kala, 2010).

4. CONCLUSION

The local traditional medicine (TM) knowledge was the basic source for preliminary selection of medicinal valued plants, so the conservation of plant diversity of sacred groves is therefore most important for the management and sustainable development in these fragile ecological and life support systems. Sacred groves or sacred trees serve as a home for birds and mammals, and hence, they indirectly help in the biodiversity conservation of living organisms.

5. ACKNOWLEDGEMENT

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A COMPARATIVE ACCOUNT OF MICROMORPHOLOGICAL AND ANATOMICAL STUDIES ON SOME MANGROVE SPECIES

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ABSTRACT

"Mangrove" term has been applied historically to plants which live in muddy, wet soil in tropical or subtropical tidal waters. India has approximately 7, 00, 000 hectares of area covered by mangroves along the estuaries and major deltas. Gujarat has 1650 sq.km. long coastline area which is exclusively economical zone. Mangroves in Gujarat are divided into four zones Gulf of Kutch, Saurashtra coast, Gulf of Khambat and South Gujarat Coast. Jamnagar coast which comes under the Gulf of Kutch zone is notified as the marine national park and Sanctuary. In the present study four commonly growing mangroves Avicennia marina, Sonneratia apetala Sonneratia caseolaris and Rhizophora mucronata from the coastal area of Jamnagar in Gujarat have been evaluated for the leaf micromorphological and anatomical features. Leaf epidermal peels were used for the evaluation of micromorphological features and serial anatomical sections were observed for the anatomical features. Results revealed that the four species growing in the same locality showed variation both micromorphologically and anatomically. Micromorphological studies revealed presence of diacytic stomata in A. marina, while anomocytic cyclocytic stomata were found in R. mucronata. Stomata were confined to the lower epidermis so the leaves were hypostomatic. In both the species of Sonneratia leaves were amphistomatic.The stomata are cyclocytic and staurocytic type in S. caseolaris and in S. apetala they are staurocytic but not cyclocytic. Secretory cavities lined by 2-3 layers of epithelial cells were present in R. mucronata while in A. marina bicellular cavities were present. Gelatinous fibres were present in the cortex of the petiole in R. mucronata. Anatomical variations were observed in the leaves of all the four different species, on the basis of which they could be differentiated.

Key words: Mangroves, micromorphology, anatomy, leaf, stomata, trichome

1. INTRODUCTION

The mangrove ecosystem is an interface between terrestrial forests and marine ecosystems and includes diversified micro-habitats of fauna and floral species, such as a mangrove dominated forests, mudflats, adjacent coral reefs and contiguous water courses, like rivers, bays inter creeks and channels and black waters (Tomlinson, 1994). The architecture especially the micromorphology of mangrove leaves has drawn much attention time to time. (Nandy et al., 2005; Seshavatharan & Srivalli; 1989; Das & Ghose, 1993; Ramaswamy & Kannabiran; 1996) Most of the trees and shrubs are adapted to the partly saline and partly submerged coastal ecosystems called as mangrove ecosystems by various means like presence of stilt or prop roots, succulent leaves with thick cuticle, sunken stomata, salt glands pneumatophores and viviparous germination of seeds. Mangrove structural characterization has been proved with functional explanations. Cuticle, mesophyll zone and stomatal characterization relate to transpiration and photosynthesis; salt glands and water storage tissues are attributed to maintenance of salt balance and the increased number of vessels per unit area is related to water stress. (Datta et al., 2005)

There are approximately 70 species of true mangroves of which some 65 contribute significantly to the structure of mangrove forests. Approximately 15 species occur in South-East Asia, approximately 15 species occur in Africa, and around 10 species occur in the America. Mangrove forests are best developed on tropical shorelines where there are large areas available between high and low tide points.

Sundarbans of W. Bengal represent the largest stretch of mangroves in the country. It accounts for about 10% of the mangroves in the world, covering an area of 12,000 square kilometers of which third part lies in India and rest is in Bangladesh. Gujarat has 1650 sq.km. long coastline area, which is exclusively economical zone. Though the maximum area under marine influence is large (62.3% of Indian Coastline area) it is not having wide diversity of mangrove. The reason for that is the rainfall and other climatic conditions are not favorable hence, only few species prefer to grow in such environment. (Singh, 2000)

Ecological and economical values of mangroves are recognized globally. As a result of the great economic importance of mangroves they have been exploited a lot. As per IUCN criteria for threats, categories like Rhizophora, Ceriops, Sonneratia, Aegiceras, Bruguiera and Acanthus have exterminated or are on the verge of extermination and their distribution is restricted on few islands with less population.

Rhizophoraceae, often considered to be a true mangrove family, has only four of its 16 genera inhibiting a mangrove habitat. Avecenia marina probably displays one of the broadest distributions over the Indian Ocean to the Western Pacific when compared to other mangrove trees of the region. Sonneratia apetala and Sonnertia caseolaris are found in Sunderbans, Orissa, Andhrapradesh, Tamil Nadu, Goa, Karnataka, Maharashtra, Gujarat and Andaman and Nicobar Islands. In Gujarat, it is distributed in the Tapti Sanctuary near Surat and some patches are also seen in the Marine National Park, Jamnagar. Rhizophora mucoranta commonly occurs on the coasts of the Indian Ocean and the West-Pasific.

In the present study four commonly growing species of mangroves from the coastal area of Jamnagar in Gujarat have been evaluated for the leaf micromorphological and anatomical features.

2. MATERIALS AND METHODS

All the plant samples used in the present study were collected from natural habitat. They were collected from a patch at the Marine National Park, Bedibandar, Jamnagar, Gujarat (Fig. 1, A, B). This Marine National Park is India's first Marine Sanctuary and National Park is found in the Gulf of Kutch. The Gulf of Kutch located on the west coast of India is an arm of the Arabian Sea.

2.1. Micromorphology

All the plant part of different species were collected in separate bags. Collected leaves were fixed on the spot in FAA (Berlyn and Miksche, 1976) these FAA fixed samples were used to obtain epidermal peels. Portions of the leaves taken from the median part (midway between the tip and base) from ten accessions of each species. They were put into Jeffreys maceration mixture (10% Chromic acid and concentrated hydrochloric acid) and kept in oven at 60^{O} C for 20-25 minutes. The adaxial and abaxial epidermises were separated by using needles and forceps. Each of these samples were then thoroughly washed in water, stained in 0.05 % aqueous toluidine blue in 1% borax, mounted in 50% glycerine and observed under light microscope. Epidermal cell features like shape and size of epidermal cells and stomata as well as the stomatal type, stomatal index etc. were studied using epidermal peels. For Stomatal index and size, counting and measurement of stomata by micrometry technique were done at uniform magnification in 10 different peels from both the epidermal layers.

2.2. Anatomy

For the anatomical study, fixation, embedding and sectioning were made following Johansen (1940) and Sass (1958) with suitable modification. The FAA fixed leaves were dehydrated on Tert-butyl alcohol and were embedded in paraffin wax with ceresin, mp 58-60 deg C. (Johansen, 1940) Transverse sections (TS) were obtained at 8-12 μm thickness on rotatory microtome. Ribbons were spread on glass slide using 1% Haupt's adhesive (Berlyn and Miksche 1976). A modified method of staining was used in which the slides were directly stained in 0.5% aqueous toluidine blue in 1% Borax, air dried and deparaffinized in xylene and mounted in DPX. Along with the microtome sections, the hand cut TS of leaf were also taken using ordinary razor blade and these sections were stained in 0.5% aqueous toluidine blue in 1% Borax.

Photomicrographs of sections and epidermal peels were made using Olympus CX41, Japan with bright field and fitted with camera attachment. Films used were "Prophoto, Kodak", 100 ASA.

Fig. 1

Fig 1: A. Mangrove Habitat at Marine National Park, B. Pneumatophores of Mangrove species

3. RESULTS

3.1. Micromorphology of Leaves

Epidermal sculpturing has provided little systematic information but has considerable diagnostic value. In this study, epidermal surfaces revealed a number of important micromorphological characters which also exhibited variations that were of great significance. Fig. 3 represents the micromorphological features of diagnostic value observed in the four different studied species. Results on the leaf epidermal peel showed that stomata are found only on lower epidermis in A. marina and R. mucronata, indicating it to be hypostomatic while the leaves of both species of Sonneratia were amphistomatic. Table1 depicts the characteristic morphometric features observed in the epidermal layer of the studied species,

Both adaxial and abaxial epidermal cells were polygonal with anticlinal walls straight or slightly arched (Fig.2.). Epidermal cells above the midrib region were polygonal and the cells were elongated with the end walls straight or oblique (Fig, 2, F.). The epidermal layer is completely covered by a very thick cuticle. Length and width of the epidermal cells varied in the different species. The maximum epidermal cell size was observed in Avicennia marina and the smallest epidermal cells were that of Rizophora mucronata.Adaxial and abaxial epidermal cells did not show much variation in size.

Stomata in all the studied species appeared to be sunken. In A. marina diacytic stomata are present and in R. mucronata anomocytic cyclocytic stomata are found, while the stomata are cyclocytic and staurocytic type in S. caseolaris and in S. apetala they are staurocytic but not cyclocytic. Abnormal stomata , i.e., stomata occurring in a cluster of two to three having common subsidiary cells was observed in R. mucronata (Fig.2. G, H, arrow) .

A. marina and R. mucronata lower epidermal layer cell is interrupted by secretory pores (Fig.2.B, H). These pores were lined by four to five layers of radially arranged flattened epithelial cells. Salt glands were present on the lower surface of Avicennia marina which though could be distinctly observed in the epidermal peels but were clearly distinguished in the transverse view of the leaf.

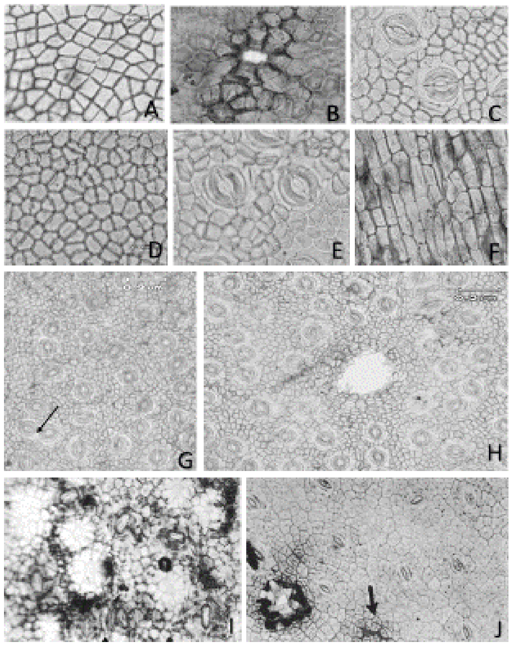

Fig. 2

Fig 2: A. Upper epidermis of A. marina, B. Lower epidermis of A. marina showing secretory pores, C. Lower epidermis of A. marina showing diacytic stomata, D. Upper epidermis of R. Mucronata, E. Lower epidermis of R. mucronata, F. Upper epidermis of R. mucronata showing mid-vein, G. Abnormal stomata of R. mucronata, H. Abnormal stomata of R. mucronata, I. Upper epidermis of S. caseolaris, J. Lower epidermis of S. apetala

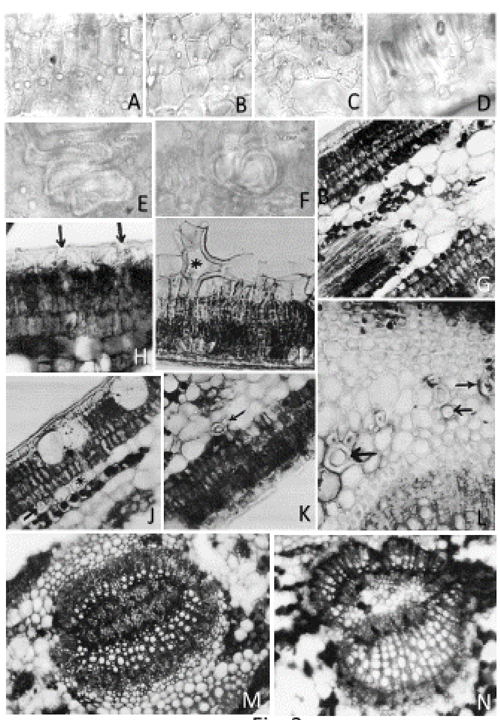

Fig. 3

Fig 3: A. Palisade layer, B. Hypodermal layer, C. Spongy parenchyma, D. Peltate salt gland on lower epidermis, E. Elongated sclereids, F. Rounded sclereids, G. T.S. of S. caseolaris isobilateral leaf, H. Sunken stomata of S. caseolaris Note the cuticle over arching guard cells, I. T.S. of S. apetala leaf showing branched sclereids (asterix) (arrowpoints to large cavity below epidermal layer), J. T.S. of S. caseolaris leaf showing branched sclereids, K. T.S. of S. caseolaris leaf showing rounded sclereids, L. T.S. of S. apetala leaf showing rounded sclereids, M. Midrib of S. caseolaris, N. Midrib of S. apetala.

4. ANATOMY OF LEAVES

Transverse section revealed that leaves of A. marina and R. mucronata were dorsiventral with a clear differentiation of upper and lower region. Epidermal layer covered with thick cuticle layer was followed by hypodermis made up of thin walled compactly arranged large polygonal water storing cells (Fig.3.B).The number of hypodermal layer in A. Marina was more (5-7 Layers) compared to that of R. mucronata (2-3 layers). Mesophyll could be differentiate into palisade and spongy layer, below the hypodermis 3-4 layered palisade layer was present in both the species. Rhizophora leaf palisade layer differed from Avicennia leaf palisade in its cell length being reduced gradually towards the inner layers. Spongy tissue comprises of elongated armed cells with large intercellular spaces (Fig.3,C). The lower epidermal cells intermittently at short distance showed presence of peltate salt trichomes (Fig.3.D) .The salt trichomes or glands had a stalk made up of one or two elongated cells and "T" shaped terminal cells. In the spongy tissue layer sclereids both elongated and round were observed intermittently (Fig.3.E, F).

Transverse section revealed that leaves of S. apetala and S. caseolaris were isobilateral. Epidermal cells are cubical shaped in S. caseolaris and in S. apetala cells are barrel shaped. Both upper and lower epidermises showed presence of 3-4 palisade layers below them. Stomata could be located on both the epidermises. Guard cells are covered by thick cuticle which forms prominent ledges over the sto-

Table.1: Characteristic features of stomata and epidermal cells

Plant Species	Stomata					Epidermal Cells		
	Type	Location	Length (μ)	Width (μ)	Index	Shape	Length (μ)	Width (μ)
Avicennia marina	-	Upper epidermis	-	-	-	Polygonal	30.90 ± 0.20	24.90 ± 0.15
	Diacytic	Lower epidermis	27.30 ± 0.16	22.45 ± 0.13	10.46	Polygonal	32.20 ± 0.19	23.40 ± 0.14
Rhizophora mucronata	-	Upper epidermis	-	-	-	Polygonal	14.5 ± 0.79	8.90 ± 0.44
	Anomocytic	Lower epidermis	51.60 ± 0.17	31.78 ± 0.20	3.13	Polygonal	15.60 ± 0.8	9.10 ± 0.55
Sonneratia caseolaris	Cyclocytic & Staurocytic	Upper epidermis	31.30 ±0.15	20.14 ± 0.16	3.36	Polygonal	24.60 ± 0.45	16.55 ± 0.45
		Lower epidermis	33.12 ± 0.16	21.15 ± 0.18	3.2	Polygonal	23.89 ± 0.45	15.47 ± 0.30
Sonneratia apetala	Staurocytic & Cyclocytic	Upper epidermis	30.12 ± 0.18	19.55 ± 0.15	2.7	Polygonal	23.24 ± 0.33	14.39 ± 0.25
		Lower epidermis	32.50 ± 0.17	21.30 ± 0.14	3.1	Polygonal	22.25 ± 0.55	13.50 ± 0.89

matal pore (Fig.3, H, arrow). In S. caseolaris, the adaxial and abaxial both palisades are made up of three layers and cells of abaxial pallisade are smaller than adaxial palisades.(Fig.3,G) While in S. apetala, adaxial palisade is made up of three layers and abaxial palisade is made up of three layers. (Fig.3,I). Spongy tissue in between the palisade layers is thin walled polygonal and compactly arranged unlike Rhizophora and Avicennia in which they are lobed or armed and elongated. Rounded and elongated branched sclerieds are present in spongy layer. (Fig.3,I,J, aterix) In Sonneratia sps. rounded sclereids are denser below the upper palisade (Fig.3,L) and branched sclereids are accumulated towards the lower end. Four vascular bundles arranged two oppositely facing each other are present in the midrib. The vascular bundles are placed with their xylem tissue towards the centre and phloem facing towards the epidermal layers (Fig.3, M, N).

5. DISCUSSION

The mangroves are a group of salt tolerant plant species which occur in the tropical and subtropical inter tidal estuarine regions, sheltered coast lines and creeks and are dominated by partly submerged sclerophyllaous plant species which are taxonomically unrelated. The present investigation reveals the comparative leaf micromorphological and anatomical features of Avicennia marina, Rhizophora mucronata, Sonneratia caseolaris and Sonneratia apetala. The lamina surface has been the subject of more investigations than other plant surfaces and since many of the variable features are constant within taxa they often have taxonomic applications. (Stace 1969, Ru dall 1992)

Epidermal cell in Rhizophora are characterized by their thick cuticular membrane, straight epidermal cell walls, absence of stomata from the upper epidermis, absence of an epidermal venous system apart from the midribs, total absence of trichomes and cyclocytic subsidiary cells. Previously it was assumed that cork-wart-like structure develops either where the epidermis is interrupted (Stace, 1965) or where a modified epithelium is formed (Fahn, 1979). However, Farooqui (2000) proposed that cork-warts are merely modified stomatal complex; the radial rows of elongated epidermal cells around the stomata gradually increase in number leading to a small opening, the stomatal cavity, in the center.

In Avicennia there is a presence of T-shaped salt gland towards the lower epidermis which performs the function of salt secretion. Outer stomatal ledge rarely conspicuous, single, subsidiary cells always two, diacytic type of stomata. The cuticle is considerable thick in many mangroves and the outer epidermis is always cutinized. Artz (1936) reported that non-stomatal water loss is restricted by the presence of strongly cutinized thickened outer epidermal cells. The cuticle is smooth in Avicennia and uneven Rhizophora. Waisel (1972) assumed that the cuticle of mangrove leaves is an adaptive feature. The plant cuticle is a lipophilic extracellular membrane consisting of the amorphous biomolecular cutin (Holloway, 1982) and cuticular waxes (Baker et al., 1982) which are embedded within the cutin polymer.

Epidermal cells in S. caseolaris are cubical in shape and in S. apetala are barrel shaped. The size of the epidermal cells is larger in S. apetala than S. caseolaris. Leaves are hyperstomatic in both species of Sonneratia but there is a considerable difference of the stomata in both the species with respect to the shape of guard cells, size of stomata and the stomata ledges. The shape of guard cells in S. caseolaris is oval to round whereas that in S. apetala is pyriform or kidney shaped. In S. caseolaris the outer wall of the guard cell is thicker than the inner wall whereas in S. apetala the inner wall of the guard cell is thicker than the outer wall. The stomata size is slightly bigger in S. caseolaris than S. apetala. The stomatal ledges can be seen very prominently in S. caseolaris hence the stomata are more deeply sunken in S. caseolaris than S. apetala. (H.B. Singh & M. Vishwananthan, 2000) The mucilage pores are found on both the layers in S. caseolaris whereas in S. apetala they are found only in the upper epidermis. The multicellular salt glands are not found in S. caseolaris but in S. apetala they are found on both the epidermal layers. In S. caseolaris adaxial and abaxial both palisade are three layered while in S. apetala adaxial palisade is three layered and abaxial palisade is two layered.

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ROLE OF PLANTS IN SOME RITUALS OBSERVED AMONG KERALA BRAHMINS DURING EARLY CHILDHOOD

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ABSTRACT

In this research paper the role of 16 plants are mentioned which find their use in some customary rituals among Kerala Brahmins during early childhood. Among these, both wild and cultivated species are there most of which are found growing in Kerala in homesteads. All the plants recorded have medicinal properties and most of them are used in traditional Ayurvedic preparations. The nine customary rituals presented here start with the administering of herbal juices to the new born and continues with 'Panthrandam Japam' and more at different phases of his/ her life till the child is 4 year old when he/ she is introduced ritualistically into the world of 'Scripts in Malayalam language'- The Fifty one letters in Malayalam'. Thus the present investigations into Indian traditions once again exemplifies the fact that they are designed with foresight so that they still remain relevant even with the ever changing social and scientific principles of modern times and is worthy of being transferred to the posterity.

Key words: 16 plants, medicinal properties, cultivated species, ayurvedicpreparations , posterity.

1. INTRODUCTION

Plants have always influenced regional traditions related to religions all over the world. The rituals and customs are thus directly or indirectly related to plant species grown within a climatic spectrum and have influenced lifestyles of human race since time immemorial. Phytogeography of a region plays significant roles in the way in which customary rituals are observed traditionally. In the wake of biodiversity concerns and issues of Global warming, the author has tried to explain certain customs during the childhood within a specific community and its relation to local plants grown within the area.

2. METHODOLOGY

The author's own experiences who is hailing from the community, the discussions with the senior members of the community and a book written in Malayalam language written in 2001 by late Smt. Cheruvakkara Parvathy Antherjanam titled as 'Antherjanangalude Acharanushthanangal'('The customs and rituals among the womenfolk of Brahmin community') together formed the basis of this paper.

The vernacular, popular and botanical names along with the family and the respective rituals are given in order which is observed from the date of birth of the child till the child's fourth birthday.

3. OBSERVATIONS

3.1. a. Paval(Vern.); Bitter gourd; Momordicacharantia – Cucurbitaceae – Fresh leaf juice is used.

b. Manjal(Vern.); Turmeric; Curcuma longa – Zingiberaceae– Rhizome is used.

c. Brahmi(Vern.); Herpestrismoniera – Scrophulariaceaeand Centellaasiatica – Apiaceae– Fresh leaf and stem are used.

The above mentioned components are mixed with sugar candy powder and given to the new born in liquid form in empty stomach for a week.

It is believed that the herbal juice removes lung conjustion, destroys intestinal worms, improves voice clarity and intelligence.(C.P. Antherjanam, 2001)

3.2. Darbhapullu; Darbha; Desmostachyabipinnata – Poaceae – Dry stem with leaves are used.

The ritual is known as 'Panthrandamjapam'. The new born is laid on anew, white dhothi. Brahmins sit in a circle around the baby holding the dried darbha leaves the tips of which are tied together, which touches the child as they recite 'Slokas' from 'PurushaSookhtham', BhagyaSookhtham', 'Saraswatham'. Later 'Panchaksharam'(Om Namashivaya') is also recited.

3.3. Vayambu;Sweet flag; Acoruscalamus–Araceae – Dried rhizome is used.

The ritual is called 'Vayambukodukkal'. A thin golden wire is inserted into a long piece (5-6 cm) of dried rhizome. Selecting an auspicious time, the rhizome is rubbed on whetstone and the paste is mixed with fresh butter or ghee and is given to the child on empty stomach.
It is believed that the intake of the above mentioned, improves intelligence, tones the intestine and improves voice clarity.

3.4. Ilanji ; Spanish cherry; Mimusopselanji –Sapotaceae – Fresh leaves are used.

The ritual is called 'Anthi Uzhiyal' .This starts from the 12th day of the child's birth and is performed during dusk. Keeping the infant on the lap of the mother/ grandmother, 6 leaves are taken and one oil wick each is kept on each leaf towards its tip. In two small, shallow saucers made of tin or brass black and red liquid (water with powdered charcoal for black and a combination of turmeric and quicklime for red colours respectively) are taken. The lit wick on the leaf is rotated round the child 3 times and is put in the black and red water one after the other.
It is believed that this act will ward away evil spirits from the newborn.

3.5. Plavu; Jackfruit tree; Artocarpusheterophyllus– Moraceae

The ritual which is performed selecting an auspicious day and time, is called Vathilpurappadu. The father carries the child and gets out of the house through the eastern entrance, in front of whom will be another person carrying 'Ashtamangalyam' (A brass plate with spread red silk cloth on which 8 auspicious objects are kept in small wooden 'Cheppus' like few paddy seeds, paddy grains, one turmeric rhizome, little saffron, a piece of sandalwood, a garland made of *'Dashapushpam', special mirror made of brass called 'Valkannadi' and a sacred text written on palm leaf, mostly 'Devi Mahatmyam'). Both together circumscribe the jackfruit tree 3 times, chanting 'MangalyaSookhtham'.

3.6. a. Incha(Vern.); Soap bark; Acacia caesia – Mimosaceae – Bark is crushed, dried and used.

b. NenmeniVaka (Vern.); Siris tree; Albizzialebbek – Mimosaceae – Leaves are dried, powdered and used.

c. Ari (Vern.); Rice; Oryzasativa – Poaceae – Seeds are used

d. Rudraksham(Vern.); Bead tree; Elaeocarpusganitrus – Elaeocarpaceae – Seeds are used

e. Kadukka(Vern.); ChebulicMyrobalan; Terminaliachebula-Combretaceae - Seeds are used

f. Ilanji ; Spanish cherry; Mimusopselanji –Sapotaceae –Seeds are used- Seeds are used

During the 6th month, the child for the first time is fed with cooked rice which has an accompaniment of 8 vegetarian dishes and a sweet preparation called 'Payasam'.This ceremonial custom practiced during an auspicious day and time is called 'Choroonu'.
During this occasion, the child is made to wear ornaments, for the first time. Seeds of 'Rudraksham', 'Kadukka' and 'Ilanji' are incorporated into the making of gold ornaments like chain and ring.

3.7. a.Vayara (Vern.); Hog vine; Merremiaumbellata - Convolvulaceae

b. Karuka(Vern.); Bermuda grass; Cynodondactylon - Poaceae

Performed during all birthdays, from first birthday onwards, before having lunch,thisritual is named 'VayaraUzhiyal'. A brass container with the snout ('Kindi') containing water is kept by the side of the child.water. Standing behind the child and facing the east, a bunch of 'Vayara', 3 culms of 'Karuka',little rice and 'Valkannadi' are held togetherand rotated round the 'Kindi' and the child.
After this , 'Dashapushpamala' is kept on the hair. Lunch is served after this.

3.8. a. Ari (Vern.); Rice; Oryzasativa – Poaceae – Seeds are used

b. Karimbu(Vern.); Sugarcane; Saccharumofficinarum – Poaceae – Fresh stem is used

c. Kadalipazham(Vern.); Banana; Musa paradisiaca–Musaceae – Fruits are used

b. Munthiri(Vern.); Grape; Vitisvinifera – Vitaceae – Fruits are used.

c. Nalikeram(Vern.); Coconut; Cocosnucifera-Arecaceae – Fruits are used.

These plants are used in 2 rituals called 'Poojavaypu' and 'Ezhuthiniruthal' which are done prior to the introduction of the child , to the world of '51 scripts of Malayalam language'.

Both rituals are performed in 'Kanni' month of Malayalam calendar. 'Poojavaipu' is done on the evening of 'Durgashtami' and on the 3rd day is 'Vijayadashami', when 'Ezhuthiniruthal is done.

During 'Poojavaipu', elaborate adorations are done for Lord Ganapathy, Goddess Saraswathi,Vedavyasan(Hermit of Dwaparayugam who divided the Vedam into 4 parts) and Lord Dakshinamoorthi. Popped rice(Malar), beaten rice (Avil), jaggery, a special type of banana variety called 'Kadali', black dry grapes, sugar candy, *'Panchamrutham'(a combination of 5 natural sweet substances-Table-1)*'Thrimadhuram'(A combination of 3 natural sweet substances – Table-2)) and tender coconut water are the offerings during the 3- days of adoration. 'Palpayasam'- a liquid sweet prepared by cooking freshly pound non boiled rice in cow's milk with sugar is a very special offering on 'Ezhuthiniruthal' or 'Vidyarambham' day.

'Ezhuthiniruthal', is performed during the 3rd or 4th birthday of the child but has to be completed before the 5th birthday. The child is given bath, made to wear a small, new dhothi and sits in the lap of his/her father or grandfather or any other learned person in front of the arrangement done for 'Poojavaipu'. Holding the child's tongue with the left hand, using a golden ring, starting from the auspicious prefix 'Hari Shree GanapathayeNamah:' all the 51 Malayalam scripts are written on the toungue. Later, holding the child's right index finger, the letters are once again made to write in rice which is kept in a medium sized round brass container (Uruli)

Only after 'Vidhyarambham',the child is considered eligible for formal education.

Table 1: Components of 'Panchamrutham'

Sl.no.	Ingredient	Botanical source/ Bot. name with family
1.	A banana variety called'Kadali'	Musa paradisiaca - Musaceae
2.	Jaggery	Saccharumofficinarum - Poaceae
3.	Sugar candy	Saccharumofficinarum - Poaceae
4.	Dry, black grapes	Vitisvinifera - Vitaceae
5.	Honey	-
6.	Ghee	-

Table 2: Components of 'Thrimadhuram'

Sl.no.	Ingredient	Botanical source/ Bot. name with family
1.	Dry, black grapes	Vitisvinifera - Vitaceae
2.	Sugar candy	Saccharumofficinarum - Poaceae
3.	Honey	-
4.	Ghee	-

4. DISCUSSION

All the nine rituals recorded in this research paper, show case an array of wild plants and crop plants, most of which grow well in the climatic conditions in Kerala.

Leaf juice of bitter gourd, rhizome of turmeric and leaves and stem of 'Brahmi' has therapeutic values. Leaves as emetic and purgative, rhizome as laxative and purifier of blood and the third component as nervine tonic, mild purgative and a cure for bronchitis etc.Centellaasiatica is highly medicinal and is known to increase memory power and voice clarity, cure bronchitis and purify blood. Desmostachyabipinnattais cooling and culms have diuretic properties. (Kirtikar and Basu, 1981).

Dried rhizomes(roots) of Acoruscalamus were used in ancient Indian system of medicine to enhance memory, increase speech quality and to recover from stroke. Recent studies by Kumar and Vandana show the invaluable therapeutic properties of the plant and ascertain its roles as an anti ulcer, anti-spasmodic, analgesic, anticonvulsant, antibacterial and anti-inflammatory agents. The major phyto constituent is βAsarone (2013).

The smoke produces from burning flowers of Mimusopselanjihas properties for curing asthma. (Kirtikar and Basu, 1981).

Saponins are present in the bark of Acacia caesia and act as mild cleansing agents. Antimicrobial properties have been attributed to the plant extracts of A. caesia (Thambiraj and Paulsamy, 2011). The leaves of Albizzialebbekcontains many alkaloids, glycosides and saponins and are active in resisting the growth of bacteria like Staphylococcus aureusand Pseudomonas aeruginosa(Chulet et al., 2010). Sakat et al have experimentally shown that the aqous solutions of seeds of Elaeocarpusganitrushave antihypertensive activity in rats (2009). Antifungal properties against Candida albicans also have been attributed to the seeds by Singh et al. (2010). An ayurvedic preparation namely 'Triphala' – a combination of 3 herbal constituents-has its main ingredient as Terminaliachebulaand is known for its ability to gently cleanse and detoxify the system(www. Oneworld.alc.org). Experiments have proved that the phyto constituents in the plant acts against myocardial damage in rats (Suchalata and Devi, 2005)

Studies on Merremiaumbellata by Ganjir,Behera and Bhatnagar (2013) show the cytotoxic and antioxidant properties of the vine and consider it as the 'Potential Candidate for Drug Development'. A great volume of research on the grass Cynodondactylon, clearly validates its medicinal properties and in India it is widely used as an offering to Lord Ganesha. Burning of this grass is done for special poojas which is offered in prayer called as 'KarukaHomam'. This plant is used a s a cure for asthma, bronchitis, as an emetic and antipyretic (www.hort.purdue.edu) to name a few medicinal properties. Singh et al in their studies with the plant, have identified its qualities in controlling diabetes, lowering serum Creatinine level and there by efficiently improving kidney functions (2009).

Among all the different varieties of banana available in Kerala, 'Kadali' variety is mainly used in Hindu rituals and as an offering. The exact reason behind this is unknown. But some references point out to its qualities in relieving 'Vata- Pithadoshas' of the body and is a good remedy for Anaemia and increased Blood Pressure(www.ayurveda- recipes.com).

Other plants mentioned in the paper are cultivated plants like jackfruit tree, rice, coconut and sugarcane which are suitable for Kerala's climate and soil and have a good number of nutritional and commercial values. Grapes have found its place in the customs and practices of the state even though it is not found in cultivation here. But the combination of grapes with ghee and other ingredients is known to increase the capacities of the cognitive domain(As told to the author by ShriSajeeshNamboothiri,Bappatta Illam, Kakkancheri, Kozhikode,Kerala).

Few customary rituals mentioned in this paper, clearly evaluate the integral role of plants in each and every one of them. As townships are spreading their wings in all directions, in course of time there are chances that all of those mentioned above which are mostly seen in rural areas may disappear sooner or later. As man becomes more 'sophisticated' in his lifestyles and approach to life, he hardly thinks as to what we are losing in this 'rat race' towards 'NOTHINGNESS'. The decision is ours- yours and mine! Either to revive the culture and protect the 'HERITAGE' for the posterity or to forget the past and live in the illusion of the glittering future which would never come at all! Remember – by enacting the rituals we are just not mechanically replaying something which our ancestors were performing , but protecting and conserving a whole lot of 'Green Treasure' for the generations to come.

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A PRELIMINARY SURVEY OF SPIDERS (ORDER: ARANEAE) IN MURIYADKOL WETLANDS- A PART OF VEMBANAD-KOL RAMSAR SITE

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ABSTRACT

The study provides a basic inventory of spider fauna collected from the MuriyadKol wetlands based on a preliminary survey conducted during a period of 10 months from January to October 2014. The study area was dominated by paddy fields. The study identified 94 species belonging to 63 genera and 18 families. Salticidae was found to be the most diverse family which is represented by 19 genera, followed by family Araneidae with 11 genera. The orb weavers (38 %) were found to be the most dominant guild followed by stalkers (32%)> space web spiders > foliage runners> ambushers> ground runners. The study also provides the first report of the genus Micrommata of family Sparassidaefrom India,which has a more Palearctic distribution. The most dominant spiders in the rice paddy ecosystem were Tyloridastriata and Pardosapseudoannulata. The vertical stratification of common spiders relative to the time period on the rice paddy was also elucidated in the present study.

Key words: Arachnology, ecology, biodiversity,paddy field, new report, guild, vertical stratification.

1. INTRODUCTION

Spiders are an integral part of the biodiversity since they play many important roles in ecosystems as predators and sources of food for other creatures (Sebastian et al., 2011). They are the most omnipresent and numerous predators in both agricultural and natural ecosystems (Zahl, 1971). Spiders constitute the largest order of class Arachnida and is the seventh largest order among any other organisms with a total of 45,119 species in 3,932 genera and 114 families globally (World Spider Catalog, 2014).Being exclusively predatory they play a major role as natural control agents and spider guilds having different ecological niches may collectively play an important role in suppressing the populations of pest insects (Nyffelerand Benz, 1987; Hodge, 1999; Ghafoor, 2002; Peckar, 2004).

Wetlands are integral part of river basins or extension of sea and are considered as one of the most productive ecosystems of earth (John et al., 2003). Many studies (Dobel et al., 1990; Gravesen et al., 2000; Buchholz, 2009, Komposch, 2000) explored the diversity and ecology of spiders of wetlands around the world. Spiders are known to be good ecological indicator in wetland areas (Gravesen et al., 2000). Little ecological work has been done on the spiders in the wetlands of India and inventories of spiders from this habitat is rare. Most of these studies were limited to the agroecosystemsonly, mainly Riceagroecosystems (Banerji et al., 1993, Pathak et al., 1999, Battacharya, 2000, Sebastian et al., 2005, Sudhikumar, 2007, Jayakumar and Sankari, 2010 and Sebastian et al., 2011). Kerala has the largest area under wetlands in India (Nayar and Nayar, 1997), but still the spiders of these fragile ecosystems remains largely unexplored. The spider fauna of central Kerala is more rich and diverse compared with any other region in India. This is because of the complex interaction of various climatic factors such as high rainfall and humidity with diverse topographical features, central Kerala possess many smaller but diverse environmental niches that can support a diverse spider fauna (Sebastian et al., 2011). Few studies were conducted by Sebastian et al., 2005; Sudhikumar, 2007 in the wetlands of Kerala but they were confined to the rice agro ecosystems. There is a dearth in literature pertaining to the diversity and ecology of spiders in the wetlands of India.

The Kol wetland, which is part of the Vembanad-KolRamsar site, is spread into Thrissur and Malappuram Districts of Kerala and remains as one of the major fresh water wetlands of Kerala.The Kol wetland is extremely rich in biodiversity and is the favourite destination for a large number of migratory birds (Jayson, 2002). MuriyadKol wetland is a part of the south Kol lands and consists of a total field area of 1,215 hectors and is among the eight fresh water wetlands of Kerala(John et al., 2003).Rice is the major crop in the region and is considered the 'rice bowl' of Thrissur and Malappuramdistricts of Kerala.The associated landscapes are dominated by various other crops such as bananas, arecanut, tapioca, coconut and vegetables;the region is also marked by vast tracts of abandoned grass lands, temporarily flooded plains, lakes, streams and a river system.Research on biodiversity and ecology in agro ecosystem is highly valuable, as it gives an insight into the predation of spiders on herbivorous pests (Maloney et al., 2003) and knowing how profound changes in environment affect spider colonization (Oberg, 2007). So the spiders of paddy fields were also sampled in this study. The guild structure of spiders of the wetland and the vertical stratification of spiders of paddy is also elucidated in the present study. This study provides an inventory of spiders of this unique ecosystem and helps understand certain aspects of their ecology in the wetland ecosystem.

2. MATERIALS AND METHODS

2.1. Study area

The study area is spread over an area of 57.75 Square kilometres located 8 kms northeast of Irinjalakuda town and falls between 10°25'32", 10°18'47" N latitude 76°17'19", 76°12'48" E longitude (Fig. 1). The area is geographically distributed in Muriyad, Porathissery, Velukkara and Parappukkara Panchayaths and part of Irinjalakkuda municipality, and drained by the Kurumali tributary of the Karuvannurriver. The area recorded a minimum temperature of 21°C and a maximum of 38°C. Humidity ranges from 85-95 % during June-September and 70 % during January with an average rainfall of 2757 mm out of which 67.3% is received during S-W monsoon and 18% during N-E Monsoon (Johnkutty and Venugopal, 1993). Most of the region lies 1-2 m below Mean Sea Level. The major crop of the region is paddy and cultivation is done by pumping out water from the wetland into bunds and maintaining it with specialized pumping system called petti and para (Jeena, 2010). The paddy fields at 10°19'46" N latitude and 76°16'01" E was selected for studies on vertical stratification.

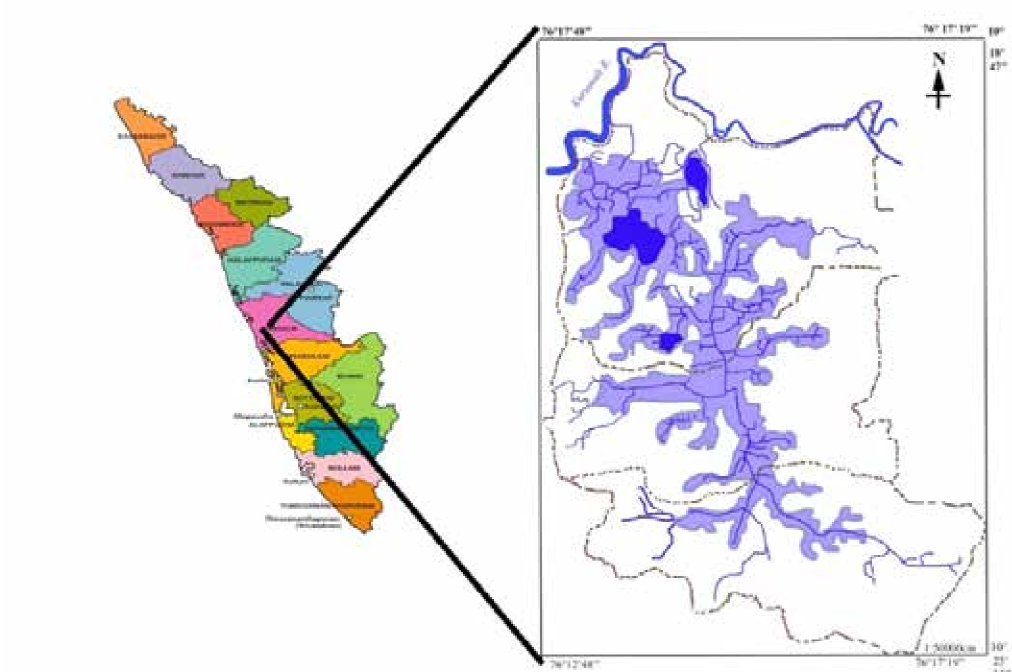

Fig. 1: Study area

2.2. Survey

The survey was conducted for a period of 10 months from January to October 2014. Transects of 50 m x 3m were placed in selected habitats like paddy ecosystem, abandoned wetlands, and mixed crops, fringes of wetlands and temporary water-logged areas. Sampling was done by sweeping (diameter 0.38m), vial tapping, aspirator, aerial hand collection and beating. Pit fall trapping was found to be unreliable as incessant rains flooded the apparatus most of the time. The spiders were collected in plastic bottles and preserved in 70% ethyl alcohol with proper labels. The spiders were identified up to the species level with the help of available literature (Tikader, 1987; Barrion and Litsinger, 1995; Sebastian and Peter, 2009).

2.3. Guild structure and vertical stratification

The studies on guild structure was based on the ecological characteristics of the spiders families collected during the study and classified according to their foraging manner, nature of web, prey species, microhabitat use, site tenacity and daily activity (Young and Edwards, 1990). The vertical stratification studies on paddy crop was conducted during the Virippu season from 12th august to 17th September 2014. The fully grown rice plants with an average height of 85 cm were sampled for spiders at each of the four zones (Zones A, B, C and D) on the basis of height (0-20, 20-40, 40-60, >60 cm) from the water level twice a week. Spiders were collected at four time intervals, 0800-0900 hrs, 1300-1400 hrs, 1700-1800 hrs and 2000-2100 hrs. This was done to see if there is any change in the position of the spiders at different time periods. 4 quadrates of 1m x 1m placed on the four corners of the paddy field was sampled carefully and adjacent plots of paddy were sampled for each time interval. The spiders present at a particular zone was identified and numbered in the field. Different plants were sampled for each zones to minimise the disturbance to spiders on other zones while sampling a zone on a plant.

3. RESULTS

3.1.Survey

The study identified 94 species of spiders belonging to 63 genera and 18 families from the MuriyadKol wetlands (Table 1). Families Salticidae and Araneidae were found to be most diverse in terms of generic diversity represented by 19and 11 generarespectively (Table 2). Whereas family Araneidae lead the list with most number of species (22), followed by family Salticidae (21).The dominant spiders of the wetland were Pardosapseudoannulata (family Lycosidae), Tyloridastriata (family Tetragnathidae), Araneusellipticus (family Araneidae), Oxyopesjava nus(familyOxyopidae), Tetragnathaviridorufa and T. javana(familyTetragnathidae), Neosconamukerjei and N. bengalensis (family Araneidae) and Hippasaagelenoides (family Lycosidae). The most dominant species of spiders in the paddy fields were Tyloridastriata and Pardosapseudoannulata. The dominant species of family Salticidae that were commonly encountered in the paddy fields were Bianoralbobimaculatusand Curubistetrica. The genusTetragnathaexhibited the most diverse number of species among genera with 7 species, which was followed by genus Neoscona (5 species) and genus Oxyopes (4 species). In terms of species diversity the family Araneidae lead the list with 22 species, followed by family Salticidae and family Tetragnathidae with 21 and 11 species respectively. The study also found a species belonging to the genus Micrommata, Latreille, 1804 of family Sparassidae, making it the first report of this genus from India. The species of this genus usually occur in the palearctic region except a species described from South Africa.

3.2. Guild structure

A guild is defined as a group of species that exploit the same class of environmental resource in a similar way (Daniel et al., 1991). Six guilds of spiders were identified in the study area using the guild classification described by Uetz (1999). Orb weavers represented the dominant guild (39 %), others being stalkers (28 %) > space web builders (11 %) > foliage runners (10 %) > ambushers (7%) > ground runners (5 %) (Fig.2).

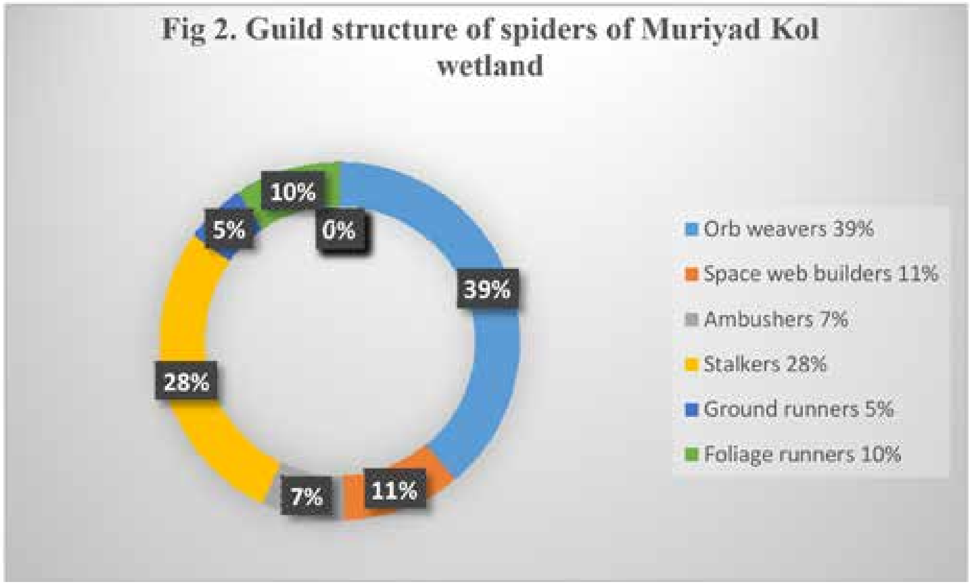

Table 1: List of spiders collected from the MuriyadKol wetlands of Kerala.

Table 2: List of families collected from the MuriyadKol wetland showing the number of genera and species.

	FAMILY	No. OF GENERA	No. OF SPECIES
1	FamilyAraneidae	11	22
2	FamilyClubionidae	2	2
3	FamilyCorinnidae	1	1
4	Family Eutichuridae	1	2
5	FamilyHersiliidae	1	1
6	FamilyLycosidae	3	4
7	Family Oxyopidae	2	5
8	Family Pholcidae	3	3
9	FamilySalticidae	19	21
10	FamilyScytodidae	1	1
11	Family Selenopidae	1	1
12	FamilySicariidae	1	1
13	FamilySparassidae	3	4
14	FamilyTetragnathidae	3	11
15	FamilyTheridiidae	5	7
16	Family Theridiosomatidae	1	1
17	Family Thomisidae	3	4
18	Family Uloboridae	2	3
	TOTAL	63	94

2.2. Vertical stratification

The spiders collected from each zone of the rice plant during each of four time periods were analysed for changes in the spatial position of each of the selected spiders in relation to different time periods. A total of 1396 samples were analysed in the study and the vertical distribution of spiders in percentages on different zones at different time is provided in table 3. Two way ANOVA was done on the number of spiders for each species in different zones and various time periods. This determined whether difference between the zones and time intervals of the day where significant for the spiders of each species. Two way analysis of variance was done on 5 dominant spiders commonly found on the paddy fields (Table 4). Pardosapseudoannulata and Bianoralbobimaculatus had significant difference in the location of the population between different zones and various time periods of the day. Whereas, Oxyopesjavanus, Tyloridastriata and Araneusellipticus had significant difference in the location of spiders on different zones only. The ANOVA of the interaction of time and zones indicated a significant differences in the location of all species tested except Araneusellipticus. So it is clear that both these factors together play an important role in the vertical stratification of dominant spiders of paddy ecosystem. Tetragnathajavana and Lariniachloriswere found almost entirely on zone D. The location of selected species spiders on rice plant during 1300-1400 hrs and the percentage of the population found in each zone of the total population of each species collected during that time is given in fig. 3.

Table 3. Vertical distribution on rice plant of all spiders collected during the virippu season (August – September, 2014) from the paddy fields of MuriyadKol wetlands.

Time period	% of spiders collected in			
	Zone A	Zone B	Zone C	Zone D
0800-0900	26.9	35.3	24.6	13.2
1300-1400	29.5	30.3	31.8	8.4
1700-1800	21.1	44.4	22.8	11.7
2000-2100	3.4	49.4	39.9	7.3

Table 4: Two way ANOVA of five species of spiders commonly found on the Rice plants of MuriyadKol wetlands of Kerala during August- September, 2014.

Species										
Source of variance	O. javanus		P. pseudoannulata		T. striata		B. albobimaculatus		A. ellipticus	
	p	F	P	F	P	F	P	F	P	F
Time	0.53[d]	0.74	0.03[c]	3.15	0.96[d]	0.10	0.046	2.80	0.52[d]	0.768
Zone	7.25E-11[b]	25.14	1.44E-22[b]	87.17	1.16E-18[b]	60.50	3.5E-05[b]	9.29	2.06E-12[b]	30.68
Interaction (time x zone)	0.002[a]	3.27	1.08E-18	27.34	0.003[a]	3.20	0.007[a]	2.85	0.32[d]	1.18

[a]P<0.01 [b]P<0.0001 [c]P< 0.05 [d]not significant at the 0.05 level

4. DISCUSSION

The present survey of spiders from the Muriyad-Kol lands of Kerala presents 5 % of the total 1,686 recorded species in India (Keswani, 2012) and 22 % of total 417 species reported from Kerala (Jose, 2005). 18 of the 38 families reported from Kerala is represented from the wetland ecosystem. A combination of flooding intensity, water levels in the nearest river system and grazing are important factor for the species composition of spiders in wet grasslands particularly marshy areas (Gravesen, 1999, Galle et al., 2011). The spider fauna of the wetlands is mainly constituted by the water loving species of the genera Tetragnatha and Tylorida(family Tetragnathaidae) and genus pardosa (family Lycosidae). The unique geographic properties of the Kol wetland and occasional conditioning of some parts of the wetland for agriculture provides a wide range of habitats within the wetland complex. The species composition of spiders can differ considerably as the effect of changes in the habitat and landscape properties within the same ecosystem types (Galle et al., 2011).

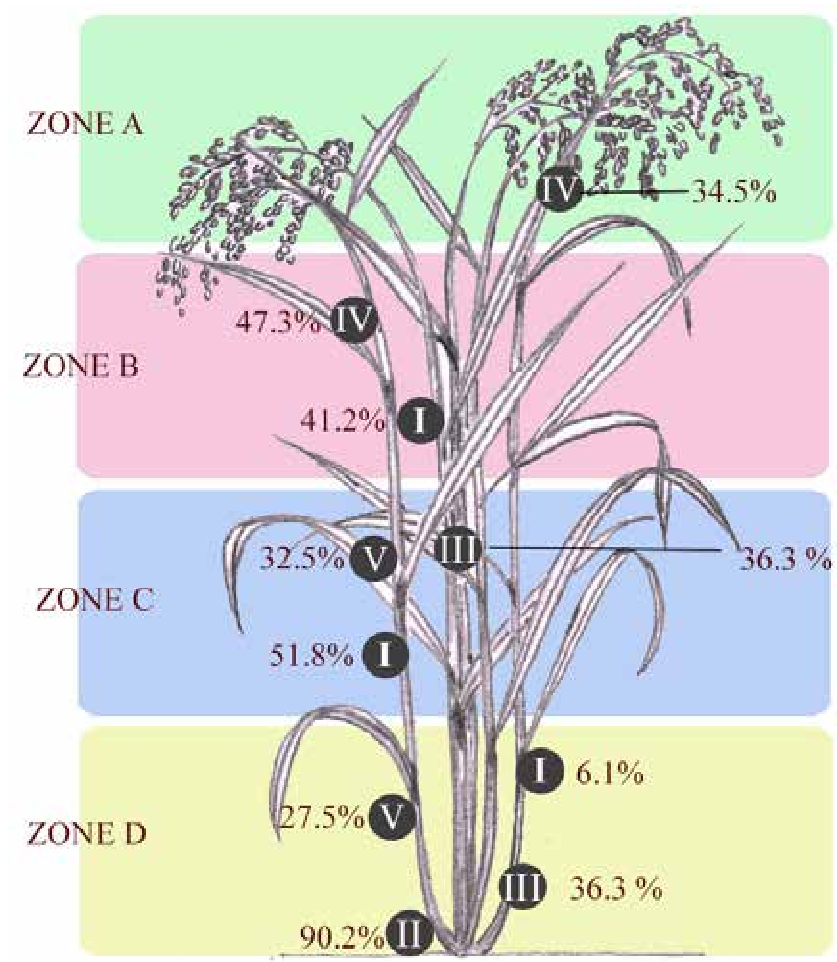

Fig 3: Location of selected species of spiders on rice plant during 1300-1400 hrsand the percentage of the population found in each zone of the total population of each species collected during that time.

I - Tyloridastriata
II - Pardosapseudoannulata
III – Oxyopesjavanus
IV – Araneusellipticus
V – Bianoralbobimaculatus

The rice land spiders of different regions of Kerala-were studied by Sudhikumar, 2007, Sebastian et al., 2005 and Sebastian et al., 2011. Pardosapseudo-annulataand Tetragnathamandibulata were found to be one of the most abundant spider in most of these studies. Contrary to this, Tyloridastriata was found abundantly in the paddy ecosystems of MuriyadKol wetland. This may be because the paddy was sampled only during the virippuseason from May to August 2014 at the height of the south-west monsoon.

The guild structure of spiders was elucidated following the guild classification of Uetz et al. (1999). Even though the substrata for attachment of web is generally low in wetland ecosystem especially in the paddy fields, the orb weavers dominated the wetland constituting 39 % of the total collection. This is in contrast with the findings of Sebastian et al., 2005 in paddy ecosystem. The sampling was done from different habitats such as fringes of wetlands, abandoned grass lands and temporary waterlogged areas, apart from paddy fields. The structural complexity of the vegetation may determine the guild composition of a habitat (Young et al., 1990) and indirectly affect the herbivore damage to the vegetation.

The vertical stratification of spiders were elucidated in some major crops by LeSarand Uniziker, 1978,Pekar, 2005 and Zachary et al., 2013. Sudhikumar, 2007 studied the vertical stratification of spiders in the rice paddy ecosystem of Kuttanad region of Kerala. Most of the Araneidae and Tetragnathidae species which spins perfect orb webs were mainly found foraging in the canopy of the rice plants. Ground spiders such as the Lycosids are found foraging in the ground or water level for most of the day time (Sudhikumar, 2007), but as dusk falls in they ascend into the upper zone (zones B and C). They stay inverted on the leaves possibly waiting for prey. The spiders which builds irregular cob webs were commonly found in the lowest zone. The study also found significant difference in the location of Pardosapseudoannulata and Bianoralbobimaculatus between different zones and at different time intervals. Oxyopesjavanus, Tyloridastriata and Araneusellipticus had significance difference in the population density at different zones of the rice plant. Time period and zone are dependent on each other for all tested populations of spiders except Araneusellipticus. This means that the location of population of some spiders can change at various combinations of zone and time intervals.The proportion of the population of spiders of all the species combined were found higher in zones B and C compared to the other zones. This may be due to the stability of the stem of the rice plant at these zones which provides an ideal base for anchoring web, and the minimal effect of wind and temperature.

5. CONCLUSION

The present study is a pioneering work on the diversity and ecology of spiders of MuriyadKol wetlands. The study provides a basic inventory of spiders of this unique and threatened ecosystem. The spiders of wetlands, like any other organism, is threatened by the rampant and indiscriminate destruction of wetlands. The present study was instrumental in throwing light into the unknown world of the spiders of the region. Further studies into the ecology and diversity is essential to completely understand the complex role the spiders play in the various habitats of the wetlands.

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ERIOPHYOID MITES (ACARI: ERIOPHYOIDEA) FROM SUB-HIMALAYA, WEST BENGAL

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ABSTRACT

Eriophyoid mites are tiny and obligatory plant parasites. Many of them are serious pest on variety of plants, both economical and wild. Eriophyoid mites belong to phylum Arthropoda, subphylum Chelicerata, class Arachnida and subclass Acari.

The two districts viz., Darjeeling and Jalpaiguri of sub-himalayan West Bengal lying between 88 – 90 E longitudes and 263' – 27N latitudes have been surveyed for eriophyoids since 1991. These districts represent interesting geographical regions and are characteristic by wavy plain land and hilly tracts. Such type of lands accompanied with a fair hot and cold climate and moderate rainfall exhibit a very interesting ecological niche where a unique floristic pattern prevails extensive field surveys were made during the year 1991-2014. Galls and other mite located deformities viz., leaf edge rolling, hairy outgrowth, erinea etc. are relatively easy to locate. The shoots of several species of plants were collected and placed in individual polythene bags with appropriate levels, notes on the nature of symptoms, if any, or unknown plants, proper herbaria were made for their identification. Chakrabarti et al. (1980) described 2 eriophyoid species for the first time from Darjeeling, Chakrabartri and Pandit (1991-onwards) made faunistic surveys in several places in North Bengal on zonal basis and published a series of account on the taxonomy of eriophyoid mites (1996, 1997, 2001, 2007, 2008, 2009).

Altogether, 82 eriophyoid species under 33 genera of 7 subfamilies viz., Aberoptinae, Ashieldophyinae, Cecidophyinae, Eriophyinae, Nothopodinae, Phyllocoptinae and Diptilomiopinae were collected and identified. Of these, 25 new species and 4 new genera viz,. Indotegolophus Chakrabarti et al. (1980) Protumescoptes Pandit and Chakrabarti (2000), Tergamplum and Isoannulus Chakrabarti and Pandit (2009) were described from this area. The remaining 57 species are reported here for the first time from India. Altogether, 70 host plants were screened and out of these 49 species were found to harbour these mites.

Key words: Eriophyoid mites, subhimalaya,West Bengal.

1. INTRODUCTION

Eriophyoid mites belong to the phylum Arthropoda, subphylum Chelecerata, class Arachnida, subclass Acari and superfamily Eriophyoidea are exclusively plant parasitic arachnids. The Acari comprising mites and ticks, form one of the largest and biologically most diverse group of arachnida. Some of them are potential pest of crops and other agricultural and forest plants. These mites are entirely phytothagous and seek microenvironments in which they live, feed and reproduce (Jeppson et al., 1975). According to Channabasavanna (1966) the nature of symptoms that this group of mites induces on the host plants is so varied no other single group of arachnids can match with this respect in this group of mites.

Among all mites, eriophyoids are rather peculiar in several ways. They are not only microscopic in size but show great reduction in body structures. Structurally they possess a more or less elongate, averaging about 170 microns in length, vermiform, worm like having two pairs of legs in both adult and nymph also, body setation reduce to minimum and genitalia are proximal just behind coxae II. Biologically also they are interesting because certain exhibit two different forms of females, a primary forms known as "Protogyne" which reproduce same season in which it is formed and other a secondary form known as "Deutogyne" which is adapted for hibernation during seasonal condition and which does not normally reproduce in the season in which it is formed.

Eriophyoid mites are negatively phototrophic, they are normally found on the undersurface of leaves, twigs or are found on leaf lamina or in angle formed by the major vein. The eriophyoid mites, the most peculiar among the mites, are often found in various malformed or deformed plant parts. Some species induce several deformities on their host plants, like galls, warts, big buds, crowded buds, outgrowth of excessive hairs, witches broom effect etc. (Channabasavanna 1966). Keifer et al. (1982) provided an elaborate illustrated guide of plant abnormalities caused by eriophyoid mites in North America.

1.1. Study area: The present area of study has been restricted in the two districts viz., Darjeeling and Jalpaiguri districts of sub Himalayan West Bengal. These two districts belong to the North Bengal. It is the portion of Indian subcontinent lying between 88 – 90 E longitudes and 263' – 27N latitudes. This area attracted immense interest to Biologist for several reasons. This area is floristically rich both in terms of abundance and diversity. There are many reserve forests viz., Dasmile jangal, Garumara forest, Jaldapara forest, Lataguri forest etc. in that area.

1.2. Host Association: During feeding some eriophyoid mites inject saliva in the plant tissues that affects plants in the various ways, Mani (1964). Some of the malformations caused by eriophyoid mites in the plants are given below:

1.2.1. Leaf edge roll: A fairly common induced deformity is leaf edge rolling. This symptom appears on young leaves and continues to persist on older leaves unless the later drop off. The edge rolling commonly seen on the leave of pomegranate is a typical instance.

1.2.2. Erinea: Felty outgrowth of the dense hairs or papillae on the leaf surfaces, tender stem and buds etc, as wooly covering is a very common type of symptoms. It is known as erinum. Erinea are not closed growths, but enabled to find shelter within hair masses.

1.3. Galls: Galls are pathologically developed cells, tissues, organs of plants. It provides interior turgid cells or papillae on which the brood feeds and hairy out growth are often found on upper surface of galls. All eriophyoid galls have the escape holes. The different types of galls that are formed by eriophyoids are pouch galls, bead galls, finger galls and nail galls etc. (Mani, 1964).

2. OBJECTIVES

The present study would reveal the following information on eriophyoid mites :

1. Zonal basis surveyed in North Bengal for eriophyoid mites.

2. Description of new species that may be collected.

3. List of hosts plants herboured by these mites.

3. MATERIALS AND METHODS

Eriophyoid species are normally most abundant of their host plants during summer and monsoon at tropical regions. Galls and other mite located deformities viz., leaf edge rolling, hairy outgrowth, erinea etc. are relatively easy to locate. All types of vegetation were taken into consideration for present investigation. The shoots of several species of plant have been collected and placed in individual polythene bags with appropriate levels. In case of unknown plant proper herbarium were made for their identification. Permanent microscopic preparation of the mites was made in laboratory. Mites thus mounted on slides were studied under phase contrast microscope for their identification.

The morphological terminology have been followed Lindquist (1996) and generic classification have been followed Amrine et al. (2003). Morphological studies of eriophyoid have been followed the techniques of Lillo et al. (2010).

Though eriophyoid research is old for more than one century but appropriate technique for cleaning and mounting such a delicate creature is still lacking. For a long time, the modified Berlese fluid commonly known as "Hoyer's medium" has been used for this purpose (Baker and Wharton, 1952).

The mounted materials are studied using a prism type camera lucida built onto a Leitz Dialux 20 microscope with provision for phase illustration.

4. DISCUSSION

So far, about 3442 species under 301 genera of this group of mites are known from different parts of the world. Of these, Channabasavanna 60 species under 4 genera from South and North India,

Chakrabarti et al. (1980) described 2 eriophyoid species for the first time from Darjeeling, Chakrabartri and Pandit (1991-onwards) made faunistic surveys in several places in North Bengal on zonal basis and published a series of account on the taxonomy of eriophyoid mites (1996, 1997, 2001, 2007, 2008, 2009).

Altogether, 79 eriophyoid species under 32 genera of 8 subfamilies viz., Aberoptinae, Ashieldophyinae, Cecidophyinae, Eriophyinae, Nothopodinae, Phyllocoptinae, Diptilomiopinae and Rhyncphytoptinae were collected and identified (Table 1). Of these, 21 new species and 4 new genera viz,. Indotegolophus (Chakrabarti & Mondal, 1980), Protumescoptes (Pandit & Chakrabati 2001) Tergamplum and Isoannulus (Chakrabarti and Pandit, 2009) were described from this area. The remaining 58 species are reported here for the first time from India.

Altogether, 70 host plants were screened and out of these 49 species were found to harbor these mites.

Table 1: List of eriophyoid species on Sub-Himalaya of West Bengal (1996-2009) Eriophyoid species Host plant Subfamily: Nothopodinae

1. Cosella ventilogi Chakrabariti et al., 2008 Ventilog deticulata Willd. Subfamily: Ceciphyinae
2. Colomerus trichodesmae Chakrabarti & Pandit, 1997 Trichodesma khasianum Clarke
3. Cosetacus eupatoria Chakrabarti & Pandit, 1997 Eupatorium odoratum L,
4. Cosetacus prostateti Pandit & Chakrabarti, 2007 Dipterocanthus prostetus
5. Idosetacus cleistanthus Chakrabarti & Pandit, 1997 Cleisthanthus sp. Targamplum n. gen Chakrabarti & Pandit, 2009 Callicarpa longifolia Lam.
6. Targa plum callicarpa Chakrabarti & Pandit, 2009 Callicarpa longifolia Lam. Isoannulus n. gen Chakrabarti & Pandit, 2009 Glochidioon multi loculare Voigt
7. Isoannulus bengalensis Chakrabarti & Pandit, 2009 Glochidioon multiloculare Voigt Subfamily: Ashieldophyinae
8. Ashieldophyes glochidionae Chakrabarti & Pandit, 2009 Glochidioon multiloculare Voigt Subfamily: Eriophyinae
9. Aceria fissistigma Pandit & Chakrabarti, 2001 Fissistigma rubigenosa Griff. Subfamily: Phylocoptinae Indotegolophus n. gen. Chakrabarti & Mondal, 1980
10. Indotegolophus darjeelingensis. Chakrabarti & Mondal, 1980 Symplocos sp
11. Paratetra himalayana Chakrabarti & Roy, 1980 Patentilla sp
12. Acaricalus artocarpi Chakrabarti & Pandit, 1997 Artcarpus lakoocha Roxb
13. Aculops jalpaiguri ensis Pandit & Chakrabarti, 2001 Beilschmiedia sp.
14. Neodichopelmus cordiae Chakrabarti & Pandit, 1997 Cordia myxa L. Protumescoptes n.gen Pandit & Chakrabarti, 2001 Antedesma ghaesembilla Gaertn
15. Protumescoptes antedesmae Pandit & Chakrabarti, 2001 Antedesma ghaesembilla Gaertn
16. Vasates lakoochae (Fig 1) Pandit & Chakrabarti, 2001 Artcarpus lakoocha Roxb
17. Tegolophus perviflorii Pandit & Chakrabarti, 2007 Lagerstroemia parviflora Rhyncphytoptinae
18. Diptilomiopus indicus Chakrabarti & Pandit, 1996 Ficus sp.
19. Neorhynacus lakoochii Pandit & Chakrabarti, 2007 Artcarpus lakoocha Roxb
20. Diptilomiopus lagerstroemia Chakrabarti & Pandit, 1997 Lagerestroemia thorelli
21. Vimola guajavae Chakrabarti & Pandit, 2009 Psidium guajava L.

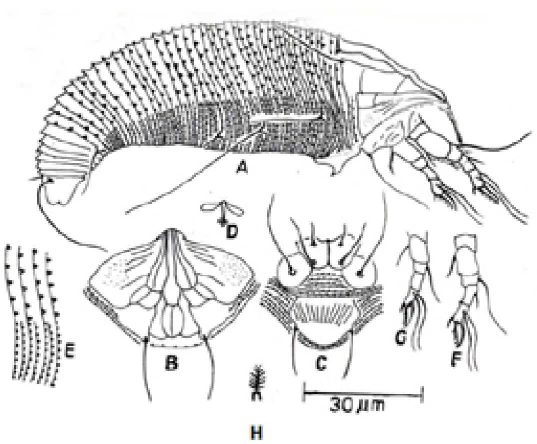

Fig 1: Vasates lakoochae; A-Lateral view of mite, B-Prodorsal shield, c- Coxigenital region, D-Apodeme, E-Lateral view of dorsoventral annuli, F-Leg I, G-Leg II, H- Empodium.

5. CONCLUSION

Eriophyoid mites are host specific micro-arthropods. In spite of rich and varied vegetation of sub-Himalayan West Bengal, the Eriophyoid fauna has so far not been explored here properly. Further investigation is required for the study of this group of mites. Authors hope many new species may be explored from this region.

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VEGETATIONAL COMPOSITION AND REGENERATION STATUS OF MANGROVES IN CHETUWAI BACKWATERS, KERALA

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ABSTRACT

This study was carried out in the Chetuwai backwaters in Thrissur district. The main objective was to study the natural regeneration status of mangrove and to correlate the fruit production with effective regeneration. This study confirmed that the mangrove system of Chetuwai have 6 species of true mangroves including 5 species of trees and 1 shrub, with varying regeneration status. Dominant species in the formation was Rhizophora mucronata with the highest number, whereas the lowest number of mature trees is contributed by the species Excoecaria agallocha. Although the entire system looks like a Rhizophora dominated community, other species such as Bruguiera cylindrica, Excoecaria agallocha, and Avicennia officinalis also tend to increase towards landward side. The regeneration studies observed that the major share of regeneration was contributed by Rhizophora mucronatawhereas Excoecaria agallocha was not represented in the regeneration.

Immense growth and tight competition offered by Rhizophora mucronata and Acanthus ilicifolius for light and space, have resulted in retarding the number of regeneration survivals in other species and also affected the natural ecological salinity gradient of species in the area. Analysis of the light and soil characteristics in the Chetuwai mangrove system helped to derive the correlation between the present distribution of species and its regeneration with light intensity, pH (revealed the acidic nature of soil) and Electrical conductivity. From this study we can infer that, if we allow these conditions to continue as such, this would lead to biodiversity degradation through competition within each species and between species.

Key words: Chetuwai, mangroves, flower, fruit, regeneration status, soil characteristics, light etc.

1. INTRODUCTION

Mangrove forests are one of the most productive ecosystems that occurs as coastal tropical formations in tropical and sub-tropical latitudes. These mangrove plant communities are often called as 'mangal', 'tidal forest', 'coastal woodlands', or 'oceanic rain forests'(Kathiresan and Bingham, 2001).

Mangroves supports a vast majority of human population living in coastal areas by providing essential resources, which include forestry and fishery products, and services for their livelihood. Mangrove forests are great natural stabilizers of the coastal belt and provide a green cover to disperse the energy of cyclones, tidal incursions, wind, storms etc. Mangrove tree species show distinct zonation, as salinity plays a vital role in their distribution, productivity and growth (Twilley and Chen, 1998).

The success of natural regeneration is limited by various factors like suitability of the area and the species, production of abundant propagules and seeds, favourable site conditions for germination cum establishment, degree of biotic interference and other abiotic factors. Regeneration on the natural regeneration status of these mangroves, helps us to understand the regeneration and recruitment patterns of different species. The study of soil properties like electrical conductivity and pH are important in determining the presence of a species.

Regeneration studies helps to understand the present status of mangroves and its natural restoration in a particular area. These studies can be used to identify the need and the method of in-situ conservation for various mangrove species and thus is an important conservation tool for sustainable management of natural resources.

2. MATERIALS AND METHODS

2.1. Study area location

The Chetuwai mangroves of Thrissur district are situated in the latitude 10° 32' N and longitude 76° 26 'E between Cochin and Calicut in Kerala. The study was conducted for six months and was located in a small estuary formed by the rivers Chetuwaipuzha and Karanjirapuzha. This newly formed mangrove ecosystem was also subjected to various anthropogenic pressures.

2.2. Methods

Preliminary reconnaissance survey was done to study the location and also for the selection of transects for the transect survey. Transect survey was done to identify species distribution patterns and examine the correlation between mangrove association and natural conditions. All the individuals present in the study area was grouped into "mature trees" and "regeneration". Regeneration would refer to all the mangrove vegetation with a girth at breast height (gbh; equivalent to girth at 1.37m from the base of the tree)< 2.0 cm and are below reproductive stage. Whereas, individuals having girth≥ 2.0 cm (gbh) was considered as trees. In the case of Rhizophora, the girth was measured just above the top prop root.The flowers and fruits in the sample plots were tagged to review the phenological changes that take place during the study period.

Tree stand measurements were done in sample plots of 4 x 4 meters dimensions (16 sq. m.). Sample plot survey recorded data such as: species, height, GBH and regeneration. Monthly readings were taken for regeneration, flower and fruit. The floral assessment was rated while the fruit assessment was quantified. During monthly visits the number of propagules dispersedfrom the sample plots was recorded, which would help in correlating with the natural regeneration percentage. The light intensity at each plot was measured using a lux meter.

Soil samples were collected from the sample plots, from depth of 0-20 cm and were stored in polybags. Samples were further dried in shade, pulverized, sieved and brought to the laboratory. Soil samples were analysed for pH and Electrical conductivity (E.C).

3. RESULTS AND DISCUSSIONS

3.1. Floristic composition of true mangroves in Chetuwai backwaters

The floristic study of the mangrove stand identified Rhizophora mucronata, Bruguiera cylindrica, Avicennia officinalis and Excoecaria agallocha as the tree species; and Aegiceras corniculatum and Acanthus ilicifolius as the shrub's. One of the islands seems to be a monoculture of Rhizophora mucronata, with a few Bruguieracy lindrica and Aegiceras corniculatum. The other island is inhabited by Acanthus ilicifolius, followed by Bruguiera cylindrica, Rhizophora mucronata, Avicennia officinalis and Aegiceras corniculatum.

The total number of trees belonging to all the sample pots was 364 in number. The maximum number of trees belonged to Rhizophora mucronata, constituting about 88% of the total; it was followed by Aegiceras corniculatum, with 5% and then comes Avicennia officinalis, with 4%. The least belonged to Bruguiera cylindrica, with 3% of all the trees (Table 1).Most of the mangrove forests show a specific pattern of zonation. Particular species is gregariously distributed in a specific zone. In Chetuwai, the proximal zone is characterized by the preponderance of Aegiceras corniculatum and Acanthus ilicifolius. However in some patches, Avicennia officinalis has replaced Acanthus ilicifolius in the proximal zone. The Intermediate zone is primarily comprised of species like Bruguiera cylindrica and Rhizophora mucronata. This zone also characterized by the presence of Excoecaria agallocha, which is few in number. Study conducted by Jose (2003) in Kannur mangroves revealed that Dharmadom which is located near to marine zone has high Avicennia marina population while in other locations under study A. officinalis dominates is found towards the marine zone and Avicennia officinalis. This zonation is totally different from Chetuwai mangrove zonation.

Table 1: Percentage representation of mature trees in all the sample plots

Mangrove Species	Percentagerepresentation
Rhizophora mucronata	88%
Bruguiera cylindrica	3%
Aegiceras corniculatum	5%
Avicennia officinalis	4%

3.2. Girth class (gbh class) distribution of trees in the study area

This study grouped the trees into gbh classes, based on species. The Rhizophora mucronata was grouped into gbh classes of 5 cm, due to the presence of large number of big trees belonging to this species. Whereas Bruguiera cylindrical, Avicennia officinalis, and Aegiceras corniculatum were grouped into gbh classes of 3 cm.

3.3. Rhizophora mucronata

A total of 319 Rhizophora mucronata trees were grouped into gbh classes (Table 2). The gbh classes of 10 cm – 15 cm and 15 cm -20 cm together constitute 82 % of the total trees in all the Rhizophora mucronata gbh classes. The highest number of trees falls under the gbh class of 10 cm – 15 cm; this was followed by the gbh class of 15 cm – 20 cm, this was again followed by 20 cm- 25 cm and 5 cm – 10 cm. the least number of trees fall under the gbh class of 25 cm – 30 cm.

Table 2: Percentage representation of gbh classes to the Rhizophora mucronatatrees and to the total trees.

gbh class	Percentage of Rhizophora mucronatatrees (Percentage of the total trees)
5 cm - 10 cm	5.33 % (4.64 %)
10 cm - 15 cm	42.32 % (36.89 %)
15 cm - 20 cm	39.18 % (34.15 %)
20 cm - 25 cm	11.59 % (10.10 %)
25 cm - 30 cm	1.57 % (1.37 %)

3.4. Bruguiera cylindrica, Avicennia officinalis, and Aegiceras corniculatum

Bruguiera cylindrica was represented by 11 trees in the sample plots. Of the total 11 trees, 6 trees fall under the gbh class of 9 cm- 12 cm, this was followed by 2 trees in the gbh class of 12 cm- 15 cm. There were one representative each from the gbh classes of 6 cm -9 cm, 15 cm- 18 cm and 18 cm – 21 cm. Avicennia officinalis was represented by 16 trees. Of which, 6 trees each fall under the gbh classes of 6 cm- 9 cm and 9 cm -12 cm. They are followed by 2 trees each in the gbh classes of 3 cm- 6 cm and 12 cm – 18 cm. A total of 18 trees represented Aegiceras corniculatum. Ofthese, 10 trees fall under the gbh class of 6 cm- 9 cm, this was followed by the gbh class of 9 cm- 12 cm with 4 trees and again by the gbh class of 3 cm – 6 cm with 3 trees. There was only one representative in the gbh class of 12 cm- 15 cm (Table 3).

Table 3: Percentage of trees in each gbh class to the species and to the total trees

gbh class	Bruguiera cylindrica	Avicennia officinalis	Aegiceras corniculatum
3 cm – 6 cm	0	12.50 % (0.55 %)	16.67 % (0.82 %)
6 cm-9 cm	9.09 % (0.27 %)	37.50 % (1.64 %)	55.55 % (2.73 %)
9 cm - 12 cm	54.54 % (1.64 %)	37.50 % (1.64 %)	22.22 % (1.09 %)
12 cm - 15 cm	18.18 % (0.55 %)	12.50 % (0.55 %)	5.55 % (0.27 %)
15 cm - 18 cm	9.09 % (0.27 %)	0	0
18 cm - 21 cm	9.09 % (0.27 %)	0	0

3.4. Regeneration

The study area had a good regeneration of Rhizophora mucronata, and then it is followed by Bruguiera cylindrica and Aegiceras corniculatum. Of the total regeneration found in the backwater area, the least number was contributed by Avicennia officinalis. There were no propagules for Excoecaria agallocha.

a) Total regeneration present in the sample plots at the start of the study period

Of the total regeneration 115 was obtained 67% is contributed by Rhizophora mucronata, about 19% is contributed by Aegiceras corniculatum, it is followed by Bruguiera cylindrical with 12% of the total regenerations. The least regeneration was found for Avicennia officinalis, which is about 2 % of the total. There was no regeneration found for Excoecaria agallocha (Table 4).

Table 4: Total regeneration present in the sample plots

Species	Total Regeneration
Rhizophora mucronata	77 (67%)
Bruguiera cylindrica	14 (12%)
Aegiceras corniculatum	22 (19%)
Avicennia officinalis	2 (2%)
Excoecaria agallocha	0

b) Regeneration during the six month study period

During the study period, a net regeneration of 69 was obtained for all the species. The highest regeneration was obtained for Rhizophora mucronata with 74% of the total. It is then followed by Aegiceras corniculatum with 17% of the total. The least regeneration present was for Bruguiera cylindrica with 9%. There was no regeneration present both forAvicennia officinalis and Excoecaria agallocha (Table 5).

Table 5: Percentage regeneration obtained during study period

Species	Number of regeneration
Rhizophora mucronata	51 (74%)
Bruguiera cylindrica	6 (9%)
Aegiceras corniculatum	12 (17%)
Avicennia officinalis	0
Excoecaria agallocha	0

The number of mature trees and also the regeneration of many species are observed to be poor, even though the anthropogenic disturbance in this area is said to become very low recently. But In this mangrove backwaters, Rhizophora mucronatais found in almost all the sample plots and is also having the highest number of seedlings. This is followed by Aegiceras corniculatum, then by Bruguiera cylindrica. Avicennia officinalis and Excoecaria agallochawere found to have very few or no regeneration. Not only out of the two islands, one appears to be the monoculture of Rhizophora mucronata, but also Rhizophora mucronata propagules share the major proportion of seedlings present irrespective of the other species present and that those which have flowered and bear fruits.

3.5. Light Intensities

Much of the study area has open canopy and hence has much below crown light intensities in many sample plots. The light intensities vary from 5.7 lac to 2620 lac. In the mangrove system, the Rhizophora mucronata dominated island has thick canopy cover and hence observed to have less light below the canopy. But however there were some openings that had been created due to the dying of trees which ultimately resulted in higher light intensities. While considering the other mangrove island, it is almost covered by Acanthus ilicifolius, and also, Aegiceras corniculatum and Avicennia officinalisin the periphery. This island also has some Bruguiera cylindrica and a few Rhizophora mucronata. Hence higher intensities of light reach the ground.

3.6.Soil Analysis

1.1.1. 3.7.Electrical Conductivity of Soil Samples

The Electrical Conductivity of the soil samples was measured. In most of the cases the value lay in between 9 to 14. The highest was in sample plot 7 with a value 14.77 and the least in sample plot 12 with a value 2.4.Decrease in electrical conductivity observed with depth may be due to the presence of lower salt content.

1.1.2. pH of Soil Samples

The pH of all the sample plots was measured to find whether soil is acidic or alkaline (Table 6). All the values fell in the acidic range, with maximum acidity in sample plot 11 and least in sample plot 9.

Table 6: Soil sample pH in the sample plots

Plot no.	pH	Electrical Conductivity (@ 200 mhos)	Light intensity or lux (in lakhs)
1	6.67	12.63	16.28
2	6.47	14.57	5.74
3	6.87	11.4	20.41

4	6.57	13.47	12.22
5	6.57	9.97	1245.33
6	6.34	13.17	11.28
7	6.59	14.77	109.03
8	6.96	9.5	12.40
9	6.93	9.87	10.41
10	6.41	8.27	15.79
11	5.98	7.13	595.26
12	6.56	2.4	542.80
13	6.35	9.13	2620.43
14	6.42	9.5	336.56

Studies done by Sesakumar (1984) in various mangrove soils revealed that the pH values of these soils are generally acidic. Decrease in electrical conductivity observed with depth may be due to the presence of lower salt content. Increase in pH and nutrient content with inundation reported from Sunderbans (Sah et al., 1985). Increase in pH with depth is also attributed to water movement (Kuraishi et al., 1990).

3.7.Statistical Analysis

1.1.3Correlation between fruiting, flowering and regeneration in the case of Rhizophora mucronata

This proved that there is significant correlation between fruiting and regeneration in Rhizophora mucronata and that to at 1% level of significance (Table 7). There is no other correlation between flowering, fruiting and regeneration in case of Rhizophora mucronata.

Table 7: Correlation between fruiting, flowering and regeneration in the case of
Rhizophora mucronata

Parameters	Flower	Fruit	Regeneration
Flower	1	-0.040	0.204
Fruit	-0.040	1	0.464**
Regeneration	0.204	0.464**	1

** Correlation is significant at the 0.01 level

1.1.3. Correlation between fruiting, flowering and regeneration in the case of Bruguiera cylindrica

This proved there is significant correlation between flowering and fruiting, and also between fruiting and regeneration in the case of Bruguiera cylindrica. All these parameters are correlated at 1% level of significance (Table 8).

Table 8: Correlation between fruiting, flowering and regeneration in the case of Bruguiera cylindrica

Parameters	Flower	Fruit	Regeneration
Flower	1	0.786**	0.774**
Fruit	0.786**	1	0.671**
Regeneration	0.774**	0.671**	1

** Correlation is significant at the 0.01 level

1.1.4. Correlation between fruiting, flowering and regeneration in the case ofAegiceras corniculatum

This proved there is significant correlation between flowering and fruiting, and also between fruiting and regeneration in the case of Aegiceras corniculatum. All these parameters are correlated at 1% level of significance (Table 9).

Table 9: Correlation between fruiting, flowering and regeneration in the case of Aegiceras corniculatum

Parameters	Flower	Fruit	Regeneration
Flower	1	0.768**	0.681**
Fruit	0.768**	1	0.523**
Regeneration	0.681**	0.523**	1

** Correlation is significant at the 0.01 level

1.1.5. Correlation between fruiting, flowering and regeneration in the case of Avicennia officinalis

This proved that there is significant correlation between flowering and fruiting, at 1% level of significance in the case of Avicennia officinalis (Table 9). There are no other parameters correlated.

Table 9: Correlation between fruiting, flowering and regeneration in the case of
Avicennia officinalis

Parameters	Flower	Fruit	Regeneration
Flower	1	0.727**	-0.124
Fruit	0.727**	1	-0.099
Regeneration	-0.124	-0.099	1

** Correlation is significant at the 0.01 level

1.1.6. Correlation between flowering of different species with pH, Electric conductivity and light intensity

This correlation has proved that there exists significant negative correlation with pH, for flowering in the case of both, Aegiceras corniculatum and Avicennia officinalis at 5% level of significance. There is no correlation between any other parameters and other species in case of flowering (Table 10).

Table 10: Correlation between flowering of different species with pH, Electric conductivity and light intensity

Parameters	Rhizophora mucronata	Bruguiera cylindrica	Aegiceras corniculatum	Avicennia officinalis
pH	0.298	-0.112	-0.530*	-0.623*
Electric Conductivity	-0.373	-0.075	-0.284	-0.292
Light intensity	-0.202	-0.077	0.47	0.144

*Correlation is significant at the 0.05 level

1.1.7. Correlation between fruiting of different species with pH, Electric conductivity and light intensity

There is significant negative correlation between light intensity and Fruiting in the case of Rhizophora mucronata, at 5% level of significance (Table 11).

Table 11: Correlation between fruiting of different species with pH, Electric conductivity and light intensity

Parameters	Rhizophora mucronata	Bruguiera cylindrica	Aegiceras corniculatum	Avicennia officinalis
pH	0.324	-0.055	-0.173	-0.234
Electric Conductivity	0.221	0.005	-0.131	-0.153
Light intensity	-0.541*	-0.062	0.421	0.347

*Correlation is significant at the 0.05 level

1.1.8. Correlation between Regeneration of different species with pH, Electric conductivity and light intensity

In the case of Aegiceras corniculatum, there is significant correlation between regeneration and light intensity at 1% level of significance. Also in Avicennia officinalis there exists correlation between regeneration and light intensity at 5% level of significance. Whereas in the case of Rhizophora mucronata, there is significant negative correlation between regeneration and electrical conductivity at 1% level of significance (Table 12).

Table 12: Correlation between Regeneration of different species with pH, Electric conductivity and light intensity

Parameters	Rhizophora mucronata	Bruguiera cylindrica	Aegiceras corniculatum	Avicennia officinalis
pH	-0.070	-0.097	-0.397	-0.268
Electric Conductivity	-0.695**	-0.015	-0.230	-0.141
Light intensity	0.029	-0.165	0.823**	0.625*

* Correlation is significant at the 0.05 level, ** Correlation is significant at the 0.01 level

This shows that when light intensity is higher, regeneration appears to be more. But in the case of Rhizophora mucronata, regeneration is less when electrical conductivity is high. Correlation also shows that the regeneration is also positively influenced by light intensity in Avicennia officinalis. No other correlation was obtained between fruiting of a species and parameters like pH, EC and light intensity.

4. CONCLUSIONS

Present study indicates that one island is a monoculture of Rhizophora mucronata and the backwater system as a whole is constituted by Rhizophora mucronata. These trees with thick canopy create immense competition, with respect to light, space, etc., to its own and other seedlings regenerating below it; mainly Bruguiera cylindrical resulting in less number of regeneration.

Aegiceras corniculatum and Avicennia officinalis are found in the periphery of the mangrove back water system. These species are not only few in number, but also face insufficient regeneration due to its positioning in the periphery above the water body; resulting in loss of much of the mature propagules from the study area.

If these conditions and pattern of growth prevail in the study area for some period of time, the mangrove system would gradually exist as monocultures of Rhizophora mucronata on one island, and that of Acanthus ilicifolius, on the other island leading to loss of natural ecological diversity of the area.

The measures that can be taken to prevent this loss of ecological diversity are to subject the mangrove backwaters to the most appropriate and the scientific management of mangroves. These may be done by the raising mangrove nursery for the planting of seedlings of the existing mangrove species according to the natural salinity gradient of the mangrove species or the tolerance of a particular species to a particular range of salinity, which is also worthy in economic sense as it provide employment and income for many local people and hence helps in participatory management of these backwater mangrove systems. The selective cutting of the Rhizophora mucronata and Acanthus ilicifolius, to avoid competitions between and within species and the most important is to protect these mangrove areas from anthropogenic destruction like cutting of trees, sand mining, pollution etc.

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DIVERSITY OF SPIDERS IN CHETTUVA MANGROVE ECOSYSTEM, KERALA

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ABSTRACT

Systematics provides an essential foundation for understanding, conserving and using biodiversity. Yet for many groups of organisms we lack even such basic information as the identity and numbers of species found in the tropical region, where many of the biodiversity hotspots are located. Spiders are an especially diverse and ecologically important group whose ecological dominance have been the subjects of intense study. Despite this long history of research and their ecological importance, considerable gaps remain in our understanding of spider fauna, especially of the mangrove ecosystem. A more complete inventory of spiders is essential to advance understanding of their ecology, evolution, and behaviour, and to take full advantage of their demonstrated value in conservation priority setting, biomonitoring and biological control. Spiders generally have humidity and temperature preferences that limit them to areas within the range of their physiological tolerances, which in turn makes them ideal candidates for land conservation studies. Therefore, documenting spider diversity patterns can provide important information on the biodiversity of this tropical ecosystem. Chettuva situated in the latitude 10°31'57"N and longitude 76°2' 48"Ein Thrissur district of Kerala,is a significant mangrove zone in Kerala.This study is a pioneering attempt to reveal the diversity of spiders in this mangrove ecosystem. Fortnightly faunistic surveys of spiders associated with the mangrove ecosystem were conducted over a period of 8 months from August 2013 to March 2014. The study area covered approximately fifteen hectors of land with typical mangrove vegetation. A total of 76 species of spiders coming under 56 genera under 18 families were collected from the study area. Of the 18 families sampled, the family Araneidae was found rich in number of species. This family was represented by 17 species. The numerically abundant species was Pisaura gitae of family Pisauridae. The collected spiders can be divided in to 9 guilds based on the feeding behaviour as orb web weavers, foliage hunters, bark hunters, ground runners, sheet web weavers, diurnal hunters, scattered line weavers, diurnal ambushers and nocturnal hunters.

This study revealed that spider fauna in the study area is qualitatively rich. It is expected that further studies will expose more diversity details of spider fauna in this ecologically important location and bring this otherwise neglected animal group onto the conservation radar screen. Since spiders as a group may even provide useful conservation tools as ecological indicators in rapid biodiversity measurement, there is an urgent need to provide taxonomic resources for groups from tropical ecosystems in the view of current global biodiversity crisis.

Key words: Taxonomy, araneae, mangrove ecosystem, ecology, guild structure

1. INTRODUCTION

Mangroves represent a typical ecosystem found along many tropical coasts and estuaries (Pannier, 2009). Mangroves are trees or shrubs that grow in salty water in hot places like the tropics. Mangroves make a special saltwater woodland or shrub land habitat, called a mangrove swamp, mangrove forest, mangrove or mangal. Mangroves grow on one third of tropical shores. The vegetation consists of evergreen trees and shrubs belonging to several unrelated families and share similar habitat and similar physiognomy (Basha, 1992).Mangroves protect the shoreline from being eroded by storm waves. The intertidal existence to which these trees are adapted represents the major limitation to the number of species able to thrive in their habitat. High tide brings in salt water, and when the tide recedes, solar evaporation of the seawater in the soil leads to further increases in salinity. The return of tide can flush out these soils, bringing them back to salinity levels comparable to that of seawater. At low tide, organisms are also exposed to increases in temperature and desiccation, and are then cooled and flooded by the tide. Thus, for a plant to survive in this environment, it must tolerate broad ranges of salinity, temperature, and moisture, as well as a number of other key environmental factors, thus only a select few species make up the mangrove tree community. Because of the uniqueness of mangrove ecosystems and the protection against erosion they provide, they are often the object of conservation programs, including national biodiversity action plans. The unique flora with their specialized ecological characteristic creates a suitable habitat for a set of peculiar fauna living in their own highly specialized ecosystem. Man in his rage for supremacy over nature, failed to understand the intimate 'ecological niche' of mangroves. In order to meet his fancies, man started replacing the natural vegetation with his pet ideas in the name of agricultural and industrial development, a process that has led to a total annihilation of vast extents of mangrove vegetation in the Kerala coasts.

Order Araneaeis an extremely diversified group distributed all over the world. Spiders can be found in all continents, with the exception of Antarctica. They have conquered almost all terrestrial environments and some aquatic too. Spiders are considered the seventh largest arthropod group, surpassed in number of species only by the order Acari and five orders of insects, comprising until now 39,882 species named by arachnologists (Platnick, 2014). The great success of these animals is probably due to their innovation in the use of silk, which result in a big capability of adaptation, culminating in a high diversity in this group. Spiders are ancient animals with a history going back many millions of years. They have always been with us, an ancient source of fear and fascination. They are abundant and widespread and are natural controllers of insect populations. Generally, the spider distribution depends on the zone location and floral diversity. Spider zonation pattern is probably influenced by complex factor combinations rather than one factor which include biotic relationships such as competition and predation.

Though spiders form one of the most ubiquitous and diverse groups of organisms existing in India, their study has always remained largely neglected. They have, however, largely been ignored because of the human tendency to favour some organisms over others of equal importance because they lack a universal appeal (Humphries et al., 1995). Due to the scarcity of workers much of the arthropodan diversity in mangrove ecosystems remains unexplored. As a result, the disappearance of many species remains undocumented. With the extinction of such species any prospect for their future utilization ceases. Considering the importance of spiders in the natural suppression of many insect pests and as bioindicators, urgent efforts are needed to understand their diversity. The aims of this study were to investigate the diversity of spiders in Chettuva mangrove ecosystem and to reveal their functional role in the ecosystem. Though the study of spiders from this ecosystem is still far from complete, the present study will forms a basis for further investigations on this group.

2. MATERIALS & METHODS

1.1. Study area

Chettuva mangrove forest is located in the latitude 10°31'57"N and longitude 76°2' 48"E, is a significant mangrove zone in Kerala. In this zone, Chettuva River and Karanjira River join together and form a small estuary. Chettuva backwater is located in between Engandiyur Panchayat and Kadappuram Panchayat of Thrissur District in Kerala. These private zones are reclaimed but about 5 hectors of mangrove zones are present here. The perennial bar mouth connecting the sea is about 1.5 km west of the mangrove formation. The dominant vegetation is Rhizophora mucronata forming a dense column of 4-8 m height on the periphery of the shallow mud flat which extends to about 500 m in North-South direction and the middle portion is interrupted by tidal pools and creeks bordered by the shrub, Acanthus ilicifolius. Other species such as R.apiculata, Avicennia officinalis, Aegiceros corniculatum, Clerodendron inerme are encountered along with dense coconut farms on the landward side. Branches, roots and leaves of mangroves are shelter to a variety of insects and animals. Mangroves thrive in salty water environments. Reptiles, crabs, birds and insects, including spiders, are part of the mangrove ecosystem. Coastal tourism is one of the major threats to this area. A lot of mangroves have been cleared for the construction of health resort and hotel. In 2010, Government of Kerala has declared Chettuva as heritage village.

1.2. Study method

The investigation was carried out for a period of 8 months from August, 2013 to March, 2014; which included monsoon and post-monsoon seasons. Spiders were collected twice in a month in the evening (4.00 pm) up to late evening (6.00 pm). An all-out search method was used for collecting the spiders. Each site was thoroughly examined for the possible spiders. Collection was conducted mainly by handpicking method. Aerial sampling of spiders was done by searching leaves, trunks, and spaces in between, from knee height up to maximum overhead arm's reach and transferring them into collection bottles. Smaller spiders were collected by leading them into tubes containing alcohol with the help of a brush dipped in alcohol. Spiders found on the webs were caught in the jar by holding it open beneath them and by tapping these spiders into it with the lid. Specimens collected were transported to the laboratory. Comparatively large specimens were photographed in the field itself before collection with the help of special digital camera and lens (Canon EOS 5D SLR and Canon 180 mm macro lens). Specimens were preserved in 70% alcohol with proper labeling of locality, date, and other notes of importance for further studies. Preserved specimens were examined under a stereo zoom microscope (Leica-MS5) in the laboratory for taxonomic identification. Spiders were identified up to species level with the help of available literature (Sebastian & Peter, 2009).

Ecological characteristics relating to foraging manner, nature of web, prey species, microhabitat use, site tenacity and daily activity pattern at family level were subjected to guild classification. A guild (or ecological guild) is any group of species that exploit the same resources, often in related ways. The spider guild classification was composed according to the families collected during the study. Designation of spider guild was based on the ecological characteristic known for the family (Young & Edwards, 1990).

3. RESULTS

A total of 76 species of spiders coming under 56 genera under 19 families were collected from the study area (Table 1). Of the 19 families sampled, the family Araneidae was found rich in number of species. This family was represented by 18 species. The numerically abundant species was Pisauragitae of family Pisauridae. Voucher specimens were preserved in 70% alcohol and deposited in a reference collection lodged with the Centre for Animal Taxonomy and Ecology, Department of Zoology, Christ College, Irinjalakuda, Kerala, India.

Table 1: Checklist of spiders collected from Chettuva mangrove ecosystem during the study.

I. ARANEIDAE SIMON, 1895

1. Arachnura angura Tikader, 1970
2. Araneus nympha (Simon, 1889)
3. Argiope anasuja Thorell, 1887
4. Argiope catenulata (Doleschall, 1859)
5. Argiope pulchella Thorell, 1881
6. Chorizopes bengalensis Tikader, 1975
7. Cyclosa bifida (Doleschall, 1859)
8. Cyclosa confraga (Thorell, 1892)
9. Cyrtarachne raniceps Pocock, 1900
10. Cyrtophora cicatrosa (Stoliczka, 1869)
11. Eriovixia excelsa (Simon, 1889)
12. Eriovixia laglaizei (Simon, 1877)
13. Gasteracantha geminata (Fabricius, 1798)
14. Gasteracantha hasselti C.L. Koch, 1837
15. Gea subarmata Thorell, 1890
16. Neoscona mukerjei Tikader, 1980
17. Neoscona nautica (L. Koch, 1875)
18. Parawixia dehaani (Doleschall, 1859)

II. CLUBIONIDAE WAGNER, 1887

19. Clubiona drassodes O. P.Cambridge, 1874

III. CORINNIDAE KARSCH, 1880

20. Castianeira zetes Simon, 1897

IV. CTENIDAE KEYSERLING, 1877

21. Ctenus cochinensis Gravely, 1931

V. HERSILIIDAE THORELL, 1870

22. Hersilia savignyi Lucas, 1836

VI. LINYPHIIDAE BLACKWALL, 1859

23. Linyphia urbasae Tikader, 1970

VII. LYCOSIDAE SUNDEVALL, 1833

24. Hippasa holomerae Thorell, 1895
25. Lycosa bistriata Gravely, 1924

VIII. MITURGIDAE SIMON, 1885

26. Cheiracanthium danieli Tikader, 1975

IX. NEPHILIDAE SIMON, 1894

27. Herennia multipuncta (Doleschall, 1859)

X. OXYOPIDAE THORELL, 1870

28. Oxyopes bharatae Gajbe, 1999
29. Oxyopes birmanicus Thorell, 1887
30. Oxyopes hindostanicus Pocock, 1901
31. Oxyopes javanus Thorell, 1887
32. Oxyopes shweta Tikader, 1970

XI. PHOLCIDAE C.L. KOCH, 1851

33. Artema atlanta Walckenaer, 1837
34. Crossopriza lyoni (Blackwall, 1867)
35. Uthina atrigularis Simon, 1901

XII. PISAURIDAE SIMON, 1890

36. Pisaura gitae Tikader, 1970

XIII. SALTICIDAE BLACKWALL, 1841

37. Bavia kairali Samson, 2007
38. Bianor angulosus (Karsch, 1879)
39. Hyllus pudicus Thorell, 1895
40. Hyllus semicupreus (Simon, 1885)
41. Menemerus bivittatus (Dufour, 1831)
42. Myrmarachne plataleoides (O.P.Cambridge, 1869)
43. Phintella vittata (C.L. Koch, 1846)
44. Portia fimbriata (Doleschall, 1859)
45. Rhene flavicomans Simon, 1902
46. Telamonia dimidiata (Simon, 1899)
47. Thiania bhamoensis Thorell,1887

XIV. SCYTODIDAE BLACKWALL, 1864

48. Scytodes thoracica (Latreille, 1802)

XV. SPARASSIDAE BERTKAU, 1872

49. Heteropoda hampsoni Pocock, 1901
50. Olios milleti (Pocock, 1901)

XVI. TETRAGNATHIDAE MENGE, 1866

51. Leucauge decorata (Blackwall, 1864)
52. Leucauge dorsotuberculata (Tikader,1982)
53. Leucauge pondae Tikader, 1970
54. Leucauge tessellata (Thorell, 1887)
55. Opadometa fastigata (Simon, 1877)
56. Tetragnatha viridorufa (Gravely, 1921)
57. Tylorida ventralis (Thorell, 1877)

XVII. THERIDIIDAE SUNDEVALL, 1833

58. Achaearanea durgae (Tikader, 1970)
59. Achaearanea mundula (L. Koch, 1872)
60. Argyrodes ambalikae Tikader, 1970
61. Argyrodes andamanensis Tikader, 1977
62. Argyrodes fissifrons (O.P.Cambridge, 1869)
63. Argyrodes gazedes (Tikader, 1970)
64. Chrysso picturata (Simon, 1895)
65. Coleosoma blandum (Cambridge, 1882)
66. Theridion incertum (O.P.Cambridge, 1885)
67. Theridion manjithar (Tikader, 1970)
68. Theridula angula (Tikader, 1970)

XVIII. THOMISIDAE SUNDEVALL, 1833

69. Camaricus formosus Thorell, 1887
70. Misumena indra Tikader, 1963
71. Oxytate virens (Thorell, 1891)
72. Thomisus lobosus Tikader, 1965

XIX. ULOBORIDAE THORELL, 1869

73. Miagrammopes extensus (Simon, 1889)
74. Uloborus danolius (Tikader, 1969)
75. Uloborus krishnae (Tikader, 1970)
76. Zosis geniculata(Olivier, 1789)

3.1.Functional groups:

The collected spiders can be divided in to 9 functional groups (guilds) based on the feeding behaviour as orb web weavers, foliage hunters, bark hunters, ground runners, sheet web weavers, diurnal hunters, scattered line weavers, diurnal ambushers and nocturnal hunters (Figure 1). The dominant guild was of the orb weavers and it comprised of 30 species of spiders. Spiders of the families Araneidae,Tetragnathidae, Nephilidae and Uloboridae fall under this category. Spiders of the category diurnal hunters formed the next dominant guild in this ecosystem comprising of 17 species of spiders. Spiders of the families Oxyopidae, Pisauridae and Salticidae fall under this category. The order of dominance of other guilds was scattered line weavers (14 species), ground runners (5 species), diurnal ambushers (4 species), foliage hunters and nocturnal hunters (2 species each), bark hunters and sheet web weavers (1 species each).

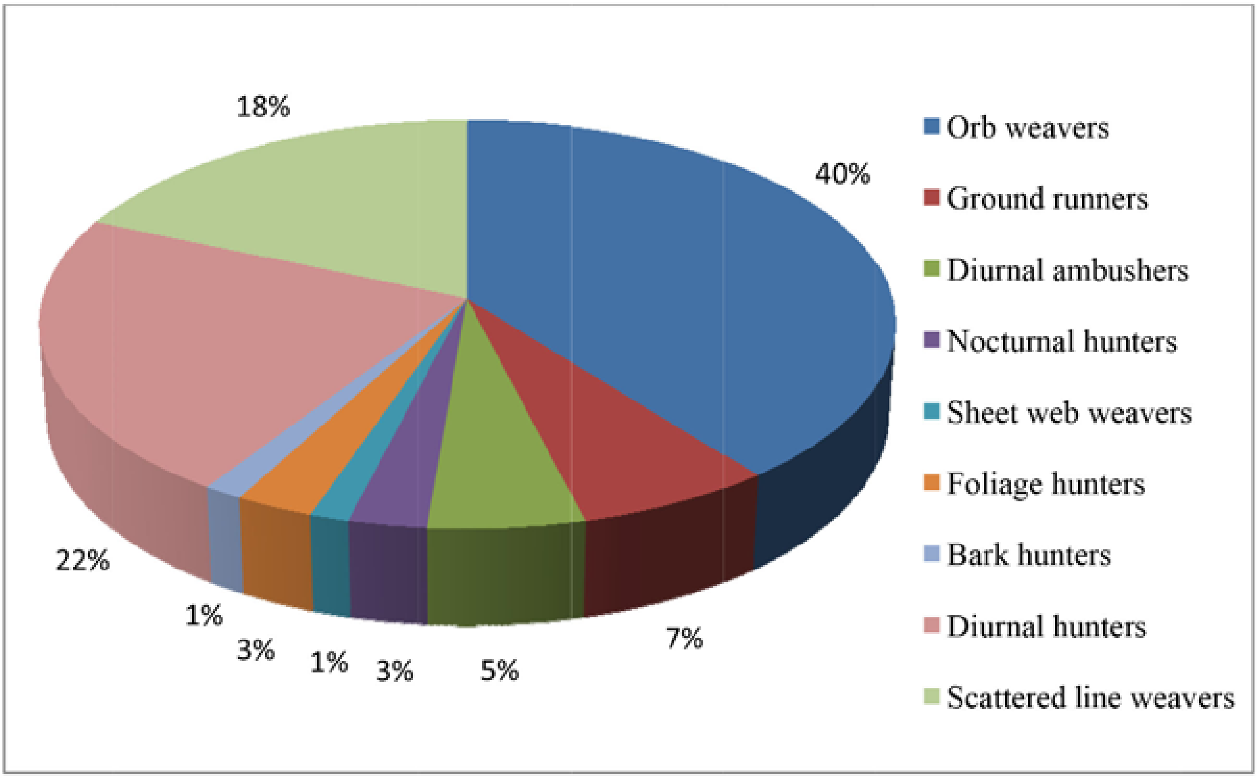

Figure 1: Guild structure of spiders in Chettuva mangrove ecosystem

Figure 1: Guild structure of spiders in Chettuva mangrove ecosystem

1.1. Family diversity

Out of the 59 families recorded in the Indian region, 19 families arediscovered in this mangrove ecosystem. This represents 35% of the total families recorded in India. Araneidae was the dominant family in this biome, which is composed of 17 species of 12 genera. Salticidae and Theridiidae were the next dominant families with 11 species each. Tetragnathidae (8 species), Oxyopidae (5 species), Thomisidae (4 species) and Pholcidae (3 species) was the order of dominance of the other majorfamilies in this ecosystem.

1.2. Generic diversity

Out of the 252 genera recorded from the Indian region, 56 genera are discovered in Chettuva mangrove ecosystem. Maximum generic diversity was found inAraneidae (12), Salticidae (10), Theridiidae (6) and Tetragnathidae (5). The number of generarecorded here is higher than that of other major Indian spider studies viz., Andaman and Nicobarislands - 33 genera, Sikkim - 41 genera and Calcutta - 47 genera (Tikader&Biswas, 1981).

1.3. Species richness

A total of 76 species are discovered from a limited area of 15 hectors. Thisnumber is very high compared with other regions like Andaman and Nicobar islands - 65 species,Sikkim- 55 species and Calcutta - 99 species (Tikader&Biswas, 1981).The above three studies were conducted over a period of one to two years while the present study was limited to eight months.

4. DISCUSSION

Of about 1442 species reported from India (Sebastian & Peter, 2009), 76 species have been recorded from Chettuva mangrove ecosystem. The high species diversity of spiders in this ecosystem can be attributed to the high diversity of plants and insects (Swarupanandan et al., 2000). It can be assumed that a high floral diversity sustains a high faunal diversity by providing diverse microhabitat especially for invertebrates. Unlike other ecologically important zones, there is no previous work to compare the spider diversity. This indicates the need for further sampling in this area. Because of the complex interaction of various climatic factors like saline intrusion and humidity, with topographical features mangroves holds many smaller but diverse environmental niches. The presence of diverse habitats like scrub jungles and bushes in this ecosystem are further evidence to this.

Higher trophic levels have been repeatedly found to be especially sensitive to environmental change, either because they operate at a larger spatial scale than other groups, becoming more sensitive to, e.g., fragmentation, or because they are subject to the same factors as lower trophic levels as well as being strongly dependent on lower trophic groups and their changes, thus experiencing a synergistic effect (Voigt et al., 2007). Spiders therefore ought to be a good indicator taxon to reflect ecological change.

There are many environmental factors that affect species diversity (Rosenzweig, 1995).However, when spiders were divided according to their functional group there was a significant effect of habitat on the diversity of these groups. The collected spiders of Chettuva mangrove ecosystem classified in to 9 functional groups (guilds) based on the feeding behaviour. The web building and foliage running spiders rely on vegetation for some part of their lives, either for finding food, building retreats or for web building. Several authors have tried to define spider guilds by using foraging strategies to predict arthropod prey group as the shared resource (Uetz et al., 1999; Dias et al., 2010). Flying arthropods are mainly captured by different types of webs, epigean arthropods by wandering spiders or tube web hunters, arboreal arthropods by sheet webs, etc. Therefore, although many guild classification systems exist for spiders, these are usually based solely on foraging strategy, although different strategies may be directed towards similar prey and similar strategies may be directed towards different prey.

The structure of the vegetation is therefore expected to influence the diversity of spiders found in the habitat. Studies have demonstrated that a correlation exists between the structural complexity of habitats and species diversity (Hawksworth & Kalin-Arroyo, 1995). Diversity generally increases when a greater variety of habitat types are present (Ried & Miller, 1989). Uetz (1991) suggests that structurally more complex shrubs can support a more diverse spider community. Downie et al. (1999) and New (1999) have demonstrated that spiders are extremely sensitive to small changes in the habitat structure; including habitat complexity, litter depth and microclimate characteristics. Spiders generally have humidity and temperature preferences that limit them to areas within the range of their “physiological tolerances” which make them ideal candidates for land conservation studies (Riechert & Gillespie, 1986). Therefore, documenting spider diversity patterns in this ecosystem can provide important information to justify the conservation of this ecosystem.

The most striking result is the surprisingly high diversity in this biome compared with other biomes that have been surveyed in India. The number of species found here is a lot higher than in other studies conducted in Western Ghats (Sugumaran et al., 2005). However, that study was conducted for a period of more than one year and sampling for the present study was done in a limited period only. Culin & Yeargan (2013) noted that the species richness of spiders is significantly higher in systems that have not been heavily manipulated. Species richness is only one way of assessing habitat quality. A site with major vegetation complexity can present more variety of prey or simply more opportunities for spiders to build snares and retreats. Functional diversity is positively related with habitat complexity, with more complex habitats being more functionally diverse. The uniqueness of species compositions, as indicated by levels of endemism and habitat specialization, is more important in establishing regional conservation priorities (Platnick, 1991). This study serves as a baseline for future study of spiders in mangrove ecosystems. Such studies can build upon this one by using additional collecting methods and/or collecting in different seasons. Future studies can build upon this data and continue to catalogue the poorly documented spider fauna and perhaps discover new species along the way.

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SOME ECOLOGICAL OBSERVATIONS ON THE ORCHIDS OF SATHYAMANGALAM TIGER RESERVE

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ABSTRACT

This paper discusses the results of orchid surveys carried out in Sathyamangalam Tiger Reserve (Latitude 11º 29’ 15” to 11º 43’ 11” N and Longitude is 76º 50’ 69”to 77 º 27’ 22” E), Eastern Ghats, southern India. This work forms part of a comprehensive exercise of assessment of threatened plants of Tamil Nadu initiated by the state Forest Department. Filed surveys were done during December 2013 to November 2014 and the orchid specimens were collected and herbarium made using standard procedures. A total of 18 orchid species belonging 12 genera were found. Of these, three are terrestrial and remaining 15 are epiphytes. The 15 epiphytic orchid species were found growing on 11 host tree species. Several orchid species favored Pterocarpus marsupium as their host. Orchids were found in various habitat types of Sathyamangalam Tiger Reserve, the highest number of species (n=12) occurring in the West Coast semi-evergreen forest. Of the 18 species, four are endemic and one species comes under IUCN threatened (vulnerable) category. Some of the orchids are used for their medicinal value.

Keywords: Orchids, ecology, Sathyamangalam

1. INTRODUCTION

Orchids (Family; Orchidaceae), the most beautiful flowers in god’s creation, comprise a unique group of plants. Orchidaceae is the second largest family of flowering plants in the world, comprising of about 779 genera and 22,500 species (Mabberley, 2008).They have diverse habits with variously modified vegetative and floral structures. According to Misra (2007) 1,331 species (186 genera) of orchids are found in our country. Himalayas are their main home for orchids and they area also scattered in Eastern and Western Ghats. They are very sensitive to habitat degradation and fragmentation. Based on their varying habits, orchids are classified as holomycotrophic or saprophytic (growing on dead and decaying matter), terrestrials (growing on ground) and epiphytic (growing on trees or shrubs).

The Indian subcontinent has diverse climatic regimes, forest types and habitat conditions that provide a favorable environment for accommodating various life forms such as Orchids. Being separated by high mountain ranges of the Himalayas in the north and in the south by Arabian Sea, Bay of Bengal and Indian Ocean, the isolation of Indian flora to a large extent helps in the evolution of endemic taxa. The endemism in the flora of a country or geographical region provides an important insight into the biogeography of that region and also to the centers of diversity and adaptive evolution of the floristic components of that region (Nayar, 1996). The present work is list out of Orchid species in Sathyamangalam Tiger Reserve. The present work forms part of a comprehensive exercise of assessment of endemic and threatened plant species of Tamil Nadu initiated by the state Forest Department. List of orchid species recorded in Sathyamangalam Tiger Reserve along with some ecological notes is provided here.

2. MATERIALS AND METHODS

Sathyamangalam Tiger Reserve encompasses large contiguous Reserve Forests extending over 1455 sq km with 14 different types of vegetation. It is located between the latitudes 11° 29”15’ to 11° 43”11’ N and longitude 76°50”69” to 77°27” 22’ E. The Sathyamangalam Wildlife Sanctuary has been declared as a Tiger Reserve on 15 March 2013. The diversity of habitats has got an assemblage of several species of rare plants, invertebrates, fishes, amphibians, and reptiles. This sanctuary also harbours several threatened and endemic plant species including. The mountain range has served type locality for some plant taxa. Although the area is rich in plant diversity, very few attempts have been made to document the flora of Sathyamangalam Tiger Reserve.

Sathyamangalam Tiger Reserve has many forest types such as Carnatak umbrella thorn forest, Dry Grassland, Dry Savannah, Dry tropical riverine Forest, Hardwickia Forest, Moist Bamboo brakes, Riparian fringing forest, Southern secondary moist mixed deciduous forest, Southern thorn forest, Southern thorn scrub, Secondary dry deciduous forest, Southern dry mixed deciduous forest, southern most mixed deciduous forest and West coast semi-evergreen forest. Frequent plant exploration trips were made to collect the plant species from different vegetation types during various seasons. The field survey was conducted betweenDecember 2013 and November 2014.The Orchid specieshas been listed based on Forest types and the host trees. Field identification of plants was done with the help of regional floras, and reports viz. Collett (1921), Nair (1977), Rau (1975, 1981), Polunin & Stainton (1984), Chowdhery & Wadhwa (1984) and Aswal & Mehrotra (1994). Herbarium specimens hasbeen prepared as per Jain & Rao's Manual (1977) and specimens were deposited in SACON Herbarium at Coimbatore.

3. RESULTS

During the present study a total of 18 orchid species belonging to 13 genera were recorded in the Sathyamangalam Tiger Reserve. Among the 18 orchids, three species are terrestrial, remaining fifteen are epiphytic (Table1).The epiphyte orchids are mostly found in hard wood trees. Several orchid species (5 out of 18) favored Pterocarpus marsupium as their host. During this study three endemics, Aerides crispa, Coelogyne nervosa, Habenaria longicorniculata and one threatened Vanda spathulata. Even though most of the orchids are growing in high altitudes like sholas, number of orchid species (n=12) were found in West coast semi-evergreen forest of this tiger reserve.

Table 1: List of Orchid species recorded in Sathyamangalam Tiger Reserve

S.No	Name of the Orchid	Forest type	Name of the Host Tree	Habit	Endemic and Threat Status
1	Acampe praemorsa (Roxb.) Blatter & McCann	West Coast Semi evergreen forest, Southern secondary moist mixed deciduous forest	Celtis tetrandra Roxb. Alstonia scholaris(L.) R.Br. Syzygium cumini L.	Epiphytic	-
2	Aerides crispa Lindl.	Southern moist mixed deciduous forest, Secondary dry mixed deciduous forest	Bauhinia racemosa Lam. Haldina cordifolia Roxb. Psydrax dicoccos Gaertn. Pterocarpus marsupium Roxb. Phyllanthus emblica L.	Epiphytic	Endemic to Peninsular India
3	Aeride sringens (Lindl.) Fischer	Southern moist mixed deciduous forest, Secondary dry deciduous forest, West Coast Semi evergreen forest	Bauhinia racemosa Lam. Haldina cordifolia Roxb. Pterocarpus marsupium Roxb. Ficus benghalensis L	Epiphytic	-

4	Bulbophyllum fischeri Seidenfaden	West Coast Semi evergreen forest, Eucalyptus Plantation	Eucalyptus tereticornis Sm. Artocarpus heterophyllus Lam. Greville arobusta A. Cunn. ex R.Br.	Epiphytic	-
5	Coelogyne nervosa A. Rich.	West Coast Semi evergreen forest, Southern moist mixed deciduous forest	Litsea stocksii (Meisner) Hook.f. Cinnamomum macrocarpum Hook.f. Allophylus cobbe (L.) Raeusch. Pterocarpus marsupium Roxb.	Epiphytic	Endemic to Peninsular India
6	Cymbidium aloifolium (L.) Sw.	West Coast Semi evergreen forest,	Pterocarpus marsupium Roxb. Pterocarpus santalinus L. Terminalia bellirica Gaertn.	Epiphytic	-
7	Gastrochilus acaulis (Lindl.) Kuntze	West Coast Semi evergreen forest,	Schefflera capitata Wight &Arn. Cinnamomum macrocarpum Hook.f. Celtis tetrandra Roxb.	Epiphytic	-
8	Habenaria longicorniculata Granham	Dry Grassland, West Coast Semi evergreen forest	-	Terrestrial	Endemic to India
9	Habenaria plantaginea Lindl.	Secondary dry deciduous forest, Southern dry mixed deciduous forest	-	Terrestrial	-
10	Luisia birchea Blume	Southern moist mixed deciduous forest	Psydrax dicoccos Gaertn. Haldina cordifolia Roxb Anogeissus latifolia Roxb. Ex DC.	Epiphytic	-
11	Luisia zeylanica Lindl.	Southern moist mixed deciduous forest, West Coast Semi evergreen forest,	Phyllanthus emblica L. Anogeissus latifolia Roxb. Ex DC.	Epiphytic	-
12	Oberonia santapaui Kapadia	West Coast Semi evergreen forest,	Celtis tetrandra Roxb. Chionanthus mala-elengi Dennst. Phyllanthus emblica L.	Epiphytic	-

13	Oberonia verticillata Wight	West Coast Semi evergreen forest,	Litsea stocksii Hook.f. Cinnamomum macrocarpum Hook.f. Sterculia foetida L.	Epiphytic	-
14	Peristylus goodyeriodes (D. Don) Lindl.	West Coast Semi evergreen forest, Riparian fringing forest	-	Terrestrial	-
15	Polystachya flavescens (Jacq.) Garay & Sweet	Dry Grassland, Southern secondary moist mixed deciduous forest	Syzygium cumini L. Pterocarpus marsupium Roxb Terminalia bellirica Gaertn.	Epiphytic	-
16	Rhynchostylis retusa (L.) Blume	Southern moist mixed deciduous forest, Southern secondary moist mixed deciduous forest	Ficus microcarpa L.f. Eucalyptus tereticornis Sm. Melia azedarach L.	Epiphytic	-
17	Vanda spathulata (L.) Spreng.	Secondary dry deciduous forest, Southern thorn scrub, Southern thorn forest	Catunaregam spinosa Thunb. Tamilnadia ulginosa Retz. Azardirachta indica Ness	Epiphytic	Endemic to Peninsular India (Vulnerable)
18	Vanda testaceae (Lindl.) Reichb	West Coast Semi evergreen forest, Southern moist mixed deciduous forest, Southern secondary moist mixed deciduous forest	Phyllanthus emblica L. Chionanthus mala-elengi Dennst. Mitragyna parvifolia Roxb.	Epiphytic	-

4. DISCUSSION

In Sathyamangalam Tiger Reserve, 18 orchid species including three endemics and one threatened species were found. During the earlier study, only six orchid species were reported from here. While Subramanian and Kalyani (1977) reported Luisia birchea and Vanda testaceae in Dhimbam Ghats, Ramasubramanian (1997) recorded Habenaria planteginea, Habenaria viridiflora, Liparis prazeri, Peristylus goodyeroides, Polystachya flavescens, Vanda testacea. Jalal and Jayanthi (2012) reported 130 endemic species in the Peninsular India, which includes Western Ghats region (n=123) followed by Deccan Plateau (n= 29) and Eastern Ghats (n=22). Endemic taxa are found to be occurring in isolated/restricted habitats due to geological and climatic changes (Nayar, 1996).Endemic taxa occur in restricted areas, which are usually isolated by geographical or temporal barriers (Ahmedullah & Nayar, 1987). Occurrence of three endemic orchids and several non-orchid species (Balasubramanian and Murugesan, 2010) and Murugesan et al. (2009a and 2009b) in Sathyamangalam Tiger Reserve indicates that it is an important area of endemic plant distribution in Peninsular India.

5. CONCLUSION

Several anthropogenic activities were found in orchid habitats that might lead to the declining of orchid population. The epiphytic orchid populations likely to be affected due to cutting of trees by tribal's here. In our study area, the mixed dry deciduous forest has coupled with scrub tracts which are more prone to fire. The ground fire has a profound effect on the vegetation and wildlife, which also forms a threat to orchids thriving in dry forest habitat.

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STUDY OF GRASS LAND BIODIVERSITY TO EVOLVE STRATEGIES FOR CONSERVING KEY SPECIES-BLACKBUCK AND ITS HABITAT

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ABSTRACT

Grasslands are the most neglected abused and least protected ecosystems in India. Grasslands remained unprotected as they were not notified as ‘Protected Areas’ under the Wildlife (Protection) Act, 1972 and were also not notified as ‘Protected’ or ‘Reserve Forest’ under the Indian Forest Act. The grasslands were now facing anthropogenic pressure and most plant ecologists considered that the grasslands of India owe their existence primarily to biotic factors such as fire and grazing. They also fragmented due to developmental activities. Hence it was need of the hour to evolve strategies to conserve and sustain the quality of these habitats.

Blackbuck (Indian Blackbuck (Antelope cervicapra)) is one of the antelopes endemic to the grasslands of Indian subcontinent. It accorded high protection status and considered as Schedule-1 animal under The Wildlife (Protection) Act 1972 of India. They were designated as ‘Near Threatened’ as per the Red Data Book of IUCN. Due to immense pressures through poaching and destruction of grasslands, Blackbucks are now restricted only to few isolated and fragmented pockets across India. Among which Jayamangali Blackbuck reserve (located in Tumkur district of Karnataka) is one such habitat.

Species conservation cannot be achieved unless the habitat and ecosystem is conserved. Apart from Blackbucks this grassland also harbors varieties of fauna and flora. Thus conservation strategies of Blackbucks need to involve conserving its habitat and biodiversity as well. The main objective of this study was to document the bio diversity of this grassland and also to understand issues/challenges which threaten the very existence of key species.

Periodical field visits, lying of transacts for the census of Blackbucks, study of vegetation, interview the people to understand the issues and concerns etc., were undertaken to explore the rich diversity of the habitat and also to understand the extent to which the Blackbucks were threatened due to human interventions and the resilience exhibited by the community to conserve these animals.

This paper highlights biodiversity richness of the habitat in terms of different forms of flora and fauna species and the suggestions made towards addressing some of these issues by evolving strategies like expansion of habitat area, de rooting the exotic trees, reduce the plantation activities. The recommendations for declaring the grassland as ‘community conservation reserve’ as to transfer the ownership to community and to empower them to conserve the habitat is another management process which support conservation of biodiversity and sustaining the grassland habitat.

Key words: Grassland, blackbuck, tumkur, biodversity, habitat conservation, census, community conservation

1. INTRODUCTION

Grasslands support the livelihoods of millions of people and their livestock. India supports highest livestock densities in the world with more than 500 million livestocks. More than 50% of these livestock depends on the grassland ecosystem for fodder. With the increase in human population, demand for food production has increased the pressure on these grassland ecosystems both from expansion of agriculture as well from increased grazing pressure. The pressure becomes intensive when these ecosystems were fragmented in the name of development activities. The Planning Commission report of 2011, which states that India’s pastures have reduced from 70 million ha in 1947 to 38 million ha in 1997, is an evident for the intensive pressure on these eco systems. Most of these grasslands are outside the boundaries of 'Protected Area' and they cannot be viewed or managed in the traditional conservation method because of the extensive spread of this ecosystem as well as the presence of dense human populations.

Grasslands because of their unique characteristics and often interspersed with shrubs and trees, home to a host of endangered wild species that are adapted to the arid conditions. The grasslands of arid and semi-arid regions of peninsular India are considered as prime habitat for several critically endangered species such as the Great Indian Bustard (Ardeotis nigriceps), Lesser Florican (Sypheotides indica) and other endangered and endemic species such as Indian wolf (Canis lupus pallipes), Indian fox (Vulpes bengalensis) and Blackbuck (Antelope cervicapra). Conservation of any of these species is closely associated with the conservation of their habitat.

Blackbuck (Indian Blackbuck-Antelope cervicapra) is one of the antelopes endemic to the Indian subcontinent with an estimated population of about 35,000 in the wild. High protection status has been accorded to Blackbuck by the Wildlife (Protection) Act 1972 (Traffic India, 1990) of India, placing this species in the Schedule-1 along with tiger and rhino and other highly threatened animals. Blackbucks were designated as 'Near Threatened' as per the Red Data Book (IUCN, 2013). Due to immense pressures of large scale poaching and destruction of grasslands Blackbucks have become restricted only to few isolated pockets across India and presently they are found only in few states of India (Menon, 2000). In Karnataka, Blackbucks were found in few pockets as in the Ranebennur Blackbuck Sanctuary and in few districts as reported by Manu, (2011). In the present study area, notified as Jayamangali Blackbuck Conservation Reserve, in Tumkur district, scattered population of Blackbucks were found in grasslands of Mydanahalli and few surrounding villages, (located 20 kms, south west of MadhugiriTaluk).

2. NEED FOR UNDERSTANDING THE BIODIVERSITY OF THE GRASSLAND

Zafar-ul-Islam and Rahmani, (2011) of BNHS, Bombay, have undertaken many studies on conservation of grasslands and biodiversity. Many committees and commissions had been constituted by Ministry of Environment and Forests to study and recommend strategies and action plans for conserving habitat and biodiversity. In Karnataka, studies on Blackbucks and their habitats along with the ecology of the protected area at Ranebennur Blackbuck Sanctuary were conducted by Krishnan, (1972); Bustard population and exotic species by Neginhal, (1980) and the status survey report by Karanth and Singh, (1981). In similar lines Tumkur-based Wildlife Aware Nature Club (WANC) conducted studies on biodiversity of the Jayamangali reserve and initiated actions to declare the study area as Blackbucks conservation Reserve.

According to the Report of Task Force on 'Grasslands and Deserts' by Government of India Planning Commission (2006), grasslands were the most neglected, abused and least protected ecosystems in India. They remained unprotected as they were not notified as 'Protected Areas' under the Wildlife (Protection) Act, 1972 (Traffic India, 1990), and were also not notified as 'Protected' or 'Reserve Forest' under the Indian Forest Act, 1927 (IFA, 1927). The grasslands were now facing anthropogenic pressure and most plant ecologists considered that the grasslands of India owe their existence primarily to biotic factors such as fire and grazing (Champion and Seth, 1968; Dabadghao and Shankaranarayan, 1973; Gadgil and Meher-Homji, 1985). Hence it was need of the hour to evolve strategies to conserve and sustain the quality of these ecosystems they inhabit rare flora and faunal species.

Karnataka is home to a variety of different pastoral communities and the man animal conflict has been managed through traditional methods. Given the complex nature of these ecosystems, conservation of grasslands is a challenging task. The field studies conducted in the present study area, at Tumkur District, since 1997 till date re-confirmed that the habitat was highly productive, it being used and maintained due to anthropogenic causes, the dependency on its resources by a large number of people and by a variety of wildlife species made it a significant area for many wildlife too. This Reserve provided habitat for various mammals, birds, reptiles, amphibians, insects, butterflies and plants in addition to the study animal, Blackbuck. The main aim of the study was to understand the biodiversity of the grassland and later to evolve strategies and action plan for conserving the key species Blackbuck as the number and size had considerably come down.

3. MATERIALS AND METHODS

To understand the biodiversity of the study area, habitat structure, change in land use pattern and most important the anthropogenic pressures on the habitat diversity of the habitat which would provide relevant data to monitor the wellbeing of the habitat and key species, few strategies such as, survey, field visits, interviews and conducting census by Line transact method (Charles et al., 1968) were employed. Efforts have been made to involve the community around the habitat to encourage active participation for evolving and implementation of sustainable conservation strategies.

The following field tools such as topo maps, survey sheets, equipment like GPS, binoculars, cameras and monocular telescopes. Interview sheets were used to record data from panchayaths, villagers to understand bio-diversity and related issues.

4. RESULTS AND DISCUSSIONS

4.1. Study of the Habitat

According to Champion and Seth's (1968) classification, the natural vegetation of this reserve was classified as Southern Tropical Thorn Forests (6A) and as per ICAR classification; these grasslands were classified as Sehima-Dichanthium. The reports suggested that these grasslands and forests consisted of open and low vegetation that was characterized by thorny trees. The second level of vegetation was poorly developed which consisted of spiny and 'xerophytic' species. Shrubs of the dominant vegetation as observed were, such as Prosopis sp. Dodonaea viscosa, Cassia auriculata and Lantana camara. During the brief wet season lower level also could be differentiated. The typical grasses of the region included Chloris montana, Cynodon dactylon, Aristida adscensionis, and Dactyloctenium sp. etc.

During the survey it was observed that the Reserve consisted of different habitat types such as plantations, open grasslands, cultivated area, nullahs, check dams, soak pits and other vegetation. The distribution pattern given in the Table 1 showed that 42% (maximum) of the total Reserve area was covered by plantation (Fig 1).

Table 1: Different Habitat types in the Reserve

Type of Habitat	Area in Hectares
Plantation area	137
Open grassland	60
Cultivated area	67
Nullah/check dams	23
Other vegetation	36

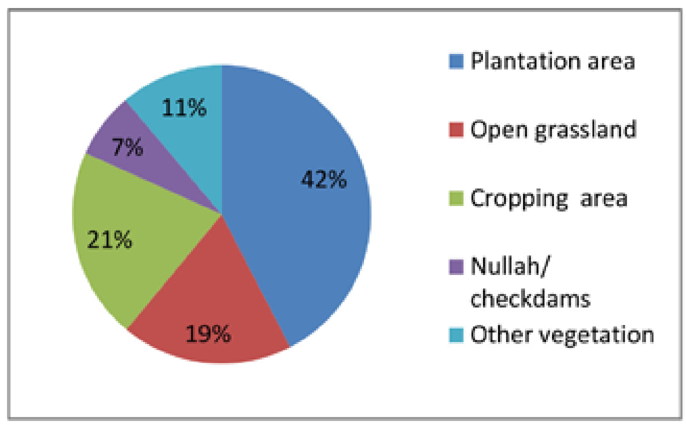

Fig. 1: Different Habitat types and percentage of area covered in the Reserve

4.2. Study of Blackbucks

Exclusive censuses were conducted to understand the population dynamics of Blackbuck. The censuses conducted by Line transact method to estimate the population of Blackbuck in 2009 (Census report 2009) had shown a large number of Blackbucks of about 454, whereas the census of 2012 (Census report 2012) showed a decline in their number to about 257. These figures showed a declining trend in overall population figures when compared to earlier census conducted in 2002 (610 number of Blackbucks) and 1997 (408 number of Blackbucks).

The census data is shown in detail in Table 2 and Fig. 2.

Table 2: Blackbuck census data showing population structure of males, females and fawns

Year	Male	Female	Fawn	Total
1997	No records available			408
2002	202	335	73	610
2009	129	280	45 +4	454
2012	105	125	27	257

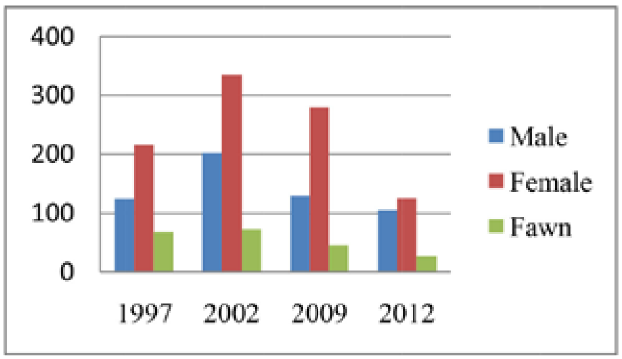

Fig 2: Graphical representation Blackbuck census data from 1997, showing population structure of males, females and fawns.

4.3.Floral and Faunal study

Fig 3 & 4 shows the graphical representation of floral and faunal species under each category in the Reserve.

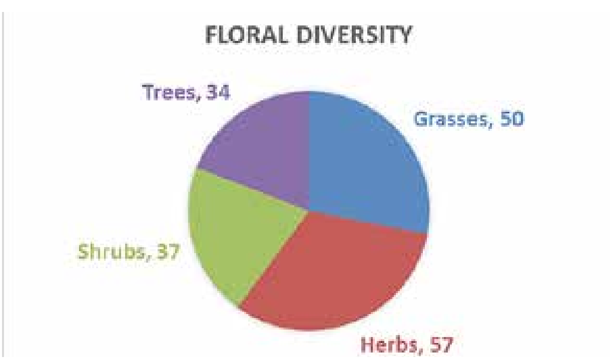

Fig 3: Graphical representation of floral species under each category identified in the Reserve

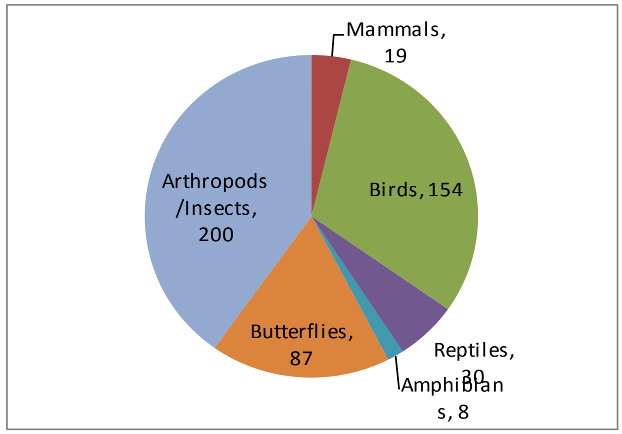

Fig 4: Graphical representation of faunal species under each category identified in the Reserve

4.4. Study of Floral and Faunal diversity

During the study period, floral diversity recorded are as follows; 35 types of trees, 36 types of shrubs, 57 types of herbs and 50 types of grasses along with a few un-identified species were recorded in the grassland. Similar observations were made by Prasad (1981), Zafar and Rahmani (2011), Ranjitsinh (1982).

As per the data documented from the censuses, it was concluded that the study area had 19 species of mammals belonging to 11 families, 154 species of birds from 45 families (out of which 22 species were migratory), 30 species of reptiles from 02 orders, 8 species of amphibians belonging to 4 families, 87 species of butterflies belonging to 7 families and many arthropods such as spiders, millipedes, wasps, ants, termites, bugs and beetles also had been recorded but the list was incomplete as there were many unidentified members of this phylum yet to be identified. Some of the villagers claimed to have observed Great Indian Bustard (Choriotis nigriceps) and Hyaena (Hyaena hyaena) in the distant past. Some of the ground birds observed in the Reserve like Indian courser (Cursorius coromandelicus) and painted sandgrouse (Pterocles indicus) were totally dependent on these habitations.

4.5. Study of issues related to Grassland

1.1.1. Plantation of Exotic Species

Total 137 hectares of the total Reserve area was planted under different schemes (Table 1 & Fig 5). 42% of the Reserve was planted with exotic species like Eucaluptus and Acacia, excluding Neem (Azaridicta indica) and Tamarind (Tamarindus indica) which was about 4-5%. The remaining deciduous woodland continued to be cleared for agriculture land, while the pasture that had been created was itself threatened by overgrazing and invasive weeds. These plantations converted the Reserve in to a habitat unsuitable for Blackbucks.

Apart from exotic species, Lantana camara and Parthenium hysterophorus are, were the two main invasive species observed in the study area.

Years	Area (in hectares)
1984-85	13
1987-88	10
1988-89	20
1989-90	10
1991-92	71
1992-93	13
	137

Table 3: History of plantation activities in the Reserve along with the area of plantation.

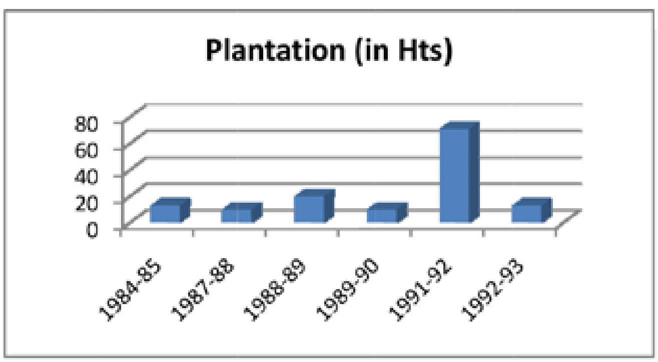

Fig 5: Graphical representation of plantation area covered with exotic species in the Reserve

1.1.2. Overgrazing and competition for forage ground

The present study showed that there were 26 villages in the periphery of this Reserve and most of the sheep and goats which grazed in and around this Reserve belonged to these villages. The records of the total cattle population estimated in 1997 were around 24,907 and a census made during 2012 revealed an increase in their population to 35,489. Several village pastures commonly used by cattle was either encroached by human habitation or invaded by exotic thorny shrub, Prosophis juliflora, which had resulted in the loss of grazing areas for the cattle. This had intensified the grazing pressure on the nearby grassland i.e, the Reserve area and also increased the completion for fodder between Blackbucks and domestic grazing animals (Fig 6).

The grassland also faces threats from development activities such as road construction, extension of irrigation activities, change in land use pattern and cropping patterns etc.

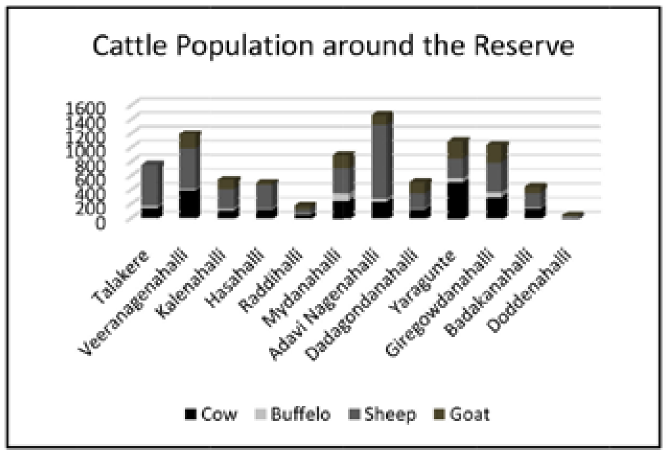

Fig 6: Graphical representation of cattle population in the villages around the Reserve

5. DISCUSSION

Biodiversity survey conducted in this study period confirmed the presence of rich diversity of flora and fauna in the Reserve area. This was an evidential record to prove the biological value of the Reserve. This also helped to understand the habitat and species specific issues with respect to Blackbucks, by observing their behavior, population dynamics and issues such as seasonal habitat utilization, quantitative and qualitative availability of forage in the feeding grounds, fragmentation of habitat, unchecked growth of exotic species etc.

The reports of census conducted during 1997 showed only the total number of Blackbucks found in the reserve. The censuses which were conducted later to 1997 that is 2002, 2009 and 2012 showed interesting figures of male, female and fawn. Maximum number of female was observed when compared to those of male and fawn during the entire census period. But continuous decline in the number male, female and fawns revealed that the animals were facing problems in their habitat due to man-animal conflict. The number of males had declined from 202 in 2002 to 105 in 2012 and females and fawns showed a similar reduction in number from 335 and 73 during 2002 to 125 and 27 during the 2012 census respectively.

This study threw light on the major problems for the conservation of the Blackbucks of the Jayamangali Blackbuck Reserve, which were of two fold, one being the typical man-animal conflict issue and the other, shrinkage of habitat both in terms of quality and expanse. The Reserve facing pressure due to the developments and changes happening in and around the Reserve was documented in detail. The villages surrounding the Reserve were home to a large population of domestic animals comprising cattle, sheep and goats.

The prey-predator relationship, population densities; the food web, behaviour of animals and birds, migratory species, etc. was assessed during the study period which certainly helped in understanding other related factors required to conserve the ecosystem as a whole.

6. CONCLUSION

Grasslands are often considered as waste lands. Furthermore, in the name of waste land development and social forestry, these common lands / common grazing lands were planted with invasive species which cannot be consumed by the local livestock thereby the productivity of these common lands was decreased and the pressure often shifted again to cultivated lands. Despite focus by the MOEF and recommendations by the Planning Commission and the Grassland Task Force, on ground there is no concerted action on grassland management.

The habitat quality was evaluated by considering the biodiversity of large mammals, birds, plants, butterflies, amphibians, reptiles and insects. Since there were lacunae on the detailed information for majority of the grasslands in other parts of India, it was difficult to value the biodiversity richness. Therefore the presence or absence of key species such as Blackbucks, Great Indian bustard, wolf, hyena etc., were considered as indicators of species richness and importance of grassland habitats in Karnataka.

Since habitat was the prime element in conservation of species and in situ conservation encompasses conservation of entire ecosystem of the region, documentation of the floral diversity helped to explore the inter-linkages, dependent and interdependent factors of flora and fauna which in turn helped to establish their inter-relationships and also to estimate the significance of the grassland as a habitat to blackbuck. While considerable information and data on India's grassland biodiversity exists at various levels, there is no networking and systematizing of the scattered information. These efforts will definitely help to evolve informed strategies for management of habitat and key species of grasslands.

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MICROHABITAT DISTRIBUTION, DIVERSITY AND CONSERVATION STATUS OF FRESHWATER FISHES OF PAMBAR RIVER, SOUTHERN WESTERN GHATS, KERALA, INDIA

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ABSTRACT

Aquatic ecosystems of southern Western Ghats contribute significantly to the ichthyofaunal diversity, endemicity and uniqueness of Western Ghats. This paper intends to bring out the conservation status of freshwater fishes of Pambar river (10˚ 08' N 77˚ 7' E - 10˚ 21' N 77˚ 14'E), one of the three east flowing rivers of Kerala. Twenty four species belonging to six families and seventeen genera were collected from seven sampling stations viz., Koottar (10˚21' 08" N 77˚14' 12" E), Champakkadu (10˚19' 58" N 77˚13' 9" E), Thoovanam (10˚ 17' 14" N 77˚11' 18" E), Kovilkadavu (10˚ 15' 07" N 77˚ 10' 02" E), Anakkalpetty (10˚14' 45"N 77˚ 09' 24" E), Pallanadu (10˚14' 14" N 77˚ 08' 51" E) and Lakkom (10˚11' 17.15" N 77˚ 06' 50.95"E) at different altitudes along the ~32 km drainage in Kerala. Bimonthly stratified samples made during May 2012 to July 2014 revealed the dominance of family Cyprinidae with fifteen species (62%) followed by Balitoridae (20%). Three exotic species viz., Oreochromis mossambicus (Peters,1852), Gambusia affinis (Baird,S.F & Girard,1853) and Cyprinus carpio Linnaeus,1758 and three IUCN Red Listed species (2014) viz., Garra hughi (Endangered), Tor khudree (Endangered) and Barbodes wynaadensis (Critically Endangered) have been identified from this region and their conservation strategies are suggested along with the diversity studies.

Key words: Pambar river, ichthyofaunal diversity, species richness, conservation.

1. INTRODUCTION

The Western Ghats, a chain of mountain ranges extending almost parallel to the west-coast of India has been enlisted in the UNESCO'S World Natural Heritage Sites recently as one of the world's eight 'hottest hotspots' of biological diversity exceptionally of its immense treasure of endemic plants and animals. At least 325 globally threatened species occur in the Western Ghats (Myers et al., 2000). The Western Ghats and the associated river drainages are rich in freshwater fish diversity (Kottelat and Whitten, 1996; Shaji et al., 2000; Dahanukar et al., 2004, 2011). Southern Western Ghats preferably harbours an admirable gradient of ichthyofaunal diversity with significant standard of endemism and uniqueness than those of other geographical regions of the Western Ghats (Dahanukar et al., 2011). The State of Kerala, part of Southern Western Ghats innervating with innumerable drainages including major 41 westward flowing and 3 eastward flowing rivers and hence it became tagged as a target for various aspects of ichthyological investigations. Pioneer ichthyological investigations of Day (1865,1878,1889); Pillai (1929); John (1936); Hora & Law (1941); Silas (1951a & b) and subsequent efforts of Remadevi & Indra (1986); Pethiyagoda & Kottelat (1994); Kurup (1994); Easa & Shaji (1995); Menon & Jacob (1996); Manimekalan & Das (1998); Kurup and Ranjeet (2002); Kurup et al. (2004); Ajithkumar et al. (1999); Thomas & Ajithkumar (1999); Raju et al. (1999a & b); Bijukumar (2011) have been illustrated various aspects of freshwater fishes of Kerala at different temporal periods. The present study investigates the distribution, diversity and conservation status of freshwater fishes of Pambar river, one of the prominent eastward flowing rivers of Kerala.

2. MATERIALS AND METHODS

2.1. Study Area

Pambar river(10˚ 08' N 77˚ 7' E - 10˚ 21' N 77˚ 14'E) in Southern Western Ghats is one of the three eastward flowing rivers of Kerala. It originates in the Anaimudi Hills at an elevation of ~1950 m above MSL and it flows eastwardly through the Talaiyar valley until it merges with the river Chinnar at Koottar inside the Chinnar Wildlife Sanctuary after a course of ~32 km in Kerala. Later, it drains as the river Amaravathi in the State of Tamil Nadu and then finally empties into the river Cauvery, a major river system in the Indian subcontinent. The important tributaries of the river Pambar are Eravikulam Ár, Kanni Ár, Pullikkadu Odai and Nagimuth Odai, which are all having their origin from the State of Kerala. The region shows an average annual rainfall of 1800 mm, since the upstream and downstream regions of the river falls under the tropical humid and tropical semi-arid climatic zones respectively.

2.2. Sampling and Analysis

Bimonthly stratified random sampling has been carried out during May 2012 to July 2014 at 100 m reach of all the seven sampling stations viz., Koottar (10˚ 21' 08" N 77˚14' 12" E), Champakkadu (10˚19' 58" N 77˚13' 9" E), Thoovanam (10˚ 17' 14" N 77˚11' 18" E), Kovilkadavu (10˚ 15' 07" N 77˚ 10' 02" E), Anakkalpetty (10˚14' 45"N 77˚ 09' 24" E), Pallanadu (10˚14' 14" N 77˚ 08' 51" E) and Lakkom (10˚11' 17.15" N 77˚ 06' 50.95" E). A wide range of gears such as gill net, cast net, scoop net, specially crafted mosquito net and finely framed and fabricated electro-fishing unit were employed to minimize any sampling bias. Representatives of each species were photographed and preserved in 5% formaldehyde and then transferred to the laboratory for further studies. Taxonomic status of each species has been identified with classical literature of Talwar & Jhingram (1991), Jayaram (2010) and picturesque handbook of Shaji (2013). Conservation status of each species has been scrutinized with the data retrieved from the IUCN Red List of Threatened Species (2014). The species richness and their conservation status are represented statistically.

3. RESULTS

Twenty four species belonging to six families and seventeen genera were collected from seven sampling stations (Table 1). Cyprinidae is the most abundant family with fifteen species (62%) followed by Balitoridae (20%). Endangered species Garra hughi, Tor khudree and critically endangered Barbodes wynaadensis have been identified from this region. Of the total species enlisted, three are exotic viz., Oreochromis mossambica, Cyprinus carpio and Gambusia affinis and five (20%) are exclusively ornamentals (Fig. 1). Among the seven sampling stations, Chambakkadu shows significantly high species richness(S=21) followed by Koottar (S=18) and Thoovanam (S=17) (Fig. 2).

Table 1: Fish species composition, distribution & IUCN conservation status (2014) in Pambar river.

Sl. No.	Family/ Species	Micro-habitat distribution							Ornamental / Food fish	IUCN Status
		S1	S2	S3	S4	S5	S6	S7		
I.	Cyprinidae									
1.	Barbodes carnaticus (Jerdon,1849)	--	--	--	+	+	+	+	FF	LC
2.	Barbodes wynaadensis (Day,1873)	--	--	--	+	+	+	+	FF	CR
3.	Barilius bendelisis (Hamilton,1807)	--	--	--	+	+	+	+	FF/OR	LC
4.	Barilius gatensis (Valenciennes,1844)	--	--	+	+	+	+	+	FF/OR	LC
5.	Cyprinus carpio Linnaeus,1758	--	--	--	+	+	+	--	FF/EX	VU
6.	Devario malabaricus (Jerdon,1849)	--	+	+	+	+	+	+	FF/OR	LC
7.	Esomus danricus(Hamilton,1822)	--	--	--	--	--	+	+	FF/OR	LC
8.	Garra gotyla stenorhyncus (Jerdon,1849)	--	--	+	+	+	+	+	FF/OR	LC
9.	Garra hughi Silas,1955	--	--	--	--	+	+	+	FF/OR	EN

10.	Garra mullya (Sykes,1839)	--	--	+	+	+	+	+	FF/OR	LC
11.	Garra sp.	+	+	--	--	--	--	--	FF/OR	----
12.	Puntius fasciatus (Jerdon,1849)	--	+	+	+	+	+	+	FF/OR	LC
13.	Puntius punctatus (Day,1865)	--	--	+	+	+	+	--	FF/OR	LC
14.	Salmophasia acinaces (Valenciennes,1844)	--	--	--	--	--	+	+	FF	LC
15.	Tor khudree (Sykes,1839)	--	--	--	--	+	+	+	FF	EN
II.	Balitoridae									
16.	Bhavania australis (Jerdon,1849)	--	--	--	--	+	+	+	OR	LC
17.	Mesonoemacheilus triangularis (Day,1865)	--	--	+	+	+	+	+	OR	LC
18.	Mesonoemacheilus pambarensis Remadevi& Indra,1994	--	--	--	--	--	+	+	OR	VU
19.	Nemacheilus monilis Hora,1921	--	--	--	--	+	+	+	OR	LC
20.	Schistura semiarmatus (Day,1867)	--	--	--	--	+	+	+	OR	LC
III.	Channidae									
21.	Channa gachua (Hamilton,1822)	--	--	--	--	--	+	+	FF/OR	LC
IV.	Cichlidae									
22.	Oreochromis mossambicus (Peters,1852)	--	--	+	+	+	+	--	FF/EX	NT
V.	Poecilidae									
23.	Gambusia affinis (Baird,S.F&Girard,1853)	--	--	--	+	--	--	--	OR/EX	LC
VI.	Clariidae									
24.	Clarias dussumieri (Valenciennes,1840)	--	--	+	+	--	--	--	FF	NT

(S1- Lakkom; S2-Pallanad; S3-Anakkalpetty; S4-Kovilkadavu; S5-Thoovanam; S6-Chambakkadu; S7-Koottar)(LC-Least Concern; VU-Vulnerable; NT-Near Threatened; EN-Endangered; CR-Critically Endangered)(OR-Ornamental, FF-Food Fish, EX-Exotic)

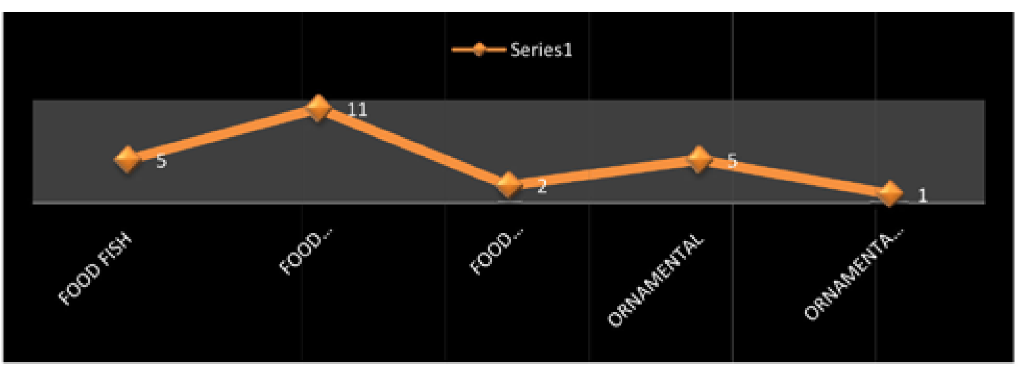

Fig. 1: Food fish/ornamental/exotic fishes in Pambar river

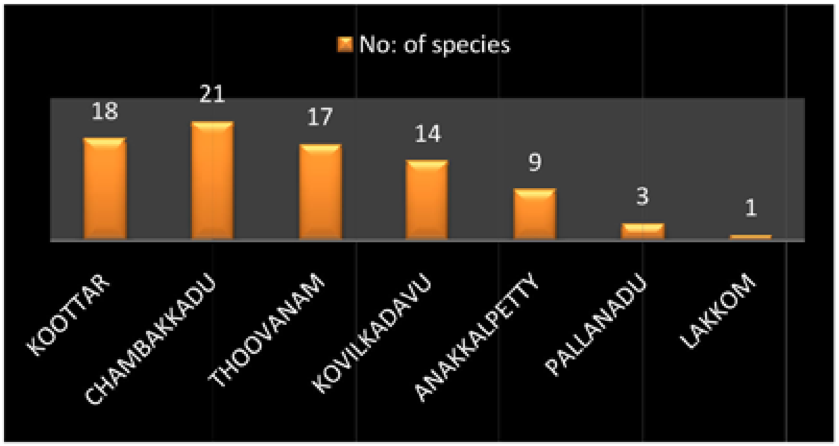

Fig. 2: Fish Species Richness In Different Sampling Stations of Pambar River

4. DISCUSSION AND CONCLUSION

The upper and lower reaches of Pambar River fall under tropical humid and tropical semi-arid climatic conditions respectively. As compared to the lower reaches, the upper regions viz., Lakkom and Pallanadu have suitable water temperature for cold-water fishes and hence the regions marked a very poor ichthyofaunal diversity.The upper and lower reaches of Lakkom is known for trout species. The introduction and development of aquaculture of trout in Munnar High Range,Kerala commenced in 1909 and by 1941 a trout farm was established in Eravikolam, followed by another one at Rajamallay (Sehgal, 1999). Species composition and the distribution pattern of ichthyofauna of Pambar river recharge the cumulative gene frequency of southern Western Ghats as incredible since it merely has a total drainage distance of ~32km in Kerala. Even though, there are limited comprehensive studies have been done so far, the ichthyofaunal investigations of Easa & Shaji (1996) in Pambar river enabled them to report Barilius bendelisis as a new record from Kerala and Garra menoni is the second report of the species from a different location. Mesonoemacheilus pambarensis Remadevi & Indra, 1994 and Tor remadevii Kurup & Radhakrishnan, 2010 were originally described from the Pambar river inside the Chinnar Wildlife Sanctuary.

Eleven species of the total (45%) are edible as well as ornamental while twenty five are exclusively ornamental in nature (Table. 1). Among the 106 ornamental species of Kerala, ten species including Puntius fasciatus (Melon barb) have already secured position in the national and international markets as ornamental fishes (Kurup et al., 2004). Twenty six percent of the total species have been slipped into the threatened category of IUCN Red List (2014) (Fig. 3). Barbodes wynaadensis (Day, 1873) was considered to be endemic to the streams in the Wayanad region of Kerala, until Manimekalan (1998) and subsequently, Yazdani et al. (2001) recorded the species from Mudumalai, Tamil Nadu and Arunachalam et al. (2005) recorded it from Abbey Falls near Madikeri, Kodagu, Karnataka (Ali et al., 2014). Distribution of critically endangered Barbodes wynaadensis (Day, 1873) in Pambar river is hopeful and at the same time it demands to frame out new management and conservation policies for their proper maintenance. While Tor khudree and Garra hughi belong to the endangered category of IUCN Red List (2014), they are restricted to limited locations as compared to the critically endangered Barbodes wynaadensis.

Presence of three exotic species viz.,Oreochromis mossambicus, Gambusia affinis and Cyprinus carpio raise apprehensions on the ichthyofaunal diversity of the region. Among them Oreochromis mossambicus registers a wide range of distribution. The Krishna river at Wai was severely affected by introduced alien fishes like Poecilia reticulate, Gambusia affinis and Oreochromis mossambicus (Raj et al., 2014). Distinct morphological and low energy conditions of the river at Anakkalpetty and upper reaches of check dam at Kovilkadavu favour the establishment of native catfish Clarias dussumieri. No any illegal fishing practice or overfishing has been noticed during the study period. People belong to the tribal community employ a good variety of gears ranging from traditional traps to cast net.Present investigation on species composition, distribution and current conservation status of freshwater fishes in Pambar river could be a baseline data to mould multi-facets action research in future including native gene pool assessment and conservation.

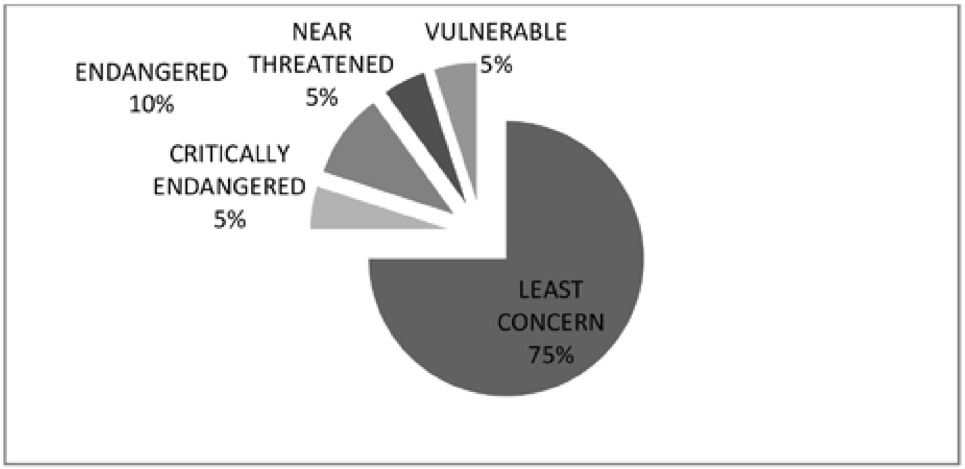

Fig. 3: conservation status of fish species occuring in pambar river

(Only twenty species are listed here. Three species are exotic to the country and identity of one species needs confirmation).

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WATER QUALITY STATUS OF VELLAYANI FRESHWATER LAKE, THIRUVANATHAPURAM, KERALA, AS INDICATED BY PHYTOPLANKTON INDICES

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ABSTRACT

Lakes are vital and vulnerable freshwater systems that are critical for the sustenance of all life. The declining quality of the water in these systems threatens their sustainability and is therefore a cause for concern. The phytoplankton in a reservoir is an important biological indicator of the water quality**.** The present attempt is to employ the use of algae as bio indicator to determine the quality of Vellayani Lake, which is the largest fresh water lake in Thiruvananthapuram district, Kerala. The sampling of the phytoplankton was done in all the months of 2013 at different sites of the lake. Shannon Weiner Diversity Index and Palmer's algal pollution index were calculated from the phytoplankton collected. A list of most pollution tolerant genera and species as suggested by Palmers index was prepared for all sampling stations. The number scored by each genera are totalled to get the value of algal genus index. In the present study a score above 20 for the Palmer Index and Diversity index value below 3 were observed and this confirms organic pollution in the lake.

Key words: Bio indicator, shannon weiner diversity index, palmer index, organic pollution

1. INTRODUCTION

Water is the most important resource for all kinds of life and is adversely affected qualitatively as well as quantitatively. Lakes are vital and vulnerable freshwater systems that are critical for the sustenance of all life. The declining quality of the water in these systems threatens their sustainability and is therefore a cause for concern. Rapid increase in urbanization, industrialization and agriculture development has resulted in the deterioration of the quality of water. The quality of water in any ecosystem provides significant information about the available resources for supporting life in that ecosystem.

These are waterways of strategic importance across the world, providing main water resources for domestic, industrial, and agricultural purposes (Faith, 2006). The maintenance of healthy aquatic ecosystem is depended on the physico-chemical properties and biological diversity. The algal flora constitutes a vital link in the food chain and its productivity depends on water quality at a given time (Meshram and Dhande, 2000). The phytoplankton in a reservoir is an important biological indicator of the water quality**.** Phytoplankton study provides a relevant and convenient point of focus for research on the mechanism of eutrophication and its adverse impact on an aquatic ecosystem. Bio indicators are taxa or groups of organisms that show signs that they are affected with environmental pressure because of human activities or the destruction of biotic system (McGeoch, 1998). Algae are one of the most rapid bio indicator of water quality changes due to their short life spans, quick response to pollutants and easy to determine their numbers (Plafkin *et al.,*1989). Early recognition of differences in the quantity and quality of plankton in lakes contributed to the origin of the trophic system of lake classification.

The occurrence and abundance of this phytoplankton varies seasonally and their study provides a relevant focus for research on eutrophication and its adverse impact on aquatic life. This also serves as a useful tool for the assessment of water quality and in understanding the basic nature of the lake.

2. MATERIALS AND METHOD

Vellayani Lake, or *Vellayani Kayal* as known in local language, is the largest fresh water lake in Thiruvananthapuram district of Kerala. Vellayani Lake lies between 8^0 24'09"-8^0 26'30" N Latitude and 76^0 59' 08"- 76^0 59'47" E Longitude. The lake is bordered by Thiruvallom and Nemom villages of Neyyatinkara Taluk. Major part of the lake is stagnant but a small portion flows to Karamana River. It is the main source of water supply to four nearby panchayats. Present attempt is to identify the phytoplanktons of the lake during the pre- monsoon and monsoon period of 2013.

Plankton Analysis

Water samples were collected from 8 sites of Vellayani Lake during the pre-monsoon, monsoon and post monsoon period of 2013. Plankton net (mesh size 25 µm) was swept on surface water and plankton collected were transferred into separate plastic bottle/containers. Surface water was sieved through plankton net to obtain planktons. Glycerine was used for mounting the material and observed under advanced Research microscope. The algal genera were identified referring various monographs (Anand, 1980 and Desikachary, 1998) and literature cited. These planktons were fixed and preserved in 4% formalin. The formalin fixed plankton samples were centrifuged at 1500-2000 rpm for 10-12 min. The phytoplankton settled at bottom were diluted to a desirable concentration in such a way that they could be easily counted individually under compound binocular microscope and phytoplankton were measured and multiplied with the dilution factors using Sedgwick Rafter cell (Welch, 1948; Smith, 1950; APHA, 2005). Shannon – Weiner Diversity index of the 5 classes of phytoplanktons was also calculated for the study period.

Palmer's algal genus index

Palmer (1969) prepared a list of 60 genera tolerant to organic pollution and also generated Algal Genus Index based on the algal data, for the rating of organic pollution of a water body.

3. RESULT AND DISCUSSION

Diversity of phytoplankton: Detailed microscopic examination of phytoplanktons revealed 5 families consisting of 42 genera of phytoplankton in the order: Chlorophyceae (13genera), Bacillariophyceae (17 genera), Cyanophyceae (7genera) and Euglenophyceae (4 genera) *Chrysophyceae* (1 genera).

Chlorophyceae - *Ankistrodesmus ,Cosmarium, Closterium, Coelastrum Pediastrum, Scenedesmus, Schroederia, Staurastrum, Staurodesmus, Tetraedron, Hydrodictyon, Spirogyra, Golenkinia. Tedrastrum*

Cyanophyceae - *Anabaena, Arthrospira, Cylindrospermum, Merismopedia, Oscillatoria,*

Synechococcus, *Microcystis*

Bacillariophyceae - *Aulacoseira, Pinnularia, Pleurosigma, Eunotia, Fragillaria, Gyrosigma Synedra, Cyclotella, Gomphonema, Melosira*, *Nitzschia, Cymbella, Rhizosolenia, Navicula, Surirella, Tabellaria*

Euglenophyceae- *Euglena, Phacus, Trachelomonas, Lepocinclis*

Chrysophyceae - *Chrysococcus*

The Diversity index of the 5 classes of phytoplanktons was computed using Shannon – Weiner diversity Index formula:

Shannon's Index $H' = -\sum p_i \ln p_i$

Where p_i = the proportion of individuals of species i.

Chlorophyceae showed a diversity index of 2.71, Bacillariophyceae 2.82, Cyanophyceae, Euglenophyceae and Chrysophyceae with an index value of 1.7, 1.9, and 1.07 respectively.

Palmer's algal genus index was calculated by totalling the score given for each phytoplankton index in the pollution indicator list prepared by Palmer (1969). (Table-1)

Table – 1 Pollution index of algal genera. (Palmer, 1969)

GENERA	POLLUTION INDEX	ABUNDANCE OF PHYTOPLANKTON IN THE SAMPLE
Anacystis	1	
Ankistrodesmus	2	+
Chlamydomonas	4	
Chlorella	3	
Closterium	1	++
Cyclotella	1	
Euglena	5	+
Gomphonema	1	
Lepocinclis	1	
Melosira	1	++
Micractinium	1	
Navicula	3	++
Nitzschia	3	++
Oscillatoria	4	
Pandorina	1	
Phacus	2	++
Phormidium	1	
Scenedesmus	4	++
Stigeoclonium	2	
Synedra	2	++

(++ indicates abundance of a phytoplankton genera in the lake)

As per the list, abundance of *Synedra, Phacus, Ankistrodesmus, Melosira, Euglena, Navicula, Nitzschia, Scenedesmus, Closterium* was observed in the sample collected from the lake during the study period. The score assigned for each genera were counted and the Index Value obtained was 23, which indicates organic pollution in the lake.

4. CONCLUSION

In the present study a score above 20 for the Palmer Index and Diversity index value below 3 were observed and this confirms organic pollution in the lake. Although several ecological studies have been performed in the Vellayani Lake, it is under constant threat of urbanization and anthropogenic influences. The lake is under the threat of pollution, encroachment and sand mining. Hence a continuous monitoring of the water quality status is essential in order to create awareness about the value and relevance of aquatic bodies.

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PLANT DIVERSITY OF MANGROVES IN ESTUARINE ECOSYSTEM OF UTTARA-KANNADA DISTRICT WITH SPECIAL REFERENCE TO KALI RIVER FROM KAIGA TO KARWAR

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ABSTRACT

India has 67,429 wetlands covering an area of 4.1 million hectare. Mangroves are salt tolerant forest ecosystem of tropical and subtropical intertidal regions near river mouths with high productivity. Karwar is a coastal district of Karnataka state situated in the Western Ghats of Sahyadri, Western coast of India. River Kali or Karihole is a major river of the northern Karnataka at lat.14 48'N and Long.74 07'E. Documentation, conservation and management of estuarine ecosystem have become an international priority because of its ecological, economical and social significance. Total 163 species of plants belonging to 101 genera and 40 families have been recorded of the 15 species of eumangroves reported from Karnataka; as many as 13 species were found growing here. Mangrove genera have been recorded from different biotopes of this Kali estuarine environment. The survey was carried out for a period of two years from November 2008 to October 2010. Monthly census of flora was done in order to know their seasonal flowering and fruiting occurrence. Mangrove ecosystem supports high secondary productivity to improve the fertility of the region. Mangrove forest and estuaries are the breeding and nursery ground for a number of marine organisms including the commercially important shrimp, crab and fish species. Decomposition of the litter contributes to the production of Dissolved Organic Matter (DOM), the recycling of nutrients both in the mangroves and in adjacent habitats ultimately support fishery resources. Hence loss of mangroves not only affects society indirectly, there are also direct economic repercussions through loss to the entire fishing industry. My paper concludes that the above area is juxtaposed with highly diverse plants, animals, birds, insects, amphibians, reptiles and many other microbial forms. Role of mangrove at Kaiga-Karwar is better represented as food webs or networks. This more complex reality has instead become the preferred representation to depict the transfer of food and hence energy through ecosystem. Food webs are drawn by representing plant/animals as nodes and the interactions between them as the lines that link them. As any other ecosystem, the mangrove ecosystem interactions are uni-directional, indicating who eats who and can also have weights, indicating the amount of energy transferred between groups. This representation includes a lot more of the detail and complexity of real ecosystem in and around Kaiga and has a theoretical framework within which it can be viewed and analysed through theory, which indicates a reversal of energy transfer.

The suggestion was that if a network has multiple redundant pathways for energy flow then it should be harder to disrupt. The allure of this idea is evident; it suggests that simple consideration of the eating habits of different organisms might be enough to explain the complexity of real ecosystems. The idea supports the preservationist bent ecologists understandably tend to have by suggesting that maintaining species richness and ecosystem complexity is key to stabilising ecosystems. It was also concluded that ecosystem would absorb some amount of species loss without collapsing… Time to think? That is the reassurance from mangrove ecosystem of Kaiga-Karwar.

Key words: Anthropogenic, Coastal, Conservation, Endangered, Sustainable Development

1. INTRODUCTION

India is blessed with enormous water resources in the form of numerous rivers, streams, wetlands, lakes etc. By virtue of its geographical position and varied terrain and climatic zones, it supports a rich diversity of inland and coastal wetlands. India has 67,429 wetlands covering an area of 4.1 million hectare. Mangroves are salt tolerant forest ecosystem of tropical and subtropical intertidal regions near river mouths with high productivity. Coastal Karnataka is the central part of the Malabar Coast which extends to Dakshina Kannada, Udupi and Uttarakannada. Mangrove formation is a tropical phenomenon mostly confined to tropical coastal areas, sometimes extending to subtropics. Van

Rheede in the year 1943 reported for the first time about the mangrove plants in the Malabar Coast.

The total coastal line in Karnataka is approximately 320 km which presents varied geomorphologic features in the form of long beaches, some time intercepted by rocks forming attractive beaches. Sometimes coastal land is dissected by the rivers joining sea with the formation of shallow lagoons or estuaries. We can also see the elevated sandy ridges which are called sand dunes with an height of about 8-10m. Sharavathi, Aghanashini, Gangavali and Kali are the major rivers of Uttarakannada districts joining the sea. Karwar is a coastal district of Karnataka state situated in the Western Ghats of Sahyadry , Western coast of India. River Kali or Karihole is a major river of the northern Karnataka at lat.14 48'N and Long.74 07'E. Documentation, conservation and management of estuarine ecosystem has become an international priority because of its ecological, economical and social significance. Kali estuary extending from Kodibag(S) and Devbag (N) at the river mouth up to Kunnipet Kaiga Township(S) and Kardra (N), stretching to a distance of about 35kms. Another small river called Mavinahalla also joins this estuary, converting it into an estuarine complex. So far, 163 species of plants belonging to 101 genera and 40 families have been recorded (table 1) of the 15 species of eumangroves reported from Karnataka, as many as 13 species were found growing here. Mangrove genera have been recorded from different biotopes of this Kali estuarine environment. This includes the major mangrove genera such as Avicennia (3 species), Bruguiera (2species), Rhizophora (2 species), Sonneratia (2 species) and one species each of Aegiceras, Excoecaria, Lumnitzera and Kandelia. Among these Sonneratia alba, Rhizophora apiculata and Avicennia officeinalis are the most dominant species. All details of plants found in Beaches and Mangroves of Karwar- Kaiga are provided. They belong to the family

1, Rhizophoraceae (Rhizophora apiculata, R.mucronata, Bruguiera, gymnorrhiza, B.cylindrica, Kandeliacandel)

2, Avicenniaceae (Avicennia officinalis, A.alba, A.marina)

3, Sonneratiaceae (Sonneratia caseolaris, S.alba)

4, Combretaceae (Lumnitzera, racemosa)

5, Euphorbiaceae (Excoecaria agallocha)

6, Myrsinaceae (Aegiceras corniculatum)

7, Acanthaceae (Acanthus ilicifolius)

8, Pteridaceae (Acrostichum aureum)

9, Fabaceae (Caesalpinia crista, C.bonduc, Dalbergia spinosa, Derris trifoliata, D.scandens, Acanthospermum, Acanthospermum hispidum L., Achyranthes corymbosa L., Achyranthes aspera, Acrocephalus indicus, Aerva lanata,

Aeschynomeme indica, Ageratum conyzoides, Alternanthera sessilis, Alysicarpus vanginalis, Amaranthus spinosus, Ammannia baccifera, Anacardium occidentale, Bacopa monnieri, Blumea lacera, Blumea oxyodonta, Blumea virens, Boerhavia diffusa, Borassus flabellifer, Borreria articularis, Borreria pusilla, Brachiaria ramose, Bulbostylis barbata, Calophyllum inophyllum, Calotropis gigantea, Canavalia rosea, Cardiospermum halicacabum, Cassia tora, Cassytha filiformis, Casuarina equisetifolia, Cerbera odollam Gaertner, Ceriops decandra, Chromolaena odorata, Cleome viscosa, Cocos nucifera, Coldenia Procumbens, Corchorus aestuans, Crotalaria nana, Crotalaria retusa, Crotalaria striata, Crotalaria verrucosa, Croton bonplandianum, Cyanotis cristata, Cynodon dactylon, Cynosurus aegyptius, Cyperus arenarius, Cyperus compressus, Cyperus malaccensis, Cyperus rotundus, Cyperus stoloniferus, Dactyloctenium aegyptium, Datura metel, Dentella repens, Derris scandens, Desmodium triflorum, Digitaria bicornis, Digitaria longiflora,Echinochloa frumentacea, Eclipta alba, Emilia sonchifolia, Epaltes divaricata, Eragrostis riparia, Eragrostis tenella, Eragrostis tremula, Eragrostis unioloides, Erythrina variegata, Euphorbia articulate, Euphorbia hirta, Evolvulus alsinoides, Fimbristylis argentea, Fimbristylis cymosa, Fimbristylis ferruginea, Fimbristylis polytrichoides, Geissapis cristata, Glinus oppositifolius, Grangea maderaspatana, Hedyotis corymbosa, Hedyotis herbacea, Hedysarum bupleurifolius, Heliotropium indicum, Hybanthus suffruticosum, Hydrophylax maritima, Hygrophila auriculata, Hyptis suaveolens, Ipomoea maxima, Ipomoea pes caprae, Ischaemum aristatum, Ischaemum indicum, Ischaemum semisagitatum, Justicia prostate, Justicia simplex, Launaea sarmentosa, Leea indica, Lindernia antipoda, Lindernia ciliata, Lindernia crustacea, Ludwigia hyssopifolia, Mariscus pedunculatus, Mariscus squarrosus, Merremia tridentata, Murdannia nudiflora, Ocimum tenuiflorum, Opuntia dillenii, Pandanus tectorius, Panicum repens, Paspalum vaginatum, Perotis indica, Phyla nodiflora, Phyllanthus amarus Schumann, Physalis minima, Polycarpaea corymbosa, Poreteresia corymosa, Portulaca oleracea, Premna latifolia, Pycreus polystachyos, Rungia pectinata, Salvadora persica, Sarcostemma acidum, Scaevola plumieri, Scaevola taccada, Scoparia dulcis, Sesamum orientale, Sesuvium portulacastrum, Sida acuta, Sida cordata, Solanum nigrum, Solanum surattense, Spermacoce pusilla wallich, Sphaeranthus indicus, Spinifex littoreus, Sporobolus virginicus, Stachytarpheta jamaicensis, Tephrosia hamiltonii, Thespesia populnea, Tridax procumbens, Triumfetta rhomboidea, Urginea indica, Vernonia cinera, Vitex trifolia, Waltheria indica, Wedelia biflora, Ziziphus mauritiana, Zornia gibbosa spanoghe, Zoysia matrella.

Estuarine environment provides a functional role of those different benthic faunal components as a part of their bioturbatory activities and as an integral component of litter decomposition vis – a vis biogeochemical cycles in this estuarine ecosystem functioning. Maximum biogenic alteration of the sediments by virtue of burrowing, feeding, defecation, tube like shelter building etc leading to modification of physical, chemical , biological properties of sediments, have been made by Brachyuran crabs, followed by polychaetes, molluscs, brachiopods and cnidaria. However, the functional role of different micro arthropods in the decomposition of mangrove plants litter have been found to be maximum than other macrobenthic faunal components. Besides, survival strategies based on different behavioural manifestation of all such benthic fauna have been found to import profound effects on sediment-water-faunal-floral linkages and helped maintaining the ecological health of estuarine ecosystem.

Majority of the mangrove forest of Karnataka have declined due to anthropogenic pressures in the recent years. During the last 25 years some reduction in Mangrove cover of Karnataka has been due to human interference and development activities. Some of the major problems faced by the shore front areas of Karnataka coast are related to coastal erosion, siltation, pollution, destruction of mangrove swamps, salt marshes, sea level rise, landslides and slope failure, pressure of population, Industrialization, road transport etc. The objective of this paper is to study plant diversity of mangroves along coast of Karwar district for conservation of estuarine ecosystem and mangroves for sustainable development. Different estuaries of Karwar were visited frequently for study. Plants were identified with the help of standard literature and floras. The studies reveal that, estuarine ecosystem of Kali River shows biodiversity of Mangroves with 163 species of plants belonging to 101 genera, and 40 families have been recorded. Sonneratia , Avicinnea are the more common genus. This estuarine complex formed by rivers Kali and Mavinahalla (Uttarakannada District of Karnataka) along the West Coast, supports mangrove vegetation along its shores and mud flats. Floristic studies have revealed that the isolated and remnant patches of mangrove forest of this area are rich in species diversity of both eu-mangrove and mangrove associate plants.

1.1. Climate

The climate in the coastal region is characterized by high humidity nearly all the year round. The summer from March to May, the monsoon season from June to September, the post –monsoon season from October to November and low temperature season from December to February. The average rainfall in Karwar is 3,680mm. More efforts should be made by the government, concerned authorities, policy makers etc., to conserve estuarine ecosystem and biodiversity of mangroves by different methods such as education and awareness programmes to local people about ecological values of mangroves for sustainable development.

2. MATERIALS AND METHODS

The survey was carried out for a period of two year from November 2008 to October 2010. Monthly census of flora was done in order to know their seasonal flowering and fruiting occurrence. The population of flora was estimated from 6.00 am to 8.00 am by direct counting method. Documentation/Checklist was done by using boat, Raft for the island on the either side of the Kali river (Fig 1) and rest of the area by road, around 9 small island were visited during the period and flora were recorded within a transect of 20m in various sites.

2.1. Study Area

Kali River (figure1) originates at Diggi, near Ambikanagar in Joida taluk. It flows in south - western direction and receive many halla or hole on its journey before it discharges in to Arabian Sea at Karwar in Uttarakannada district. Most of the areas are Evergreen to Semi- Evergreen forests are confined to the western part of the basin. Many of the hills are covered with heavy forests while ravines and valleys produce luxuriant trees known for their great height and size. Arecanut, also called betel nut is a widely used article of consumption and is grown in valleys. The study area encompasses extending from left bank of the river Kunnipet Kaiga township(S) and right bank of the river Kardra(N), stretching to a distance of about 35kms Kodibag(S) and at the river mouth up to Devbag(N). following are the villages/places where checklist done, Kunnipet, Mallapur, irpage, Bolve, Kerwadi, Katar, Kadiye, Devalmakki, Bargal, Wylwada, Kharge and Kharge jug, Halga jug, Siddar, Umli jug, Kinner, Shirvad, Makheri, Kadwad, Sunkeri, Nandangadda, Kodibag, Nadibag all are on the left bank of the river and on the right side of the river is Kadra, Satar sare, Bore, Gotegali, Wayl balni, Sakal balni, Byre, Hapkarni, Hoti, Shingudda, Ambrayi, Barge, Ulga, Katne, Bhouvri, Madewada, Halga, Pile wada, Basung, Agali, Halge jug, Gopshitta, Bolshitta, Hankon, Amle, Hotegali, Asnoti, Kolge, Dhol, Sadashivgad, Devbag.

Fig 1: Kali River

2.2. Habitat and Productivity

The coastal areas with diversified habitats within a radius of 5 km are characterized by estuarine systems, mangroves, rocky, sandy, tidal flats and coral reef patches. The occurrence of such different habitats within narrow region probably brings about higher degree of interactions among the different habitats and supports high species diversity. Mangrove ecosystem supports high secondary productivity to improve the fertility of the region.

Mangrove forest and estuaries are the breeding and nursery ground for a number of marine organisms including the commercially important shrimp, crab and fish species. Decomposition of the litter contributes to the production of Dissolved Organic Matter (DOM), the recycling of nutrients both in the mangroves and in adjacent habitats and ultimately supports fishery resources. Hence loss of mangroves not only affects society indirectly, there are also direct economic repercussions through loss to the entire fishing industry.

In many coastal areas, mangroves are substitute for fodder. Thus mangroves reduce pressure on scarce pastureland. Till recently mangroves were the main source of tannin for the leather industry and are still exploited in many areas in India for this purpose. Mangrove wood has a high caloric value and burns very well. This character has become a curse; in many areas both rural and urban communities are heavily dependent on mangrove wood for fuel. Honey collection from mangrove area is exclusively practiced in Bengal and Orissa. The finest honey is collected from mangroves which fetches a good price. Pioneering investigation are now showing the mangrove and their associated fauna can be source of valuable products like black tea, mosquito ides, Gallo tannins, microbial fertilizers, antiviral drugs, anti tumor drugs and UV-screening compounds(Ravi & Kathiressan , 1999; Premanthan et al., 1992)

3. CONCLUSION

It is believed that if the mangrove communities along the banks of estuaries and coastlines were disturbed or destroyed, there would be no habitat or food to support the organisms in the areas. Furthermore, the loss of these mangrove-related ecosystems would disturb natural ecological systems over a considerable area and result in large-scale economic loss and socio-cultural change in coastal communities (Aksornkoe, 1991). There is a belief that the increasing floods in Bangladesh are due to the loss of mangroves in the past few decades and there is not much disagreement regarding this view in the scientific community. More efforts should be made by the government, concerned authorities, policy makers etc to conserve estuarine ecosystem and biodiversity of mangroves by different methods such as education and awareness programmes to local people about ecological values of mangroves for sustainable development.

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Photo : Puttaraju, K


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DISTRIBUTION AND DIVERSITY OF CRABS FROM PULICAT LAGOON

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ABSTRACT

We carried out a detected study on the fauna of Pulicat lagoon 2013 onwards to update the list of available brachyuran crabs reported from the coastal lagoon Pulicat. Our observations clearly showed that the lagoon of Pulicat support in terms of diversity, abundance and distributions of organisms on a large scale. During our survey a total 32 species of crabs were recorded. The well known family such as Portunidae, Grapsidae, Ocypodae, and Matutidae contributed more number of individual species. The Portunidae family is commercially important inturn included viz. Scylla serrata, Portunus sanguinolentus, Portunus pelagicus, Charybdis natator, Podophthalmus sp. and Charybdis truncata. Earlier studies revealed that the faunal diversity studies need updated data atleast biannually. It helps to create awareness towards coastal lagoons conservation along with formulation of Policies. The exclusive intertidal groups namely the brachyuran crabs are very important by way of their dominance among other fauna, biomass strength above all posses rich sources of nutrients in due course of time may compensate to same extent the demand for fish meal. Few of them are known as medicinally valuable edible food resource for mankind.

Key words: Pulicat lagoon, brachyura, crab diversity

1. INTRODUCTION

Marine crabs are distributed globally in different depths and different habitat in the marine environment. They are found with higher diversity in reef environments and are also widespread on shallow shores and intertidal regions. It is economically important and has high proteins and minerals. The skeletons are used as food for livestock's and poultries. Crabs are one of the ecologically important faunal communities in the marine ecosystem since they play significant roles in detritus formation, recycling of nutrients and overall dynamics of ecosystems.

Brachyura harbors rich diversity and total 5000 species belonging to 700 genera have been identified worldwide (Shukla et al., 2013). In India, 28 families, 270 genera and 700 crab species, reported (Venkattaraman and Warfar, 2005). Kathirvel (2008) reported 26 families, 152 genera 404 species in Tamilnadu. Chennai coast has witnessed an annual crab landings were over 1500 t (Thangaraj Subramanian, 1998).

The pulicat lagoon extending between 13° 20' and 13° 40' N lat. and 80° 14' to 80° 15' E log. formed out of back water of the Bay of Bengal. It is the second largest brackish water lagoon having an area of approximately 600 km. About 46,000 ha (84%) of it is in Andhra pradesh, the remaining 6,000 ha (16%) lies in Tamil nadu. Salinity of the lake varies from 25 to 45 ppt which is greatly influenced by monsoonal rains, even slight precipitation causes a perceptible lowering of salinity. The lake is fed by two rivers which enter from the North- West, the Kalangi being more important. The sea mouths regions followed Kunankupam, Light house kuppam, Koraikuppam, Sattankuppam, Jamilabad and Kulathumedu. In the present study describes the distribution and diversity of crabs from Pulicat lagoon in Tamil Nadu.

2. MATERIALS AND METHODS

The present study is based on surveys conducted during the regular bimonthly sampling periods. Six sampling stations were selected along a spatial grid of the Pulicat lagoon covering a distance of about five kilometers. The sampling station is about one kilometer apart from each other.

1.1. Sample collection

Crabs were collected from August 2013 to October 2014; photos were taken by the Sony digital camera and preserved in 5% formalin. The genus and species level identification were done using the taxonomic keys (Chhapgar, 1975).

1.1. Study area

Station 1: (Kunankupam):
Location: 13°25'29"N,80°19'27"E
Station 2: (Light house kuppam): Location: 13 °25'07"N,80 °19'03E
Station 3: (Koraikuppam): Location: 13°24'08N,80°19'40E
Station 4: (Sattankuppam): Location: 13 °25'00N,80 °19'07E
Station 5:(Jamilabad):
Location:13°25'39''(13.427527) N,80°18'26(80.3073)
Station 6: (Kulathumedu): Location :13°25' 31N,80 °19'32E

3. RESULT AND DISCUSSION

The results of crab species distribution in different stations in Pulicat lagoon are given in the Table1. The crabs population were observed in all the six stations, Station 1 (Kunankupam), 7 species of family Potrunidae, 6 species of Ocypodidae., 3 species of Matutidae., 2 sp of Sesarmidae. Whereas families like Parthinopidae, Grapsidae, Epialtidae and Eriphiidae were represented by single species.

A total number of 18 species were recorded in Station 2 (Light house kuppam) 7 species belongs to Portunidae, 4 species of family Ocypodidae. Other families like Parthinopidae, Grapsidae, Epialtidae and Eriphiidae were reported by single species.

In this station 3 (Koraikuppam) a total numbers of 16 species were present 6 species belongs to Ocypodidae, 6 species belongs to Portunidae, 2 species of Sesarmidae and 2 sp of Matutidae. The results of station 4 (Sattankuppam) showed total of 9 species were observed. Ocypodidae 6 species belongs 2 sp belongs Portunidae., 1 species of family Sesarmidae.

In station 5 (Jamilabad) totally 12 species were observed 5 sp of family Ocypodae, 4 sp of Portunidae., 1 sp of family Parthinopidae. Station 6 (Kulathumedu) showed a total number of 17 species among them 7 sp belongs to the family Ocypodae; Portunidae, Sesarmidae, Matutidae, Epialtidae, Grapsidae, Eriphiidae 1sp.,

Crabs of the world 6,793 species belongs to 1,271 genera belongs to 93 families, and prepared by (Ng et al., 2008). Bertini et al. (2004) recorded 79 brachyuran species representing 9 super families (20 Majoidea, 7 Parthenopoidea) and 41 genera in bottom on the northern coast of Sao Paulo state in Brazil. In Taiwan waters 548 species belonging to 36 families including twenty new records reported by (Ng et al., 2001). Sakthivel and Fernando, (2012) reported have been the 7 families, 15 genera and 34 species and in Mudasal Odai and 7 families 15 genera and 31 species in Nagapattinam coast.

In west coast 226 species reported, east coast 461 species, Bay Islands 520 species (Dev Roy, 2013); Andaman and Nicobar Islands 220 species (Tikader et al., 1986) after that 837 species reported from Andaman and Nicobar Islands by Ajmal Khan (Ajmal Khan et al., 2002). In Pulicat lagoon more number of specie showed that this ecosystem offer good habitat for crabs.

Table 1: Brachyuran crabs diversity of Pulicat lagoon

S.No	Name of the family	Name of the species	S1	S2	S3	S4	S5	S6
1	Ocypodidae	1. Uca mjoebergi	+	+	+		+	
		2. Uca annulipes (Female)		+	+	+	+	+
		3. Uca crassipes	+		+	+	+	
		4. Uca acuta		+	+	+		+
		5. Uca annulipes (male)	+	+	+	+	+	+
		6. Uca splendid	+		+	+	+	+
		7. Uca triangularis						+
		8. Uca para dussumieri	+					+
		9. Ocypode ceratopthalma	+			+		+
2	Portunidae	10. Charybdis acutifrons	+	+	+		+	
		11. Portunus sanguinolentus	+	+	+	+		
		12. Podophthalmus vigil	+	+	+		+	
		13. Portunus pelagicus	+	+	+			
		14. Scylla serrata	+	+			+	
		15. Charybdis feriata	+	+	+	+		+
		16. Charybdis Natator	+	+	+		+	
3	Parthinopidae	17. Parthenope echinatus	+	+			+	
4.	Sesarmidae	18. sesarma reticulatum			+			
		19. Sesarma chiromantes bidens			+	+		+
5	Grapsidae	20. Grapsus albolineatus	+	+				+
6	Matutidae	21. Matuta victor	+					
		22. Matuta planipes	+		+			
		23. Ashtoret lunaris	+		+			+
7	Epialtidae	24. Libinia emarginata	+	+				+
8	Eriphiidae	25. Eriphia verrucosa	+	+				+
		Total	18	15	16	9	10	13

Fig. 2: Crabs in the Pulicat lagoon; a. Uca mjoebergi , b. Uca annulips, c. Uca crassipes, d. Uca acuta, e. Uca annulipes, f. Uca splendid, g. Uca triangularis, h. Uca paradussumieri, i. Charybdis acutifrons, j. Portunus sanguinolentus, k. Podophthalmus vigil , l. Charybdis feriata, m. Portunus pelagicus, n. Scylla serrata, o. Ashtoret lunaris, p. Parthenope echinatus, q. Sesarma chiromantes bidens, r. Charybdis natator, s. Grapsus albolineatus t. sesarma reticulatum, u. Libinia emarginata, v. Ocypode ceratopthalma, w. Eriphia verrucosa, x. Matuta planipes, y. Matuta victor.

4. CONCLUSION

From the present study it was observed that 25 species belong to 8 families of brachyuran fauna in Pulicat lagoon. These studies revealed the marine crab diversity in brackish water shores and muddy region environment of Pulicat lagoon in Tamil nadu. The study opens up the future research strategies on marine crab's diversity, distribution and species luxury of this region.

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THE IUCN RED LIST OF THREATENED SPECIES: AN ASSESSMENT OF CORAL REEF FISHES IN GULF OF MANNAR, SOUTHEAST COAST OF INDIA.

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ABSTRACT

The IUCN Red List is set upon precise criteria to evaluate the extinction risk of thousands of species and sub species. Although coral reef fishes enjoy a great deal of interest around the world, little is known about the conservation status of most of them. Currently, only a small number of coral reef fishes are listed on the IUCN Redlist of Threatened species, but the number that are threatened is believed to be much higher.The reefs of Gulf of Mannar is one of the major coral formations along the mainland coast of India. Studies on Gulf of Mannar reef fishes revealed the presence of thirty species with IUCN status. Most of them included were having 'least concern' status and two of them included in 'near threatened' and two in Data deficient category. The dominant families were Chaetodontidae, Labridae and Serranidae. Most of the species recorded were from the Order Perciformes (93%). To aid in assessing the extinction risk facing coral reef fishes, large scale census of the abundance and distribution of individual species are critically important.

Key words: IUCN, Gulf of Mannar, least concern, near threatened, data deficient.

1. INTRODUCTION

The IUCN Red list is recognized as the most comprehensive source of information on the global conservation status of plant and animal species and can be used as a tool for measuring and monitoring changes in the status of biodiversity and our knowledge of the taxa. Redlists are widely accepted tools available to conservationists worldwide for focusing the attention on species of conservation concern. The IUCN Groupers and Wrasses specialist Group (GWSG) was formed in 1998 in response to concern that a large number of reef fishes in the grouper and wrasse families are particularly vulnerable to fishing. Today reef fishes form an integral part of the reef communities, modifying benthic community structure and forming a major conduit for the movement of energy and material (Wainwright and Bellwood, 2002). Although coral reef fishes enjoy a great deal of interest around the world, little is known about the conservation status of most of them. Currently , only a small number of coral reef fishes are listed on the IUCN Redlist of threatened species, but the number that are threatened is believed to be much higher (Zgliczynski, 2013). Gulf of Mannar is a home to many species of reef fishes and very specifically to the ones that catch the attention of marine ornamental fish traders. So an assessment of coral reef fishes in Gulf of Mannar is utmost important regarding the conservation aspect.

2. MATERIALS AND METHODS

Species included in the study were selected from different sites of Gulf of Mannar namely Tuticorin (N-08^{0}47'37.5" latitude and E-078^{0}09'37.0" longitude),Vembar (N-09^{0}04'28.5" latitude and E-078^{0}21'58.5" longitude), Keelakarai (N-09^{0}13'34.8" latitude E-078^{0}47'14.6" longitude), Mandapam (N-09^{0}16'30.7" latitude and E-079^{0}09'04.3" longitude) and Rameswaram (N-09^{0}17'39.6" latitude and E-079^{0}19'42.0" longitude) during the period of 2012-2013.

3. RESULTS AND DISCUSSION

List of fish species included on the 2014 IUCN Red list observed in Gulf of Mannar during 2012-2013 is given in Table 1.

Thirty species representing 11 families of fishes included on the IUCN list were found during surveys. Of the species found, 26 species (86%) are categorized by the IUCN as least concern, 2 as near threatened and 2 as Data Deficient. Epinephelus malabaricus and Epinephelus merra are the two species (both from Serranidae) observed during the study that are listed as near threatened. Two of the listed species (Epinephelus undulosus and Torquigener brevipinnis) are included in the data deficient

Table 1: List of fish species included on the 2014 IUCN Red list observed in Gulf of Mannar during 2012-2013

Family	Species	Ecological information[a]			IUCN status[b]
		Max.Length(TL cm)	Depth Range(m)	Habitat[c]	
Acanthuridae	Acanthurus nigricauda	40	1-30	B,R.A	LC
	Acanthurus xanthopterus	70	1-100	R.A	LC
	Naso brevirostris	60	2-122	R.A	LC
Balistidae	Sufflamen fraenatuS	38	8-186	R.A,O	LC
Carangidae	Alectis ciliaris	150	60-100	R.A	LC
Chaetodontidae	Chaetodon auriga	23	1-40	R.A	LC
	Chaetodon collare	18	1-20	R.A	LC
	Chaetodon decussatus	20	1-30	R.A	LC
	Chaetodon octofasciatus	12	3-20	R.A	LC
	Chaetodon gardineri	17	2-91	R.A	LC
	Chaetodon vagabundus	23	5-30	R.A	LC
	Heniochus acuminatus	25	2-75	R.A,RA	LC
Labridae	Bodianus neili	20	5-18	R.A	LC
	Halichoeres nigrescens	14	3-10	R.A	LC
	Hemigymnus fasciatus	30	1-25	R.A	LC
	Stethojulis albovittata	14	2-15	RA,NM	LC
	Thalassoma lunare	45	1-20	R.A	LC
Lutjanidae	Lutjanus decussatus	35	2-35	R.A	LC
Pomacanthidae	Apolemichthys xanthurus	15	5-25	R.A,NM	LC
	Pomacanthus semicirculatus	36	20-350	D,C	LC
Scatophagidae	Scatophagus argus	38	0-5	RA,A	LC
Serranidae	Cephalopholis argus	60	1-40	RA,NM	LC
	Cephalopholis sonnerati	57	10-150	RA,NM	LC
	Epinephelus diacanthus	55	10-300	D	NT
	Epinephelus malabaricus	234	0-150	RA,A	NT
	Epinephelus merra	32	0-50	RA	LC
	Epinephelus undulosus	120	24-90	RA	DD
Tetraodontidae	Torquigener brevipinnis	10	20-100	D	DD
Theraponidae	Terapon theraps	36	20-350	D,C	LC

[a] Fish Base served as the source for ecological information
[b] IUCN assessment information is based on the 2014 IUCN Red List of Threatened Species; NT -near threatened, DD -data deficient, LC- least concern
[c] A-Amphidromous , B-Brackish water, C-Catadromous, ,D-Demersal, NM-Non Migratory, O-Oceanodromous ,RA-Reef Associated

category. Chaetodontidae, Groupers (Serranidae) and Labridae accounted for more than 63% (19 species) of the IUCN listed species encountered during the survey. Chaetodontids have been suggested as 'indicator organisms' of coral reef conditions, as the significant changes to their population levels and/or behavioural traits may be an indication of changing or stressful conditions on coral reefs (Reese, 1981; Crosby and Reese, 1996). The result of the present study showed a significant dominance of Chaetodontids in the threatened category, from which we can infer a future decline in the population of chaetodontids in the study area. Hence it is an indication of stressful condition in that coral reef area.

4. CONCLUSION

Coral reefs threatened by a host of human activities. Overexploitation is generally considered as the primary threat facing coral reef fishes (Friedlander and De martini, 2002 ; Reynolds et al., 2002,2005; Dulvy et al., 2003; De Martini et al., 2008).Widely distributed species are thought to face extinction compared to species with restricted ranges (Hawkins et al., 2000). If illegal ornamental reef fishery is left unchecked for a few more years the result would be disastrous. A better understanding of these processes will led to enhanced ability to assess the status of coral reef fishes to set priorities for conservation action.

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NEXT GENERATION SEQUENCING AN APPROACH FOR BIODIVERSITY CHARACTERIZATION

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ABSTRACT

Biodiversity is the diversity of genes, species and ecosystems, or the variety of every living organism and can be defined at many different levels, from allelic diversity and heterozygosity to the variation of population distribution in a region (Lovejoy, 1997) Biological diversity often poses a major challenge for ecologists who seek to understand ecological processes or conduct bio monitoring programs. Environmental samples commonly contain a high taxonomic diversity of small sized organisms (e.g., meiofauna in marine benthic sediments, with numerous specimens lacking diagnostic morphological characters (i.e. larval stages in plankton tows) or partially digested organisms in gut or faecal contents, making it difficult to identify species within a reasonable timeframe and with sufficient accuracy. DNA-based community analyses have offered some alternatives to traditional methods and have become even more promising with the availability of ultra-sequencing platforms now supplanting cloning. Taxon detection from bulk samples can be achieved using PCR amplification followed by deep sequencing of homologous gene regions. Sequences are then compared to libraries of reference barcodes for taxonomic identification. This so-called "metabarcoding" approach has been used as a powerful means to understand the diversity and distribution of meiofauna. It has also been found to be an effective tool for assessing the diversity of insects collected from traps and characterize the diet of predators and herbivores through analysis of their faeces or gut content. Nevertheless, metabarcoding is still a relatively new approach, and both methodological and analytical improvements are necessary to further expand its range of applications.

Key words: Environmental samples- DNA-based- PCR amplification- metabarcoding- identification

1. INTRODUCTION

Biological diversity may be defined as the variation present in all species of plants and animals, their genetic material and the ecosystems in which they occur. Diversity can occur at three levels: genetic diversity (variation in genes and genotypes), species diversity (species richness) and ecosystem diversity (communities of species and their environment). The importance of biodiversity for humankind has been well recognised in the recent decades and many would argue that diversity is essential for allowing sustainable development of various human activities. Biological diversity can enable social and economic systems to flourish in ways that allow the poorest to meet their food and nutritional needs and retain the cultural diversity of countries throughout the world (Shiva, 1994). The biological resources of each country are important, but not all countries are equally endowed, and cooperation between countries is needed for effective conservation and use of our global biodiversity.

2. NEXT GENERATION SEQUENCING

Mass sequencing of environmental samples has been at the forefront of ecology and biodiversity research in recent years. NGS technologies have facilitated analysis of environmentally derived samples from a variety of ecosystems including freshwater, marine, soil, terrestrial and gut microbiota. The majority of these studies seek to answer the question of what is present in a given environment. Through the use of the massive amounts of sequence data produced by NGS platforms, researchers have been able to observe the slight changes in community structure that may occur following anthropogenic or natural environmental fluctuations (Leininger et al., 2006; Fierer et al., 2007). These small alterations, although highly informative of ecosystem health and stability, are not discernible with less sensitive, traditional, molecular tools such as Sanger sequencing (Sogin et al., 2006; Huse et al., 2010; Xuet al., 2012). Regardless of the ecosystem studied or the specific ecological question asked, the vast majority of studies making use of NGS platforms and environmental samples have employed the 454 pyrosequencing platform mainly because of its longer sequence read lengths. A variety of sample sources and sequence-generation workflows are outlined below.

Several studies have analysed soil bacterial diversity by examining 16S rDNA amplicons (e.g. Roesch et al., 2007; Rousk et al., 2010; Nacke et al., 2011). Results suggest that agricultural management of soil may significantly influence the diversity of bacteria and archaea (Roesch et al., 2007). Other studies have focused on soil fungal diversity in both forest and agricultural settings by analysing ITS amplicons (Acosta-Martı´nez et al., 2008; Bue´e et al., 2009; Jumpponen et al., 2010; Rousk et al., 2010). An alternate approach has been to target all soil microbiota, from archaea to fungi, using either total RNA (Fierer et al., 2007) or selected functional gene amplicons (Leininger et al., 2006).

Marine environments have also been the subject of ecological research employing NGS technology. Analyses of marine bacterial communities have been conducted using 18S rDNA (Huber et al., 2007) and 16S rDNA (Sogin et al., 2006) amplicons. Frias-Lopez et al., (2008) studied microbial community gene expression in ocean surface waters through transcriptomic sequencing analysis of cDNA libraries. Mou et al., (2008) investigated functional assemblages within seawater through a NGS analysis of functional metabolic gene regions within bacterioplankton. Marine eukaryotic microbiota was investigated through NGS analysis of 18S rDNA amplicons (Stoeck et al., 2010). A shotgun sequencing approach was employed to investigate microbial and viral diversity in sea water (Williamson et al., 2008). Marine viromes were also investigated by Angly et al., (2006). Rare and extreme habitats such as acid mines (Edwards et al., 2006) and coral reefs (Wegley et al., 2007) are now also readily subjected to NGS-based analysis of biodiversity.

Four recent articles have outlined the application of NGS approaches to analyse of freshwater environmental samples. Ficetola et al. (2008) combined an NGS approach with conventional Sanger sequencing of cytochrome b amplicons to detect the presence of bullfrogs in freshwater samples. Also, freshwater microbialities were investigated with a whole-genome shotgun approach to provide further insight into fossil stromatolite communities (Breitbart et al., 2009). Amplicons of 18S rDNA were used to investigate protist diversity in freshwater samples (Medinger et al., 2010). Recently, short fragments of COI DNA barcodes were used to provide species-level identification of freshwater macro invertebrates from benthic samples (Hajibabaei et al., 2011). This environmental barcoding study demonstrates the efficiency of 454 pyrosequencing in environmental bio-monitoring projects by comparing benthic macro-invertebrate communities from both urban and conservation areas. The analysis of these benthic samples can provide a real-world test of NGS approaches for bio-monitoring applications (see Baird & Hajibabaei, 2012 in this issue).

Next-generation technology has also been employed in recent research into terrestrial environmental samples, both ancient and modern. Haile et al., (2009) utilized both 454 pyrosequencing and conventional Sanger sequencing methods in the analysis of ancient DNA recovered from Arctic permafrost cores. Sønstebø et al. (2010) analysed permafrost samples to identify ancient plant species. Both pathogens associated with colony collapse disorder in honey bees (Cox-Foster et al., 2007) and plant viruses from infected tomato plants have been identified with NGS technology (Adams et al., 2009). A variety of terrestrial microhabitats, specifically soil, leaf litter and canopy epiphytes in a Costa Rican rainforest, have been examined using NGS approaches (Creer et al., 2010; Porazinska et al., 2010). Amplicons of 16S rDNA have been utilized to explore the sensitivity of topsoil in determining vertebrate presence and diversity in regions with known species compositions (Andersen et al., 2011).

Many studies have used NGS technology in diet analysis and in the investigation of gut microbial ecology. Some of these studies have included analyses of herbivore diet from gut contents using the plastid trnL sequence (Pegardet al., 2009; Soininenet al., 2009; Valentini et al., 2009; Kowalczyk et al., 2011). Also, several studies have been conducted on the effect of diet on the gut microbiome of mice using 16S rDNA amplicons (Turnbaughet al., 2008, 2009; Murphy et al., 2010; Ravussin et al., 2011; Serino et al., 2011). Recently, an investigation of the diet of bats was conducted using short COI amplicons. By enabling species-level identification of dietary components, NGS application to diet analysis allows a comprehensive relationship of the diet of sympatric cryptic species (Razgour et al., 2011).

Besides 454 pyrosequencing, the sequencing capacity of Illumina platforms has been successfully utilized for assessing microbial community diversity using short fragments of 16S rDNA (Lazarevic et al., 2009). Paired- end sequencing can increase the read length for Illumina sequencing applications. However, potential sources of error, including sequencing artefacts and taxonomic misidentification, should be taken into consideration when using short-read NGS tools to discover the biodiversity of environmental samples (Degnan&Ochman 2011). A recent study (Miller et al., 2011) has shown the promise of the Ion Torrent semiconductor platform for the assessment of intraspecies genetic diversity in an endangered mammal species. Medingeret al., 2010studied the diversity and the seasonal community turnover of alveolates (Ciliophora and Dinophyceae) in an oligotrophic freshwater lake by SSU amplicon sequencing with NGS as well as by classical morphological analysis. They show that NGS and morphological analyses generally capture frequency, shifts of abundant taxa over our seasonal samples.

2.1. Environmental barcoding through next-generation sequencing (NGS):

Many studies, subsequently, have used NGS approaches in the analysis of biodiversity in various habitats and taxonomic groups from all domains of life (see several articles published in this special issue). With the advancement of methodologies in data generation and analysis, NGS tools can become more feasible in clinical or environmental studies. Recently, we demonstrated the potential to use these technologies to extract species-level information on key bioindicator insect species from standard river biomonitoring samples, using a combination of cytochrome c oxidase (COI) DNA barcodes linked to a locally generated barcode reference library (Hajibabaei et al., 2011). NGS platforms offer a huge potential increase in the potential information that can be generated. In the case of the Roche 454 system, with approximately 1 M sequencing reads per run, it is now possible to consider analysis of environmental samples in terms of the simultaneous analysis of different taxonomic groups.

3. CONCLUSION

The introduction and advancements in next-generation sequencing have revitalized research in environmental samples. New methods of gathering sequence data, however, require optimization and benchmarking before being utilized on samples of unknown nature to avoid false negatives and biased results. The excitement of using new platforms has generated momentum among researchers to apply NGS tools in various applications involving environmental DNA. Rapid progress in the last 5 years has provided optimism for a bright future for the field of next-generation environmental DNA analysis.The large amount of sequence reads provided by NGS methods provide a unique opportunity to resolvethe discrepancy between morphological and molecularstudies. Furthermore, due to the large amount ofsequencing data produced, it is anticipated that it willbe possible to address the species richness of protists. Using the 454 technology, we show the limitations of SSU sequences for measuring species abundances and the strength of NGS for estimating species richness.

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EVALUATION OF MOSQUITO DIVERSITY IN SELECTED COASTAL DISTRICTS OF KERALA HAVING ENDEMICITY OF FILARIASIS

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ABSTRACT

Mosquitoes are a group of haematophagus insects that are involved in the transmission of many dreadful diseases. Inventory on mosquito diversity is essential to have an idea about the epidemiology of different diseases confining to varied geographical areas. Such systematic inquiries will also help to evaluate the transmission risk of vector-borne diseases in a better way. Tracts of some of the coastal districts of Kerala are known forthe persistenceof many mosquito borne diseases, especially filariasis. Repeated reports of this disease in recent years signify the need to assess the diversity of mosquito vectors confining to these areas. Hence, thediversity and abundance of mosquito vectorsfalling in the northernregionsof Kerala, ie. Ponnani (Malappuram District), Vellayil (Kozhikode District) and Thalassery (Kannur District), has been carried out, with respect to seasons. Sampling of both larvae and adult mosquitoes were carried out from heterogeneous habitats in premonsoon and post monsoon seasons to determine the species composition, relative abundance and distribution. Mosquito larvae collected were reared to adults in the laboratory. All the mosquitoes were subjected to species level identification following standard manuals.(Christophers, 1933 and Barraud, 1934).

Diversity studies on the adult mosquitoes in the three districts showed higher species diversity during post monsoon season (4 genera, 10 species) than pre monsoon season (3 genera,8 species). However a reversal in species diversity has been noticed with mosquito larvae, with higher species diversity during Premonsoon season (5 genera, 15 species) than Post monsoon season (4 genera,12 species).In both the seasons Culex was the most predominant genus with higher species diversity followed by Anopheles. On an overall assessment it has been noticed that mosquito diversity from the coastal tract of northern districts of Kerala comprisedof several important vectors of infectious diseases such as dengue, chikungunyaand malaria, in addition to filariasis.

Key words: Vectors, abundance, species diversity, culex, anopheles.

1. INTRODUCTION

Mosquitoes are the most extensively studied group of haematophagus insects, seriously affecting the health of human beings.Though an insect, they are widely distributed across the globe and are acting as vectors of a large number of appalling diseases such as Chikungunya, Malaria, Dengue fever, Filariasis etc., affecting millions of people every year. The rate at which the diseases get transmitted among humans and also the resistance acquired by these insects against various control measures makes them unique and the disease cycle complicated. Counteractive studies for effectively managing these remarkably resistant insects are still persisting as a serious challenge.

The diversity of mosquito borne diseases rampant in different sectors of the world depends to a greater extent on the socio-economic and cultural status of people. Increasing population density, deteriorating infrastructure, inadequate access to health, water, and sanitation services are some of the factors contributing to the risk of disease transmission (Macintyre, et al. 2002).Climatic conditions and environment play a significant role in the spatial and temporal distribution of mosquito vectors (Wanji et al., 2009). They breed in natural or man-made habitats such as pools, rivers, lakes, tree holes etc. with a variety of oviposition sites (Rattanarithikul et al., 2005). Larval distribution is greatly influenced by several factors such as types of water source, elevation, water movement, water temperature and associated vegetation(Rattanarithikul et al., 2005). Oviposition, development of larva, adult emergence and many other processes take place in larval habitats, thus playing an important role in determining adult diversity, distribution and abundance (Overgaard et al., 2002).

Inventory on mosquito diversity is essential to have an idea about the epidemiology of different diseases confining to varied geographical areas. Such systematic inquiries will also help to evaluate the transmission risk of vector-borne diseases in a better way.In India, various studies have been carried out on the biodiversity of mosquitoes with respect to geographic locations (Dhanpal and Naik, 1986; Nagpal and Sharma, 1987; Khame and Khaliwal, 1988). These studies provide information on the distribution of mosquito species in different regions or states (Rajavel et al., 2001). Recent years have witnessed the occurrence of many vector borne diseases in the northern coastal districts of Kerala. Most of such diseases were mosquito borne, resulting in immense suffering to the inhabitants. The ultimate reason behind these devastating diseases has to be thoroughly demarcated,in such a way that the vector control units and other related health organizations can design proper counteractive measures.

The present study has been outlined to assess the diversity and abundance of mosquito vectors falling in the northern regions of Kerala i.e., Ponnani (Malappuram District), Vellayil (Kozhikode District) and Thalassery (Kannur District). Reports on high endemicity of filariasis in these districts in the recent past have necessitated the diversity assessment of mosquito vectors. The study also highlights various management measures to be carried out to control disease rampancy.

2. MATERIALS AND METHODS

Ponnani, Vellayil and Thalassery are sited along the coastal tract of northern districts of Kerala ie, Malappuram, Kozhikode and Kannur districts respectively(Plate 1).All the sampling sites were characterized by heterogeneous type of aquatic habitats, which normally influences the breeding and emergence of mosquito vectors.

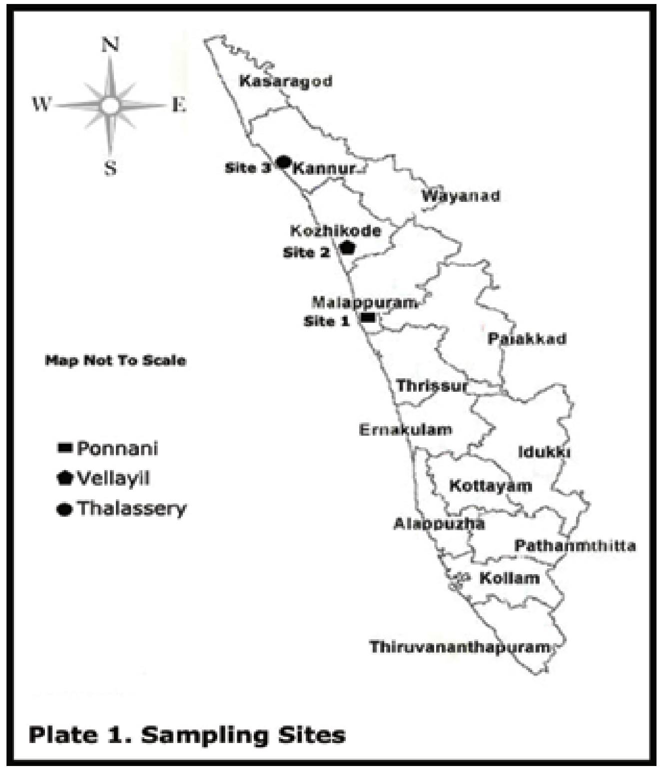


Plate 1: Sampling sites

2.1. Sampling of mosquito larvae

Sampling of mosquito larvae and pupae were carried out for two seasons (pre monsoon and post monsoon) from sixheterogeneous water bodies falling in the three locations with the help of a dipper. The larval habitats generally monitored include canals, pond, pits and sewerages. The collected larvae / pupae were brought to the laboratory for rearing, followed by species level identification. For rearing, water samples containing larvae / pupae from each site were transferred to plastic jars. All the jars were covered with net of small mesh size to avoid escape of adult mosquitoes. A lid was maintained in the net for collection of adult mosquitoes from the jars. No artificial food was given to the larvae as the water samples from the respective sites were enriched with nutrients. Emerging adult mosquitoes were collected with the help of a manual aspirator and killed with cotton swab of ethyl acetate.

2.2. Sampling of adult mosquitoes

Collection of adult mosquitoes was carried out using oral aspirators and test tubes. Adult mosquitoes that were resting indoors, outdoors and moving around and biting men were collected during morning and evening hours. The collected specimens were brought to the laboratory for identification and documentation.

Species level identification of mosquitoes, both larvae and adults, collected during pre-monsoon and post monsoon seasons was carried out using taxonomic keys provided in "The fauna of British India, including Ceylon and Burma" by Christophers (1933) and Barraud (1934). The seasonal variation in mosquitoes was analysed in terms of relative abundance and distribution (Rydzanicz and Lonc, 2003; Sengil et al., 2011).The mosquito species were also classified in the following relative abundance classes ie. Satellite species (relative abundance <1%), Sub-dominant species (relative abundance <5%) and dominant species (relative abundance >5%) following Trojan (1992).The following classes were used to represent the distribution status of different species as C1 (sporadic: 0-20%); C2 (infrequent: 20.1-40%); C3 (moderate: 40.1-60%); C4 (frequent: 60.1-80%; and C5 (constant: 80.1- 100%), following Dzieczkowski (1972). Percentage densities of different genera in all the sampling sites during both the seasons were also analysed and reported.

3. RESULTS AND DISCUSSION

Relative abundance and distribution status of mosquito species in the premonsoon and post- monsoon seasons are represented in Tables 1 and 2 respectively. Similarly percentage density of different genera in all the sampling sites during Premonsoon and Post monsoon seasons are depicted in Figure 1 and 2 respectively.

The coastal tracts of Kerala are known to be endemic towards many mosquito borne diseases. Such diseases aregetting widespread in other areas too. Reports of filariasis and other vector borne diseases in the northern coastal tract in recent years is a major concern of the health authorities of the state. With the aim of providing adequate information on the diversity and distribution of mosquito vectors in these areas, the present study has been taken up. The outcome of the study is likely to help the authorities of the local self governance or state health department in constituting appropriate control measures and management plans to safeguard the people at risk of various dreadful diseases.

Taxonomic identification of total mosquitoes collected from all the three districts in the premonsoon season revealed that they represent a total of 15 species falling in 5 genera. Similarly Relative abundance and distribution status of total mosquitoes in the premonsoon season were calculated.It is noticed that Culex quinquefaciatus, Anopheles stephensiand Culex sitiens were the most predominant species in terms of relative abundance and distribution. Maximum number of mosquito species was reported from Ponnani of Malappuram district. (9 species) and a minimum of 8 species each were reported from Thalassery (Kannur district) and Vellayil (Kozhikode district). The filarial vector Culex quinquefaciatus was noticed in all the habitats selected in each district.

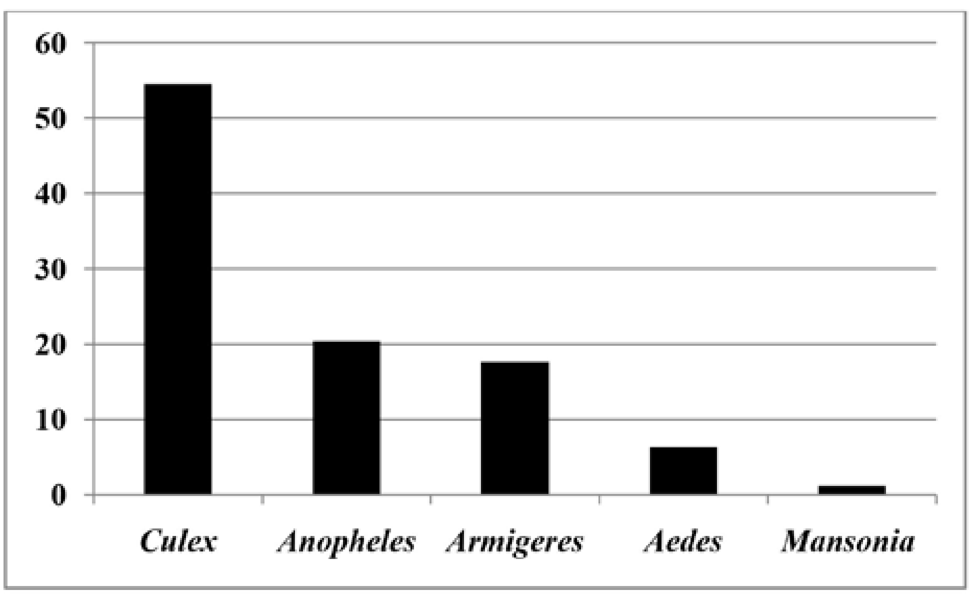
Table 1: Relative abundance and distribution status of mosquito species in the Premonsoon season

Location	Mosquito species	Rel. abun. (%)	Rel. abun. status	Distribution (%)	Distribution status
	Anopheles splendidus	14.35	Dominant	33.33	Infrequent
	Anopheles stephensi	9.13	Dominant	33.33	Infrequent
Ponnani (Malappuram)	Anopheles theobaldi	9.31	Dominant	16.66	Sporadic
	Armigeres aureolineatus	1.74	Subdominant	33.33	Infrequent
	Mansonia. annulifera	1.3	Subdominant	16.66	Infrequent
	Culex luscocephala	3.04	Subdominant	16.16	Infrequent
	Culex quinquefasciatus	17.39	Dominant	50	Moderate
	Culex sitiens	26.52	Dominant	83.33	Constant
	Culex vishnui	17.39	Dominant	66.66	Frequent

Vellayil (Kozhikode)	Aedes aegypti	7.29	Dominant	50	Moderate
	Armigeres annulipalpis	34.04	Dominant	66.66	Frequent
	Mansonia. annulifera	1.82	Subdominant	16.66	Sporadic
	Culex bitaeniorhynchus	3.68	Subdominant	16.66	Sporadic
	Culex gelidus	3.04	Subdominant	16.66	Sporadic
	Culex quinquefaciatus	24.62	Dominant	83.33	Constant
	Culex sitiens	13.68	Dominant	50	Moderate
	Culex vishnui	11.85	Dominant	66.66	Frequent
Thalassery (Kannur)	Aedes aegypti	11.88	Dominant	33.33	Infrequent
	Anopheles stephensi	31.19	Dominant	83.33	Constant
	Anopheles subpictus	3.96	Subdominant	16.66	Sporadic
	Anopheles vagus	4.46	Subdominant	16.66	Sporadic
	Armigeres annulipalpis	8.91	Dominant	33.33	Infrequent
	Culex gelidus	1.98	Subdominant	16.66	Sporadic
	Culex mimeticus	1.98	Subdominant	16.66	Sporadic
	Culex quinquefasciatus	26.73	Dominant	83.33	Constant
	Culex sitiens	8.91	Dominant	16.66	Sporadic

Data onpercentage densities of the five genera (Culex, Anopheles, Aedes, Mansoniaand Armigeres) in all the sampling sites (Figure 1) revealed that Culex were the predominant group (54.53%) followed by Anopheles (20.38%) and Armigeres (17.61%). Occurrence ofAedes (6.31%) and Mansonia (1.14%) were rare during the period of study.

Figure 1: Percentage density of different genera in all the sampling sites during Premonsoon season



Similarly, a total of 17 species belonging to 4 genera have been reported for the sites during post monsoon season. In terms of relative abundance and distribution, Culexquinquefaciatus, Culex sitiens and Culex epidesmus were the most predominant species. Maximum species diversity was reported from the Thalassery municipal area of Kannur district(11 species) and a minimum diversity of 8 species was reported from Vellayil of Kozhikode district.

Table 2: Relative abundance and distribution status of mosquito species in the Premonsoon season

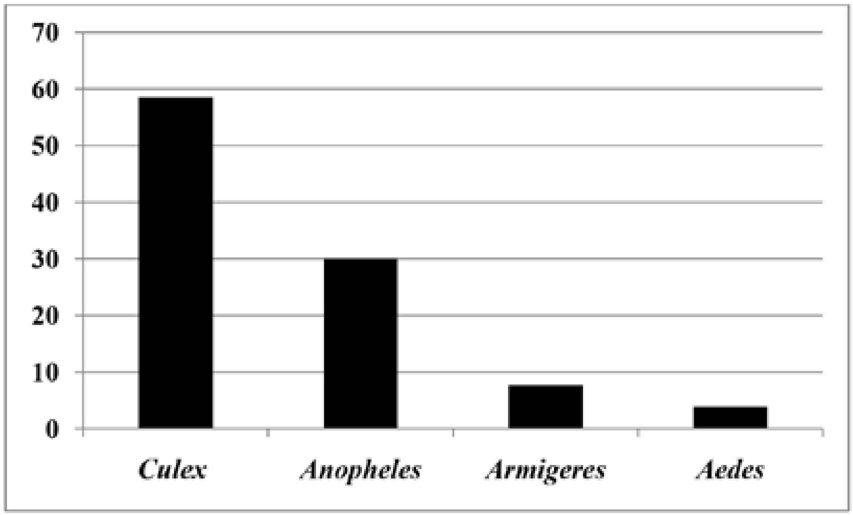
Location	Mosquito species	Rel. abun. (%)	Rel. abun. status	Distribution (%)	Distribution status
Ponnani (Malappuram)	Aedes albopictus	1.632	Subdominant	16.66	Sporadic
	Anopheles splendidus	10.33	Dominant	33.33	Infrequent
	Anopheles stephensi	12.4	Dominant	33.33	Infrequent
	Anopheles vagus	4.13	Subdominant	16.66	Sporadic
	Armigeres subalbatus	9.09	Dominant	33.33	Infrequent
	Culex luscocephala	0.41	Satellite species	16.66	Sporadic
	Culex quinquefasciatus	48.76	Dominant	83.33	Constant
	Culex sitiens	12.39	Dominant	33.33	Infrequent
	Culex vishnui	0.83	Satellite species	16.66	Sporadic
	Culex whitmorie	0.82	Satellite species	16.66	Sporadic
Vellayil (Kozhikode)	Anopheles subpictus	8.09	Dominant	33.33	Infrequent
	Armigeres annulipalpis	1.89	Subdominant	16.66	Sporadic
	Armigeres subalbatus	2.36	Subdominant	16.66	Sporadic
	Culex bitaeniorhynchus	12.74	Dominant	33.33	Infrequent
	Culex epidesmus	25.47	Dominant	50	Moderate
	Culex quinquefasciatus	16.98	Dominant	33.33	Infrequent
	Culex sitiens	15.57	Dominant	50	Moderate
	Culex vishnui	12.26	Dominant	16.66	Sporadic
Thalassery (Kannur)	Aedes aegypti	8.09	Dominant	33.33	Infrequent
	Aedes vittatus	3.47	Subdominant	16.66	Sporadic
	Anopheles stephensi	16.76	Dominant	50	Moderate
	Anopheles vagus	3.47	Subdominant	16.66	Sporadic
	Armigeres annulipalpis	9.83	Dominant	16.66	Sporadic
	Culex epidesmus	4.05	Subdominant	16.66	Sporadic
	Culex luscocephala	2.31	Subdominant	16.66	Sporadic
	Culex gelidus	3.47	Subdominant	16.66	Sporadic
	Culex quinquefaciatus	28.32	Dominant	66.66	Frequent
	Culex sitiens	17.92	Dominant	33.33	Infrequent
	Culex vishnui	2.31	Subdominant	16.66	Sporadic

Percentage densities of the four genera Culex, Anopheles, Armigeresand Aedes in all the sampling sites during Post monsoon season were 58.45%, 29.95%, 7.73% and 3.86% respectively.

Figure 2: Percentage density of different genera in all the sampling sites during Post monsoon season.

On an overall assessment it has been noticed thatthe diversityof adult mosquitoes in the three districts showed higher species diversity during post monsoon season (4 genera, 10 species) than pre monsoon season (3 genera, 8 species). However a reversal in species diversity has been noticed with mosquito larvae, with higher species diversity during Premonsoon season (5 genera, 15 species) than Post monsoon season (4 genera, 12 species). In both the seasons Culex was the most predominant genus with higher species diversity followed by Anopheles.

The results haveshown the existence ofdiverse group of mosquito species across the northern coastal districts of Kerala with respect to seasons, which can act as potential carriers of so many diseases.The mosquito communities sampled included several important vectors of infectious diseases such as Dengue, Chikungunya, Malaria andFilariasis. Irrespective of the seasons,Culex quinquefasciatus and



Culex sitiens were the most predominant species in terms of relative abundance and distribution. Also Culexquinquefaciatus, the filarial vector, was sampled from all the habitats. The present data implies the urgent need forinstituting appropriate measures for controlling these vectors and safeguarding populations at risk of mosquito-borne diseases, especially filariasis.

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COASTAL PHYTODIVERSITY OF KARAIKAL DISTRICT, U.T OF PUDUCHERRY, INDIA

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ABSTRACT

Coastal environments are among biologically diverse and productive terrestrial ecosystems. Plant communities provide a significant contribution to the ecology and conservation of coastal ecosystems. Now a days, coastal ecosystems are severely threatened all over the tropics due to their location near the ocean and ideal spots for tourism. Therefore understanding the ecology of the organisms that inhabit these regions is extremely important for conservation activities. The Karaikal district is one of French establishments of the U.T of Puducherry with long coastal border of Bay of Bengal. The coastal boarder has a length about 20 Kilometers and a breadth about seven hundred meters. The present work is to understand the floristic composition of the Karaikal coastal vegetation through a detailed analysis of species composition. Results of the study revealed that a total of 170 plant species belonging to 119 genera and 47 families were recorded during the study period. Among them, Fabaceae with 20 species followed by Poaceae with 19 species are the dominant plant families recorded in this work. Habit wise distribution shows comparatively higher representation of herbaceous plant species in this study area. Three endemic plants such as Leucas diffusa, Eragrostis riparia and Manisuris myuros have also been reported from the coastal area. Seven rare plants, namely Aristida funiculata, Canavalia lineata, Chloris montana, Derris trifoliata, Heliotropium zeylanicum, and Phyllanthus rotundifolius were recorded from the coastal area of Karaikal District. These coastal and estuarine habitats have been under tremendous anthropogenic pressure in addition to cyclones and tsunami disturbances. The present study clearly indicates that coastal areas are the unique floral wealth as well as pockets of conservation of rare and endemic plants in the district.

Key words: Phytodiversity, coastal flora, floristic analysis, Karaikal district

1. INTRODUCTION

Coastal areas have a long history of human habitation and exploitation around the world. Coastal ecosystems are among the biologically and economically productive ecosystems in the world and the same is true for India where these ecosystems are both a source of livelihood as well as range of ecological services. India has a vast extent of coastline of about 8000 km spanning 13 maritime mainland States and Union Territories, which are home to a diversity of coastal and marine ecosystems, comprising significant biodiversity at national and global level (Venkataraman and Wafar, 2005).

At present, India's coastal and marine ecosystems are under increasing threat. Numerous direct and indirect pressures arising from different types of economic development and associated activities are having adverse impacts on coastal and marine biodiversity across the country. Major anthropogenic drivers of ecosystem degradation and destruction include land use, overexploitation of species, spread of invasive alien species, impacts of agricultural, domestic and industrial sewage and plastic waste. Additionally, climate change is likely to have a growing impact on coastal and marine ecosystems by increase in extreme weather events such as sea level rise, increase the sea surface temperatures and ocean acidification. Coastal habitats are also destructed by powerful natural weather phenomena, such as tsunamis, cyclones, hurricanes and storms. Many indirect drivers of ecosystem change also play major role on demographic, socio-political, cultural, economic and technological factors.

East coast of Indian continent is generally shelving with dry evergreen forests, beaches, lagoons, deltas and marshes. The tropical dry evergreen forests of Indian East Coast have been degraded into tropical dry evergreen scrublands over the centuries, and characterized by thorny species. Only five percent of the ecoregion remains as forests, which is found in isolated pockets of East coast. Less than one percent of this ecoregion lies in protected areas like Marakkanam, northwest of Pondicherry and Point Calimere wildlife sanctuary of Tamil Nadu. It is estimated that 95% of the original forest cover has been cleared in the East coast over the centuries, and the species composition of the remaining forests have also been altered by intensive human use including the removal of all the taller trees (Wikipedia, 2014). In particular, the coastal areas of Tamil Nadu and Puducherry are assuming greater importance owing to increasing human population, urbanization and accelerated industrial activities. The Tsunami in December 2004 has devastated extensive stretches of coastal areas and destructed the most of the coastal vegetation (Murthy et al., 2006).

Coastal flora primarily includes the halophytic plants closest to the area of salt spray and wave wash, often concentrated within a distinct strand zone. The soils in coastal sandy areas are usually deficient in major nutrients, highly saline and drought influences on coastal flora. Coastal plants are also disturbed in plant dispersal failures, alien plants competition and anthropogenic impacts. In the present study, coastal region of Karaikal district in Union Territory of Puducherry was selected as a study site for plant exploration. The study area is an ideal site for study the diversity of plant resources of the coastal area with its varied topography and climatic conditions constitutes delta vegetation, mangroves and plain fertile ecosystems near sea. Until recently no serious attempts had been made scientifically to document the plant diversity of Karaikal district. As a result, their true richness of species was often questioned by non-conservationists. Therefore, present paper elucidates the enumeration of plant species distributed of coastal regions of Karaikal district.

2. MATERIALS AND METHODS

2.1. Study area

Karaikal is located on the Coramandal coast lies between (10° 49' and 11° 01' N and 79° 43' and 79° 52' E), one of the four erstwhile French establishments in India and one of the district of the Union Territory of Puducherry. The coastal boarder of Karaikal District has a length about 20 Kilometers and a breadth about seven hundred meters. Apparently, the coast is flat and sandy with marshy and clayey texture. Climate of Karaikal District is very warm and dry throughout the year. Based on the climate, three seasons were recognized such as winter (December, January, February and March), summer (April, May, June and July) and rainy (August, September, October, November) seasons. The average annual rainfall varies from 827 mm to 2100 mm (during last ten years) and it is received both from Northeast monsoon (October to December) and Southwest monsoon (June to September). Throughout the year, the coastal areas of Karaikal show higher relative humidity (average value 78%).

2.2. Field Work:

Intensive exploration trips will be undertaken for about consecutive years from 2011 to 20l4 Field trips were made at frequent intervals especially to obtain through collection of ephemerals and other small plants staggered over different seasons around the year. Special attention will be given to data relating to habit, ecological features, local names, etc. Further every attempt will be made to study the phenology of each plant, its life cycle, relative abundance and distribution. Each specimen was carefully examined in natural conditions and identification using publications of Gamble and Fischer (1915-1936) and Matthew (1982; 1983; 1988; 1991 and 1999) as well as use of various floras, monographs and revisions, provisional identification was made. Botanical nomenclature followed in the text conforms to the Flora of Tamil Nadu by Nair and Henry (1983); Henry et al., (1987, 1989). Further, every attempt was made to check the identity of plants by the way of type method and evaluate the taxonomic status of the taxa concerned.

2.3. Herbarium Work

The fresh specimens were soaked in 1 % formaldehyde and processed into herbarium specimens (Henry et al., 1989; Forsberg & Sachet, 1965). The herbarium sheets were deposited in plant science laboratory of Avvaiyar Government College for women, Karaikal, U.T of Puducherry. Identification was confirmed after matching the specimens with authentic and type specimens in Madras Herbarium (MH), Coimbatore, Tamil Nadu and Central National Herbarium, Howrah (CAL), West Bengal. The nomenclature of the plants has been up-to-date by strict application of the rules as given in the International Code of Botanical Nomenclature.

3. RESULTS AND DISCUSSION

The present study was carried out on the species composition of coastal flora of Karaikal district. A total of 170 species in 119 genera and 47 families were recorded during the study period. Of these, dicotyledons were represented by 138 species belonging to 99 genera and 42 families, while monocotyledons contributed by 32 species belonging to 20 genera and 5 families (Table-1). Families with maximum number of species include Fabaceae (20) followed by Poaceae (19) Amaranthaceae (10), Cyperaceae (9), Convolvulaceae (8), Euphorbiaceae (7), Asteraceae (7), Cucurbitaceae (6), Rubiaceae (6), Solanaceae (6) and Malvaceae (5). This qualitative floristic survey conducted for the first time in this district which showed the wealth of costal flora.

Table 1: Total taxa in coastal flora of Karaikal district

Taxa	Dicotyledons	Monocotyledons	Total
Family	42	5	47
Genus	99	20	119
Species	138	32	170

Habit-wise distribution of plants in the coastal flora of Karaikal district shows comparatively higher representation of herbaceous plant species (51%) followed by undershurbs, climbers, shrubs and trees (Table-2). Only two liana species are recorded in the study are Derris trifoliata Lour., and Wattakaka volubilis (L.f.) Stapf . Only 13 species of tree species are recorded in the study exhibit that less number of coastal trees due to frequent cyclone disturbances in the study area.

Many rare and endemic species were collected during the present study. Three endemic plants such as Leucas diffusa Benth, Eragrostis riparia (Willd.) Nees and Manisuris myuros L have also been reported from the coastal of the study area. Seven rare plants Aristida funiculata Trin & Rupr, Canavalia lineata DC.Prodr., Chloris montana Roxb., Derris trifoliata Lour., Heliotropium zeylanicum (Burm.f.) Lam., and Phyllanthus rotundifolius Klein ex Willd. (Table-3) were collected from the coastal area of Karaikal District.

Table 2: Habit-wise distribution in the coastal flora of Karaikal district

S.No.	Habit forms	Number of plant Species	Distribution (%)
1	Liana	2	01.17
2	Tree	13	07.65
3	Shrub	16	09.41
4	Climber	18	10.59
5	Undershrub	34	20.00
6	Herb	87	51.18
	Total	170	100.00

Table 3: List of plant species recorded in the coastal flora of Karaikal District

S. No	Botanical Name	Family	Habit
1	Abutilon indicum (L.) Sweet	Malvaceae	Undershrub
2	Acacia leucophloea (Roxb.) Willd.	Fabaceae	Tree
3	Acacia nilotica (L.) Willd. ex Del. subsp. indica (Benth.) Brenan	Fabaceae	Tree
4	Acalypha lanceolata Willd.	Euphorbiaceae	Herb
5	Acanthus ilicifolius L.	Acanthaceae	Undershrub
6	Achyranthes aspera L.	Amaranthaceae	Herb
7	Aeluropus lagopoides (L.) Trin ex Thw.	Poaceae	Annual herb
8	Aerva lanata (L.) Juss. ex Schultes	Amaranthaceae	Herb
9	Allmania nodiflora (L.) R. Br. ex Wight	Amaranthaceae	Herb
10	Alternanthera paronychioides A.St.	Amaranthaceae	Herb

11	Alternanthera pungens Kunth	Amaranthaceae	Herb
12	Alysicarpus monilifer (L.) DC.	Fabaceae	Herb
13	Alysicarpus vaginalis (L.) DC.	Fabaceae	Herb
14	Amaranthus viridis L.	Amaranthaceae	Herb
15	Aristida adscensionis L.	Poaceae	Annual herb
16	Aristida funiculata Trin & Rupr.	Poaceae	Annual herb
17	Aristolochia bracteolata Lam.	Aristolochiaceae	Herb
18	Aristolochia indica L.	Aristolochiaceae	Herb
19	Arthrocnemum indicum (Willd.) Moq.	Amarnthaceae	Herb
20	Avicennia marina (Forssk.) Vierh	Acanthaceae	Shrub
21	Azadirachta indica A. Juss.	Meliaceae	Tree
22	Bistella dichotoma (Murr.) Bullock	Vahliaceae	Herb
23	Blumea aurita (L.f.) DC.	Asteraceae	Undershrub
24	Blumea axillaris (Lam.) DC.	Asteraceae	Undershrub
25	Blumea obliqua (L.) Druce	Asteraceae	Herb
26	Boerhavia diffusa L.	Nyctaginaceae	Herb
27	Boerhavia erecta L.	Nyctaginaceae	Herb
28	Borassus flabellifer L.	Arecaceae	Tree
29	Calophyllum inophyllum L.	Calophyllaceae	Tree
30	Calotropis gigantea (L.) R.Br.	Apocynaceae	Shrub
31	Canavalia lineata DC. Prodr.	Fabaceae	Climber
32	Canthium coromandelicum (Burm. f.) Alston	Rubiaceae	Shrub
33	Cardiospermum halicacabum L.	Sapindaceae	Climber
34	Casuarina equisetifolia L.	Casuarinaceae	Tree
35	Chloris barbata Sw.	Poaceae	Annual herb
36	Chloris montana Roxb.	Poaceae	Annual herb
37	Citrullus colocynthis (L.) Schrader	Cucurbitaceae	Climber
38	Citrullus lanatus (Thunb.) Matsumura & Nakai	Cucurbitaceae	Climber
39	Cleome angustifolia Forssk.	Cleomaceae	Herb
40	Cleome aspera J. Koen ex. DC.	Cleomaceae	Herb
41	Cleome viscosa L.	Cleomaceae	Herb
42	Clerodendrum inerme (L.) Gaertn.	Verbenaceae	Shrub
43	Coccinia grandis (L.) Voigt	Cucurbitaceae	Climber
44	Corallocarpus epigaeus (Rottl. & Wild.) Clarke	Cucurbitaceae	Climber
45	Cressa cretica L.	Convolvulaceae	Herb
46	Crotalaria angulata Mill.	Fabaceae	Herb
47	Crotalaria pallida Dryand.	Fabaceae	Undershrub
48	Crotalaria retusa L.	Fabaceae	Undershrub
49	Croton bonplandianum Baill.	Euphorbiaceae	Undershrub
50	Cyanotis cristata (L.) D. Don	Commelinaceae	Herb
51	Cyperus arenarius Retz.	Cyperaceae	Perennial herb
52	Cyperus rotundus L.	Cyperaceae	Perennial herb
53	Cyperus stoloniferous Retz.	Cyperaceae	Perennial herb

54	Dactyloctenium aegyptium (L.) Willd.	Poaceae	Annual herb
55	Datura innoxia Mill.	Solanaceae	Undershrub
56	Datura metel L.	Solanaceae	Undershrub
57	Derris trifoliata Lour.	Fabaceae	Liana
58	Dicerma biarticulatum (L.) DC.	Fabaceae	Undershrub
59	Digitaria ciliaris (Retz.) Koeler	Poaceae	Annual herb
60	Dipteracanthus patulus (Jacq.) Nees	Acanthaceae	Undershrub
61	Dodonaea angustifolia L.f.	Sapindaceae	Shrub
62	Enicostema axillare (Lam.) Raynal	Gentianaceae	Herb
63	Eragrostis riparia (Willd.) Nees	Poaceae	Annual herb
64	Eragrostis tenella (L.) P. Beauv ex Roem. & Schultes	Poaceae	Annual herb
65	Eragrostis viscosa (Retz.) Trin.	Poaceae	Annual herb
66	Euphorbia serpens H.B.K.	Euphorbiaceae	Herb
67	Evolvulus alsinoides (L.) L.	Convolvulaceae	Herb
68	Ficus benghalensis L.	Moraceae	Tree
69	Fimbristylis argentea (Rottb.) Vahl	Cyperaceae	Annual herb
70	Fimbristylis cymosa R. Br.	Cyperaceae	Perennial herb
71	Fimbristylis dichotoma (L.) Vahl	Cyperaceae	Annual herb
72	Fimbristylis polytrichoides (Retz.) R. Br.	Cyperaceae	Annual herb
73	Fimbristylis triflora (L.) Schum. ex Engler	Cyperaceae	Perennial herb
74	Geniosporum tenuiflorum (L.) Merr.	Lamiaceae	Herb
75	Gisekia pharnaceoides L.	Molluginaceae	Herb
76	Glinus oppositifolius (L.) A. DC.	Molluginaceae	Herb
77	Gmelina asiatica L.	Verbenaceae	Shrub
78	Gomphrena serrata L.	Amaranthaceae	Herb
79	Heliotropium curassavicum L.	Boraginaceae	Herb
80	Heliotropium zeylanicum (Burm.f.) Lam.	Boraginaceae	Undershrub
81	Hybanthus enneaspermus (L.) F. Muell.	Violaceae	Herb
82	Hyptis suaveolens (L.) Poit.	Lamiaceae	Undershrub
83	Indigofera aspalathoides Vahl ex DC.	Fabaceae	Undershrub
84	Indigofera linnaei Ali	Fabaceae	Herb
85	Indigofera tinctoria L.	Fabaceae	Undershrub
86	Ipomoea carnea Jacq.	Convolvulaceae	Shrub
87	Ipomoea coptica (L.) Roth ex Roem. & Schultes	Convolvulaceae	Climber
88	Ipomoea marginata (Desr.) Verdc.	Convolvulaceae	Climber
89	Ipomoea pes-caprae (L.) R.Br.	Convolvulaceae	Climber
90	Jatropha gossypifolia L.	Euphorbiaceae	Shrub
91	Jatropha tanjorensis Ellis & Saroja	Euphorbiaceae	Shrub
92	Justicia tranquebariensis L.f.	Acanthaceae	Undershrub
93	Lannea coromandelica (Houtt.) Merr.	Anacardiaceae	Tree
94	Launaea sarmentosa (Willd.) Sch.-Bip. ex Kuntze	Asteraceae	Herb
95	Leptadenia reticulata (Retz.) Wight & Arn.	Apocynaceae	Climber

96	Leucas aspera (Wild.) Link	Lamiaceae	Herb
97	Leucas diffusa Benth.	Lamiaceae	Herb
98	Lindernia crustacea (L.) F. Muell.	Linderniaceae	Herb
99	Luffa cylindrica (L.) M.Roem.	Cucurbitaceae	Climber
100	Manisuris myuros L.	Poaceae	Annual herb
101	Martynia annua L.	Martyniaceae	Undershrub
102	Melochia corchorifolia L.	Malvaceae	Undershrub
103	Merremia tridentata (L.) Hall.f.	Convolvulaceae	Herb
104	Microstachys chamaelea (L.). Müll.-Arg.	Euphorbiaceae	Herb
105	Mollugo cerviana (L.) Ser.	Molluginaceae	Herb
106	Mollugo disticha Ser.	Molluginaceae	Herb
107	Mollugo pentaphylla L.	Molluginaceae	Herb
108	Mukia maderaspatana (L.) M. Roem.	Cucurbitaceae	Climber
109	Murdannia spirata (L.) Brueckner	Commelinaceae	Herb
110	Nesaea prostrata (Ham.ex Dillwyn) Suresh	Lythraceae	Herb
111	Oldenlandia corymbosa L.	Rubiaceae	Herb
112	Oldenlandia pumila (L.f.) DC.	Rubiaceae	Herb
113	Oldenlandia stricta L.	Rubiaceae	Herb
114	Oldenlandia umbellata L.	Rubiaceae	Herb
115	Operculina turpethum (L.) Silva Manso	Convolvulaceae	Climber
116	Opuntia stricta var. dillenii (Ker Gawl.) L.	Cactaceae	Shrub
117	Pandanus odorifer (Forssk.) Kuntze	Pandanaceae	Shrub
118	Parthenium hysterophorus L.	Asteraceae	Undershrub
119	Paspalum scrobiculatum L.	Poaceae	Perennial herb
120	Paspalum vaginatum Sw.	Poaceae	Perennial herb
121	Passiflora foetida L.	Passifloraceae	Climber
122	Pedalium murex L.	Pedaliaceae	Undershrub
123	Peltophorum pterocarpum (DC.) Baker ex Henye	Fabaceae	Tree
124	Pentatropis capensis (L.f.) Bullock	Apocynaceae	Climber
125	Pergularia daemia (Forrsk.) Chiov.	Apocynaceae	Climber
126	Perotis indica (L.) Kuntze	Poaceae	Annual herb
127	Phyla nodiflora (L.) Greene	Verbenaceae	Herb
128	Phyllanthus amarus Schum. & Thonn.	Phyllanthaceae	Herb
129	Phyllanthus rotundifolius Klein ex Willd.	Phyllanthaceae	Herb
130	Phyllanthus virgatus Forsst.	Phyllanthaceae	Herb
131	Physalis pruinosa L.	Solanaceae	Undershrub
132	Pongamia pinnata (L.) Pierie	Fabaceae	Tree
133	Portulaca oleracea L.	Portulacaceae	Herb
134	Portulaca pilosa L.	Portulacaceae	Herb
135	Prosopis juliflora (Sw.) DC.	Fabaceae	Tree
136	Pycreus pumilus (L.) Nees	Cyperaceae	Undershrub
137	Rauvolfia tetraphylla L.	Apocynaceae	Undershrub
138	Rhizophora apiculata Blume	Rhizophoraceae	Tree

139	Rhizophora mucronata Poir.	Rhizophoraceae	Tree
140	Sauropus bacciformis (L.) Airy Shaw	Euphorbiaceae	Herb
141	Scoparia dulcis L.	Plantaginaceae	Herb
142	Senna alata (L.) Roxb.	Fabaceae	Shrub
143	Senna occidentalis (L.) Link	Fabaceae	Undershrub
144	Sesuvium portulacastrum (L.) L.	Aizoaceae	Herb
145	Sida acuta Burm.f.	Malvaceae	Undershrub
146	Sida cordata (Burm. f.) Borssum	Malvaceae	Undershrub
147	Sida cordifolia L.	Malvaceae	Undershrub
148	Solanum insanum L.	Solanaceae	Undershrub
149	Solanum trilobatum L.	Solanaceae	Climber
150	Solanum virginianum L.	Solanaceae	Undershrub
151	Spermacoce hispida L.	Rubiaceae	Herb
152	Sphaeranthus indicus L.	Asteraceae	Herb
153	Spinifex littoreus (Burm.f.) Merr.	Poaceae	Perennial herb
154	Sporobolus maderaspatanus Bor	Poaceae	Annual herb
155	Sporobolus virginicus (L.) Kunth	Poaceae	Annual herb
156	Suaeda maritima (L.) Dumort.	Amaranthaceae	Undershrub
157	Suaeda monoica Forssk. ex Gmel.	Amaranthaceae	Shrub
158	Suaeda nodiflora (Willd.) Moq.	Amaranthaceae	Undershrub
159	Tephrosia purpurea (L.) Pers.	Fabaceae	Undershrub
160	Tephrosia villosa (L.) Pers.	Fabaceae	Undershrub
161	Tinospora cordifolia (Willd.) Miers ex Hook. f. & Thoms.	Menispermaceae	Climber
162	Trianthema triquetra Rottl.	Aizoaceae	Herb
163	Tribulus terrestris L.	Zygophyllaceae	Herb
164	Urochloa panicoides P. Beauv	Poaceae	Annual herb
165	Vernonia cinerea (L.) Less.	Asteraceae	Undershrub
166	Vitex negundo L.	Verbenaceae	Shrub
167	Vitex trifolia L.	Verbenaceae	Shrub
168	Wattakaka volubilis (L.f.) Stapf	Apocynaceae	Liana
169	Ziziphus mauritiana Lam.	Rhamnaceae	Shrub
170	Zoysia matrella (L.) Merr.	Poaceae	Annual herb

4. CONCLUSION

Coastal areas of Karaikal District harbor good vegetation including mangrove species. The coastal and estuarine habitats have been under tremendous human induced stresses due to their immense economic, recreational and transport services in addition to cyclones and tsunami disturbances. The present study clearly indicates that coastal areas are the unique pockets of conservation of rare and endemic plants in the district.

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DIVERSITY OF MURICID SHELLS (MOLLUSCA: GASTROPODA) ASSOCIATED WITH THE TRAWL BY-CATCH OF KERALA COAST, INDIA

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ABSTRACT

Muricidae is the second largest family of marine gastropod molluscs belonging to the order Neogastropoda, with over 1,600 extant described species. The members of the family show a cosmopolitan distribution and are characterized by the presence of varices, tubercles or spines with a marginal or lateral nucleus. There are 44 species under nine genera of muricids recorded from the Indian waters. Muricids forms a major component of the by-catch in shrimp trawls operated along Kerala coast. As a mobile non-selective fishing gear, trawl net collects every organism in its path. The non-commercial or non-target species and the non-commercial juveniles landed along with the target species are termed as by-catch or discarded catch. A study was undertaken to delineate the diversity of muricid gastropods associated with the trawl by-catch of Kerala coast. The specimens were collected from different landing centers along Kerala coast, including Sakthikulangara, Neendakara (Kollam), Thoppumpady (Ernakulam), Ponnani (Malappuram), Beypoore, Chombala (Kozhikode) and Azhikkal (Kannur). The collected specimens were cleaned, photographed and the shells were preserved dry for identification to species level. Thirteen species of muricids were recorded during the study viz. Chicoreus ramosus (Linnaeus), Ergalatax contracta(Reeve), Haustellum haustellum(Linnaeus), Indothais lacera (Born), Maculotriton serriale (Deshayes), Morula granulata(Duclose), Murex trapa(Roding), M. tribulus(Linnaeus), Purpura bufo(Lamarck), P. panama (Roding), Rapana rapiformis(Born), Mancinella alouina (Roding) and Vokesimurex malabaricus(Smith). Shannon diversity index recorded a higher value of 2.022 and the Margalef species richness index was 2.005.During the study period, Rapana rapiformis and Murex trapa showed the maximum abundance. Neendakara-Sakthikulangara coast of Kollam District of Kerala showed maximum diversity of muricid gastropods. The landed shells were collected by the local people for supplying them to the shell handicraft industry.

Key words: Muricoidea, bycatch, discards, ornamental shells.

1. INTRODUCTION

Neogastropoda is the most diversified order among gastropods and they are entirely carnivorousas well as active predators. Muricid gastropods are the most species richand taxonomically complex group of neogastropod molluscs belonging to the super family Muricoidea within the family Muricidae. The members of the family include purpuras, murex and rock shells and the shape is uneven, normally by means of a raised spire as well as strong sculpture with spiral ridges and axial varices (3 or more in number on each whorl), often bearing spines, tubercles or blade-like processes. They are abundant in the intertidal zone of rocky coast and reef ecosystem while their distribution extends from littoral and sub littoral zones to as deep as 1900m. According to the recent classification (Bouchet and Rocroi, 2005), the Muricidae composed of 10 subfamilies. Of these, Muricinae is the largest subfamily which includes the common murex shells of the Indian coast. About 180 species belonging to 28 genera are identified worldwide and 44 species within nine genera from the Indian coast. Sexes are separate and the fertilization is internal. Eggs lay in protective corneous capsules, generally hatched out as crawling juveniles or more rarely as planktonic larvae. The members of the family are carnivorous and feed on barnacles, other molluscs, crustaceans and small fishes. Being predators, they play a significant role in the structuring of marine intertidal communities (Menge, 1974; Morton, 1999, 2004; Peharda and Morton, 2005; Harding et al., 2007).

During the last five decades, the increase in commercial fish production all over the world has been accompanied by an increase in the landings of by-catch and discards. Trawl net is dragged through the sea bottom, gathering a wide array of organisms as by-catch. These operations yield the target resources such as shrimp and cephalopods along with a non-target by-catch of heterogeneous species of ground/ column fishes and non-edible benthic biota belonging to many taxa. Globally shrimp trawling contributes to the highest level of discards (Kumar and Deepthi, 2006).The term 'discarded catch' or 'discards' denotes the portion of the catch that is returned to the sea as unusable and the term 'by-catch' means the incidental catch of non-target species plus the discarded catch. The discarded catch include a wide variety of benthic biota such as non-edible crabs, stomatopods, bivalves and gastropods, hermit crabs, echinoderms, gorgonids, juveniles of shrimps and finfishes of little or no market value.

The muricid shells have an attractive ornamentation and are widely collected by the shell collectors for making shell crafts. In addition to the ornamental value, some of them are edible such as Murex, Concholepas, Truncilariopsis, Bolinus, Chicoreus, etc (Barco et al., 2010). Buhle and Ruesink(2009) reported the economic importance of some muricids as pests of commercial important oysters(Ocinebrina and Urosalpinx). Kerala coast is rich in gastropod diversity and the muricids forms a dominant group in the trawl-by-catch. Many fishermen families among coastal villages are actively engaged in the collection of these shells and also in the shell handicraft industry. From Kerala waters the studies regarding the muricid diversity associated with the trawl by-catch are limited. The present study aims to prepare a database on the muricid gastropods associated with the trawl by-catches off Kerala coast.

2. MATERIALS AND METHODS

The specimens were collected from the different landing centres along Kerala coastincluding Sakthikulangara, Neendakara (Kollam), Thoppumpady (Ernakulam), Ponnani (Malappuram), Beypoore, Chombala (Kozhikkode) and Azhikkal (Kannur). The period of collection was from September 2012 to September 2014. The collected specimens were cleaned and photographed. After taking the necessary measurements the specimens were sundried and preserved for further study. The collected specimens were identified with the help of identification keys (Robin, 2008; Rao, 2003). Abundance of the species was noted. Biodiversity indices were calculated by using PAST software (Hammer et al., 2009).

3. RESULTS AND DISCUSSION

Taxonomic Account

Phylum : Mollusca

Class : Gastropoda

Order : Neogastropoda

Super Family: Muricoidea

Family : Muricidae

Thirteen species of muricidsbelonging to three subfamilies were recorded during the study (Table 1).

Table 1: List of Muricid gastropods recorded from the Kerala coast

Subfamily	Species
Ergalataxinae	Ergalatax contracta(Reeve)
	Maculotritonserriale (Deshayes)
Muricinae	Chicoreusramosus (Linnaeus)
	Murex trapa(Roding)
	M. tribulus(Linnaeus)
	Haustellum haustellum(Linnaeus)
	Vokesimurex malabaricus(Smith)
Rapaninae	Indothais lacera (Born)
	Mancinellaalouina (Roding)
	Morula granulata(Duclose)
	Purpura bufo(Lamarck)
	P. panama (Roding)
	Rapana rapiformis(Born)

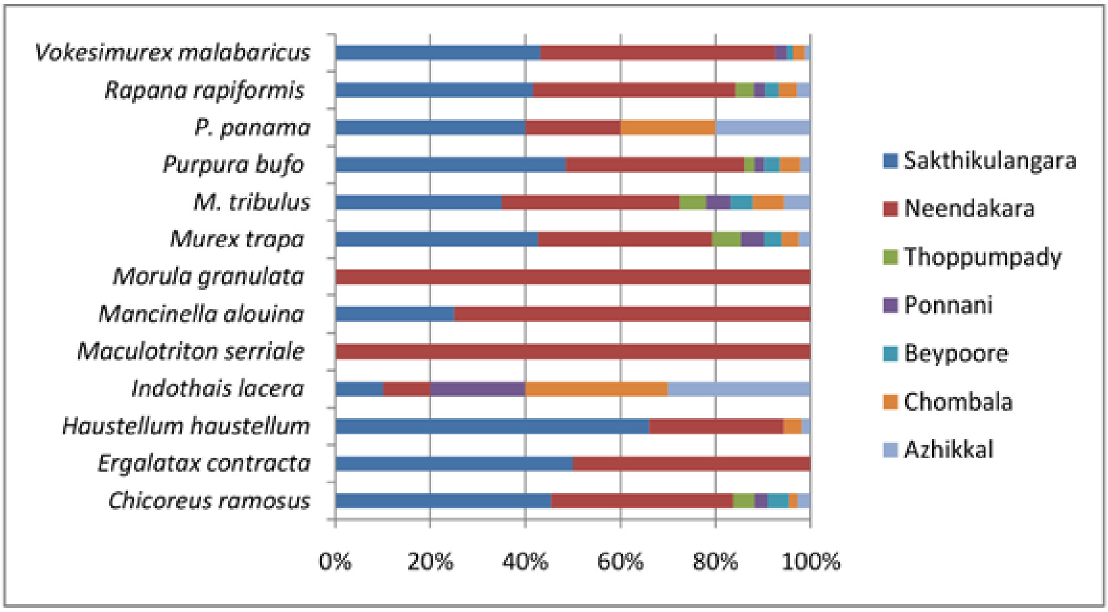

Fig 1: Bar Diagram showing the abundance of species from different locations of Kerala

Table 2: Diversity indices of Muricid shells of Kerala coast

Taxa S	13
Individual	397
Shannon Weiner index- H	2.022
Dominance D	0.1693
Simpson 1-D	0.8307
Evenness- e^H/S	0.581
Margalef	2.005

During the course of the study, the highest number of species was observed in Sakthikulangara-Neendakara coast. M.trapa, M. tribulus, R.rapiformis, P.bufo was the most dominant species while the least abundant specieswas M.serrialeobserved during the study period. As a raw material for shell craft industry, muricidsare heavily exploited on a commercial scale.Of the collected species, M. trapa, M. tribulus and R. rapiformis are widely collected by the shell-craft industries in Neendakara-Sakthikulangara coast, which is the biggest marine fish landing centre in Kerala. Besides these ornamental values, the operculum of some of the gastropods also have export demand. In Neendakara-Sakthikulangara coast the dried operculum of R. rapiformis yield Rs.300/Kg and the shells by Rs. 3/piece. Subfamily Rapaninae contributed the maximum number of species (6) followed by Muricinae (5) and Ergalataxinae(2)in the present samples.

From the biodiversity indices calculated, Shannon diversity index of muricid shells recorded a higher value of 2.022 indicates that Kerala coast is rich in muricid shell diversity. The value of Dominance index, 0.1693 showed the dominance of some species and the Evenness index was less (0.581) and it point out that the species were evenly distributed along Kerala coast. Appukuttan and Philip (1995) reported 29 species of gastropods from the trawl by-catches of Neendakara-Sakthikulangara coast. Five species of muricids were reported during this study. Babu et al. (2011) described 21 species of ornamental gastropods from the trash landed in the Madasalodai landing centre, south east coast of India. Two species of muricids obtained in this survey. Kumar (2008) made an extensive report on the by-catch associated diversity of organisms along the south west coast of India. He recorded 135 species of molluscs, 72 species of arthropods, 18 species echinoderms, 10 species of sponges and cnidarians and one species each of bryozoa and sipunculida.11 species of muricids were recorded on this survey. Muricidae is the species rich and most morphologically diverse gastropod family largely exploited for shell craft industries.

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CORAL DISEASE PREVALENCE IN KARIYACHALLI ISLAND, GULF OF MANNAR, SOUTHEASTERN INDIA

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ABSTRACT

Coral disease is a rising problem on all reef areas worldwide as it significantly contributes to coral reef destruction. The present study was conducted to assess the coral disease status in the Kariyachalli Island (N08^{0}57.024' E078^{0}15.016') in Tuticorin coast of Gulf of Mannar. Two sites were fixed for the assessment of percentage of disease cover and coral size class. In each study site two depth were chosen <2m depth and >2m depth. Overall percentage of disease prevalence in Kariyachalli Island was 10.65% and the black band was found as high with 2.83% followed by white band 2.38%, white plaque 2.35%, pink spot 1.82%, yellow band 1.8%, black spot 1.33%, yellow spot 1.03% and tumor 0.19% at <2m depth. In >2m depth, black band was found as high with 1.37% followed by white plaque 1.29%, pink spot 1.28%, white band 1.1%, yellow spot 0.82%, yellow band 0.81%, black spot 0.73% and tumor 0.16%. Six coral genera were affected with disease in both depths. Black band was the most common disease in Acropora sp., and Porites sp. followed by white plaque in Acropora sp., Porites sp. and Turbinaria sp. Few tumor patches were also observed in Acropora sp. The other species affected were Montipora sp., Gonistrea sp., Favia sp. and Favities sp. Among the corals Porites sp. and Acropora sp. were most affected genus. Most affected coral size classes were 21-40cm at both depths. The sources of anthropogenic factors causing diseases need to be checked and reduced to maintain the health of the corals. Degraded reef areas can be rehabilitated using disease resistant coral species to retain the biodiversity.

Key words: Coral diseases, Kariyachalli Island, Gulf of Mannar, anthropogenic factors

1. INTRODUCTION

In recent years, reports of diseases affecting corals have increased (Raymundo et al., 2005). Coral disease was thought to be primary causes of recent coral reef deterioration (Aronson et al., 2005). In 1990s, coral reef diseases have emerged to add to the stress upon reef communities (Cervino and Smith, 1997; Antonius and Ballesteros, 1997; Cervino et al., 1997). Diseases are more harmful to the survival of the coral reefs than sedimentation, pollution, physical degradation, or all other threats combined (Hayes and Goreau, 1998). Coral disease has been documented in more than 102 species of corals across 54 countries and the rate of discovery of new diseases have increased dramatically with more than 29 syndromes now described (Green and Bruckner, 2000; Weil, 2004).

India has four major coral reef areas which are Andaman and Nicobar Islands, Gulf of Kach, Lakshadweep Islands, and Palk Bay and Gulf of Mannar. All the major reef types such as fringing, atoll and barrier occur in India along with some patch reefs. Fringing reefs are found in the Gulf of Mannar. The Gulf of Mannar (GoM) is located in Tamil nadu, on the mainland of south east India. The islands in the Gulf of Mannar Marine National Park are grouped into four namely, Mandapam group (7 Islands), Keezhakarai group (7 Islands), Tuticorin group (7 Islands). These Islands are located between latitude 8°47' N and 9°15'N and longitude 78°12'E and 79°14'E.

The present investigation aims on disease prevalence, types of coral disease and infected coral genera in size class within two depth sites of Kariyachalli Island (Fig 1) N08^{0}57.024' E078^{0}15.016' (Tuticorin group).

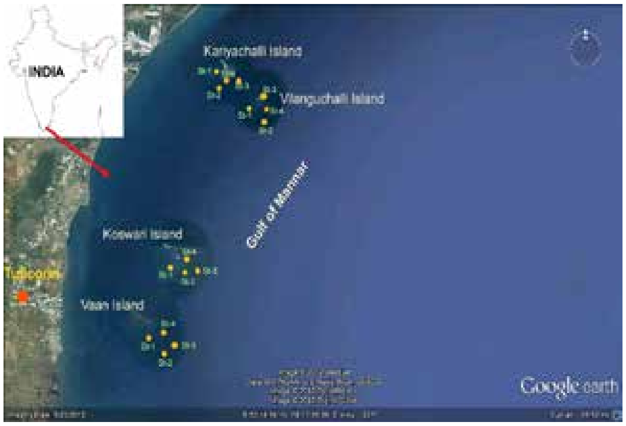

Fig. 1: Map showing Kariyachalli Islands

2. MATERIALS AND METHODS

2.1. Disease Identification

The coral diseases were identified by following the coral disease handbook of Raymundo and Harvell, (2008) by the following steps.,

a) Lesion

Lesions are the dots that indicate wounds seen in corals focal is a dot, multifocal is a dots that keep appearing over a period of time and diffuse is the dots that keeps accumulating on a corals spot.

b) Rate of Improvement of a Coral

This indicates the time the coal suffers, whether it spreads or not, as well as the recruitment process of new corals. This can be measured by day, week, month, or even year. It can be classified as Rapid, Moderate and not progressing.

Indicator	Description
Rapid	Acute
Moderate	Sub acute
Not Progessing	Chronic

c) Lesion Colour

The colour of the lesion that affects the coral can be white, yellowish, pink, or even black. Each colour indicates a different disease that the coral suffers.

d)Line of Indicator

This describes the 4 categories that people use to identify a disease which are colour, thickness, shape, and dividing line.

Indicator	Description
Colour	The colour of the line seen at the coral
Thickness	Describes how thick the lesion is. Usually, the thinner the better, the thicker the sicker the coral is.
Shape	The shape can vary through the different diseases such as., linear, annular, and irregular
Dividing Line	The lines that one can see in between the affected corals and the healthy ones

2.2. Assessment of coral diseases

Assessment was carried out in Kariyachalli Island of Gulf of Mannar from January 2013 to December 2013. Study location was selected in Kariyachalli Island randomly using Manta tow technique. In total 2 sites are located around Kariyachalli Island in two different depth sites (<2m depth and >2m depth). Surveys were conducted using the Line Intercept Transect (LIT) method to quantify coral disease prevalence (English et al., 1997). 8 transects were laid in each site, transect covers an area measuring 20 X 4 m (2 m on each side of the transect line) and 20 m distance was given between each transect.

Disease prevalence in a study site is calculated by a simple formula;

$$\text{Disease prevalence} = \frac{\text{Number of diseased colonies per site}}{\text{Number of colonies examined per site}} \times 100$$

3. RESULT

3.1. Identification of coral disease:

The coral diseases were identified by following the coral disease handbook of Raymundo and Harvell, (2008). Totally eight types had been observed they are as follows.,

White plaque disease (WPD), White band disease (WBD), Pink spot disease (PSD), Yellow band disease (YBD), Black band disease (BBD), Black spot disease (BSD), Yellow spot disease (YSD) and Tumors (T).

a) White plaque disease (WPD): It spreads and causes damage to the coral colonies. Affected portion extend around the healthy colonies and the affected portion gets colonized by secondary algae, which prevent the recovery from the disease. Affected colonies are often found dead. Sometimes recovery is observed in small lesion. Lesion was diffused, the rate of progression was sub acute. And colour was white with irregular shape.

b) White band disease (WBD): .White colour band was appeared. Disease affected colony dies more often. It has a high spreading rate. Pattern of the lesion are linear, the rate of progression was chronic and the border was discrete.

c) Pink spot disease (PSD): Pink colour lesion appears 3-5 mm diameter in the coral colony, affecting 3-4 polyps. Occasionally it extends around the colony and appears like pink line. Dead portion is occupied by filamentous algae. Lesion pattern was multifocal, the rate of progression was sub acute and the lesion border shape was discrete.

d) Black band disease (BBD): Dark brown or black bands between the live coral tissue and recently diseased dead portion. Disease spreading rate is higher in the summer. BBD affected portion gets colonized by secondary algae. Lesion was annular and liner, rate of progression was acute and the lesion border shape was discrete.

e) Black spot disease (BSD): Brown or black in colour, Black spot begins as small dark pigmented circles; affected portion loses the zooxanthellae. Lesion pattern was annular and irregular, rate of progression was sub acute and the lesion border shape was diffuse.

f) Yellow band disease (YBD): The leading edge of the band remains pale yellow or lemon coloured. Tissue previously affected gradually darkens prior to full tissue loss. Tissue loss is not high when compared with black band disease and dead portion gets colonized by secondary algae. Lesion was annular and linear, rate of progression was sub acute and the lesion border shape was diffuse.

g) Yellow spot disease (WSD): Acute tissue loss reveals intact bare skeleton. Sometimes lesions heal and disappear. Lesion pattern is annular, rate of progression was acute and the lesion border was discrete.

h) Tumor (T): Tumor affected coral colony would have sphere-shaped swelling (composed of the coral tissue and skeleton). Lesion pattern is diffuse, rate of progression was acute and the lesion border was diffuse.

3.2. Assessment of coral diseases

3.2 Total prevalence of coral diseases

Survey was carried out in the month of January 2013 to December 2013. Black band disease was the highest among diseases with 2.10% followed by white plaque disease with 1.82%. The other diseases recorded were White band, Pink spot, Yellow band, Black spot, Yellow spot and Tumor diseases with 1.74, 1.55, 1.31, 1.03, 0.93 and 0.18% respectively. 10.65% of the total live coral cover was affected by the disease (Fig 2).

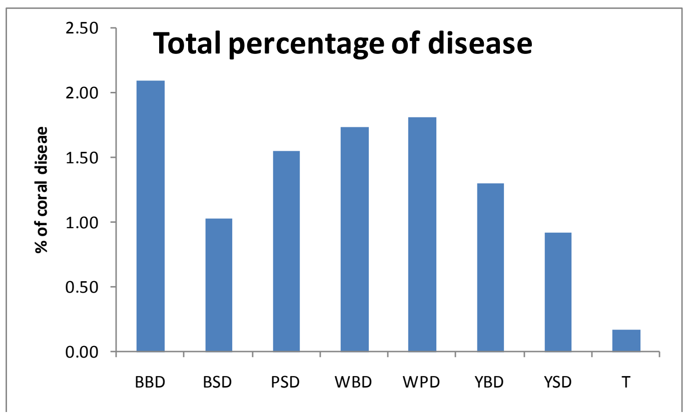

Fig. 2: Total coral disease prevalence in Kariyachalli Island

3.2.1. Depth wise prevalence of coral diseases

Two sites are fixed in Kariyachalli Island in depth gradient as <2m depth and >2m depth. Disease average differed in one type to another.

At <2 m depth, Black band disease was the highest among diseases with 2.83% followed by white band disease with 2.38%. The other diseases recorded were White plaque, Pink spot, Yellow band, Black spot, Yellow spot and Tumor diseases with 2.35, 1.82, 1.8, 1.33, 1.03 and 0.19% respectively. 13.73% of the total live coral cover was affected by the disease. (Fig 3).

At >2 m depth, Black band disease was the highest among diseases with 1.37% followed by white plaque disease with 1.29%. The other diseases recorded were Pink spot, White band, Yellow spot, Yellow band, Black spot and Tumor diseases with 1.28, 0.82, 0.81, 0.73 and 0.16% respectively. 7.56% of the total live coral cover was affected by the disease (Fig 4).

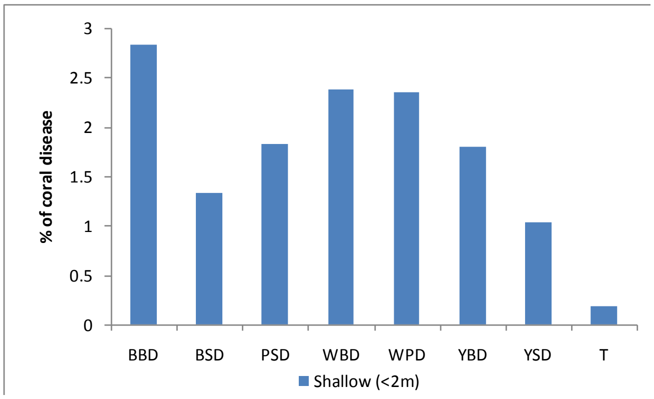

Fig. 3: Coral disease prevalence in Kariyachalli Island (<2m depth)

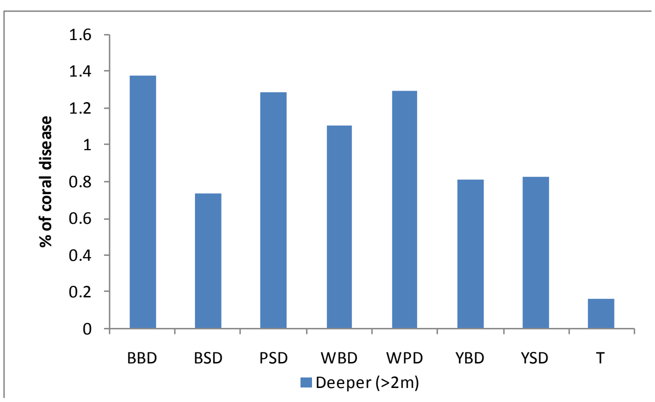

Fig. 4: Coral disease prevalence in Kariyachalli Island (>2m depth)

3.2.2. Diseased coral genera in Kariyachalli Island

Totally seven types of coral genera such as Acropora sp., Montipora sp., Favia sp., Favites sp., Porites sp., Goniastrea sp. and Turbinaria sp. were found with diseases. The coral genus Porites sp. showed severe damage was found to be affected by six different types of diseases (BBD, PSD, WBD, WPD, YBD and YSD) so it is a dominant coral genera affected by disease followed by Acropora sp. in BBD, WBD and WPD. And other genera Montipora sp. was affected by WBD, Favia sp., Goniastrea sp. and Favites sp. were affected by BSD, and Turbinaria sp. was affected by WPD.

3.2.3. Disease affected coral size class in Kariyachalli Island

The most affected coral size class category in <2m depth site was 21-40 cm gets affected by BBD, BSD, WBD and WPD as 0.86, 0.6, 1.38 and 0.7% followed by size class of 81-160 cm gets affected by PSD, WPD, YBD and YSD as 0.54, 1.21, 0.16 and 0.27% followed by 41-80 cm gets affected by BBD, BSD, WBD, WPD, YBD and YSD as 0.31, 0.28, 0.15, 0.18, 0.29 and 0.8% (Fig 5).

The most affected coral size class category in >2m depth site was 21-40 cm gets affected by BBD, BSD, WBD and WPD as 0.43, 0.19, 0.67 and 0.63% followed by size class of <160 cm gets affected by PSD and WPD as 0.67 and 1.15% followed by 81-160 cm gets affected by PSD, WPD, YBD and YSD as 0.38, 0.95, 0.23 and 0.18% (Fig 6).

4. DISCUSSION

Coral disease has clearly been a major cause of coral mortality in past few decades. A dramatic decline of coral reefs over past few decades (Kuta and Richardson, 1996; Pandolfi et al., 2003) has been noted. Recent surveys conducted in Australia (Willis et al., 2004), Western Indian Ocean (McClanahan, 2004), Philippines (Raymundo et al., 2004), and Red Sea (Loya et al., 2004) illustrate the widespread, global distribution of coral diseases in the Indo-Pacific region. Already 19% of the world coral reefs have been lost and a further 35% is seriously threatened (Wilkinson, 2008). Willis et al. (2004) recorded a prevalence of 7.2-10.7% coral diseases in eight sites along the Great Barrier Reef. Raymundo et al. (2005) recorded 14.2% diseases in eight sites in the Philippines. Santavy et al. (2001) assessed coral disease at 32 stations throughout the Florida Keys and found disease prevalence to range from 1.0% to 28.2%. Considering these percentages, the percentage of diseased corals in Palk Bay is significantly high. The present study in Kariyachalli Island showed an increasing trend in the disease prevalence during the course of the study (January 2013 to December 2013). Totally 10.65% of the total live coral cover was affected by the disease, among them 13.73% from depth of <2m and 7.56% from depth of >2m. Totally 8 distinct types of coral diseases

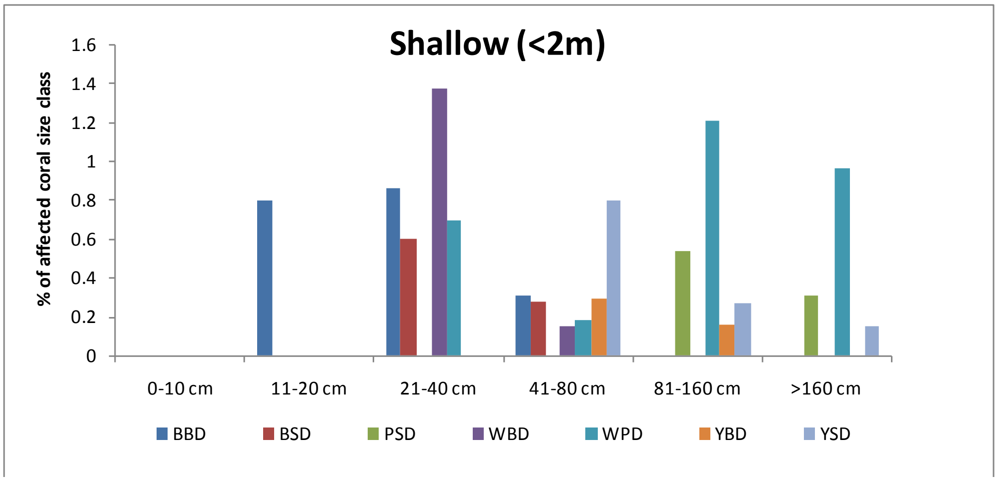

Fig. 5: Disease affected coral size class in <2m depth of Kariyachalli Island

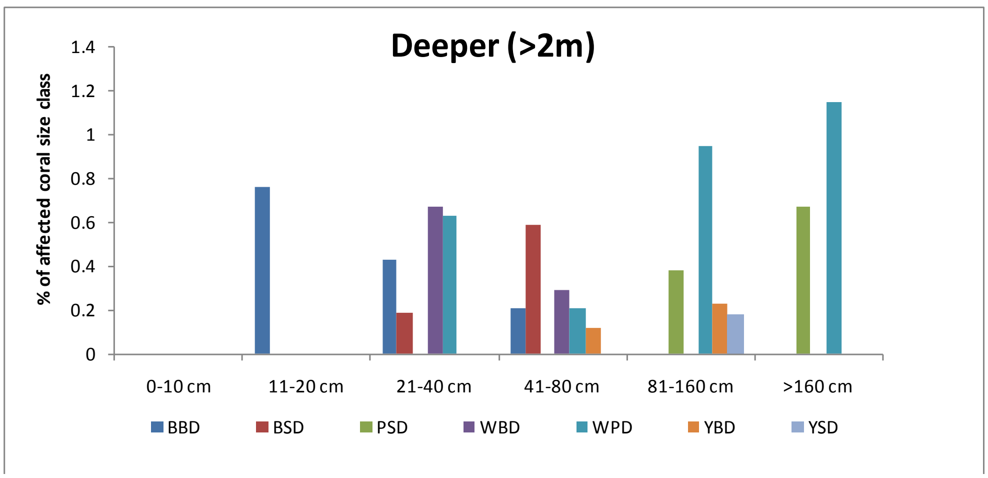

Fig. 6: Disease affected coral size class in >2m depth of Kariyachalli Island

were recorded in the studied area. Seven major coral genera were affected by diseases in Kariyachalli Island; Primarily Porites followed by Acropora sp., Montipora sp., Favia,sp., Favites sp., Goniastrea sp. and Turbinaria sp. Coral colony with the size of 21-40 cm was mostly affected. Dominant disease black band was found to affect 11-10 cm, 21-40 cm and 41 to 80 cm size coral colonies heavily.

5. CONCLUSION

The coral reefs in the Gulf of Mannar (GoM) are severely damaged by human impacts mainly coral mining, destructive and unsustainable fishing practices, industrial and domestic pollution and coastal developmental activities. In order to keep the coral health in Kariyachalli Island, anthropogenic stress due to pollution should be minimized in a span of time and immediate large scale research support to investigate these problems have to be implemented so that the reefs could be saved.

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ENUMERATION OF FOLIICOLOUS LICHEN BIOTA IN SHIVAMOGGA DISTRICT, KARNATAKA

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ABSTRACT

Foliicolous lichens are one of the poorly documented groups of organisms found exclusively in evergreen forests. Very few works has been done on this group of lichens in India. Hence, the present study is carried out to document the diversity of foliicolous lichens in evergreen, shola and semi-evergreen forest patches of Shivamogga district, Karnataka, India. Thirty three species of foliicolous lichens are documented in the present study belonging to 16 genera and nine family. Among them Porina multiloculata, P. epiphylla, P. karnatakensis and are the most dominant species. Whereas, Mazosia bambusae, Porina nitidula, P. semecarpi, P. microcarpa and Tapellaria phyllophila are less dominant species. Calamus thwaitesii supports wide range of foliicolous lichens. Cinnamomum macrocarpum, Dimocarpus longan, Memecylon malabaricum and Pinanga dicksonii are the other important plant species commonly supporting the foliicolous lichens in the study area. In the small study area we have selected, we are able to document 33 species of epiphyllous lichens. More exploration may yield many additions to the present knowledge.

Key words: Epiphyllous, mazosia, porina, shola, tapellaria

1. INTRODUCTION

Lichens are complex organisms involving in a symbiotic relationship between a photobiont and a mycobiont. These can grow in various habitats from ice cold region to hot desserts. All most all materials can act as substrate for these organisms. But trees can be considered as major substrate provider and hence, we can see a large number of epiphytic lichens. These epiphytes frequently cover the bark of trees, shrubs and lianas (corticolous lichen) as well as leaf surfaces (foliicolous lichens). Due to difficult taxonomy and accessibility complete site inventories of foliicolous lichens is not yet carried out in paleotropical country like India.

As many as 925 species of foliicolous lichens have been recorded worldwide. Over 380 species (62 genera) of foliicolous have been described from Asia, which includes 135 species from India and its island territories (Awasthi, 2010). The information on occurrence of these lichens is far from complete for the Western Ghats. Shivamogga is in the central region of the Western Ghats and has very diverse vegetation and climatic conditions. It is an adobe for life. Hence, the present study is aimed to enumerate diversity of foliicolous lichens in evergreen, shola and semi-evergreen forest patches of Shivamogga district, Karnataka, India.

2. MATERIALS AND METHODS

The Western Ghats in Karnataka state is spread across seven districts and it hosts various vegetation types like tropical evergreen forests, moist deciduous forests, dry deciduous forests, scrub jungles, sholas, savannas including high rainfall savannas, peat bogs and Myristica swamps. Shivamogga district is in the central part of this region and it comprises all most all vegetation types present in the Western Ghats. This area is not previously explored for the diversity of foliicolous lichens. During the present investigation we selected four study sites representing two vegetation types; in which Agumbe and Chakra-nagara study sites represent evergreen forest and Kodachadri, Joga represent moist deciduous forest. We considered only two forest types for the study because the foliicolous lichens are only found in evergreen and moist deciduous forests. Latitude, longitude and altitudes of sampling sites noted down using hand-held GPS (Garmin Etrex, USA). Map of the study sites created in Quantum GIS (Version 1.7.4, Figure 1).

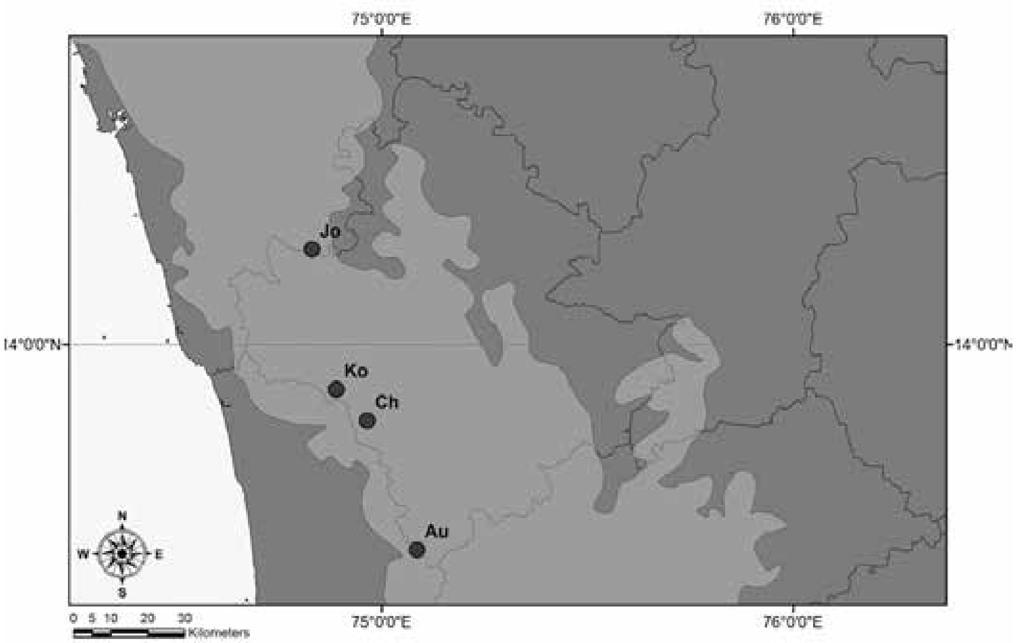

Figure 1: Study area showing sampling points. Au-Agumbe, Ch-Chakra-nagara, Ko-Kodachadri, Jo-Joga

The sampling sites were repeatedly surveyed for foliicolous lichens during August 2012 to July 2013. Foliicolous samples were collected using the methodology described by Lücking & Lücking (1996) in Gradstein et al. (1996). Fifty meter square quadrats laid in a homogenous stand of forest and phorophytes reaching a height of up to 3 meter were considered for sampling both in the shady understory and in the light gap microsites of the understory vegetation. From each phorophyte individuals, a single branch with comparatively much foliicolous lichen was selected as a sample and up to 10 leaves having foliicolous lichens were collected. Not more than 50 specimens were collected from a single quadrat. Samples from different phorophytes were put into different paper pouches and labelled with a field number. In the field note book field numbers were noted and under each of its details about the specimens like collection date, time, collector's name, phorophyte name, GBH, sample location in the phorophyte and other characters. The host tree species were identified with the help of published floras (Gamble, 2000).

Thus collected leaves were brought to the laboratory and cleaned. Leaves were pressed under slight pressure to make herbaria. Lichen colonies were observed under stereomicroscope and marked. Colonies were cut into small pieces, pasted to a thick white paper card of dimension 13 x 10 cm and are put into herbarium packets. The lichen herbarium packets of 13.5 x 11.5 cm were made with a thick brown paper. Printed labels giving full details of the specimens pasted on the herbarium packets. Voucher specimens of all collections have been deposited in the herbarium of the Department of Applied Botany, Kuvempu University, Karnataka and important specimens were in CSIR – National Botanical Research Institute herbarium (LWG), Lucknow.

Identification of specimen of foliicolous lichens was based on examination of morphological and anatomical features. Morphological characters of thallus, ascomata and conidiomata were examined under stereomicroscope. Hand cut sections and squash preparations were made for studies of the anatomy of thalli and reproductive structures, including perithecia, apothecia, campylidia, pycnidia, and hyphophores and examined under Carl Zeiss Stemi 2000C stereomicroscope and Carl Zeiss Primo Star microscopes. Photographs were taken with AxioCamERc5s camera mounted on the microscope and stereoscope. Images were processed in Axio Vision LE (AxioVs40 V 4.8.2.0) software. Anatomical characteristics were observed on hand cut sections mounted in water and 10% KOH (K). The amyloid reaction of the ascus was studied in Lugol's solution (0.2% I and 0.6% KI) after pre-treatment with KOH. All measurements of refer to material examined in water. Microchemical reactions and spot tests were performed according to Orange et al. (2001).

The general classification of foliicolous lichens up to generic level was followed as per the keys by Lücking (1992) and the internet key developed by Lücking (2000). More detailed identification is done by using the manuals viz., Foliicolous lichenized fungi – Flora Neotropica Monograph (Lucking, 2008); A Key to the Microlichens of India, Nepal and Sri Lanka (Awasthi, 1991). Foliicolous Lichen nomenclature followed according to Lücking et al. (2000) for species described until 2000 and for species described after 2000 the most recent literature for the taxon are followed. The online Data base services like Encyclopaedia of Life (www.eol.org) and JSTOR Global Plants (http://plants.jstor.org/) are also browsed for synonyms and other taxonomic queries. The phorophytes names were followed as per database of http://www.theplantlist.org/ and http://www.tropical.org/.

3. RESULTS AND DISCUSSION

A total of 33 species of foliicolous lichens belonging to 16 genera and nine families recorded from the four sampling site of Shivamogga district (Table 1). Among all sampling sites, Agumbe is the richest place for the diversity of foliicolous lichens followed by Chakra-nagara, whereas, Kodachadri is the least diverse. Porina karnatakensis, Tricharia allostrigosa and P. multilaculata were the most frequent species. Whereas, many taxa (Badimia pallidula, Byssoloma leucoblepharum, Calopadia puiggarii, Fellhanera fuscatula, F. rhapidophylli, Graphis foliicola var. major, Mazosia bambusae, Porina microcarpa, P. nitidula, P. semecarpi, and Tapellaria phyllophila) were observed only once during the study, indicating the critical distribution. Some important species found in the study area are given in fig 2 and 3. The lichen family Trichotheliaceae is the most common comprising 14 species in two genera (Porina=13 species and one Trichothelium species). Echtolechiaceae is the most diverse family with four genus and five species. Pilocarpaceae is the other important family represented by seven species in three genera. Whereas, Bacidiaceae, Roccellaceae, Graphidaceae, Gyalectaceae represented by one species each.

Table 1: Foliicolous lichen in four study sites

Foliicolous Lichen Taxa	Family	Agumbe	Kodachadri	Chakra-nagara	Joga	Shivamogga (Total)
Bacidia apiahica	Bacidiaceae	2	0	0	0	2
Badimia pallidula	Echtolechiaceae	1	0	0	0	1
Bullatina aspidota	Gomphillaceae	5	0	0	0	5
Byssolecania fumosonigricans	Pilocarpaceae	1	0	1	0	2
Byssoloma leucoblepharum	Pilocarpaceae	1	0	0	0	1
Byssoloma subdiscordans	Pilocarpaceae	1	1	0	0	2
Calopadia fusca	Echtolechiaceae	2	0	0	1	3
Calopadia puiggarii	Echtolechiaceae	1	0	0	0	1
Coenogonium luteum	Coenogoniaceae	3	0	2	0	5
Fellhanera bouteillei	Pilocarpaceae	2	0	0	0	2
Fellhanera fuscatula	Pilocarpaceae	1	0	0	0	1
Fellhanera rhapidophylli	Pilocarpaceae	0	1	0	0	1
Fellhanera semecarpi	Pilocarpaceae	0	0	3	0	3
Graphis foliicola var. major	Graphidaceae	0	0	1	0	1
Gyalectidium filicinum	Gyalectaceae	3	0	1	0	4

Mazosia bambusae	Roccellaceae	1	0	0	0	1
Porina atriceps	Trichotheliaceae	2	0	0	1	3
Porina epiphylla	Trichotheliaceae	9	2	1	1	13
Porina fulvella	Trichotheliaceae	0	2	0	0	2
Porina karnatakensis	Trichotheliaceae	9	2	3	2	16
Porina microcarpa	Trichotheliaceae	0	0	0	1	1
Porina multiloculata	Trichotheliaceae	5	3	1	3	12
Porina nilgiriensis	Trichotheliaceae	4	0	2	0	6
Porina nitidula	Trichotheliaceae	1	0	0	0	1
Porina octomera	Trichotheliaceae	1	1	0	2	4
Porina pallescens	Trichotheliaceae	0	0	2	0	2
Porina palniensis	Trichotheliaceae	1	1	0	0	2
Porina santessonii	Trichotheliaceae	3	0	2	0	5
Porina semecarpi	Trichotheliaceae	1	0	0	0	1
Sporopodium xantholeucum	Echtolechiaceae	1	2	2	4	9
Tapellaria phyllophila	Echtolechiaceae	1	0	0	0	1
Tricharia allostrigosa	Gomphillaceae	3	2	3	7	15
Trichothelium alboatrum	Trichotheliaceae	4	0	0	0	4

The diversity indices for each study sites and overall diversity for Shivamogga is calculated separately. The Shannon index for the foliicolous lichens in Shivamogga is 3.072 which can be considered as good. The Simpson (1-D) is found to be 0.9369 for Shivamogga. The alpha diversity indices values for individual study sites is given in the table 2.

Table 2: α diversity indices of four sampling sites and Shivamogga district in total

	Agumbe	Kodachadri	Chakra-nagara	Joga	Shivamogga
Taxa_S	27	10	13	9	33
Individuals	69	17	24	22	132
Dominance_D	0.0649	0.1142	0.09028	0.1777	0.06313
Simpson_1-D	0.9351	0.8858	0.9097	0.8223	0.9369
Shannon_H	2.996	2.232	2.477	1.944	3.072

Moist deciduous forests in Kodachadri and Joga shares similar diversity (J=0.4615), whereas, other two sites of evergreen forest (Agumbe & Chakra-nagara) have similar foliicolous lichen biota. This is also in accordance to the forest types that is sites with evergreen forest were similar and sites with moist deciduous forest are similar (Figure 2). But the similarity index in between evergreen forest is less compare to moist deciduous forest. This is because, in evergreen forest each study sites comprises unique species composition whereas, in moist deciduous study sites more number of same species observed.

Strigula was predominantly colonize on the leaves of C. malabatrum. The lichen genera Tricharia and Aderkomyces were found on Calamus thwaitesii and Pinanga dicksonii. Hence, we observed some kind of affinity between lichens and phorophytes. There were no effects of vertical zones on distribution of the lichens on any phorophyte species, this is because we considered only below three meter height plants for the lichen collection and there is no significant different between height classes.

4. CONCLUSION

The present study is the first attempt to enumerate the foliicolous lichens in the Western Ghats. Although we selected small study area (Shivamogga), we are able to record good number of foliicolous lichens. The difference in the diversity profile between the forest types is also substantial. More study related to the lichen-phorophyte affinities needed to confirm any kind of specificity. A detailed explo-

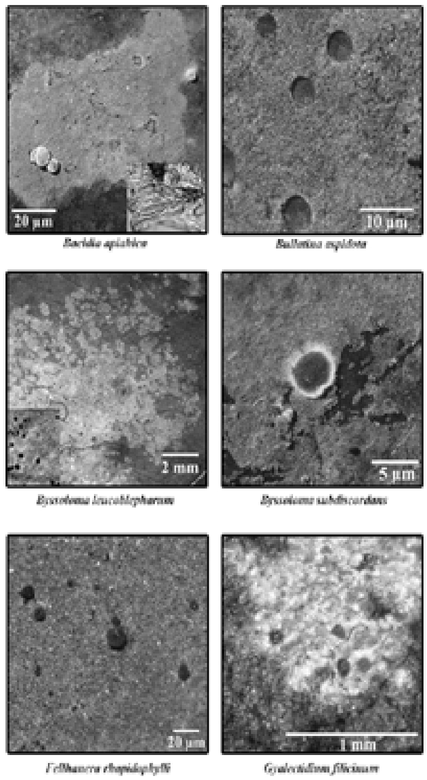

Figure 2: Some Interesting Foliicolous lichens of Shivamogga district

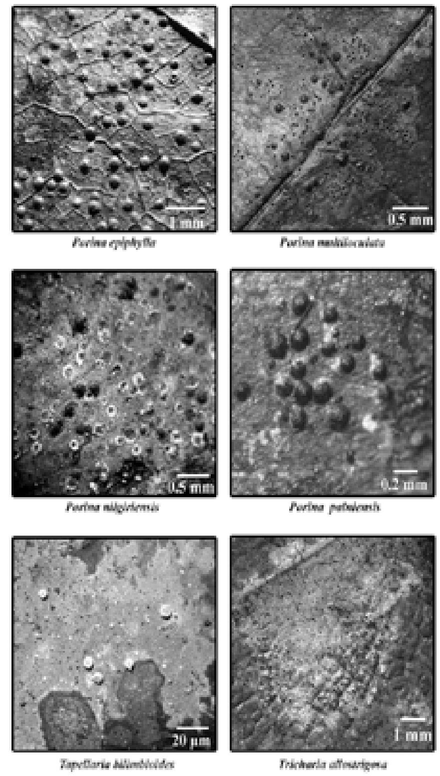

Figure 3: Some Interesting Foliicolous lichens of Shivamogga district

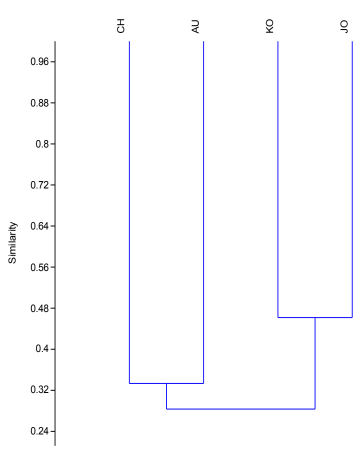

Figure 4: Cluster diagram of Jaccard index for beta diversity showing the similarity

The Morishita beta diversity index between the study sites were given in Table 3. This index shows that the diversity between Kodachadri and Joga were similar i.e., more than 70% (0.71454) of the species found in these two sites were same. Whereas, less than 40% of the foliicolous lichens found in Agumbe and Joga were same. The beta diversity between other study sites was moderate.

Table 3: Morishita beta diversity index between study sites.

	Agumbe	Kodachadri	Chakra-nagara	Joga
Agumbe	1	.	.	.
Kodachadri	0.59027	1	.	.
Chakra-nagara	0.59149	0.50347	1	.
Joga	0.39647	0.71454	0.5513	1

3.1. Lichen-Phorophyte Affinity

The plants that provide substrate for the lichens are considered as phorophytes instead of host. The plant species like, Arenga wightii and Calamus thwaitesii support wide range of lichens. Cinnamomum macrocarpum, Dimocarpus longan, Hopea parviflora, Knema attenuata, Litsea floribunda, Memecylon malabaricum, M. talbotianum, M. umbellatum and Pinanga dicksonii were the other plants supporting highest number of foliicolous species. The genus ration is also needed to know the complete diversity of the foliicolous lichens in the Western Ghats.

5. ACKNOWLEDGEMENT

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TAXONOMY, SYSTEMATICS AND DISTRIBUTION OF MARINE ORNAMENTAL CRABS (CRUSTACEA: DECAPODA: BRACHYURA) ALONG CHENNAI COAST, TAMIL NADU, INDIA

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ABSTRACT

The present study discusses the Taxonomy, Systematics and Distribution of marine ornamental crabs in Chennai coast, Tamil Nadu, India. The brachyuran crabs collected from three different stations (Kasimodu, Marina and Besant Nagar) included 18 different species coming under 14 genera: Calappa, Matuta, Jonas, Arcania, Lyphira, Cryptopodia, Parthenopidae, Charybdis, Lupocyclus, Demania, Neoxanthias, Liagore, Eurypanopeus, Eucrate and in the order of Decapoda and family Calappidae, Corystidae, Leucosidae, Parthenopidae, Portunidae, Xanthidae and Euryplacidae viz., Calappa capellonis, Calappa clypeata, Calappa lophos, Calappa philargias, Matuta planipes, Jonas choprai, Arcania elongata, Lyphira perplexa, Cryptopodia angulata, Parthenope longimanus, Charybdis natator, Charybdis feriatus, Lupo cyclus philippinensis, Demania indiana, Neoxanthias michelae, Liagore rubromaculata, Eurypaenopus orieantalis and Eucrate indica. The crabs were enlisted based on the taxonomic positions in terms of species availability and key characters. In this study, 06 (Jonas choprai, Cryptopodia angulata, Lupocyclus philippinensis, Demania Indiana, Liagore rubromaculata, and Eurypaenopus orieantalis) species of brachyuran crabs were recorded for the first time in Chennai coast and 02 species (Neoxanthias michelae and Eucrate indica), of crabs were recorded for the first time in Indian waters. These crabs with attractive color and morphological features make themselves as good candidates for aquarium purpose.

Key words: Taxonomy, systematics, distribution, decapods

1. INTRODUCTION

In recent years, considerable efforts have been focused on the minimization of negative impacts caused by the harvest of marine ornamental species from the wild (Wood, 2001). Nevertheless, the marine segment of the aquarium trade industry still predominantly relies on wild collected specimens, with over 90% of the traded species being taken from coral reefs (Tlusty, 2002). The growing demand of highly priced marine ornamentals has contributed to the endangered status of certain groups such as syngnathid fishes, stony corals, and giant clams (Bruckner, 2001). Although fishes and corals are still the most heavily traded ornamental marine species for the aquarium, many decapod species are also highly popular among hobbyists. In addition, a few freshwater decapods have also been recently targeted by the aquarium trade (Lukhaup, 2002): species of Caridina H. Milne Edwards, 1837; Neocaridina Kubo, 1938; and Cherax Erishson, 1846. Marine decapods receive the "ornamental status" mainly because of their dazzling coloration and delicacy, hardiness in captivity, and by being "reef safe" (they do not harm other aquarium organisms). Nevertheless, if a species presents mimetic adaptations, displays associative behavior (particularly fish cleaning and symbiotic association), or performs a specific function on the reef aquarium (such as eating nuisance organisms), it may also be targeted by the marine ornamental industry.

The efforts on conservation and management of decapod crustaceans have long been entirely focused on crustacean fisheries for human consumption. However, once ignored crustacean species are now highly valued resources, commending high market prices in the aquarium industry. The growing awareness on the pressure caused by the harvest of wild populations has urged the need to implement sustainable collection practices and regulations to develop proper culture technologies (Calado et al., 2003).

Decapod crustaceans are very common invertebrates inhabiting the marine environment. Brachyuran crabs comprise approximately 5000 species worldwide (Melo, 1996) and, due to their great abundance, they may be considered as one of the most relevant groups of the marine benthos, both in terms of biomass and community structure. In India 705 brachyuran crab species, 28 families, 270 genera have been reported (Venkataraman and Wafar, 2005). Tamil Nadu coast has 404 species of crabs belonging to 26 families and 151 genera (Kathirvel, 2008). There were number of studies about the diversity of brachyuran crabs in Chennai coast (Thangaraj Subramanian, 2001; Krishnamoorthy, 2007; Lakshmi Pillai and Thirmilu, 2008). Hence, the present study emphasized 18 species of ornamental crabs belonging to 14 genera and 07 families were recorded. These crabs are attractive color and morphological features make them good candidate for aquarium purpose.

2. MATERIALS AND METHODS

2.1. Study region

Brachyuran crabs were collected from coastal areas of Chennai specifically at Kasimodu (Station-I), Marina (Station-II) and Besant Nagar (Station-III) fish landing centers (Fig.1) located in southeast coast of India, Tamil Nadu.

Sample collections were carried out for a period of one year (July 2013-June 2014). Collections were made by intensively visiting landing centres and collecting live and dead animals. The animals were brought to the laboratory, cleaned with brush and identified using appropriate references (Alcock, 1898; Sakai, 1976; Deb, 1986; Galil and Clark, 1994; Chen and Ng, 1999 and 2004; Krishnamoorthy, 2007).

3. RESULTS AND DISCUSSION

A total of 18 species of ornamental crabs belonging to 07 families and 14 genera were recorded from Chennai coast. Hence, emphasis is given on their spectacular color, certain striking patterns on their carapace and chelipeds, size and availability. Among the three stations, Kasimedu has maximum species richness in terms of ornamental crabs. 18 species of ornamental crabs were recorded in Kasimedu followed by 14 species in Marina and 12 species in Besant Nagar.

Totally 778 species crabs were collected from the above said stations and they were identified viz., Calappa capellonis, Calappa clypeata, Calappa lophos, Calappa philargias, Matuta planipes, Jonas choprai, Arcania elongata, Lyphira perplexa, Cryptopodia angulata, Parthenope longimanus, Charybdis natator, Charybdis ferriatus, Lupocyclus philippinensis, Demania indiana, Neoxanthias michelae, Liagore rubromaculata, Eurypaenopus orieantalis and Eucrate indica. Among these, the highest species composition of Matuta planipes, Arcania elongata, Charybdis feriatus, Charybdis natator, Calappa lophos, Calappa capelonis, Calappa clypeata observed in all the three stations and minimum numbers of Neoxanthias michelae species were observed in station-I (Table-1 and Fig-1). At the outset, the maximum percentage composition was observed for Matuta planipes (19.5%) and the minimum (0.1%) of Neoxanthias michelae. Thus the present study revealed that the maximum species distribution was observed in Station 1 followed by 2 and 3, respectively (Fig-2). In this study, 06 (Jonas choprai, Cryptopodia angulata, Lupocyclus philippinensis, Demania Indiana, Liagore rubromaculata, and Eurypaenopus orieantalis) species of decapodans were recorded for the first time in Chennai coast and 02 species (Neoxanthias michelae and Eucrate indica), of crabs were recorded for the first time in Indian waters. These crabs with attractive color and morphological features make themselves as good candidates for aquarium purpose.

The crabs are marketed at very nominal rate as raw material for fish/poultry meal and fertilizer preparation. Their capture from the wild may have determined impact as they are an important entity in the natural ecosystem. Hence for aquarium / ornamental purpose, they should be reared and suitable protocols developed for larval rearing as depending only on the wild can lead to increased exploitation also. Unfortunately for most of the species, larval development is unknown. Most of the crabs form association with hard and soft corals, echinoderms, sponges and mollusks regarding which further studies are needed. These ignored species can attain the status of highly valued crustaceans in the aquarium industry if culture techniques are standardized and behavioural pattern studied. The marine segment of the aquarium trade industry still predominantly relies on wild collected specimens, with over 90% of the traded species being taken from coral reefs (Tlusty, 2002).

Table 1: Distribution of Ornamental crabs along the three stations of Chennai coast

S.No	Name of Species	Station-I	Station-II	Station-III	Total
1	Calappa capellonis	39	16	12	67
2	Calappa clypeata	29	16	21	66
3	Calappa lophos	36	21	19	76
4	Calappa philargias	19	07	10	36
5	Matuta planipes	72	39	41	152
6	Jonas choprai	06	0	02	08
7	Arcania elongata	36	17	21	74
8	Lyphira perplexa	16	09	15	40
9	Cryptopodia angulata	02	0	0	02
10	Parthenope longimanus	19	10	12	41
11	Charybdis natator	32	19	21	72
12	Charybdis ferriatus	27	17	31	74
13	Lupocyclus phillipinensis	04	02	06	12
14	Demania indiana	03	0	0	03
15	Neoxanthias michelae	01	0	0	01
16	Liagore rubromaculata	12	11	15	38
17	Eurypaenopus orieantalis	06	0	04	10
18	Eucrate indica	05	0	0	04
	Total	363	184	230	778

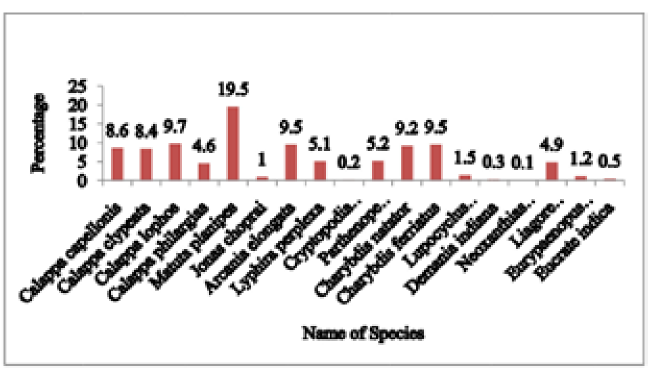

Fig 1: Percentage of Ornamental crabs along Chennai coast

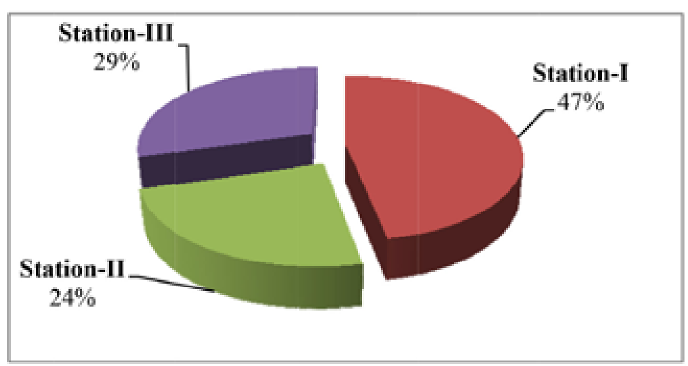

Fig 2: Station wise distribution of Ornamental crabs along the Chennai coast

3.1. Taxonomical details of ornamental crabs

Phylum-Arthropoda; Super Class- Crustacea; Sub Class- Malacostraca; Super Order –Eucaridae; Order –Decapoda; Infra Order- Brachyura; Sub Order- Dendrobrachiata; Section- E u - branchyura; Family- Calappidae Dana, 1852; Sub Family- Calappinae Alcock, 1896; Genus- Calappa Weber, 1795;

1. Calappa capellonis Laurie, 1906

Description: Front thick and obtusely truncate, covered with coarse tubercles, hepatic regions depressed.

Color: Dark orange to red brown.

Distribution: Indo-Pacific, Chennai, Bay of Bengal, north east and Western Australia and Korea coast.

Remarks: It is easily distinguished from other species occurring in the area by its posterior border produced beyond the level of the margins of clypeiform expansions.

2. Calappa clypeata Boradaile, 1903

Description: The posterior border is produced pronouncedly beyond the level of the posterior margins of the clypeiform expansions.

Color: Greenish yellow

Distribution: Indo-Pacific, Chennai, Bay of Bengal, north east and Western Australia.

Remarks: It is one of the common species available in the study area, throughout the year.

3. Calappa lophos (Herbst, 1782)

Description: carapace smooth, clypeiform expansion well developed, anterior border of endostominal septum deeply concave, no spine on the posterior border of the carapace in the middle.

Color: carapace red/brown in color with white lines, the chelipeds are white with irregular brown spots and markings.

Distribution: Indo-Pacific, East and West coast of India, Persian Gulf, Dares-Salam, Laccadives, Ceylon and Australia.

Remarks: This is a common species occurring throughout the year in the Chennai coast. It is easily distinguished by the smooth carapace, beaded posterior border with indistinct tooth.

4. Calappa philargius (Linnaeus, 1758)

Description: carapace smooth, anterior border of endostominal septum strongly convex and projecting; posterior border marked with three prominent spines; one in the middle and one on either side.

Color: Body light brown in color, the characterized by distinct brown/red spots two each claw and one around the eye.

Remarks: It is easily distinguished from other species occurring in the area by its posterior produced beyond the level of the margins of clypeiform expansions.

5. Matuta planipes Fabricius, 1798

Description: tubercle at the angle of propodus where it touches the external angle of the merus indistinct. Carapace coloured with vermicular red line, forming spots or incomplete rings on the anterior portion of the carapace. The posterior region with narrow longitudinal loops.

Color: Carapace with reticulating brown lines forming small rings anteriorly and larger, elongate loops posteriorly.

Distribution: Indo-Pacific: India, West Australia and Japan and North China.

Remarks: The presence of tubercle at the angle where the propodus comes in contact with distal lobule of the merus clearly distinguishes the species from other species.

FAMILY: CORYSTIDAE Samouelle, 1819

Genus: Jonas Jacquinot, 1853

6. Jonas choprai Serene, 1971

Description: Carapace distinctly oval, ca. 1.4 times longer than broad; dorsal surface distinctly glabrous, convex transversely and longitudinally, posterior twothirds covered with numerous small, sounded, evenly spaced granules, anterior half covered with lower and more obscure granules, frontal regions appearing almost completely smooth; regions well defined with prominent gastric and cervical grooves. The present record is the first report of this species from the study area. Registration number: 231.

Color: Diffused with Pale red color.

Distribution: Indo-Pacific: India: Parangipettai, Chennai, Taiwan

Remarks: This species differs from Jonas formosae by the form of inner super orbital spine, inner infra orbital spine, external orbital tooth, as well as form and proportions of the carapace.

FAMILY: LEUCOSIDAE Dana, 1852
SUBFAMILY: PHILYRINAE Rathbun, 1937
Genus: Arcania
7. Arcania elongata Yokoya, 1933

Description: carapace is circular and covered sparsely with uniform sized tubercles. Eleven spines present in the circumference of carapace, the one in the middle of posterior border the longest.

Color: Pale pinkish.
Distribution: Indo-Pacific: East coast of India, Ceylon, Japan and Singapore.
Remarks: It is distinguished from other species of this genus by the globular carapace with eleven spines on its margin. This species occurs rarely in the Chennai coast.

8. Lyphira perplexa Galil, 2009

Description: carapace convex and sub globular surface is smooth and polished.

Color: Orange brown.
Distribution: Indian Ocean, India and Persian Gulf.

Remarks: This species usually inhabits the intertidal area but every very often it comes in trawl and dredge collections and exhibits a variety of color patterns.

FAMILY: PARTHENOPIDAE Meirs, 1897
SUB FAMILY: ATHRINAE Dana, 1852
Genus: Cryptopodia H.Milne Edwards, 1834

9. Cryptopodia angulata Ed. and Lucas, 1841

Description: carapace pentagonal, posterior and posterolateral margins deeply dentate and all angles produced into curved spines. The present record is the first report of this species from the study area. Registration number: 232.

Color: Pink color.

Distribution: India, Maldives, Srilanka, Singapore, Australia and Gulf of Thailand.

Remarks: This species differs from Cryptopodia echinosa the carapace is more triangular in shape and the degree of granulation on its surface is high in Cryptopodia echinosa while the carapace of Cryptopodia angulata is more pentagonal shape, the branchial, gastric and cardiac regions are strongly inflated and gastric region is deeper in C. echinosa than in C. angulata.

10. Parthenope longimanus (Linnaeus, 1764)

Description: Carapace carinate, surface granular, cheliped enormously developed. The median rostral process thin.

Color: Reddish to light brown.

Distribution: Indo-Pacific: Phillipines, Gulf of Thailand, Ambonia, Ceylon, India and Maruities.

Remarks: This is one of the common species occurring throughout the year in the Chennai coast.

FAMILY: PORTUNIDAE Rafinesque, 1815

Genus: Charybdis

11. Charybdis natator (Herbst, 1794)

Description: Carapace is marked with several transverse granulated ridges. Chelipeds are considerably strong, covered with tubercles.

Color: carapace brown with the granulated ridges and tubercles bright red.

Distribution: Indo-Pacific: India, Southeast coast of Africa, Arabian Gulf, Pakistan and Srilanka.

Remarks: This species commercially exploited along Tamil Nadu coast.

12. Charybdis feriatus Linnaeus, 1758

Description: Carapace broader than long with six antero lateral teeth; six front teeth with round tip; arm with three sharp spines on anterior border and no spines on posterior border.

Color: Dark pink color with characteristic cross mark in the centre of carapace with white and pink color bands.

Distribution: Indo-Pacific: India, Southeast coast of Africa, Arabian Gulf, Pakistan and Srilanka.

Remarks: This species commercially exploited along Tamil Nadu coast.

13. Lupocyclus philippinesis Semper, 1880

Description: Carapace only slightly broader than long, covered with a short pile and patches of microscopic granules and granular ridges. Anterolateral border bearing six spiniform teeth, including outer orbital corner. Front cut into four triangularly shaped teeth, medians smaller but much more produced than laterals. The present record is the first report of this species from the study area. Registration number: 233.

Color: This crab uniformly yellowish with a dark band at the base of the fingers of the chelipeds and brown finger tips.

Distribution: Madagascar, the Seychelles, Karachi, north-west India (Konkan coast), Madras, the Andaman and Laccadive Islands, Thailand, Indonesia, the Philippines and Japan.

Remarks: The identity and distinction of the three very similar species L. philippinensis Semper, 1880, L. strigosus Alcock, 1899 and L. sexspinosus Leene, 1940 urgently need to be clarified by examination of the type material (where possible) and if needed by designation of a neo type for the lost type specimens of L. philippinensis.

FAMILY: XANTHIDAE Alcock, 1898

SUB FAMILY: XANTHINAE Alcock, 1898

ALLIANCE: HALIMDOIDAE Alcock, 1898

Genus: Demania

14. Demania indiana Deb, 1986

Description: Carapace pentagonal in shape; very convex fore and aft and moderately so from side to side, the dorsal surface of the carapace is with numerous small granules. The regional areoles covered with squamiform tubercles, most apparent and pointed along the antero lateral sides, almost absent or indistinct in the middle and anterior part; large, smooth and posterior side of the third carapace anterior part; large, smooth and posterior side of the third carapace is pea shaped. Registration number-178.

Color: In the natural environment Demania indiana is brick red in colour. When preserved in formalin the crab loses its color.

Distribution: East coast of India, Bay of Bengal, Chennai coast.

Remarks: Demaina indiana and Demania toxica are very similar morphologically in certain distinctive characters. When identified keenly, a prominent blunt spine or teeth on the upper left distal corner of merii of walking legs of D. indiana Deb are the recognized difference when compared with D. toxica Garth specimen.

Genus: Neoxanthias Serene & Vadon, 1981

15. Neoxanthias michelae Serene & Vadon, 1981

Description: carapace 2M very distinct, separating from 1M. 6L diversed into two lobules; posterior very smaller than other; 1R+2R. 4th tooth of anterolateral margin less protruded and much rounded. The present record is the first report of this species from Indian waters. Registration Number: 235.

Color: Brick red color.

Distribution: Taiwan, Philippines and India (Bay of Bengal).

Remarks: This species was described from relatively deepwater in the Philippines and has not been reported from elsewhere. It is an interesting new record for India.

16. Liagore rubromaculata De Haan, 1835

Description: Carapace quadrilateral, smooth, Chelipeds massive, carapace and chelipeds with large red spots.

Color: Carapace light brown with reddish spots and legs are with red bands.

Distribution: Indo-Pacific, India, Hongkong and Japan.

Remarks: The genus Liagore includes two species namely rubromaculata and L. erythmatica. The present study reveals that L. rubromaculata rare occurrence in Chennai coast.

17. Eurypaenopus orieantalis (Sakai, 1939)

Description: Carapace transversely sub ovate, length a little more than two thirds width; convex; surface naked and smooth to the naked eye, regions well defined. Fronto-orbital borders more or less half and front a third or little more than a third width of carapace. The present record is the first report of this species from the study area. Registration number: 229.
Color: The crab reddish orange in color.
Distribution: Japan, Sangmai Bay, Taiwan, Philippines and India (East coast).
Remarks: This species was described from relatively deepwater in the Japan (Sangmai Bay) and has not been reported from elsewhere. It is an interesting second new record for India.

FAMILY: EURYPLACIDAE Stimpson, 1871
Genus: Eucrate

18. Eucrate indica Castro and Ng, 2010.

Description: Carapace transversely hexagonal, antero lateral borders arched, three antero lateral teeth posterior to short, triangular outer orbital tooth. Orbits short, conspicuous notch between front, orbit, conspicuous notch on median portion, shallow notch on outer portion of curved, thick median lobe, eye peduncles short, as long corneas; large, spherical corneas. The present record is the first confirmed report of this species from Indian waters. Registration Number:

Color: Two large, irregular, red-brown spots on the median portion of the dorsal surface of the carapace, each flanked by two smaller, vertically placed spots. In formalin preservation the natural color is changed.

Distribution: Persian Gulf, India, Andaman Sea coasts of Thailand and Peninsular Malaysia.

Remarks: The populations that had been identified as E. alcocki from the Indian and Western Pacific oceans are clearly different in their carapace color patterns.

Fig: 3 Distribution of Ornamental crabs recorded along the Chennai coast

a) Calappa capelonis

(b) Calappa clypeata

(c) Calappa lophos

(f) Jonas choprai

(d) Calappa philargius

(g) Arcania elongata

(d) Calappa philargius

(h) Lyphira perplexa

(i) Cryptopodia angulata

(j) Parthenope longimanus

(k) Charybdis natator

(l) Charybdis feriatus

(m) Lupocyclus philippinesis

(n) Demania indiana

(o) Neoxanthias michelae

(r) Eucrate indica

(p) Liagore rubromaculata

(q) Eurypaenopus orieantalis

4. CONCLUSION

Thus we can conclude that the Chennai coast situated along the South east coast of India has provided sufficient taxonomical information and distribution of Ornamental crabs. Particularly the Matuta planipes, Arcania elongaa, Calappa lophos, Calappa clypeata, Liagore rubromaculata species are common in three study areas when compared to other species. The described information may be useful for identification of ornamental crabs. Key to genera and species has been given along with distribution of each species.

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DIVERSITY OF LITSEA IN CHIKKAMAGALURU DISTRICT, KARNATAKA

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ABSTRACT

The study gives a report on the diversity of Litsea (Lauraceae) occur in Chikkamagaluru district of Karnataka, India. Study was conducted in two habitats of Kemmannugundi and Mullayyanagiri regions. Extensive field surveys were conducted for survey of the species by laying six belt transects of 250×4 m size. The data indicated that four species of Litseaoccurred in the study sites; namely, Litsea floribunda, Litsea stocksii, Litsea glabrata and Litsea mysorensis. L. floribunda showed higher density when compared with other species, all the four species distributed frequently in Kemmannugundi whereas, in Mullayyanagiri only L.floribunda species is present. These trees commonly associated with other tree species are Cinnamomum verum, Neolitsea cassia, Maesa indica, Memecylon malabaricum and Syzygium cumini.

Key words: Associated species, Kemmannugundi, lauraceae, Mullayyanagiri, Western Ghats

1. INTRODUCTION

The genus Litsea consists of about 400 species which is largest genus in the family Lauraceae distributed in tropical and subtropical Asia, Australia, New Zealand, North America and subtropical South America (Chaing et al., 2012). In India about 45 species are distributed in evergreen and semi evergreen forests of the Western Ghats (Bhuniya et al., 2010), some species are also found in Meghalaya, Manipur, Assam and Sikkim. Among 45 species 40 of which are endemic to peninsular India, 11 species are found in Karnataka (Saldanha, 1996).

The Litsea trees are evergreen dioecious with alternate or whorled leaves, inflorescence is pedunculate axillary umbellate or corymbose racemes. Bracts are present, 4-6 in numbers perianth tube companulate, anthers four celled. Ovary free or covered by perianth, style curved, stigma dilated, fruit ovoid or globose (Gamble and Fischer, 1998).

Leaves and barks of Litsea stocksii and L. glutinosa are used as medicines. Essential oils like citral, lauric acid and oleic acid extracted are used commercially for the preparation of insecticides, perfumes, flavours and colognes. Oil extracted from Litsea cubeba is a good competitor of Chinese lemon oil due to its low cost of production and easy method of cultivation of the species. Decoction of different parts of the plant used to cure burns, sprains, cough, bronchitis and paralysis (Bhuniya et al., 2009).

The taxonomy of the family Lauraceae is still not settled compare to other families.It is poorly understood due to its great diversity, inadequate morphological characters and lack of investment in taxonomic work. Litsea is a very interesting tree species in Western Ghats of India occur in evergreen and semi evergreen forests, information on its diversity, distribution and genetic relatedness within populations are not fully explored. Hence in this present studywe focused to study the diversity and distribution of Litsea species in Chikkamagaluru district, Karnataka.

2. MATERIALS AND METHODS

2.1. Study areahe study area covers Kemmannugundi and Mullayyanagiri in Chikkamagaluru district situated between 12°54’ to 13°53’ N and 75°04’ to 76°21’ E in the Western Ghats regions of Karnataka (Fig.1). The sampling sites have rich forest vegetation such as evergreen and semi evergreen forests, the wide range of ecological conditions and altitudinal variation resulted in diverse vegetation in study area. Mullayyanagiri is the highest elevated region in Karnataka. In Kemmannugundi and Mullayyanagiri region the temperature varies between 10° to 32° C across the different months of the year.

Fig 1: Map showing sampling sites in Chikkamagaluru District, Karnataka

2.2. Tree sampling and Data analysis

Extensive field surveys carried out throughout the year to know the diversity distribution and phenology of the Litsea species. Stratified random sampling method is used to collect the tree data, three belt transacts of 250×4 m was laid in each study sites and girth was measured at breast height using a girth tape.

Species density, frequency, abundance, importance value index and basal area of plant were calculated by following Mishra (1968), Mueller-Dambois and Ellenberg (1974). The importance value index was calculated by summing of relative density, frequency and relative dominance.Species diversity index was calculated by Shannon Wiener index (1963), the species dominance index was calculated by using Simpson (1949).

3. RESULTS AND DISCUSSION

The four species of Litsea occurred in the two study sites; namely, Litsea floribunda, Litsea stocksii, Litsea glabrata and Litsea mysorensis. These four species collected from the study sites, identified through some morphological characters using standard floras and herbarium samples were prepared. L. floribunda is present in Kemmannugundi and Mullayyanagiri, but the L. stocksii, L. glabrata, L. mysorensis only present in Kemmannugundi region absent in Mullayyanagiri (Table.1).

The results showed that L. floribunda frequently present in all the transects, the frequency of L. glabrata is 0.67, L. mysorensis 0.33, L. stocksii 1.0. The L. floribunda showed highest density 46.67 and 33.67 it covers a basal area of 1904.79 m^2/ha and 885.27 m^2/ha (Table.1) in Mullayyanagiri and Kemmannugundi respectively, L. mysorensis showed lesser density and basal area compare to all the species.

Abundance and frequency (A/F) ratio of all the Litsea species in the study sites is >0.05, itshowed a clumped or contagious pattern of distribution this is because it is a dioecious tree, clumping of individuals of the same species is often clearly related to gap formation and dispersal, pollination mechanism of the species. Upadhaya et al. (2003) investigated on the same family members Cinnamomum and Neolitsea it also showed clumped pattern of distribution.

A total of 15 associated species belong to 10 families were recorded in both Kemmannugundi and Mullayyanagiri study sites (Table 2).Five species belong to family Lauraceae, this is because of preference of same environmental factors from the genera. Callicarpa, Cinnamomum, Cryptocarya, Neolitsea and Syzygium species are frequently distributed in all the transects of Kemmannugundi. Cinnamomum showed high density (21.33) per transect in Mullayyanagiri where as Memecylon, Ochlandra, Psychotria showed low density (0.33) in both the study sites (Table.2). Actinodaphne, Cryptocarya, Macaranga and Neolitsea cassia only present in Kemmannugundi absent in Mullayyanagiri region.

Shanon index is a diversity index taking into account of number of individuals as well as number of taxa. The Shanon and Simpson index of Kemmannugudi is 2.32, 0.82 respectively and 1.65, 0.69 in Mullayyanagiri respectively (Fig.2).According to Shanon and Simpson indices Kemmannugundi has highest species richness area compare to the Mullayyanagiri region. The Shanon index of the Kemmannugundi region is lower (2.32) compare to Sulimudi forests of Western Ghats, Kerala (2.64) (Magesh and Menon 2011) and Simpson value higher (0.82) compare to Vagamon region (0.36) (Brilliant et al., 2012).

Table 1: Frequency, density, abundance, IVI, A/F ratio of Litsea sp. in Kemmannugundi and Mullayyanagiri

Species	Fre	Den/ trans	Abun	RF	RD	RA	IVI	A/RF	Basal area m2/ha
Kemmannugundi									
Litsea floribunda	1.00	33.67	33.67	7.32	37.14	29.93	44.46	4.60	885.27
Litsea glabrata	0.67	2.00	3.00	4.88	2.21	2.67	7.09	0.61	1.77
Litsea mysorensis	0.33	1.00	3.00	2.44	1.10	2.67	3.54	1.23	0.48
Litsea stocksii	1.00	7.00	7.00	7.32	7.72	6.22	15.04	0.96	39.48
Mullayyanagiri									
Litsea floribunda	1.00	47.67	47.67	10.00	50.00	44.90	60.00	4.77	1904.79

Table 2: Frequency, density, abundance, IVI, A/F ratio of the associated species in Kemmannugundi and Mullayyanagiri.

Species	Kemmannugundi					Mullayyanagiri				
	Fre	Den/ Trans	Abun	IVI	A/F	Fre	Den/Trans	Abun	IVI	A/F
Actinodaphne sp.	0.33	1.67	5.00	4.28	2.05	-	-	-	-	-
Callicarpa tomentosa	1.00	2.67	2.67	10.26	0.36	1.00	1.67	1.67	11.75	0.17
Cinnamomum verum	1.00	11.00	11.00	19.45	1.50	1.00	21.33	21.33	32.38	2.13
Cryptocarya sp.	1.00	4.67	4.67	12.47	0.64	-	-	-	-	-
Glochidionsp.	0.67	3.67	5.50	8.92	1.13	0.67	3.00	4.50	9.81	0.68
Macaranga peltata	0.67	1.67	2.50	6.72	0.51	-	-	-	-	-
Maesa indica	0.67	4.33	6.50	9.66	1.33	1.00	3.67	3.67	13.85	0.37
Memecylon malabaricum	0.33	0.33	1.00	2.81	0.41	0.33	0.33	1.00	3.68	0.30
Neolitsea cassia	1.00	5.00	5.00	12.84	0.68	1.00	4.33	4.33	14.55	0.43
Neolitsea zeylanica	0.67	2.33	3.50	7.45	0.72	-	-	-	-	-
Nothapodytes foetida	0.33	1.33	4.00	3.91	1.64	0.67	2.33	3.50	9.11	0.53
Ochlandra travancorica	0.33	0.33	1.00	2.81	0.41	0.33	0.33	1.00	3.68	0.30
Psychotria nigra	0.33	0.33	1.00	2.81	0.41	0.33	0.33	1.00	3.68	0.30
Syzygium cumini	1.00	4.00	4.00	11.73	0.55	0.67	4.67	7.00	11.56	1.05
Vernonia arborea	0.33	1.00	3.00	3.54	1.23	0.33	0.33	1.00	3.68	0.30

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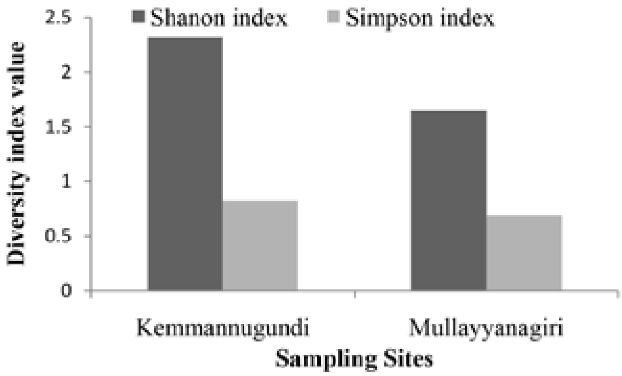

Fig 2: Shanon and Simpson diversity index in Kemmannugundi and Mullayyanagiri

4. CONCLUSION

This study revealed that the two study sites harboured four Litsea species (Fig 3) and Litsea floribunda showed good species richness. Litsea stocksii, Litsea glabrata and Litsea mysorensis showed low species richness in Kemmannugundi whereas these species absent in Mullayyanagiri. A total of 15 associated species belong to 10 families were recorded; Laural members are the dominant associated species in both the study sites.

Fig 3: Four Litsea Species

5. ACKNOWLEDGEMENT

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BIODIVERSITY AND CONSERVATION OF MARINE MAMMALS IN INDIA

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ABSTRACT

Marine mammals are a diverse group of about 120 species of mammal. They are primarily ocean-dwelling or depend on the ocean for their food. They include the cetaceans like whales, dolphins, and porpoises, the sirenians like manatees and dugong, the pinnipeds like seals and walrus and otters and polar bears. Several marine mammal species are under the categories, vulnerable or endangered due to commercial exploitation. At global level, most species are currently protected from commercial exploitation. In India, there are about 30 species of marine mammals. All these marine mammals are protected under Wildlife (Protection) Act, 1972 of India. In India, information available on the distribution of marine mammals is scanty. Information is mainly received from the stranding records, sightings, gear entanglement and fisheries by-catch. With a view to create awareness about the importance of conservation and management of marine mammal biodiversity among the researchers, students and various stakeholders of the marine ecosystem, this paper has been prepared. The paper mainly deals with the biodiversity of marine mammals, threats, conservation measures taken and various agencies involved in the research, conservation and management of marine mammals in our country.

Key words: Marine mammals, by-catch, conservation

1. INTRODUCTION

Interest in wildlife in general and marine mammals in particular, have increased significantly in recent years, both in the general public and in the scientific and management communities. Further, there is increasing awareness of the integral importance of marine mammals to healthy ecosystems and of growing threats that a variety of human activities pose to these animals and their environments. The term, "Marine mammals" include members of five mammalian groups: Cetaceans (dolphins, whales and porpoises), pinnipeds (seals, sea lions and walruses), sirenians (manetees, dugongs and sea cows), sea otters and the polar bears. Indeed, marine mammals are not a natural biological grouping. The most important criterion is that they must get all or most of their food from the aquatic environment. It is not essential that they actually live in the sea. The level of dependence of these mammals on the marine environment for their existence varies considerably with species. For instance, dolphins and whales are fully dependent on the marine environment for all stages of their life, whereas seals feed in the ocean, but breed on land.

1.1. Why are marine mammals important?

- Marine mammals are highly recognizable charismatic mega fauna.
- They play important roles in maintaining marine ecosystems, especially through regulation of prey populations. Hence, they are an integral component of the marine environment.
- They are key stone species, meaning they are species that are essential for the proper functioning of an ecosystem and which if depleted or removed lead to a significant alteration, or even collapse of that ecosystem.
- Tours specifically to see marine mammals especially cetaceans, is a global industry worth over a billion dollar indicates the extent of public interest and fascination for these animals. This is one reason marine mammals are treated as conservation "Flagship species" or "Umbrella species".

1.2. Biodiversity

A total of 129 species of marine mammals have been recorded so far at the global level. Marine mammals are widely distributed throughout the globe, but their distribution is patchy and coincides with the productivity of the oceans. It has been reported that species richness is at its peak around 40° latitude, both north and south due to the highest levels of primary production in these regions. Total species range is highly variable for marine mammal species. Of these 129 species of marine mammals reported from all over the world, stranding and sighting records show that the Indian seas are a habitat of 25 species of cetaceans and one species of sirenian.

Order: Cetacea (Whales, Dolphins & Porpoises)
Suborder: Odontoceti (Toothed Whales)
Family: Delphinidae (Marine Dolphins)
1. Delphinus delphis (Common Dolphin)
2. Globicephala macrorhynchus (Short-Finned Pilot Whale)
3. Grampus griseus (Risso's Dolphin)
4. Orcaella brevirostris (Irrawaddy Dolphin)
5. Orcinus orca (Killer Whale)
6. Peponocephala electra (Melon-Headed Whale)
7. Pseudorca crassidens (False Killer Whale)
8. Sousa chinensis (Indo-Pacific Hump-Backed Dolphin)
9. Stenella attenuata (Spotted Dolphin)
10. Stenella coeruleoalba (Striped Dolphin)
11. Stenella longirostris (Long-Snouted Spinner Dolphin)
12. Steno bredanensis (Rough-Toothed Dolphin)
13. Tursiops truncatus (Bottlenose Dolphin)
Family: Phocoenidae (Porpoises)
14. Neophocaena phocaenoides (Finless Porpoise)
Family: Physeteridae (Sperm Whales)
15. Physeter macrocephalus (Sperm Whale)
Family: Kogiidae
16. Kogia breviceps (Pygmy Sperm Whale)
17. Kogia simus (Dwarf Sperm Whale)
Family: Ziphiidae (Beaked Whales)
18. Ziphius cavirostris (Cuvier's Beaked Whale)
Family: Platinistidae
11.Platanista gangeticus (Ganges river dolphin)
Family: Phocoenidae
12.Neophocaena phocoaenoides (Finless porpoise)
Suborder: Mysticeti (Baleen Whales)
Family: Balaenopteridae (Rorquals)
1. Balaenoptera acutorostrata (Minke Whale)
2. Balaenoptera edeni (Bryde's Whale)
3. Balaenoptera borealis (Sei Whale)
4. Balaenoptera physalus (Fin Whale)
5. Balaenoptera musculus (Blue Whale)
6. Megaptera novaeangliae (Humpback Whale)
Order: Sirenia
Family: Dugongidae (Dugong)
Dugong dugong (Dugong)

1.3. Threats to marine mammals

Several marine mammal populations are vulnerable or endangered due to commercial exploitation for their blubber, meat, ivory and fur and by-catch, pollution and habitat degradation. Most species are currently in protection from commercial use.

Direct hunting

Marine mammals have long been highly prized targets of human looking for a good source of food, furs, oil and other range of products. They were attractive subjects of human exploitation, but their relatively inaccessible habitats made them hard to hunt until the last few hundred years. But, in few decades ago, direct hunting was a serious concern. In recent decades, the direct killing of whales and dolphins has become much less important and the indirect deaths of especially dolphins and porpoises have increased dramatically. Internationally, all of the Indian Ocean north of 55°S has been a whale sanctuary since 1979. Even so, the effects of the historical exploitation of rorquals and sperm whales in the region are possibly evident even today. There is now no doubt that more cetaceans die incidentally in fishing nets each year than from any other threat including whale and dolphin hunting. Directed hunting of cetaceans is not reported to be a serious threat in our region, but the populations of the Dugong have all been drastically reduced, mostly on account of the demand for its flesh for consumption. The dugongs, in its last Indian strong hold – in the Gulf of Mannar and Palk Bay – the position of Dugong is far from satisfaction. The prime threat comes from illegal hunting to satisfy the great local demand for Dugong meat. Dugongs have been caught in a variety of nets in these areas.

1.1.1. Fishing

Fishing can affect all marine mammals in many ways. First, human fishing activity can deplete the prey species of cetaceans. The FAO estimated that 70% of the world's commercial fish stock are fully fished, over exploited, severely depleted, or only slowly recovering from depletion. A more direct way that fisheries impact marine mammal populations is through bycatch of these animals in fishing gear (accidental entanglement). Globally, bycatch is a major source of cetacean mortality, killing at least 3, 00,000 whales and dolphins (as well as slightly more pinnipeds) annually. There are indications that the incidental mortality of dolphins and whales in the Indian seas is no less than elsewhere in the world. Fisheries bycatches possibly constitute the greatest threat to Indian marine mammals

1.1.2. Gill net catch

One of the greatest threats faced worldwide by small cetaceans today is that of incidental bycatches or accidental entrapment in gillnet operated for other species. Gillnet contributed 68.9% to the incidental catch.

1.1.3. Tuna fishery bycatch: The tunas are caught in large purse seine nets by drawing the strings of the 'Purse'. Many dolphins are trapped along with tuna and may drown in the process.

1.1.4. Abandoned nets: Abandoned or lost fishing nets, which may be kilometres long, float in the water, trapping and drowning all animals such as marine mammlas, seabirds and turtles indiscriminately.

1.1.5. Pollution

One of the most insidious and widespread threats to cetacean populations is marine pollution. Pollution comes in many forms like industrial waste, agricultural chemicals, sewage, radioactive discharge, litter, oil and noise.

1.1.6. Habitat degradation

The high rate of physical loss and degradation of cetacean and sirenian habitats has become a serious issue. Many cetaceans have precise physical habitat requirements in terms of depth, freshwater access, coastal access and other aspects. If they lose or displaced from these habitats, it can have serious consequences for the health and viability of population especially if their use is linked with reproduction or foraging. Habitat loss, fragmentation and degradation are caused by many factors which include land reclamation, dams and barrages, bridges, harbours and other coastal and offshore construction, dredging, siltation, fishing and aquaculture, boat traffic and other noise pollution.

Table 1: Conservation status of marine mammals in India

Sl. No	Species name/Common Name	IUCN Status	India Status*
1.	Balaenoptera acutorostrata (Common Minke whale)	Least Concern	Data Deficient
2.	Balaenoptera edeni (Bryde′ s whale)	Data Deficient	Data Deficient
3.	Balaenoptera musculus (Blue whale)	Endangered	Endangered
4.	Balaenoptera physalus (Fin whale)	Endangered	Endangered
5.	Delphinus capensis (Long beaked common dolphin)	Data Deficient	Least Concern
6.	Dugong dugon (Sea cow)	Vulnerable	Endangered
7.	Feresa attenuate (Pygmy killer whale)	Data Deficient	Data Deficient
8.	Globicephala macrorhynchus (Short-finned pilot whale)	Data Deficient	Data Deficient

9.	Grampus griseus (Risso′ s dolphin)	Least Concern	Least Concern
10.	Indopacetus pacificus (Indo-Pacific beaked whale)	Data Deficient	Data Deficient
11.	Kogia breviceps (Pygmy sperm whale)	Data Deficient	Data Deficient
12.	Kogia sima (Dwarf sperm whale)	Data Deficient	Data Deficient
13.	Megaptera novaeangliae (Humpback whale)	Least Concern	Data Deficient
14.	Neophocaena phocaenoides (Finless porpoise)	Vulnerable	Near Threatened
15.	Orcaella brevirostris (Irrawaddy dolphin)	Vulnerable	Vulnerable
16.	Orcinus orca (Killer whale)	Data Deficient	Data Deficient
17.	Peponocephala electra (Melon-headed whale)	Least Concern	Data Deficient
18.	Physeter macrocephalus (Sperm whale)	Vulnerable	Vulnerable
19.	Platanista gangetica (South Asian River dolphin)	Endangered	Endangered
20.	Pseudorca crassidens (False killer whale)	Data Deficient	Data Deficient
21.	Sousa chinensis (Indo-Pacific humpbacked dolphin)	Near Threatened	Near Threatened
22.	Stenella attenuata (Pan tropical spotted dolphin)	Least Concern	Data Deficient
23.	Stenella coeruleoalba (Striped dolphin)	Least Concern	Data Deficient
24.	Stenellalongirostris (Spinner dolphin)	Data Deficient	Least Concern
25.	Steno bredanensis (Rough-toothed dolphin)	Least Concern	Data Deficient
26.	Tursiops aduncus (Bottlenose dolphin)	Data Deficient	Least Concern
27.	Ziphius cavirostris (Cuvier′ s beaked whale)	Least Concern	Data Deficient

(Source: Jeyabaskaran et al., 2013)

1.1. Marine Mammal Research in India

Kumaran (2002) reviewed the research work carried out on the marine mammals in India. He mentioned that due to non-existence of a comprehensive research programme and adequately trained research teams in India; information available is fragmentary and is often of dubious scientific quality. Further, he added that lack of understanding of the biology of most of the species and absence of quantitative data on the anthropogenic impacts are serious impediments to the conservation of marine mammals in India. He has recommended a sampling protocol for marine mammal research.

1.2. Marine Mammals Protection: Laws and Initiatives

International

- International Whaling Commission

- International Union for Conservation of nature and Natural Resources (IUCN)
- Convention on International Trade in Endangered Species
- Convention on Migratory Species

India

- Indian Wildlife (Protection) Act, 1972 - All the marine mammals of the region is afforded protection under the Indian Wild Life Protection Act, 1972. Hunting of these animals is not permitted and is punishable with fines and imprisonment.
- Task force for conservation of Dugong has been constituted by the Ministry of Environment and Forests
- Marine Mammal Conservation Network of India – It is a platform devoted to collection of database and conservation of marine mammals of the Indian seas.

2. CONCLUSION

In India, marine mammal research is still in its infancy stage. At present, Wildlife Protection Act, 1972 and creation of awareness are the only efforts taken for the conservation of marine mammals. As information on marine mammals is highly essential to take appropriate conservation measures, marine mammal research needs to be given importance.

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EVALUATION OF GENETIC SIMILARITY AMONG ACCESSIONS OF GEOPHILA REPENS L. USING MARKERS

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ABSTRACT

Genetic relationship was analysed among 11 different accessions of Geophila repens. Plants were collected from 10 different localities in Kerala and one from Andaman Islands. The morphological characterization of Geophila repens was carried out using 46 qualitative and 32 quantitative morphological characters. Statistical analysis of the quantitative characters showed maximum similarity among the accessions. Biochemical marker –SDS PAGE was also used to analyse relationship among accessions. Polymorphism at molecular level was studied by Random Amplified Polymorphic DNA (RAPD) and Inter Simple Sequence Repeats (ISSR) marker techniques. All the eleven accessions were subjected to Polymerase Chain Reaction (PCR) using 20 arbitary decamer primers in RAPD and 12 primers in ISSR. Bands were scored and data were analysed. Similarity matrix was constructed from the binary data with Jaccards coefficients and the dendrogram was generated with unweighted pair-group method arithmetic average (UPGMA) algorithm, using NTYSYS. Both RAPD and ISSR markers gave reliable amplification profile for obtaining the genetic relationships among 11 accessions of Geophila repens. Even though the markers gave varying clustering patterns, the accessions gave higher similarity values. The differences found among the dendrogram generated by RAPDs and ISSRs may be due to the difference in the number polymorphim of loci obtained and the difference in character and properties of RAPD and ISSR loci. Both the similarity matrix and the dendrogram generated using various marker systems revealed that there is not much of genetic diversity which could be attributed to the scarcity in distribution of the species. The result suggests a need to undertake better conservation strategies to ensure its existence.

Key words: Geophila repens, morphological characterization, sds page, random amplified polymorphic dna (rapd), inter simple sequence repeats (issr)

1. INTRODUCTION

Geophila repens L. of the family Rubiaceae is a prostrate herb having medicinal properties, found in the forest areas of Western Ghats, Eastern Ghats, Assam and Andaman islands. This plant is used in the traditional medicinal practices as a drug to combat severe jaundice and other lever ailments. Though with great medicinal potential, Geophila is a totally under explored herb with respect to its active compounds and its action. Further the plant is not widely distributed and is seen only in the forest undercover only in specific patches where there is less sunlight and more humidity. Being restricted to specific pockets in forest areas, the accessibility to this plant is quite difficult. Moreover, due to scarcity in distribution there is a threat to its existence due to over exploitation and dwindling nature of forest due to rapid urbanization and industrialization. Literature survey regarding Geophila repens shows that not much work is done on the plant especially characterization, conservation or medicinal aspects of the plant.

Assessment of genetic diversity within a plant population is important for conservation of genetic resources (Sarikamis et al., 2010) and has always been a primary concern in population and evolutionary genetic studies (Cheema et al., 2010). The genetic diversity between plant genotypes can be estimated either by determining their level of polymorphism for genetic markers or by analysis of morphological traits.

Morphological markers have been used to identify varietal genotype and genetic purity based on the assessment of phenotypic characteristics (Bayorbor et al., 2010), and it provides basic information for plant systematics. Polygenic morphological traits also serve as genetic markers for various plant germplasm management and taxonomy. But morphological characters are generally dominant traits and they often exhibit epistatic interaction with other genetic traits (De Vienne et al., 2003). The problems rendered by morphological markers can be overcome by using genotype specific protein markers. Among the biochemical tests sodium dodecyl sulphate- polyacrylamide gel electrophoresis (SDS-PAGE) is the most widely used technique for variety identification and variability analysis as it is reliable, simple, rapid and cost effective (Cheema et al., 2010; Ahmed et al., 2010). However morphological and protein markers are influenced by the stages of plant growth as well as environmental factors and hence may give erroneous results (Sharma et al., 2004). These limitations can be overcome by the advent of DNA markers, which have the advantage of being virtually unlimited without disturbing the physiology of the organism.

DNA-based markers may extend and complement characterization based on morphological or biochemical descriptions, providing more accurate and detailed information than classical phenotypic data (Campos et al., 2005). The PCR (Polymerase chain reaction) based methods such as Random Amplified Polymorphic DNA (RAPD) is faster and cheaper and Inter simple sequence repeats (ISSR) are simple, cost-efficient, robust, multilocus markers generated by inversely oriented microsatellite repeat anchored primers amplifying regions between adjacent SSR loci (Reddy et al., 2002).

PCR based markers have been used to characterize a wide range of plant species, however no such reports are available with Geophila repens. In view of this, our present study addresses the issue of cataloging of G. repens accessions using morphological markers, biochemical markers and molecular markers such as RAPD and ISSR.

2. MATERIALS AND METHODS

A total of 11 accessions of Geophila repens were collected from various localities, out of which 10 were from Kerala and one from Andaman Islands (Table 1). The accessions were characterised using various markers viz- morphological characters, biochemical marker (SDS PAGE) and DNA based molecular markers (RAPD and ISSR).

Table 1: Accessions of Geophila repens collected from different localities

No.	Location	Collection site	Acc. Code	Acc. No.
1	Palode	TBGRI gene bank	Tg	KUBH 5588
2	Kulathoopuzha	Dalikarikkakam	DK	KUBH5590
3	Anchal	Kadamankode	Kd	KUBH5592
4	Kollam	Mukkada	Md	3157
5	Kottayam	Uzhavoor	Ur	KUBH5595
6	Perumbavoor	Iringol	Il	KUBH5596
7	Ernakulam	Thattekkad	Td	3024
8	Trichur	Peechi	P	KUBH5598
9	Palakkad	Dhoni forest	Dh	KUBH5599
10	Kannur	Mattanoor	Mr	KUBH5600
11	Andaman islands	Dhania khadi	An	2801

Morphological analysis of 11 accessions of the plant was carried out using 78 morphological characters- 46 qualitative and 32 quantitative characters (Table 2. And 3.). For each character 10 samples were analysed from each accessions. The data were recorded and tabulated for further analysis. Since qualitative characters do not revealed any variability, the data obtained from quantitative characters alone were subjected to statistical analysis.

Table 2: List of qualitative characters selected for morphological analysis

Sl. No.	Characters selected	Charac. Code	Sl. No	Characters selected	Charac. Code
1	Distribution	Dn	24	Calyx surface	Clsr
2	Habit	Ht	25	Calyx longevity	Cll
3	Stem surface	Ssf	26	Calyx colour	Clc
4	Presence of stipule	Stp	27	Corolla shape	Cos
5	Type of stipule	Stt	28	Corolla colour	Coc
6	Shape of stipule	Stsp	29	Corolla dorsal surface	Cod
7	Nature of petiole	Npt	30	Corolla ventral surface	Cov
8	Petiole surface	Pts	31	Uniformity in stamen length	Slu
9	Leaf colour	Lc	32	Anther colour	Anc
10	Leaf shape	Ls	33	Anther shape	Ans
11	Leaf texture	Lt	34	Filament colour	Flc
12	Leaf surface	Lsr	35	Filament nature	Fln
13	Leaf margin	Lm	36	Heterostyly	Ht
14	Leaf apex	La	37	Style colour	Syc
15	Leaf base	Lb	38	Style surface	Sys
16	Equality of leaf base	Lbe	39	Stigma colour	Sgc
17	Venation	Vn	40	Stigma type	Sgt
18	Infloresence type	Int	41	Fruit shape	Fts
19	Peduncle surface	Pns	42	Fruit colour	Ftc
20	Pedicel surface	Pds	43	Fruit surface	Fts
21	Bract (present/absent)	Bt	44	Seed type	Sdt
22	Shape of bract	Bts	45	Seed colour	Sdc
23	Shape of calyx	Cls	46	Seed shape	Sds

Table 3: List of quantitative characters selected for morphological analysis

Sl. No.	Characters selected	Charac. Code	Sl. No.	Characters selected	Charac. Code
1	Internode length	Il	17	Length of calyx lobe	CLl
2	Petiole length	Pl	18	Length of corolla	Col
3	Lamina length	Ll	19	Number of corolla lobes	Con

4	Lamina breadth	Lb	20	Length of corolla lobes	Coll
5	Lamina area	La	21	Breadth of corolla lobes	Cob
6	Lamina perimeter	Lp	22	Length of corolla tube	Ctl
7	Lateral vein pair number	Lv	23	Number of stamens	Sn
8	Number of stipules	St	24	Length of anther	Al
9	Length of stipules	Ls	25	Length of filament	Fl
10	Number of flowers/inflorescence	Fl	26	Height of ovary	Oh
11	Length of peduncle	Pd	27	Length of style	Stl
12	Number of bracts	Bt	28	Number of stigma	Stn
13	Length of bracts	Bl	29	Fruit diameter	Fd
14	Pedicel length	PLl	30	Fruit height	Fh
15	Calyx length	Cl	31	Seed length	Sdl
16	Number of calyx lobe	Cn	32	Seed diameter	Sd

Biochemical characterization of Geophila repens was carried out by protein profiling of young leaf samples from various accessions. Protein profiling was carried out as per the standard procedure (Laemmli, 1970). Molecular characterization of the accessions of G.repens was done using RAPD and ISSR markers. For DNA isolation, young and fresh leaves were taken from the collected plants. Total genomic DNA from the young leaves was isolated following the modified Murray and Thompson (1980) method using cetyl trimethyl ammonium bromide (CTAB). RAPD analysis was carried out using a set of 20 decamer primers (Vision Scientific, India) and ISSR analysis was carried out using a set of 12 primers (Finnzymes, Bangalore). The data obtained from all the four marker systems were subjected to statistical analysis using the software package NTYSYS Pc 2.0 (Rohlf, 2000). The data obtained using different marker systems were analysed by considering each accession as an operational taxonomic unit (OTU).

In morphological characterization statistical parameters such as variability, analysis of variance, heritability and genetic gain were calculated. The morphological characters analysed from the 11 accessions were pooled together, standardized and subjected to Hierarchical Cluster Analysis (Johnson and Wichern, 2001). The binary data obtained from polypeptide, RAPD and ISSR marker systems were also analysed individually and in combination of the three using Dice's coefficient (Dice, 1945) to determine pair wise comparison to estimate the genetic relationship among the accessions of G. repens. A Proximity Matrix was prepared by calculating the Squared Euclidean Distances between accessions and a dendrogram was constructed illustrating the closeness of the relationship between the accessions. Bootstrap analysis was also conducted using the software program WINBOOT to check the reliability of the dendrogram constructed. Multivariate relationships among OTUs were estimated through principal component analysis (PCA).

3. RESULTS

Morphological data concerning 46 qualitative characters and 32 quantitative characters were collected from 11 accessions of Geophila repens. Of the 32 quantitative characters studied, statistical analysis was restricted to 26 morphological characters which showed variation among eleven accessions. The mean values of quantitative characters studied from 11 accessions of Geophila repens were calculated. In all the characters analysed there is not much difference in the minimum and maximum values in any of the characters observed. Moreover six of the characters did not show much variability among accessions. The genotypic and phenotypic co-efficient of variation obtained in the present study are less than 30% revealing a low degree of variability among the accessions with regard to the characters studied. Analysis of variance does not reveal significant variation at 5% level of significance for all the quantitative characters suggesting there is not much variation among the accessions studied with regard to these characters

Heritability for each of the quantitative characters was calculated to determine whether the variability obtained for the quantitative characters are heritable (Table 4). In the present study only five characters namely petiole length, pedicel length, lamina breadth, lamina length and lamina perimeter showed percentage of heritability value above 60%, suggesting that the phenotypic variability is mainly due to the genotypic effect and not because of the environmental influence. Variation regarding majority of the characters is not heritable and the changes if any are due to environmental influence. The genotypic and phenotypic correlations between pairs of quantitative characters showed that all the leaf characters were found to be highly correlated genotypically and phenotypically at both 5% and 1% levels. But most of the characters especially characters pertaining to the essential whorls were negatively correlated.

The proximity matrix obtained using quantitative characters had the highest similarity value of 1.00 (100% similarity) among accessions 9 (Dh), 10 (Mr) and 11 (An), which are closely located in the dendrogram as a sub clad in Cluster I (Fig.1.). This was supported by a bootstrap value 96%. Accessions 4 (Md) and 8 (P) also exhibited a similarity value of 1.00 (cent percent correlation) and were grouped together (Table 5.). The grouping of these accessions exhibited a high level of confidence with the bootstrap value of 98%. The accessions from nearby geographic localities were grouped together in the cluster. In general the matrix obtained from the morphological data showed high similarity. The least similarity value recorded was 0.90 between accession6 (Il) and accessions 1 (Tg) and 2 (Dk).

Table 4: Heritability for quantitative morphological characters of accessions of Geophila repens. (in %)

Sl No.	Characters	Heritability (%)
1	Petiole length	79.77
2	Pedicel length	67.37
3	Lamina breadth	65.31
4	Lamina length	62.85
5	Lamina perimeter	62.23
6	Lamina area	57.72
7	Length of style	51.37
8	Length of stipules	50.44
9	Fruit diameter	50.33
10	Length of calyx lobe	41.02
11	Length of corolla tube	39.62
12	Lateral vein pair number	37.56
13	Length of peduncle	30.99
14	Length of corolla	25.00
15	Length of anther	24.98
16	Internode length	24.03
17	Calyx length	20.94
18	Length of filament	20.34
19	Breadth of corolla lobes	19.52
20	Number of flowers / inflorescence	18.30
21	Seed diameter	17.17
22	Fruit height	16.47
23	Seed length	13.27
24	Height of ovary	12.50
25	Length of bracts	6.33
26	Length of corolla lobes	1.36

and between accessions 5 (Ur) and 9 (Dh) (Table. 6). Cluster analyses using the UPGMA were carried out on the similarity matrices based on Dice coefficient (Fig. 2). The grouping of accessions in the dendrogram was supported by a higher bootstrap value of up to 80%.

Table 5: Proximity matrix obtained from morphological characters using Dice's coefficient in eleven accessions of Geophila repens

Accession	Accession										
	Tg	Dk	Kd	Md	Ur	Il	Td	P	Dh	Mr	An
Tg	1.00	0.99	0.94	0.98	0.95	0.90	0.93	0.98	0.98	0.99	0.99
Dk		1.00	0.94	0.99	0.95	0.90	0.94	0.98	0.98	0.99	0.99
Kd			1.00	0.98	1.00	0.99	0.99	0.97	0.98	0.97	0.97
Md				1.00	0.99	0.95	0.98	1.00	1.00	1.00	1.00
Ur					1.00	0.99	0.99	0.98	0.98	0.98	0.98
Il						1.00	0.98	0.95	0.95	0.94	0.94
Td							1.00	0.98	0.98	0.97	0.97
P								1.00	1.00	1.00	1.00
Dh									1.00	1.00	1.00
Mr										1.00	1.00
An											1.00

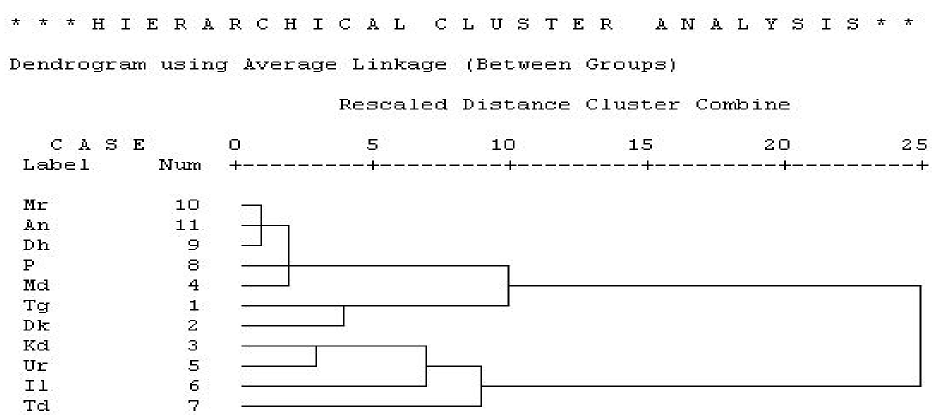

Fig 2: Dendrogram based on the morphological data among accessions of Geophila repens

3.1. Biochemical marker

SDS-PAGE banding pattern revealed 32 bands among 11 accessions with molecular weights ranging from 3.8 to 414.5 K Da. Out of the 32 markers, none of the bands were monomorphic and thus exhibited cent percent polymorphism in the banding pattern. The number of bands obtained from each OTUs ranged from 10 to 19 bands, with accession 11 (An) having least number of bands (10) and accession 3 (Kd) having highest number of bands (19). The genetic similarity values estimated form the protein marker showed a wide gradation ranging from 1.00 (100% similarity) between accessions 7 (Td) and 9 (Dh) to 0.00 (no similarity) obtained between accessions 1 (Tg) and 11 (An)

3.2. RAPD profile

The 20 RAPD primers gave reliable amplification profile for obtaining the genetic relationships among 11 accessions of Geophila repens. The banding profiles generated by the primers yielded a total of 163 amplification products of which 98 bands were polymorphic and the remaining 65 were monomorphic. The percentage of polymorphism exhibited by the accessions is 60.12%. Polymorphism revealed by each primer ranged from 2-9 with an average number of 8.4 bands per primer. The distance matrix generated in RAPD on the basis of Dice coefficient revealed high level of genetic similarity among the accessions though there is no 100% similarity (Table 7). The pair wise genetic similarity ranged from 0.78 to 0.95. The similar-

Table 6: Similarity matrix of eleven accessions of Geophila repens using Dice's coefficient from the polypeptide marker system

Accession	Tg	Dk	Kd	Md	Ur	Il	Td	P	Dh	Mr	An
Tg	1.000	.444	.218	.250	.028	.677	.594	.193	.359	.480	.000
Dk		1.000	.700	.284	.571	.352	.480	.571	.057	.524	.452
Kd			1.000	.757	.894	.129	.400	.612	.471	.297	.193
Md				1.000	.800	.480	.434	.364	.655	.612	.400
Ur					1.000	.444	.400	.480	.000	.594	.352
Il						1.000	.855	.267	.622	.914	.073
Td							1.000	.850	1.000	.945	.444
P								1.000	.800	.748	.736
Dh									1.000	.748	.160
Mr										1.000	.492
An											1.000

Fig 2: Dendrogram based on polypeptide data of accessions of G. repens

ity matrix was subjected to UPGMA clustering and based on the similarity matrix a dendrogram was obtained. The cluster analysis showing the grouping between accessions is displayed in Fig. 3.

The dendrogram analysis indicates that the 11 accessions are grouped together into two major clusters. Cluster I is the major cluster comprising of nine accessions grouped together of which accession 3 (Kd) lies as an outlier. Highest value for genetic similarity (0.95) was estimated between accessions 6 (Il) and accession 9 (Dh) and between accessions 8 (P) and 10 (Mr). These accessions were seen clustered together in the dendrogram, in two subclusters respectively and their grouping was substantiated by bootstrap analysis. The association of accession 1 and 2 are supported by a maximum bootstrap value of 97%. Lowest estimated value (0.78) is between accession 1 (Tg) and accession 4 (Md).

3.3. ISSR analysis

ISSR analysis was carried out on 11 OTUs using 172 amplicons from 12 primers. All the primers used produced about 7 to 20 amplicons and the polymorphic fragments produced per primer ranged from 7-19 with an average of 14.33 bands per primer. Out of the total 172 amplicons produced by the primers 156 were polymorphic and 16 monomorphic. The accessions revealed an average polymorphism of 90.69%. The data obtained from ISSR analysis were subjected to statistical analysis to generate a similarity matrix based on Dice coefficient. The analysis revealed high level of genetic similarity among the accessions (Table 8). Greater similarity was estimated between accession 6 (Il) and accession 7 (Td), which had highest value 0.778. Lowest value for genetic similarity (0. 521)

Table 7: Similarity matrix obtained from the RAPD data of eleven accessions of Geophila repens using Dice's coefficient

Accession	Tg	Dk	Kd	Md	Ur	Il	Td	P	Dh	Mr	An
Tg	1.00	0.86	0.83	0.78	0.80	0.83	0.81	0.81	0.81	0.81	0.79
Dk		1.00	0.83	0.83	0.85	0.88	0.86	0.84	0.86	0.84	0.84
Kd			1.00	0.85	0.87	0.89	0.87	0.86	0.88	0.87	0.84
Md				1.00	0.91	0.87	0.91	0.85	0.87	0.87	0.85
Ur					1.00	0.90	0.94	0.91	0.92	0.91	0.86
Il						1.00	0.94	0.93	0.95	0.92	0.91
Td							1.00	0.94	0.94	0.94	0.91
P								1.00	0.94	0.95	0.89
Dh									1.00	0.94	0.90
Mr										1.00	0.90
An											1.00

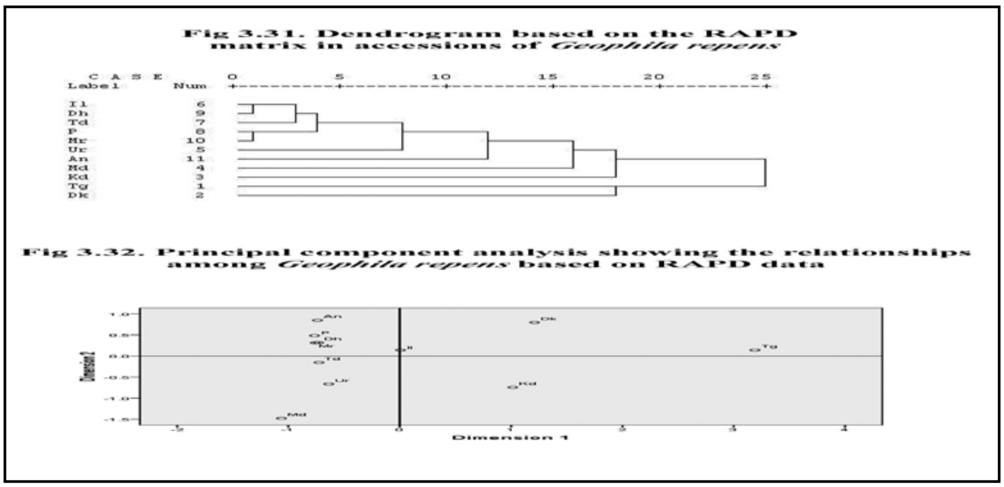

Fig 3: Dendrogram showing the cluster analysis of genetic similarities based on RAPD data with 20 primers

was estimated between accessions 1 (Tg) and accession 10 (Mr). A tree diagram of the accessions was obtained when the similarity values were subjected to UPGMA clustering (Fig. 4). The dendrogram analysis indicates that the 11 accessions were grouped into two clusters, A and B. In cluster A, nine accessions, are pooled together which is again grouped into two sub clusters. The remaining two accessions are grouped into cluster B. The dendrogram analysis is substantiated by the boot strap value.

Principle component analysis was carried out to confirm the result obtained by the cluster analysis regarding the association among the accessions. The positioning of accessions in the scatter plot was similar to the separation obtained in the cluster analysis. There were only minor differences in the spatial arrangement of the accessions in the scatter plot. The percentage variability accounted by the PC ranged from 29.47% to 9.93%. The two components together showed a cumulative variance of 53.53% and the Eigen values ranged from 3.24 to 9.93.

Table 8: Similarity matrix of ISSR data using Dice coefficient in eleven accessions of Geophila repens

Accession	Accession										
	Tg	Dk	Kd	Md	Ur	Il	Td	P	Dh	Mr	An
Tg	1.000	.735	.689	.735	.686	.652	.658	.606	.623	.521	.593
Dk		1.000	.772	.739	.677	.661	.667	.667	.680	.636	.631
Kd			1.000	.759	.700	.637	.660	.639	.654	.575	.615
Md				1.000	.757	.767	.760	.683	.667	.615	.660
Ur					1.000	.705	.723	.730	.700	.603	.663
Il						1.000	.778	.679	.742	.624	.676
Td							1.000	.696	.734	.608	.683
P								1.000	.732	.635	.674
Dh									1.000	.641	.687
Mr										1.000	.725
An											1.000

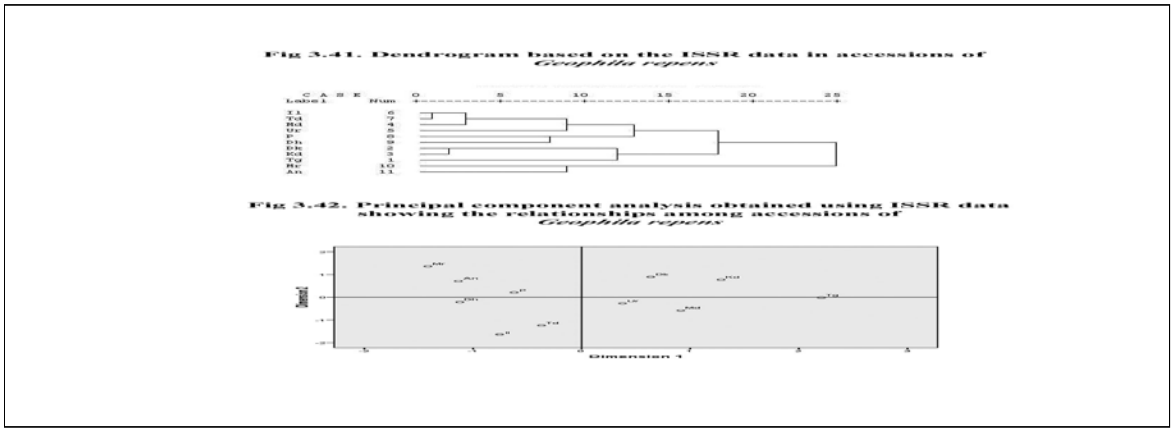

Fig 4: Dendrogram based on the ISSR data in accessions of G. repens

3.4. Pooled data from the three marker systems

The morphological data and the three molecular data polypeptide, RAPD and ISSR when analysed individually revealed discrete data regarding the similarity among accessions. In order to assess the extent of genetic similarity among the accessions; the data obtained from different marker systems were combined. A distance matrix was generated by combining the data from the four (morphological, protein, RAPD and ISSR) marker systems (Table 9). The similarity matrix obtained from the pooled data using Dice coefficient revealed a high degree of genetic similarity among the accessions. The dendrogram generated also substantiated the matrix data (Fig. 5.).

The data obtained from the combined analysis of the four marker systems were different from those obtained in the individual clustering. The intra cluster groupings were also different in all the clusters obtained, both individual and combined. But overall data from all the marker system and combined data revealed that great similarity exist between the accessions even though the clusters are not exactly congruent to each other. The distance matrix also showed high similarity values among the accessions.

Characterization of 11 accessions of G. repens was carried out by examining the data obtained from morphological analysis, molecular markers like polypeptide analysis and DNA based markers like RAPD and ISSR. The analysis was done to employ these marker systems to assess the level of genetic similarity among eleven accessions of G. repens. Morphological characterization carried out in Geophila repens using 46 qualitative characters and 32 quantitative characters showed that the qualitative characters does not show any kind of variation among the eleven accessions chosen for the study. This clearly indicated that the accessions are similar morphologically and variations were only in the quantitative aspect of the characters. Morphological markers are a classical method to distinguish

Table 9: Similarity matrix of the pooled data of the four marker system using Dice coefficient in eleven accessions of Geophila repens

Acces-sions	Accessions										
	Tg	Dk	Kd	Md	Ur	Il	Td	P	Dh	Mr	An
Tg	1.00	0.89	0.78	0.82	0.78	0.74	0.76	0.81	0.81	0.80	0.81
Dk		1.00	0.82	0.85	0.82	0.76	0.80	0.85	0.85	0.85	0.85
Kd			1.00	0.81	0.81	0.74	0.76	0.79	0.79	0.78	0.78
Md				1.00	0.85	0.78	0.82	0.82	0.82	0.82	0.83
Ur					1.00	0.79	0.83	0.85	0.83	0.82	0.81
Il						1.00	0.83	0.79	0.82	0.79	0.78
Td							1.00	0.85	0.85	0.83	0.82
P								1.00	0.89	0.88	0.87
Dh									1.00	0.87	0.86
Mr										1.00	0.89
An											1.00

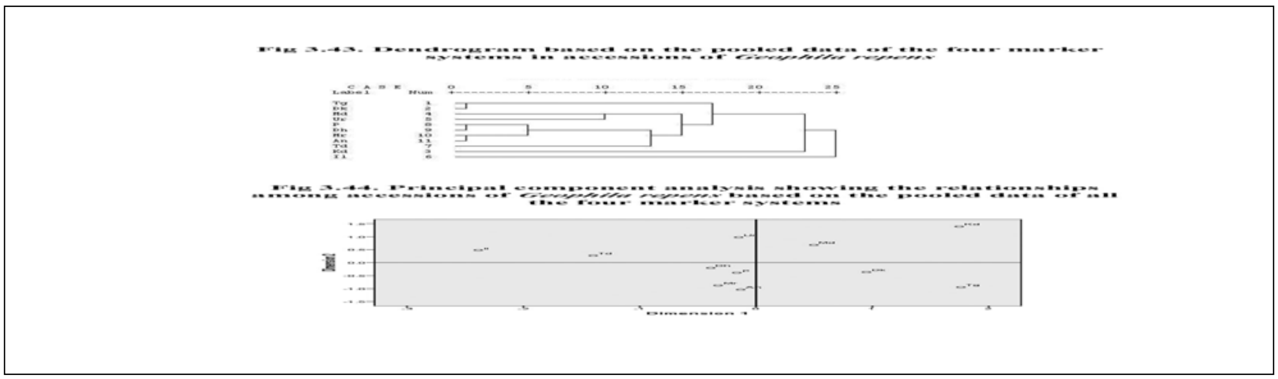

Fig 5: Dendrogram based on the pooled data of the four marker systems in accessions of Geophila repens

4. DISCUSSION

variation based on the observation of the external morphological differences and are used to evaluate distinctness, uniformity and stability (Peterson et al., 1994). Studies on germplasm characterization have been carried out frequently using characterization of plant morphological attributes for apricot (Ruiz and Egea, 2008), water melon (Szamosi et al., 2009), safflower (Elfadl et al., 2010) and vineyard peach (Nikolic et al., 2010).

Among the quantitative characters analysed, the floral characters remained constant in all the members. The GCV and PCV analysed for each characters and majority of the characters showed very low values showing little variation among the accessions Analysis of variance and heritability analysis does not reveal any significant variation among the accessions. The mean sum of squares obtained for majority of the characters was very low, except for those concerning foliar characters. The values were not found to be significant at 5% level, showing there is not much variability in the characters analysed between the accessions. The genotypic and phenotypic correlation between the accessions were also analysed for the characters among accessions. The genotypic correlation coefficient reflects the inherent association between two characters either due to pleiotropic effect of genes or linkage while the phenotypic correlation refers to the observable correlation between two plant characters. Much of the characters do not reveal any correlation between genotypic and phenotypic expressions showing that the variations revealed are not heritable and is greatly influenced by the environmental conditions.

The morphological analysis based on the dendrogram and subsequent distance matrix revealed greater similarity among the accessions. However, morphological characterization may not be as accurate always, since traditional methods using morphological traits for classification of germplasm is largely unsuccessful in establishing the diversity and relationships among different species owing to difficulties arisen due to the inefficiency of the technique (Virk et al., 2000) and environmental influence, on traits of interest (Rao and Chari, 2007). Therefore, they should be used in conjunction with other more reliable methods of characterization such as biochemical or molecular markers since molecular markers provide a better coverage of the genome, resulting in a better estimation of relationships (Duran et al., 2005; Smýkal et al., 2008). However, for the majority of traits, interactions between genotype and environment complicate the evaluation process. Molecular markers have the potential to facilitate this procedure, increase the reliability of decisions, and substantially save time.

Biochemical markers may extend and complement characterization work based on morphological description providing more accurate and detailed information as the electrophoresis patterns of the protein fractions directly represent the genetic background of the proteins to certify the genetic make-up (Rehana et al., 2004). In the present study, SDS-PAGE profile of the leaf proteins showed 100% polymorphism among the accessions, thereby demonstrating divergent banding pattern among accessions. The foliar proteins when used as a marker revealed the presence of 32 bands among 11 accessions with molecular weights ranging from 3.8 to 414.5 KDa.

The varying number and position of bands of the protein analysis were ample enough to create 11 different banding patterns among the accessions studied. There was wide range in the similarity values among the accessions in the similarity matrix. The similarity values obtained from the matrix obtained using Dice coefficient range from 1.00 to 0.00. The classification of accessions obtained in the dendrogram was also substantiated by a higher bootstrap value. Damerval et al. (1987) hypothesized that the quantitative variations in gene product levels revealed by electrophoretic techniques is a more important basis for detection of morphological and adaptive change than classical variability. However, biochemical characterization too has limitations as all the genetic changes occurring at the DNA level are not detected at protein level as only parts of the genome which are expressed can be detected. Hence molecular characterization in conjunction with biochemical parameters may be more appropriate for such studies.

In the present study RAPD analysis revealed low level of genetic variation among the accessions of G. repens. RAPD profiling using 20 primers revealed polymorphism of about 60. Similarity matrix obtained using Dice coefficient gave pair wise genetic similarity values ranging from 0.95 to 0.78. The robustness of the dendrogram was substantiated by high bootstrap values. These similarities measure the relative genetic relatedness among the accessions within a group. A higher similarity would mean more genetic relatedness among the accessions within the group. The result is on par with the RAPD analysis of Typhonium sp. (Rout, 2006) and Ixora sp. (Rajaseger et al., 1997). RAPD technique is advantageous as it can yield a large number of loci and may provide a more representative sample of the genome than proteins and allozymes do. However, the RAPD technique has also some limitations like dominant allelic expression, which will bias the estimates of genetic diversity and population genetic structure (Lynch and Milligan, 1994; Isabel et al., 1993; Szmidt et al., 1996).

ISSR- PCR (Inter Simple Sequence Repeat- Polymerase Chain Reaction) is simple and useful for estimating genetic diversity in plants as this method produces more complex marker patterns than the RAPD approach (Parsons et al., 1997; Chowdhury et al., 2002), and are more reproducible than RAPD markers (Goula˜o and Oliveira, 2001). ISSR analysis carried out in the accessions of Geophila revealed an average polymorphism of 91% with about 4 primers giving 100% polymorphism. The grouping of accessions in the cluster is supported by a high bootstrap value. In the present study higher polymorphism was observed using ISSR marker system compared to RAPD. The difference may be due to difference in the methods used to characterize the DNA. The difference could be explained in terms of functional constraints since some of the

RAPD bands are concerned with functional loci (Penner, 1996). ISSR markers are preferred more than RAPD for the assessment of genetic characterization due to their higher reproducibility, and ability to amplify large number of DNA fragments per reaction, representing multiple loci across the genome (Kaushik et al., 2003). Further, in RAPD, polymorphism occurs mainly due to point mutation or insertion- deletion mechanisms, whereas slippage accounts for the polymorphism in ISSR (Milbourne et al., 1997).

The amplification profiles and the level of polymorphism for each of the three marker systems were quite variable. SDS PAGE analysis revealed a high level of polymorphism (100 %) among accessions of G. repens, whereas RAPD and ISSR markers detected approximately 60.12 % and 91 % polymorphism. The dendrograms generated by all the four marker systems showed greater variation in the grouping of accessions. The wide variation in genetic similarity among the accessions by the DNA-based markers used in the study reflects a high level of polymorphism at the DNA level. Lack of agreement of molecular data with morphological classification is also observed here. The difference in the dendrogram pattern may be due to the difference in the kind of information provided by each marker systems. Divergence in the clustering pattern among different markers was also reported previously (Powell et al., 1996; Kaundun and Park, 2002; Barbosa et al., 2003).

The level of similarity determined by morphological traits was very high, and was comparable to that of molecular markers. This may be due to the fact that morpho- agronomic traits encompass both genotypic and environmental effect. Observations above tend to emphasize uniformity of all the marker systems. However, any of the marker systems does not reveal any location specific differences among the accessions. Dendrograms did not indicate any clear pattern of clustering according to the location from which they were collected. Similar results were obtained in Azukibean (Yee et al., 1999) and in groundnut (Dwivedi et al., 2001) and Crocus sativus (Grilli et al., 2004).

Genetic diversity assessment of plants using DNA markers in tandem with morphological analysis helps to cross the limitation of morphological parameters as a source of estimating variability (Ali et al., 2007). The advantages of using different marker systems are that they may have different applications, specific to their characteristics, and they can generate information at many different loci. Among all marker systems RAPD and ISSR marker systems are preferred because the technical simplicity and speed of RAPD and simplicity reproducibility and greater polymorphism of ISSR markers. The ISSR markers target regions between microsatellite loci distributed across the genome, while the RAPD markers scan the entire genome and, hence, genome-wide genetic variation could be detected using DNA-based marker systems (Pamidiamarri et al., 2009). All marker systems examined in this study were found efficient enough to unravel the genetic relationship among accessions, but the degree of resolution varied depending on the technique applied.

The combined effect of all the four marker systems in the pooled data revealed greater similarity values compared to individual marker systems. Higher similarity values obtained in the combined data may be due to increased number of loci involved in the analysis. One major importance of the integration of markers to study diversity is that it allows for better discrimination among accessions than a single method and also give a better coverage of the genome (Siragusa et al., 2006). The combined application of molecular and morphological methods is useful to unravel the taxonomic relationships in complex taxa and to describe the distribution pattern of the genetic and phenotypic variation (Tovar-Sánchez and Oyama, 2004; Hagidimitrou et al., 2005). At higher similarity levels, clusters sub group into small clusters. Accessions collected from same regions as well as different regions in Kerala and the one collected from Andaman Islands were in closely formed groups which clearly indicate that the geographic differentiation of the accessions of Geophila repens is not extensive. Steiner et al. (2001) noted that geographic distance among the collection site is not associated with plant genetic distance but ecologic similarity is related to genetic similarity. This study also clearly indicated close genetic relationships between accessions collected from various localities. The similarity of this kind may be because of similar environmental conditions.

Genetic diversity is critical for adaptation to environmental changes and for long term survival of a species. Lower level of variation occurs when the plant population undergoes increased selfing, thereby leading to homozygosity (Ellstrand and Elam, 1993). Small population size increases the level of inbreeding and genetic drift, thereby reducing genetic variability. So in species with small range and reduced number of individuals, low levels of variability are expected (Barret and Kohn, 1991) and thus rare species are genetically not very diverse. In the present study reduced variability is observed among the accessions of Geophila repens. The plant is not widely distributed and is seen only in the forest undercover as specific patches where there is less sunlight and more humidity. Reduced variability may be the reason for scanty distribution of this species. Fragmentation of continuous habitat into smaller and more isolated patches can potentially alter the spatial distribution of genetic diversity (Fenster and Dudash, 1994; Fore and Guttman, 1992). This lack of variability may result in lack of adaptability of the species to thrive even in slightly varied environmental conditions. Hence effective measures have to be taken for the conservation and multiplication of this medicinal plant as habitat destruction may create threat to the existence of this valuable species.

5. ACKNOWLEDGEMENT

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BUFFER ZONE – AN ESSENTIAL COMPONENT TO SUSTAIN A HEALTHY ECOSYSTEM IN A HUMAN-DOMINATED LANDSCAPE

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ABSTRACT

Taralu (N 12° 46-47'/E 77° 31-32') is a village of about 434 acres bordering one of last largest remaining scrub forest of the country, the Bannerghatta National Park (BNP), situated in Karnataka, southern India. The terrain of Taralu was found to be a mixture of habitats, apart from scrubland and forest covers as an extension of BNP. 47% of the total land area has been converted to agricultural plots to provide food for the growing demand. It seemed important to study the impact of conversion of almost half of the land areas for human usage, on reptilian -fauna. Besides, a report revealed that cropland ecosystems support biodiversity and help in their survival (Grace Communications Foundation, 2011).

To understand the influence of cropland on biodiversity, an agricultural area of varied human activity quotients was chosen and block sampling approach was adopted. The total sampling area chosen was about 3.5 acres with two cultivated lands (Cult 1 and Cult 2) of varied human-interaction and a buffer zone with minimal interference from human/cattle activity. A 5 point human-reptile interaction scale was standardized assuming maximum hours of human/cattle activity do not exceed 6 hrs. The chosen blocks were graded on this scale and sampling of these blocks was carried out simultaneously for the 30 days (1st – 30th April, 2014) of this study. The data collected resulted that buffer housed 62% of recorded individuals when compared to Cult 1 and Cult 2 during hours of peak human interference. Another parallel study in Taralu also revealed that agricultural plots support close to 50% of the total individuals of the recorded reptilian-fauna and sustain a minimum of 10 different taxa (out of 20 recorded species). Justification of this finding was however, beyond the scope of this study, it could be taken that cropland ecosystems do support a wide range of species and that buffer area around agricultural plots could act as a very good refuge for the reptilian-fauna present.

Key words: Buffer zone, cropland ecosystem, reptiles, Taralu, Bannerghatta, agriculture, human impact,

1. INTRODUCTION

The level of biodiversity within a habitat is a good measure of the health of an ecosystem. Ecosystem properties in a given space and time seems to be dependent on the biodiversity of the organisms present and their distribution patterns and abundances (Hooper et al., 2005).

Understanding biodiversity within areas have been extended both globally and locally and a number of studies are being conducted at various levels. This has contributed to a great depth of comprehension of biodiversity. The knowledge on herpetofauna of India has also been developing from more than 150 years through efforts of many researches. Today, India has been reported to have about 518 species from the class Reptilia (3 species of crocodilians, 279 species of snakes, 202 species of lizards and 34 species of chelonians), out of which 192 species are endemic to India (Aengals et al., 2011).

Amphibians and reptiles play a major role in ecological food webs, as both predators and preys. As consumers of insects, rodents, and other pest species, herps also provide a significant benefit to agricultural and recreational activities (Marks, 2006). However, habitat modification may cause alteration of prey-predator dynamics in a disturbed habitat (Tewkabury et al., 2006; Donovan et al., 1997; Byers et al., 2002) A lot of interference with habitats and landscapes due to a variety of factors has resulted in modification of the habitats.

Amphibians and reptiles are considerably sensitive to their habitat (Marks, 2006). Amphibian and reptile species often respond differently to habitat alteration i.e.; abundance of some species may increase while others decline (Bailey et. al., 2006). Moreover, the interference of humans with habitats and landscapes seem to be escalating with the growing population. A decade ago, more than 80 % of the global land surface was estimated to be influenced by human presence and activities such as cultivation, urbanization and transport (Sanderson et al., 2002). Land clearing primarily for agriculture is, perhaps, the single most important cause of environmental degradation, loss of species and depletion of ecological communities worldwide (Schur, 1990).

Considering that habitat alteration within a given area influences the presence of biodiversity and hence alters the characteristics of the ecosystem, the current study was conducted in the region of Taralu (N 12° 46-47'/ E 77° 31-32'), which covers approximately 434 acres of area situated in the Karnataka state of southern India. The positioning of the selected study area borders one of the last remaining scrubland called the Bannerghatta National Park (BNP). The current study was conducted due to the following reasons:

(i) Lack of any prior study or literature on the diversity of local reptilian fauna of the region and their distribution patterns. Considering the habitat variation within the region of Taralu, it seemed important to understand the habitat preference of reptiles recorded.

(ii) Conversion of 47 % of the total land area of Taralu into agriculture lands. It could be important to study the impact of conversion of almost half of the land areas for human usage, on the reptilian fauna. Besides, cropland ecosystems have also been proven to sustain biodiversity and support in their survival. (Grace Communications Foundation, 2011). In order to comprehend the influence of cropland ecosystems on the reptiles present, this study was conducted.

Hence, a two pronged approach was devised to undertake the present study and the objectives were formulated as following:

1. To record the diversity of reptilian fauna in Taralu that is situated very close to the Bannerghatta National Park and to understand species occurrence and distribution with respect to habitat niches present in Taralu.

2. The region of Taralu is continuously altered due to the growing human needs. Agricultural land involves both human and cattle activity expecting the reptiles to be restricted to areas adjacent to forest or vegetation regions at the periphery of crop fields in the hours of high interference. In this regard the second objective to understand their prevalence and interaction in cropland ecosystems considering the presence of humans was devised.

2. METHODOLOGY

2.1. Study area:

This study was conducted in the region of Taralu that is situated on the outskirts of southern Bangalore, India. The geographical positioning of the selected area seems to have an important impact on the collection of biodiversity of the given area. Being situated in close proximity to the Bannerghatta National Park (BNP) (Figure 1) which belongs to the last largest remaining scrub forest of the country, placed on the confluence of the Eastern and the Western Ghats (Varma et al., 2009), Taralu could be an expansion of the biodiversity of BNP and could cover a variety of reptilian taxa.

Figure 1: Map depicting the study area and its geo-

graphical proximity to the Bannerghatta National Park.

However, the terrain of Taralu was found not to be confined to scrubland habitation. The area exposes a mixture of habitats viz., scrubland and dry deciduous forest as an extension of the vegetation of the BNP including a number of lentic aquatic ecosystems and other human-dominated niches and agricultural lands as a result of change in land-use patterns through days. With such an array of feasible habitat areas for reptiles, this region is assumed to be congenial for the reptilian fauna. Though the conditions seemed to be quite favourable for the reptiles, not many studies were conducted in this region to understand the diversity of reptilian fauna. This study hopes to understand the species diversity of reptiles found in the region supplemented with gauging their habitat and microhabitat preferences.

2.2. Study Design:

2.2.1. Count of Reptilian - Fauna:

Vegetation was considered as a factor to define the different types of habitats in the given region. As aforesaid, Taralu could be considered as an assortment of 5 different habitats (Table 1).

Table 1: 5 different habitats of Taralu

S.No.	Habitat Type	Prominent vegetation types within the given habitat
1.	Scrubland (s) – Naturally occurring scrubland area or temporarily left undisturbed by human activity	Mesquite (Prosopsis juliflora), Chromolaena (Chromolaena odorata) shrub verbenas (Lantana camara)
2.	Dry Deciduous Cover (f)	Red catechue (Acacia chundra) Ceylon satinwood (Chloroxylon swietenia)
3.	Lentic Aquatic System (A) - Naturally occurring aquatic puddles, naturally dried up systems or dried due to extensive anthropogenic activities such as sand flitration, de-silting activities	Reeds (Phragmites australis) lotus (Nelumbo nucifera) common purslane (Portulaca spp.)
4.	Agricultural Area (a) – Human-controlled plots that are either under man-powered agricultural practices or machine-run systems that are used for growing of crops	Finger millet (Eleusine coracana), tomato (Solanum lycopersicum), alfalfa grass (Medicago sativa), sapota (Manilkara zapota), sugarcane (Saccharum sp.), banana (Musa sp.), arecanut (Areca catechu) coconut (Cocus nucifera).
5.	Human – dominated landscapes (h) - Regions of intense human activity including houses, cattle/ poultry sheds, roads, industries and other man-made buildings	shrub verbenas (Lantana camara), coconut trees (Cocus nucifera), mango trees (Mangifera indica) and tamarind trees (Tamarindus indica)

A random sampling approach of the various types of habitats of Taralu (as in Figure 2 and 3) was conducted in the region to identify the species, estimate the population and understand the habitat and microhabitat preferences. The survey was carried out in day time and night time to enhance the encounter rates of reptiles found for 30 days in the month of April 2014 (1st – 30th). The sampling period varied from 4 to 8 hrs a day and sampling all the possible areas in the vicinity from ground level crevices, burrows to the tree branches in the regions sampled with minimal alteration in the habitat.

A data sheet was prepared entailing the species recorded, sex of the species wherever evident, time of sighting, the habitat index in which it was first spotted, the microhabitat in which it is present, GPS of the given area and duration of the sampling.

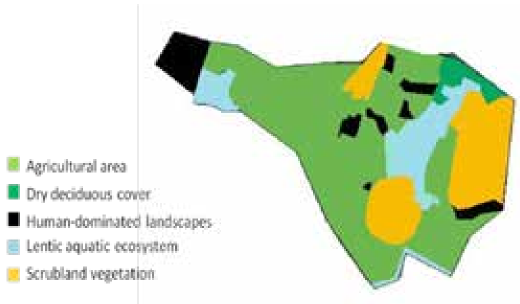

Figure 2: Area map of Taralu
Figure 3: Graphical representation of the types of habitats across the region of Taralu

2.2.2. Analysis of an altered habitat:

Agricultural areas found in the region had varied human activity quotients at different seasons ranging from undisturbed area to plots that are dominated regularly by agricultural practices. To obtain data on these various areas, block sampling approach was adopted.

Block sampling involves division of the area depending on activities patterns followed by equal sampling of all the blocks selected simultaneously. The plot chosen was a cultivated are of about 3.5 acres with varied levels of interference with respect to human/cattle activity bordered on one end by a buffer zone with minimal disturbance (Figure 4 and 5).

To understand the human/cattle activity in these zones, a trial run was conducted for 1 day from 0600h to 1800h assuming that human activity is negligible after sun set. During the trial run, it was observed that the human/cattle activity predominantly happened between 0930h and 1530h. Assuming that the maximum human-reptile interference (HRI) will be not more than 6 hrs in a day, human-reptile interaction scale was standardized (Table 2).

Table 2: Human – Reptile Interaction Scale

S.No.	Scale	Activity Pattern (Human/Cattle)
1	0	Negligible activity (less than an hour a day)
2	1	Very low activity (1-2 h a day)
3	2	Low activity (2-3 h a day)
4	3	Moderate activity (3-4 h a day)
5	4	High activity (4 – 5 h a day)
6	5	Very high activity (5 – 6 h a day)

The cultivated area was segmented into Cultivated1 (Cult1) and Cultivated2 (Cult2). Despite, Cult 1 and Cult 2 being cultivated lands; they showed difference in the human interference levels. Cult1 was focused on tall trees at 1m apart majorly coconut trees (Cocus nucifera), sapota trees (Manilkara zapota) and some banana plantations (Musa sp.) as well. The ground covered with clutters from these trees was left undisturbed. This block was not exposed to cattle grazing and hence, minimized human/cattle activity not exceeding more than 3 h a day and hence, was given 2 on the HRI scale (Figure 6).

Figure 4: Block Count Sampling area (yellow) in reference to Taralu Field Study Center (TFSC) and Bannerghatta National Park (BNP)
Figure 5: Map depicting the compartmentalization of blocks to understand human impact on reptilian-fauna

On the other hand, Cult2 was majorly controlled to short plantations including alfalfa grass (Medicago sativa), tomato (Solanum lycopersicum) and sugarcane (Saccharum sp.) separated from each other by a row of arecanut palms (Areca catechu) and coconut trees (Cocus nucifera). Cult2 region was allowed for cattle grazing almost every day exceeding 5 hrs a day and hence, was given a grade of 5 on the HRI scale (Figure 6).

Buffer zone comprises a wide range of vegetation. Shrub verbenas (Lantana camara) was predominant in this region, besides having bamboo (Dendrocalamus strictus), coat buttons (Tridax procumbens) and mesquite (Prosopsis juliaflora). This region had negligible human/cattle interference with a scale of 0 on the HRI scale (Figure 6).

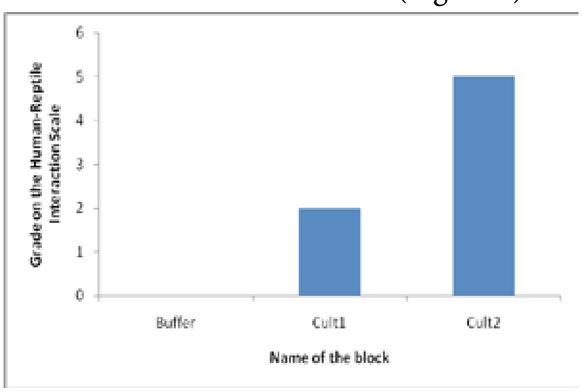

Figure 6: Graphical representation of the variation in HRI levels within the selected plots

Sampling of these blocks was carried out simultaneously for the 30 days of this study, restricted to the morning hours of 0900h to 1200h. The sampling time varied from 1 to 3 hrs a day and the number of members sampling differed from 1 to 8 for a sampling period.

A data sheet containing time of sighting, the block of sight, the microhabitat in which the reptile was first sighted, GPS of the given area and duration of sampling was considered for the mapping of the reptiles within these blocks. An analysis of the block preferred by the reptiles co-relating it to the human interference was also done.

3. RESULTS

3.1. Count of Reptilian - Fauna:

The random sampling conducted exposed 20 species of reptiles in the region of Taralu. The species richness varied with the habitat of encounter. A comparison of the number of species and individuals found to the habitat index are plotted in the Figure 7. This co-relation graph suggests that the number of individuals encountered is unexpectedly high in human-dominated landscapes and agricultural lands. Moreover, the number of species in human-dominated seems to be the highest with 12 taxa found and agricultural land and aquatic with 10 types of fauna present each.

3.2. Analysis of an altered habitat:

As aforesaid, the 3 blocks viz., Buffer and the two mentioned agricultural lands (Cult1 and Cult2) that were sampled had varied level of human – interference. They were graded 0, 2 and 5 on the human-reptile interaction scale for Buffer, Cult1 and Cult2 regions, respectively.

Many factors could contribute to the differences in occurrence of reptiles among these blocks including vegetation, temperature gradient, prey-predator availability and other ecosystem requirements. However, the data collected resulted that buffer had the maximum number of individuals compared to Cult1 and Cult2, indicating that human-interference could be affecting the pattern of distribution of reptiles in a given area at least during the hours of maximum interference when the study was conducted. Figure 8 indicates that 62% of the reptiles encountered were confined to areas of human-interference of 0.

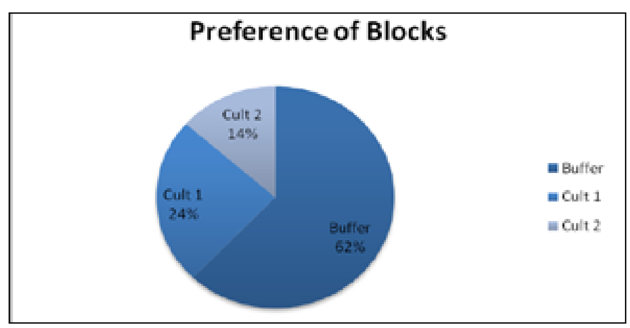

Figure 8: Preference of blocks pronounced by the reptiles in the sampled areas

4. DISCUSSIONS

Taralu has, therefore been asserted to sustain a minimum of 20 reptile species in this season. Though a

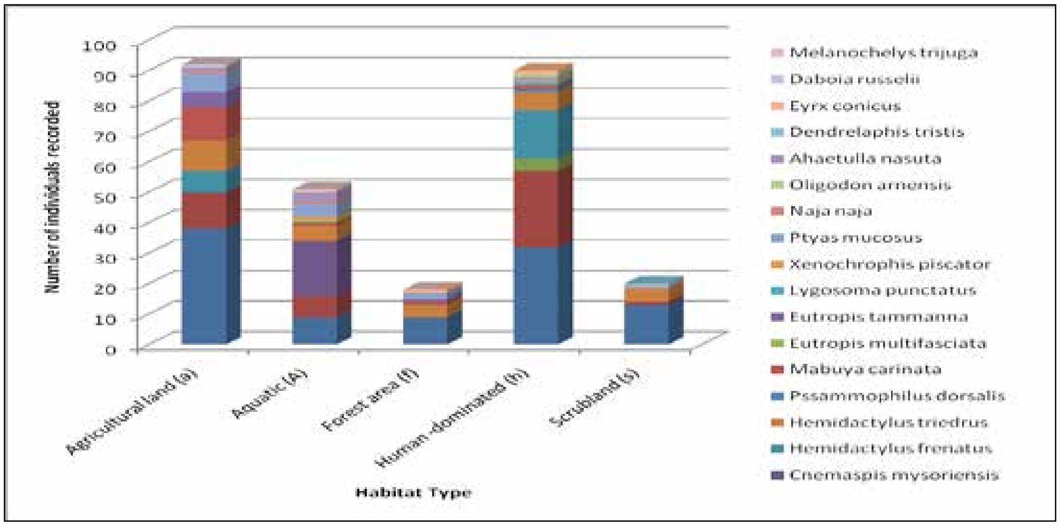

Figure 7: A co-relation of habitat index and species richness

profound land transition has taken place over the years resulting in hike in man-controlled regions, from the study it seems to be evident that human-dominated areas enclose the highest number of individuals of reptiles among the other habitat options. This could propose that the human habitation areas have become enlarged and thus, the increase in reptiles adapting to these put forth situations. Else, these human domains as such could offer some ecological benefits to the reptiles which have been beyond the scope of this study. A further analysis taking into account the ecological requirements of the recorded species and an analysis of preference of habitat could help in highlighting the obtained result. On analysis of a scenario within a sample agricultural plot which revealed that comparison between less, moderate and high human-dominated areas, had differences in the number of reptiles recorded. From the block sampling, it could be taken that human/cattle activity in an area like agricultural plot seems to have been affecting the movement of the reptilian-fauna present and that it recorded the maximum number of individuals in the undisturbed patches. Hence, it could be taken that buffer zones do support survival of species in a given agricultural land by providing a good refuge cover. A further detailed study on agricultural lands could help in obtaining devices to improve the cultivation patches to being a viable habitat for reptiles which could include addition of buffer zones to such fragments.

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ROOT STUDIES OF FODDER COWPEA VARIETIES AS INFLUENCED BY SOIL MOISTURE STRESS LEVELS

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ABSTRACT

A field experiment was conducted in the upland area of the Instructional Farm of College of Agriculture, Vellayani, Trivandrum during the summer season of 2012. The objective of the study was to identify drought tolerant varieties of fodder cowpea. The investigation was conducted as two separate experiments, one in open and another in shaded situation (25-35 per cent shade). The design was laid out in split plot with four replications. The main plot factor included four soil moisture stress levels, M1: presowing irrigation + life saving irrigation; M2 :presowing irrigation + irrigation at IW/CPE ratio 0.4; M3 : presowing irrigation + irrigation at IW/CPE ratio 0.6; M4 : presowing irrigation + irrigation at IW/CPE ratio 0.8. The sub plot factor included five fodder cowpea varieties, V1-UPC-618, V2-UPC-622, V3-Bundel Lobia-1, V4-COFC-8 and V5-CO-5. Presowing irrigation was given to all the plots uniformly upto 10 days after sowing for germination and establishment. Thereafter irrigation was given as per the treatments based on the evaporation data and depth of irrigation. Significantly higher root dry weight (0.43 g) was recorded by irrigation at IW/CPE ratio of 0.8 (M_4) in shade. COFC-8 (V_4) recorded higher root dry weight of 0.80 g in open and shade. Significantly higher root: shoot ratio (0.47) was recorded by life saving irrigation (M_1) followed by irrigation at IW/CPE ratio of 0.4 (M_2) (0.45) in open. Among the fodder cowpea varieties COFC-8 (V_4) recorded significantly higher root: shoot ratio (0.41). The treatments had no significant effect on root: shoot ratio of fodder cowpea in partial shade.

Key words: Soil moisture stress levels, irrigation, varieties, partial shade

1. INTRODUCTION

A serious drawback of sustainable livestock production system in Kerala is the inadequate seasonal distribution of fodder production. The quantity and quality of herbage available in the lean dry months from January to May is very low. Therefore it is imperative to develop a fodder production system that increases the availability and improves the quality of herbage in the dry summer months. Fodder cowpea (Vigna unguiculata L. Walp) is a legume inherently more tolerant to drought than other fodder legumes (Fatokun et al., 2009) and considered as a crop capable of improving sustainability of livestock production through its contribution in improving seasonal fodder productivity and nutritive value. The dairy homesteads of Kerala are mostly experiencing light stress of varying intensities.V. unguiculata grows well in shade andis useful as a component crop of silvipastoral systems. Evaporative demand is greatly reduced in the shaded environment and soil water availability for the pasture will be maintained at a higher level than in open through the combined effect of less evaporation from soil and lower transpiration rates of the pasture. V. unguiculata grows well in shade and is useful as a component crop of silvipastoral systems (Bazil, 2011).It has shade tolerance, quick growth and rapid ground covering ability. Summer cowpea irrigated according to a schedule based on IW/CPE ratio of 0.8 recorded the maximum dry matter production (Subramaniam et al., 1993) and plant height (Kher et al., 1994). Fodder cowpea varieties CO-5, COFC- 8, UPC - 618, UPC-622, Bundel Lobia-1 are high yielding and suitable for cultivation in Kerala (Rajasree, 1994; Lakshmi et al., 2007; Gayathri, 2010). It is the most widely cultivated fodder legume in areas where rainfall is scanty and soils are relatively infertile. Most households that keep livestock raise fodder cowpea as an intercrop with other crops and fodder cowpea forms an integral component of crop livestock farming system (Singh and Tarawali, 2011). Keeping this in view, the present study was taken up with the objective of identifying drought tolerant varieties of fodder cowpea suitable for the dry summer months.

2. MATERIALS AND METHODS

A field experiment was conducted in the upland area of the Instructional Farm of College of Agriculture, Vellayani, Trivandrum during the summer season of 2012. The investigation was conducted as two separate experiments, one in open and another in shaded situation (25-35 per cent shade). The design was laid out in split plot with four replications. The main plot factor included four soil moisture stress levels, M1: presowing irrigation + life saving irrigation; M2: presowing irrigation + irrigation at IW/CPE ratio 0.4; M3: presowing irrigation + irrigation at IW/CPE ratio 0.6; M4: presowing irrigation + irrigation at IW/CPE ratio 0.8. The sub plot factor included five fodder cowpea varieties, V1-UPC-618, V2-UPC-622, V3-Bundel Lobia-1, V4-COFC-8 and V5-CO-5. Presowing irrigation was given to all the plots uniformly upto 10 days after sowing for germination and establishment. Thereafter irrigation was given as per the treatments based on the evaporation data and depth of irrigation. . The quantity of water applied to each plot in one irrigation was 600 litres. FYM @ 10 t ha^{-1} was applied uniformly to all the plots at the time of final preparation of land. Entire dose of phosphorus was given as basal @ 30 kg ha^{-1}. Nitrogen @ 40 kg ha^{-1} and potassium @ 30 kg ha^{-1} were given in two equal splits, one as basal and one after one month of sowing. The fodder cowpea varieties as per treatments were sown at a spacing of 30 x 15cm @ 2 seeds $hole^{-1}$ on 14^{th} January 2012 both in open as well as in shade (25-35 per cent).Observations on root volume, root:shoot ratio and root dry weight were taken. Root volume was recorded by water displacement method. Root shoot ratio was determined by calculating ratio of weight of dried roots and shoots of five plants and the mean value arrived.

3. RESULTS

The results on the effect of soil moisture stress levels and varieties on root volume in open and shaded condition are presented in Table1&2. The results revealed that the treatments had no significant effect on root volume of fodder cowpea. However, irrigation at IW/CPE ratio of 0.8 (M_4) recorded a higher root volume of 4.40 cm^3 in open and 2.55 cm^3 in shade, through not significantly different from the others. Among the varieties, COFC-8 (V_4) recorded higher root volume in both open and shade.

The results on the effect of soil moisture stress levels and varieties on root: shoot ratio in open and shaded conditions are presented in Table 1&2. Significantly higher root: shoot ratio (0.47) was recorded by life saving irrigation (M_1) followed by irrigation at IW/CPE ratio of 0.4 (M_2) (0.45) in open. Among the fodder cowpea varieties COFC-8 (V_4) recorded significantly higher root: shoot ratio (0.41). Interaction effect was significant in open condition and COFC-8 given at life saving irrigation (m_1v_4) recorded higher root: shoot ratio (0.51) which was on par with m_1v_1 and m_2v_4. The treatments had no significant effect on root: shoot ratio of fodder cowpea in partial shade.

The results on root dry weight of fodder cowpea showed that soil moisture stress levels and varieties had significant effect on root dry weight in open and shade. Significantly higher root dry weight (0.72 g) was recorded by irrigation at IW/CPE ratio of 0.8 (M_4) in open. COFC-8 (V_4) recorded higher root dry weight of 0.80 g in open. M x V interaction was significant and COFC-8 irrigated at IW/CPE ratio of 0.8 (m_4v_4) recorded higher root dry weight of 0.99 g in open.Significantly higher root dry weight (0.43 g) was recorded by irrigation at IW/CPE ratio of 0.8 (M_4) in shade. COFC-8 (V_4) recorded higher root dry weight of 0.41g in shade. M x V interaction was significant and Bundel Lobia-1 irrigated at IW/CPE ratio of 0.8 (m_4v_3) recorded higher root dry weight (0.55 g) in partial shade.

4. DISCUSSION

The study revealed that soil moisture stress levels had significant effect on root: shoot ratio only in open condition. Life-saving irrigation recorded significantly higher root: shoot ratio in open. Water stress results in significant reduction in stem dry weight and increased root length. Increase in root biomass in water stressed fodder cowpea may be due to the ability of the plant to divert assimilates to enhance the growth of the roots so as to

Table.1. Effect of soil moisture stress levels and varieties on root volume, root: shoot ratio and root dry weight of fodder cowpea

Treatments	Root volume (cm^3)		Root : shoot ratio		Root dry weight (g)	
	Open	Shade	Open	Shade	Open	Shade
Soil moisture stress levels (M)						
M_1- Life saving	3.20	1.70	0.47	0.11	0.59	0.29
M_2- IW/CPE = 0.4	3.50	1.75	0.45	0.10	0.58	0.24
M_3- IW/CPE = 0.6	4.20	2.35	0.32	0.12	0.66	0.39
M_4- IW/CPE = 0.8	4.40	2.55	0.27	0.12	0.72	0.43
SEm (±)	0.532	0.377	0.019	0.003	0.021	0.013
CD (0.05)	NS	NS	0.011	NS	0.031	0.022
Varieties (V)						
V_1 - UPC 618	4.00	2.06	0.38	0.12	0.66	0.32
V_2 - UPC 622	3.75	2.06	0.38	0.10	0.66	0.32
V_3- Bundel lobia-1	3.69	2.13	0.36	0.10	0.58	0.36
V_4- COFC -8	4.19	2.19	0.41	0.12	0.80	0.41
V_5 - CO-5	3.56	2.00	0.35	0.11	0.49	0.29
SEm (±)	0.602	0.334	0.015	0.010	0.016	0.020
CD (0.05)	NS	NS	0.015	NS	0.022	0.030

Table.2. Interaction effect of soil moisture stress levels and varieties on root volume, root: shoot ratio and root dry weight of fodder cowpea

Treatments	Root volume (cm^3)		Root : shoot ratio		Root dry weight (g)	
	Open	Shade	Open	Shade	Open	Shade
M x V						
m_1v_1	3.00	1.75	0.49	0.11	0.65	0.25
m_1v_2	3.75	2.00	0.46	0.09	0.69	0.29
m_1v_3	3.50	1.25	0.47	0.08	0.49	0.24
m_1v_4	3.00	1.75	0.51	0.10	0.72	0.42
m_1v_5	2.75	1.75	0.40	0.10	0.46	0.23

m_2v_1	4.50	2.00	0.44	0.11	0.60	0.23
m_2v_2	3.25	1.50	0.43	0.10	0.68	0.25
m_2v_3	2.25	1.75	0.45	0.11	0.48	0.24
m_2v_4	3.75	1.50	0.50	0.10	0.71	0.23
m_2v_5	3.75	2.00	0.43	0.11	0.45	0.29
m_3v_1	4.50	2.50	0.31	0.13	0.75	0.34
m_3v_2	3.75	2.00	0.31	0.12	0.57	0.40
m_3v_3	4.75	3.00	0.33	0.12	0.49	0.40
m_3v_4	4.75	2.25	0.32	0.13	0.78	0.46
m_3v_5	3.25	2.00	0.32	0.08	0.72	0.34
m_4v_1	4.00	2.50	0.28	0.12	0.72	0.45
m_4v_2	4.25	2.75	0.24	0.11	0.74	0.33
m_4v_3	4.25	2.50	0.28	0.11	0.87	0.55
m_4v_4	5.25	2.75	0.30	0.16	0.99	0.51
m_4v_5	4.50	2.25	0.26	0.11	0.32	0.32
SE m (+)	0.602	0.334	0.015	0.010	0.016	0.020
CD (0.05)	NS	NS	0.029	NS	0.045	0.059

exploit deeper soil layers for water. This accords with reported observations by Stasovski and Peterson (1991) and indicates that root growth is usually much less depressed than shoot growth, leading to a typical increase in root: shoot ratio. Similar results were reported by Hayatu and Mukhtar (2010) in cowpea genotypes.

There was significant variation in root: shoot ratio between varieties in open condition. Among the varieties, COFC-8 recorded higher root: shoot ratio in open. Increases in root biomass and root : shoot ratio were recorded in all the fodder cowpea genotypes when grown under water stressed conditions (Hayatu and Mukhtar, 2010).Interaction effect was significant in open condition and COFC-8 at lifesaving irrigation and IW/CPE ratio of 0.4 recorded higher root : shoot ratio which was on par with UPC-618 receiving lifesaving irrigation. Similar results were also reported by Hayatu and Mukhtar (2010) in fodder cowpea genotypes, showing variation in root : shoot ratio at different soil moisture stress levels.

The study revealed that soil moisture stress levels and varieties had significant effect on root dry weight of fodder cowpea in both open and shade. Root dry weight was significantly higher at higher levels of irrigation. Heenan and Thompson (1984) observed reduced root proliferation under water stressed condition compared to well irrigated plants. Moreover, stress could lead to several physiological and biochemical changes which are directly and indirectly related to root generation. For instance, the stress induced changes in the level of endogenous growth hormones and carbohydrate which could result in a differential rooting pattern. At IW/CPE ratio of 0.8, the roots were deeper and had more weight and volume. Availability of sufficient water favoured better root growth. This supports the findings by Hayatu and Mukhtar (2010) in fodder cowpea genotypes.There was significant variation in root dry weight between varieties in open and shade. Among the varieties, COFC-8 recorded higher root dry weight in open and shade. This could be attributed to the better ability of this variety to produce better root characters.M x V interaction was significant in open and partial shade. COFC-8 irrigated at IW/CPE ratio of 0.8 recorded significantly higher root dry weight in open. Under partial shade, Bundel Lobia-1 irrigated at IW/CPE ratio of 0.8 recorded significantly higher root dry weight. . Similar results on reduction of root dry weight due to moisture stress was reported by Hayatu and Mukhtar (2010) in fodder cowpea genotype

5. CONCLUSION

From the results of the study, it was concluded that higher levels of irrigation recorded higher root volume and root dry weight in both open and partial shade. However lifesaving irrigation recorded higher root shoot ratio in open condition. Among the varieties, COFC-8 recorded higher root dry weight and root shoot ratio.

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AGROBIODIVERSITY OF KUTTANAD WETLANDS IN THE CONTEXT OF PROMISING AGROFORESTRY PRACTICES AND RESOURCE SUSTAINABILITY

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ABSTRACT

The Kuttanad wetland system in Kerala is very special by virtue of the fact that it is located 1.0 to 2.5 m below mean sea level and that it has a poor tree wealth, but an extensive area for cultivation of wetland crops especially paddy and coconut. However, there are home gardens which provide an idea of local knowledge on plant resource management offering directions to develop agroforestry systems suited to the whole wetland system, extending from the coastal lowlands lining the Arabian Sea in the west and the lower reaches of midlands in the east, covering the districts of Alappuzha, Kottayam and Pathanamthitta. Agroforestry symbolizes a sustainable land use management system, which integrates growing of agricultural crops and forest trees together in the same piece of land, which is economically and ecologically desirable, and socially acceptable to the local population. In this background, a study has been undertaken to analyze the plant wealth of Kuttanad wetlands, with particular reference to home garden and bund based agroforestry practices in terms of species composition, diversity, utilization potential and preferences by the local community. The results of documentation and subsequent analysis reveal the potential for systematic development of agroforestry in the wetland system involving plant resources such as timber trees; fire wood and soft wood trees; fibre, paper and pulp yielding resources; spices, beverages and vegetable crops; medicinal plants; fencing plants and a host of other plant resource which are sustainably advantageous to the local population. The study led to the identification of promising agroforestry species suited to the wetlands, which are ecologically compatible and economically viable.

Key words: Agrobiodiversity, Kuttanad, wetlands, agroforestry, sustainability

1. INTRODUCTION

Importance of wetlands in livelihood security is the key aspect of environmental concern all over the world. The Ramsar Convention on wetland has given emphasis to certain areas of sensitivity in conservation and sustainable development. One such designated Ramsar site is the Vembanad Lake and associated wetlands demarcated as what is locally known as 'Kuttanad'; it is a very special ecosystem by virtue of the fact that it is located 1-2.5 m below mean sea level. An area which has not received focus of attention is agroforestry, which will give a new dimension to the Kuttanad wetlands. It has been noticed that the whole wetland system is poor in tree wealth, which has affected not only the economic gains of the people but also the ability to moderate the impacts of environmental risks particularly with reference to climate change.

Agroforestry symbolizes a sustainable land use system, which integrates growing of agricultural crops and forest trees together in the same piece of land for maximum production of food, fodder and wood and other products of economic use, and which is economically and ecologically desirable and socially acceptable to the local population. In agroforestry systems there are both ecological and economical interactions between the different components (ICRAF, 1993). The main thrust of the present study has been on floral diversity of Kuttanad in which economically important plants including food, medicinal and socially important species have been documented. In order to analyze the existing/ traditional agroforestry practices in the home gardens of Kuttanad wetlands, a homestead based survey has been conducted, focusing on agroforestry resources and their utility aspects. Home gardens can serve as models for the design of improved agroforestry systems (Kumar and Nair, 2004). The study also made an attempt to evolve information on promising agroforestry species suited to in wetland area as well as their utility in socio-economic facets, which will improve the sustainability of bioresources and ecological services.

2. METHODOLOGY

The Kuttanad wetland area extends from North latitudes 9^0 8' to 9^0 52' and East longitudes from 76^0 19' to 76^0 44' comprising of 54 revenue villages spread over Alappuzha, Kottayam and Pathanamthitta districts of Kerala State. The present study was conducted in that part of Kuttanad wetland ecosystem under Alapuzha district, which is a highly complex, unique rice-growing tract of Kerala lying 1.0 - 2.5 m below MSL. Several trips were made during 2008–2012 covering all seasons to assess the status and distribution of vegetation in the area. The field survey conducted in the home gardens, bunds and agricultural fields of native farmers were mainly focused on documenting the existing/traditional agroforestry components, and identification of promising agroforestry species, both native and acclimatized exotics, and notable integrations including livestock, fishery and trade. The plants were identified and documented based on the district Flora of Alappuzha (Sunil and Sivadasan, 2009) and checklist of flowering plants of Kerala (Sasidharan, 2004). In documenting the traditional uses and farming practices, native farmers, traditional healthcare practitioners, and village elders were consulted.

3. OBSERVATIONS

The home garden and bund based survey of the Kuttanad wetlands revealed the nature and composition of existing agroforestry practices, which throw light on the scope of developing sustainable agroforestry packages for the wetland area. A unique feature of the existing agroforestry operation in the lowland zone is the traditional practice of pisciculture in ponds within homesteads. Similarly, the abundant growth of the different varieties of Nymphaea spp. (Water lily) and Nelumbo nucifera (Sacred lotus), which are of horticultural value in ponds and other small neglected water bodies (including abandoned paddy fields), a characteristic of the area, offer great scope in projecting aqua-floriculture as an ecologically compatible and economically viable agroforestry system for the lower regions of Kuttanad. The homesteads possess plant resources suited to typical wetland environments and few mangrove associates as promising components of the system. The home gardens of upper Kuttanad areas possess an assortment of fruit crops, medicinal plants, timber plants and other plants of economic importance, of which timber yielding and fruit trees are dominant owing to its multipurpose utility. The typical home gardens of the area possess optimum plant resources with effective land utilization, having a direct bearing on economic sustainability. In the agricultural fields, agroforestry practices are associated with the bunds; most of the low lying land areas being dominated by paddy cultivation, associated bund areas are utilized for planting minor crops and other plants. Thus the bund areas of the paddy fields of varying dimensions are utilized for agroforestry operations, though in an unorganized form.

The existing agroforestry operations of Kuttanad wetlands can be broadly divided into homestead agroforestry and field agroforestry. The dominating agricultural crops of the bund region are coconut, plantains, tubers, vegetables and fruit plants. The trees like Mangifera indica (Mango), Ailanthus triphysa (Perumaram), Anacardium occidentale (Cashew nut tree), Artocarpus heterophyllus (Jackfruit tree), Thespesia populnea (Poovarasu) are planted in a random manner without any proper organization. Sometimes these woody perennials are planted to mark the boundary. Food based plant resources in the study area are mainly formed by paddy, the main staple food for the people of Kerala. Apart from Oryza sativa, the cultivated species of paddy, there are wild relatives of the crop in the study area, namely O. rufipogon and Leersia hexandra. The medicinally important rice variety "njavara" was cultivated widely in some parts of Kuttanad but now it is in scarce. A variety of crop plants mainly fruit plants, vegetables, and spices like Garcinia gummi-gutta (Malabar gamboge) and Myristica fragrans (Nutmeg) are commonly found in the homesteads of Kuttanad.

A total of 421 species of flowering plants have been documented from the entire study zone, of which 210 species are identified as economically important elements, including agroforestry species. A checklist of economically important plants including agroforestry species documented from the area is given in Table-01. The agroforestry components could be categorized as timber trees; fire wood and soft wood trees; fibre, paper and pulp yielding resources; oil yielding plants; vegetables and spices; beverages, support trees and fencing plants; manure yielding plants; avenue plants; and medicinal plants, which evidently cover food plants, industrially relevant plants, among other economically useful plants. The categories of agroforestry plants and their uses are described below.

Table 1: Checklist of potential agroforestry resources of Kuttanad wetlands

Botanical name	Uses														
	Fiber	Oil	Spices	Paper pulp	Beverages	Vegetable	Supporting	Fire wood	Fence	Manure	Avenue	Ornamental	Fruit	Medicinal	Wood
Abelmoschus esculentus						√									
Acacia auriculiformis				√				√			√				√
Acacia mangium				√				√			√				√
Adenanthera pavonina											√			√	
Aegle marmelos							√				√			√	
Ailanthus excelsa				√				√			√				√
Ailanthus triphysa								√			√				√
Alangium salvifolium														√	
Albizia lebbeck				√			√	√			√			√	√
Alpinia calcarata												√		√	
Alpinia galanga												√		√	
Alstonia scholaris								√			√			√	√
Anacardium occidentale								√					√	√	√
Ananas comosus	√								√				√	√	
Annona glabra									√	√			√		
Annona muricata										√			√	√	
Annona reticulata													√	√	
Annona squamosa													√	√	
Aphanamixis polystachya											√			√	√
Aporusa lindleyana							√			√			√	√	
Artocarpus communis						√	√				√		√	√	
Artocarpus heterophyllus							√	√		√	√		√	√	√
Artocarpus hirsutus							√	√		√	√		√	√	√
Asparagus racemosus						√						√		√	
Averrhoa bilimbi						√							√	√	
Averrhoa carambola						√					√		√	√	
Azadirachta indica		√									√			√	√

Bacopa monnieri														√	
Bambusa bambos				√					√					√	√
Bambusa vulgaris									√			√			√
Barringtonia acutangula										√	√			√	√
Barringtonia racemosa										√	√				√
Bauhinia acuminata												√			
Biophytum reinwardtii														√	
Bixa orellana										√	√	√		√	
Buchanania lanzan							√				√		√	√	√
Caesalpinia pulcherrima											√	√		√	
Caesalpinia sappan										√				√	
Callistemon lanceolatus											√	√			
Calophyllum calaba		√						√			√			√	√
Calophyllum inophyllum		√					√	√	√		√			√	√
Calotropis gigantea									√	√				√	
Capscicum annum			√			√								√	
Capscicum frutescens			√			√								√	
Carallia brachiata							√	√			√				√
Carica papaya						√							√	√	
Carissa carandas												√	√	√	
Caryota urens														√	√
Cassia fistula								√		√	√	√		√	√
Cassia occidentalis										√				√	
Casuarina equisetifolia								√	√		√				√
Catharanthus roseus												√		√	
Ceiba pentandra	√	√					√	√			√			√	√
Centella asiatica														√	
Cerbera odollam							√		√					√	
Chrysophyllum cainito											√		√		
Cinnamomum malabatrum			√								√			√	
Cinnamomum verum			√								√			√	
Cissus quadrangularis						√								√	
Citharexylum subserratum									√		√	√			
Citrus limon						√							√	√	
Citrus maxima								√					√	√	
Clerodendrum inerme									√					√	
Clitoria ternatea												√		√	
Cocos nucifera	√	√					√	√							√
Coffea arabica					√			√						√	
Colocasia esculenta						√									
Commiphora caudata								√		√		√		√	√
Crateva magna										√	√	√			

Cucumis sativus						√									
Cucurbita maxima						√									
Curcuma longa			√			√								√	
Dalbergia sissoo								√			√				√
Delonix regia								√			√	√			√
Desmodium gangeticum														√	
Dioscorea alata						√									
Diospyros ebenum								√			√				√
Eclipta alba														√	
Elaeocarpus serratus						√					√		√	√	√
Erythrina variegata				√			√		√					√	√
Eucalyptus globulus		√		√				√			√			√	√
Ficus benghalensis								√			√			√	√
Ficus hispida										√				√	√
Ficus racemosa								√			√			√	√
Ficus religiosa								√			√			√	√
Flacourtia jangomas						√					√		√		
Garcinia gummi-gutta		√	√					√					√	√	√
Garcinia mangostana											√		√		√
Garcinia xanthochymus											√		√	√	√
Gardenia jasminoides									√		√	√		√	
Gliricidia sepium							√	√	√	√					
Glochidion zeylanicum											√		√		
Gloriosa superba												√		√	
Glycosmis pentaphylla										√			√	√	
Grevillea robusta							√	√			√				√
Hedychium coronarium												√			
Hibiscus rosa-sinensis						√						√		√	
Hibiscus tiliaceus							√	√	√	√				√	√
Holigarna arnottiana										√				√	√
Hopea parviflora								√						√	√
Hydnocarpus pentandra		√						√			√			√	√
Hygrophila schulli														√	
Indigofera tinctoria														√	
Jatropha curcas		√					√		√	√				√	
Justicia adhatoda									√			√		√	
Lagenaria siceraria						√									
Lagerstroemia reginae											√			√	√
Lannea coromandelica							√	√		√	√			√	√
Lawsonia inermis									√			√		√	
Leucaena leucocephala										√				√	
Litsea coriacea															√

Lophopetalum wightianum								√		√					√
Lycopersicon esculentum						√									
Macaranga peltata							√	√		√	√				√
Mallotus philippensis														√	√
Malpighia glabra												√	√		
Mammea longifolia		√						√			√			√	√
Mangifera indica						√	√	√			√		√		√
Manihot glaziovii							√		√						
Manilkara zapota											√		√	√	
Maranta arundinacea						√								√	
Memecylon umbellatum								√						√	
Mesua ferrea											√	√		√	
Michelia champaca											√	√		√	
Mimusops elengi		√									√	√	√	√	√
Monocharia vaginalis														√	
Morinda tinctoria														√	√
Moringa pterygosperma						√	√		√					√	
Momordica charantia						√								√	
Morus alba									√				√	√	
Murraya koenigii			√			√								√	
Murraya paniculata											√	√			
Musa paradisiaca	√					√							√		
Myristica fragrans			√			√					√			√	
Myristica malabarica											√			√	
Nelumbo nucifera												√		√	
Nephelium lappaceum										√			√		
Nerium oleander												√		√	
Nymphaea nouchali												√			
Nymphaea pubescens												√			
Nymphaea stellata												√			
Ochlandra scriptoria				√											
Ocimum americanum												√		√	
Ocimum gratissimum												√		√	
Ocimum sanctum												√		√	
Olea dioica								√		√				√	√
Pandanus amaryllifolius	√		√			√								√	
Pandanus fascicularis	√						√		√					√	
Pandanus kaida	√						√		√					√	
Pandanus unipapillatus	√						√		√					√	
Panjanelia longifolia							√				√				√
Passiflora edulis													√	√	
Pavetta indica												√		√	

Peltophorum ferrugineum										√	√			√	√
Persea macrantha								√			√				√
Phyllanthus emblica						√							√	√	√
Pimenta dioica			√								√			√	
Piper betle														√	
Piper longum			√											√	
Piper nigrum			√											√	
Plectranthus ambonicus														√	
Plumeria rubra									√		√	√		√	
Polyalthia longifolia							√		√		√	√		√	√
Pongamia pinnata		√								√	√	√		√	√
Pouteria campechiana											√		√	√	
Premna serratifolia														√	
Psidium guajava								√					√	√	
Pterocarpus marsupium							√				√				√
Punica granatum													√	√	
Ricinus communis		√												√	
Samadera indica		√							√		√			√	
Samanea saman								√		√	√				√
Santalum album		√						√			√			√	√
Sapindus laurifolia											√			√	√
Saraca asoca											√			√	√
Sauropus androgynus						√								√	
Schleichera oleosa														√	√
Sesamum orientale		√								√					
Sesbania grandiflora						√				√				√	
Sida cordifolia														√	
Sida rhomboidea														√	
Solanum melongena						√									
Spathodea campanulata								√			√			√	√
Spondias pinnata											√		√	√	√
Strobilanthes ciliatus												√		√	
Strychnos nux-vomica								√						√	√
Swietenia macrophylla											√				√
Swietenia mahagoni								√		√	√				√
Syzygium aromaticum			√					√			√			√	√
Syzygium caryophyllatum								√			√		√	√	√
Syzygium cumini								√			√		√	√	√
Syzygium jambos								√			√		√	√	√
Syzygium malaccensis								√			√		√	√	√
Syzygium zeylanicum													√	√	
Tabernaemontana alternifolia										√		√		√	

Tabernaemontana divaricata							√		√	√		√		√	√
Tamarindus indica			√				√	√			√		√	√	√
Tecoma stans								√				√		√	
Tectona grandis								√						√	√
Terminalia bellerica								√			√		√	√	√
Terminalia catappa							√	√		√	√		√	√	√
Terminalia paniculata							√	√		√	√			√	√
Theobroma cacao					√						√		√	√	
Thespesia populnea							√	√	√	√	√			√	√
Trichosanthes cucumerina						√									
Vateria indica								√			√			√	√
Vetiveria zizanioides		√							√					√	
Vitex negundo									√					√	
Zingiber officinale			√											√	
Zizyphus mauritiana								√					√	√	

3.1. Wetland plant resources of relevance in agroforestry

Aquatic vegetation is an important floral group significant to the wetland which has not been exploited for economic gains. In this connection mention may be made of economically viable components like the Bambusa spp. (Bamboo), Pandanus spp. (Screw pine), and Thespesia populnea (Poovarasu). These are promising agroforestry elements for large-scale cultivation in the wetland area. These plants check soil erosion and protect bunds and banks from flooding, at the same time as forming raw material for industries like mat, craft, pulp and timber. Nymphaea spp. (Water lily) and Nelumbo nucifera (Sacred lotus) offer scope for aqua-floriculture in abandoned paddy fields, pools and ponds of the area. Bacopa monnieri (Brahmi), Centella asiatica (Kodangal), Eclipta alba (Kayyonni), Hygrophila schulli (Vayalchulli), Monocharia vaginalis and (Karimkoovalam) are semi-aquatic medicinal herbs, suited for the wetland area which offer scope for large-scale cultivation. Azolla is a nitrogen-fixing plant, which enhances the soil fertility, and it can also be used as a good cattle feed.

3.2.Timber and softwood yielding plants

Timber yielding plants constitute a major part of the agroforestry resources. Hard wood trees are distributed in the home gardens, bunds, and in the sacred groves. Notable among them are Artocarpus heterophyllus (Jackfruit tree), A. hirsutus (Anjili), Dalbergia sissoo (Sissoo), Hopea parviflora (Kambagam), Swietenia mahagoni (Mahogany), Tectona grandis (Teak), Terminalia paniculata (Maruthi) and Thespesia populnea (Poovarasu). These are of value in house construction and furniture making; some of them are used in sculpturing and also for making musical instruments. Diospyros ebenum (Ceylon ebony), Mimusops elengi (Elenji), Persea macrantha (Uravu), Pongamia pinnata (Pongu), Schleichera oleosa (Poovanam), Strychnos nux-vomica (Kanjiram), Tamarindus indica (Tamarind) and Terminalia bellerica (Thanni) also yield timber for various purposes. Soft wood trees like Ailanthus excelsa (Pongiliam), Alstonia scholaris (Ezhilampala), Albizia lebbeck (Karivaka), Ceiba pentandra (Panjimaram), Erythrina variegata (Murukku), Hibiscus tiliaceus (Velipparuthi), Lannea coromandelica (Uthi), Mangifera indica (Mango), Macaranga peltata (Vatta), Panjanelia longifolia (Azhantha), Peltophorum ferrugineum (Copper pod tree), Samanea saman (Rain tree), Sapindus laurifolius (Soap nut tree), Terminalia catappa (Indian badam) are fast growing trees of economic value. Panjanelia longifolia and Ailanthus excelsa are two important plants of this category, which are traditionally used for making catamaran by local fishermen. Most of these trees are distributed in the homesteads and some are restricted to the bunds in agricultural fields. Often certain trees like Alstonia scholaris, Ceiba pentandra, Delonix regia (Gulmohar), Leucaena leucophala (Subabul), Peltophorum ferrugineum, Samadera indica (Karinjotta), Spathodea campanulata (Scarlet-bell tree) and Terminalia catappa are commonly planted as avenue trees, but are not found in agricultural fields.

3.3. Fibre yielding plants

The existing agroforestry resources offer great scope for sustainable utilization of natural fibre resources like Ceiba pentandra (Panjimaram), Pandanus spp. (Screw pine), Ananas comosus (Pineapple) and plantation crops like coconut and plantain. Pandanus fascicularis, P. kaida, and P. unipapillatus provide fine fibres from their long leaves, which are mainly used for weaving high quality mats. It is also used for making craft items and other utility articles like baskets, bags, carpets, toys, etc. The fibres of Ananas leaves can also be used for weaving crafts and other ornamental articles. Ceiba pentandra is a fast growing tree, which offers fibres, obtained from the dried fruits; these fibres are long, fine and of desirable quality, mainly for filling pillows, beds, making toys and other related articles. Fibres from plantation crops like coconut and plantain also offer multipurpose uses, including raw material for coir industry.

3.4. Oil yielding plants

Certain agroforestry species yield oil, which are variously used as medicine, biofuel, edible oil, lighting oil, etc. Hydnocarpus pentandra (Marotti), Azadirachta indica (Neem), Garcinia gummi-gutta (Malabar gamboge), Mimusops elengi (Elenji), Pongamia pinnata (Pongu), Ricinus communis (Avanakku), Samadera indica (Karinjotta), Mammea longifolia (Suran punna), Ceiba pentandra (Panjimaram) are medicinal oil yielding plants; the seed oil of Hydnocarpus pentandra (Marotti) is used in the treatment of leprosy, rheumatism and skin problems. Oil extracted from the seeds of Calophyllum inophyllum (Punna), C. calaba (Cherupunna), Jatropha curcas (Kadalavanakku) and Pongamia pinnata, form potential bio-fuel alternatives apart from their wide medicinal uses. Oil from Ceiba pentandra is mainly used in soap making, and Castor (Ricinus communis) oil is highly medicinal. Seed oil from Mimusops elengi and Sesamum orientale (Gingelly) are used for cooking and preparation of medicines. Volatile oils like Sandal oil and Vetiver oil are highly aromatic and medicinal, and are extensively used in perfume industry.

3.5. Paper pulp yielding plants

Acacia auriculiformis (Acacia), A. mangium (Mangium), Bambusa bambos (Thorny bamboo), B. vulgaris (Yellow bamboo), Erythrina variegata (Murukku), and Ochlandra spp. (Eetta) are the common paper pulp yielding plants in the area, which are of commercial value. Of these, Acacia auriculiformis, Bambusa spp. and Ochlandra scriptoria (Kulanji) are comparatively fairly distributed. Others are not found frequently and they are mainly used as support plants for climbing crops, and also as live fence in homesteads. Being a wetland area, scope for introduction of these plants especially Ochlandra and Bambusa in these areas will check soil erosion and enhance bund protection.

3.6. Fruit yielding plants/fruit plants

A notable share of agroforestry species preferred by the natives are potential fruit plants having multiple uses. Agricultural fields of various zones harbour different species of fruit plants and most of them are also timber yielding trees. The fruit plants preferred by the natives are mostly of multipurpose utility, especially of timber yielding, fodder yielding or with medicinal uses. The common fruit yielding plants having timber value are Artocarpus heterophyllus (Jackfruit tree), A. hirsutus (Anjili), Anacardium occidentale (Cashew nut tree), Elaeocarpus serratus (Kara), Garcinia gummi-gutta (Malabar gamboge/Kudampuli), Mangifera indica (Mango), Mimusops elengi (Elenji), Phyllanthus emblica (Nelli), and Tamarindus indica (Tamarind/Valanpuli). Underutilized fruit plants like Aporusa lindeyana (Vetti), Annona glabra (Kattatha/ Cherimoyer), Artocarpus hirsutus (Anjili), Averrhoa bilimbi (Irumbanpuli), A. carambola (Anapulinchi), Buchanania lanzan (Kulamavu), Ficus racemosa (Athi), Glycosmis pentaphylla (Panal), Ixora coccinea (Thechi), Morus alba (Mulberry), Spondias pinnata (Ambazham), Syzygium cumini (Njaval), S. jambos (Seema-chamba), and S. zeylanicum (Poochappazham) are commonly seen in agricultural fields/bunds. The fruit resources of the area are valuable commercially for the preparation of value added products like jams, juices and squashes. At the same time underutilized fruit resources have to be exploited for optimum utilization of resources leading to economic sufficiency of the farmers.

3.7. Vegetable plants/parts used as vegetable

Different agroforestry species provide vegetables for consumption and also for the market. Mainly fruits, leaves, flowers and roots (tubers) of the plants are used as vegetable and most of them form a part of the daily dishes of the natives. Major fruit vegetables are Abelmoschus esculentus (Lady's finger), Annona muricata (Mullatha), Artocarpus communis (Breadfruit), A. heterophyllus (Jackfruit), Averrhoa bilimbi (Irumbanpuli), Averrhoa carambola (Anapulinchi), Capscicum annum (Red chilly), C. frutescens (Kanthari), Carica papaya (Papaya), Citrus spp. (Lemon), Cucumis sativus (Cucumber), Cucurbita maxima (Pumpkin), Elaeocarpus serratus (Kara), Phyllanthus emblica (Nelli), Mangifera indica (Mango), Moringa pterygosperma (Muringa), Momordica charantia (Bitter gourd), Solanum melongena (Brinjal) and Syzygium jambos (Seema-chamba). Cassia occidentalis (Thakara), Moringa pterygosperma (Muringa), Sauropus androgynus (Chikurmanis), Sesbania grandiflora (Agathi), etc. are agroforestry species providing leaves as vegetable which are also used as medicinal plants. Flowers of Sesbania grandiflora and Moringa pterygosperma are used as vegetables due to their medicinal property. Tubers of Asparagus are highly medicinal, are used for pickling and for making other preparations. Sauropus androgynus is a well known leafy vegetable, the leaves of which are a rich source of Iron.

3.8. Spices

Spices and condiments like Piper nigrum (Pepper), Curcuma longa (Turmeric), Zingiber officinale (Ginger), Myristica fragrans (Nutmeg), Garcinia gummi-gutta (Malabar gamboge), Syzygium aromaticum (Clove), Cinnamomum verum (Cinnamon), Pimenta dioica (Allspice), Murraya koenigii (Curry leaf) and Pandanus amaryllifolius (Rambha) are the major spices and condiments cultivated in the area, of which Piper nigrum, Myristica fragrans, Garcinia gummi-gutta, and Syzygium aromaticum are cultivated frequently as intercrops among coconut plantations of upper and middle Kuttanad zones. Other elements are mainly limited to home gardens either in kitchen garden or in ornamental garden along with other showy plants. Zingiber officinale and Curcuma longa are planted as intercrops in plantain orchards.

3.9. Beverages

Coffea arabica (Coffee) and Theobroma cacao (Chocolate nut tree/Cocco) are the two beverage plants found in the area. Generally these plants are propagated as plantation on large scale in the midlands and highlands of the State. But in most of the areas of Kuttanad, it is restricted to the home gardens because of less land availability.

3.10. Support plants/plants as live support

An additional use of certain agroforestry species is that its branches or plant as a whole provides live support for climbing crops. Ceiba pentandra (Panjimaram), Erythrina variegate (Murukku), Gliricidia sepium (Seemakkonna), Hibiscus tiliaceus (Velipparuthi), Jatropha curcas (Kadalavanakku), Manihot glaziovii (Kattu rubber), Moringa pterygosperma (Muringa), etc. are the common support plants used in home gardens and bunds. The poles of above plants are also used for making support frames for climbing vegetables like Momordica charantia (Bitter gourd), Trichoxanthus cucumerina (Snake gourd), Vigna unguiculata (Kottappayar) and for cash crops like Piper nigrum (Pepper), Piper betle (Betel leaf) and Vanilla planifolia (Vanilla). The common tree species such as Albizia lebbeck (Karivaka), Aporusa lindleyana (Vetti), Artocarpus communis (Breadfruit), A. heterophyllus (Jackfruit tree), A. hirsutus (Anjili), Buchanania lanzan (Kulamavu), Ceiba pentandra (Panjimaram), Grevillea robusta (Silver oak), Hibiscus tiliaceus (Velipparuthi), Jatropha curcas (Kadalavanakku), Lannea coromandelica (Uthi), Macaranga peltata (Vatta), Mangifera indica (Mango), Panjanelia longifolia (Azhantha), Tabernaemontana heyneana (Kundalappala), Terminalia paniculata (Maruthi), Thespesia populnea (Poovarasu), Cerbera odollam (Othalam) are also used as live support for growing Pepper and Dioscorea (Yam) and thereby provide an additional use other than timber.

3.11. Fire wood/fuel wood

Most of the agroforestry species provide wood fuel for homes and industries. In some cases entire plant is useful as firewood, while in others parts, especially lateral branches or branchlets are used for the purpose. The plants used as fire wood are Anacardium occidentale (Cashew nut tree), Albizia lebbeck (Karivaka), Carallia brachiata (Vallabham), Ficus benghalensis (Banyan), Garcinia gummi-gutta (Malabar gamboge), Grevillea robusta (Silver oak), Holigarna arnottiana (Charu), Litsea coriacea (Maravettithali), Macaranga peltata (Vatta), Mallotus philippensis (Kurangu-manjal), Morinda tinctoria (Manjanathi), Peltophorum ferrugineum (Copper pod tree), Spathodea campanulata (Scarlet-bell tree), Tabernaemontana heyneana (Kundalappala), Terminalia catappa (Indian badam), etc. In case of certain timber trees, the parts form a potential source of fuel wood; examples of such plants are Acacia auriculiformis (Acacia), Acacia mangium (Mangium), Artocarpus heterophyllus (Jackfruit tree), A. hirsutus (Anjili), Carallia brachiata (Vallabham), Casuarina equisetifolia (Kattadi), etc. Use of agroforestry species as firewood is an inevitable aspect and it will reduce over exploitation of existing vegetation and thus help conserve biodiversity.

3.12. Fencing/hedges

Fencing is a common feature of agricultural fields and homesteads of the area where it is more prevalent in middle Kuttanad and lower Kuttanad areas than in upper Kuttanad zone. Homesteads in upper Kuttanad prefer live fencing using woody perennials of multiple uses. Erythrina variegata (Murukku), Glyricidia sepium (Seemakkonna), Jatropha curcas (Kadalavanakku), Justicia adhatoda (Adalodakam),Lawsonia inermis (Mylanchi), Manihot glaziovii (Kattu rubber), Moringa pterygosperma (Muringa), Morus alba (Mulberry), Gardenia jasminoides (Gandharajan), Tabernaemontana alternifolia (Kundalappala), Sauropus androgynus (Chikurmanis), Thespesia populnea (Poovarasu), and Vitex negundo (Karinochi) are the common fencing plants of upper Kuttanad. Live fencing in the middle Kuttanad also represents the above species, and in addition Cerebera odollam (Othalam), Hibiscus tiliaceus (Velipparuthi), Samadera indica (Karinjotta) are commonly used. Fencing plants of lower areas is critical and suited to the ecological specialty of the zone which include Cerbera odollam, Thespesia populnea, Hibiscus tiliaceus, and Pandanus spp. Hedges are planted in certain home gardens and agricultural plots for checking soil erosion apart from other uses. The common hedge plants are Ananas comosus (Pineapple), Bambusa bambos (Thorny bamboo), B. vulgaris (Yellow bamboo), Calotropis gigantea (Erukku), Ochlandra spp. (Eetta), Pandanus spp., Samadera indica, Gardenia jasminoides, Tabernaemontana alternifolia and Vetiveria zizanioides (Ramacham).

3.13. Manurial plants/plants yielding green manure

Some of the agroforestry species are promising green manure resources. Careya arborea (Pezhu), Glyricidia sepium (Seemakkonna), Glycosmis pentaphylla (Panal), Lannea coromandelica (Uthi), Leucaena leucocephala (Subabul), Macaranga peltata (Vatta), Olea dioica (Edana), Samanea saman (Rain tree), Tabernaemontana alternifolia (Kundalappala), Terminalia paniculata (Maruth), Thespesia populnea (Poovarasu) are the commonly used manurial plants. The leaves and tender parts are used as green manure in crop fields and in homestead cultivation. Use of agroforestry species for green manure ensure quality of the produce and will reduce the environmental degradation, especially of water and soil.

3.14. Avenue plants/ plants used in avenues

Avenue plants are generally associated with parks, gardens, roadsides, sacred places and areas of public importance. Most of the timber yielding plants either hard wood or soft wood are used as avenue plants, important among them are Acacia auriculiformis (Acacia), A. mangium (Mangium), Adenanthera pavonina (Manchadi), Albizia lebbeck (Karivaka), Alstonia scholaris (Ezhilampala), Aphanamixis polystachya (Chemmaram), Artocarpus heterophyllus (Jackfruit tree), A. hirsutus (Anjili), Barringtonia racemosa (Attupezhu), Carallia brachiata (Vallabham), Casuarina equisetifolia (Kattadi), Ceiba pentandra (Panjimaram), Dalbergia sissoo (Sissoo), Diospyros ebenum (Ceylon ebony), Eucalyptus globulus (Eucalyptus), Grevillea robusta (Silver oak), Leucaena leucocephala (Subabul), Mimusops elengi (Elenji), Peltophorum ferrugineum (Copper pod tree), Pongamia pinnata (Pongu), Swietenia macrophylla (Manthagany), Samanea saman (Rain tree), Tamarindus indica (Tamarind), Terminalia arjuna (Neermaruthu), T. bellerica (Thanni), T. paniculata (Maruthi), Thespesia populnea (Poovarasu) and Vateria indica (Vellapayin). Certain ornamental plants with attractive flowers or leaves or canopy are also used for the purpose and mention may be of Bixa orellana (Lipstick tree), Caesalpinia pulcherrima (Rajamalli), Callistemon lanceolatus (Bottle brush), Cananga odorata (Kattuchempakam), Cassia fistula (Kanikkonna), Citharexylum subserratum (Fiddlewood), Michelia champaca (Chempakam), Murraya paniculata (Honey bush), Plumeria rubra (Ezhachempakam), Saraca asoca (Asokam), and Terminalia catappa (Indian badam). Avenue plants associated with roadsides and other pollution prone areas absorb dust and gaseous pollutants and thereby purify air, reduce noise pollution and enhance the greenery and aesthetics of the locality.

3.15. Ornamental plants

The ornamental plants of home gardens in Kuttanad have many uses like medicinal, fruits yielding and even fodder apart from its primary function of imparting beauty and attraction. A unique feature in the case of ornamental plants is that most of these are medicinally useful for the treatment of various diseases and general healthcare. The common medicinal ornamentals of the home gardens are Alpinia calcarata (Chittaratha), Asparagus recemosus (Sathaveri), Bixa orellana (Lipstick tree), Caesalpinia pulcherrima (Rajamalli), Calotropis gigantea (Erukku), Catharanthus roseus (Ushamalari), Citharexylum subserratum (Fiddlewood), Clitoria ternatea (Sankupushpam), Commiphora caudata (Kilimaram), Gloriosa superb (Menthonni), Hibiscus rosa-sinensis (Shoe flower), Indigofera tinctoria (Neelayamari), Lawsonia inermis (Mylanchi), Mammea longifolia (Suran punna), Murraya paniculata (Honey bush), Nelumbo nucefera (Lotus), Nerium oleander (Arali), Nymphaea spp. (Water lily), Ocimum spp. (Thulasi), Pavetta indica (Paveta), Saraca asoca (Asokam) and Tabernaemontana divaricata (Nandyarvattom). Fruit yielding plants such as Carissa carandas (Karanda), Malpighia glabra (Barbados cherry) and Passiflora edulis (Passion fruit) are also grown in the home gardens considering their aesthetic appearance and fruit value.

3.16. Medicinally important agroforestry components

Agroforestry resources offer scope for medicinal resources including herbs, shrubs and trees. Alpinia calcarata (Chittaratha), Asparagus racemosus (Sathaveri), Bacopa monnieri (Brahmi), Catharanthus roseus (Ushamalari), Centella asiatica (Kodangal), Clitoria ternatea (Sankupushpam), Hygrophila schulli (Vayalchulli), Nelumbo nucifera (Sacred lotus), Ocimum sanctum (Thulasi), Vetiveria zizanoides (Ramacham), etc. are some of the important herbal medicinal resources of the area. Bund areas of paddy fields, riverine belts, and ponds can be effectively used for the cultivation of these plants. Some of these plants can be incorporated into integrated aqua-forestry practices leading to a profitable and sustainable system. Abandoned paddy fields and large ponds of the area can be profitably utilized for the cultivation of Nelumbo nucifera. Vetiveria zizanioides is the medicinal grass notable for its aromatic roots and medicinal value, also used as a hedge plant in agricultural fields.

4. DISCUSSION

Agroforestry according to Bene et al. (1977) is a sustainable management system for land that increases overall production by combining agricultural crops, tree corps and forest plants, and/or animals simultaneously or sequentially with application of management practices that are compatible with the cultural pattern of the local population. According to Nair (1979), agroforestry is a land use system that integrates trees, crops and animals in a way that is scientifically sound, ecologically desirable, practically feasible and socially acceptable to the farmers. Through successful practice of agroforestry in the wetland areas, it is possible to minimize all aspects of hazardous effects to the wetland system due to pollution and human interactions through proper land and resource management.

Sustainable development should meet the various needs of the present and future generations. These needs can be ecological, economical, social, cultural or spiritual. With trees it becomes easier to attain sustainable development, which is also the uttermost goal of agroforestry research (Land and People, 2003). Trees are a natural feature of rural landscapes and provide a range of benefits to farming communities. Trees on farms may be a relic of the native vegetation or may be exotic, introduced species. Trees can provide fruits and nuts, fodder for animals, timber and fuel wood, industrial products (oils, gums, resins, tannins, latex, etc.) and also traditional medicinal and cosmetic products (Andersson and Sinclair, 1993). Agroforestry is the practice of integrating trees on farms in order to increase the overall productive capacity of the land. It is a well established management practice for tropical crops that require association of shade trees.

Owing to the low lying land characteristics, agricultural practice in Kuttanad is mainly focused on paddy cultivation. Elevated areas are limited and are mainly utilized for habitation; cultivation in these areas includes crops like coconut, plantain and vegetables. In addition to these crops, timber trees, medicinal plants and other plants of economic importance are also cultivated based on the needs of the natives and economic utility. Agroforestry operations in this wetland system, involving particularly the existing indigenous and acclimatized exotic species, are generally amenable to the natives. Agroforestry practices are therefore, important for effective planting, management and utilization of plant resources for sustainable monitory benefits that are socially acceptable, scientifically sound and agro-ecologically suited to the area.

Even though, the area harbours different fibre yielding resources, the natives mainly focus on Pandanus spp. and coconut for the extraction of the fibres and production of valuable articles, because of job opportunities and sustainable economic gain. The underutilized fibre yielding plants like Ceiba pentandra, Ananas and Musa are to be fully exploited for alternative means of benefits leading to economic sustainability of the local inhabitants. Incorporation oil-yielding plants into the agriculture fields and homesteads and also its successful exploitation towards maximizing the utilization of land will also enhance economic returns. Medicinal plant diversity of the area shows the scope for large-scale cultivation and industrial linkage for economic prosperity of natives. With a view of monitory benefits, these medicinal resources can be sustainably incorporated into agroforestry practices for evolving potential agroforestry packages suited to the ecological specificity of the area.

The phenomenon of climate change is related to the increasing level of CO_2 in the atmosphere from various sources and even methane emission from flooded rice fields, apart from emission of other gaseous pollutants and particulates. Any increase in carbon load of the air will eventually lead to an increase in atmospheric temperature, if the hazard is not adequately controlled. The vegetation and its composition, particularly the tree wealth, could be very crucial for ameliorating the impacts of climate change. The leaf system and its spread can effectively enhance the photosynthetic activity in which CO_2 is captured and O_2 is released (Nair et al., 2010). Kuttanad area is below sea level and therefore vulnerable to sea water intrusion due to rising level of the sea which is perceived to occur as a result of climate change. The increased tree wealth will increase the green cover or leaf canopy which will absorb more CO_2 and other trace gases and emit O_2 which in turn has a mitigating effect of the climate change problem to which the Kuttanad wetland is vulnerable.

5. CONCLUSIONS

Existing native/traditional agroforestry practices in the agriculture fields and homesteads of Kuttanad were analyzed and documented through field visits coupled with consultation of farmers, traditional healthcare practitioners and village elders. The agroforestry practices and resources in the area cover a spectrum of areas grouped under agricultural crops, naturally growing field crops, vegetable crops, fruit plants, medicinal plants, timber plants, spices, ornamentals, fencing and fodder plants and other plants of economic importance. While analyzing the economic plant wealth, it is clear that paddy cultivation is the most dominant in the entire Kuttanad wetland system. Also of noticeable is the interest in coconut cultivation, which is a common resource in the wetland system. Fruit plants like Mangifera indica, Artocarpus heterophyllus, and Garcinia gummi-gutta dominate the homestead orchards throughout the area. Thespesia populnea is the most commonly found timber tree species along with other planted species like Ailanthus excelsa, Swietenia macrophylla and Artocarpus hirsutus. Aqua-floriculture, involving Nymphaea and Nelumbo, offers an important agroforestry practice in the wetland system. Pandanus, Bambusa and Ochlandra are the commonly occurring natural raw material resources for industries, which have a key role in wetland agroforestry development.

The study led to the identification of promising agroforestry species suited to the wetland habitat, the cultivation of which are ecologically compatible and economically viable. Data gathered on the multiple uses of agroforestry species throw light on the scope of organized agroforestry development in the wetland system. The tree wealth of Kuttanad wetland by and large is poor, which has to be increased for sustainability of resources and ecological services. It is therefore imperative that increased green cover in the low lying Kuttanad wetland system through agroforestry development could have advantageous environmental effects apart from economic benefits.

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EFFECT OF BORDEAUX MIXTURE ON HISTOPATHOLOGY OF DIFFERENT TISSUES OF MYSTUS VITTATUS EXPOSED TO DIFFERENT CONCENTRATIONS OF BORDEAUX MIXTURE FOR 96 HRS

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ABSTRACT

Fungicides play an important role among the different plant protection chemicals. Bordeaux mixture, a cu containing fungicide is widely used in agriculture plantations. LC $_{50}$ values exposed for 24, 48, 72 and 96 hours of Bordeaux mixture were calculated. LC $_{50}$ values were found to be 14.29, 9.463, 7.921 and 7.24 ppm exposed to different concentrations of Bordeaux mixture. Histopathological analysis of different tissues like muscle, gill and liver of Mystus Vittatus exposed to different concentrations of Bordeaux mixture for a period of 96 hrs were carried out. The pathological changes were more evident in fishes exposed to lethal concentrations. The normal architecture of the tissues were lost .Among the different tissues exposed, gills were the most affected one. Liver cells also showed hepatic degenerations with extensive congestion and necrosis. Thus the present study confirmed that Bordeaux mixture which is considered as one among the safest fungicide can induce histopathological damages in different tissues of fishes.

Key words: Fungicide, LC $_{50}$, congestion, necrosis, hepatic degeneration

1. INTRODUCTION

Fungicides play an important role among the different plant protection chemicals.These agrochemicals upon entering water bodies affect all life forms especially fishes (Metleve et al., 1983). Bordeaux mixture, a cu containing fungicide is widely used in agriculture plantations like rubber, coffee, pepper, cardamom, arecanut and coconut plantations. Studies conducted by Asha et al. (2003) confirmed that copper present in Bordeaux mixture acts as the key factor in altering the water quality conditions, thereby predisposing the fishes to different types of diseases. Copper is also capable of bioaccumulation in the tissues. Copper can also alter physiological parameters like suppression of essential enzymes (Brown, 1978) which plays a significant role in maintaining immune responses in fishes.

Bioassay studies have been recognized as the standard method for determining the measurement of toxicity (APHA, 1992). They serve as a basic tool for understanding the limiting effect of various chemicals on organisms. The heavy metals present in these fungicides enter into the body of organisms through nutrients and surrounding water medium and causes both superficial and systemic morphological changes (Rema Devi, 1996., Madhukumar, 2003). The objective of the present study aims to determine the lethal concentration (LC $_{50}$) for 24, 48, 72 and 96 hrs of Bordeaux mixture to the fresh water cat fish, Mystus vittatus and to determine the histopathology of different tissues like liver, gills and muscles exposed to different test solutions of Bordeaux mixture.

2. MATERIALS AND METHODS

Experimental fish: The fresh water Indian catfish or striped dwarfish Mystus vittatus (Siluriformes: Bagridae) found in fresh water bodies around agricultural areas was selected for the present study.

Collection and acclimation: Mystus vittatus collected from Vellayani lake in Thiruvananthapuram District was stocked in a glass tank and maintained in laboratory conditions for 10 to 15 days. Pure tap water which was kept overnight was used for keeping the fishes throughout the experiment. The fishes were fed with fish meal on alternate days and feeding was stopped on the previous day before the experiment to reduce the effect of excreta in the test medium.

Fungicide: The test solution of Bordeaux mixture was prepared by following standard methods adopted from APHA (1992). The stock solution was prepared by dissolving 1gram copper sulphate in 1 litre of water and calcium hydroxide separately in 1 litre of water. They were then mixed thoroughly. From this stock solution, different concentrations of test samples ranging from1 to 20 ppm were prepared by proper serial dilutions.

Range finding test: Prior to each toxicity experiments, range finding tests were carried out to determine the range of toxicants to be used for definitive toxicity studies. . Series of different concentrations were prepared and toxicity was determined. The range finding tests were conducted in plastic troughs of 10 L capacity and five fishes of equal size (10.36 +- 0.87 cms) were exposed to each concentration for a period of 4 days and mortality were noted. Based on the results, the highest concentration at which all the fishes survived and the lowest concentration at which all the fished died were noted.

Determination of LC $_{50}$ values; the acute toxic levels of toxicity of Bordeaux mixture were determined using static renewal tests. The concentrations selected for 24, 48, 72 and 96 hrs LC $_{50}$ determination are shown in Table 1. The LC_{50} calculations were done with the help of SPSS 16.0 version for windows. The test solutions were renewed every 24 hrs by fresh solution with the same concentration.

Histopathological analysis: Mystus vittatus were exposed to different test solutions of Bordeaux mixture (2.41 ppm as sub-lethal concentration and 15.46 ppm as lethal concentration) for a period of 96 hrs and the pathological changes in different tissues like liver, gills and muscles during the exposure period were recorded.

3. RESULTS

The lethal concentration for 50 % mortality of the test animal was determined after exposure to various test concentration and are recorded. The toxicity was assessed by bioassay procedures and LC_{50} was determined for 24 hr, 48 hr, 72 hr, and 96 hrs by probit analysis and is shown in the Table 1. No mortality was observed in the control during the experiments. This test was conducted to gain preliminary information about the toxicity of Bordeaux mixture to fishes.

Table 1: Data on 24, 48, 72 and 96 hr LC_{16}, LC_{50} and LC_{84} slope function and 95% confidence limits for mortality curves of fishes exposed to different concentrations of Bordeaux mixture

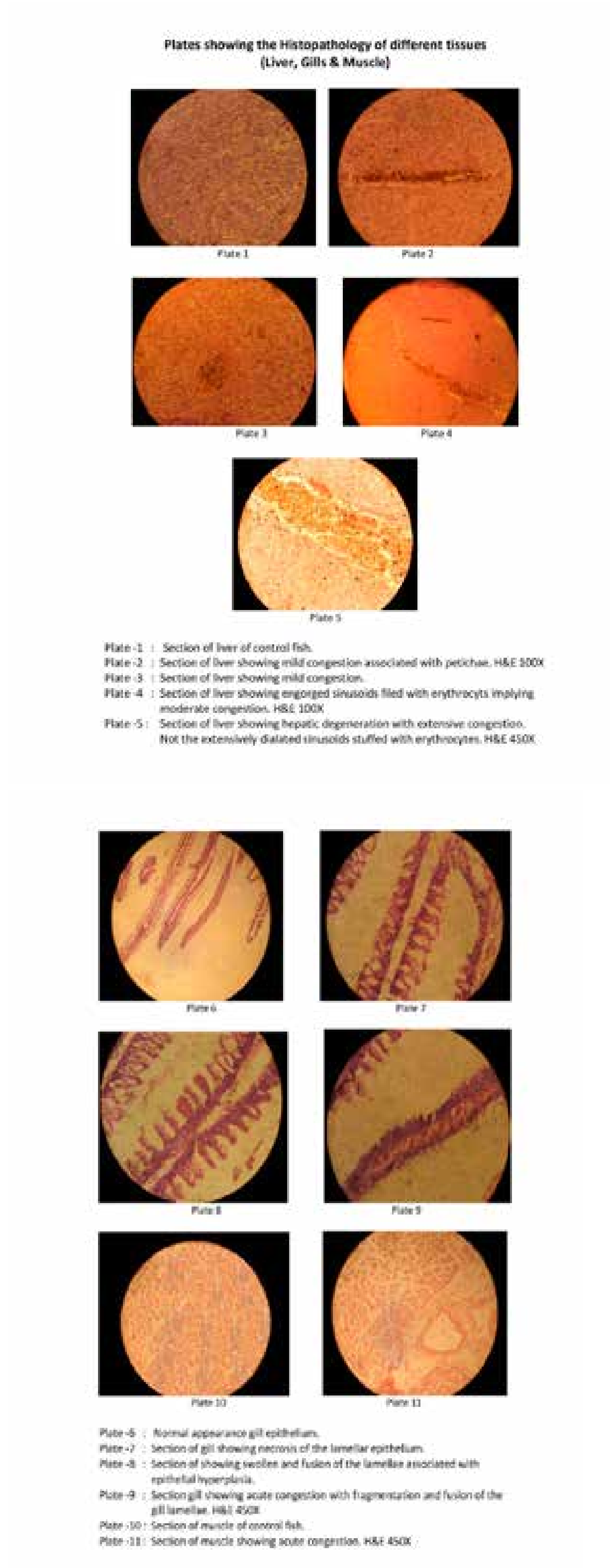
Time (hr)	LC_{16}	LC_{50}	LC_{84}	95% confidence limit LC_{50}	Slope	95% confidence Limit
24	11.023	14.299	17.664	12.061–16.463	10.242	3.852 – 16.632
48	7.159	9.463	12.519	7.241 – 11.285	7.737	3.008 – 12.466
72	5.113	7.921	12.294	5.387 – 10.057	4.929	1.964 – 7.894
96	4.161	7.241	12.643	4.708 – 9.649	3.891	1.637 – 6.145

From the results of the present study, the 96 hr LC_{50} value of Mystus vittatus of 10.36±0.87 cms is 7.241 ppm and the confidence limit obtained were 4.708 (lower limit) and 9.649(upper limit).

The histopathological changes were more evident in specimens exposed to the lethal concentration than sub-lethal concentrations of Bordeaux mixture and were not observed in the control fishes. The histology of normal liver of control fishes shows an intact outer protective membrane covering the liver. Liver cells were vacuolated and uniform in size. The nuclei of the hepatocytes are spherical with a regular surface and show uniform size, shape and orientation (Plate 1).Normal architecture of the liver was lost in many places in all the treated fishes. In tissues exposed to sub lethal concentrations of Bordeaux mixture, there were focalized necrotic areas with the presence of erythrocytes. Mild congestion was observed in the liver exposed to sub lethal concentration (Plates 2&3). The engorged sinusoids were filled with erythrocytes which imply moderate congestion (Plate 4). The hepatocytes were shrunken and had lost their original shape. Extensive congestion was seen in tissues exposed to lethal concentration for 96 hrs (Plate 5). Hepatocytes also lost their polygonal appearance due to the presence of vacuoles. Hypertrophy of the endothelial cells of the central vein was also observed.

The gills of Mystus vittatus subjected to sublethal and lethal concentrations of Bordeaux mixture showed altered histological features. The presence of heavy mucus covering in the gills was the first visible gross change. The destruction was more severe in fishes subjected to lethal concentrations than in sub lethal concentrations. Extensive congestion with degenerative changes of the gill epithelium was noticed in fishes exposed to lethal concentrations for 96 hrs (Plate 6 & 7). Hypertrophy, shortening and fusion of the secondary lamellae were noticed in the treated fishes (Plate 8). In few filaments, the epithelial tissues were replaced with red blood corpuscles. Hyperplasia of the epithelial cells of the secondary lamellae was also observed in the exposed fishes.

Occasional oedematic changes manifested by the accumulation of fluid were noticed in the muscle tissues. The muscle fibres were also thickened and separated from each other. Muscle fibres were also seen separated. The distended muscle fibres also showed congestion (Plate 10).In the present study, no specific changes could be observed in the muscles at 2.41 ppm exposure level. But at higher lethal concentration concentrations, muscle tissues are much affected by the toxic action of the Bordeaux mixture. In the treated fishes, oedematic changes with fluid accumulation were noticed in the muscles.



Plates 1-11: Histopathology of different tissues (Liver, Gill, Muscle)

4. DISCUSSION

Fishes can be considered as one of the best bio-indicators of water pollution. Any changes in the water quality parameters caused marked effect in the entire physiology or biochemistry of the animal which in turn predispose them to different types of diseases. From the results of the present study, the 96 hr LC_{50} value of Mystus vittatus of 10.36±0.87 cms is 7.241 ppm and the confidence limit obtained were 4.708 (lower limit) and 9.649(upper limit).

Since liver acts as an organ of detoxification and accumulation of heavy metals, extensive changes were observed in its structure. The cellular damage of the liver was more severe and prominent in fishes exposed to lethal concentrations than in sub-lethal exposure. Similar necrosis, haemorrhages and degenerations of liver tissues were observed by Loganathan et al. (2006) when Labeo rohita (Ham.) was exposed to zinc. Liver is considered as an established organ in fishes and plays an important role in the uptake, accumulation, biotransformation and excretion of xenobiotics (Heath, 1995). The long term exposure of fishes to metals results in excessive accumulation in the liver (Yammamoto, 1997; Jamila, 1992) and is known to affect the physiology and biochemical processes. Hence liver tissues are very much affected by the chemical toxicants. The heavy metals present in the Bordeaux mixture interferes with the normal functioning of the liver and causes specific alternations which in turn resulted in the total malfunctioning of the organ. In the present study, Mystus vittatus was found to accumulate high concentrations of copper in the liver resulting in the degeneration of the hepatocytes.

Gills are most sensitive because it comes into direct contact with the heavy metal polluted environment. Epithelial hyperplasia of the secondary lamellae was noticed in the gills and their sensitivity increases with increase in the concentration of the toxicant. Similar results were obtained by Rameshkumar et al. (1997); Karan et al. (1998); Kalele and Dhande (2005) and Mishra et al. (2005) and Athikesavan et al. (2006). In general, the different changes observed in the gills of Mystus vittatus exposed to different concentrations corroborates with the findings in the gills of several fishes exposed to a variety of heavy metals suggesting the generalized influence of metals on gill tissues. Toxic substances may cause damage to gill tissues, thereby reducing the oxygen consumption and disrupting the osmoregulatory functions of aquatic organisms (Ghate and Mulherkar, 1979). In dilute solutions, heavy metals precipitate in mucus secretions and the interlamellar spaces becomes filled with this precipitate which disrupts the respiratory functions of the gills. At low concentrations, the permeability of the membrane is lost. Thus the gills exposed to Bordeaux mixture appear to be a prime response to the toxic influence of heavy metals.

In the present study, no specific changes could be observed in the muscles at 2.41 ppm exposure level. But at higher lethal concentration concentrations, muscle tissues are much affected by the toxic action of the Bordeaux mixture. The extent of damage depends upon the uptake and bioaccumulation of the metal. Muscles generally accumulate the least amount of metals. Similar degeneration in muscle tissues were noted by Das and Mukherjee (2006) in Labeo rohita exposed to Hexachlorocyclohexane.

5. CONCLUSION

Thus the present study confirmed that Bordeaux mixture is capable of causing histological alterations in fishes. Even though, this is considered as one among the safest plant protection chemical, the heavy metal copper is the main ingredient which in turn predispose them to different types of diseases. Whenever copper compounds are used as an ingredient for plant protection activities, it should be used judiciously to avoid environmental degradation.

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PARTICIPATORY CONSERVATION, PRESERVATION AND DOMESTICATION OF WILD FOOD RESOURCES FOR FOOD SECURITY AND LIVELIHOOD GENERATION IN JAWHAR, A TRIBAL BLOCK OF THANE DISTRICT, MAHARASHTRA

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ABSTRACT

Consumption of wild plant species can be dated long back among different communities and tribes. Wild edible plants (WEPs) have been traditionally used as a source of subsistence mainly by rural communities. During stress conditions when there is scarcity of food, these wild foods help them to overcome their hunger. Tribal communities make up their deficiency in food stock by supplanted it with wild edible plants in their daily diet. During the monsoon season, wild leafy vegetable play important part in providing essential proteins, micronutrients and vitamins. Nowadays these plants are getting wiped out because of habitat destruction and changing trends in agriculture.

Jawhar is well known tribal block of Thane. Hilly area of Jawhar having more diversity of Wild food resources which was collected by the Tribal communities including wild fruits, vegetables, nuts, berries, tubers and leafy plants etc. from nearer forest area to fulfill their nutritional food requirement. They have rich crop biodiversity and abundant traditional knowledge of plant resources, but nowadays their living and consumption pattern has been changed and these valuable food resources becoming rare and extinct day by day.

During the study, 72 plants were documented consisting of 50 vegetable species, 15 fruits species and 7 tuber species on different parameters like edible part, method of preparation, season of availability, propagation methods, storage life, market value, medicinal importance, cultural aspects etc. A nursery of 8 wild edible plant species was established at village level and standardized suitable method for product development from 6 wild edible plants. People enjoy wild fruits during summer and rainy season and the forest products are the main source of vegetable in their daily diet. The newly emerged shoots, tender leaf, tender stalks are used for vegetable preparation having minimum processing and seasoning requirements. Some of them preserved for short duration with simple local preservation techniques like pickling, salting, drying etc

Key words: Hunger, Scarcity, Propagation, Consumption, Preservation

1. INTRODUCTION

Consumption of wild plants is one of the important strategies adopted by people in developing countries in order to meet their daily requirements in times of food scarcity, or to supplement their diet with micronutrients. It is intrinsically linked to strong traditional customs and cultural systems. The diversity in wild plant species offers variety in family diets of indigenous communities and sales from surpluses add to the income and thus further contribute to house-hold food security.

Several attempts have been made to list wild edibles of Maharashtra and India but presently some species are on way of extinction. It is thus necessary to focus on developing strategies for their propagation. For some which are still available in abundant quantity, there is a need to developed value added products from such underutilized wild fruits. The paper presents an attempt to explore the traditional knowledge of wild edible food resources from Jawhar, Thane district of Maharashtra state. This paper aims at bringing wild edible plants in focus.

1.1. Documentation of Wild Food Resources from various part of India

Vartak and Kulkarni (1987) studied the monsoon wild leafy vegetables from hilly regions of Pune and neighbouring districts Maharashtra states. Total 42 wild leafy vegetables of reliable tribal groups were studied with special emphasis on their recipes. Patil and Patil (2000) studied 36 wild edible angiospermic species from Nasik district of Maharashtra. They used leaves, tubers, rhizomes, bulbils, fruits, seeds, flowers, etc as complementary resources in their diet or in a time of scarcity of food.

Bhogaonkar et al. (2010) studied the wild edible plants of Melghat forest Dist. Amravati. They documented the 42 plant species belonging to 23 families consumed by the tribal and other locals of Melghat area. The study included the name of the plant, the family along with their part used and method of preparation.

Mahadkar and Jadhav (2013) investigated the total 50 wild edible plants from Kolhapur district. Out of them 18 plants are used as leafy vegetables, 21 fruits species and 3 three tuberous rhizome. All 50 plants documented along with their medicinal uses and food values.

Deshmukh and Shinde (2010) documented potential 29 wild edible fruit plants consumed by tribal communities from Kalsubai-Harishchandragad which was declared a wild-life Sanctuary in Maharashtra state, India.

Deshmukh and Waghmode (2011) studied the food potential of some traditional wild edible fruits consumed by tribal communities in Western Ghats region of Maharashtra. Among them 11 fruit plant species were investigated for their nutritional food value and medicinal uses.

However, until very recently no systematic efforts were made for domestication and preservation of wild food recourses.

2. MATERIALS AND METHODS

2.1. Location:

Jawhar tahsil in Thane district of Maharashtra is aptly known as the home of aboriginals who are locally known as "Adiwasis". They comprise 90% per cent of the total district population and are mostly concentrated in forest area. In recent years the total forest area has been decreasing leading thus comprising a threat to the biodiversity of the region. Historically Jawhar has recorded six severe famines in the years of 1899-1902, 1907-08, 1918-19, 1941-42, 1965-66 and 1966-67; during that time wild vegetables provided nutrition to tribal people. In today's global warming scenario conservation of this native source of food is among the needs of the hour, because this species are locally adapted and have the resilience to sustain growth in acute climatic conditions.

10 villages were selected and visited frequently for data collection, food processing training and Nursery development.

2.2. Base line survey:

Primary data collection was gathered from forest areas, village level field visits, and meetings with villagers. For this purpose meetings were arranged with different age-groups ranged from school children, young generation, women, males and vaidus. Base line survey was done taking into consideration different parameters like habitat, propagation material, edible part, consumable time, season of availability, storage life, medicinal use, market value, cultural /aesthetic aspects etc.

2.3.Selection of plant species:

Information was collected on 72 plant species out of which 12 species were selected for raising a nursery. Data was collected through primary survey, and short listing of promising species was done by taking into consideration parameters like abundance, availability, less utility, people's preference for consumption, preservation potential of reducing species, nutritional importance, and market value.

Seed collection was done from the forest area in the proper season. They were dried well and stored in airtight bags. Sowing was done in raised beds and saplings were transferred in bags during the rainy season.

2.4. Nursery raising and plantation of shortlisted wild food resources:

For the purposes of conservation, domestication and propagation of wild plant species, a nursery was established in Chouk village, Jawhar. A Shade net (Green cloth of 90 %) of – 20x30x10 ft (l x w x h) was built using bamboo and local materials, black coloured nursery bags were filled with 5 kg of a mixture of Sand: Soil: Compost (1:1:1). The seeds used were treated with water for 24 hours to facilitate quick germination. Stem cuttings of 25-30 to 30-45 cm long hard wood were used having 2-3

Table 1: List of species for conservation and preservation

Conservation		Preservation	
Local name	Botanical name	Local name	Botanical name
Tetu	Oroxylum indicum L. Vent.	Bhokar	Cordia dichotoma Forst.f
Kharsheng	Radermachera xylocarpa K.Schum	Kakad	Garuga pinnata Roxb.
Bahava	Cassia fistula	Aliv	Meyna laxiflora Robyns
Toran	Ziziphus rugosa l.	Pendhra	Tamilnadia uliginosa (Retz.)
Ghugurval	Flacourtia indica (Burm. F.)	Bamboo shoots	Bambusa arundinacea Roxb.
Shiri	Holostemma ada-kodien Schult.		
Vagheti	Capparis zeylanical L.		
Bafali	Pimpinella wallichiana Gandhi.		
Tembhurni	Diospyros peregrina (Gaertn.) Gurke		
Kukurval	Sterculia foetida		

nodes and apical bud (Fig 1).

Fig-1: Nursery raising of wild food plants

3. RESULTS AND DISCUSSIONS

3.1. Documentation

The tribal people consumed 72 species in different forms based on different aspects such as seasonality, habitat, habit, edible part used, current status/ availability and medicinal use, traditional preservation methods (if any),method of preparation etc.

3.2. Seasonality:

Most of the wild vegetables that are naturally regenerated in Jawhar forest are available in rainy season. There are very few vegetables that are consumable or available during summer and winter seasons. List of plants available per season is presented in Table 2.

3.3. Propagation material:

On the basis of the primary data collected after observation of the natural regeneration, the propagation status of the WFRs were classified i.e. seed, stem, tubers and both seeds and stem cutting (Table 3). Out of that 43 can be propagated through seeds and stems, 5 species propagated through stems cutting, 24 species propagated by vegetative plant material like tubers and 10 species both seeds and stem cutting.

3.4. Current status:

The current status signifies the availability of wild edible food resources in Jawhar forest region. The successive interviews, discussions and field meetings with villagers ranging from school children up to elderly people from selected villages, were key factors of selecting WFRs. They were categorized as Extinct, Endangered, Vulnerable, Rare and Abundant (Table 4).

Table -2: List of plants available per season

Sr	Season	Plant Species
1	Rainy	Shewal, Chai vel, Aalimb, Loth, Ulshi, Lunda, Khadak teri, Bafali, Kurdu, Kawali bhaji, Kartoli, Vasta, Kena, Math, Bhovara, Bondara, Katemath, Zadi Ratale, Kuala, Rankeli, Sapud, Tetu, Pendhra, Tandulka, Kochi, Karanda, Tera,
2	Winter	Asand, Dhaman, Kharbat, Payar, Tebhurni, Vagheti, Kharsheng, Sulsule, Sanbal, Tagada, Nadukali, Kuda, Bhokar, Mokha
3	Summer	Bahava, Kukurval, Kahdol, Sol, Karval, Fatangara, Bos, Vagheti, Toran, Moh, Karvand, Humb, Kakad, Ghugurval, Chokhi Karvand, Aliv

Table -3: Classifications of plant species on the basis of propagation material

Sr.	Propagation material	Plant species
1	Seed	Aliv, Bandgul, Dhaman, Gometi, Gaygoyar, Gal phal, Humb, Kharbat, Moh, Mek, Petar, Payer, Tebhurni, Toran, Vaghoti, Bondara, Bafali, Bhovara, Chichrdi, Chunch, Fatangara, Kate math, Keni, Kurdu, Kuala, Pathari, Pochi, Sulsule, Sanbal, Tokar, Takala, Tandulka, Terda, Veda math, Dongar jeera, Tokar, Bahava, Tagada, Shiri, Kuda, Kukurval, Kahndol
2	Stems	Pendhra, Karval, Zadi ratale, Nadukali, Mokha
3	Tubers	Kartoli, Badadya, Bos, Chai vel, Gidgvadi, Kavali bhaji, Khadak Teri, Lothi, Ulshi, Lundha, Rankeli, Sapud, Sheval, Sol, Dudh Halinda, Jangali Suran, Kali alu, Kochi, Kadu Kand, Karanda, Tera, Teri. Vach kand, Kavadar
4	Seeds and stem both	Ambada, Asand, Bhokar, Chokhi karvand, Ghugurval, Kakad, Kharsheng, Tetu, Katesavar, Kohrul

Table -4: Classifications of plant species on the basis of current status

Sr.	Category of Availability	Plant species
1	Extinct 100/1	Chokhi karvand, Chichardi, Dongar jeera
2	Endangered 100/10	Asand, Gal phal, Kharbat, Fatangara, Pochi, Pathari, Rukh slu, Rajkohor,
3	Vulnerable 100/20	Petar, Tembhurni, Vagheti, Bhuiphod, Chai vel, Dethachi bhaji, Ghidhavadi, Lundha, Sheval, Vaste, Veda math
4	Rare 100/30	Ambada, Bhokar, Dhaman, Ghugurval, Humb, Payar, Toran, Akkarghode, Bafali, Dinda, Karval, Kharsheng, Lalkurdu, Mokha, Rankeli, Sapud, Tetu, Tikhi bhaji, Dudh halinda, Kadu Karanda, Ulshi, Vach kand, Zadi ratale, Shiri, Bahava
5	Abundant	Aliv, Bandgul, Gaygovar, Gometi, Kakad, Kartoli, Kapalphodi, Karvand, Moh, Mek, Pendhra, Bondara, Badadya, Bos, Bhovara, Girjala, Ghol, Jangali suran, Kate math, Keni, Kurdu, Kuala, Kavali bhaji, Kardai, Kohrul, Khadak Teri, Lothi, Math, Sulsule, Sol, Sanbal, Takala, Tandulka, Terda, Jangali Suran, Kali Alu, Kochai, Karanda, Suran, Tera, Teri, Tagada, Kuda, Kavdar, Kukurval

3.5. Propagation of selected wild food resources:

The wild food resources like Tetu, Kharsheng, Shiri, Bafali and Ghugurval having papery seed material required 6-9 days for germination. Toran, Bahava, Tebhurni seed material having hard seed coat required 10-13 days for germination.

3.6. Documentation

For the primary data collection people from all age groups were interviewed. Age old person were interviewed, in order to get acquainted with information existence, seasonal aspects, habitat, edible plant part, habit, method of preparation, season of availability, medicinal use, cultural aesthetic value etc. Women provided information about the traditional recipe preparation from wild food resources. Elderly people and 'Vaidus' had given details about the medicinal aspects.

3.7. Conservation

Villagers give details about material used for propagation, possibility of propagation, stump selection for propagation, youth involvement in nursery raising, stump procurement and plantation, etc. The data collected will be analysed and a report prepared with the purpose of organizing cluster-wide meetings and initiate events on exposure and training key farmers on preparing nurseries and initiating propagation of important local forest species.

3.8. Preservation

Women have given information about traditional preservation practices. Potential fruits for preservation, stage of maturity for preservation. It is essential to train SHG group or tribal women to ensure the preservation of wild fruits and provide opportunities for uplifting their economy by creating market products.

4. CONCLUSION

Availability of diversified food over sustained period of time is a key concern for the rural communities of Jawhar.

There has been an acute need for exploration of the natural resources and documentation of the existing traditional knowledge. During the field survey, meetings and discussions with various age groups from different villages were carried out. It was found that there were decreasing trends among the villagers to consume WFRs due to the easy availability of cultivated vegetables in the market, and the fact that the young generation is not aware of the value of wild food resources. However the choice of cultivated fresh plants available in the local markets is quite limited. It is therefore essential to create awareness among both the rural and urban population of the availability and benefits from consuming wild food plants.

In that respect, 9 species were identified and nursery propagation and cultivation initiated to reduce pressure on natural forests. Such initiatives hold great potential for generating economic benefits for resource- poor farmers. Processes and products from wild food resources get attention in the urban markets; hence it is essential to develop various appropriate linkages. Wild food resources are essential source of nutrition and conservation and hence their storage and domestication is important for livelihood of the people. Some wild food resources have nutritional potential and their market value will be increased by cultivation as a crop and value addition.

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WEED BIODIVERSITY IN CROP FIELDS OF SOUTH COASTAL ANDHRA PRADESH, INDIA.

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ABSTRACT

Weeds cause serious ecological problem in crop fields. Weed species can reduce crop production 12-98 %, depending on type of cultivation. It also results in reducing the high quantities of minerals, nutrients and moisture more efficiently than the crops in farm lands as they grow faster than the crops. The diversity and distribution of weed diversity is mainly dependant on soil, climatic, cropping, fertilizers and management factors. The present paper discusses the weed species diversity and distribution in various crop fields of south coastal Andhra Pradesh. The study is mainly conducted based on field survey across different cropping seasons during the year 2013-2014. Empirical field survey has been conducted in selected areas of various agricultural fields, since paddy is predominant crop in this region. The survey for the current was mainly conducted in rice fields followed by cotton and sugarcane. A total of 168 weed species were documented during the field survey belonging 50 different families of plant kingdom such as Mimoceaceae, Fabaceae Cesalpinaceae Amaranthaceae, Euphorbiaceae, Poaceae, Asteraceae Rubiaceae, Cyperaceaeand, Bignoniaceae etc. Out of 168 species, 27 were monocots and 147 species were dicots. The dominant families found in the study included Poaceae, Fabaceae, Acanthaceae, Amaranthaceae, Rubiaceae, Cyparaceae which consists of minimum ten species each. This paper mainly discusses about weed species diversity and distribution in crop fields and their management.

Key words: Biodiversity, weeds, rice field, cotton field, Andhra Pradesh.

1. INTRODUCTION

The undesirable or unwanted plants that grow in agricultural fields along with crops are known as weeds. Weeds being unwanted plant species growing along with crops and affect crop production. There are large numbers of weeds species growing widely in cultivated fields of India, of which some are introduced while others are native. Weeds are a menace as they have faster growth rate than the crop resulting in its rapid spread throughout the fields. It also absorbs higher nutrient content with greater efficiency than crop plants thus limiting its availability to crop plants (Murty et al., 2011). Weed species differ from other plants in their adaptation mechanisms to the local environment. In addition, they have peculiar characteristics in natural habitats which make them more competitive enhancing their growth (Vishwas et al., 2013). Generally weeds grown in all type of ecosystems but their intensity is greater in manmade ecosystem such as crop fields wherein farmers desire growth of only agricultural crops and unprecedented growth of weeds in these lands will affect the farmers adversely. These weeds compete with agricultural crops for space, sun light, and nutrients which has an impact on the growth rate of desired crops thereby reducing yield and affecting quality (Kumar et al., 2013). Weed diversity causes great economic loss in crop fields with the yield reducing from 12 to 51 % (Vishwas et al., 2013). Weed species also support diversity in animals like insects and micro organisms that may cause reduced crop production. The herbaceous species growing in cultivated lands are highly influenced by different factors like the biotic and abiotic factors, type of cultivation, season of cultivation (Kharif and Rabi), type of soil, irrigation types, use of fertilizers and type of weed management. The present study explores the different weed species and their distribution across different crop fields of Nellore district.

1.1. Study area and Geographical location

The current study focused on the south coastal district of Andhra Pradesh, Nellore district with an average latitude 14.43° N, longitude 79.97° E and at an elevation of 59 ft. The district spreads over an area of 13076 sq.km, accounting 4.75% of the total area of the state. The district is bounded in the east by Bay of Bengal, north by Prakasam district, south by Chittoor district and Chengalpattu district of Tamil Nadu State and on the west by Veligonda hills (Figure 1). The district primarily has 3 natural divisions from south to north and western belt.

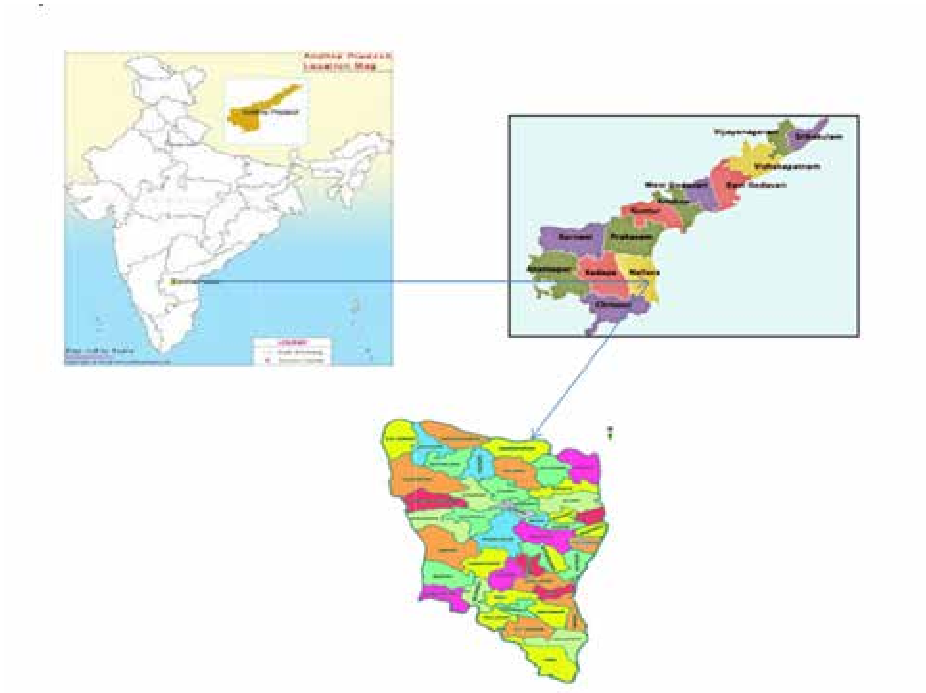

Figure 1: Geographical location of the study area

1.2. Climatic features

The study area falls under semi arid region of southern India. Climatically the study area is very hot with less rain fall and high temperature during summer months. Of the region have three seasons - summer from March to mid June, rainy season from September to November, rain fall mainly depend on North-west moon soon, the average rain fall is 992 mm in both seasons and winter from December to mid February. .

1.3. Land use and Agriculture

The total geographical area is distributed across 13.6 lakh hectares; of which around 20.09% is under forest land, 10.56% is barren and uncultivable land and non agricultural activates take up about 18.68%. The total area sown for cultivation forms 25.96% and cultivable waste and fallow lands consists of around 17.75%. The region has agricultural activities in both the Kharif and Rabi season. Rice (Oryza sativa) is the major crop cultivated throughout the district followed by Cotton, Tobacco, Chilly, Sugarcane etc. More recently farmers have started to venture into aquaculture. Vegetables and pulses are commonly grown in small areas and kitchen gardens for their own requirements.

2. MATERIALS AND METHODS

The present studies main objective is to document the weed flora in different crop fields such as Rice, Cotton and Sugarcane. Since rice is predominant crop in the study area, the study focused mainly on rice fields followed by cotton and sugarcane.

2.1. Survey and sampling

The documentation of weeds in the study area has been conducted through extensive field survey during the study period. Random sampling methods were followed for the documentation and collection of specimens. The study was carried during 2013-2014 in different cropping seasons. The studies were conducted in selected areas (taluk) of the district i.e. Atmakur, Udayagiri, Gudur and Rapur. Several field trips were made to assess the weed species. Each field visit involved spending 7-10 days in the study area during each cropping season. The specimens were collected from the crop fields and its taxonomical character such as flowers, fruit, colour, odor, roots characters was recorded. Photographs of the sample specimens were taken for recording purposes. A herbarium was prepared wherein the specimens were preserved according to BSI rules and regulations.

2.2. Herbarium Preparation:

For preparing the herbarium, standard method was followed as developed by the Botanical Survey of India (BSI). The herbarium specimens were collected from all the selected fields; after collection the plant specimens were trimmed nicely before the poisoning process. The specimens were poisoned with alcohol and mercuric chloride and placed in between the news papers before being tied with field pressers. Dipping of specimen in mercuric chloride is called dry method. The newspaper changed every alternative day till the specimen dried up completely. Dried specimens were mounted on herbarium sheets (28 × 42 cm), while large specimens especially long grass were mounted on herbarium sheets with different shapes like M, N, V and W (Pullaiah, 2007). All the specimens were identified using flora books and with the help of regional herbarium center.

3. RESULT AND DISCUSSION

Extensive field survey was carried during the study period. In the present study a total 168 weed species were found in different agricultural fields belonging to 137 genera and 50 families (Figiure 2 and 3). Out of these 168 species, 27 were monocots and 141 were dicots; all monocots were dominantly present in both the crop fields. The dominant families were recorded from the study region and included species like Poaceae, Euphorbaceae, Fabaceae, Amaranthace, Asteraceae, Asclepiadaceae, Cyperacae, Convolvulaceae, Acanthaceae, Malvaceae, Solanaceae, Commelinaceae, Lamiaceae, Caesalpiniaceae, Cleomaceae and Onagraceae (Figure-4). Monocot represents the 16.06 % of the total weed flora of the region and 83.92 % were dicots. The top ten (10) families listed above contributed to 55.95 % of the total documented weed species.

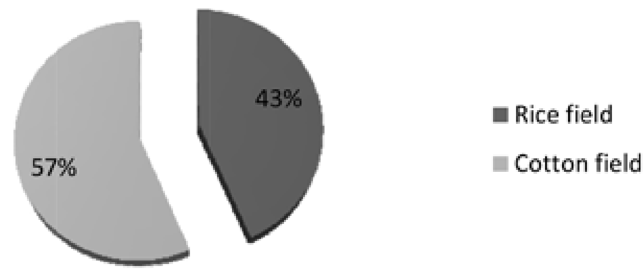

Figure 2: Weed species in the crop fields

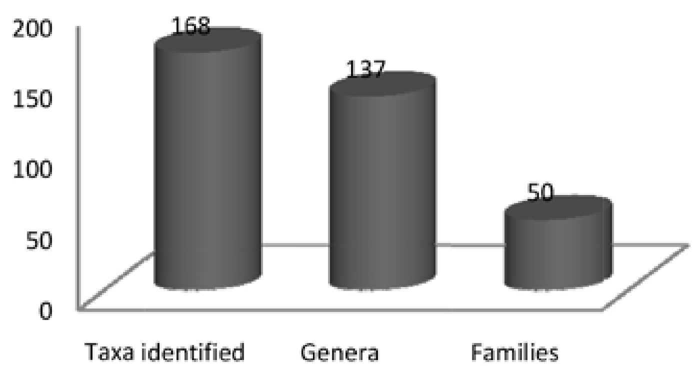

Figure 3: Weed diversity in crop fields

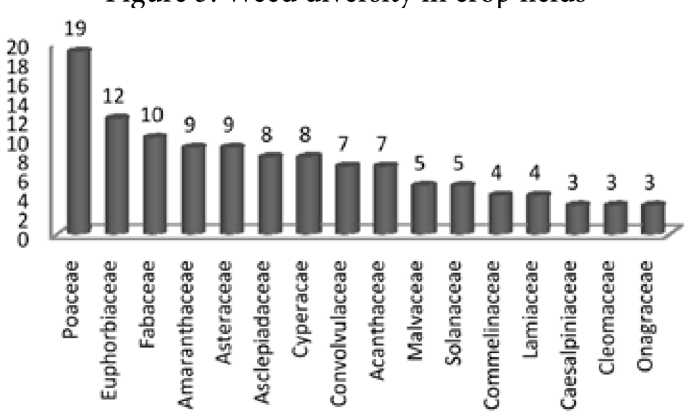

Figure 4: Dominant families in the study region

3.1. Weeds species from only Rice field

(Oryza sativa): Out of 168 species 41 weeds were recorded only from the rice field; belonging to 25 families and 34 genera. In rice field monocots, sedges were predominantly distributed. The families that were present in rice field according to dominance are as follows: Poaceae (8), Cyperaceae (7), Scrophulariaceae (3), Portulacaceae (2), Pontederiaceae (2), Polygonaceae (2), Nymphaceae (2). The rest of the families were present as single species.

3.2. Weeds species from only Cotton field

(Gossypium herbaceum): 72 species were recorded only from cotton field which belonged to 30 families and 64 genera. In cotton fields dicot species were present in abundance. Asclepiadaceae (8), Fabaceae (6), Euphorbiaceae (5), Convolvulaceae (5), Amaranthaceae (4), Euphorbiaceae (4), Malvaceae (4), Solanaceae (4), Asteraceae (3), Cucurbitaceae (3), Acanthaceae (2), Caesalpiniaceae (2), Lamiaceae (2), Menispermaceae (2), Mimosaceae (2), Rubiaceae (2), Verbenaceae (2) and other family's single species were reported.

3.3. Weeds in Rice and Cotton field:

Out of 168 weed species, 55 species were reported in both the fields which belonged to 21 families and 47 genera (Fig.4). Twenty one (21) family species of plant kingdom were distributed in greater frequency in both the fields. The dominant families recorded included Poaceae (10), Euphorbiaceae (07), Asteraceae (05), Amaranthaceae (05), Commelinaceae (04), Fabaceae (04), Cleomaceae (02). The other species were as listed from both the fields (Figure 5).

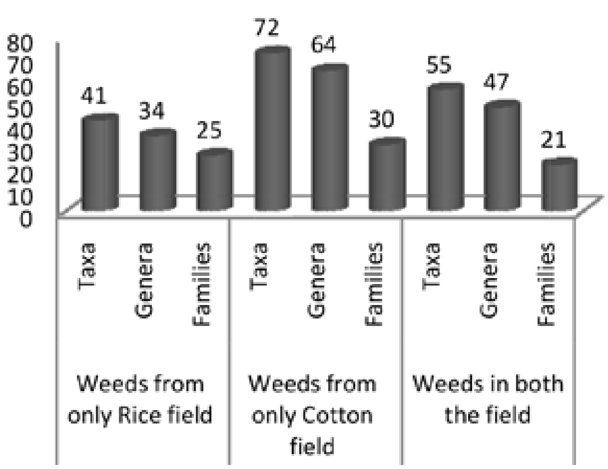

Figure 5: Species distribution in crop fields

3.4. IUCN (International Union for Conservation of Nature) status of weed species: IUCN provides the threatened species' taxonomy, conservation status and global distribution. There is also availability of information on flora and fauna in IUCN and evaluation of the weeds was done using this IUCN red list categories and criteria. The main objective of the IUCN is to highlight those species of plants and animals that are facing a high risk of global extinction i.e., Critically Endangered, Endangered and Vulnerable. IUCN provides data on extinct species of plants and animals and for those where insufficient information is available as data deficient. IUCN also evaluates the least concern species of flora and fauna for the sake of transparency, with all the least concern species being now included in IUCN the Red List (http://www.iucnredlist.org/about). So broadly the identified species can be categorise as extinct, data deficient, not evaluated and least concern. In the study area a total 168 weed species were documented which included herbs, grasses, sedges, aquatic plants, shrub, semi shrub and creepers. The IUCN status has given value of species, their range and distributionand based on the IUCN list, one specie (Eclipta prostrata) was recorded under Data deficient (DD), 128 species are under Not evaluated and 39 species were reported as Least concern as per IUCN category such as Aeschynomene indica, Alternanthera sessilis, Ammannia baccifera, Aponogeton natans, Asteracantha longifolia, Bacopa monnieri, Brachiaria reptans, Centella asiatica, Commelina benghalensis, Cyperus difformis, Cyperus iria, Cyperus pangorei, Cyperus rotundus, Dentella repens, Desmodium triflorum, Echinochloa colona, Eichhornia crassipes, Fimbristylis dichotoma, Fimbristylis ferruginea, Grangea maderaspatana, Hydrilla verticillata, Ischaemum indicum, Lemna gibba, Ludwigia octovalvis, Mimosa pudica, Monochoria vaginalis, Nymphaea stellata, Nymphoides hydrophylla, Panicum psilopodium, Phyla nodiflora, Pistia stratiotes, Polygonum barbatum, Polygonum glabrum, Rhynchosia minima, Saccharum spontaneum, Sphaeranthus indicus, Tephrosia purpurea, Typha angustifolia and Wolffia globosa. No Endangered and Vulnerable species were reported (Figure 6). The recorded species from rice and cotton field and IUCN status has given Table 1.

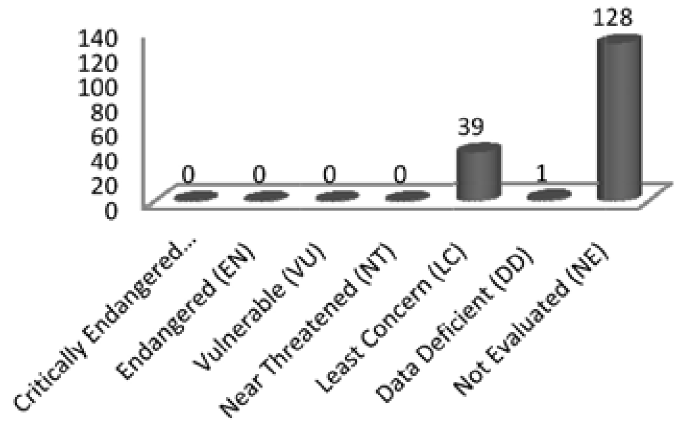

Figure 6: IUCN Status of weed species

Table-1: Inventory of weed species from crop fields

S.No	Botanical Name	Vernacular Name	Family	Rice field	Cotton Field	IUCN Status
1	Abutilon indicum (L.) Sweet	Tutturubenda	Malvaceae	-	+	NE
2	Acalypha indica L.	Muripenda	Euphorbiaceae	-	+	NE
3	Achyranthes aspera L.	Uttareni	Amaranthaceae	+	+	NE
4	Aerva lanata (L.) Juss. Ex Schultes	Pindikura	Amaranthaceae	+	+	NE
5	Aeschynomene indica L.	Jeeluga	Fabaceae	-	+	LC
6	Ageratum conyzoides L.		Asteraceae	+	+	NE
7	Alternanthera pungens Kunth		Amaranthaceae	-	+	NE
8	Alternanthera sessilis (L.) R. Br.	Ponnaganti	Amaranthaceae	+	+	LC
9	Alysicarpus vaginalis (L.) DC.		Fabaceae	+	+	NE
10	Amaranthus spinosus L.	Mullu thotakura	Amaranthaceae	-	+	NE
11	Amaranthus viridis L.	Thotakura	Amaranthaceae	-	+	NE
12	Ammannia baccifera L.		Lythraceae	+	-	LC
13	Anisomeles malabarica (L.) R. Br. Ex Sims	Moga-bira	Lamiaceae	-	+	NE
14	Apluda mutica L.	Konda gaddi	Poaceae	+	+	NE
15	Aponogeton natans (L.) Engl. & K.Krause	Kittigaddalu	Aponogetona-ceae	+	-	LC
16	Argemone mexicana L	Kittanara	Agavaceae	-	+	NE
17	Aristida adscensionis L.	Cheepuru gaddi	Poaceae	+	+	NE
18	Aristida setacea Retz.	Cheepuru gaddi	Poaceae	-	+	NE
19	Aristolochia bracteolata Lam.	Gadidagadapaku	Aristolochiaceae	-	+	NE
20	Asteracantha longifolia (Schum.) Heine		Acanthaceae	+	-	LC
21	Bacopa monnieri (L.) Pennell		Scrophulariaceae	+	-	LC
22	Barleria prionitis L.	Mullagorinta	Acanthaceae	+	+	NE

23	Basilicum polystachyon (L.)Mo-ench.		Lamiaceae	-	+	NE
24	Bergia capensis L.		Elatinaceae	+	-	NE
25	Boerhavia diffusa L.	Atikamamidi	Nyctaginaceae	-	+	NE
26	Brachiaria reptans (L.) Gard.& Hubb.		Poaceae	+	+	LC
27	Brassica nigra L.	Avalu	Brassicaceae	-	+	NE
28	Calotropis gigantea (L.) R.Br.	Jilledu	Asclepiadaceae	-	+	NE
29	Calotropis procera R. Br.	Tella Jilledu	Asclepidaceae	-	+	NE
30	Cardiospermum halicacabum L.	Buddakakara	Sapindaceae	-	+	NE
31	Celosia argentea L.		Amaranthaceae	+	+	NE
32	Cleome viscosa L.	Kukkavaminta	Cleomaceae	+	+	NE
33	Centella asiatica (L.) Urban		Apiaceae	+	-	LC
34	Centotheca lappacea (L.) Desv.		Poaceae	+	+	NE
35	Chloris barbata (L.) Sw		Poaceae	+	+	NE
36	Cleome aspera Koen. Ex DC.		Cleomaceae	+	-	NE
37	Cleome gynandra L.	Vaminta	Cleomaceae	+	+	NE
38	Clitoria ternatea L.	Adavichikkudu	Fabaceae	-	+	NE
39	Coccinia grandis (L.) Voigt	Donda	Cucurbitaceae	-	+	NE
40	Cocculus hirsutus(L.) Diels	Dusari teega	Menispermaceae	-	+	NE
41	Commelina benghalensis L.		Commelinaceae	+	+	LC
42	Commelina longifolia Lamk		Commelinaceae	+	+	NE
43	Corchorus aestuans L.		Tiliaceae	+	-	NE
44	Corchorus trilocularis L.		Tiliaceae	+	+	NE
45	Crotalaria pusilla Heyne ex Roth.		Fabaceae	-	+	NE
46	Crotalaria retusa L.		Fabaceae	-	+	NE
47	Croton banplandianum Bail.	Kusuma	Euphorbiaceae	+	+	NE
48	Cryptostegia grandiflora		Asclepiadaceae	-	+	NE
49	Cucumis callosus (Rottler) Cogn.	Nakka dosakai	Euphorbiaceae	-	+	NE
50	Cyanotis tuberosa (Roxb.) Schult. & Schult.f.		Commelinaceae	+	+	NE
51	Cynodon dactylon (L.) Pers.	Garika	Poaceae	+	+	NE
52	Cyperus difformis L.		Cyperaceae	+	-	LC
53	Cyperus haspan L.		Cyperacae	+	-	NE
54	Cyperus iria L.		Cyperacae	+	-	LC
55	Cyperus pangorei Rottb.		Cyperaceae	+	-	LC
56	Cyperus rotundus L.	Thunga	Cyperacae	+	+	LC
57	Dactyloctenium aegyptium (L.) P.Beauv.		Poaceae	+	+	NE
58	Datura metel L.	Nalla Ummetta	Solanaceae	-	+	NE
59	Dentella repens (L.)Forst.&Forst.f		Rubiaceae	-	+	LC
60	Desmodium triflorum (L.) DC		Fabaceae	-	+	LC

61	Dichanthium annulatum (Forssk.) Stapf.		Poaceae	+	+	NE
62	Digera muricata (L.) Mart.	Chenchalaku	Amaranthaceae	+	+	NE
63	Digitaria bicornis (Lam.) Roem, & Schult.		Poaceae	+	-	NE
64	Digitaria ciliaris (Retz.) Koel		Poaceae	+	+	NE
65	Diplocyclos palmatus (L.) Jeffrey		Cucurbitaceae	-	+	NE
66	Dipteracanthus patulus (Jacq.) Nees		Acanthaceae	+	+	NE
67	Echinochloa colona (L.) Link.		Poaceae	+	+	LC
68	Eclipta prostrata (L.)L.	Guntagalijeru	Asteraceae	+	-	DD
69	Eichhornia crassipes (Mart.) Solms	Gurrapudekka	Pontederiaceae	+	-	LC
70	Eleocharis geniculata (L.) Roem. & Schult.		Cyperaceae	+	-	NE
71	Emilia sonchifolia (L.) DC		Asteraceae	-	+	NE
72	Eragrostis tenella (L.) Beauv. Ex Roem. Ex Schult.		Poaceae	+	-	NE
73	Euphorbia hirta L.	Nanabala	Euphorbiaceae	+	+	NE
74	Euphorbia indica Lam.		Euphorbiaceae	+	+	NE
75	Euphorbia thymifolia L.		Euphorbiaceae	+	+	NE
76	Evolvulus alsinoides L.	Vishnukrantham	Convolvulaceae	-	+	NE
77	Fimbristylis dichotoma (L.) Vahl		Cyperaceae	+	-	LC
78	Fimbristylis ferruginea (L.) Vahl. Enum.		Cyperaceae	+	-	LC
79	Gomphrena celosioides Mart.		Amaranthaceae	-	+	NE
80	Grangea maderaspatana (L.)Poir.		Asteraceae	+	+	LC
81	Hedyotis puberula (G.Don) Arn. Pugill.	Chiruveru	Rubiaceae	-	+	NE
82	Heliotropium indicum L.	Nagadanthi	Boraginaceae	-	+	NE
83	Hemidesmus indicus (L.) Schult	Sugandhapala	Asclepiadaceae	-	+	NE
84	Hybanthus ennaespermus (L.) F.V.Muell		Violaceae	-	+	NE
85	Hydrilla verticillata (L.f.) Royle.		Hydrocharitaceae	+	-	LC
86	Ipomoea aquatic Forsk	Panjaku	Convolvulaceae	+	-	NE
87	Ipomoea carnea Jacq.	Samudrapala	Convolvulaceae	-	+	NE
88	Ipomoea obscura (L.) Ker-Gawl.		Convolvulaceae	-	+	NE
89	Ischaemum indicum (Houtt.) Merr.		Poaceae	+	-	LC
90	Jatropha gossypiifolia L.	Sima nepalam	Euphorbiaceae	-	+	NE
91	Justicia adhatoda L.	Addasaram	Acanthaceae	+	+	NE
92	Kirganelia reticulate (Poir.) Baill.		Euphorbiaceae	-	+	NE
93	Lantana camara L.	Phalikampa	Verbenaceae	-	+	NE

94	Lemna gibba L.		Araceae	+	-	LC
95	Leptochloa chinensis (L.) Nees		Poaceae	+	-	NE
96	Leucaena leucocephala (Lam.) de Wit		Mimosaceae	-	+	NE
97	Leucas aspera (Willd.) Link	Tummi	Lamiaceae	-	+	NE
98	Lindernia ciliate (Colsm.) Pennell		Scrophulariaceae	+	-	NE
100	Ludwigia octovalvis (Willd.)Bold		Onagraceae	-	+	LC
101	Ludwigia parviflora L.		Onagraceae	+	-	NE
102	Marsilia quadrifolia L.		Marsileaceae	+	-	NE
103	Merremia aegyptia (L.) Urban.		Convolvulaceae	+	+	NE
104	Merremia tridentata (L.) Hall.f.	Elikachevalaku	Convolvulaceae	-	+	NE
105	Mimosa pudica L.		Mimosaceae	+	+	LC
106	Mollugo nudicaulis Lam.		Molluginaceae	+	+	NE
107	Monochoria vaginalis (Burm.f.) Presl		Pontederiaceae	+	-	LC
108	Mukia maderaspatana (L.) Roem.		Cucurbitaceae	-	+	NE
109	Nelumbo nucifera Gaertn.	Tamara	Nelumbonaceae	+	-	NE
110	Nymphaea stellata Willd.	Allitamara	Nymphaceae	+	-	LC
111	Nymphoides hydrophylla (Lour.) O.Ktze		Nymphaceae	+	-	LC
112	Ocimum americanum L.Cent.	Kukka thulasi	Lamiaceae	+	+	NE
113	Oxalis corniculata L.		Oxalidaceae	-	+	NE
114	Oxystelma esculenta (L.f.) R.Br.		Asclepiadaceae	-	+	NE
115	Panicum psilopodium Trin.		Poaceae	+	-	LC
116	Parthenium hysterophorus L.	Congress kalupu	Asteraceae	+	+	NE
117	Passiflora foetida L.	Gabbudonda	Passifloraceae	-	+	NE
118	Pavonia zeylanica (L.) Cav	Chirubenda	Malvaceae	-	+	NE
119	Pedalium murex L.	Yenugapalleru	Pedaliaceae	-	+	NE
120	Pergularia daemia (Forssk.) Chiov.	Juttepala tega	Asclepiadaceae	-	+	NE
121	Peristrophe paniculata (Forsk.) Brummitt		Acanthaceae	-	+	NE
122	Perotis indica (L.) Kutze.		Poaceae	+	-	NE
123	Phyla nodiflora (L.) Greene	Bokkenaku	Verbenaceae	+	-	LC
124	Phyllanthus amarus Schum.&Thonn.	Nelausiri	Euphorbiaceae	+	+	NE
125	Phyllanthus debilis Klen ex Willd.		Euphorbiaceae	+	+	NE
126	Phyllanthus virgatus Forst.		Euphorbiaceae	+	+	NE
127	Physalis minima L.	Budama	Solanaceae	-	+	NE
128	Pistia stratiotes L.	Antaratamara	Araceae	+	-	LC
129	Polygonum barbatum L.		Polygonaceae	+	-	LC
130	Polygonum glabrum Willd.		Polygonaceae	+	-	LC
131	Portulaca oleracea L.		Portulacaceae	+	-	NE
132	Portulaca quadrifida L.		Portulacaceae	+	-	NE

133	Prosopis juliflora (Sw.) DC.	Karratumma	Mimosaceae	-	+	NE
134	Rhynchosia minima (L.) DC.		Fabaceae	-	+	LC
135	Rivea hypocrateriformis (Desr.) Chhoisy.	Boddi tega	Convolvulaceae	-	+	NE
136	Rostellularia japonica (Thunb.) Ellis		Acanthaceae	+	+	NE
137	Ruellia tuberosa L.		Acanthaceae	-	+	NE
138	Saccharum spontaneum L.	Rellu	Poaceae	+	+	LC
139	Sebastiania sesban (L.) Merr.	Jeeluga	Fabaceae	+	+	NE
140	Securinega leucopyrus (Willd.) Muell.-Arg.	Tellapurugudu	Euphorbiaceae	-	+	NE
141	Senna auriculata L.	Tangedu	Caesalpiniaceae	-	+	NE
142	Senna italica (Mill.) Lam.	Nela tangedu	Caesalpinaceae	-	+	NE
143	Senna occidentalis L.	Kasintha	Caesalpiniaceae	+	+	NE
144	Sesamum alatum Thonn.		Pedaliaceae	+	+	NE
145	Sida acuta Burm.f.		Malvaceae	+	+	NE
146	Sida cordata (Burm.f.)	Gayapaku	Malvaceae	-	+	NE
147	Sida cordifolia L.		Malvaceae	-	+	NE
148	Solanum nigrum L.	Kamanchi	Solanaceae	-	+	NE
149	Solanum xanthocarpum Schrad & Wendl	Mullavankai	Solanaceae	-	+	NE
150	Spermacoce hispida (L.) K.Schum	Madana	Rubiaceae	+	+	NE
151	Sphaeranthus indicus L.	Bodasaram	Asteraceae	-	+	LC
152	Stachytarpheta jamaicensis (L.) Vahl		Verbenaceae	-	+	NE
153	Stemodia viscosa Roxb.		Scrophulariaceae	+	-	NE
154	Tephrosia purpurea (L.) Pers	Vempali	Fabaceae	+	+	LC
155	Tinospora cardifolia (Willd.) Hook.f. & Thoms	Tippa teega	Menispermaceae	-	+	NE
156	Tonningia axillaries (L.) O. Ktze		Commelinaceae	+	+	NE
157	Trianthema portulacastrum L.		Aizoaceae	+	-	NE
158	Tribulus terrestris L.	Palleru	Zygophyllaceae	+	+	NE
159	Tridax procumbens L.	Gaddi chamanthi	Asteraceae	+	+	NE
160	Tylophora indica (Burm.) Merr.	Kakkupala tega	Asclepiadaceae	-	+	NE
161	Typha angustifolia L.	Jambu thunga	Typhaceae	+	-	LC
162	Vernonia cinerea (L.) Less.		Asteraceae	+	+	NE
163	Vinca rosea (L.) G.Don		Apocynaceae	-	+	NE
164	Vigna trilobata (L.) Verdc.	Pillipesara	Fabaceae	+	+	NE
165	Waltheria indica L.		Sterculiaceae	-	+	NE
166	Wattakaka volubilis (L.f) Stapf	Kalisi	Asclepiadaceae	-	+	NE
167	Wolffia globosa (Roxb.) Hartog & Plas		Araceae	+	+	LC
168	Xanthium indicum Koen. Roxb.	Marulamatangi	Asteraceae	-	+	NE

Note: + Present, - Absent, NE- Not Evaluated, LC- Least concern, DD-Data deficient

4. DISCUSSION

It is essential to understand weed species to control weed diversity in crop fields. Several studies have been conducted on weed diversity and their distribution in various crop fields across the global level. To name a few, Saritha (2013) studied Celosia argentea in groundnut fields of Chittor district, Vishwas and Prakash (2013) studied the weeds of Satara district of Maharashtra, Sharrif and Forghanipoor (2011) studied the ecological character of weed flora of Iran, Kiran and Rao (2013) explored the weed flora of rice fields in Krishna district, Olorunmaiye and Olorunmaiye (2008) reported weeds of Maize field in Nigeria, Ramamoorthy et al.(2004) has discussed weeds of dry lands and how they can be controlled, Bambaradeniya and Gunatilleke (2002) described about ecological aspects of weed flora in an irrigated rice field of Sri Lanka, Abd el-ghani et al.(2013) studied weeds of Nile valley in Egypt, Bukun (2005) reported weeds of Cotton field in Turkey. Murthy and his team has done much work on weeds in various crops of Andhra Pradesh with different aspects such as weeds in turmeric fields of Visakhapatnam and Kadapa (2011, 2014) where around 120 weeds were reported with various ecological aspects, weed diversity of north coastal Andhra Pradesh (2011), Phytosociological attributes of weeds in rice fields of Vishakhapatnam (2010), Phtytosociological attributes of North coastal Andhra Pradesh in (2012) and weed distribution in Sugarcane Fields (2013).

Ramamoorthy et al. (2004) said that the weed species diversity and distribution is dependent on climatic, edaphic and biotic factors. Sharrif and Forghanipoor (2011) reported more salinity and pH cause low weed diversity; however in the current the study region maximum numbers of species were reported. It covers 23.4% of weed species of Andhra Pradesh which was reported by Pullaiah and Chennaiah (1997).

Murthy and Venkaiah (2011) had reported 532 weed species in different crops such as rice, sugarcane, ground nut, finger millet and seasum but from this study 168 weeds species were exclusively present in rice and cotton fields. A total of 46% species are recorded form the rice fields, Echinochloa spp., Ischaemum indicum and Cyperus spp. are highly trouble species in rice fields (Bambaradeniya and Gunatilleke, 2002). The studies shows that Poaceae, Cyperaceae, Amaranthaceae, Asteraceae, Commelinaceae, Euphorbiaceae and Scrophulariaceae species are highly distributed in rice fields where as in cotton fields Euphorbiaceae, Fabaceae, Poaceae, Solanaceae, Asclepiadaceae, Amaranthaceae and Acanthaceae are the most dominant species. Weed diversity in vegetable crops was studied by Gaddeyya and Kumar (2014) and they reported Asteraceae, Fabaceae, Euphorbiaceae and Amaranthaceae as the dominant families in vegetable crops. Of the total Cyperus spp., Echinochloa spp., Euphorbia hirta, Parthenium hysterophorus, Tridax procumbens are predominantly present. Similar studies conducted in Satara region by Vishwas and Prakash (2013) reported that Parthenium hysterophorus, Ageratum conyzoidis and Euphorbia geniculata were dominant weed species in crop fields. It is reported that Parthenium hysterophorus is mainly waste land species and spread throughout cultivation fields. Tamado and Milberg (2000) reported from Ethiopia, Parthenium hysterophorus, a species that has spread rapidly and now affects the livelihood of numerous small-scale farmers. Most of the weeds are herbaceous species, it's annual or biennial rather than perennial, these species complete their life cycle in shorter period leading to higher breeding (Kelton and Price, 2009).

From the study region around 18 submerged, emerged and marshland weed species were recorded such as Aponogeton natans, Asteracantha longifolia, Bacopa monnieri, Bergia capensis, Cyperus rotundus , Eclipta prostrate, Eichhornia crassipes, Hydrilla verticillata, Ipomoea aquatic, Lemna gibba, Marsilia quadrifolia, Monochoria vaginalis, Nelumbo nucifera, Nymphaea stellata, Nymphoides hydrophylla, Phyla nodiflora, Typha angustifolia and Wolffia globosa, of this Eichhornia crassipes, Nymphaea stellata, Nelumbo nucifera, Hydrilla verticillata and Typha angustifolia. These are of primary concern in Indian agricultural fields (Varshney et al., 2008).

The present study shows that the majority of weed species reported from a handbook of some south Indian weeds by Tadulingam and Narayana (1932) were described about 108 weeds and in the revised edition 64 more species have been added by Rajasekhara and Sakharam (1955).

IUCN status is described as the value of a species and their range of distribution. From the study region a total of 39 least concern weeds are reported; of this Brachiaria reptans, Commelina benghalensis, Panicum psilopodium, Tephrosia purpurea found rich in cotton fields and Cyperus rotundus, Lemna gibba, Marsilia quadrifolia were found high in rice fields. Of the total least concern species 12 are aquatic weeds.

5. CONCLUSION

Studies on weed biodiversity in crop fields are essential to help prevent them. Many researchers have worked on weeds of Andhra Pradesh in various crops in different regions except the present study region. Keeping this in view, the present study was under taken to reveal weeds of this region. The present study describes the detailed weed diversity in rice and cotton fields and this investigation is helpful to make effective weed management and high yield production. It is also highly helpful to agriculturists, taxonomists and policy makers to make suggestion for farmers in the weed management and for high crop production. The study is a preliminary attempt made to document the weed diversity in rice and cotton fields, further research work is needed to carry for inventory of weeds in other crops and control weeds.

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Weeds in Rice field

Rice and Weed specie

7. REFERENCE

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DEVELOPMENT OF AN EFFECTIVE PROCESS FOR THE UTILIZATION OF TRASH FISHES FOR HUMAN CONSUMPTION

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ABSTRACT

Commercial fishing aims at the targeted sea foods, but incidentally caught several other non targeted sea foods which are referred to as 'by catch' and 'trash fishes'. The trash fishes generally comprises juveniles and low value fishes. They often decay more easily than other valuable fishes because of the insufficient storage condition. Under normal weather conditions, they deteriorate very fast. Most of the trash fishes is being dried unhygenically and used for poultry feed, whereas some are discarded in the sea shore itself. These underutilized resources can be used in profitable way by developing value added products. In the present study, the dominant trash fish in Tuticorin fishing harbor juveniles of Leiognathidae species. This species is landed in huge quantity such as nearly 1000 tonnes/day. Edible fish powder (EFP) was developed from Leiognathus sp. for human consumption. The biochemical parameters like protein, lipid, ash and moisture content of EFP was 52.6, 0.44, 11.4 and 3.4 percentage respectively. Highly preferred food products like cutlet and soup were developed by incorporating 40% of EFP. Organoleptic assessments of Leignathus sp. incorporated food products were excellent when assessed by 25 panel members including educated and uneducated people. The study on the shelf life of fish powder stored in normal room condition showed that it was stable for 5 months without showing any of the above acceptable level of spoilage indicators. The results revealed that the edible fish powder can be added to any types of food as protein supplement to improve its nutritive value.

Key words: Trash Fishes, Leiognathus sp., nutritional value, shelf life, waste utilization

1. INTRODUCTION

Sea food industry is a potential foreign exchange earner and source of livelihood for the vast majority of population in the coastal belt of India. Fish consumption continues to increase steadily worldwide and seafood is gaining its popularity because of its health benefits (Joong Kyun Kim, 2011). In recent years, fast food technology has been acquiring importance rapidly due to the increase of civilization and socioeconomic factors. In the last two decades, fish consumptions have increased by awareness of consumers about essential fatty acids, mineral and vitamin content of fish. There are several kinds of ready-to-eat seafood value added products such as cakes, crackers, burgers, fish fingers, marinated products (Cakli et al., 2005; Boran and Kose, 2007). Large quantities of commercially important juvenile fishes are fished as bycatches and were discarded as waste (Immaculate et al., 2013). Demand for meat products has considerably increased in recent days because of its safe, nutritive composition and accepted sensory qualities (Desmond, 2006; Kemi et al., 2006). Recently, manufacturing meat basis products from new kinds of meat sources such as fish and poultry have been developed (Farouk et al., 1999). In general there is no special fishery for trash fish. Trash fish is therefore a by-product of fishing for higher value fish, crustaceans and mollusks and the composition of trash fish will vary depending on the type of gear used to fish but most is from trawling (Peter Edwards et al., 2004).

Mince-based foods are among the several new forms of value-added seafood available to U.S. consumers (Wes Harrison et al., 2002). Besides, the anchovy is the most important trade fish in the coastal shelf of the Black sea because of processed fish oil and consumed fresh. Anchovy is caught between September and March by a commercial fishing vessel using a purse seine net. Anchovy is generally consumed fresh in Turkey due to its perishable meat (Alcicek et al., 2010).

Low value fishes are mainly preferred by a narrow spectrum of low and middle income consumers and the demand often fluctuated with seasons and availability and prices of high value species. Among the trash fishes juveniles of Leiognathidae by family was found to be dominant in Tuticorin fish landing center. Total length of trash fish of the juvenile Leiognathidae varied from 2.0 to 10.0 cm and the average total length was 8.5 cm. Consumers prefer usually above the size of 7 Cm of this species. However small sized Leiognathus sp. (<4 cm) also enter the landing center due to the usage of small mesh size nets. Low value marine by catch are utilized as fish protein concentrate and edible fish powder with de boned fish was already studied (Gopa Kumar and Nair, 1997). Edible fish powder was prepared from red meat of tuna (CIFT 2006). Edible fish powder was prepared from small marine fishes without deboning the fishes (Chattopadhay, 2004). The acceptability of bread fortified tilapia fish flour was reported earlier (Adeleke, 2010). This paper aims to utilize the bycatch resource of juvenile Leiognathus species to control the wastage of protein rich resources.

2. MATERIALS AND METHOD

For this present study juvenile Leiognathus species was selected among the trash fish is shown in Fig.1 available in tuticorin District. The average length is 4 to 6 Cm and width is 2 to 4 cm these are by catches in shrimp trawlers and they are discarded as trash fish. Fishes were collected from the fishing harbour and brought to the laboratory in ice box for further work.

Figure 1: Trash Fishes in Tuticorin fishing harbour

2.1. Preparation of fish powder

The head, fins and viscera of the fishes were removed and were washed thoroughly. It was hygienically sun dried by keeping it on fish drying racks. . Before and after drying of juvenile Leiognathus is shown in Fig. 2 and Fig. 3. During drying the samples it was checked in frequent intervals for proper drying of the samples. After drying the samples it was minced well and the Edible Fish Powder (Fig. 4) is packed in LPDE packaging material and stored in refrigerator for further use.

Figure 2: Leiognathus species before drying

Figure 3: After Drying of Leiognathus species

Figure 4: Edible Leiognathus species Powder

2.2. Proximate Composition

The proximate composition such as moisture content, protein, lipid and ash were determined according to AOAC 1990 standard method. The moisture content was determined by drying the samples in a hot air oven at 100 -105°C for 16 hours until a constant weight was obtained. Protein content was estimated by following Lowry's method (Lowry, 1951). Lipid content is determined by using gravimetric method of Folch et al. (1957). Total ash content was determined by combusting the samples in the muffle furnace at 550°C until the white colour of the samples.

2.3. Biochemical and Microbial Changes:

Free fatty acid (% of oleic acid) were analyzed by using standard method (Egan, 1981) and changes in biogenic amine such as TMA-N, TVB-N (mg N /100g) was determined by the Conway micro diffusion method (Conway, 1947). pH of the edible fish powder was measured in a slurry made with distilled water (1:10) and measured using pH meter (Hanna pH meter 213). Peroxide Value (PV), was determining according to the Egan et al., 1997 method and it was expressed as mEq of peroxide oxygen/kg of fat. The Thiobarbituric acid (TBA) (mg malondialdehyde/kg fish flesh) was analysed according to Kirk and Sawyer 1991 method. The microbiological characteristics such as Total Plate Count (CFU/g) and Total Fungal Count (Cfu/g) were estimated by APHA (Vsnderzant, 1992) method using Plate Count Agar and Potato Dextrose Agar respectively. Pathogenic bacteria like Escherichia coli (MPN value); Salmonella and Vibrio (25 g) were enumerated by following the method of USFDA 1995.

2.4. OrganolepticAnalysis:

The organoleptic quality was tested with a taste panel of 9 to 10 members. The appearance, colour, odour, taste texture and overall acceptability were determined by using hedonic scale of 1 to 9 (Amerine, 1965). The edible seafood fish powder was assessed by adding 50% of the total ingredient of the common foods items such as Fish Soup and Fish cutlet were prepared. The dishes were assisted and rated in the order of 9 for excellent 6 for good and below 4 for poor or unacceptable.

3. RESULTS AND DISCUSSION

The juvenile Leiognathus species was prepared as edible fish powder. The powder was colourless and odourless which almost contains 85% to 90% of protein. In these era most of the food which we consume contains mainly fat and carbohydrates are needed energy production which act as a source of calories. Other nutrients like minerals, protein and vitamins are found in smaller amounts.

Present study reveals that the trash fish of juvenile Leiognathus species contains high in protein and can be used as s food supplements. It can be also be used as the main ingredient or as a substitute in other common foods. The moisture content of the dried product was reduced below 6% level for microbial safety. The dried product was ground and packed in LDPE pouches. Proximate composition of Edible Fish Powder was shown in Table 1. The moisture content of Edible fish Powder was 2.4%. The Spoilage indicators for Edible Fish Powder were shown in Table 2.

Biogenic amines such as TMA-N, TVB-N are produced from degradation of proteins and non protein nitrogenous compounds mainly as a result of microbial activity (Connel, 1975). TVB-N and TMA-N value were well within the acceptable limit of 30 - 35 mg N /100g and 10 -15 mg N/100g for fishery products. Lipid hydrolysis occurs in fresh fish muscle with the release of FFA 1.1% oleic acid but FFA formation does not occur in fresh edible fish powder. The loss of freshness was due to the relationship between FFA which was reported by (Barasst, 1987 and Ozogul, 2005). The most important index is pH which determines the quality of fish (Okeyo, 2009).

The Edible fish Powder had pH 7.15 which indicated good quality. Primary lipid oxidation was evaluated by means of PV. Thiobarbituric acid (TBA) is a widely used as an indicator for the assessment of degree of secondary lipid oxidation (Nishimoto, 1985). However the PV values were found to be vey less in fresh edible fish powder. This indicates primary lipid oxidation occurs initially but in the case of edible fish powder there was no lipid oxidation. TBA values were also very less in edible fish powder because of the absence of secondary lipid oxidation. The results of biochemical and microbial qualities indicate that our raw material and edible fish powder were good in nutrition and quality.

The Organoleptic quality of edible fish powder soup and fish cutlet was presented in Table 4. The colour of fish soup was very excellent and the texture taste also played a good role. Even though 40 % of the

Edible Fish Powder was added the taste was very acceptable by the consumers. Fish cutlet also gave good results in organoleptic testing. Its appearance resembled other cutlet products and also did not give any off flavour or odour due to addition of high percentage of Edible fish powder. Consumers highly liked these products which gave the overall acceptability as good. The Organoleptic analysis of fish soup and fish cutlet is presented in Table 3.

Table 1: Proximate composition of Edible Fish Powder

Proximate composition	Edible fish powder (%)
Protein	19.64
Lipids	2.51
Moisture content	2.4
Ash	11.14

Table 2: Spoilage indicators for Edible Fish Powder

Spoilage indicators	Values
pH	7.13
TMA – N (mg/100g)	0.27
TVB-N(mg/100g)	1.31
FFA (%)	0.14
TBA (malondialdehydemg/100g)	0.42
PV (meqo2/kg fat)	0.38
TPC	1.4×10^2
TFC	-

Table 3: Organoleptic analysis Sea fish soup and Sea fish cutlet

Sensory parameters	Seafood cutlet	Seafood soup
Appearance	9	8.5
Colour	8	9
Odour	9	8.5
Taste	8	8
Texture	8.5	9
Flavour	9	8.5
Overall Acceptability	8	8

4. CONCLUSION

From the present study it was found that even from the trash fishes like juvenile Leiognathus species edible fish powder can be prepared, so that these waste can be utilized properly. This Edible fish Powder had a very attractive colour, odour and less moisture content so that we can be stored for long time. Nutritional studies showed that these fish powder products can be consumed by all type of consumers. From the results we found that the edible fish powder had high protein content and low lipids. If these products were handled hygienically in all the process then we can prevent microbial contamination. Present study reveals that the edible fish powder product can act as an alternative source for protein for the consumers.

5. AKNOWLEDGEMENTS

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GENDER DEFINED ROLES IN HOME GARDENS FOR FOOD SECURITY AND BIODIVERSITY MANAGEMENT

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ABSTRACT

Gender dimensions of biodiversity management recognize that biodiversity security means food security. It gives insight on the gender-based roles of men, women and children in home garden agriculture, and local resources management. Biodiversity is a broader term encompassing diversity that is spanning between ecosystem and species and within species too. With modernisation and commercialisation the biodiversity loss is a reality that poses serious threat to the living community in the niche it exists. Conserving biodiversity is important and crucial to maintain the human existence and welfare. Both men and women have different roles in conserving biodiversity in the family community in terms of the labour, property rights and decision making processes. This role differentiation reflected upon their knowledge and skill in relation to biodiversity and ecosystem.

Key words: species, conserving, knowledge, ecosystem, participation

1. INTRODUCTION

The biodiversity loss is a reality that poses serious threat to the living community in the niche it exists with modernisation and commercialisation. The ecosystem is being widely destructed to meet the commodity driven community and excessive exploitation of resources is the greatest threat being faced by the mankind. The impact of biodiversity loss depends on the gender and economic status. The rural areas with its majority as poor people and dependent on home garden farming system will be more affected than others. The greatest wealth of the rural areas is its natural resources and home gardens nurture biodiversity with rural poor depending on these resources for meeting its food, water, fuel and medicines. Degradation of natural sources of their needs will directly affect their existence. Resource depletion also increases the drudgery of woman and affects the total livelihood of the community. The burden of the women for providing food to the family will increase and poverty will also rise when the resource bases vanishes. Hence for the sustenance of life both in the present and future it is essential for looking onto sustainable practices for managing natural resources and the role of women becomes important with special reference to agro biodiversity and food security.

2. METHODOLOGY

The gender based division of activities, decision making, resource utilisation and benefits derived by men and women can be estimated by activity analysis, resource analysis and benefit analysis. The study was undertaken to determine the nature and extent of participation of rural women in various agricultural activities. Thus female members of the selected specialized home gardens were the respondents of the study. Overall participation was calculated by summing up all the activities done by the women either regularly or occasionally by giving a value of 2 for regularly, 1 for occasionally and zero for never. The items of operation intended for measuring the extent of women's participation in various home garden is presented in the table explaining the results. Based on the women's participation the activities were ranked on the basis of total scores.

3. RESULTS AND DISCUSSION

Home garden simply is a land area surrounding a house in which annual and perennial crops are grown with no specific arrangement. It also includes subsidiary activities like animal husbandry, pisciculture, sericulture, apiculture etc. to meet the needs of the family and to generate additional income. Within family members and family farms, it is important to differentiate the relative roles of women and men in achieving desired food security and ecosystem integrity in terms of biodiversity richness. These households and communities organise production and resource management around gender division of labour and responsibilities.Home garden women play a key role in such agro-biodiversity based food production systems. In a study conducted from 60 home gardens in Thiruvananthapuram district it was evident from the table 1 that among the various home garden activities applicable for women, majority of the women engaged themselves in activities like kitchen gardening and then followed by activities like rearing poultry, post-harvest operations and applying irrigation.

Table 1: Extent of women participation in various agricultural activities in the home gardens N=60

Home garden Operations	Mean Frequency- Thiruvananthapuram			Total
	Nedumangadu	Neyyatinkara	Chirazhinkeezhu	
Land Preparation	0	5	3	8
Applying manure	2	5	4	11
Uprooting Seedling	0	6	4	10
Planting Seedling	8	8	6	22
Applying Fertilizer	3	7	6	16
Drain Preparation	0	0	0	0
Weeding	4	7	6	17
Applying Irrigation	10	13	8	31
Fencing	0	0	0	0
Applying Insecticides	0	5	2	7
Kitchen Gardening	16	15	16	47
Harvesting	7	9	9	25
Post-Harvest Operations	11	12	10	33
Rearing Poultry	20	9	11	40
Rearing Livestock	10	5	7	22

Upon a chi square analysis of the frequency distribution, it was found that there was a significant difference in the score obtained for home garden activities like rearing of poultry, uprooting seedlings and applying irrigation among the three districts. As evident from the results, the women in the specialized home gardens tend to focus their involvement mainly towards the proximity of the home i.e. in the kitchen gardening activities like growing essential vegetables which require the little effort like chillies, brinjal, amaranthus etc. and those which could be used for the daily culinary chores. The same can be said in case of poultry rearing, as what was seen in from home gardens with poultry as its specialized component. The units of poultry involved are more or less managed by the women in the specialized home gardens. Since in non-commercial cases of poultry rearing there involved only minimal tasks and efforts that need to be adhered in managing the poultry population, it was considered the duty of the women folk to cater the section. Later, themselves involving with more intensity after acquisition of necessary skills for commercial poultry rearing. Hence there is a significant contribution from the women folk in the management of a livestock specialized home garden. While coming to post harvest operations, usually in smaller specialized home gardens, the levels of post-harvest operations was under a level that could be handled by both men and women in the home gardens. So in certain cases the participation of women was seen to be in a commendable level along with men of the family. While considering activities like, applying irrigation, harvesting, planting seedling, and applying fertilizer, the extent of participation was consider to be admirable. They got themselves involved in almost all the activities related to the specialized component beginning from, planting, weeding, applying pesticides and fertilizers and land preparation. Women in the home gardens of the three taluks tend to deter from activities like drain preparation and fencing either due to the lack of need or skill involved in the two. Those activities were completely handled by the men in the family or by hired labour.

The management of home garden is highly gender based. It gives insight on the gender-based roles of men, women and children in home garden agriculture, and local resources management. Mainstreaming gender in conserving biodiversity is important. Men and women manage natural resources in different ways. Each of them has varied and distinct knowledge related to biodiversity. Women are highly depended on natural resources mainly to feed the family. They are carrying the main responsibility of feeding the family and this is seen mostly in the rural households. Due to this division of labour and responsibility in home, makes women more dependent on natural resources. The gender roles in home garden vary based on different ethnic and cultural setting. Both male and female are equally responsible in overall home garden management in urban areas but in the rural households women is mainly concerned with home garden management.

All over the world, women is the key player in conserving biodiversity be it, the home gardening, herbalists, wild plant collectors, plant domesticators and seed custodians. They often have indigenous knowledge about native species and hence rely mostly on natural resources to meet their family needs. With their specific biodiversity knowledge and increasing experience, women act as a major a driving force in conserving and initiating evolution in biodiversity as they need continued access to natural resources to maintain their status as home keepers as well as for the welfare of the family as a whole. Like in every platform, women's knowledge and experience in biodiversity conservation is important. It is thus imperative to adopt gender differentiated practices and positive steps to assure the full and active participation of both men and women in preserving home garden biodiversity. There is a need to develop a gender sensitive database on knowledge systems specifically for home gardens that will serve as information to satisfy the biophysical and socio-economic requirements. Biodiversity is a broader term encompassing diversity that is spanning between ecosystem and species and within species too. Biodiversity in simple terms refers to the variation in life forms, other components present in the ecosystem as well as in the nature of interactions between various components.This interaction makes life possible on this planet including for humans. The influence of humans and other natural processes for over billions of years is the main reason for the biodiversity that we see today. It can be rightly referred to as the web of life in which we are an integral part.Natural resources are crucial for the existence of humans. Humans are widely depended on the rich biodiversity present and this is one of the main reasons why they will be the most affected by the increasing loss in biodiversity. This loss threatens our food supplies, sources of fuel, medicines, timber and energy.

Within family members and family farms, it is important to differentiate the relative roles of women and men in achieving desired food security and ecosystem integrity in terms of biodiversity richness. These households and communities organise production and resource management around gender division of labour and responsibilities. Home garden women play a key role in such agro-biodiversity based food production systems. All over the world, women is the key player in conserving biodiversity be it, the home gardening, herbalists, wild plant collectors, plant domesticators and seed custodians. They often have specialized indigenous knowledge about native species and hence rely mostly on natural resources to meet their family needs. With their specific biodiversity knowledge and increasing experience, women act as a major a driving force in conserving and initiating evolution in biodiversity as they need continued access to natural resources to maintain their status as home keepers as well as for the welfare of the family as a whole. Like in every platform, women's knowledge and experience in biodiversity conservation is important. Men get more involved in physically tedious tasks. Children cannot be excluded from home gardening. They will be more involved in ornamental flower cultivation, watering and assisting parents in simple important tasks. So home gardening is not the domain of only one single gender. It is thus imperative to adopt gender differentiated practices and positive steps to assure the full and active participation of both men and women in preserving home garden biodiversity. Skill training in agriculture should also focus on women along with men since in home garden women is more involved in crop management rather than in large farms where men will be more involved.

4. CONCLUSION

One dominant feature of home garden is its great diversity in life forms. In many places across the world, home gardening is a traditional conservation system, where some key versatile plant species are grown by local farmers near their houses (Galluzi et al., 2010). Many studies have focussed on Home Gardens, investigating their potential to host biodiversity or to alleviate poverty (Reyes-Garcia et al., 2012). The richness in the agro biodiversity in home garden indicates the role of home gardens as repositories of biodiversity. The maintenance of home garden will ensure the conservation of biodiversity and food security from the individual level. Each household with home garden can find its source of quality nutritious food from the rich natural resources within it. Family farming involving all the members in a family with definite roles is another important feature of home gardens. This ensures both nutritional and food security to individual households. Both men and women have different roles in conserving biodiversity in the family community in terms of the labour, property rights and decision making processes. This role differentiation reflected upon their knowledge and skill in relation to biodiversity and ecosystem. There is a need to develop a gender sensitive database on knowledge systems specifically for home gardens that will serve as information to satisfy the biophysical and socio-economic requirements. Programmes for conserving biodiversity and food security should focus on women rather than accepting their services and neglecting them.

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ICT FOR AGRICULTURE AND FOOD SECURITY

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ABSTRACT

The paper focuses on the ICT (Information Communication Technologies) in agriculture and food security. ICT have the potential to reach many farmers with timely and accessible content. ICT can improve food security and address farmers' problems and needs across the economy to increase the agricultural production. An exploratory and desk study was conducted during 2012-2014 in Thiruvananthapuram, Kerala to inventories and document agri-expert systems evolved worldwide and popular ICT projects in India to increase the agricultural production and enhance the food security across the country. Agri-expert systems explore the role of ICT in agricultural sector and its role for increased sustainable agricultural production aiming at food security. Based on the review of literature, internet search and discussion with experts 72 agri-expert systems were inventorised and documented. Among these the popular agri-expert systems widely used in Kerala are KAU-fertulator and e-Crop doctor developed by center for e-learning, Kerala Agricultural University for fertilizer calculation and digital plant protection advisor for the crops of Kerala based on the latest recommendations. ICT initiatives like e-Choupal, e-Sagu (sagu means cultivation in Telugu) are popular projects empowering farming community to ensure food security. To mainstream such ICT efforts and knowledge management for agriculture and food security, it is necessary to put in place a centralized search engine, or harvester, to access the decentralized and dispersed digital agricultural information repositories and network of experts.

Thus the study would help the administrators to make necessary policy interventions for streamlining the development and use of ICT in agriculture.

Key words: Agriculture, expert system, food security, communication, e-crop doctor

1. INTRODUCTION

Past two decades witnessed an average annual growth of agriculture sector with less than half (around 3%) of the overall average growth of the economy (6 - 7%). Still, agriculture and allied sectors is the pivotal sector for ensuring food and nutritional security, sustainable development and for alleviation of poverty. There are projections that demand for food-grains would increase from 192 million tonnes in 2000 to 345 million tonnes in 2030. Hence in the next 20 years, production of food-grains needs to be increased at the rate of 5.5 million tonnes annually (NAAS, 2009). In the agriculture sector constant application of latest ideas and better work technologies is essential to enhance productivity in the interest of economic well-being of farmers and for ensuring food security. Still, in India agriculture extension activities are mainly based on radio and television discussions, person to person contacts, publications, and exhibit of products, fertilizers and seeds at farmers' fairs. Recently, enormous efforts are being made in India for adoption and absorption of information technologies for agriculture information communication. The National Agriculture Policy lays emphasis on the use of Information and communication Technology (ICT) for achieving a more rapid development of agriculture in India. ICT use should attract special attention, as food security is being emphasized globally. Among the several ways of addressing food security, ICT should be considered first because of its capabilities. The past decade has proved the importance of ICT in promoting social and economic development at international, national and local levels (Baryamureeba, 2007). Computer technology in its recent advancement focusses on software programmes that are available to assist in filling the knowledge of experts for analysis and design of complex problems. The Expert System in agriculture is a simple expert system based on agriculture related problem solving models; include diagnostics model, prediction model and farm management model (Nitin et al., 2013). Among ICT's for agricultural extension, e-choupal, e-sagu (www.esagu.in), e-arik (www.earik.in), India development gateway (www.indg.in) and e-aAqua (www.aaqua.org) are notable examples (Saravanan, 2010). Agricultural data distributed and resides over different places and controlled by different stake-holders in India which is required by agriculture community at different stages of agriculture system. Consequently, all experts' advice/information is not possible to provide physically at farm/ organizational level to desire agriculture community. Therefore there is immense potential to bridge this rural-urban gap by incorporating extension services in agriculture through ICT initiatives and attain food security. Hence this theoretically oriented study.

2. MATERIALS AND METHODS

The food insecurity situation is effected by global warming, population growth, focus on bio-energy, low technology acceptance, unfavorable policies, sustainability criteria, changing natural risk-situation, subsidies etc. Further, food crisis has aggravated further because of frequent severe droughts and floods, soil erosion, climate change, and diversion of arable lands to urbanization, industrialization (Di Walter, 2010). As natural resources are continuously shrinking and deteriorating, we have to increase the agricultural production in future to meet the projected demand of food-grains in our country (Dahiya and Singh, 2011). Therefore we need ICT based comprehensive computerized expert systems and ICT projects for management and extension because right information and its timely communication is sought to put Indian agriculture on high growth trajectory. This paper scrutinises the impact of new ICTs on agriculture, outlines emerging opportunities, and offers some guidance to build food security. Hence an exploratory and desk study was conducted during 2012-2014 in Thiruvananthapuram, Kerala to inventorise and document agri-expert systems evolved worldwide and popular ICT projects in India aimed at increasing the agricultural production and food security across the country.

3. RESULTS AND DISCUSSION

Information and Communication Technology (ICT) in Agriculture is emerging field focusing on the enhancement of agriculture. The Agriculture sector is gearing itself to make optimal use of the new information and communication technologies. Actually, limited resources, population growth and environmental concerns are some of the challenges in augmenting the agricultural productivity; and this could further be affected if there is adverse effect. Therefore, ICT usage should take care of these issues. In many developing countries including India, farmers determine fertilizer usage and its amount with the help of retailers, but its automated and calculated implementation is required to improve the productivity that is made possible using ICT tools like expert systems.

3.1. Expert systems for Agriculture and Food security

The problems in agriculture are often multidisciplinary and very complex because of complex events. Expert systems approaches will succeed with this kind of problems. It has many methods for uncertainty and reasoning using whatever on the hand. Currently many people are forced to make decisions about agricultural activities without enough knowledge. Many of them have inadequate training about agriculture and needs to be managed. Expert systems can facilitate knowledge transfer and can guide growers to take decision into different aspects of crop management for increasing the productivity and the profit margin and also combines the experimental and experiential knowledge with the intuitive reasoning skills of a multitude of specialists to aid farmers in making the best decisions for their crops which leads to increasing production and ensuring food security. Many expert systems have been developed in agriculture to help farmers in taking proper decisions and for getting better yield. The results of inventorisation of the expert systems related to agriculture and allied enterprises through a desk study accessing internet for three months are as follows.

At least 72 agri-expert systems were identified and documented. Among these expert systems 30 expert systems were developed in India by different organizations under the support of government and private establishments to ensure and enhance the capability of extension professionals in utilizing agricultural expert systems for the benefit of farming community for increasing production in agriculture. Among these the popular agri-expert systems widely used in Kerala are KAU Fertulator (2012.01) developed by Centre for E- Learning, Kerala Agricultural University is user friendly software for calculating fertilizers based on latest general recommendations for Kerala, India. KAU E-Crop Doctor is a digital plant protection advisor developed by Centre for E- Learning for the crops of Kerala based on the latest recommendations. These expert systems also got awards like, The Asia pacific digital empowerment foundation award-2013 and World education award-2014. Software named 'CROP-9-DSS' incorporating all modern features like, graphics, photos, video clippings etc. has been developed by KAU. This package will aid as a decision support system for identification of pest and diseases with control measures, fertilizer recommendation system, water management system and identification of farm implements for leading crops of Kerala. 'CROP-9-DSS' will act as an expert system to agricultural officers, scientists in the field of agriculture and extension workers for decision-making and help them in suggesting suitable recommendations for farmers to adopt (Ganesan, 2007). KISSAN KERALA CROP HEALTH DECISION SUPPORT SYSTEM (CHDSS) is an online expert system in Kerala to help the farming community to identify various pests, disease and other nutritional deficiencies of their crops through an interactive model and take suitable control measures on time. Farm Extension Manager was designed to provide comprehensive information on production and marketing of major crops in Wayanad. The crops covered by the different expert systems used by the farmers of Kerala are presented in Table 1. Hence expert systems enhance the end user to get the information on all type of crops and solving the problem with in a limited time for increasing the productivity in the country.

Table 1: Popular expert systems and crops covered

Type of Expert systems	Crops
'CROP-9-DSS'	Coconut, Rice, Cashew, Pepper, Banana, Amaranthus, Bhindi, Brinjal and Cucurbits.
Kissan Kerala (CHDSS) (from http://www.kissankerala.net:8080 KISSAN-CHDSS/ English/index1.html)	Coconut, Arecanut, Cocoa, Banana, Pepper, Nutmeg and Vanilla etc.
Farm Extension Manager	Banana, Pepper, Coconut, Rice and Coffee
KAU Fertulator and E-Crop Doctor	Rice, Banana, Pepper, Arecanut, Coconut, Yams, Sweet potato, Tapioca, Chinese potato, Beans, Amaranthus, Okra, Tomato, Chilli, Brinjal, Cucurbits, Cabbage, Cauliflower, Amarphophalus, Colacasia, lablab, Cashew, Oil palm, Cocoa, Coffee, Tea, Cotton, Sugar cane, Ground nut, Sesame, Jasmine, marigold, mango, pineapple, cardamom, ginger, turmeric, cinnamon, clove, garcinia, nutmeg and fodder crops.

3.2. ICT initiatives for Agriculture and Food security

ICT projects in giving right information at right time about the crop production and protection aspects to the farming community to attain food security. Agricultural system is the most heterogeneous in nature and production of different crops depend on many diverse resource and random factors such as climate, temperature, edaphic conditions, fertilizers, soil nutrient, cropping systems and rotation, quality seed, pesticides, irrigation scheduling and socioeconomic situation. It is not possible to provide or make available all information and advice about every crop, floriculture, viniculture, live-stock, fisheries, horticulture etc. by traditional information technology or manually to different community of farmers and scientists. The concise review of popular ICT projects was presented.

ICTs offer services like marketing, storage, transportation etc. to compete farmers in the market. ITC e-choupal is a cost-effective means of dealing directly with farmers to buy agricultural products for export. The system is now becoming a meta-market for rural India. e sagu (sagu means cultivation in Telugu) uses the medium of digital photos of farmers‘ fields to provide expert advice. Warana Model, iKisan, Tata Kisan Kendras are some models that are offering informational, transactional and extension services to farmers. Some important ICT initiatives in Kerala Agriculture are e-Krishi for web based farm advisory services, Digital Green for farmer participatory video for agricultural extension, KISSAN Kerala for agricultural content processing and dissemination system and Village Knowledge Centres (VKCs) for location specific content generation. ICT initiatives will deliver the information instantly for the community of interest. In this way ICTs can improve economy of nation (GDP) and poverty can be alleviated helping the nation to attain food security.

4. CONCLUSION

This paper has conferred the usefulness and need of ICTs in rural agriculture to attain food security. Development of an expert system on agricultural crops will help growers in faster dissemination of expert advice for different locations at the same time and will guide them to take decision into different aspects of crop management for increasing production. ICTs can make a significant contribution to increase the system efficiency, productivity and sustainability of small scale farms is an area where farming involves risks and uncertainties, with farmers facing many threats from poor soils, drought, erosion, pests and diseases. ICT should therefore, be used to meet the needs of the local people in sharing the indigenous and the acquired knowledge. This will solve the challenges and lead to increased agricultural production, increased awareness and sharing of information that will eventually ensure food security for all.

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HOME GARDENS: ARMAMENT OF BIODIVERSITY

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ABSTRACT

Home gardens are specialized sustainable agro-eco system with or without an extended garden where there is constant interaction and interrelation between various components. Increased population pressure, emerging nucleotide family structure and decreased area under agriculture has resulted in fragmentation of land area which makes home garden the 'next generation farming system' that is unique. Home gardens are characterized by structural and functional complexity but provides benefit to both ecosystem and people of rural and urban areas. Studies reveal that home gardens are considered to be biodiversity hotspots, knowledge reservoirs and contributors of wild relatives of crop species. In a small area under home garden we can find a wide range of species richness with trees, shrubs, medicinal plants, spices, and even traditional trees which spread light on the cultural significance of home gardens etc. The increasing population, massive industrialization, agricultural transformation, under development, tradition cum cultural erosion etc. are major crucial factors that have resulted in massive exploitation of natural resources and biodiversity loss that are necessarily the components of agriculture which aids in the development of a family, society, state and the nation. The study undertaken discusses about the role of home gardens in conservation of biodiversity and cultural heritage.

Key words: agro-eco system, family, knowledge, sustainability, structure and function

1. INTRODUCTION

Tropical agroforestry home gardens can be defined as land use systems that include deliberate associations of trees, herbaceous crops, and/or animals, in close interaction with a household (Fernandes & Nair, 1986). Home gardens are typical agroforerstry ecosystem which is widely recognized for their role in production of food, medicine and other useful products; this has led to attempts to improve the productivity of home gardens. Previous studies on home gardens concentrated on the improvement of nutritional status and increase in vegetable production. Home gardens are farming system with unique genetic diversity and reservoirs of traditional knowledge. This realization has led to initiatives to study this farming system inorder to get a deeper understanding about insitu conservation of biodiversity by home gardens.

Home gardens of Kerala are farming systems which represent low to medium input sustainable agro-ecosystems. The species composition of home gardens varies on each of horizontal and vertical spatial arrangements. Home gardening has met various demands of farming families including their basic needs, social- cultural needs and financial needs. This shows the four pillars of sustainability: economical, ecological, cultural and political sustainability. Moreover the concept of sustainability focuses on the practices adopted by home garden farmers for conservation of agro-biodiversity and to meet the socio economic and cultural needs of the present and the future generation. Home garden farming system adheres to the ecologically friendly farming systems and fostering sustainability in ecological succession (IAASTD, 2009). Home gardening has contributed to food security in ways, such as direct access to a diversity of nutritionally rich foods; increased purchasing power from savings on food bills and income from sales of garden products, and fall-back food provision during seasonal lean periods (Akosa, 2011). Individual farmers spend more time in the gardens, paying particular attention to the survival of individual crops; maximizing each crop yield and the total farm output than in the case of conventional farming.

2. METHODOLODY

The study area was stratified based on the three agro-climatic units of Thiruvananthapuram district. A total of 35 farmers were randomly selected and surveyed using pre-tested and well- structured interview schedule.

3. RESULT AND DISCUSSION

The results of the exploratory study explains the continuing use of crop plants, passed down from one generation to the next, making home gardens important sites for conserving plant genetic resources and sustaining a vibrant diversity. Different components of home garden interacts in various manner and work towards attaining sustainability. This is enabled due to the synergistic interaction between diverse components in the home gardens. Based on intensity of components added to home gardens they develop their own structure and function. From unplanned structure, home gardens became structured by replacing food crops to cash crops and commercial crops. The type of structure would define the functions of home gardens and together it contributes to the sustainability of the system and conservation of biodiversity.

The nature of continuing use of crop plants in the home gardens of study (n=35) revealed that coconut was the dominant perennial base crop of homesteds with its occurance in 88.37% of the home gardens. Rubber based homesteads accounted to 11.43%. The horizontal integration of crop components in the 35 selected home gardens is presented in Table 1.

Table 1: Continuing use of crop plants. (n=35 Home gardens)

Crop rotation	No. of Home Gardens	Percentage to total	Level of horizontal integration per cropping season
Coconut+Vegetables (Chilly/ Bhindi/Bittergourd/Amaranthus)	13	37.14	3
Coconut+Banana+Vegetable (Amaranthus)	7	20.00	4
Rubber + Pineapple	4	11.43	2
Coconut+Arecanut+Tubers (Yams/Colocasia/Tapioca/ Sweet potato)	11	31.43	4
	35	100	

Table 1 revealed that 'Coconut + Vegetables' was the dominant cropping pattern observed in maximum number of home gardens (37.14%) with three levels of horizontal integration followed by 'Coconut+ Arecanut + Tubers' (31.43%) with four levels of horizontal integration, 'Coconut + Banana + Vegetables' (20.00%) with four levels of horizontal integration and 'Rubber + Pineapple' (11.43%) with two levels of horizontal integration. However it should be observed that wherever vegetables are integrated two to three different vegetable formed a part of horizontal integration wherein the major vegetables of inclusion in home gardens were chilly, bhindi, bitter gourd, amaranthus and yard long bean. In case of tubers the major crops plant inclusions were yams, colocasia, tapioca and sweet potato. The results clearly point that inclusions with vegetables and tubers to the base crop is not only helping the farmers with increased profitability but also augments biodiversity.

Apart from the components mentioned in the table some of the crops (that does not fall under numerical dominance) are pepper, multipurpose tree species (including minor perennial fruit crops), medicinal plants (tulasi, Coleus aromaticus, asparagus) and ornamentals. Inclusion of livestock and poultry were also seen in home gardens which changed these cropping systems to farming system. About 19 home gardens (55.00%) integrated poultry and 4 home gardens (11. 43%) had livestock component. Hence, it can be inferred that there is a declining trend of including cow as a farming component in home gardens. This could be because of reduction in area scale of home gardens, increased rearing cost, fodder unavailability, nucleotide family structure etc. Home gardens with specialization can generally improve the home garden income and can thereby contribute to the overall annual income of the home garden family (Rahul, 2013). Specialized components not only produce for the family but surplus generated is sold in markets for generating additional income.

Scarce resources available is managed properly to obtain maximum output in terms of produce and minimum output in terms of loss of biodiversity, soil degradation and nutrient loss satisfying the pillars or circle of sustainability. The major components of home gardens that foster economical sustainability are the management of scarce resources through sufficient technology interventions for cropping practices, sustainable water management, sustainable nutrient management etc. Ecological importance of home gardens are seen in soil and water conservation methods like husk burial, husk pitched bunds, roof water harvesting etc. 12-15% of home gardens followed the practice of biofencing by planting Glyricidia, Thespesia, Erythrina and Pineapple along borders which again signifies importance of biodiversity and resource recycling. Home gardens play a major role in socio cultural attributes of farming by considering beliefs, health and well being of family, aesthetics etc. Examples for conserving biodiversity through socio-cultural sustainability is the presence of sacred groves, planting of tress with astronomical importance and innovative courtyards and indoors. The socio-religious importance of home garden cannot be under estimated as even today structures like Kudumbakshethram and Kavu exist in Kerala home gardens (Thomas,2004). In order to overcome the limitations of scale in Home garden and non-Home garden systems, vertical farming including terrace farming, precision farming and protected cultivation shall be fostered maintaining its biodiversity. Acts, rules and regulation, policies and extension intervention should emerge in the field of home gardens to promote this unique sustainable agro-ecosystem.

4. CONCLUSION

Home gardens are subsistence farming system with high diversity and complexity to fulfill a wide range of economical, ecological and socio cultural needs. Individual households must pursue their own agenda for food security/safety, additional income and ecosystem integrity. Home gardens acts as a source of safe food cum nutritional security and augments economic security through sale of surplus. Greater the diversity of crops grown, the better the food and income in household. Also, this is an ever-evolving system that helps the farmers to overcome the fluctuations of seasonality of the production system. Home gardens contributes significantly to conserve the native biodiversity and provide subsistence for household. Management of home gardens by compensating the available scarce resources and harbouring diversity are strategies for conserving regional biodiversity and fulfilling the elements of food and nutritional security. Biodiversity of our planet can only be safe when people find a way towards sustainable and stable livelihood.

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SEED SOVEREIGNTY FOR FOOD SECURITY AND LIVELIHOOD IMPROVEMENT"- COMMUNITY LED EFFORTS IN CONSERVATION AND REVIVAL OF INDIGENIOUS CROP DIVERSITY IN JAWHAR AND DHADGAON TRIBAL BLOCKS OF MAHARASHTRA

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ABSTRACT

In recent years seed has transformed from a 'community resource', carefully bred, conserved and evolved, into a 'commercial proprietary resource'. Traditional practices of agriculture have been vanishing and farmers are increasingly dependent on external sources such as hybrid seeds, chemical fertilizers and highly toxic insecticides which resulted in steep escalation in input cost, environmental degradation, reduction in the biodiversity and rise in mono-cropping. Under the pressure of unpredictability, the agricultural systems all over the world are required to find suitable solutions for food security in the backdrop of above challenges. Genetic diversity is a key element in farmer's livelihood strategies particularly in areas under high ecological, climatic and economic stresses and risks. India has a number of landraces of food crops that are resistant to pests, can grow on poor soils and can sustain under the changed climatic conditions with high nutritive values. It is essential to conserve these landraces. Farmer led conservation and development of improved varieties gives hope not only for nurturing agro-biodiversity but also for providing food security and sustainable livelihoods.

BAIF Development Research Foundation initiated a community led conservation and revival of Crop diversity in Jawhar block of Thane district and Dhadgaon Block of Nandurbar District, Maharashtra since 2007. The process and methodologies adopted are mapping of crop landraces, on-farm conservation, characterization and evaluation with community level with community seed banking and seed exchange programme for sustainable livelihood.

Key words: Genetic diversity, conservation, indigenous crops, biodiversity, traditional knowledge, community-led varietal selection, seed Banks, PPV & FR Act.

1. INTRODUCTION

The seed has become the site and symbol of freedom in an age of manipulation and monopoly of its diversity. It plays the role of Gandhi's spinning wheel in this period of recolonization through free trade Vandana Shiva (1997: 126)

As both the basis of sustenance and all food-systems and as a foundation of all agricultural production systems, seed has become a prominent symbol and one of the contested and indispensable resources the availability and variability of which directly affects nutrition and consumption-patterns.

Up until the boom of the development of inbreeding/ hybridization, farmers were mostly sole sovereigns over their seeds. The decisions on what seed to plant, save, who else might be allotted or get access to the seed either in the form of propagating material or food was governed by the cultural norms of the local communities that were operating open systems based on reciprocity, gift exchange and communality rather than market-exchange, thus facilitating and stimulating dissemination of seed (Zimmerer, 1996; Brush, 2004; Salazar et al., 2007). The ongoing recombination of genetic material resulted in the agronomic resilience characterizing farmers' varieties and landraces and constitutes the genetic foundation upon which world food production should be based (Kloppenburg, 2008).

The introduction of the highly productive semi-dwarf wheat and rice cultivars and vertical resistance breeding typical of the "green revolution" marks a continuous and progressive process of eroding of the role of the farmer in the effective reproduction of planting material. While there is no question that given the proper conditions and outputs, the "miracle crops" have increased yields, the fact remains that farmer's choice of cultivars was limited as there were relatively few of these high-yielding varieties available. Thus the door has been opened for private capital to profit from the seed sector and seed which was a 'community resource', carefully bred, conserved and evolved over thousands of years, has transformed into a 'commercial proprietary resource' (Brush, 2000; Kloppenburg, 2008).

In addition the wide-spread adoption of dwarf varieties, has resulted in shortage of fodder- an important resource for marginal farmers, has increased the use of external inputs as hybrid seeds, chemical fertilizers and highly toxic insecticides in turn causing in steep escalation in production cost, environmental degradation, reduction of on-field biodiversity and rise in mono-cropping. Today 75% of the world's food is generated from only 12 plants and 5 animal species, making the global food system increasingly susceptible to shocks (Altieri, 2008). That brings up the need for agricultural systems all over the world to find suitable solutions for food security in the backdrop of the above challenges and under the conditions of increased ecological, climatic and economic stresses and risks.

In most developing countries farmers, women in particular - had persisted in developing locally adapted planting materials. As per FAO data approximately 1.4 billion people live in family-farms and are largely self-reliant and provisioning for their seeds and planting material (FAO, 2009). India has a number of landraces of food crops that are resistant to pests, can grow on poor soils and can sustain under the changed climatic conditions with high nutritive values. It is essential to conserve these landraces as many farmers see advantages in maintaining these varieties even in the form of alternatives that can meet their needs.

Genetic diversity is important both to individual farmers and farming communities and to agriculture in general, this is why in 2007 BAIF Development Research Foundation has initiated a community-led conservation and revival of crop diversity.

1.1. Rationale for the Intervention

Fig 1: Study Area

The hill ranges in India are known for their native crop diversity and interior hilly regions are beyond modernization of agriculture, these areas have retained traditional crop cultivars and knowledge of their specific qualities and agronomic practices.

Two such locations in focus are Jawhar block in Thane district and Dhadgaon block in Nandurbar district of Maharashtra (Fig 1).

Jawhar Block:Jawhar block is a hilly region, which includes a part of the Western Ghats, considered to be a biodiversity “hot spot”. The average rainfall in this area is above 2500 mm. The area is a host to an amazing diversity of rice and other food crops. The typical lateritic soils are poor in nutrients, and agriculture is largely rain fed (only 5 to 7% of the Konkan region is irrigated). The topography of this area is very sloppy. The tribal communities in jawhar block are Varli, Koli Malhar, Thakur, Kathkaris, Kokana and Mahadev Koli and they are small and marginal farmer's holders. The main crops cultivated in this area are paddy, Finger millet, sorghum, Pigeon pea and Black gram.

Dhadgaon Block:Nandurbar is one of the North districts of Khandesi region of Maharashtra and includes a part of the Satpura valley. The predominant soil type is sandy loam. Agriculture is largely rain-fed. Soil erosion affects the soil fertility to a considerable extent. Dhadgaon cluster is situated in the Narmada valley 671305 m above sea level. Out of the total population in Dhadgaon cluster, 96% comprises of tribal communities, of which Pawara and Bhilla are the two major ones. The climate is dry sub-humid, average tropical savanna (dry winter). The average rainfall is 767 mm. Most of the farmers are marginal and the average land holding varies from 1/2 to 20 acres. Maize and sorghum are the major crops meant for food and fodder requirements of the communities.

The modern 'high yielding varieties' did not have any significant effect on these regions during the first 2-3 decades of the Green Revolution; hence, genetic diversity remained surprisingly high However, during the last 2 decades, there has been a gradual erosion of indigenous biodiversity with most of the indigenous rice varieties being replaced by high yielding varieties such as Ratna and Jaya, which are considered to be the most responsive the area. These high yielding varieties have not resulted in any spectacular increase in yield in this region. The majority of farmers, especially the resource-poor tribal farmers could not afford to purchase fertilizers which are normally recommended along with these varieties.

Farmers have reported declining soil fertility, thereby resulting in a reduction in crop yield. Pest and disease attack on crops is increasing and there is a narrow range of varieties of hybrids available in the market. In the remote areas of Dhadgaon block, a few farmers continue to cultivate traditional varieties on a small portion of their land, mainly for household consumption. Thus, many of these crops still have their presence despite negligence over the last 2 decades. This is indicative of their potential role in the cropping systems of India, especially in small landholdings. It is now accepted that continued production and use of local cultivars on farms can play a significant role in the conservation of within-species genetic diversity (Brush S. B., 2000), moreover farmer varieties with a reduced geographic range are often well- adapted to local conditions, intended for local consumption and relying on local resources. An increasingly important part of the flow of technological goods to farmers is improved crop varieties, selected from outstanding farmer varieties, and the basis of such improvement and conservation programs should be the participation of farmers who would use and replicate the results. This approach is referred to in the literature as “Participatory Plant Breeding”(Weltzein, 1996; Whitcombe, 1996, Eyzaguirre, 1996) and is the foundation of BAIF's intervention.

2. METHODS AND MATERIALS

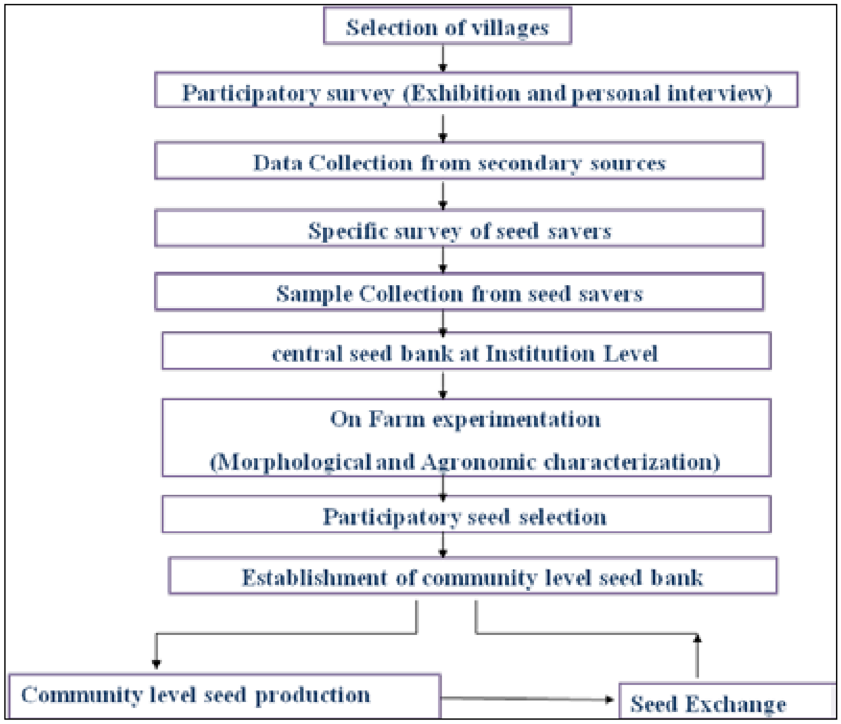
BAIF Development Research Foundation has initiated community-led conservation and revival of crop landraces in Thane and Nandurbar districts since January 2007 through the establishment of the Green and Appropriate Technology Resource Centre (GATRC) at Jawhar, with the following objectives:

- To revive and conserve diversity of landraces and local knowledge associated with it, with special focus on food security, risk mitigation and livelihood development.

- To undertake agronomical and morphological characterization of crop landraces along with trials for productivity enhancement of worthy cultivars under organic agriculture practices.

- To encourage establishment of community-managed seed banks and village level seed production and multiplication.

The process development and methodologies adopted are shown in the following flow chart Community-level crop germplasm conservation model is a unique approach for conservation, revival and sustainable use of crop diversity. Capacity building of seed savers and farmer groups for participatory seed selection, production and exchange, is a critical aspect of the programme.



2.1. Steps Taken

PARTICIPATORY SURVEY FOR CROP DIVERSITY DOCUMENTATION:

Taking as a starting ground people's perception about their use, value, specific properties and factors affecting productivity, and in close collaboration with the farmers who have kept such local or traditional landraces under cultivation, valuable information on locally available cultivars, reasons for extinction or maintaining cultivation has been collected by means of seed exhibitions and fairs, personal interviews, group meetings, participatory rural appraisals, etc. The surveys have been completed in 7 blocks of Thane district and 2 blocks in Nandurbar district. During this drive, more than 4000 farmers have been reached.

2.2. Participatory survey and seed exhibition

This work has been done in participatory manner by involving elderly and knowledgeable farmers and women-farmers in nearby area.This approach helped to validate the authenticity of crop landrace conserved by seed keeper, specific trait in it and to know more about farmers practices and methods of seed selection and upgradation.

3. RESULTS AND DISCUSSION

3.1. Establishment of Seed

Sustainability of seed conservation programme requires a mechanism at the community level for seed selection, seed production and exchange and establishing an independent seed security system at the village level.

A seed saver committee has been formed to ensure quality seed production, management of seed exchange and establish market linkages. Seed production and Seed selection methods are assured by seed saver committee through Shivar Feri (field visit) wherein they can facilitate suitable methods to participating farmers. Seed saver committee has an authority of monitoring seed plots for quality seed production. Now these seed saver committees are capable of managing Insitu conservation centres of paddy, finger millet and proso millet landraces.

A central seed bank has also been established at Jawhar for storage, cataloguing and maintaining a database of crop landraces collected from various locations. The objective is to ensure easy access of seeds for researchers, students and farmers, establishment of demonstration plots and maintaining purity of landraces. A permanent accession code has been provided to each landrace collected. Well dried seed samples collected.The samples collected in the central seed bank have gone through a series of experiments to check morphological and agronomical characters for scientific validation and preparing a detailed database of individual landraces.

The seed bank has a collection of 400 landraces which includes: paddy (225), finger millet (27), proso millet(10), foxtail millet(02), maize(06), sorghum(06), pulses(32),Cowpea(20),Pigeon pea(10) ,Vegetables(44),Tubers(05) etc. Farmers interested in growing such landraces in their fields can borrow seed from the Seedbank in Jawhar, as such it is in fact operating as a community seed bank and promoting in situratherthan ex situ conservation

Cataloguing and Proper maintenance of Seed Bank

3.2. Agro-morphological characterizations of paddy landraces

Agro-morphological characterizations of crop landraces are valuable in future crop development and improvement programs. Our information about the local availability of landraces is incomplete and it is therefore urgent to collect document them.

After purification & Upgradation cycles for 3 years, Agro –Morphological characterization of 55 landraces of paddy, maize (5) and sorghum (6) has been done as per the DUS Guidelines provided by Protection of Plant varieties and Farmers Right's Authority (PPV & FRA), New Delhi.

In situ conservation centres

3.3. Participatory seed and varietal selection

Participatory seed selection is very important for maintaining genetic purity and yield improvement of crop landraces. Participatory varietal selection provides scope for cost-effective varietal selection from farmers' own resources, while enhancing their access to crop varieties, production alternatives and thus assuring food security.

Participatory seed & varietal selection is conducted by formation of farmers' groups comprising of 5-10 members, who visit in situ germplasm centres where number of landraces of paddy, finger millet, proso millet are planted in different land types. They interact with other each other, see crop performance and finally assign a score value based on criteria for selection of landrace such as grain and fodder yield, resistance to pests, crop stand, disease tolerance, plant strength, panicle length, effective tillers, lodging susceptibility, maturity days, suitability to land, drought tolerance, end use etc. Participation of farmers for selection of varieties was undertaken in four stages of plant growth i.e. early stage, flowering, maturity and harvest.

About 225 farmers were trained in participatory seed and varietal selection which includes village youths and women farmers.

3.4. Community level seed production of Worthy Landraces

Worthy crop landraces were selected by participatory method and with a scientific back up on the basis of different criteria like:grain and fodder yield, pest and disease resistance, suitability to land, end use, suitability to climate change etc,. Purified,upgraded elite germplasm of promising landraces of paddy, finger millet and proso millet are distributed to selected farmers for seed production. Package of practices for community level seed production by organic method for paddy, Finger millet and Proso millet had been developed during kharif 2013. 26 farmers have been involved in seed production of paddy (15), finger millet (03), proso millet (03). Community level seed production of different crop landraces has been done in Table 1

Table 1: Community level seed production of different crop landraces

sr	Crop	No of landraces	Quantity (Quintle)
1	Paddy	15	50
2	Finger Millet	3	2.5
3	Proso Millet	3	2

Farmer exposure to In situ conservation centres

3.5. Knowledge Building and Knowledge Transfer

Field training programmes on Participatory seed selection have been conducted to educate farmers about maintaining seed purity in paddy, finger millet, proso millet, maize and sorghum. Community-level seed exhibition is an important tool for increasing awareness of the farming communities about crop diversity in their area and the need for conservation. It is also helpful in ensuring community participation in field programmes.

As "seeing is believing", field exposures and field days are conducted regularly. Field training programmes on various topics such as seed treatment, nursery raising, paddy transplantation by single seedling method, ridges and furrows method for finger millet and Proso millet cultivation etc has been conducted for 360 participants. Through community seed fairs, seed exhibitions, Field days, reached upto 4200 farmers in different parts of Maharashtra.

4. CONCLUSION

Currently 724 farmers from 11 villages of Thane and Nandurbar districts are directly involved in conservation, seed production and community level seed banking programme. Organic package practices have been introduced and taught to these farmers for increasing crop production and lowering cost of cultivation.

The lessons we have learnt establishing and replicating the model of intervention and working closely with tribal and marginalized farmers are:

- Farmers are willing to maintain crop diversity.
- Farmers' views about seed and varietal selection are important.
- Seed fairs and exhibitions are useful tools to collect traditional knowledge and resources.
- Crop demonstration centres play a vital role in conservation.
- Fodder value is a major aspect from the point of view of farmers.
- Conservation of Crop landraces suitable in the conditions of changing climatic conditions increased nutritional needs is very much needed.

Even so, there are significant challenges that have to be overcome with every new location and every replication attempt. The major ones we have come across during our experience are related to searching and identifying local crop diversity and the traditional knowledge of agricultural practices, growing habits, end use and preparation of products associated with them. Many varieties have been lost or are at the verge of extinction and usually there is lack of secondary data as they have never been documented. Many varieties just exist in the memories of elderly people, however such people- repositories of local knowledge and having information about specific traits are also not easy to identify and data triangulation is difficult to achieve.

Another major concern is the fact that farmers of the region would like to change the varieties they are growing every 2-3 growing season or so. That results in uncertain availability of seeds and disappearing landraces. Seed banks may provide a respite in that tendency as often farmers have not lost interest in these crops and would like to go back to them. Those factors raise several major concerns: first one is regarding seed storage without disturbing seed viability, especially for crops such as paddy, for which seed germination percentage drops dramatically after 2 years. To counter for that, BAIF is maintaining viability of seeds by growing them in dedicated conservation and seed propagation plots. However, in the backdrop of changing climate and shifting and uncertain monsoon-patterns, increased occurrences of both biotic and abiotic stresses, such as drought, and other adverse environmental factors, such forms of on farm conservation without implementing proper risk- management mechanisms are potentially vulnerable.

4.1. The way Ahead

The study Suggest the following plan for development and improvement of crop diversity in the tribal blocks.

- Strengthening farmer's knowledge about seed production and developing network of community seed banks for reaching wider target.
- Yield improvement of local crop landraces by changing cultivation practices, improving soil fertility, and pest and disease management by disseminating information about organic inputs for reducing cost of production. Production of healthy food is major focus in future.
- Providing means for sustainable livelihood and income generation and socioeconomic integration. The plans include marketing of surplus production through community seed bank network and Development of value added food items for fetching good market value.
- Focus on conservation and revival of pulses, local vegetables and wild food resources for improving food security and nutritional status.
- Further studies at chemical and molecular level are needed to validate people's knowledge about the nutritional value. DNA Finger printing and bar coding of crop Landraces would be of great use in future breeding initiatives.
- Proper seed storage systems at community level for securing seed viability by developing medium-term storage facilities.
- Safeguarding these resources, maintained, conserved and improved by local communities for generations, by using every available legal instrument, such as the PPV & FR Act and the Geographic Indications Act.

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GUILD STRUCTURE OF SPIDER (ARANEAE) IN VEGETABLE FIELD

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ABSTRACT

Spiders belong to order Araneae and are cosmopolitan in distribution. They play a major role as bio-control agents of insect pests with their diverse range of life styles and foraging behaviours. The ecological guild concept has been of great interest to arachnologists, who often use this concept to understand how a group of species that exploit the same class of environmental resources in a similar way. It is well known that guild structure varies with different crops and within a crop at different stages, as plant architecture varies in them. We assessed the spider of different guilds and their densities in different stages of Brinjal (Solanum melongena), a most commonly cultivated vegetable in this region. The study was carried out Moongilthottam, Nagapattinam district, Tamil Nadu, India between April 2007 and March 2010. A brinjal field of 0.3 acre was sampled using six random plots (1x1m) at fortnightly intervals. The density assessment of spider guilds was carried out in different stages of brinjal from seedling stage to the last harvest stage and reported as number /cent.

In total, eight different guild structures of spider viz., orb-web, social-web, space-web, funnel-web, and sheet-web weavers, ground runner, stalker and ambusher were recorded in different stages of the brinjal. Overall, non-web weavers were significantly higher number than the web-weavers ('t' test; $p<0.05$) in all the crop stages. Among the non-web weavers, stalkers were the predominant ones irrespective of crop stages, with the highest population (198.9 ± 21.41/cent) recorded in the vegetative stage. Among the web-weavers, the density of funnel-web weavers was highest in all the stages of the brinjal except ripened stage. On the other hand, orb-web weavers population was higher (37.8 ± 5.24) in the flowering stags and followed by ripened stage (31.1 ± 5.95). Except social-web weavers and stalkers, all other groups had significant variations (ANOVA; $p<0.05$) in relation to crop stages of the brinjal. Variations in structural complexity i.e., vegetation structure and microclimate associated with different crop stages are suggested as possible reasons for such differences in spider guild structure. The assemblages of different guilds of spiders with specific foraging tactics in different stages of the brinjal indicated that spiders are likely to have stabilizing effect on prey population in the brinjal fields.

Key words: brinjal, crop stages, guild, solanum melongena, spider density, web and non-web weavers.

1. INTRODUCTION

Spiders (Order: Araneae) one of the most familiar and fascinating creatures, are among the stars of the natural world. They have a very diverse range of life styles and foraging behaviours (Turnbull, 1973; Wise, 1993) create special attention to the naturalist because of their unique weaving capability to construct their web with geometrical precision and beauty. Based on the foraging strategies spiders are categorized into many guilds "a group of species that exploit the same class of environmental resources in a similar way" (Root, 1967,1973). Arachnologists have widely embraced the guild concept, as the different manners in which spiders forage for a common resource-prey i.e., arthropods, is obvious. As many as 11 guilds were recorded by Post and Riechert (1977). Uetz et al. (1999) classified the spiders in to nine guilds based on the ecological characters of the spider family. There have been numerous attempts to classify spiders into two guilds viz., web-building and hunting groups (Uetz, 1977). The web-building spiders are grouped into sheet-web builders, wandering sheet/tangle-weavers, orb-weavers, and space-web weavers, while hunting spiders are grouped into foliage runners, ground runners, stalkers and ambushers (Uetz et al., 1999).

The spiders are cosmopolitan in distribution. They are reported to be distributed extensively in the crop fields including vegetable fields (Tikader, 1987).

The vegetable crops are damaged by a large number of insect pests and the presence of natural enemies is most important for controlling their pests. The brinjal (Solanum melongena, L.) plant is one of the most common vegetables grown throughout India with spiders well represented. Indeed, few studies have been reported on spiders to be abundant in vegetable and in brinjal (Satpathi, 2004; Vuong et al., 2001). The spiders viz., Oxyopes javanus,O. lineatipes, Argiope pulchella, Neoscona mukerjei, Leucauge celebasiana and Nephila maculate were found to be one of the most effective bio-control agents against the insect pests of vegetable crops in the Eastern Himalayas (Satpathi, 2004). The lycosid spiders population was recorded to be more among the natural enemies in five vegetables viz., Tomato, Watermelon, Hot pepper, Chinese Cabbage and Potato in Chinju, Korea (Vuong et al., 2001). The report of Regional Research Station, Kalimpong under Bidhar Chandra Krishi Viswavidhalaya, West Bengal, India (during 1994 to 1997) recorded the presence of spiders in vegetable crops (Satpathi, 2004). Among them in brinjal Lycosa pseudoannulata, Pardosa sumatrana, O. lineatipes, Tetragnatha maxillosa and Leucauge celebasiana were commonly recorded.

Spiders can limit insect densities as well as stabilize their population by virtue of their micro- habitat use, prey selection, polyphagy and obligate predatory feeding strategies (Young and Edwards, 1990; Marc and Canard, 1997; Marc et al., 1999; Nyffeler and Sunderland, 2003). Hunting spiders have a greater diet breadth than web-weavers (Nyffeler, 1999) and might be better at controlling in insects pests than web-weavers because most species of hunting spiders are capable of capturing a wide variety of prey (insect) types and size (Young and Edwards, 1990). Enders (1974) also pointed out that, hunters which follow a "Pursue and Kill" foraging strategy are usually active predators. However, web-builders which follow a passive "Sit and Wait" strategy can also control more insect populations because they often capture and kill more prey than they consume. Thus, in the diverse group of spiders in an agriculture ecosystem, there will probably be one or more species that will attack a given pest and stabilize its population and as such the spiders might be effective biological control agents because of their different hunting strategies (Marc et al., 1999).

Even though the diverse feeding groups of the spiders might play a vital role as a governing factor for the insect pest control, the density of their population is more important because, the efficiency of pest control is related to the number of spiders in the field. Additional significance is that spider density variation might not only be temporary but could also between different crops. In general the density of spiders is expected to be a function of plant size and complexity (Pekar, 2005). Indeed spider species and their numbers had been reported to show variations not only with regards to crop seasons but also in response to crop stages (Sahu et al., 1996; Satpathi, 2004). Sudhikumar, et al. (2005) reported a significant difference in the population of spiders between the two cropping seasons of paddy. On the other hand, Satpathi (2004) found the richness and density of spiders to be increased with the development of paddy. Agnew et al. (1985) reported that Tetragnatha laboriosa and Oxyopes salticus to occur regularly in all stages in the groundnut fields of Eastern Himalayas. This paper examines the variations in the guild structures of spider populations and their densities in different crop stages of brinjal in Moongilthottam Village, a part of the Cauvery Deltaic Region, of south India.

2. MATERIALS AND METHODS

The spider populations were studied in a sample area of 33 cent (0.3 arce) in the brinjal (Solanum melongena, L.) fields of Moongilthottam Village, Mayiladuthurai Taluk of Nagapattinam District (Cauvery Deltaic Region), Tamil Nadu, south India during 2007-2010. Intensive surveys in six random plots of 1x1m dimension were carried out in the selected field. The locations of the quadrats were different in each day of observation throughout the study period in order to avoid a deterrent attraction for the other animals. The observations were made fortnightly during morning hours (between 6am to 8am), when the spiders were more active. The area around each plant was searched for possible webs and the plants were thoroughly examined from the bottom to the top for spiders. The spiders were identified to the species level with the help of standard keys (Tikader 1987; Barrion and Litsinger, 1995; Sebastian and Peter, 2009) and the spider guilds were classified based on Uetz et al. (1999) and Sebastian and Peter (2009). Populations of different species of spiders and their guilds were estimated in different stages of the brinjal by direct count method (Sebastian et al., 2005) and their densities were reported as number /cent. The densities were reported as Mean $\pm$ 1 S.E. The differences in the densities between web-weavers and non-web weavers were analyzed by student's't' test and among the different stages of paddy by 'ANOVA', at 5% level of significance.

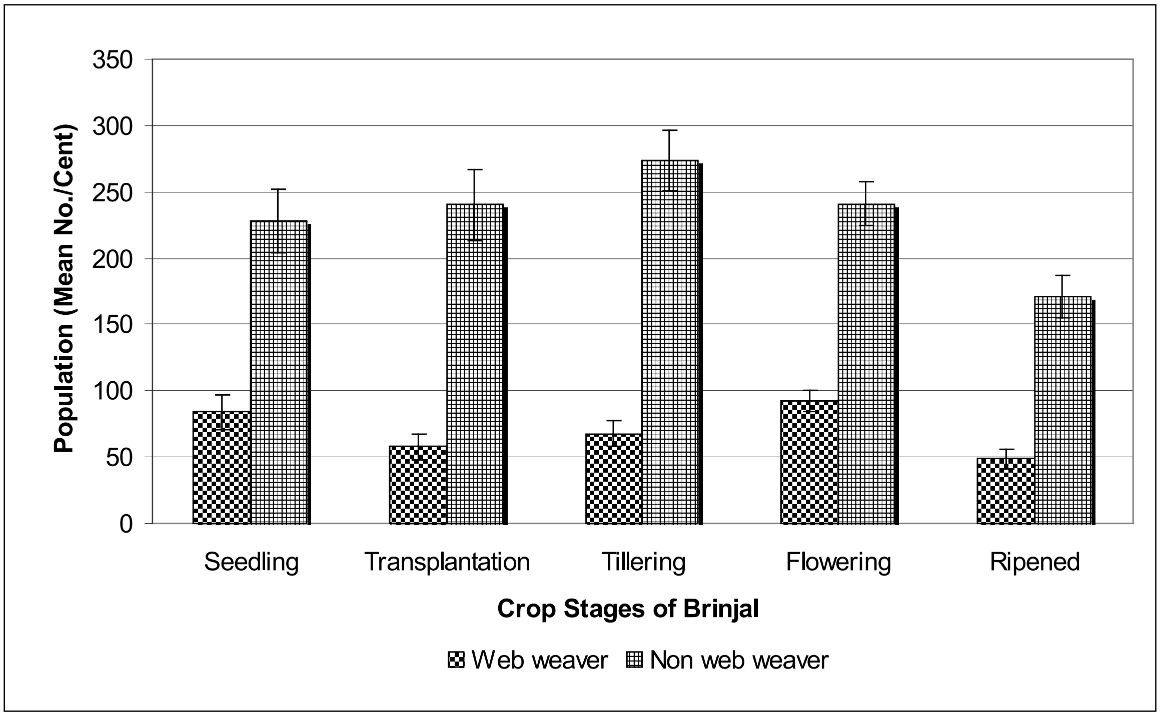
3. RESULTS

Spiders of eight guilds viz., Orb-web weavers (Araneus anasuja, Gasteracantha geminata, Neoscona sp, Leucauge decorata, Tetragnatha javana,), Social-web weavers (Stegodyphus sarasinorum), Space-web weavers (Achaearanea sp.), Funnel-web weavers (Hippasa agelenoides, Hippasa greenalliare), Sheet-web weavers (Atypena formosana), Ground runners (Pardosa pseudoannulata, Pardosa sumatrana), Stalkers (Oxyopes javanus, Oxyopes lineatipes, Oxyopes shweta, Oxyopes sunandae, Peucetia viridana, Myrmarachne orientales, Plexippus paykulli, Plexippus petersi) and Ambusher (Thomisus pugilis) were observed in the present study plot at the Moongilthottam area of Cauvery Deltaic Region, south India and their populations varied in different stages of the brinjal (Table 1). Except social-web weavers and stalker all the other spider guilds varied significantly (ANOVA; p<0.05) with different stages of the brinjal. Among the web-weavers, funnel-web weavers and sheet-web weavers were recorded throughout the study period and the funnel-web weavers was predominant one in the seedling stage with a mean density of 64.0 ± 10.61/cent. The orb-web weavers were found from the vegetative stage to the ripened stage with the maximum of (37.8 ± 5.24/cent) in the flowering stage, while the social-web weavers were found only in the seedling and flowering stages and the space-web weavers were not recorded during the vegetative stage. In the non-web weaver, stalkers were the predominant ones irrespective of crop stages, with the highest population (198.9 ± 21.41/cent) were recorded in the vegetative stage. The ambusher was recorded only three stages with fewer densities (Table 1). The total population of non-web weavers were significantly higher than web-weavers in all the crop stages of brinjal fields and their peak was observed in the tillering stage of the present study (Fig.1; 't' test; p<0.05). This study also recorded that both the web weavers and non-web weavers declined in the ripened stages (Fig.1).

Table 1: Densities (No. / cent) of spiders of different guilds in the brinjal fields in and around Mannampandal, Cauvery Deltaic Region, South India (values are mean$\pm$1SE; significant 'F' values (p<0.05) are indicated by bold letters).

Crop Stages	Guilds of spiders							
	Web Weavers					Non-web weavers		
	Orb-Web	Social-Web	Space-Web	Funnel-Web	Sheet-Web	Ground Runner	Stalker	Ambusher
Seedling (n=30)	0	1.3 ± 1.33	2.7 ± 1.85	64.0 ± 10.61	16.0 ± 4.54	62.7 ± 13.24	165.3 ± 14.57	0
Transplantation (n=18)	0	0	11.1 ± 4.35	26.7 ± 6.47	20.0 ± 7.41	51.1 ± 11.11	182.2 ± 19.46	6.7 ± 3.62
Vegetative (n=36)	23.3 ± 6.83	0	0	37.8 ± 4.20	6.7 ± 2.98	68.9 ± 10.03	198.9 ± 21.41	5.6 ± 2.83

Flowering (n=72)	37.8 ± 5.24	1.1 ± 0.78	5.0 ± 1.57	40.0 ± 3.71	8.3 ± 1.93	82.2 ± 7.75	152.8 ± 12.79	6.1 ± 1.88
Ripened (n=54)	31.1 ± 5.95	0	4.4 ± 2.02	11.1 ± 2.68	2.2 ± 1.26	37.0 ± 4.71	134.1 ± 13.79	0
F	7.480	0.810	2.50	13.579	4.662	4.979	2.365	2.944
p	0.001	0.520	0.044	0.001	0.001	0.001	0.054	0.021



Student's 't' test	Seedling	Transplantation	Tillering	Flowering	Ripened
t value	5.35	6.29	8.42	8.01	7.02
p value	0.0001	0.012	0.0001	0.0001	0.001

Fig. 1: Population of web-weaving and non web-weaving spiders in different stages of brinjal in and around Mannampandal, Cauvery Deltaic Region, South India (Significant 't' values ($p<0.05$) are given separately below the figure).

4. DISCUSSION

Differences in the vegetative architecture during brinjal crop growth stages influenced the spider community in the present study, as the total population of non-web weavers was significantly higher than the web-weavers in all the crop stages in the brinjal fields. The same pattern was recorded earlier in the paddy fields of Korea (Lee et al., 1993a,1993b). The most common explanation for such variations in the spider guild structure is that the host crop induces changes in the micro environment during different stages and the level of structural complexity of crop may determine guild composition of spider fauna (Young and Edwards, 1990). In the present study, the orb-weavers populations found only from the vegetative stage and they were higher in flowering stages. Hurd and Fagan (1992) also reported that the physical structure of the environments has an important influence on the habitat preference of the spider species especially the web-building species. Cherret (1964) reported that the orb-web weavers required space and height for the construction of the web. The space-web and sheet-web weavers required moist habitat and this might perhaps be the reason that they were more in the transplantation stage of the present study. The funnel-web weavers required loose soil for their web construction and before seedlings the land was ploughed, thus they might be more in the seedling stages. The result also indicated that both the web weavers and non-web weavers declined in the ripened stages. The ripened stages of the crop had more disturbances with regard to harvest. This may be one of the reasons for the decline in the population during the ripened stages. Downie et al. (1999) and New (1999) had also demonstrated that the spiders were extremely sensitive to small changes in the habitat structure, including habitat complexity and microclimate characteristics. Thus it might be concluded that the vegetation structure might perhaps be the most important determinant in spider guild structure in the present study as reported earlier for spiders in other areas by (Greenstone, 1984) and (Scheidler, 1990).

In the present study also, eight guilds of spiders were recorded in different stages of brinjal. Assemblage of spiders has usually been described within the ecological framework of guilds (Uetz et al., 1999). The way that foraging guilds are arranged in the community might also have much to do with stabilizing effect that spiders have on prey (insect) populations. Earlier experimental evidences also suggested that habitat structure maintains a diverse spider assemblage (Uetz, 1991; Wise 1993) and may be critical to successful insect pest suppression. Assemblage of spider species might also be more effective in reducing prey densities than a single species of spider (Greenstone, 1999; Sunderland, 1999; Marc et al., 1999).

5. CONCLUSSION

From the aforementioned results it could be inferred that the vegetation structure might perhaps be the most important determinant in spider guild structure in the present study. Assemblage of spider species might also be more effective in reducing prey densities than a single species of spider. The way that foraging guilds are arranged in the community might also have much to do with stabilizing effect that spiders have on prey (insect) populations. Thus a better understanding of spider guilds, their structure and factors influencing spider community including assessment of pest (insects) population level might therefore be helpful in future studies of the arthropod pest control in vegetable crops.

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QUALITY STATUS OF COMMERCIALLY IMPORTANT FISHES AND SOCIO ECONOMIC STATUS OF FISHER COMMUNITY OF THIRESPURAM FISHING VILLAGE, TUTICORIN, SOUTHEASTERN INDIA

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ABSTRACT

Fishes are rich sources of protein, vitamins and minerals and are also known as valuable protective food. Present study was designed to investigate the quality of 20 commercially important fishes available in Thirespuram fishing village of Tuticorin district. The biochemical quality parameters such as pH, FFA, TMA - N, TVB -N, TBA and PV were analyzed. The microbial parameters such as TPC, TFC, E.coli, Salmonella, Vibrio and sensorial parameters like appearance, eye, gills, color and odour were assessed using standard methods. The quality of coastal water was also assessed. The results showed that the selected fish are contaminated with microbial population. The spoilage indicator levels exceeded the acceptable limit and the sensorial scores also exceeded due to polluted coastal water which was used for post harvest processing of the harvested fishes. Fish handling obviously contributed to the increased microbial load after harvesting. The Thirespuram coastal water was contaminated with faecal coliform and pathogens. The study on the educational and income status of the fishermen showed that 93.3% of persons involved fishing areilliterate and 68.2% of fisherman earn below Rs.5000 per month. Awareness building among fisher community on the hygienicpractices of post harvest handling and regular hygiene inspections would help to address the problem, so that harvested fishes could be wisely utilized and fisher folk would get good price for their effort.

Key words: Fish, biochemical quality, microbial quality, sensorial score, thirespuram, education and income status

1. INTRODUCTION

Sea food's role in nutrition is recognized since it provides a good balance of protein, vitamins and minerals. Fish is more perishable than other protein foods (Burgess and Shewan, 1970) and its freshness is the most important and fundamental single criteria for judging the quality (Rodriquez-Jerez et al., 2004). In unhygienic storage conditions, microorganism spoils the fish flesh. This may harmful for human health by causing infection and intoxication (Goktan, 1990). Fish meat spoil more quickly than other muscle foods, particularly when poorly handled and such spoilage is primarily bacterial in nature; about 30% of landed fish are lost through microbial activity alone (Ghaly et al., 2010). Contamination of fish with microorganism reflected environment pollution (Adeyemo, 2003). So, the microbial flora associated with fish is a reflection of their aqueous environment. If the fish habitats are contaminated by pathogenic bacteria, the consumption of these fish may be a risk to the human health.

The microbial activity in seafood produces pronounced off- odour leading to short shelf life and economic losses (Reddy et al., 1994). The deteriorative changes occurring in fish results in the gradual accumulation of volatile and carbonyl compounds in the flesh due to the effect of varieties of biochemical and microbial mechanisms. Quantification of these compounds can provide a measure of the progress of deterioration (Connell, 1995). Proper handling of fish between capture and delivery to the consumer is a crucial element in assuring final product quality. With a few exceptions, fish are considered free of pathogenic bacteria of public health significance when first caught. The presence of bacteria harmful to man generally indicates poor sanitation in handling and processing and the contamination is almost always of human or animal origin. Salmonella have been found in fish washed with polluted water and from fish-holds washed with polluted water. Salmonella has been isolated from coastal waters worldwide including Indian coastal environments (Vaidya et al., 2001).

Marine fishery occupies a predominant place in the socio-economic development of fisheries of the country and overall development of fishery sector. Fish consumption demand has been increasing rapidly worldwide. Consumer's greatest concern is the quality and safety of food they eat. It is important to popularize good hygienic practices to achieve the quality and safety of food. The quality of the product reaching the end user will greatly depend on how the fish is handled in the landing centers, preserved, packaged and transported etc. Present study was undertaken to study the quality of commercially important fishes and the socio economic status of the fisherman engaged in fishing at Thirespuram fishing village. Furthermore awareness creation to fisherman for hygienic handling of the post harvested fishes and improves their economic level from good quality fish and reduces the poverty through the making value added products from low cost trash fishes.

2. MATERIAL AND METHODS

Commercially important 20 fish samples were collected from Thirespuram landing center of Tuticorin district. Collected samples were placed in well labeled sterile plastic bags (ziplock bags) and immediately transported to the laboratory an ice box under hygienic condition for the analysis. The shore water used for washing the sea foods before taken to the auction hall were collected in 500 ml sterile bottles fitted with tight screw caps. Care was taken to avoid accidental contamination of the water during collection and transportation to the laboratory for analysis. Socio-economic characteristics viz., educational and income status of the fisherman were collected through personal interview as suggested by Singh et al., 2012).

2.1. Analytical methods

pH analysis was done by the method of Goulas and Kontaminas, (2005) using HANNA pH213 microprocessor pH meter. The changes in total volatile base nitrogen (TVB-N) and trimethylamine nitrogen (TMA-N) contents were determined by Conway micro diffusion technique (Cobb et al., 1973) and the values were expressed as mg/100 g of fish muscle.

PVwas determined according to Egan et al. (1981) and it was expressed as meq of peroxide oxygen/kg of fat. The Thiobarbituric acid (TBA) (mg malondialdehyde/ kg fish flesh) was determined according to Keet al. (1976). Each parameter wasanalyzed in triplicate. The microbiological characteristics such as Total Plate Count (cfu/g) and Total fungal count were done by the APHA (1992) method using Plate Count Agar and potato dextrose agar respectively. Total coliform, faucal coliform and E. coli were enumerated by three tubes Most Probable Number (MPN) technique (Speck, 1976). Salmonella and Vibrio (25g) were enumerated by following the method of USFDA (1995). Water samples were serially diluted and the pathogens were enumerated using spread plate method and the values were expressed as cfu/ml (AOAC, 1990). The sensory evaluation was performed by 15 trained panelists. The assessment was conducted for the appearance, eye, gills, color and odour of raw samples using a 9- point hedonic scale (Mailgaad et al., 1999).

3. RESULTS

pH values for the commercially important fish were shown in Fig.1. Among the 20 fishes highest and lowest pH values were noted in Cephalopholisformosa(7.98 ± 0.85) andCaranx sp. (7.40 ± 2.05) respectively. The spoilage indicators like FFA, TMA - N and TVB - N values were represented in Fig 2, 3 and 4). TMA - N values ranges between 17.39 ± 0.88 (E. undulosus) - 25.35 ± 0.88 mg N/100g (E. afinnis) and TVB -N values ranges between 31.75 ± 0. 39 - 44.52 ± 0.94 mg N/100g in E. merraand Istiophorus sp. respectively. TBA and PV (Fig. 5 and 6) values were found in the ranges between 9.11± 0.44 (C. formosa) - 14.93± 0.72malondialdehyde mg/100g (Sphyraena sp.) and 21.03± 0.53 (E. malabaricus) - 26.73± 0.68 meqo2/kg fat (Istiophorus sp.) respectively. The total plate count results were presented in Table 1 and the counts were above the acceptable level in all the samples. Spoilage indicator organisms of total coliform, faecal coliform and E.coli were found plentiful in all the samples (Fig. 7 - 9). All the samples were sensorially evaluated and the mean sensory scores of 15 panelists were shown in Fig.10. All the samples are nearly rejected by panelist because of their terrible odour. The microbial quality of coastal water used for post harvest processing (Table 2). TPC was found Too Numerous to Count (TNTC) and TFC was 8.3 x 10^5 (cfu/g) followed by well found TC, FC, E.coli, Salmonella and Vibrio as 1100 (MPN/100ml), 450 (MPN/100ml), 1.2 x 10^3 and 1.9 x 10^3 respectively.

The education and income status of the fishermen involved in fishing in Thirespuram coastal area were analyzed and the results are shown in Fig. 11 and 12 respectively. It was found that in 62.8% of persons involved in fishing earn below Rs 5000, 35.4% fisherman earn Rs 5000 -10000 and 1.8% of person earn between Rs 10,000 -15,000. Educational status results reveals that 93.3% fisherman are illiterate, 4.2% of fisherman were studied up to primary level where as 2.5% of fisherman were studied up to middle school.

Following deficiencies were observed in Thirespuram auction hall.

1. Improper organization of fish stalls
2. Lack of proper drainage system and no water supply
3. Poor personal hygiene of fish handlers and no proper storage facilities for fish
4. Poor proper display tables/platforms
5. Improper protection from sun, dust and animals

Table1: Microbial quality of commercially important fishes available in Thirespuram landing centre

Commercially important fishes	Microbial parameters		
	TPC x 10^8 (cfu/g)	Salmonella (25g)	Vibrio (25g)
Epinephelusmerra	8.2	+	+
Epinephelusmalabaricus	7.9	+	+
Epinephelusundulosus	6.5	+	+
Epinephelusaerolatus	9.1	+	+
Cephalopholisboenack	8.8	+	+
Cephalopholisformosa	10.1	+	+
Cephalopholissonnerati	9.0	+	+
Alectisindicus	13.43	+	+
Carangoidesarmatus	10.3	+	+
Caranx sp.	9.2	+	+
Chirocentron sp.	8.0	+	+
Scomberomorous sp.	7.9	+	+
Sphyraena sp.	9.2	+	+
Synaptura sp.,	9.2	+	+
Auxisthazard	12.3	+	+
Euthynnusafinnis	11.9	+	+
Lethrinus sp.	8.4	+	+
Atule mate	7.5	+	+
Istiophorus sp.	12.8	+	+
Strongylura sp.	10.3	+	+

Table 2: Quality of water used for post harvest handling

Quality parameters	Coastal water
TPC x 10^8 (cfu/g)	TNTC
TFC x 10^5 (cfu/g)	8.3
Total coliform (MPN/100ml)	1100
Faecal coliform (MPN/100ml)	1100
E.coli	450
Salmonellasp	1.2 x 10^3
Vipriosp	1.9 x 10^3

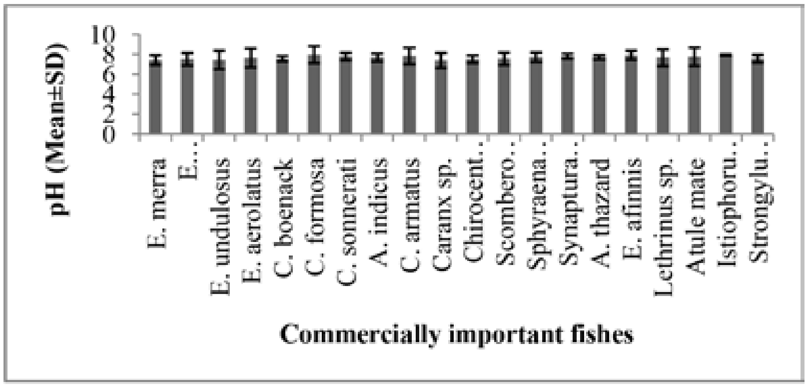

Fig. 1: pH status of commercially important fin fishes

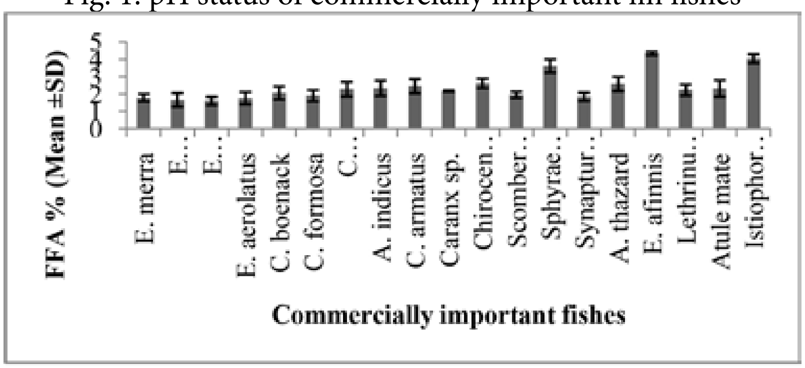

Fig. 2: FFA content of commercially important fin fishes

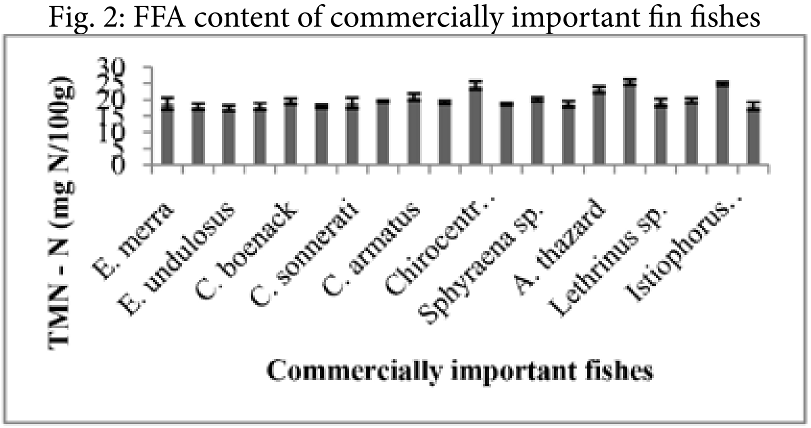

Fig. 3: Level of TMA – N content present in commercially important fin fishes

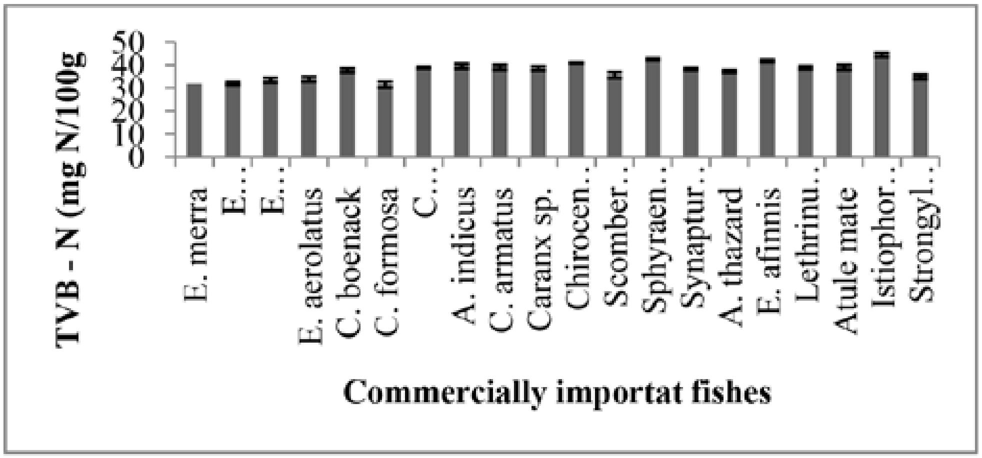

Fig. 4: Level of TVB – N content present in commercially important fin fishes

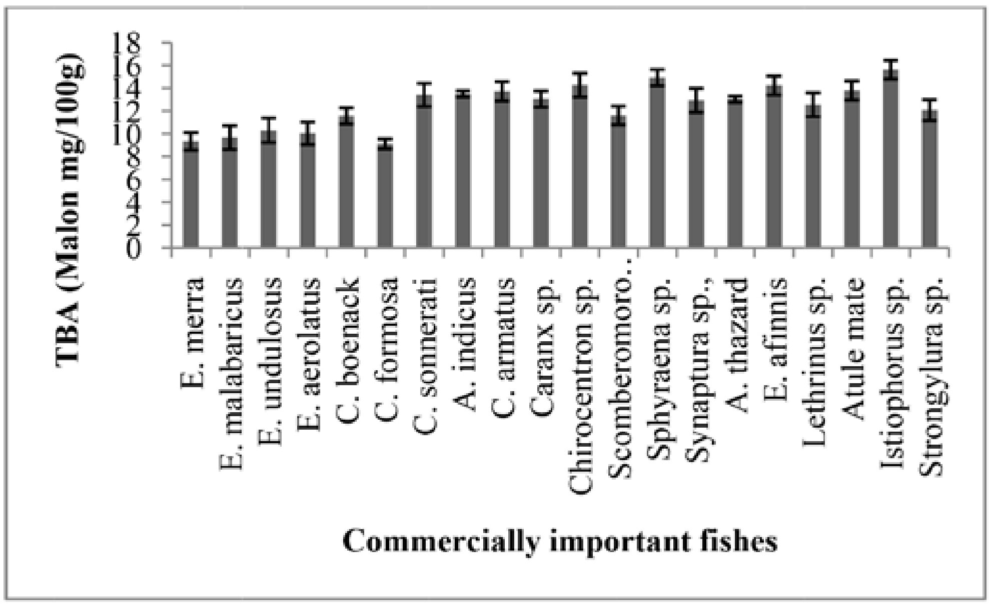

Fig. 5: TBA content present in commercially important fin fishes

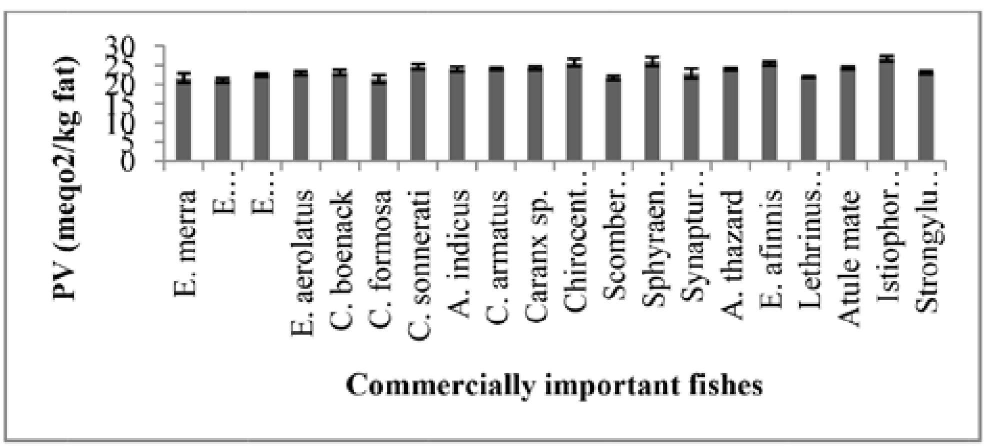

Fig. 6: PV content present in commercially important fin fishes

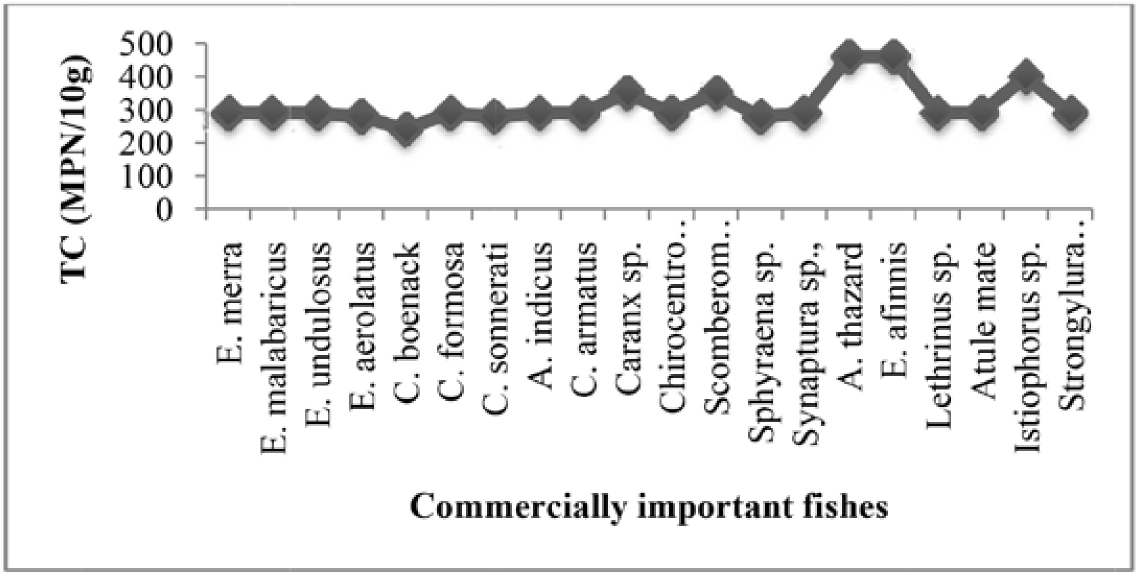

Fig. 7: Presence of Total coli forms in commercially important fin fishes

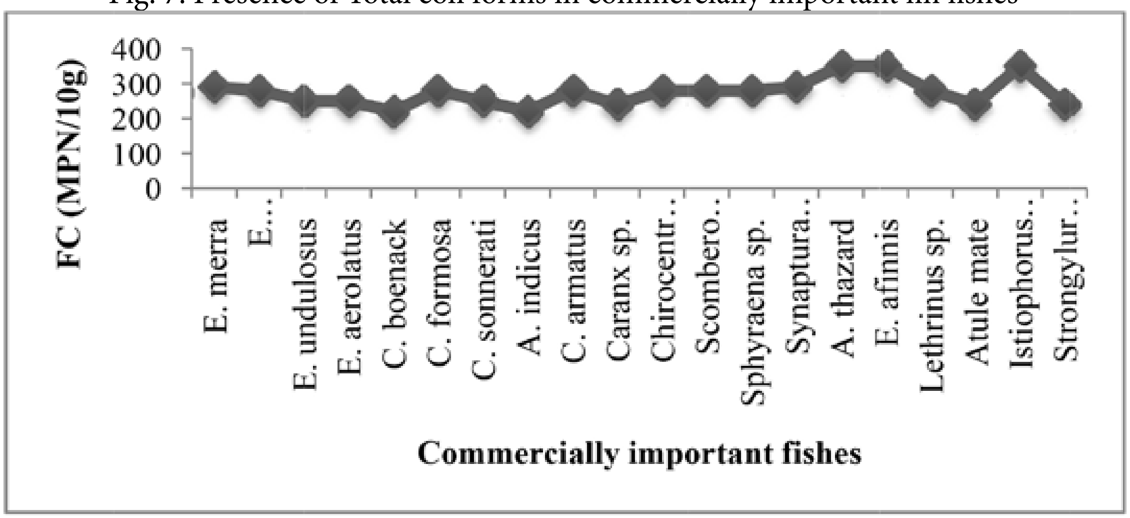

Fig. 8: Presence of Faecal coliforms in commercially important fin fishes

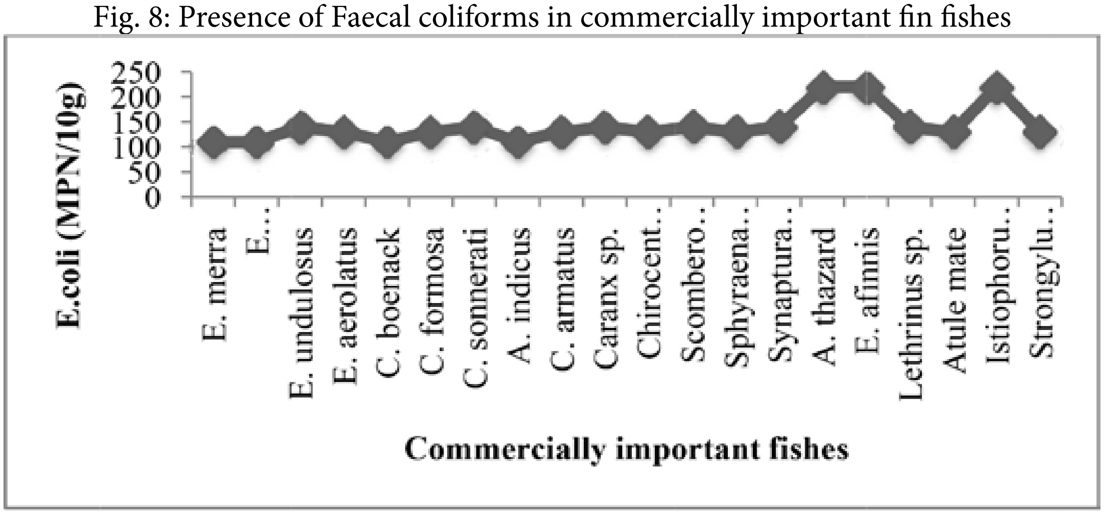

Fig. 9: Presence of E.coli in commercially important fin fishes

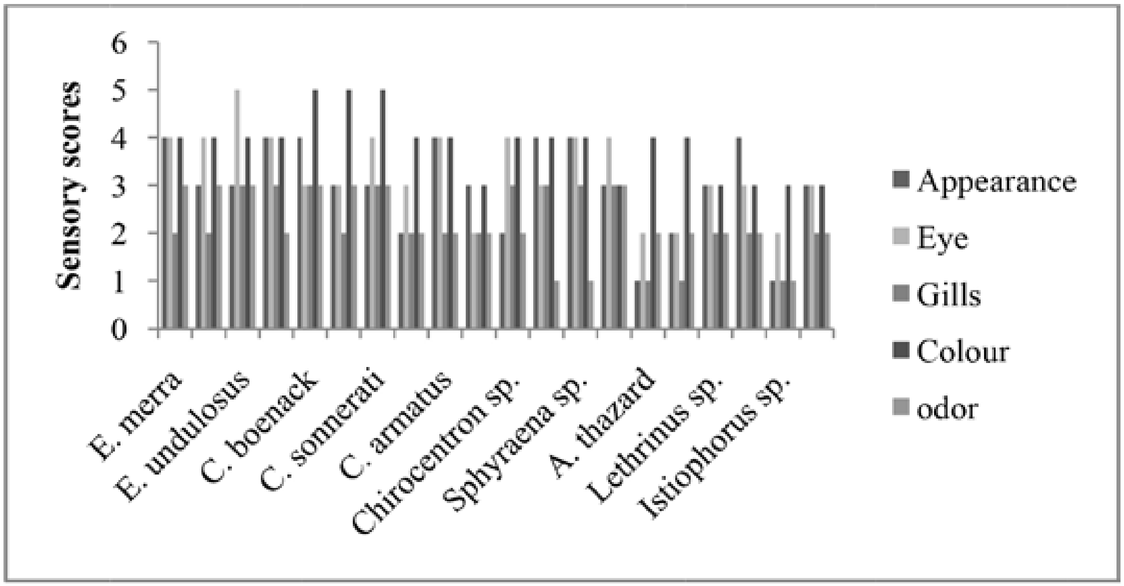

Fig. 10: Sensory scores of commercially important fin fishes

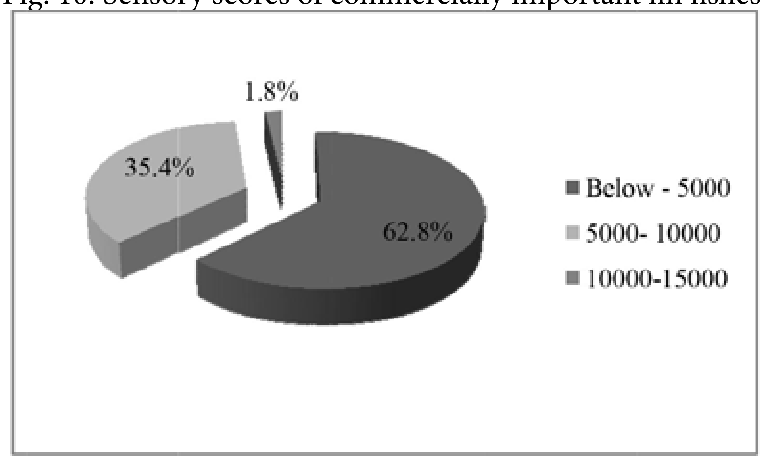

Fig. 11: Income status of fisherman community

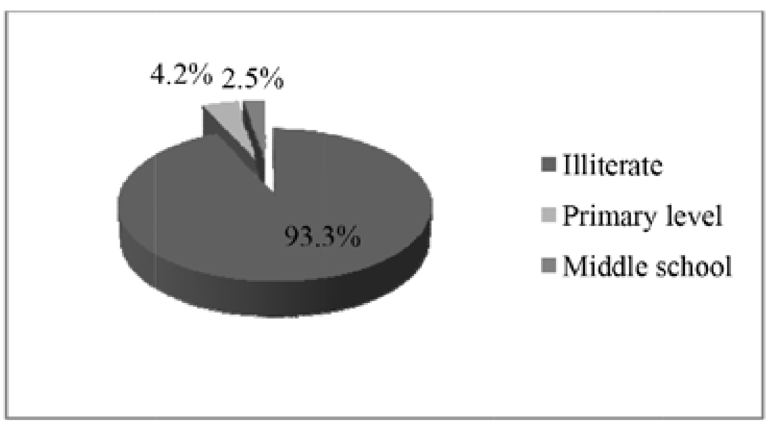

Fig. 12: Educational status of fisherman community

4. DISCUSSION

Fish and marine products freshly caught are generally free from contamination with microorganisms. However contaminations and subsequent decomposition of these products may occur when handled and treated un-hygienically. The processing and preservation of fresh fish were of utmost importance since fish is highly susceptible to deterioration immediately after harvest and to prevent economic losses (Okonta and Ekelemu, 2005). Lack of adequate fish handling, processing techniques and storage facilities contribute significantly to the low supply of fish to poor rural dwellers that form three quarters of the population in developing countries (Ayuba and Omeji, 2006). Fish harvesting, handling, processing, storage and distribution provide livelihood for millions of people as well as providing valuable foreign exchange earnings to many countries (Al-Jufaili and Opara, 2006). It had been noted that more than 20% of the processed fish were lost before reaching market. Fish processors identified the problems due to the following factors: delays in landing and processing of fish caught, inadequate processing and poor handling prior to marketing.

pH is a very important index to determining the quality of fresh fish (Pacheco-Aguilar et al., 2000). Present results shows that pH values were exceeded the acceptable limit in all the fish. According to Bremner (2002), the pH level of live fish is 7.0 and the post mortem pH varies from 6.0 to 7.1 was found to be sensorially acceptable (Erkan and Ozden, 2008). The increasing pH values could be associated with the production of basic components induced by the growth of bacteria (Simeonidou et al., 1997). Formation of FFA is a well-established post mortem feature of products resulting from enzymatic hydrolysis of esterified lipids (Ashton, 2002). FFA formation has been found to be inhibited by heating and it may be due to the hydrolysis of lipids by phospholipids (Olafsdottir,1997). Rancidity developments (primary lipid oxidation) are a major problem in the storage of fishes. In the present study FFA values exceeded the acceptable limit of 0.5 - 1.5% (Schormuller, 1969).

Trimethylamine (TMA-N) and Total volatile basic nitrogen (TVB-N) content are the most chemical parameters used for the determination of fish quality. The levels of these volatile compounds increased with the onset of spoilage. This chemical compound is the primary cause for the fishy odours, which increased as spoilage proceeds and show good correlation with sensory analysis (Ozogul and Ozogul, 2000). TMA is the best known compound produced during fish spoilage and it is mainly derived from bacterial breakdown of trimethylamine oxide (TMAO) which is an osmolyte naturally found in marine fish (Pedraso-Menabrito and Regenstein, 1990). Normally, fresh fishes are having 0.2 - 2.0 mg/ 100g TMA-N (Govindan, 1985). TMA does not increase much during the early stages of spoilage. Trimethylamine oxidase produce by spoilage organisms reduces trimethylamine oxide of fish flesh to trimethylamine that is believed to react with fish fats to produce the typical spoilage odour that are associated with fish beyond their prime (Sikorski, et al., 1990; Triqui and Bouchriti, 2003). Total volatile bases are mostly formed by bacterial or tissue autolysis leading to deteriorative odours. In the present study all the values as exceeded the acceptable limit proposed for marine species (Connell, 1975). It may be due to high microbial contamination of handling process in the auction hall. The low value of TVB-N initially is an indication of quality of fresh fish, whereas increases may be due to the action of autolytic enzymes and spoilage bacteria (Benjakul et al., 2003). Increase of TVB-N value during the storage time was reported by Jeyasekaran and Saralaya (1991) and Karungi et al. (2004). TVB-N level in fish has also been used to indicate the growth of microorganisms leading to spoilage (Lakshmanan, 2002). In our result TMA-N increased with the increase of spoilage bacterial count. These results agreed with the results of (Saritha et al., 2012).

TBA is responsible for the formation of secondary lipid oxidation, rancid flavour, off odour, colour as well as texture deterioration and nutritional value (Pearson, 1976). Peroxide value (PV) was used to determine the quality of fat/lipid, and it is widely used as an indicator for the assessment of degree of primary lipid oxidation (Masoud et al., 2008). Both the values were above the acceptable limit of 8 mg malonaldehyde kg^{-1} (Schormuller, 1969) for TBA and 10 - 20 meq per kg of fat (connell, 1995) for PV. Hawrysh (1990) reported that lipid oxidation is a process by which molecular oxygen reacts with unsaturated lipid form lipid peroxide and is catalysed by some factors, such as temperature, water activity, pH and chemical environment (Ashie et al., 1996). Our result indicates that the fishes are considered to be unacceptable for consumers.

For the assessment of spoilage, total plate count is the most common method (Rahman, 1980). By detecting the bacterial and fungal load in the fish it apparently gives an idea about the quality of the samples. In the present study entire samples bacterial counts were above the acceptable level. The level rise to exceed 10^7 count/g maximum microbiological limits for fresh fish recommended by the international commission of microbiological standard for foods (ICMSF, 1986). When TPC reaches to 10^5/g or more in food product, it is considered that these food items are spoiled (Begum et al., 2010). The high microbial load at rejection may have been due to the fish caught environment and polluted water used for post harvest processing. High bacterial load in fresh fish with no visible signs of spoilage is an indication of poor handling process of the fish handlers and washing the catches in polluted coastal water with the disposal of sewage that add to the microbial load of fishes (Sugumar, 2002).

Coliform bacteria are indicator organisms whose presence in food and water in large quantity indicates the probability of presence of pathogenic bacteria. Coliforms are abundant in the feces of warm-blooded animals, but can also be found in the aquatic environment, in soil and on vegetation (APHA, 2005). According to the IAMS, (1962) acceptable limit of total coliform was 100/g and 11/g for faecal coliform. That means the Thirespuram coastal area supply low quality of fish and unsuitable for human consumption. The presence of coliform group (E.coli) in higher range suggests contamination of the samples before or during handling and processing. These results coincided with the results of Begum et al. (2010). FC comprised about 18% of the total coliform while presence of coliform in the order of TC FC E.coli. Pathogenic bacteria like Salmonella and Vibrio were observed in all the fish samples. The detection of Salmonella and Vibrioin fresh fish samples will cause health risks to the fish consumers. The presence of Salmonella and Vibrioin these fishes indicates the contaminant environment habitats of fish and poor personal hygiene of sellers and fishermen, similar results were found by Goja (2013) found Salmonella and Vibrioin three fresh fish samples.

Sensory score results found the samples were rejected by panelist because their terrible odour. These results highly correlated with the present study biochemical and microbial results. Ola et al. (2004) reported rejection of raw fish by the taste panelists was mainly characterized by strong fishy to sour odour and soft texture.

Water quality is therefore, an important factor that determines the environmental conditions of fish. It is an indicator of excellent and poor living conditions of any fish. Present study result indicates the coastal water is heavily contaminated with heterotrophic bacteria. Thirespuram coastal water is highly polluted with coliform bacteria (Table 2). Sugumar (2002) reported that Thirespuram coastal water and sediment are heavily contaminated with faecal coliform and E.colidue to the mixing of domestic sewage. Presence of faecal coliform indicated faecal and environmental pollution and this is supported by the findings of Yagoub and Ahmed (2004). High numbers of faecal coliforms have been reported in Cherai beach, Cochin backwaters, Bhavnagar coast, Port Blair bay, Andamans and Nagore, east coast of India (Goyalet al., 1977) which was due to land runoff and continuous disposel of untreated sewage. Present study higher density of coliform bacteria in water especially the faecal coliform is responsible for higher density of these bacteria in fish body. Quick spoilage of fish after catching might be due to this higher density of these bacteria. E.coliis human originated bacteria which may be responsible for different enteric disease in human body. The higher density in fish body may be due to secondary contamination during handling and storage large quantities of coliform bacteria in water and fish are not pathogenic to human, but may indicate a higher risk of pathogens being present (Doyle and Ericson, 2006). Coliforms are not the normal flora of bacteria in fish. Due to deposition of human excreta in pond, water is contaminated and when this contaminated water is ingested by the fish, they become contaminated. Dysentery, typhoid fever, bacterial gastroenteritis and much other water borne disease may coincide with faecal coliform contamination. Presence of faecal coliform may affect humans more than it does aquatic organisms (Doyle and Ericson, 2006). Coliform presence in the fresh fish samples obtained at harvest was an indication that they were present in the environment and there is a probability that may be pathogenic bacteria in the fish or its environment.Both this finding supported with the results of Kombat (2013) at E. encrasicolusand S. auritafrom Tema and Accra.

During 1983, the economic condition or the fishermen in some selected villages of Maharashtra and Gujarat revealed that the illiteracy rate ranged from 48 - 75% and among the literates majority had primary education only. It was reported that the fishermen received an annual income between Rs 3000 and Rs 10000 in Puthiappa – Puthiangadi area of Calcutta during 1980 (Narayanakumar et al., 2000). In this area the size of the fishermen family was large (9.0) as compared to non fisherman family. Average family size in 1992 in Ernakulam district of Kerala was estimated to be 7.7, 5.5 and 5.6 for marginal small and large fish farmers respectively. The literacy level of the marginal farmers was less than high school qualification while 6 % of the small farmers were graduates and post graduates. Singh et al.2012) reportedthat the fishermen had not adopted the practices such as washing of fish on board (100.0%), sorting of fish (84.17%), evisceration and removal of gills and bleeding of big fishes (100.0%), personal hygiene (39.17%), auction hall cleaning (93.33%) and hygienic handling of fish in auction hall (86.67%). Lack of cold storage and insufficient loans/subsidies were the other problems reported by 75.83% and 74.16% of the fishermen, respectively in three fishing villages of Tuticorin. The awareness of hygienic fish handling practices by fishermen was very much influenced by educational and annual income status.

4.1.Suggestions for improvement

The following measures have been suggested for improving the quality status of landing sites.

1. Auction halls have sufficient size for work to be carried out under adequate hygienic conditions.
2. Waterproof flooring which is easy to clean and disinfect and laid down in such a way as to facilitate the drainage of the water or provided with equipment to remove water; Walls which have smooth surfaces and are easy to clean like tiled, durable and impermeable; Ceilings or roof linings which are easy to clean; Adequate natural or artificial lighting.
3. Cold rooms are necessary, a sufficiently powerful refrigeration plant to keep products at prescribed temperatures; an appropriate facility for protection against pets such as insects, rodents, birds etc.
4. Hygienic waste water disposal system and portable water facilities need for fish landing centers.
5. Road access should be provided to all landing centers.
6. Must need public toilets and fish drying yards.

5. CONCLUSION

The fishermen of Tuticorin coasts are carrying out hygienic fish handling practices on their own experiences and most of the technical aspects of carrying out right hygienic fish handling practices to get quality fish by consumers are not known to them. Change in their socio-economic characteristics is needed to bring about change in their adoption behavior. It is essential that all the fishermen be undertaken induction training so that they understand the food safety risks associated with handling fish. They need to be trained in basic hygiene and handling to ensure the production of safe seafood. Regulations should be formed to avoid the fluctuation of prices of fish commodities so that they get fair price returns for practicing hygienic fish handling operations. Sufficient number of cold storage facilities should be established in the auction hall to avoid the spoilage of the fish and utilize the trash fishes for making value added products so that maximum number of the fishermen can be benefited.

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MULTI SPECIES FARMING SYSTEM FOR THE BELOW SEA LEVEL WETLANDS OF KUTTANAD

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ABSTRACT

The Kuttanad wetlands; the rice bowl of Kerala, having an extent of 56000 ha is situated 1-1.5 m below mean sea level. In spite of the various development strategies adopted to enhance the area and production of rice, the cropping intensity of the region is hovering around 110 per cent. Now majority of the rice fields are single cropped, leaving the wetlands fallow for 6-7 months in a year, indicating below par utilisation of land, water and other valuable resources. Hence a multi species integrated farming system capable of utilising the resources fully on spatial and temporal basis was validated at the Regional Agricultural Research Station, Kumarakom of the Kerala Agricultural University during 2011-2014 period. The conventional (T1) single season rice crop was compared with (T2) rice-fish sequential farming and (T3) rice-fish- duck- male buffalo multi species integration in large sized fields of 2 ha each for productivity, income, returns, soil physico-chemical properties and water quality parameters.

The results indicated that the paddy polders in Kuttanad has an additional carrying capacity of a minimum of 5000 fishes, 750 broiler ducks and 2 male buffaloes/ha on annual basis. In this system paddy was grown during June-October season. Fish fingerlings were stocked simultaneously in nursery ponds dug nearby the rice fields with a species composition of grass carp, rohu and catla at 2:1:1 @10000 fingerlings per ha. Broiler ducklings; variety Vigoa @ 125-150/ha were grown in duck houses erected over the fish pond simultaneously. Ducklings were fed with formulated feed. Spilled over feed and excrements of duck fertilized the fish ponds. The ducklings were disposed off after 45-50 days when they attained 2.1 – 2.5 kg body weight. On annuity basis, 5-8 batches of broiler ducks were reared. Duck excrements to the tune of 9-10 tons were recycled for manuring the fish ponds.

Paddy fields were inundated after the rice harvest and the nursery ponds were broke open to release the fishes to the expanded water body. The fishes were harvested prior to the next paddy season. The paddy straw and wild grass/fodder available from a hectare of paddy field was sufficient to grow 2 male buffaloes/ha. The buffaloes in turn added 11-15 tons of manure to the system. This farming system was thus capable to produce 6-8 tons of paddy grain, 1.8 to 2.25 tons of broiler duck meat, 0.8 to 1 tons of fish and 450 to 500 kg beef meat/ha/annum compared to 6-8 tons of paddy grains alone from the conventional single season rice. Thus the multi species farming system approach, ensured round the year utilistion of kuttanad wetlands with enhanced productivity and income, generation of multiple commodities and employment, and sustained livelihood to farmers. The temporal variation in the physico- chemical properties of soil and field water were in tune with the specific requirement of the component species.

Key words : Farming, sea level

1. INTRODUCTION

The agriculture vision document for 2020 at national level envisages enhanced productivity of food grains, milk, meat, fish and egg by a whopping 28%, 61%, 76%, 91% and 69% respectively over the same during 2000-2001, which necessitates intensification of the respective sector wise production process. Intensive production processes are generally suited to monoculture systems. However such intensive systems are not sustainable and require incremental inputs to maintain productivity. Conservation of natural resources and environment are at stake under such intensive monoculture systems. During the past one decade alone, in spite of the special care and attention bestowed to increase the area and production of rice, fallowed wet lands increased by an estimated 1.09 lakh ha and rice production decreased by 1.79 lakh tons in Kerala state. The situation is alarming as a number of rice centric development activities brought out to make rice cultivation profitable and attractive has not produced the desired result. On the other hand the cropping intensity has come down, with most of paddy farmers opting for a single crop of rice which left the wetlands fallow for a considerable period annually. The primary cause of waning of interest in rice cultivation by farmers is its very low profitability.

The situation is not different in Kuttanad; the rice bowl of Kerala having an extent of 56000 ha of paddy fields. Increasing the income and profitability from wetlands is the only way to halt the negative trend. However, multiple cropping of rice in Kuttanad has limitations on account of the flood threat during the monsoon season and salinity problem during the summer season. So majority of the wetlands are cultivated immediately after the South West monsoon, but prior to the salinity incursion during the summer months. The fields remain fallow for 6-7 months after the paddy harvest. A farming system approach of year round utilization of the farm land by a judicious mix of one or more compatible enterprises with rice as the pivotal crop has been suggested as a possible strategy to increase the income and employment opportunity of farmers. Hence several attempts were made at the Regional Agricultural Research Station, Kumarakom, under the Kerala Agricultural University to develop integrated farming system models suited to Kuttanad agro eco system. The rotational system of rice and fish, integration of giant fresh water prawn (Macrobrachium rosenbergii) with rice were some positive developments in this direction. (Padmakumar et al., 2003). The utility of other endemic species like duck and buffalo in Kuttanad as integrated farming system components with rice and fish was tried by Sasidharan and Padmakumar (2012). It was hypothesised that such multispecies integrated farming system can enhance the productivity by 40-60%, cropping intensity by 200% and income by 200% from the present level. In order to evaluate the impact of the multi species integration on the total productivity, employment generation, income, net returns, cropping intensity and changes in the physico- chemical properties of the soil, field experiments were taken up at the Regional Agricultural Research Station, Kumarakom during 2011-14 periods.

2. MATERIALS AND METHODS

The field experiment was conducted in the wetlands of the Regional Agricultural Research Station, Kumarakom (9^0 30'N latitude and 76^0 30' E longitude) situated at an altitude of 1.5 m below the mean sea level. The systems were laid in large sized fields of 2 ha each and consisted of three farming system models viz, (T1) the conventional single season rice crop, (T2) rice- fish sequential farming and (T3) rice-fish- duck- male buffalo multi species integration. The systems were compared for productivity, income, returns, soil physico-chemical properties and water quality parameters.

In the monoculture rice system paddy (Oryza sativa var. fatua) was grown during June – October crop season and the field remained fallow after the rice harvest. The test variety used was Uma of 120 days duration. In the second farming system paddy was grown during the same season and rotated with fresh water fish after the harvest of rice. For this fish species composition of grass carp (Ctenopharyngodon idella), rohu (Labeo rohita) and catla (Catla catla) at 2:1:1 @10000 fingerlings per ha were stocked and reared in the in situ nursery. They were reared in the nursery pond during the rice cultivation period and released to the inundated paddy fields after the harvest of rice. The grow out field was manured with cow dung @1000 kg/ha. No supplementary feeding was done to the fishes. In the third farming system fish fingerlings were raised in the nearby fish nursery pond. The nursery pond was prepared adhering to necessary pond preparation procedures. Fingerlings were released to grow out field after the harvest of rice. In all the farming systems tried rice crop was raised as per the recommended package of practices (KAU, 2007). Broiler ducklings (Anas platyrhynchos); variety Vigoa @ 125-150/ha were grown in duck houses erected over the fish nursery pond simultaneously. The ducklings were provided a floor space of one square feet /duck. The floor of the duck shelter was made of bamboo poles with a spacing of 2.5 cm between poles. Fresh clean drinking water was provided on the sides of the duck house with linear waters.

Ducklings were reared on commercial broiler starter till 4 weeks age and later on broiler finisher ration. Spilled over feed and excrements of duck fertilized the fish ponds. The ducklings were disposed off after 45-50 days when they attained 2.1 – 2.5 kg body weight. On annuity basis, 6 batches of broiler ducks were reared. The fishes were harvested prior to the next paddy season. Two male calves of 4-5 months aged buffaloes (Bubalus bubalis)/ha were grown on a shed constructed on the field bund as the fourth component of the farming system 3. The dung from the buffalo shed was washed and flushed directly in to the fish nursery pond. The buffaloes were fed on the paddy straw and green fodder available from a hectare of paddy field and were sold for meat purpose after 15 months. The duck droppings and buffalo dung were channelised to manure the grow out field after rice crop. During the experiment period of three years, four season crops of rice, three seasons each of fish and buffalo and 15 batches of broiler ducks were raised. The yield of grain and straw of paddy, fish yield, meat yield of duck and buffalo were recorded. The fields were regularly monitored for the physico- chemical and biological properties of soil and water. Samples of field water from the inlet, outlet channels, fish nursery pond and the grow out field, and soil samples of each system were collected on every month. The field water samples were analysed for pH, EC, salinity, alkalinity, nitrite, nitrate, phosphates, potassium and sodium, while soil samples were analyzed for pH, EC, organic carbon, phosphate, potassium and sodium.

3. RESULTS AND DISCUSSION

3.1. Productivity

The productivity under the different farming systems (Table 1) indicated the vast untapped food production potential existing in kuttanad. Though the monoculture system of rice (FS.1) in which the field is fallowed after rice harvest recorded the maximum grain and straw yield of rice, the cumulative productivity under the Rice-fish- duck –buffalo system (FS.3) far excelled the other two systems. The rice yields were higher for mono culture rice systems than the other farming systems. In the present context the higher grain and straw yield for rice obtained for the FS1 may be due to the congenial physico-chemical properties of the soil (Table 3) under the flood fallow situation. There was significant variation in the yield of fish under the FS2 andFS3. The latter system (multi species integration) recorded 316% increased fish yield than the former (rice fish integration). The higher fish yield may be attributed to the availability of spilled over feed and duck excrements that fertilize the fish pond. The duck droppings and buffalo dung was a good source of nitrate and phosphate, resulting higher nutrient concentration in FS 3, which contributed to the higher primary productivity and finally the higher fish yield. Beneficial effect of duck manure and waste feed in nourishing fish ponds and enhancing fish production has been reported by Tiwari (1993). Increased fish yield to the tune of 40% under duck-fish integration in Vietnam has been reported by Man (2013) which is in conformity with the present observation. The diversity of produce is the other positive aspect of the multispecies integration which could realise animal protein in the form of duck meat and beef meat to the tune of 1148 and 460 kg/ha respectively.

Table 1: Annual productivity of rice based farming systems, Kumarakom 2012-13

Farming Systems	Rice yield (kg/ha)		Yield from other components (kg/ha)			Total Income (Rs./ha)
	Grain	Straw	Fish	Broiler duck	Buffalo	
FS.1. Rice - water fallow system	8941	12999				160938
FS.2. Rice – Fish system	7412	10917	203			153716
FS.3. Rice- Fish- Duck-Buffalo system	6891	11500	845	1148	460	410446

Inclusion of duck and buffaloes in the system thus could produce quality meat of over 1.5 tons, which had a very significant effect on the income and profitability of the system. The total income generated by the multi species integration was 155% higher than the conventional rice water fallow system.

3.2. Economic analysis

The faming system approach was evaluated on the basis of economic returns of the produces. The expenditure income, net returns and benefit cost ratio are furnished in table 2.

Table 2: Economic analysis rice based farming systems, Kumarakom 2012-13

Farming System	Expenditure (Rs/ha)	Income (Rs/ha)	Net returns (Rs/ha)	B:C ratio
FS.1. Rice - water fallow system	68269	160938	92669	2.36
FS.2. Rice – Fish system	106901	153716	46815	1.44
FS.3. Rice- Fish- Duck- Buffalo	252008	410446	158438	1.63

An additional expense of Rs.57368 was spent, when fish was integrated with rice. In order to accommodate duck and buffalo in the third farming system a further investment of Rs. 145107 was imperative. Thus, while the average expenditure for rice production for one season under FS1 was Rs.68269, the cost of production increased by 56 % for rice fish integration and 169% for fish, duck and buffalo integration.

The returns were Rs.160938 from rice ensuring net returns of Rs.92669. However the net returns from rice fish integration was lower due to lesser rice grain and fish yield from this system. The cost of production of rice in the integrated farming fields could be substantially reduced on account of the lesser land preparation cost brought about by foraging of aquatic weeds by the grass carp and tilling of the field bottoms by fish activity. Shanat (2001) reported the beneficial effect of rice fish integration in reducing rice production cost by its indirect effect on land preparation cost. The multi species integration on the contrary recorded 155% and 71% higher income and net returns respectively than the monoculture rice system. Based on economic terms the rice monoculture system seemed to be superior as the B:C ratio is highest.

3.3. Effect on physico-chemical properties of soil.

The effect of the different farming systems on the physico-chemical properties of the soil is summarised in table 3.

Table 3: Effect of Rice based Farming Systems on Physico- chemical properties of the soil over time, Kumarakom (2010-2013)

Farming system	pH		EC (dS/m)		OC (%)		Av.P (kg/ha)		Av.K (kg/ha)		Av. Na (kg/ha)	
	Year		Year		Year		Year		Year		Year	
	10-11	12-13	10-11	12-13	10-11	12-13	10-11	12-13	10-11	12-13	10-11	12-13
FS.1. Rice monoculture	5.25	5.01	0.26	0.73	3.98	5.99	4.46	5.95	283	543	12378	2810
FS.2. Rice – Fish/ prawn rotation	4.93	4.57	0.25	0.52	3.43	5.75	5.90	5.25	216	227	7851	1793
FS.3. Rice- Fish- Duck- Buffalo	4.98	4.88	0.32	0.56	3.24	5.36	4.23	4.74	249	283	11169	1765

The changes in the physico-chemical properties of the soil as influenced by the farming systems were monitored on monthly basis during the experiment period. The changes brought out during the 2010-11 to 2012-13 periods are furnished in table 3. The data on the soil pH indicated that the soils were highly acidic from the inception of the field experiment and remained to be the same, which pointed out the ineffectiveness of the farming system approach in modifying the soil reaction. The electrical conductivity of the soils however, was homogenously higher towards the end of the experiment period indicating role of factors other than multi species integration in deciding soil salinity. The high organic carbon content of the soils indicated the high inherent fertility of the soil which recorded a significant build up over time irrespective of the farming systems. The available phosphorus content of the soil was low which did not record any significant gain towards the end. The rice monoculture system recorded significant increase in soil potassium. This may be due to soil incorporation of the left over paddy straw after the rice harvest in the rice monoculture system. Though, the available sodium content of the soil was very high during the initial stage irrespective of the farming systems, recorded significant losses in available sodium content towards the close of the experiment. The overall changes in the physico- chemical properties of soil brought about by the farming systems were not significant. This may be due to the high inherent fertility of the soils under investigation. Such none response of farming systems to significant changes in the physico- chemical properties of highly fertile pokkali soil has been reported by Sasidharan et al. (2012).

4. CONCLUSIONS

The cumulative high productivity per unit area, produce diversity, year round utilization of the rice fields, higher employment generation, effective waste recycling and higher net returns made the multi species integration highly suitable to Kuttanad wetlands. The available natural resources like land and water could be utilised to the optimum extent by the proper blending of bio diversity endemic to the region. The multi species integration enhanced the total income by 2.5 times, the cropping intensity by 300%, reduced the rice production cost by 10% and ensured year round employment to the farm family.

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MEDICINAL PLANTS IN AND AROUND OF AVIKANAGAR (RAJASTHAN) AND THEIR HUMAN USE

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ABSTRACT

Since 1962, about 4000-5000 small ruminants (Sheep and Goats) are being reared in 1600 hectare land area of Central Sheep & Wool Research Institute Avikanagar (ICAR Institute), which situated at 75^0 25^0 to 75^0 25^0 E Longitude and 26^0 15^0 to 26^0 25^0 N Latitude with elevation 326 M from mean sea level. The topography of the farm is 2/3 plane and 1/3 is under gullies and ravines. Soil of the area is sandy loam (Typic ustipsamments) with medium to high infiltration rate. Organic carbon is low i.e. 0.26 to 0.36 percent with soil pH 7.6. Temperature may go as high as 48.5^0C in summer and as low as (-) 0.5^0C in winter (Hypothermic Regime). The climate of the area is semi-arid sub-tropical. The mean annual rainfall is 615 mm which vary from less than 500 mm to more than 1200 mm. Ethno medicinal survey was conducted through random sampling technique in different season and area for preceding 5 year using square quadrat method size 100x100 cm. A minimum size of quadrate was determined by species-Area-Curve method. Floral biodiversity of Avikanagar is related with the Aravalli hills. Northern tropical dry deciduous forest covers about half of the total forest area. Data on medicinal plants collected from the area under study reveal that the farm area has 90 species (43 family) of medicinal plants out of total 219 (41.1 per cent), Poaceae-10, Euphorbiaceae-7, Febaceae-6, Caesalpinaceae, Cucurbitacea, Solanaceae, Moraceae each four and others less than four sp. The interviews and discussions with traditional village community, stakeholders and in situ observations in the field reveal that local people have close association with surrounding environment and people in the vicinity the forest area have good knowledge of usefulness of plants species especially of medicinal plants. Medicinal value of the plants was discussed with different age group and it was observed that persons having 50- 65 years of age had more traditional knowledge about medicinal plants. Out of red listed plants of threatened species as given by International Union for conservation of Nature (IUCN) two species are available in the study area i.e. Commiphora wightii and Tribulus rajasthanensis, which are critically endangered species. There is an urgent need to prepare inventories and record of all ethno botanical information available among the diverse ethnic communities before the traditional culture is lost completely and all conservation measures should be adopted for saving the biodiversity of the area.

Key words: - Small ruminants, semi-arid area, rajasthan, ethno medicinal survey

1. INTRODUCTION

Herbal medicines are being used by about 80 per cent of the world populations primarily in the developing countries for primary health care. They have stood the test of time for their safety, efficacy, cultural acceptability and lesser side effects. The chemical constituents present in them are a part of the physiological functions of living flora and hence they are believed to have better compatibility with the human body. Ancient literature also mentions herbal medicines for age-related diseases namely memory loss, osteoporosis, diabetic wounds, immune and life disorders, etc. for which no modern medicine or only palliative therapy is available. These drugs are made from renewable resources of raw materials by eco-friendly processes and will bring economic prosperity to the masses growing these raw materials (Kamboj, 2000).

The rich and diversified flora of India provide a valuable storehouse of medicinal plants. The curative properties of herbs have long been known and are documented in important ancient manuscripts such as in Rig Veda, Garuda Purana and Agni Purana. (Takhar and Chaudhary, 2004). Folklore ethnobotanical information was collected on the basis of interviews with experienced people of various communities, medicine-men and native doctors such as Ojhas, Bhopas, Bhagats, Hakims, Sadhus and Vaidyas as they possess inherited knowledge (Sharma et al., 2006). Ayurveda is a traditional and most commonly practiced form of medicine in India. Ayurveda comes from the words Ayur (Life) and Veda (Knowledge). The concept of Ayurveda is based on a combined study of body (Sharira), sense organs (Indriyas), and mind (Manas and Aatma). Equilibrium of all these is related to health. When an imbalance exists among any one of the three Doshas, Ayurveda suggests a unique combination of food, exercise, meditation and herbs. Herbal medicine is still the mainstay of about 75-80 % of the world population, mainly in the developing countries for primary health care because of better cultural acceptability, better compatibility with the human body and lesser side effects (Kamboj, 2000).

2. MATERIAL AND METHODS

1.1. Study Area and Climate

Study area of Aravali hills near Avikanagar was situated 85 Km South West of Jaipur, about 5 km from Malpura town in Tonk District of Rajasthan state in India. Geographically it lies between 75° 25 to 75° 28 E longitude and 26° 15 to 26° 25 N latitude, elevated at 326 to 525 M above the mean sea level (MSL).Due to differences in altitudes a great variety of vegetation is found in the area. This area falls in the Aravali hills ranges of the semi-arid part of Rajasthan. The temperature variation is -2.0 to 48.5^0 C, Hypothermic region, mean annual rainfall remains 615 mm. which varies widely. Rainfall received from South-West monsoon which commences from third week of June to first week of July. Major part of the rainfall is received during July to September, which accounts about 90 per cent of annual rainfall. As per Champion and Seth (1968) classification, the study area of Avikanagar falls under Northern tropical dry deciduous forest (Anogeissus pendula forest) (5/E1). Soil of the area is sandy loam having pH about 7.6.

3. METHODOLOGY

Old people do not share their know-how about medicinal plants because they believe that when the medicinal plant would be disclosed its medicinal properties will be lost. Such people were convened and also accompanied in this study. Field trips were conducted with the local people who knew about the herbal medicine. The information collected from the localized people is an important aspect of ethno-botanical study. The vegetation in the study area was surveyed by random sampling technique using square quadrat method determined the size of the quadrat by species area curve method (Oosting, 1956). Study area was divided into 5 sites in four major directions such as East, West, North and South. One site among the five sites was selected in the central location. Centrally located site was distinct in topography than other four sites. Compared to other four sites it was more plane without any slope and gully except few minor furrows. A minimum size of quadrat was determined by species-Area--curve method suggested by Oosting (1956). Optimum quadrat size of 100X100 cm^2 was selected in general to all 5 sub sites. It was also in agreement with the earlier studies conducted in similar line (Galav et al., 2005).

Ethno-medicinal surveys were conducted repeatedly in different seasons and area for preceding 5 Years. The collected plants were identified by the expert in the Herbarium of Botany Department of University of Rajasthan, Jaipur. The plants were arranged alphabetically, each by its botanical name, followed by name of family and local names. The folk uses were described with details of parts used.

4. RESULTS AND DISCUSSION

Total 90 plant species belonging to 43 families have been recorded and enumerated. The data on ethno-medicinal plants such as the botanical name, families, vernacular name, part used, medicinal properties and their uses (Table-1). During the survey, medicinal value of the plants was discussed with different age group of people at different localities of the area. Persons above 50-65 years of age had more traditional knowledge about medicinal plants.

The degree of threat to natural populations of medicinal plants has increased because more than 90 per cent of the plant raw material for herbal industries in India is drawn from natural habitats (Soni, 2009). Surprisingly, wild plant species used for medicinal purposes are receiving ever-increasing attention from the scientific community and commercial enterprises. The traditional knowledge system (TKS) in India is fast eroding. There is an urgent need to prepare inventories and record all ethno-botanical information available among the diverse ethnic communities before the traditional culture is completely lost. When an aged person dies, a living encyclopaedia and database of the society is lost. Hence, an idea can be diffused among the social systems that before death, a traditional knowledge holders (TKH) should pass on the knowledge to the next generation. That could be one of the measures for conservation of saving TKS.

5. CONCLUSIONS

Tremendous number of medicinal plants survived at small area owing to protection. Out of recorded 90 ethno-medicinal plants, two critical endangered species were found at study area (Aravali hill ranges at Avikanagar) viz. Commiphora wightii and Tribulus rajasthanensis. Age old persons (50-65 years) had more knowledge about medicinal plants as compared to young ones and women. Most of the rural people use locally available ethno-medicinal plants in curing themselves and their animal as well. There is urgent need to prepare inventory and records of traditional knowledge of rural community before the traditional culture of medical treatment is lost.

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Table 1: Medicinal plants in and around of Avikanagar (Rajasthan) and their human use

Sl.No	Botanical name	Families	Vernacular name	Part used	Medicinal properties/ diseases	Uses
1.	*Achyranthes aspera* Linn. var porphyristachya HK.f.	Amaranthaceae	Latjira / Andhi Jhara / Chirchitta	Whole plant	Pneumonia, headache, earache	Cough, colds, asthma, hydrophobia, headache and ear ache. One teaspoonful seed powder is given orally once daily morning for 3-4 days with butter milk to stop bleeding from piles and to cure piles. The fresh leaf juice is filled in wound to stop bleeding immediately and to prevent infection in the wound. The root paste is applied externally at the point of scorpion sting thrice a day for two days for giving instant relief.
2.	*Aegle marmelos* (L.) Corr.	Rutaceae	Bel / Bil	Fruit pulp	Cooling, Laxative and digestive	Chronic diarrhoea and dysentery, for sexual debility, diarrhoea and constipation, one teaspoonful ripe fruit pulp is mixed with water (20 ml) and the mixture is filtered. The filtrate is given orally once a day for 3 days to treat diarrhoea. Pulp of urinear half ripe fruit mixed in water is given in diarrhoea, pulp of ripe fruit mixed with water for making sharbat.
3.	*Ailanthus excelsa* Roxb. and *Ailanthus avikanian*	Simaroubaceae	Ardu	Root / Stem bark	-	Fever , Coughs, Skin irruptions
4.	*Anogeissus pendula* Edgew.	Combretaceae	Dhok	Stem bark	-	Gastric disorder
5.	*Argemone mexicana* Linn.	Papaveraceae/ Nelumbonaceae	Jangali katela / Satayanashi/ dhaturi	Root, Stem, Latex	Laxative, Rheumatism, eye	Chronic skin disease, dropsy, intestinal infection, Applied to affected parts, poultice for the eyes. Root is given for expelling tapeworm. Diuretic, Purgative aphrodisiac, strangury, Leucoderma
6.	*Azadirachta indica* A. Juss.	Meliaceae	Neem	Leaves twigs, seed	Prophylatic, malaria worm	Leprosy and skin diseases, used for excessive bleeding, as a contraceptive

7.	*Balanites aegyptiaca* (L.) Delile	Batanitaceae	Hingota / Hingot	Seed, whole plant	Hypotensive source of diosgenin, carbuncles	Oral contraceptanives Toothache and worm in teeth are cough, Pulp of ripe fruit mixed with mother's milk is given to twice a day for 3-4 days for children suffering from pneumonia. Seed kernel is used in dysentery seed kernel powder mixed with jaggery is taken orally for sciatica.
8.	*Bauhinia racemosa* Lam.	Caesalpiniaceae	Jinja	Stem bark, leaf	Toxic, Dysurea	Weakness, Stem bark piece (5 g) is pounded in water (100 ml), kept overnight and then filtered. This filtrate is given orally once daily for 2-3 days to treat diarrhoea. Leaves are used in burning sensation of urine
9.	*Boswellia serrata* Roxb. ex Colebr.	Burseraceae	Salara / Sala	Exudate gum, Leaf paste	Skin eruption	Fragrant ointment and for impotency, Leaf paste is applied on eyes against eye infection, Fresh fruit or dried fruit crushed on stone and is taken with 1 hen egg to cure scorpion bite.
10.	*Butea monosperma* (Lam.) Taubert.	Fabaceae	Dhak / Chhilalar / Bachha/ Palash	Flower /Seed gum whole plant	Anthelmintic diarrhoea, Leucorrhoea, cuts dysentery	In leucorrhoioea, excessive bleeding, sun stroke, pain delivery, diarrhoea and hernia, Fresh stem bark gum is taken to cure diarrhoea. *Laddus* prepared from the gum, known as kamarkas, are eaten after delivery; flower juice is given to children during fever and cold. Crushed seed on red stones is given to newly born child in case of diarrhoea. Flower benefits in case of urinary and menstrual problems. Palash sharbat can reduce menstrual problems like heavy bleeding. Its leaves protect from sunstroke.
11.	*Calotropis procera* (Ait.) R. Br.	Asclepiadaceae	Aakada	Root bark Flowers powdered, Leaf	Expectorant diaphoretic	Cough, asthma, Scorpion bite. Leaves are tied on abdomen in abdominal pain.
12.	*Cassia fistula* (L.)	Caesalpiniaceae	Amaltas / Garmala	Fruit pulp / seed	Purgative laxative, Menstrual disorder	One tablespoonful of fruit pulp is mixed with equal amount of water. This mixture is administered orally once daily for a week to cure constipation, used in *rakta pralar* and diarrhoea
13.	*Citrullus colocynthis* (L.) Schard	Cucurbitaceae	Kartuma / Paparpinda	Roots Fruits-pulp	Purgative	jaundice, urinary diseases, antibacterial, constipation
14.	*Cocculus pendulus* (Forst.) Diels	Menispermacea e	Kali pilwani / Wasenbel	Roots	-	Intermittent fever

15.	*Commiphora wightii* (Arnott.) Bhandari	Burseraceae	Guggal	Oleoresin exudates, resin, latex	Expectorant aphrodisiac carminative, Urinary, Wounds pyorrhoea	Lower blood cholesterol, Applied as an antiseptic, Infusion and on wounds
16.	*Cuscuta reflexa* Roxb.	Cuscutaceae	Amer bel	Stem	-	Tonsillitis
17.	*Cyperus rotundus* Linn.	cyperaceae	Motha	Rhizome	-	Dysentery, five to ten fresh stems are chewed and juice is sucked orally to treat the water snakebite. Scraped roots with ginger and honey are given in gastric and intestinal disorder. For the treatment of malaria, decoction of equal quantities of moth rhizome, Gloe (*Tinospora cordifolia*)stem pieces and dried ginger is given thrice daily for 4-6 days.
18.	*Emblica officinalis* Gaertn.	Euphorbiaceae	Avala	Fruit raw	Diuetric and laxative	-
19.	*Euphorbia hirta* Linn.	Euphorbiaceae	Badi dudhi / Dudheli / Gudani	Whole plant	Bronchial infection, Cough, asthma, bronchitis wormicide in children, Diarrhoeal	Skin diseases (Leucodermal spots), Root paste mixed with honey is given to nursing mother for initiation or to increase lactation. Latex is applied on pimple to cure it. Juice of whole plant is used in diarrhoea
20.	*Moringa oleifera* Lamk.	Moringaceae	Sehajana	Seed oil, Leaf, fruit	Arthritis	Used arthritis, Diarrhoea ,*vata roga* and acute rheumatism
21.	*Solanum nigrum* L.	Solanaceae	Makoi	Whole plant	-	Anaemia in infant having abdominal upset, cirrhosis of liver
22.	*Tamarindus indica* L.	Caesalpiniaceae	Imili	Fruit pulp leaves	Carminative antibiotic, refrigerant and laxative	Swelling and boils
23.	*Tribulus terrestris* L.	Zygophyllaceae	Chota gokhru	Fruit	Diuretic and tonic	Stone in urinary bladder
24.	*Tridax procumbens* Linn.	Asteraceae	Jalbhora	Leaves	-	Cuts and wound
25.	*Withania somnifera* (Linn.) Dunal	Solanaceae	Aswgandh	Leaves and roots	Tonic / diuretic, antibacterial, Fever painful swellings	Joints pain / headache and rheumatism, asthma, bronchitis and abortifacient, pain, sexual potency and fertility, Root powder is given with goat milk for about 2 months to cure arthritis especially of early stage.

26.	*Syzygium cumini* (L.) Skeels.	Myrtaceae	Jamun	Bark / Fruits	-	Diarrhoea, dysentery and Diabetes
27.	*Abrus precatorius* L.	Fabaceae	Chirmi / Ratti / Gunja	Seeds / Whole plant	Purgative and aphrodisiac, Wound polyurea ,arthritis, fever	Nervous disorder , Urine obstruction, Used in healing, ear, abortifacient, Polyurea and antifertility
28.	*Grewia flavescens* A. Juss.	Tiliaceae	Gagda / Tindhari	Roots	Plaster in bones	Jointing in bones
29.	*Phyllanthus fraternus* Wobster	Euphorbiaceae	Jami avala / Seeta dhani	Leaves	jaundice	Fever
30.	*Tinospora cordifolia* (Willd.) Miers	Menispermaceae	Neemgalol / Nimgiloe/ Gloe	Stem, root, leaf	Fever	Decoction taken in fever. Stem juice kept overnight is employed in fever, typhoid, jaundice, diabetes, general disability and skin disease, stem juice is taken to cure leucorrhoea.
31.	*Ocimum sanctum* Linn.	Lamiaceae	Tulsi	Leaves juice / infusion	-	Bronchitis digestive complaint and cold, Root decoction is given in malarial fevers. Fresh root paste is applied to bites of insects and leeches.
32.	*Cynodon dactylon* (Linn.) pers	Poaceae	Dhub / Durva	Pollen extract /Whole plant		Rhinitis, asthma, piles, menorrhagia, leucorrhoea, dropsy, cough, diarrhoea, dysentery, dysuria, heamaturesia and catarrhal, ophthalmia is beneficial in rhinitis and asthma, Infusion of plant is given in bleeding piles, dropsy, cough and catarrhal ophthalmia. Paste prepared from equal quantities of fresh Doob roots and Kans (*Saccharum spontaneum*) is given with cow milk and sugar.
33.	*Saccharum bengalense* Retz	Poaceae	Munj	Leaf		Useful in burning sensation, erysipelas, blood troubles urinary complaints and eye diseases blood troubles
34.	*Desmotachya bipinnata* (Linn.) *stapf.*	Poaceae	Dhab	Root &culms	Fistula-in-anoe	The root and culms are used in thirst, asthma, jaundice and skin eruptions. Ash of dhab used in fistula-in-anoe. The root infusion is usually given in jaundice and urinary troubles twice daily till cure.

35.	*Cenchrus biflorus* Roxb	Poaceae	Barbarut	Seed		Seed are used in health improvement and muscle building
36.	*Cenchrus ciliaris* Linn.	Poaceae	Anjan	Root		Root, Decoction of root , Intestinal worms
37.	*Cenchrus setigerus* vahl	Poaceae	Dhaman	Root		Decoction of root, Intestinal worms
38.	Dactyloct*enium aegyptium* (Linn.) P. Beauv	Poaceae	Makora			The grain of makora is mixed with seeds of *Vigna aconitifolia* cooked in water, Salt and spices are taken orally to cure bellyache after child birth, The grain also cure kidney pain.
39.	*Lasiurus sindicus* Henr.	Poaceae	Shevan grass	Whole plant		Seed powder is eaten with flour of Bajra during famine.
40.	*Panicum antidotale* Retz	Poaceae	Gramano	Seed		Grain powder is eaten with flour of wheat during famine; The ash of plant is applied on burns. Also used as a fodder grass, Seed for wounds and small pox. Antidote for hydrophobia.
41.	*Terminaliya arjuna* (Roxb. Ex Dc.)W. et Arn	Combretaceae	Arjun	Stem bark		Bark is used in heart diseases, particularly to reduce obesity, It is also applied on wound &. taken in fever.
42.	*Ficus benghalensis* Linn.	Moraceae	Bargad / Bar	Latex, stem	Carbuncles, dental pain	Latex is used in genital diseases. The latex mixed with (Patasha) sugar is given to the children in cough. Bark with black pepper is given in serious cases of snake bite. Milk latex is massaged externally on scalp to prevent loss of hair. Latex is used in eye pain, semen thickness to regain sexual potentiality and in pyorrhoea
43.	*Ficus religiosa* Linn.	Moraceae	Pipal	Young leaves		Young leaves with wetted flour of wheat or Sindoor are applied on external skin eruptions and swellings. Adventitious root of papal mixed with sugar is given with fresh water in case of chicken pox once a daily for 7-8 days continuously.
44.	*Xanthium strumarium* Linn.	Asteraceae	Adasisi	Fruit	Headache	Achenes are used in headache. The leaf juice is applied on painful molars and teeth to relieve pain. Fruits are tied on the ear to control headache
45.	*Datura metal* Linn.	Solanaceae	Kala Dhatura	Seed, Leaves		Seed are used in cough. Powdered seeds with mustard oil are applied on leprosy and other wounds.

46	*Datura innoxia Mill*	Solanaceae	Dhatura safed	Latex, leaves		Insect bites (Wasp.)
47	*Pedalium murex* Linn.	Pedaliaceae	Dakhni-gokhru	Whole plant		Whole plant extract is used as a tonic for health and vigour. Decoction of fruits is used for continuance of urine and other complaints of urinary system. Seed are given to patients suffering from joint pain & lumbago and also given for better health.
48	*Chenopodium album* L.	Chenopodiaceae	Bathua	Whole plant		hepatic disorder, anti dandruff
49	*Cannabis Sativa*	Cannabaceae/cannabinaceae	Bhang/ Hemp	Whole plant		To dress wounds, cure sores. Its juice helps cure dandruff. Seeds are mixed with cattle feed for better milk yield.
50	*Acacia nilotica* willd.	Fabaceae	babool	Whole plant	Sexual, burning	Used for burning sensations in the eye and asthma
51	*Amaranthus spinosus* Linn.	Amaranthaceae	cholai	Leaf	Uninary disorder	Leaves are used orally as a diuretic, Soporific, Narcotic and Appetizer.
52	*Tecomella undulata*	Bignoniaceae	Desert teak, Marwar teak	Stem bark	Whole plant	Bark obtained from the stem is used as a remedy for syphilis. Curing urinary disorder, enlargement of spleen, gonorrhoea, leucoderma and liver diseases. Seed are used against abscess. Flower used for hepatitis.
53	*Cassia tora* L.	Caesalpiniaceae	Tarota/ Charota	Seed	Flower, All parts	Half a teaspoon of seed powder is given orally with water once daily to cure fever till it is cured. Effective against asthma and pains brought on by monsoon chills
54	*Asparagus racemosus*	Liliaceae	Satawari/ Satawar	Root	Debility impotency	Increased lactation, diabetes, muscle pain, muscular disorders, leucorrhoea, and fertility. Fresh tuberous roots considered good tonic. Roots are mixed with cow fodder for increasing lactation. Root powder with cold water is given for biliousness, also given with honey, used as tonic.
55	*Capparis deciduas*	Capparaceae	Ker	Leaf, root	Eye disease	In eyes in corneal opacity. Fresh root juice is applied to nose to cure headache, Flower buds are eaten to relieve stomach-ache, root paste is applied on scorpion bite, and powdered coal from stem is taken during fractured bone.
56	*Celosia argentea*	Amaranthaceae	Kukadli	Seeds	Uterus diseases	Crushed seed is taken orally for uterus diseases.

57	*Cicer arietinum* Linn.	Fabaceae	chana	seed	Rejuvenator	Bread prepared of gram is taken in asthma.
58	*Citrullus calocynthis* Schrad.	Cucurbitaceae	Ingalboli /	Fruit / seed	Abortificiet	Used for abortion and dental worm
59	*Clitoria ternatea* Linn.	Fabaceae	Titali matar/ Gokarni	Leaf	Eye disease	To cure swelling due to syphilis and eyes, Root juice is given in chronic bronchitis to help expectoration.
60	*Cocculus hirsutus* (Linn.) Diels	Menispermacea e	Jalimani	Leaf	Leucorrhoea	To sterility in man and leucorrhoea (sweta pradar).
61	*Convolvulus microphyllous* Sieb. Ex Spreng = *Convolvulus pluricaulis* choisy	Convolvulaceae	Bhumari /	Whole plant	Menstrual, Polyurea	To gain sexual vitality, menstrual disorder and swapan dosh
62	*Cyamopsis tatragonoloba* Taub.	Fabaceae	Ganwar	Leaf / Seeds	Asthma swellings	Used in asthma and swellings
63	*Daucus carota* Linn.	Umbelliferae	Gajar	Seed,---	Eye sight, Sterility	To cure sterility in males, eyesight, to regularize menstruation and abortifacient
64	*Dendrocalamus strictus* (Roxb.)	Poaceae	Bans	Root	Dysurea	Paste of root is orally used in dysurea
65	*Annona squamosa* Linn.	Annonaceae	Sitaphal	Root	Dyspepsia	Used orally with mother's milk
66	*Euphorbia Caducifolia* Haines	Euphorbiaceae	Thor	Latex	Body ache	Used as an abortifacient and body ache
67	*Euphorbia fusiformis* Don.	Euphorbiaceae	Mooli	Tuber	Rheumatic pain	Paste of root applied in rheumatic pain
68	*Fagonia Cretica* Linn.	Zygophyllaceae	Dhamaso	Leaves	Antifertility	Used in diarrhoea and antifertility
69	*Ficus racemosa* Linn.	Moraceae	Gular	Latex, Stem	Antifertility	To improve fertility in male and female, asthma

70	*Grewia tenax* (Fiori)	Tiliaceae	Dandi	Fruit	Dyspepsia	Fruits eaten to increase appetite
71	*Jasminus arborescens* Roxb.	Oleaceae	Chameli	Leaf	Eye disease	Juice of leaf applied in the eye diseases
72	*Jatropha gossypifolia* Linn.	Euphorbiaceae	Ratanjot	Latex	Burns, eye disease	Used in uterus diseases, burns for increase eye sight and corneal opacity
73	*Lawsonia inermis* Linn.	Lythraceae	Mehndi	Leaf	Burning sensation	Leaf paste is used in burning sensation.
74	*Lepidagathis trinervis wall.* Ex Nees	Acanthaceae	Paniru	Whole plant	Leucorrhoea	Used in leucorrhoea (sweta pradar) and fever.
75	*Leptadenia pyrotechnica* (Forsk.)Decne	Asclepiadaceae	Khinpani	Latex	Eczema	Latex applied on affected part in eczema.
76	*Luffa acutangula* Var. amara	Cucurbitaceae	Turai	Seeds, Fruit	Stone, headache	Used in headache.
77	*Mangifera indica* Linn	Anacardiaceae	Aam	Stem bark	Abortificiet	Stem bark is used as abortifacient.
78	*Musa paradisiacal* Linn.	Musaceae	Kela	Root	Antifertility, Typhoid	Juice of root is used orally to stop conception, Saffron (*Crocus sativus*) stamens mixed with banana roots is given once in the morning to cure even most complicated case of typhoid.
79	*Ricinus Communis* Linn.	Euphorbiaceae	Arandi	Leaf, Seeds	Rheumatism	Used in menstrual period and antifertility, In case of muscular injury without bleeding, leaf paste with mustard oil is applied on the affected area. Leaf paste is applied on head to relive headache, leaves boiled with maize grain is used as a rat killer.
80	*Salvadora persica* Linn.	Salvadoraceae	Pilu /	Whole plant	Constipation	Used in constipation, teeth and obesity.
81	*Sesamum indicum* Linn.	Pedaliaceae	Til	oil	Burns	In burns and in anus burning sensation.

82	*Urginea indica* (Roxb.) Kuvth	Liliaceae	Koli kanda	Tuber	Bronchical	Used in leucorrhoea and respiratory trouble.
83	*Zizyphus nummularia* (Burm. f.) Wight & Arn.	Rhamnaceae	Bordi, Jhardi	Stem bark		Bath is taken in water boiled with fruits for curing sun stroke, leaf paste is used for cutaneous diseases and healing cuts & boils. Root bark is given in case of diarrhoea in goats.
84	*Albizzia lebbeck* Benth.	Mimosaceae	Siras	Root		Dilute root paste is given orally repeatedly till the patient regains consciousness in case of snakebite, paste is also applied externally on the bite point.
85	*Curcuma domestica* Val.	Zingiberaceae	Haldi	Stem		For cold, milk boiled with turmeric and sugar is given. For catarrhal cough, fresh rhizome and Dhania (*Coriandrum sativum*) decoction is given thrice a day.
86	*Mimosa pudica* Linn.	Mimosaceae	Chui-mui	Root		Root powder with crystalline sugar for three days is given after menstruation to stop conception.
87	*Momordica Charantia* Linn	Cucurbitaceae	Karela	Root		Root paste is applied over piles.
88	*Morus alba* Linn.	Moraceae	Shahtoot	Root		Tea made from root is used twice a day for 5-7 days to treat diarrhoea.
89	*Nerium indicum* Mill.	Apocynaceae	Kaner	Root		Kaner (white flower) roots ground and fried in ghee is applied externally on the ear of patient to cure inflammation.
90	*Zingiber officinalis* Rosc.	Zingiberaceae	Adrak	Stem		Ginger tea is usually given in colds and influenza. Ginger fresh rhizome juice with honey is a domestic remedy for coughs and asthma. In case of common fever during pregnancy, dried rhizome is pounded and given orally with goat milk twice daily for 4-5 days.

CHENNELLU – A RESISTANT VARIETY OF TRADITIONAL RICE CULTIVAR IN KERALA AGAINST BACTERIAL BLIGHT

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ABSTRACT

Chennellu is one of the medicinal rice varieties of Kerala and is indigenous to Northern Kerala. Chennellu in Kannur district is used for treating diarrhoea and vomiting, another type of Chennellu called 'valiyachennellu' from Wayanad district is used for recovering from jaundice. Chennellu, the red rice, is also a good source of VitaminB1. In Asia a large number of the population consumes rice in every meal and rice accounts for more than 70% of human caloric intake in many countries. Even though the average cost of rice production is highest in Kerala when compared to other states in India; it is a hot spot for pests and diseases. The high humidity and temperature of the rice growing environments during the cropping periods increases the incidence of diseases. Bacterial blight is one of major disease of rice in Kerala caused by Xanthomonas oryzae pv. oryzae (Xoo) and is a reason for severe damage to rice crop in Kerala.

Adukkan, Ayiramkana, Chennellu, Chomala, Gandhakasala, Kayma, valichoori, veliyan and Thondi were the local rice varieties in North Kerala used for finding out the susceptibility of X.oryzae. Field grown 45 days old rice plants were inoculated with 2.5μl, 5μl, 10μl and 25μl of supernatant of 48 hour old X.oryzaepv. oryzae broth culture at a concentration of approximately 108 CFU/mL (0.5OD600nm). Inoculations by creating wounds were carried out manually on the leaves with sterile forceps. Plants were visually examined after 21 days for bacterial blight severity, and the lesion length of each leaf was measured. Disease reactions were categorized according to the lesion length. Variation in lesion length across different concentration was tested individually for each rice variety with one way ANOVA. During bacterial infection, the mean lesion length was least at the concentration of 2.5μl in Chennellu (0.5cm). In this study it was concluded that Chennellu is the resistant rice cultivar against bacterial blight among other traditional rice cultivars commonly used.

Key words: Rice, chennellu, bacterial blight, xanthomonas oryzae pv. oryzae

1. INTRODUCTION

Bacterial blight is one of the important diseases of rice and present throughout of the rice-growing regions. Reports from the Philippines, Indonesia and India estimated that bacterial blight affect the 60–75% transplanted seedlings. It also causes considerable losses in all cultivars of rice in India. In some cases, Rice yield losses by bacterial blight can reach up to 50% when plants are infected at the maximum tillering stage. Bacterial blight of rice badly affects economy of India. It is facing loss of US $60 million even if two per cent of its total paddy yield was affected by bacterial blight of rice. The loss would be a staggering US $2.4 billion if the same quantity of paddy was affected globally (Swapan, 2013).

Bacterial blight was first noticed by the farmers in Fukuoka prefecture Kyushu Island, Japan, as early as in 1884-85 and caused by Xanthomonas oryzaepvoryzae (Xoo), is a devastating pathogen of rice. It has also been extensively studied as a model disease of rice to understand the host-pathogen interactions, bacterial pathogenesis and defense responses in monocotyledonous plants (Rumdeep et al., 2012). X. oryzae is a rod-shaped, round-ended, Gram-negative bacteria. They move short distances in infected crops. Xoo enters the rice leaf through hydathodes at the leaf tip and leaf margin and also through wounds or openings caused by emerging roots at the base of the leaf sheath then gain access to the xylem(Ou, 1985). Bacteria multiply in the intercellular spaces of the underlying epithelium and spread into the plant through the xylem (Noda & Kaku, 1999). After few days bacterial cells fill the xylem vessels and ooze out through hydathodes, forming beads or strands of exudate on the leaf surface, a characteristic sign of the disease.

Effectors of Gram-negative plant pathogens are delivered into plant cells via a type III secretion system (T3SS). The T3SS consists of a Hrp pilus, resembling the flagellar biosynthetic complex, but producing a needle-like appendage hence the T3SS is encoded by hrp genes. Apart from hrp gene-encoded T3SS, T2SS (Type II secretion system) are also be found to the virulence of phytopathogenic bacteria (Alfano & Collmer, 1996). T2SS consists of several degradative enzymes such as pectatelyases, cellulases, xylanases and proteases and play important roles in the interaction of Xoo with its host (Chatterjee et al., 2003; Ray et al., 2000; Sun et al., 2005)

The management of bacterial blight of rice can be improved with the use of biological control agents. The resistant varieties induce defense related genes after the interaction with pathogens. These defense related genes assist for the potential use of biological control of plant diseases and development of innovative resistant varieties etc. This study reports the incidence of disease resistance in Oryza sativa indica group against the bacterial blight.

2. MATERIALS AND METHODS

2.1. Plant material : Seeds of nine native varieties of rice cultivars were collected from different agro-ecological zones. Adukkan, Ayiramkana, Chennellu, Chomala, Gandhakasala, Kayma, valichoori, veliyan and Thondi were used for the study. Seeds of these rice varieties were disinfected with 0.1% HgCl2 (mercuric chloride) for 1 min, followed by washing with sterilized distilled water and kept for germination in disposable petriplates.

2.2. Inoculum preparation : Xanthomonas oryzae pv. oryzae procured from Kerala Agricultural University, Vellanikara was used for the present study. Cultures were incubated on Nutrient agar (NA) medium at 27˚C for 48 h. Analytical grade chemicals from Himedia were used. Each bacterial colony on the slants were suspended in sterilized distilled water and adjusted to concentrations of approximately 109cfu/ml prior to inoculation.

2.3. Treatment of rice seeds with *Xanthomonas oryzae pv.* oryzae : Seeds of 9 local varieties of rice were kept for germination in humid petriplates for seed infection. Rice seeds were treated with cultures of X.oryzae having the dilution at 108 to 109CFU/ml when the coleoptiles of rice plants formed. 30 seeds of each variety, in triplicate, both treated and control were kept for germination in sterile Petri dishes.

2.4. Pathogen inoculation on leaves : Two days old cultures of Xanthomonas oryzae pv. oryzae (Xoo) having concentration of approximately 108 CFU/mL (0.5OD600nm) were inoculated in to nutrient broth medium and were incubated on a shaker (130 to 140 rpm) for 48–72 h at 28oC. The supernatant of Xoo broth culture after centrifugation at 5000rpm for 10min were inoculated in different volume such as 2.5µl, 5µl, 10µl and 20µl. Inoculation was carried out on manually created wounds on the plants with sterile forceps.

2.5. Determination of Lesion length: Within 4-7 days after incubation, plantlets were planted in field having pond soil and cow dung in the Botanical Garden of Calicut University. The experiment was laid out in randomized block design in plots of 6 x 4 m2 size. Separate plots were used for different isolates. 45 day old rice plants were used for bacterial challenge. The study on morphological variability has been carried out by analyzing the leaf lesion length of nine cultivars against the pathogen. The lesion length from the cut leaf tip was measured in centimetres (cm) after 21 days of inoculation.

2.6. Total protein estimation: Total protein from the three week old leaves of Xanthomonas oryzae infected rice varieties were extracted and the total protein content was measured by Lowry's assay using bovine serum albumin (BSA) as the standard (Lowry et al., 1951).

2.7. Statistics : Analysis of variance was carried out to find out the significance of variations induced by the treatments in the case of the different cultivars. Hypersensitivity reactions were categorized according to lesion length. The lesion length was 0 to 6cm classified as resistance (R) and more than 6 cm as susceptible (S).

3. RESULTS

3.1. Morphological variability

3.1.1. Effect of *Xanthomonas oryzae pv.* oryzae on germinated seeds of rice

No lesion was observed in seedlings by bacterial infection with germinated seeds. Infectivity of rice varieties at seedling stage with respect to their changes in morphological parameters by X.oryzae was observed (Table 1). Graphical representation of morphological characters of the cultivars studied on bacterial treated seeds is illustrated in fig 1.

Table 1: Morphological characters of the cultivars studied on bacterial treated seeds

4. DISCUSSION AND CONCLUSION

Bacterial leaf blight (BLB) caused by Xanthomonas oryzae pv. Oryzae is a major seed-borne pathogen of rice and is a threat to rice production in both temperate and tropical rice-growing regions, due to its high

Characters	Cultivars								
	Adukkan	Ayiramkana	Chennellu	Chomlala	Ghandakasala	Kayma	Valichoori	Veliyan	Thondi
1. Plant height (cm.)									
Control	56.5	39	37.5	35	55	49.5	27.5	31	26
Treatment	56.33	30	49.67	28.33	35	50.67	21	28	29.33
Range	0.17	9	12.17	6.67	20	1.17	6.5	3	3.33
Rank	IV	VIII	I	VII	IX	III	VI	V	II
2. Number of leaves									
Control	5	3.5	5	4	5	4	4	4	4
Treatment	4.67	3.33	4.33	4	4	4	4	4	3.67
Range	0.33	0.17	0.67	0	1	0	0	0	0.33

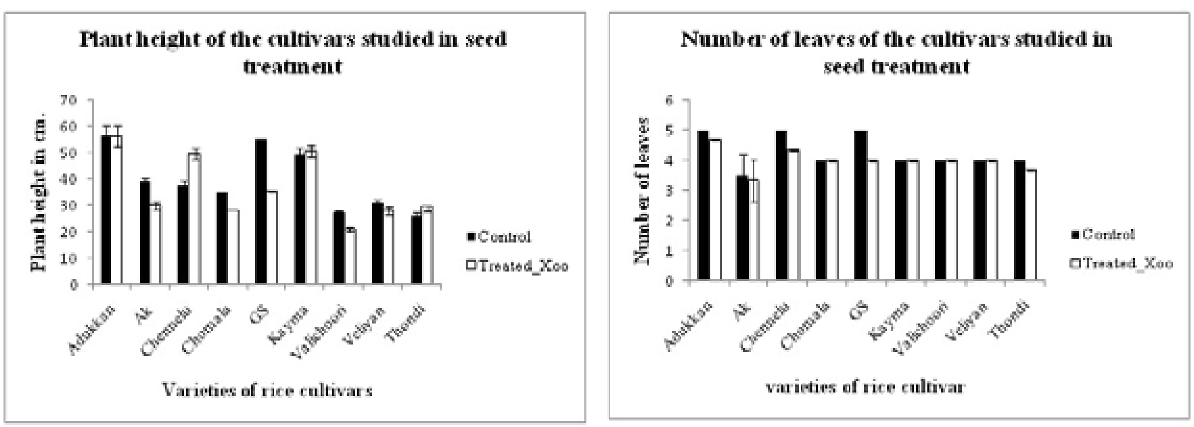

Fig 1: Graphical representation of morphological characters of the cultivars studied on bacterial treated seeds

3.1.2. Effect of *Xanthomonas oryzae* pv. *oryzae* on rice leaves

Rice leaves were inoculated with supernatant of *Xoo* and the length of the lesion was recorded after 21 dpi (Table 2).

3.1.2. Effect of Xanthomonas oryzae pv. oryzae on rice leaves

Rice leaves were inoculated with supernatant of Xoo and the length of the lesion was recorded after 21 dpi (Table 2).

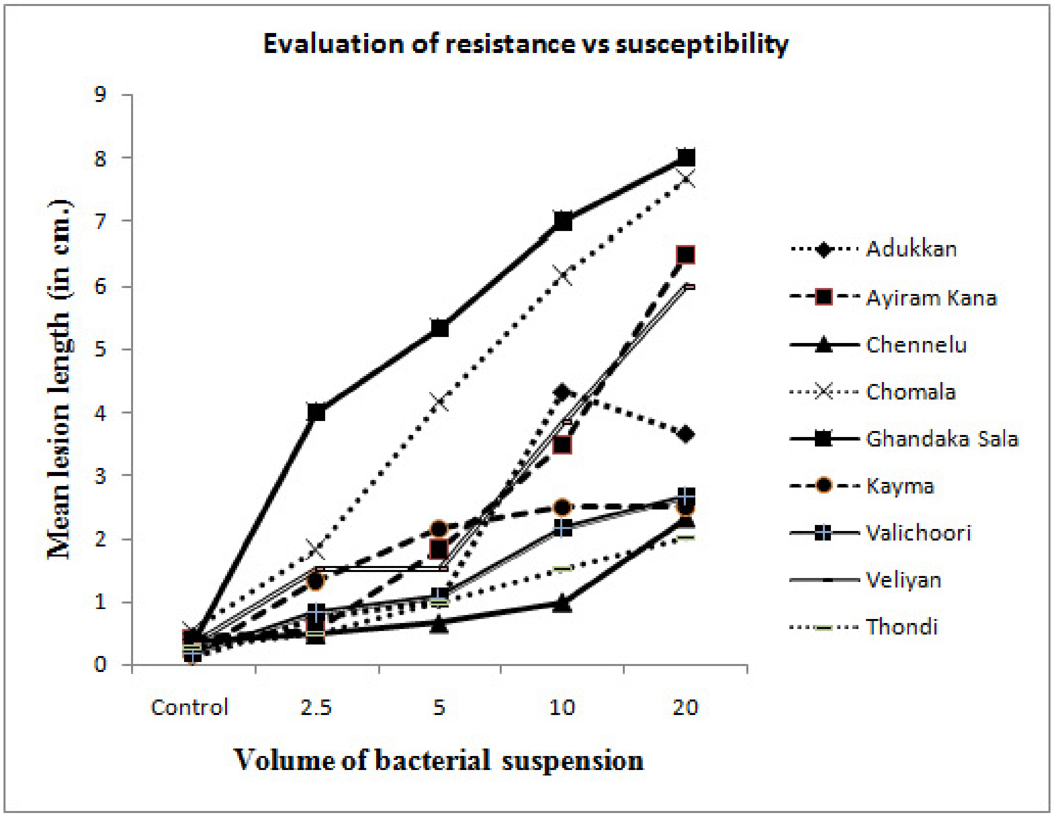

Figure 2: The mean lesion length in different rice varieties among different treatments

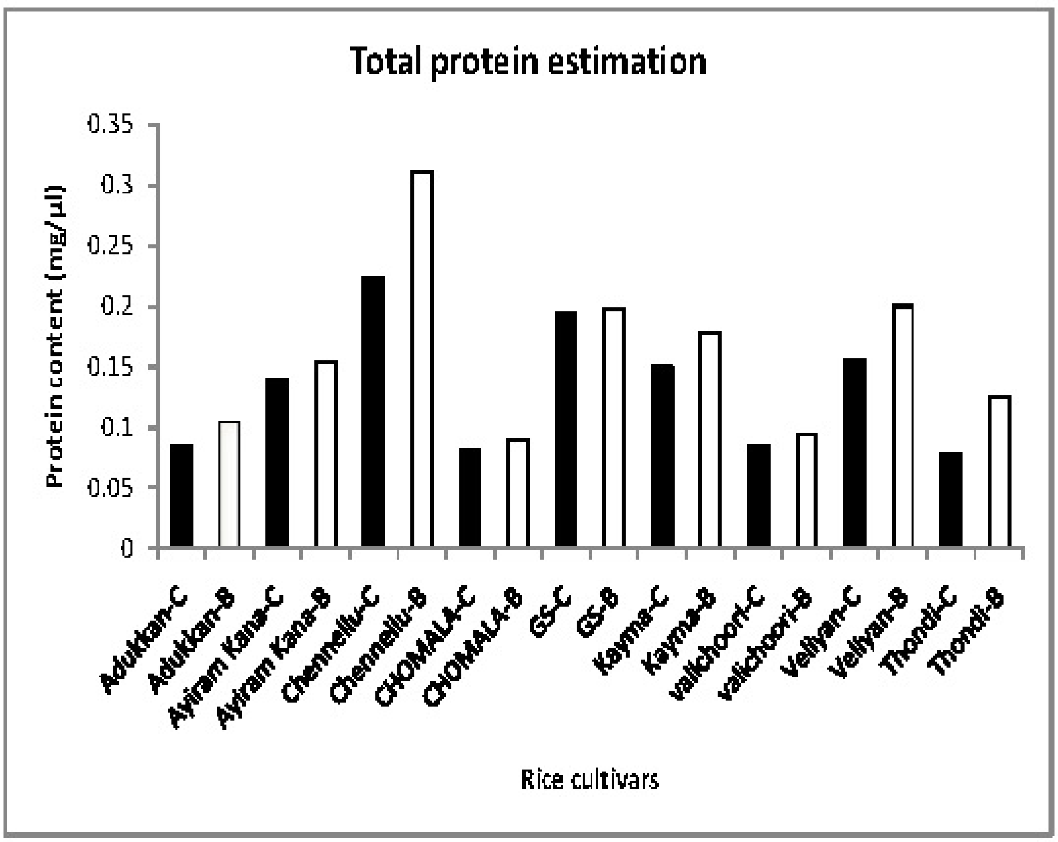

Figure 3: Effect of Xanthomonas oryzae on protein content (mg/µl) of rice cultivar

Table 2: Cultivar differences of bacterial blight severityas determined by lesion length

Treatment	Rice cultivar																	
	Adukkan		Ayiram kana		Chennelu		Chomala		Ghandakasala		Kayma		Valichoori		Veliyan		Thondi	
	Mean ± SE	CD @5 %	Mean ± SE	CD @5 %	Mean ± SE	CD @5 %	Mean ± SE	CD @5 %	Mean ± SE	CD @5 %	Mean ± SE	CD @5 %	Mean ± SE	CD @5 %	Mean ± SE	CD @5 %	Mean ± SE	CD @5 %
Control	0.133 ± 0.05	0.67	0.433 ±0.03	1.98	0.367 ±0.03	0.33	0.55±.06	1.44	0.35 ±.03	0.46	0.167±.02	0.85	0.183 ±.02	0.68	0.317 ±.02	0.72	0.283±0.02	0.06
2.5	0.733 ± 0.064		1.8±0 .298		0.5±0		1.833 ±.15		4±0 *		1.33±0.08		0.833 ±.15		1.5±.13*		0.5±0*	
5	1.033 ± 0.02*		3.5±0 .56*		0.667 ±.075		4.167 ±.37*		5.3±.15*		2.17±.2 *		1.07±.02*		1.5±.13*		1±0 *	
10	4.3 ± 0.15*		6.5±0 .129*		1±0*		6.17±0.2*		7±0 *		2.5±.13 *		2.17±.15*		3.83±.075*		1.5±0*	
20	3.67 ± 0.15*		6.5±0 .129*		2.33±.075*		7.67±.15*		8±0 *		2.5±.13 *		2.667 ±.07*		6±.13 *		2±0	

epidemic potential. BLB of rice causes considerable losses in all cultivars of rice in India. Resistance to bacterial blight is one of the most important studies in agro-biodiversity and this will help to develop and grow many resistant cultivars. During 1970s, the survey of rice breeders in 10 Asian countries listed bacterial blight as the second most important disease. There was no yield at all in some places in Kerala with the effect of bacterial blight (Swapan, 2013). Hence it has also become a major problem in many rice growing areas of Kerala (Purushothaman & Rehumath Niza). This epidemic disease was also occurred in Palghat district of Kerala during 1998 and destroyed the crop (Ganamanickam et al., 1999).

The present world population of 6.5 billion is likely to reach 8 billion by 2020. Thus rice production must be improved by making durable resistance to high yielding rice varieties. In Kerala normally hybrid varieties are used for high yield but they lack resistance to biotic and abiotic stresses. Nine different commonly used native rice cultivars of North Kerala were selected because of their resistance to stress. Bharathkumar et al. (2008) improved bacterial blight resistance in two hybrid varieties Jyothi and IR50 via backcross breeding.

Kerala is famous for different varieties of rice which include aromatic, medicinal and those fit for human consumption. Scented rice varieties are famous for their characteristic fragrance when cooked and fetch high market prices. Aromatic rice varieties are famous for their fragrance when cooked and have high market value. Gandhakasala, Jeerakasala and kayama are the main scented varieties of Wayanad. Several rice varieties are used either as medicine or as most important ingredient in medicinal preparations in Kerala. Most of the medicinal rice cultivars in Kerala are lost, some varieties viz.,Chennellu, Njavara, Karuthachembavu, Kunjinellu,etc. are still grown by farmers. Chennellu, red rice, is native to North Kerala. Chennellu with bright red grains, grown as an upland variety in parts of Kannur district is used in treatment of diarrhoea and vomiting, another type of Chennellu known as 'valiya chennellu'with straw coloured grains is grown in wet lands in Wayanad district used to recovering from jaundice (Leena, 2007).

In this study all the plant materials are native rice cultivars in North Kerala. No lesion was observed when the rice seeds were treated with pathogen. This itself shows the resistance of native cultivars. But their morphological parameters discuss that chennellu shows high resistance than the others. Difference in plant height was maximum in Chennellu with an average of 49.67cm in treatment and 37.5 cm in control and the difference between them was 12.17. Difference between treated and control was minimum in Ghandakasala with 35cm as average in treatment and 55cm as average in control.

Then the 45 day old rice leaves were inoculated with supernatant of X.oryzae showed variation in the lesion pattern and this is due to the inherent capacity of developing resistance by the development of various antibacterial proteins by the plants. Chennellu shows least lesion length in all concentrations of pathogen inoculation.

The estimation of total protein content in the leaves of X.oryzae treated rice plants showed an increase in the protein content which was prominent in Chennellu. Similar results were obtained in Fenugreek plants (Singh & Singh, 2010). According to them non inoculated plants exhibited a lesser amount of protein than inoculated plants.

This preliminary study illustrates that Chennellu is a resistant cultivar against bacterial blight. Based on the disease severity the native rice cultivars in Kerala were screened for the study of Pathogenesis related proteins.

Use of native varieties shows high resistance against bacterial blight and this study may lead to defense related genes in crop improvement.

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NEW POST-EMERGENCE HERBICIDES IN RICE FOR YIELD ENHANCEMENT IN WET LANDS

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ABSTRACT

An experiment was conducted at Kole lands in Thrissur district, Kerala to study the efficacy of post emergence herbicides in rice. The results showed that cyhalofop-butyl fs metsulfuron methyl + chlorimuron ethyl, fenoxaprop p-ethyl fs metsulfuron methyl + chlorimuron ethyl and bispyribac sodium were the effective treatments with lower weed dry matter production as well as high grain yield and B:C ratio. Maximum weed control efficiency of 97.1 per cent was obtained in hand weeded plots followed by bispyribac sodium (93.6%). The highest grain yield of 6.13 t/ha was recorded in hand weeded plot, which was on par with cyhalofop-butyl fs metsulfuron methyl + chlorimuron ethyl and fenoxaprop fs metsulfuron methyl + chlorimuron ethyl (5.8 t/ha). From this study it can be concluded that, cyhalofop-butyl fs metsulfuron methyl + chlorimuron ethyl or fenoxaprop p-ethyl fs metsulfuron methyl + chlorimuron ethyl or bispyribac sodium alone can be recommended for effective post emergence weed control and higher yield in wet seeded rice. If grasses are the predominant weeds, cyhalofop-butyl or fenoxaprop p-ethyl alone without follow up spray of metsulfuron methyl + chlorimuron ethyl, can also be recommended.

Key words: Herbicides, wet-seeded rice; post-emergence

1. INTRODUCTION

Crop-weed competition is one of the prime yield limiting biotic constraints in rice. Among the various systems of cultivation of rice, wet-seeded rice (direct-seeding of sprouted seeds in puddled soil) offers a good alternative stand establishment practice to transplanting system. It reduces labour cost and gives yield similar to transplanting, making it more economical. But weed problems are more critical in wet- seeding (Moorthy and Saha, 2002) contributing to a yield loss of 40 to 100 percent (Choubey et al., 2001; Rao et al., 2007). Among the various weed control measures, use of chemical herbicides is the most common practice as it is easier, time and labour saving, and economical compared to hand weeding (Rekha et al., 2003). For controlling mixed flora of weeds emerging simultaneously with wet-seeded rice, applications of herbicides are needed. Hence a viable recommendation would be a single application of a broad spectrum herbicide or a herbicide combination. Continuous use of same herbicide may lead to herbicide resistance in weeds and so the rotational use of different herbicides are essential for effective weed control. So the present study was conducted to evaluate the efficacy of new post emergence herbicides and herbicide combinations for weed control in wet-seeded rice, to find out the most effective herbicide or herbicide combination for cost effective weed control and to assess the response of rice and its major weeds to new herbicides.

2. MATERIALS AND METHODS

A field experiment was conducted during mundakan season (October 2011 to February 2012) in a farmer's field at Alappad in the Kole lands (10^0 31' N latitude and $76^0$13' E longitude and 1m below Mean Sea Level) of Thrissur district using the rice variety Jyothi. The soil was clayey with pH 5.5, organic C 2.1%, available P and K 26 and 281 kg/ha respectively. The experiment comprised of 13 treatments, viz., post emergent spray of metamifop (125 g/ha), metamifop (125 g/ha) with a follow up spray (fs) of carfentrazone ethyl (20 g/ha), metamifop (125 g/ha) with a follow up spray of metsulfuron methyl + chlorimuron ethyl (4 g/ha), cyhalofop-butyl (100 g/ha), cyhalofop-butyl (100 g/ha) with a follow up spray of metsulfuron methyl + chlorimuron ethyl (4 g/ha), fenoxaprop-p-ethyl (60 g/ha), fenoxaprop-p-ethyl (60 g/ha) with a follow up spray of metsulfuron methyl + chlorimuron ethyl (4 g/ha), fenoxaprop-p-ethyl (60 g/ha) with a follow up spray of ethoxysulfuron (15 g/ha), bispyribac sodium (30 g/ha), penoxsulam (25 g/ha), azimsulfuron (35 g/ha), unweeded control and hand weeded control. The trial was laid out in Randomized Block Design with three replications.

All herbicides were sprayed at 20 days after sowing (DAS) with follow up spray on next day using knapsack sprayer. Data on weed biomass and N, P and K content of weeds (at 30 DAS, 60 DAS and harvest) were recorded. Biometric observations, yield attributes, weed control efficiency (WCE), weed index (WI) and economics of production were also recorded. The prevailing labour charge in that locality, costs of inputs and extra treatment costs were taken together and gross expenditure was computed and expressed in Rupees per hectare. The price of paddy and that of straw at current local market prices were taken as total receipts for computing gross return and expressed in Rupees per hectare. Benefit cost ratio was worked out by dividing the net return with total expenditure per hectare. Data on weed biomass, which showed wide variation, was subjected to square root transformation $\sqrt{(x+0.5)}$ to make the analysis of variance valid (Gomez and Gomez, 1984). Multiple comparisons among treatment means, where the F test was significant (at 5% level), were done with Duncan's Multiple Range Test (DMRT).

3. RESULTS AND DISCUSSION

Major weed species found in experimental plot were grasses which comprised of Echinochloa colona, Echinochloa crus galli, Echinochloa stagnina and Leptochloa chinensis. Ludwigia perennis, Lindernia crustacea, Monochoria vaginalis, Sphaeranthus indicus and Alternanthera sp. were the broad leaved weeds and Fimbristylis mileacea, Cyperus iria and Cyperus difformis were the sedges present. The results showed that grasses were the dominant weed flora followed by broad leaved weeds and sedges (Fig 1).Weed biomass production to the tune of 33-38 kg/ha was registered in plots sprayed with fenoxaprop p-ethyl, metamifop and cyhalofop-butyl at 30 DAS. The highest weed dry weight of 350 kg/ha was recorded in unweeded control. By 60 DAS, weed dry weight quadrupled in unweeded control to 1300 kg/ha and the lowest accumulation of dry matter (43 kg/ha) was noticed in hand weeded plots followed by bispyribac sodium (129 kg/ha) (Table 1). The treatments metamifop fs metsulfuron methyl + chlorimuron ethyl, cyhalofop-butyl, metamifop fs carfentrazone ethyl, azimsulfuron and metamifop alone were at par with weed biomass ranging between 321-345 kg/ha. At the time of harvest also, weed biomass was minimum (65.33 kg/ha) in hand weeded plots followed by 146 kg/ha in bispyribac sodium. There was an increase in dry weight from 1300 to 2280 kg/ha in unweeded plot. The treatments cyhalofop-butyl fs metsulfuron methyl + chlorimuron ethyl and fenoxaprop p-ethyl fs metsulfuron methyl + chlorimuron ethyl were the next best treatments with lower weed biomass production.

With respect to nutrient uptake by weeds, very low N uptake of 1.5 kg/ha was noticed in bispyribac sodium sprayed plots at 60 DAS which was only one-twelfth of the uptake registered in unweeded control. Maximum uptake of 41 kg/ha was observed in unweeded control at the harvesting stage of the crop which was double the uptake at 60 DAS. Minimum uptake of 0.6 kg/ha was noticed in hand weeded plot followed by 1.6 kg/ha in bispyribac sodium. The treatments fenoxaprop p-ethyl fs metsulfuron methyl + chlorimuron ethyl, cyhalofop-butyl fs metsulfuron methyl + chlorimuron ethyl and fenoxaprop p-ethyl registered next lower values (N uptake of 3-4 kg/ha) and the treatments hand weeded control as well as bispyribac sodium recorded lower P uptake of 0.1 and 0.4 kg/ha, respectively. With respect to K uptake, the treatments fenoxaprop p-ethyl fs metsulfuron methyl + chlorimuron ethyl and bispyribac sodium were on par with 1.8 and 1.6 kg/ha respectively.

At 30 DAS, the highest number of tillers was in handweeded plot which was on par with penoxsulam, fenoxaprop p-ethyl fs metsulfuron methyl + chlorimuron ethyl, cyhalofop-butyl, fenoxaprop p-ethyl fs ethoxysulfuron and metamifop fs carfentrazone ethyl. However at 60 DAS, tiller count in hand weeded control ($592/m^2$) was significantly superior to all other treatments (Table 2).

Maximum number of productive tillers was also recorded in hand weeded treatment (215/m^2) and minimum was noticed in unweeded control with 156/m^2. The treatments cyhalofop-butyl fs metsulfuron methyl + chlorimuron ethyl and fenoxaprop p-ethyl fs metsulfuron methyl + chlorimuron ethyl were the next best treatments and were statistically on par with each other. Maximum grains/panicle (112) was recorded in hand weeded treatment as well as in cyhalofop-butyl fs metsulfuron methyl + chlorimuron ethyl (Table 2). The panicles in unweeded control plot registered 91 grains/panicle where as it was 96 per panicle for fenoxaprop p-ethyl + ethoxysulfuron which were comparable statistically. There was no significant difference between treatments for 1000 grain weight (test weight). The test weight was in the range of 28.33 to 30.67g.

The highest grain yield of 6.13 t/ha was recorded in hand weeded plot which was on par with cyhalofop-butyl fs metsulfuron methyl + chlorimuron ethyl and fenoxaprop fs metsulfuron methyl + chlorimuron ethyl (5.8 t/ha) and lowest yield of 4.03 t/ha was obtained in unweeded control (Table 2). Abraham et al. (2012) also reported about the efficacy of fenoxaprop in direct seeded rice. In the case of straw, the highest yield was obtained in hand weeding with 5.83 t/ha and lowest in unweeded control with 4.37 t/ha.

Among different treatments, maximum B: C ratio of 1.8 was obtained in cyhalofop-butyl fs metsulfuron methyl + chlorimuron ethyl, fenoxaprop p-ethyl fs metsulfuron methyl + chlorimuron ethyl, bispyribac sodium and fenoxaprop p-ethyl alone. Although hand weeding resulted in a net profit of Rs.63,075/-/ha, due to high cost of cultivation (Rs.45,825/-/ha) the B:C ratio was reduced to 1.4 and the least B:C ratio of 1.2 was noted in unweeded control.

The treatments cyhalofop-butyl fs metsulfuron methyl + chlorimuron ethyl and fenoxaprop p-ethyl fs metsulfuron methyl + chlorimuron ethyl showed the lowest weed index of 5.2 followed by bispyribac sodium (6.1). Maximum weed control efficiency of 97.1 percent was obtained in hand weeded plots followed by bispyribac sodium (93.6%) and fenoxaprop p-ethyl fs metsulfuron methyl + chlorimuron ethyl (90%). Ramachandiran and Balasubramanian (2012) also reported about the higher weed control efficiency of fenoxaprop p-ethyl fs metsulfuron methyl + chlorimuron ethyl in aerobic rice.

From this study it can be concluded that, cyhalofop-butyl fs metsulfuron methyl + chlorimuron ethyl or fenoxaprop p-ethyl fs metsulfuron methyl + chlorimuron ethyl or bispyribac sodium alone can be recommended for effective post emergence weed control and higher yield in wet seeded rice. If grasses are the predominant weeds, cyhalofop-butyl or fenoxaprop p-ethyl alone without follow up spray of metsulfuron methyl + chlorimuron ethyl, can also be recommended.

Table 1: Effect of various post emergence herbicides on weed biomass and nutrient uptake by weeds

Treatments	Weed biomass (kg/ha)			N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)		
	30 DAS	60 DAS	Harvest	30DAS	60DAS	Harvest	30DAS	60DAS	Harvest	30DAS	60DAS	Harvest
Metamifop	*6.09^{b} (36.67)	17.94^{d} (321.33)	18.22^{d} (332.00)	*1.19^{bc} (0.93)	2.02^{d} (3.59)	2.21^{fg} (4.43)	*0.76^{c} (0.09)	1.20^{b} (0.96)	1.22^{e} (1.0)	*1.30^{b} (1.19)	2.28^{de} (4.71)	2.19^{g} (4.30)
Metamifop fs carfentrazone ethyl	0.71^{c} (0)	18.35^{cd} (336.33)	21.44^{c} (459.33)	0.71^{d} (0)	2.17^{bc} (4.24)	2.57^{cd} (6.15)	0.71^{c} (0)	1.14^{d} (0.80)	1.35^{c} (1.33)	0.71^{c} (0)	2.42^{bc} (5.37)	2.79^{de} (7.30)
Metamifop fs metsulfuron methyl+ chlorimuron ethyl	0.71^{c} (0)	18.59^{c} (345.00)	21.11^{c} (445.33)	0.71^{d} (0)	1.93^{e} (3.23)	2.67^{bc} (6.68)	0.71^{c} (0)	1.08^{f} (0.67)	1.35^{c} (1.33)	0.71^{c} (0)	2.22^{e} (4.45)	2.67^{e} (6.67)
Cyhalofop-butyl	6.25^{b} (38.67)	18.59^{c} (345.00)	19.24^{d} (370.00)	1.21^{b} (0.97)	2.16^{c} (4.17)	2.35^{cf} (5.05)	0.92^{b} (0.38)	1.10^{e} (0.72)	1.27^{d} (1.13)	1.32^{b} (1.23)	2.45^{b} (5.51)	2.67^{e} (6.64)

Cyhalofop-butyl fs metsulfuron methyl+ chlorimuron ethyl	0.71^{c} (0)	13.24^{f} (175.00)	16.5^{e} (272.00)	0.71^{d} (0)	1.76^{f} (2.62)	1.98^{h} (3.45)	0.71^{c} (0)	0.85^{j} (0.22)	1.14^{f} (0.81)	0.71^{c} (0)	1.61^{g} (2.09)	2.50^{f} (5.77)
Fenoxaprop p-ethyl	5.81^{b} (33.33)	15.38^{e} (236.00)	18.22^{d} (332.00)	1.11^{c} (0.74)	1.75^{f} (2.58)	2.12^{gh} (4.0)	0.77^{c} (0.10)	0.98^{g} (0.47)	1.21^{e} (0.93)	1.27^{b} (1.12)	1.85^{f} (2.93)	2.46^{f} (5.60)
Fenoxaprop p-ethyl fs metsulfuron methyl+ chlorimuron ethyl	0.71^{c} (0)	12.46^{g} (155.00)	15.08^{f} (227.33)	0.71^{d} (0)	1.58^{g} (2.0)	1.94^{h} (3.27)	0.71^{c} (0)	0.90^{h} (0.31)	1.07^{g} (0.65)	0.71^{c} (0)	1.51^{h} (1.81)	2.28^{g} (4.73)
Fenoxaprop-p-ethyl fs ethoxysulfuron	0.71^{c} (0)	19.56^{b} (382.00)	21.73^{c} (472.00)	0.71^{d} (0)	2.25^{b} (4.58)	2.48^{de} (5.66)	0.71^{c} (0)	1.17^{c} (0.87)	1.39^{c} (1.43)	0.71^{c} (0)	2.41^{bc} (5.33)	2.91^{cd} (8.0)
Bispyribac sodium	0.71^{c} (0)	11.39^{h} (129.33)	12.07^{g} (146.00)	0.71^{d} (0)	1.40^{h} (1.48)	1.46^{i} (1.66)	0.71^{c} (0)	0.87^{i} (0.26)	0.94^{h} (0.40)	0.71^{c} (0)	1.45^{h} (1.63)	1.53^{h} (1.86)
Penoxsulam	0.71^{c} (0)	19.56^{b} (382.00)	23.23^{b} (539.33)	0.71^{d} (0)	2.25^{b} (4.58)	2.74^{bc} (7.03)	0.71^{c} (0)	1.12^{e} (0.76)	1.44^{b} (1.60)	0.71^{c} (0)	2.24^{e} (4.55)	2.93^{c} (8.10)
Azimsulfuron	0.71^{c} (0)	18.31^{cd} (335.00)	23.35^{b} (544.67)	0.71^{d} (0)	2.20^{bc} (4.37)	2.84^{b} (7.60)	0.71^{c} (0)	1.15^{d} (0.83)	1.46^{b} (1.63)	0.71^{c} (0)	2.34^{cd} (5.01)	3.11^{b} (9.23)
Unweeded control	18.71^{a} (350.00)	36.06^{a} (1300.00)	47.75^{a} (2280.00)	2.99^{a} (8.50)	4.32^{a} (18.20)	6.44^{a} (41.04)	1.09^{a} (0.70)	1.93^{a} (3.25)	2.70^{a} (6.84)	2.96^{a} (8.23)	4.17^{a} (16.90)	6.62^{a} (43.33)
Handweeded control	0.71^{c} (0)	6.59^{i} (43.00)	8.11^{h} (65.33)	0.71^{d} (0)	0.98^{i} (0.47)	1.05^{j} (0.61)	0.71^{c} (0)	0.76^{k} (0.08)	0.78^{i} (0.11)	0.71^{c} (0)	1.00^{i} (0.51)	1.08^{i} (0.68)

*√x+0.5 transformed values, Original values in the parentheses. In a column, means followed by common letters do not differ significantly at 5% level in DMRT. DAS – Days after sowing. fs - follow up spray

Table 2: Effect of treatments on tiller count, yield attributes, yield, weed index (WI) and weed control efficiency (WCE)

Treatments	Tiller count 30DAS (No./m^2)	Tiller count 60DAS (No./m^2)	Panicles (No./m^2)	Filled grains/ panicle (No.)	1000 grain weight (g)	Grain Yield (t/ha)	Straw Yield (t/ha)	WI	WCE (%)
Metamifop	230.0^{d}	530.0^{de}	187.00^{de}	102.00^{abc}	29.67	5.13^{ef}	5.60^{abcd}	16.3^{bc}	85.4^{e}
Metamifop fs carfentrazone ethyl	252.0^{ab}	541.7^{cd}	187.33^{de}	109.00^{ab}	29.33	5.20^{def}	5.37^{def}	15^{bcd}	79.8^{f}
Metamifop fs metsulfuron methyl + chlorimuron ethyl	244.3^{bc}	554.0^{bc}	189.00^{d}	102.00^{abc}	29.33	5.50^{bcd}	5.20^{ef}	9.9^{def}	80.5^{f}
Cyhalofop-butyl	255.0^{ab}	524.7^{de}	191.33^{cd}	101.67^{bc}	29.33	5.37^{cde}	5.47^{cde}	12.3^{cde}	83.8^{e}
Cyhalofop-butyl fs metsulfuron methyl + chlorimuron ethyl	232.0^{d}	556.0^{bc}	196.33^{bc}	112.00^{a}	28.33	5.80^{ab}	5.67^{abc}	5.2^{fg}	88^{d}
Fenoxaprop p-ethyl	244.3^{bc}	527.0^{de}	191.00^{cd}	105.00^{abc}	29.67	5.60^{bc}	5.17^{f}	8.4^{ef}	85.4^{e}
Fenoxaprop p-ethyl fs metsulfuron methyl + chlorimuron ethyl	258.7^{a}	554.7^{bc}	198.33^{b}	110.00^{ab}	30.67	5.80^{ab}	5.10^{f}	5.2^{fg}	90^{c}
Fenoxaprop-p-ethyl fs ethoxysulfuron	254.0^{ab}	509.7^{e}	182.33^{e}	96.00^{cd}	29.33	5.10^{ef}	5.80^{ab}	16.6^{bc}	79.3^{f}
Bispyribac sodium	235.3^{cd}	564.3^{b}	191.00^{cd}	105.67^{abc}	29.33	5.73^{b}	5.37^{def}	6.1^{f}	93.6^{b}
Penoxsulam	257.33^{a}	554.3^{bc}	190.67^{cd}	100.00^{bcd}	28.67	5.33^{cde}	5.50^{cd}	12.9^{cde}	76.3^{g}
Azimsulfuron	229.0^{d}	517.3^{e}	175.33^{f}	100.33^{bcd}	29.33	4.90^{f}	5.53^{bcd}	19.9^{b}	76.1^{g}
Unweeded control	230.7^{d}	394.0^{f}	156.67^{g}	91.00^{d}	29.33	4.03^{g}	4.37^{g}	33.8^{a}	-
Handweeded control	260.7^{a}	592.0^{a}	215.00^{a}	112.00^{a}	29.00	6.13^{a}	5.83^{a}	-	97.1^{a}

In a column, means followed by common letters do not differ significantly at 5% level in DMRT. fs - Follow up spray

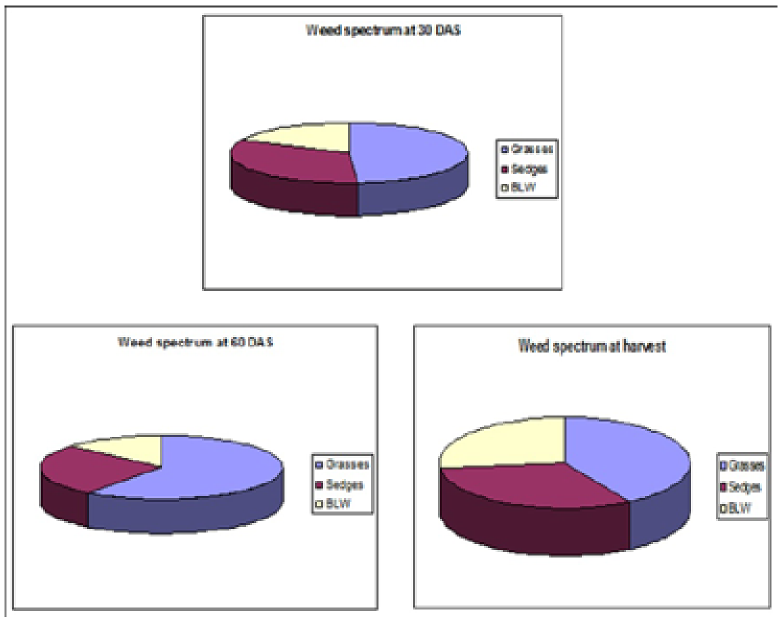

Fig. 1: Dynamics of weed spectrum in the experimental plot at various stages of the crop in unweeded control

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BIOLOGY AND HOST RANGE OF CALLOSOBRUCHUS ANALIS AND THEIR MANAGEMENT THROUGH INDIGENOUS PLANT EXTRACTS

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ABSTRACT

Pulse beetle, Callosobruchus analis (Fab.) is one of the most destructive pests of stored pulses in India. The present study revealed that use of phytochemicals extracted from native aromatic plants (Lantana camara, Eupatorium odoratum, Azadirachta indica and Clerodendrum infortunatum) is perceived as a promising alternative to protect legumes. The biology and the host preference study of C. analis on five pulse grains (Bengal gram, Green gram, Green pea, Cowpea, Black gram) revealed that the larval developmental period had an influence on the hosts. Bengal gram, cowpea and green pea, thus showed the highest ovipositional preference. Although C. analis deposited eggs on black gram, it failed to complete its life stages effectively. The growth index values cowpea and green grams are the most susceptible legume seeds and thus the most suitable hosts for C. analis. Quantitative and physical properties of the pulses revealed that seed density, total weight, swelling capacity and seed viability were reduced in infested seeds than in the uninfested seeds. The insecticidal principles isolated from L. camara, Eupatorium odoratum, Azadirachta indica and Clerodendrum infortunatum were established. The 5% ethyl acetate and hexane extract of Eupatorium and Lantana treatment, proved better than neem and control. From the present study, it is recommended that farmers have to be advised not to store cowpea and green gram seeds in the same place and/or at the same time to avoid cross infestation because of their high susceptibility to C. analis and the 5%ethyl acetate and hexane extract of eupatorium and lantana treatment can be used effectively against C. analis.

Key words: pest, stored pulses, plant extracts, treatment, larva

1. INTRODUTION

India stands among top three in terms of production of various agricultural commodities like paddy, wheat, pulses, groundnut, rapeseeds, fruits, vegetables, sugarcane, tea, jute, cotton, tobacco leaves, etc. (GOI, 2008-09). Among these, pulses are one of the important segments of Indian Agriculture after cereals and oilseeds. As a basic and appreciated food, pulses are also the cheapest food which provides proteins to most of the rural people. Cereal grains as well as pulses are usually attacked in stores by different insect pests.

Beetles belonging to the family Bruchidae (CalIosobruchus sp.) are the most important insect pests of stored legumes. Infestation by bruchids causes losses of weight, nutritional value and germination potential, and therefore the commercial value of the commodity may be reduced (Southgate 1978; Dick and Credland, 1986a). Almost aIl the varieties of different pulses have been reported to be infested by this beetle (Singh et al., 1980). The biology of pulse beetle, CalIosobruchus sp. on various stored pulses was earlier investigated by different workers (Singh and Kumari, 2000; Mandal et al., 2003)

Over years, chemical pesticides had made a great contribution to the fight against pests and diseases. However, history also shows that overzealous use of synthetic insecticides led to numerous problems unforeseen at the time of their introduction: acute and chronic poisoning of applicators, farm workers, and even consumers; destruction of fish, birds and other wild life; disruption of natural biological control and pollination; extensive ground water contamination, potentially threatening human and environmental health and the evolution of resistance to pesticides in pest populations.

Extracts from different plants have been confirmed useful against a wide range of insect pests (Sarwar et al., 2012). The application of biopesticides should be encouraged because of greater environmental protection and food safety concerns. Plant products have proved useful in industrialized countries for the protection of grain from storage pests, but these can also play a much greater role in the production and post harvest protection of food in developing countries. Such botanicals used have well-known volatile and act as natural fumigants that kill adult pests and their progeny (Sarwar et al., 2012). Considering the economic significance of gram, the severity of damage caused and the problems associated with the use of synthetic insecticides, need was felt to evaluate natural methods for the control of C. analis in storage. The present study investigated the efficacy of botanical insecticides against C. analis for a sustainable pest control strategy.

2. MATERIALS AND METHODS

The bruchid infested cowpeas were collected from the local grain market. The insect cultures were maintained in cowpea (Vigna unguiculata) at a constant temperature of 30 ± 2°C and 70±5% rh. The biology of pulse beetle C. analis was carried out under laboratory conditions on cowpea during March to June, 2014. The morphological characters, fecundity, mating time duration of development was noted.

Healthy seeds of different pulses viz., cowpea, green gram, black gram, Bengal gram, and green peas were collected from a supermarket. The insects were reared in the above mentioned seeds. The ovipositional preference, mean developmental period and per cent adult survival in different pulses were observed and recorded. Ten replications were maintained for the experiment.

The growth index (G. I) of bruchids reared on different pulses was determined using the formula: G.I = log S/T, where, S is the percentage of emerged adults and T = mean developmental time.

The per cent weight loss was calculated by using the following formula (Adams and Schulten, 1978).

Percent weight loss = U (Nd) -D (Nu) × 100

U (Nu+Nd)

Number of damaged seeds (Nd), number of undamaged seeds (Nu), weight of damaged seeds (D), weight of undamaged seeds(U)

The percent germination was computed according to Ogendoet al. (2004) as follows:

Viability index (%) = (NG x 100)

TG

Where NG= number of seeds germinated and TG = total number of seeds tested in each Petri dish.

Bio-assays

The plant species used in the experiments Lantana camara, Azadirachta indica, Eupatorium odoratum and Clerodendrum infortunatum collected from the field were shade dried, powdered and sieved to obtain the finest particles. The powder (100g) was then extracted with 500ml solvents (Hexane, ethyl acetate and water) with various polarities. The solvent was removed by filtration after 48 hours. Extracts were allowed to evaporate to get residue. It was dried and weighed and re-dissolved in known volume of respective solvents. Adults of C. analis were exposed with various increasing concentrations of each plant extracts separately. For this purpose, separate filter paper strips (3.5 cm) were coated with different concentrations (5 and 10%) of plant extracts were placed in the plastic bottles of 100ml capacity. The coated filter paper strips were air-dried before application. Only solvent treated filter papers were strips used to set control. Ten adult insects were released in the plastic bottles (100ml). For each extract, two different concentrations were used and for each concentration three replicates were set. Mortality in C. analis was recorded after 24 hr. The weevils were considered dead when there was no response after verifying from the abdomen by touching with a pin.

3. RESULTS

Copulating males were attached firmly to females by their genitalia. Females usually start to kick males about 3-7 min after mating. Mating lasts for 6-7 minute. In C. analis second mating observed 10 min after the first mating.

The oviposition period in C. analis was 6.33± 0.57days. The fecundity of C. analis was 67.33±2.88. In C. analis the egg laying started 20 min after first mating. Usually one to three eggs was laid over an individual seed. The number of eggs per seed depends upon the availability of resources and size of the seed.

The mean incubation period was 4.66±0.57 days for C. analis. Most of the eggs are hatched at the fifth day after oviposition. The C-shaped larvae look like short cream-coloured maggots hatched out from the egg. The first instar larva enters into the seed cotyledon through seed coat. The second instar larvae increase its size and weight. They voraciously feed cotyledons and took more time for completing its second instar.

The third instar larva was similar to the second instar except for size and shape. The third and fourth larval instar periods were short. The fourth instar period was shortest. The fourth instar larvae moulted into pupae. However, prior to pupation larvae excavate a pupal chamber just below the seed surface, visible as a small transparent window in the seed coat. The female emerged first and the male emerged out only one or two days after the female emergence from the seed. The percentage of emergence was noted and was 55.31±4.64 %. The sex ratio of C. analis was 1:1.8.

The larval development was completed within 13.00 ±1.00 days. The pupal period for the insects was observed as 6.33±0.57 days. The total time for the development was noted as 25.00±1.00 days. The female life span (7.33±0.57 days) and male life span (5.66±0.57 days) were significantly differed and the females live 2 or 3 days more than male.

Ovipositional preference of C. analis on different pulses was shown in Fig.1. Among the selected pulses, the green pea recorded significantly the lowest of 6.0 ±1.00 eggs /100 g seeds whereas significantly higher number of eggs (27.33 ± 1.52 eggs /100 g of seeds) was observed in green pea.

The developmental period ranged from 24.67 ± 2.08 to 34.33 ±1.15 days in different pulses (Fig.1). Among the selected pulses, the Green gram recorded significantly the lowest developmental period (24.67 ± 2.08 days) which was on par with Cowpea. Inblack gram a maximum of 34.33 ±1.15 days developmental period was observed. The result revealed that the green gram is the most preferred host for the insects. The incubation period and the pupal period were not significantly differing among the pulses (Fig.1). The highest larval period was taken by the insects developed in the black gram (21.67±1.15 days) and lowest recorded in the green gram (14.67±0.57days).

In C. analis, the mean adult survival among different pulses ranged from 4.49±1.28 to 62.76±2.42 per cent. Black gram recorded significantly lowest adult emergence of 4.49±1.28 per cent. The highest adult emergence recorded on green gram (62.76±2.42%) followed by cowpea (53.24±1.68%).

The significant difference was observed in the growth index of the insects developed in various pulses. The highest growth index was recorded in the insects developed from the green gram (0.40±0.03) and was followed by cowpea 0.31±0.01. Significantly lowest growth index was recorded in the insect developed from black gram (-0.89±0.14), bengal gram (-0.04±0.01) and green peas (-0.13±0.03) (Table 1).

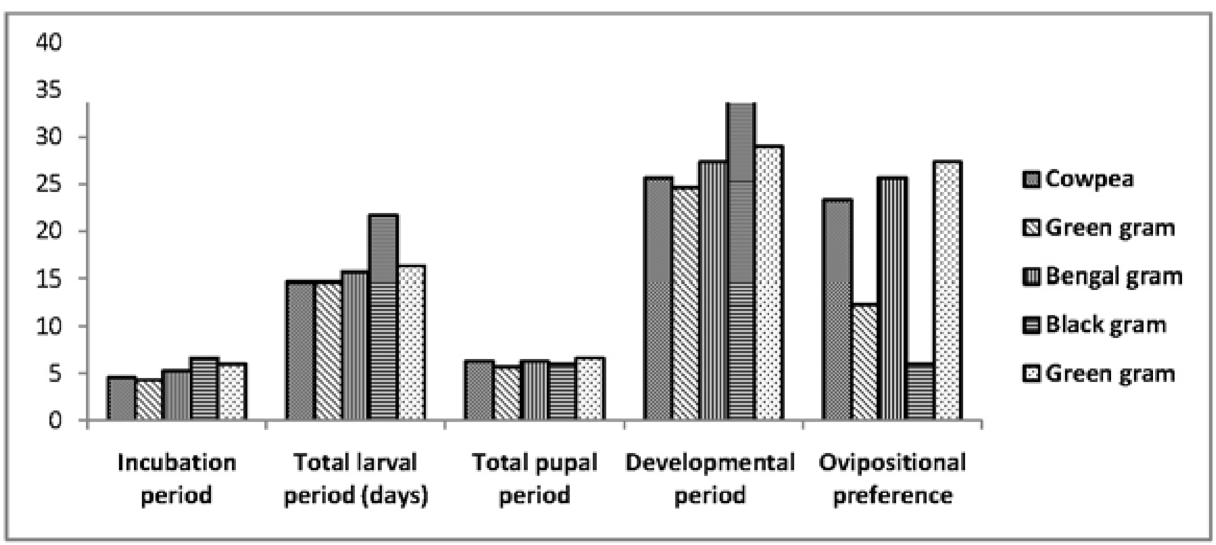

Fig 1: Host preference of C.analis under laboratory conditions.

Table 1: Weight loss, Adult emergence, and Growth index of C. analis

Host	Weight loss of seeds (%)	Percentage of emergence	Growth index
Bengal gram	18.34±1.48[c]	24.74±1.62[b]	-0.04±0.01[d]
Green gram	28.56±0.68[d]	62.76±2.42[d]	0.40±0.03[e]
Green peas	9.83±0.77[b]	21.26±1.54[b]	-0.13±0.03[c]
Cowpea	25.78±0.56[d]	53.24±1.68[c]	0.31±0.01[b]
Black gram	4.25±1.48[a]	4.49±1.28[a]	-0.89±0.14[a]

The Duncan's Multiple Range Test (P<0.05) was used and the significant differences in each column are indicated by different letters. There were 6 replicates for each variable (mean ± SE).

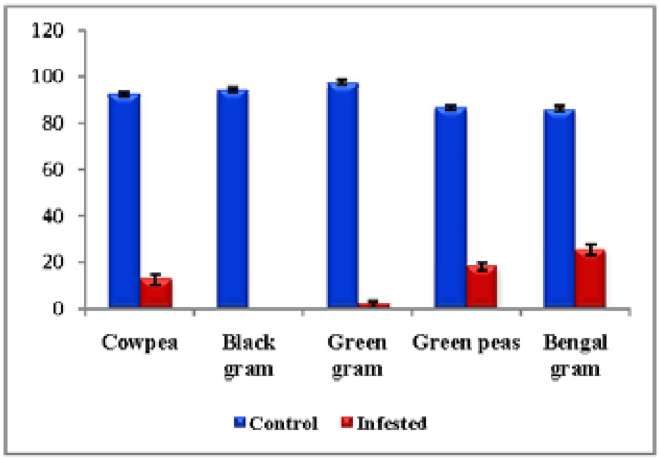

Fig 2: Germination of pulse seeds due to the infestation by C. analis

As a result of the feeding activities of the weevils, weight loss was recorded end of the first generation. Among the pulses maximum seed damage of 28.56±0.68 % was found in green gram followed by cowpea 25.78±0.56 and minimum seed damage was observed in black gram (Table 1). The present study revealed that maximum damage caused by the feeding of grubs of the pest was incurred in green gram and cowpea seeds. Further it was also observed during the study that the number of grains with more than one egg was very small.

The percentage seed viability of different pulses infested by different C. analisis recorded (Fig 2). The Callosobruchus infestation significantly affects the seed viability. The data obtained showed that infestation of pulse seeds with different Callosobruchus species reduced seed germination significantly, the infested black gram not germinated. The infested Bengal gram, green peas and soybeans germinated some extent.

Bio-assay of phytochemicals

Among the hexane extract, the lantana gave the highest mortality (20.0±10.0%) after 24 hrs exposure. when the concentration was doubled the mortality increased to 20%. And when the 5% clerodendron extract treated no mortality observed after 24 h. But when the concentration increased, the percentage of mortality also increased. The ethyl acetate extract gives the highest mortality among all the treatments. The ethyl acetate extract of lantana gave highest percentage of mortality (56.7±5.77) among treatment. The lowest mortality observed in the neem extract. In all treatments the percentage of mortality of control and in the aqueous extracts are 0.0±0.0 (Table 2).

4. DISCUSSION

Although several species of Bruchids are known to damage grains of legumes, the C. analis show greater specificity to attack stored pulses (Krishnamurthy and Rao, 1950). The mean incubation period obtained was 4.66±0.57 days in the present study. These results are also in agreement with Butani et al. 2001; Varma and Anandhi (2010). The eggs laid by C. analis were 85.76 per cent viable. This result corporated with Raghvani (1986) and Singh and Kumari (2000). Varma and Anandhi (2010) reported fecundity in C. chinensis 85.6 of eggs which are different from the present study (67.33). Butani et al. (2001) recorded a C. chinensis single female laid as many as 97 eggs during its life span.

Table 2: Bioactivity of hexane and ethyl acetate extracts on C. analis

Plant	Concentration	Percentage of mortality	
		Hexane	Ethyl acetate
Eupatorium odoratum	5%	6.67±5.77	36.67±5.77
	10%	13.33±5.77	43.33±5.77
Lantana camara,	5%	13.3±5.77	23.33±5.77
	10%	20.0±10.0	56.7±5.77
Azadirachtaindica	5%	3.33±5.77	20.0±10.0
	10%	13.3±5.77	36.67±5.77
Clerodendruminfortu-natum	5%	0.0±0.0	0.0±0.0
	10%	3.33±5.77	6.67±5.77

Host preference study of Callosobruchus sp. revealed that strong oviposition preference exhibited for Bengal gram seeds followed by green peas this may be due to large grain size. Applebaum et al. (1970) reported that Callosobruchus sp. is known to prefer to feed and develop on cowpea as their main hosts. Maximum adults were seen emerging from stored green gram seeds. The results of the present study were more or less similar to the findings of Singh (1997), Singh and Kumari (2000). This probably eliminated the physical barriers and indicates a high toxicity and/or a low nutritional value as the cause of death

From this study, it can be concluded that seeds of cowpea and green gram are the most susceptible legume seeds and thus the most suitable hosts for C. analis. These hosts had highly oviposited and percent adult emergence, the shortest developmental period, highest growth index and largest weight loss. Conversely, black gram and green beans seeds were found to be less susceptible. From host study, it may recommended that farmers have to be advised not to store cowpea and green gram seeds in the same place and/or at the same time to avoid cross infestation because of their high susceptibility to C. analis.

Pulse seeds suffered the highest weight loss among highly infested seeds. Green peas, Bengal gram, and black gram had the lowest weight losses. The result of the present experiment is comparable with those reported by Dias and Yadav (1988), Ofuya and Bambigbola (1991), Dwivedi and Sharma (1993). Weight loss in cowpea seeds was as a result of the larvae eating up the endosperm (Baidoo et al., 2010). The cowpea and green gram seeds being the most susceptible compared to other pulse grains used in the present study. They made use of the dry matter from the seeds thereby reducing the weight of pulses.

The infestation of grains influences the viability of the seed. The infested green pea and black gram sees did not germinate. This is due to the consumption of endosperm by larvae or damaging the plant embryo. The percentage of infestation decreases the viability increases.

The present laboratory results clearly demonstrated that various botanical extract containing certain volatiles/ alkaloids adversely affected the survival of the weevil C. analis. Earlier, many plant derived materials were observed possessing repellant and insecticidal activities against the insects of the stored food products (Sukumar, 1993; Desmarchelier, 1993; Coelho et al., 2010). During the present investigations, hexane and ethyl acetate plant extract of Eupatorium and Clerodendron are proved more efficient for the control of C. analis. The sustainable use of these botanical pesticides will boost the food security in those environments where investment in synthetic pest control is uneconomical. However, the promotion of botanicals as an alternative to synthetics must acknowledge that natural product toxicity could be high. Future studies must still confirm whether a botanical treatment can be safely used as a food additive before promotion to farmers.

5. CONCLUSION

Beetles belonging to the family Bruchidae are the major pests of pulses, both in the field on dry seeds and in the warehouses. Among this group Callosobruchus sp. has been identified as the devastating pest on cowpea, lentil, green gram and black gram. Usage of synthetic pesticides to control these pests is highly discouraged because of their adverse effect on human beings and environment. Although a large number of plants in various forms have been screened against major pests of stored grain, thousands are still untouched. The present study confirmed that among the four plants screened, bioactive principles from eupatorium and lantana can effectively use against C. analis.

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IMPACT OF HIGH DENSITY PLANTING IN NENDRAN BANANA IN KERALA

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ABSTRACT

Banana is the major fruit crop of Kerala, which along with plantain occupies 1,07,800 ha of area under cultivation with a total production of 8,37,439 tonnes (FIB, 2013). It is mostly grown by small and marginal farmers either in homesteads or in well drained rice fields. Nendran is the most popular commercial cultivar in Kerala owing to its adaptability to varying environments, yield stability, excellent fruit quality attributes, sustained income and multiple uses ranging from that of a valued food for infants and invalids, to culinary and table purposes as well as diverse processed products. The spatial arrangement of plants in a plantation is very important and usually involves a choice between physiological efficiency and practical utility. Increasing spacing between pits and planting more than one sucker per pit will help to reduce the cost of cultivation and enable intercropping resulting in an enhancement of total returns. In banana, traditionally sword suckers are used for planting in farmer's field. Suckers are usually infected with serious insect pests and diseases. Similarly due to variation in age and size of sucker the crop is not uniform, which results in prolonged harvest. On the other hand tissue culture plants are healthy, disease free and uniform. A research project entitled "Popularization of Tissue culture banana with high tech production Technology" was undertaken at Department of Agronomy, College of Agriculture, Vellayani during the period 2011-2014 with the financial assistance from NABARD. The study was conducted in two years. Treatments included - 2 planting patterns (Double sucker and single sucker/pit) and 2 planting materials (Tissue culture plantlets and normal suckers).Experiment was conducted in 10 farmer's fields in Trivandrum district. Pooled analysis of data showed that tissue culture double sucker planting was the best in terms of yield(t/ha) and it was on par with normal double sucker planting. When individual factor impact was analysed, double sucker planting was found to be significantly superior than single sucker planting and it resulted in 20 percent increased yield than single sucker planting.

Key words: Double sucker planting, tissue culture banana.

1. INTRODUCTION

Banana is an important fruit crop having great socio-economic significance in India. It supports the livelihood of millions of people. It is interwoven with the heritage of the nation and due to its multifaceted uses it is referred to as 'Kalpatharu' (Plant of Virtues) meaning 'herb with all imaginable uses'. It can grow well under a wide range of agro climatic situations, ecological conditions and various systems of production. Banana is the major fruit crop of Kerala, which along with plantain occupies 1,07,800 ha of area under cultivation with a total production of 8,37,439 tonnes (Farm Guide, 2013). It is mostly grown by small and marginal farmers either in homesteads or in well drained rice fields. Its year round availability, affordability, varietal range, taste, nutritive and medicinal value makes it the favourite fruit among all classes of people. It has also good export potential.

Nendran is the most popular commercial cultivar in the State owing to its adaptability to varying environments, yield stability, excellent fruit quality attributes, sustained income and multiple uses ranging from that of a valued food for infants and invalids, to culinary and table purposes as well as diverse processed products. The spatial arrangement of plants in a plantation is very important and usually involves a choice between physiological efficiency and practical utility. Increasing spacing between pits and planting more than one sucker per pit will help to reduce the cost of cultivation and enable intercropping resulting in an enhancement of total returns. In banana, traditionally sword suckers are used for planting in farmer's field. Suckers are usually infected with serious insect pests and diseases. Similarly due to variation in age and size of sucker the crop is not uniform, which results in prolonged harvest. On the other hand tissue culture plants are healthy, disease free and uniform. Tissue culture offers a rapid method of multiplication of quality, uniform, pest and disease free production of planting materials in large quantities in banana.

A research project entitled "Popularization of Tissue culture banana with high tech production Technology" was undertaken at Department of Agronomy, College of Agriculture, Vellayani, Kerala, during the period 2011-2013 with the financial assistance from NABARD. The study was conducted in two years. The study was done with the objectives to promote and popularize proven technologies by establishing model farms and to popularize of technology by training farmers.

2. MATERIALS AND METHODS

The study was carried out in Thiruvananthapuram district of Kerala in farmers' fields ie; Kattakkada and Malayinkeezhu panchayaths in first year and Kalliyur and Malayinkeezhu panchayaths in second year. Five farmers were selected from each panchayaths and thus every year ten farmers' fields were selected. Farmers having 20 cents of well drained land were selected and treatments included - 2 planting patterns (Double sucker and single sucker/pit) and 2 planting materials (Tissue culture plantlets and normal suckers). There were four treatments with 5 replications, laid out in RBD. The spacing recommended for normal planting is 2 m x 2 m (2500 plants/ha) and 3 x 2 m with two plants / pit (3332 plants in 1666 pits per ha), for double sucker planting. FYM @ 15-20 kg per plant was applied at the time of land preparation. Lime 1 kg/ plant was applied with the organic manure at the time of land preparation. N: $P_2O_{5:}K_2O$ was given @ 300:115:450 g/plant in six split doses. For double sucker planted banana an additional dose of 1/3 of recommendation for individual plant was given (400:153:600 g NPK/pit). Data on yield and yield attributes were collected and statistical analysis was done field wise and year wise.

3. RESULT AND DISCUSSION

3.1. Yield

Pooled analysis of yield data over five locations and two years showed that the effect of treatments was not significant during first year. But in second year of the study, treatments showed significant influence. Analysis of yield per hectare indicated that high density planting pattern produced maximum yield. Yield in banana is a function of number of bunches per hectare and individual bunch weight. Tissue culture double sucker planting was the best in terms of yield (t/ha) and it was on par with normal double sucker planting. When individual factor impact was analysed, double sucker planting was found to be significantly superior than single sucker planting and it resulted in 20 percent increased yield than single sucker planting. The better effect of high density planting was due to 33 percent more plant in the system thereby increasing productivity. Similar yield improvement in high density planting was reported by Venugopal(2004) , Reddy (1982), Krishnakumary et al. (1995) and Nalina (1999).

Results of this investigation show that cultivating nendran banana with two suckers/pit at a spacing of 3x2 m can improve the yield by about 18 to 22 per cent than normal system. Although banana is a crop belonging to C_3 group of plants, it has tremendous potential to equal or out yield many crop plants belonging to the C_4 group. Being adapted to grow under low light intensities (Samson, 1980), banana plants can withstand shade and hence are highly suitable for high density planting. The conventional practices followed in banana are highly labour and input intensive. From this study it is confirmed that by double sucker planting, we can reduce the cost of cultivation and increase the productivity without affecting the quality of fruits.

Table 1: Pooled analysis of impact of planting material and method on yield (t/ha)

Treatments	Yield(t/ha)	
	I year	II year
NSS	21.56	25.82
NDS	21.35	31.36
TCSS	21.23	28.3
TCDS	24.35	33.42
SE		1.119
CD	NS	3.45

NS-Normal Single sucker NDS- Normal Double Sucker TCSS-Tissue culture Single sucker

TCDS- Tissue Culture Double Sucker

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CASSAVA BASED FODDER ALLEY FARMING SYSTEM FOR FOOD-FODDER SECURITY

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ABSTRACT

An experiment was conducted during the kharif seasons of 2010,2011 and 2012 at College of Agriculture, Vellayani , Kerala in AICRP on forages scheme to find out a cassava based fodder production system and to assess the response of the system to AMF application. Cassava, variety Vellayani Hraswa was raised as the main crop and treatments comprised of three grasses (Bajra- napier hybrid, palisade grass and no grass), two legumes (fodder cowpea and no legume) and two bio fertilizers (AMF and no bio fertilizer). There were twelve treatment combinations replicated thrice in a RBD. Highest cassava yield was recorded in Cassava + AMF. Green fodder yield was maximum in T_2 (Cassava+ Bajra napier hybrid+ fodder cowpea) and it was on par with T_3 (Cassava+ Bajra napier hybrid+ AMF) and T_4(Cassava+ Bajra napier hybrid). Dry fodder yield also showed a similar trend ie; highest dry fodder yield was in T_4(Cassava+ Bajra napier hybrid) and it was found to be on par with T_2 (Cassava+ Bajra napier hybrid+ fodder cowpea) and T_3(Cassava+ Bajra napier hybrid+ AMF).). Maximum green fodder yield of cowpea was recorded in T_9-Cassava + fodder cowpea +AMF and it was found to be on par with T_{10}-Cassava + fodder cowpea. Dry fodder yield also showed same trend.

Key words: alley cropping, bajra napier hybrid, palisade grass, cow pea, cassava, arbuscular mycorrhizal fungi (amf)

1. INTRODUCTION

Due to increased pressure on land for food grain and cash crop production, good quality arable land for feed and fodder production is decreasing. Alley cropping is a method to diversify and intensify production. It is capable of stabilizing productivity and utilizing the resources more efficiently. Cassava is the most important tuber crop of Kerala which forms an integral part of most of the cropping systems of the state. Since the development of cassava in the initial stages is very slow, a sole crop of cassava does not efficiently utilize the available land, light and water during its early development stages. In paired row system of planting, cassava plants never builds up canopy to completely cover the inter space even at its rank growth phase and thus gives increased returns from cassava based intercropping system due to lack of competition with intercrops (Anil kumar, 1984). Intercropping cassava with fodder grasses with extensive fibrous root system helps to reduce soil erosion, leaching of nutrients, and decline in soil fertility.

In Kerala with predominantly acid soils, P fixation is a main problem. Arbuscular Mycorrhizal fungus (AMF), which is a fungus in symbiotic association with roots of crops have the ability to harvest even the unavailable and sparingly soluble forms of soil P and absorb it more readily than roots (Young et al., 1986). With this back ground, this present study was undertaken with the objective to find out a cassava based fodder production system and to assess the response of the system to AMF application.

2. MATERIALS AND METHODS

The experiment was started in kharif, 2010 to find the best alley cropping system based on the crop yields. Cassava, variety Vellayani Hraswa was raised as the main crop. Treatments comprised of three grasses (Bajra- napier hybrid, palisade grass and no grass), two legumes (cowpea and no legume) and two bio fertilizers (AMF and no bio fertilizer). There were twelve treatment combinations replicated thrice in a RBD. Cassava was planted in paired rows with spacing of 60/120 X 90 cm. That is 60 cm between two rows making a pair, 120 cm between two such paired rows and 90cm between plants within a row. Planting tapioca in double rows brings two rows of tapioca more closer and leaves a greater inter space into which the intercrops can be accommodated. Seeds of Bajra- napier hybrid was planted in the channels taken in the alleys of cassava@ one set/hill, at a spacing of 60 X 60 cm. Slips of palisade grass were planted in the alleys of cassava @ 2 slips/hill at a spacing of 60 X 60 cm. Seeds of fodder cowpea were sown @ 2 seeds /hole at a spacing of 30 X 15 cm in the alleys of cassava as well as between the rows of fodder grasses as per the treatments.

The soil of the experiment site was acidic in reaction, medium in available nitrogen, high in available phosphorus and low in available potassium. The experiment was conducted for three years. Data was collected on growth and yield attributes of main and intercrops. Statistical analysis of pooled data of three years was done and the results obtained are given below.

Treatment combinations are

T_1-Cassava+ Bajra napier hybrid+ fodder cowpea+ AMF

T_2-Cassava+ Bajra napier hybrid+ fodder cowpea

T_3-Cassava+ Bajra napier hybrid+ AMF

T_4-Cassava+ Bajra napier hybrid

T_5-Cassava+ Pallisade grass + fodder cowpea +AMF

T_6-Cassava+ Pallisade grass + fodder cowpea

T_7-Cassava+ Pallisade grass + AMF

T_8-Cassava+ Pallisade grass

T_9-Cassava + fodder cowpea +AMF

T_{10}-Cassava + fodder cowpea

T_{11}-Cassava +AMF

T_{12}-Cassava

3. RESULTS AND DISCUSSION

3.1. Height, yield and Harvest index of cassava

Maximum plant height of 114.97 cm of cassava was recorded by cassava + fodder cowpea and it was on par with cassava + AMF(T_{11}). Significantly higher tuber yield of 23.8 t/ha was recorded by cassava + AMF(T_{11}). Highest harvest index of 0.81 was recorded with Cassava +fodder cowpea(T_{10}), Cassava + AMF(T_{11}) and Cassava alone(T12). It was on par with Cassava+ Bajra napier hybrid+ fodder cowpea+ AMF(T_1) and Cassava + fodder cowpea +AMF(T_9).

Cassava + AMF recorded maximum height and it was found to be on par with cassava + cowpea. Inoculation of AMF might have helped cassava for greater utilization of environmental resources which in turn might have resulted in increased plant height. In sole crop plots, since there was no intercrops, cassava plants experienced lesser competition for water, nutrients, light etc. compared to the intercropped plots, where exists a tight competition. Among the alley crops, fodder cowpea plants competed less with cassava plants compared to fodder grasses. This resulted in better growth of cassava plants along with cowpea than with fodder grasses.

Highest cassava yield was recorded in Cassava + AMF. This may be due to the absence of competition in sole crop plots and beneficial effect of AMF. Among the fodder crops grown in alleys, cassava grown along with bajra napier hybrid produced comparatively low yield. This may be due to the high shading effect by the vigorous growth of grass. Among the intercrops, palisade or cowpea is a better fodder component for alley cropping in Cassava. (Table 1)

Table 1: Height, yield and Harvest index of cassava

Treatments	Height at harvest	Yield(q/ha)	Harvest index
T_1	85.45	84.2	0.79
T_2	77.86	93.84	0.78
T_3	90.47	89.62	0.73
T_4	82.35	79.82	0.68
T_5	89.45	124.48	0.77
T_6	86.43	128.98	0.77
T_7	90.45	70.55	0.68
T_8	97.26	94.96	0.70
T_9	96.45	166.68	0.79
T_{10}	114.97	127.91	0.81
T_{11}	112.77	238.45	0.81
T_{12}	108.16	229.47	0.81
CD	4.68	5.5	0.04
SE	1.59	1.87	0.013
CV	1.69	1.46	1.31

3.2. Height, Green fodder yield and dry fodder yield of fodder grass

Grass height was significantly influenced by different treatments and maximum height was recorded with T_1 (Cassava+ Bajra napier hybrid+ fodder cowpea+ AMF) and it was on par with T_2 (Cassava+ Bajra napier hybrid+ fodder cowpea). Green fodder yield was maximum in T_2 (Cassava+ Bajra napier hybrid+ fodder cowpea) and it was on par with T_3 (Cassava+ Bajra napier hybrid+ AMF) and T_4(Cassava+ Bajra napier hybrid).Dry fodder yield also showed a similar trend ie; highest dry fodder yield was in T_4(Cassava+ Bajra napier hybrid) and it was found to be on par with T_2 (Cassava+ Bajra napier hybrid+ fodder cowpea) and T_3(Cassava+ Bajra napier hybrid+ AMF).

Bajra napier hybrid recorded maximum plant height than palisade grass. Bajra Napier hybrid is a clump grass, with erect nature whereas palisade grass is a spreading grass which explains the difference in plant height between two grasses. Inoculation of AMF might have helped the grass for greater utilization of environmental resources which in turn might have resulted in increased plant height. (Kavitha, 1996).

Among the fodder crops, bajra-napier hybrid produced maximum green fodder yield and it can be attributed to the significantly higher plant height and leaf:stem ratio of the grass. Dry fodder yield was also higher in hybrid napier intercropped plots and presence of legume and AMF is found to have a positive impact on fodder yield.(Table 2).

Table 2: Height, Green fodder yield and dry fodder yield of fodder grass

Treatments	Height at harvest	Green fodder yield(q/ha)	Dry fodder yield(q/ha)
T_1	163.88	402.936	58.88
T_2	161.54	424.3	60.27
T_3	156.78	422.28	60.34
T_4	141.24	422.98	61.55
T_5	90.51	213.71	37.03
T_6	83.18	237.2	45.63
T_7	88.75	212.26	40.92
T_8	93.76	222.56	43.51
CD	6.09	11.92	2.44
SE	2.0	3.93	0.8
CV	1.63	1.22	1.57

3.3. Height, Green fodder yield and Dry fodder yield of fodder cowpea

Cowpea recorded maximum length of 92.3cm in T_1 (Cassava+ Bajra napier hybrid+ fodder cowpea+ AMF) and it was on par with T_2 (Cassava+ Bajra napier hybrid+ fodder cowpea). Maximum green fodder yield of cowpea was recorded in T_9-Cassava + fodder cowpea +AMF and it was found to be on par with T_{10}-Cassava + fodder cowpea. Dry fodder yield also showed same results. Highest yield in Cassava + fodder cowpea can be attributed to higher plant population compared to other treatments. Lowest yield in treatments involving bajra-hybrid napier may be due to high competition and shading from the hybrid. (Table 3).

Table 3: Height, Green fodder yield and Dry fodder yield of fodder cowpea

Treatments	Height at harvest	Green fodder field(q/ha)	Dry fodder yield(q/ha)
T_1	92.355	18.08	2.81
T_2	90.3	20.06	2.76
T_5	80.22	24.34	3.35
T_6	76.87	23.07	3.3
T_9	80.6	111.87	15.42
T_{10}	74.31	99.84	14.37
CD	7.09	13.49	0.75
SE	2.25	4.28	0.24
CV	2.72	8.04	3.44

3.4. Crude protein and crude fibre content of fodder grass

Maximum values for crude protein and crude fibre content of grass was recorded in treatment T_6-Cassava+ Pallisade grass + fodder cowpea. Protein content was on par with T_5-Cassava+ Pallisade grass + fodder cowpea +AMF and T_7-Cassava+

Pallisade grass + AMF. Fibre content was on par with T_4-Cassava+ Bajra napier hybrid, T_7-Cassava+ Pallisade grass + AMF and T_8-Cassava+ Pallisade grass. In general palisade grass was found to have higher protein and fibre content than hybrid napier in the alley cropping system. (Table 4).

Table 4: Crude protein and crude fibre content of fodder grass

Treatments	Crude protein (%)	Crude fibre(%)
T_1	6.22	26.3
T_2	6.8	26
T_3	6.16	26.9
T_4	7.04	28.4
T_5	7.63	27.2
T_6	7.88	28.7
T_7	7.56	28.4
T_8	6.77	28.4
CD	0.323	0.681
SE	0.106	0.224
CV	1.51	0.8

3.5. Crude protein and crude fibre content of fodder cowpea

Highest crude protein content of cowpea was recorded in treatment T_2-Cassava+ Bajra napier hybrid+ fodder cowpea and it was found to be on par with T_1- Cassava+ Bajra napier hybrid+ fodder cowpea+ AMF. Crude fibre was maximum in T_5-Cassava+ Pallisade grass + fodder cowpea +AMF and was on par with T_{10}-Cassava + fodder cowpea. (Table 5).

Table 5:Crude protein and crude fibre content of fodder cowpea

Treatments	Crude protein(%)	Crude fibre(%)
T_1	20.04	24.97
T_2	20.43	25.32
T_5	19.8	26.07
T_6	18.47	25.2
T_9	18.1	25.4
T_{10}	18.35	26.0
CD	0.991	0.472
SE	0.314	0.15
CV	1.635	0.588

3.6. Organic carbon, N, P and K status of soil after the experiment

Highest organic carbon content in soil after the experiment was observed in T_2-Cassava+ Bajra napier hybrid+ fodder cowpea and it was found to be on par with T_1-Cassava+ Bajra napier hybrid+ fodder cowpea+ AMF, T_3-Cassava+ Bajra napier hybrid+ AMF, T_6-Cassava+ Pallisade grass + fodder cowpea and T_{11}-Cassava +AMF. Highest N and K status of soil was recorded with T_9- Cassava + fodder cowpea +AMF and highest soil P content was recorded with T_8- Cassava+ Pallisade grass .(Table 6).

Table 6: Organic carbon, N, P and K status of soil after the experiment

Treatments	Organic carbon (%)	N(kg/ha)	P(kg/ha)	K(kg/ha)
T_1	0.82	337.87	42.65	71.45
T_2	0.85	306.92	55.12	78.13
T_3	0.83	365.52	61.18	90.02
T_4	0.67	336.3	60.33	66.65
T_5	0.73	325.55	59.25	105.14
T_6	0.82	339.87	49.2	86.66
T_7	0.75	336.0	43.45	75.68
T_8	0.78	341.78	72.03	92.7
T_9	0.76	368.87	55.45	117.02
T_{10}	0.73	348.56	62.88	101.58
T_{11}	0.82	336.5	57.37	94.37
T_{12}	0.77	331.81	50.4	102.1
CD	0.083	17.22	4.89	9.91
SE	0.028	5.872	1.67	3.38
CV	2.56	1.72	2.9	3.75

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DIVERSITY OF SPIDERS IN TUR AGRO-ECOSYSTEM IN RELATION TO CROP GROWTH AT KATHIAWAR, GUJARAT

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1. ABSTRACT

The crop growth fluctuation in population of some important families of spiders in a Tur (Cajanus cajan) agro-ecosystem of village Simasi of Junagadh district, Kathiawar, Gujarat was studied during July 2012 to February 2013 by standard handpicking, umbrella and pitfall trap method. The data was analyzed for species diversity (H'), evenness and richness. Out of six crop growth stages (i.e. pre-harvesting, sowing, vegetative, flowering, pod formation and ripen seed stage of Tur) the vegetative stage exhibited maximum species diversity. A total of 49 morphospecies of 33 genera from 19 families were reported during the study period.

Key words: Spiders, diversity, index (H'), tur agro-ecosystem, crop stage, Kathiawar, Gujarat

2. INTRODUCTION

The role of spiders in the biogenesis of different agro-ecosystems and their role in controlling pests have been studied by Doane and Dondale (1979), Gupta et al. (1986), Patel and Pillai (1988), Halaj et al. (1999). Spiders are predators of thrips, insect larvae, aphids, plant bugs, leaf hoppers, and flies (Nyffeler and Benz, 1980) in suppressing populations of Green Leaf Hopper, Brown Plant Hopper, White Backed Plant Hopper and also certain dipterans, lepidopterans, coleopterans and orthopterans on paddy (Barrion, 1980). The field experiments have demonstrated that spiders can reduce insect populations and crop damage (Ito et al., 1962) and Satpathi (2004).

The population fluctuations and estimate of diversity of spider species has been studied in rice agro-ecosystem (Sudhirkumar and Sebastian, 2005) and in groundnut (Trivedi, 2009). This work was carried out to study the population fluctuations and species diversity and richness of spider in different crop-growth stages including species composition of Tur (Cajanus cajan L.) agro-ecosystem at village Simasi, Tehsil Mendarda, District Junagadh, Kathiawar, Gujarat.

The field experiment was conducted during July 2012 to February 2013 for eight months from pre harvesting to ripen seed stages of the Tur crop at the village viz Simasi (21^0 21' 51.70^0 N $70^0$23'3.93^0E, 47m MSL) of Mendarda Tehsil, Junagadh District, located near South-west of Peninsular Kathiawar in Gujarat state. The climate is tropical semiarid with four distinct seasons: monsoon (June to September) and post monsoon (October and November), winter (December to February), summer (March to May). The monsoon usually starts in mid-June and ends in September in district Junagadh. An annual rainfall during 2012 was 425 mm and highest maximum and lowest minimum temperature was recorded 42.30^0C and 3.5 ^{0}C respectively (Sahu et al., 2013). Tur (Cajanus cajan L.) crop – Vaishali (seed variety and annual) was usually sown in july in Kathiawar. Tur was sown in total area 16,950 sqm (Length113mXwidth 75m of each farm-1 & 2) of black soil topography. Area shows fully irrigation by well and bore. Tur or Pigeon peas are very drought resistant, so can be grown in areas with less than 650 mm annual rainfall.

3. MATERIALS AND METHODS

Spiders were collected twice a week (4visits/week), a total of 61 visits (Farm 1 & 2 of each 8,475 sqm); areas were equally divided into 06 plots (37x37meters), using a total 20 quadrates (5mx5m size) and 45 line-transects (20 plants/10ft long line) methods. Invented spiders were caught by bare hand-picking and umbrella morning (0800 to 1000hrs) and evening (1600 to 1800hrs) at random and by pitfall traps (single pitfall/visit). Spider collection technique in crop-growth stages and month consider as (1) Pre-harvesting stage: Seeds are planted in July and caught made till mid-July, (2) Sowing stage: followed until the all germination of the sown seeds till mid-August. A dose of bio-fertilizer pesticides was sprayed (Grage Hume – Humic Acid 12% W/W with fulvic Acid, Natural Amino Acid, 35 ml liquid sol. per 15 liter water) on 14 August, (3) Vegetative stage : followed until flowering of all the plants or 3/4th area of the crop, caught obtained from late August to November, (4) Flowering stage : followed until pod formation, caught made during December, (5) Pod formation: followed till green seeds of Tur crop and caught made during January. Second dose of above bio-fertilizer pesticides was sprayed, (6) Ripen seed stage: followed entire ripening seed stage of the Tur crop during month of February.

The invented spiders were then preserved in 70% alcohol in plastic tubes. These were sorted out by placing them in a petri dish containing 70% alcohol under a Stereo Zoom microscope (DV4, Carl Zeiss); adult males and females were identified up to species level and immature up to generic level using references such as Patel (1973, '78), Tikader (1982), Tikader and Malhotra (1980), Tikader and Biswas (1981), Proszynski (1999), Gajbe (1999), Szuts and Scharff (2005), Beatty et al. (2008), http// www.orientalpictorial index salticidae and updated (Siliwal and Molur, 2007).

Quantitative estimation of species and individuals of spiders in different crop-growth stages was made using the data derived from field surveys. Evenness index (J), species diversity Shennon-Wiener (H'), Simpson's index (D) and species richness Margalef's (M) were computed (Spade Programm).

4. RESULTS AND DISCUSSION

The present work, based on a study of different spider families, revealed that different groups were active at different times of the crop-growth stages, showing their prey preference at different stages of crop-growth.

A total of 384 spiders represent 19 families, 33 genera and 49 Araneomorphae species were invented during the study period. Of these the majority of spider species belongs to two clawed hunting spiders family Salticidae (34.38%) contributed 22.45% species and 21.21 % genera, represent genera Phlegra, Sten aelurillus and Hasarius. Phlegra dhakuriensis and first record of the India (unpublished) new species Stenaelurillus nigricaudus were the abundant species of the family. Other major hunters families were Lycosidae (22.40%) pre-dominated by genus Pardosa, where Pardosa sumatrana was common; Pardosa songosa and Pardosa tatensis were uncommon species of the family. Thereafter 3rd position stands Gnaphosidae (12.50%) representing the genera Zelotes, Drassyllus and Gnaphosa. Gnephosa jodhpurensis was the most common species of the family. The intermediate groups of the spider were of family in Oxyopidae- 5.73%, Uloboridae-4.69%, Miturgidae-2.6%, Sparassidae, Theridiidae and Thomisidae were 2.08%, Corinnidae, Filistatidae, Oecobidae and Philodromidae contributed 1.56%. The minor groups of the spider belong to family Araneidae, Clubionidae, Selenopidae and Pholcidae were 1.04%, least groups were Scytodidae and Tetragnathidae contributed 0.52%.

Over all the most abundant species was Phlegra dhakuriensis, Stenaelurillus nigricaudus and Gnaphosa jodhpurensis. Rare species were Lycosa sp. Novel, Drassyllus sp., Thanatus sp., Smeringopus pallidus, Harmochirus brachiatus, Selenops sp., Runcinia sp. and Heteropoda sp.

The high abundance of two clawed hunters and ground dweller spiders could possibly due to the presence of available food source at study sites and as a lower web dwellers are members of family Araneidae, Oxyopidae, Pholcidae, and Theridiidae could possibly due to the agro-ecosystem.

3.1. Assessments in relation to Crop Growth

The entire study was conducted with different crop-growth stages in Tur agro-ecosystem. Out of six crop growth stages (i.e. pre-harvesting, sowing, vegetative, flowering, pod formation and ripen seed stages of Tur) the vegetative stage exhibited significant spider population. The majority a total of 144 spiders represent 15 families, 25 genera and 30 species during the vegetative stage and member of Salticidae represent maximum (37.5%) population and remaining were : Lycosidae and Oxyopidae 9.72%, Gnaphosidae 8.33%, Miturgidae and Thomisidae 5.56%, Sparassidae, Theridiidae and Uloboridae 4.17%, Filistatidae and Selenopidae 2.78%, least contributed by Araneidae, Philodromidae, Tetragnathidae and Pholcidae 1.39%. The abundant species were Phlegra dhakuriensis and Uloborus danolius. The second most population during flowering stage represents a total of 64 spiders, 10 families, 12 genera and 14 species, among them family Lycosidae (40.63%) represent maximum population. The abundant species were Pardosa sp. and Stenaelurillus nigricaudus and novel species were Zelotes sp., Lycosa sp. and Stetoda sp. Thereafter stands pod formation stage represent a total of 38 spiders, 7 families, 9 genera and 12 species among them member of family Lycosidae (42.11%) were abundant. The sowing and ripen seed stages represent 06 families out of total 50 and 34 spiders respectively; as pre-harvesting stage representing 04 families out of 54 spiders. The family composition was Corinnidae (3.70%), Gnaphosidae (25.93%), Lycosidae (26.63%) and Salticidae (40.74%). These reflect the species composition changed with the growth period of the crop may due to the availability of food source and predatory behaviour.

According to Pianka (1966), as the crop growth increases the prey availability allows more species to co-exist. Although, the effect of habitat heterogeneity on animal species diversity is an important determinant of species richness (Bocklen and Simberloff, 1986) and the species composition in crop-growth stages reflect their guild behaviour.

Evenness, diversity and richness of spider species in six crop-growth stages are given in Table 1 & Fig 1. The diversity index and species richness was highest (H'= 3.112, D = 17.053, M = 5.835) in vegetative stage and lowest diversity (H'= 2.20, D = 5.953) in flowering stage. In case of species richness in pre-harvesting stage had the lowest (M = 2.507) index value (Table 1). The evenness index was highest (0.965) in Ripen seed stage and lowest (0.834) in flowering stage. Although it showed the same pattern of expression in the crop-growth stages (Pearson, 1977).

Overall species richness (M) reveal highest value 5.835 in vegetative stage, thereafter it decreasing: flowering stage (3.126) > Pod formation stage (3.024) > Ripen seed stage (2.836) > Sowing stage (2.556) > Pre harvesting stage (2.507). The effect of habitat heterogeneity on species diversity of spider in agriculture ecosystem refers positive (Hurd and Fagan, 1992).

The relationship between habitat heterogeneity of the vegetation and species diversity generally depend on how habitat heterogeneity is perceived by the animal guild and different species groups are closely linked to 'keystone structures' that determine animal species diversity by their presence (Tews et al., 2004).

Table 1: Total number of Individual Spiders (N), number of Species (S), evenness index (J), Shennon-Wiener index (H), Simpson's index (D) and Margalef's index (M) in different crop growth stages of Tur agro-ecosystem during study period (Visits=61).

Sr. No.	Crop-Growth Stages	N	S	J	H	D	M
1	Pre-harvesting stage	54	11	0.938	2.25	8.379	2.507
2	Sowing stage	50	11	0.936	2.245	8.333	2.556
3	Vegetative stage	144	30	0.915	3.112	17.053	5.835
4	Flowering stage	64	14	0.834	2.2	5.953	3.126
5	Pod formation stage	38	12	0.95	2.361	9.256	3.024
6	Ripen seed stage	34	11	0.965	2.313	9.323	2.836

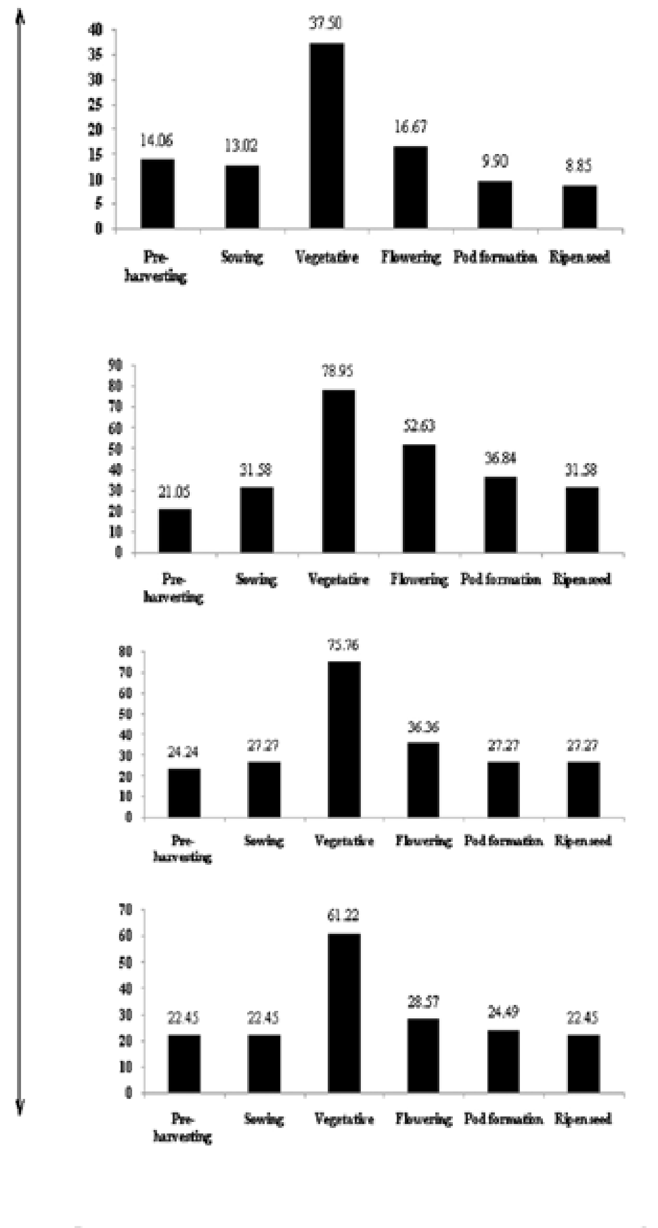

Fig 1: Percentages of Individual spiders, Family, Genera and Species in different Crop-Growth Stages of Tur Crop, Village Simasi, Tehsil Mendarda, District Junagadh, Kathiawar, Guj. (Total Visits=61).

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DIVERSITY OF CASHEW STEM AND ROOT BORERS IN PLANTATIONS

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ABSTRACT

Long horned beetles of the insect family, Cerambycidae are a highly diverse group of insects larvae which bore into the stem and roots of trees. The family comprises numerous pests of agriculture, forestry, and structural timber. Cashew stem and root borers (CSRB) are one of the major insect pests of cashew belonging to this family occurring in India and other cashew growing countries.

Among the major pests of cashew in India, widespread incidence of CSRB is an impediment in achieving the potential cashew nut yield. The key species of cashew stem and root borers recorded in India are Plocaederus ferrugineus Linn. P. obesus Gahan and Batocera rufomaculata De Geer. However, there are few other secondary stem borers, which are opportunistic and attack already infested host trees. Information on the diversity of CSRB species in the cashew plantations is studied and presented in the article.

Key words: Pest, Cerambycidae, larva, frass.

1. INTRODUCTION

In India, Cashew, Anacardium occidentale L. is grown in Andhra Pradesh, Maharashtra, Odisha, Tamil Nadu, Karnataka, Goa, Chhattisgarh and Kerala. One of the main constraints in achieving the potential cashew nut yield is the low tree stand /tree density, which is chiefly due to loss of yielding cashew trees as a result of CSRB infestation. In general, the cerambycid borers are known to feed on the tree bark by making zigzag tunnels and feeding on the wood tissue. The larvae chew the bark and wood fibers and consume the sap for nutrition; the chewed fibers, as well as excreta of the larvae, known as 'frass', is generally pushed out through crevices or holes on the tree bark resulting in the premature yellowing of canopy (Plate 1).The key species of cashew stem and root borers recorded in India are Plocaederus ferrugineus Linn., P. obesus Gahan and Batocera rufomaculata De Geer. However, there are few other secondary stem borers, which are opportunistic and attack already infested host trees. An infested cashew tree provides ample niche for proliferation of several polyphagous borer species.

The present study is aimed to record the species composition of CSRB from different cashew growing areas of India, which will help in timing the pest management activities by the farmers.

2. MATERIALS AND METHODS

The field observations on the incidence of CSRB in various cashew plantations were done by regular 'roving survey' in the cashew plantations of Directorate of Cashew Research (DCR), Puttur, Karnataka, India (12°45' N latitude, 75°40' E longitude;) and in cashew plantations of Karnataka Cashew Development Corporation (KCDC), Alankar, 12°77'N; 75°32'E and Ramakunja, 12° 79'N; 75° 32'E Dakshina Kannada Dist., Karnataka state. Larvae of CSRB were obtained from Vengurla (Maharashtra), 15° 85' N; 73° 63' E, Chinthamani (Karnataka), 13° 24'N ; 78° 4'E , Madakkathara (Kerala), 10° 55'N ; 76 ° 25'E, Bapatla (Andhra Pradesh), 15°88'N ; 80° 47' and Bhubaneswar (Odisha), 20 °27' N ; 85 ° 84'E .

The cashew plantations were regularly surveyed during the period of study (2010-2013) and cashew trees were observed for the presence of incidence of CSRB. Observations on the symptoms of incidence of CSRB were done at 0.5 to 0.75 m from the ground on the main trunk and in the collar region and exposed roots at monthly intervals. The symptoms of infestation recorded are given below:

- Occurrence of CSRB eggs in the crevices of bark or in soil near the collar region.
- Fine powdery frass at the base of the collar, stem, and fork or on exposed roots.

- Gummosis with exuded frass from the infested bark.
- Canopy condition i.e., premature yellowing of leaves, defoliation and drying of twigs.
- Exit holes on the tree trunk and splitting as well as warping of tree bark.

The field collected larvae of CSRB were placed individually in separate polythene bags (1 kg capacity) with a piece of bark as temporary feed, till it was further transferred to glass rearing bottles under laboratory conditions. The field collected CSRB eggs were placed in Petri plates and allowed to hatch.

The larvae were reared in individual rearing bottles 500 ml capacity on cashew bark. Saw dust or autoclaved frass was added on top of the bark pieces and water was sprayed into these rearing bottles on alternate days to retain the moisture of cashew bark provided as feed. Observation on the development of larva was carried out. The date of pupation was recorded. The bottles having pupation activity were set aside after covering them with a metal cap, till further adult emergence. These field collected pest stages were thus reared on cashew bark to obtain adult beetles which were identified by consulting with the experts in that field, to obtain species composition of CSRB in a given area.

During the survey, the borer larvae were collected and reared under laboratory to obtain the adult beetles for further identification by Coleoptera taxonomists and entomologists at NBAII, Bengaluru and IARI, New Delhi. The species composition of CSRB in a specified location was documented.

Larval stages of CSRB were also obtained from different cashew growing states with the support of technical personnel, along with field data regarding date of collection, location details and level of pest incidence.

3. RESULTS

The larvae collected from different locations revealed P. ferrugineus and P. obesus to be the major species among CSRB, while B. rufomaculata was encountered as a secondary borer.

Laboratory rearing of the field collected pest stages obtained from Karnataka, Kerala, Maharashtra and Odisha revealed higher incidence of P. ferrugineus. The results indicated that in the localities of Dakshina Kannada district of Karnataka state, the proportion of P. ferrugineus and P. obesus was 50: 50, whereas in Chinthamani (Karnataka), Madakkathara (Kerala), Bapatla (Andhra Pradesh) and Vengurla (Maharashtra), mean proportionate prevalence of P. ferrugineus was higher to P. obesus. Among the cashew growing states of India, the ratio of P.ferrugineus to P.obesus was 64.8 : 35.2 in Kerala, it was 72.0 : 28.0 in Maharashtra, 79.0 : 21.0 in Odisha, 78.0 : 22.0 in Tamil Nadu, 87.0 : 13.0 in Karnataka, 87.0 : 13.0 in West Bengal, 86.0 : 14.0 in Chhattisgarh and 82.0 : 18.0 in Andhra Pradesh (Fig. 1).

It could be inferred in majority that, P. ferrugineus was the dominant species; while P. obesus also co-existed in considerably lower numbers. The occurrence of B. rufomaculata on cashew was not predominant and was meager. It was not collected from Andhra Pradesh, Chhattisgarh, Goa and Tamil Nadu during the period of study.

The adults obtained by the rearing the field collected larvae occurring as borers in cashew trees from cashew plantations in Karnataka, revealed the infestation of 11 identified and 4 unidentified species of coleopterans.

This species has been reported to be a serious pest of cashew by several earlier workers during the past 3-4 decades. Extensive damage to cashew trees due to Plocaederus spp. leading to loss of tree density in cashew plantations has been recorded in this study. This species was the dominant one followed by P.obesus. The trees infested by this pest species were later colonized by other secondary borers.

The adults of P. ferrugineus (Plate 2) are chestnut red coloured longicorn beetles. The pronotum is darker compared to the elytra and had a coarse surface. A prominent lateral spine occurs on both sides of the pronotum. The males and females were of similar body proportions; however, their body size depended on the quality of larval feed. The antennae are filiform and displayed sexual dimorphism

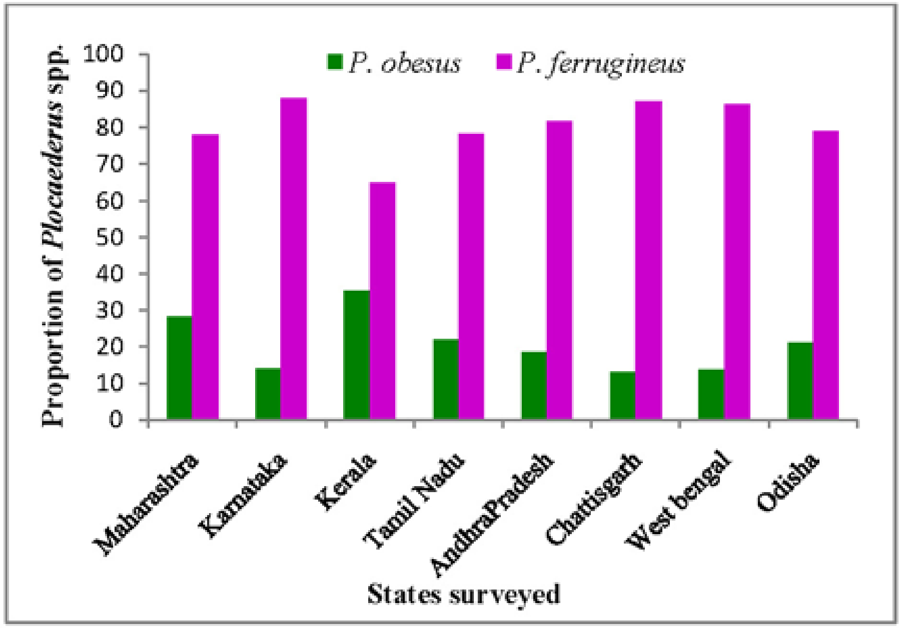

Fig 1: Proportion of P. ferrugineus and P. obesus in various cashew growing states

a. Plocaederus ferrugineus (Coleoptera: Cerambycidae)

wherein, the antennae of males were longer than the body length; while in females, it was shorter than the body length.

b. Plocaederus obesus (Coleoptera: Cerambycidae)

The adult beetles of P. obesus (Plate 3) were dull straw brown coloured longicorn beetles with a fine pubescence on the elytra. This species has been recorded to occur in association with P. ferrugineus in comparatively lower numbers. The pronotum was comparatively darker than the elytra and had a ruffled surface. A prominent lateral spine occurred on both sides of the pronotum. The antennae are filiform and had dark band at the base of each flagellomere and had serrations on the external surface. The antennal length of males was more than the length of the body; whereas, in case of females, the antenna was less or equal to body length.

Both these species could be differentiated only in the adult stage; however, the larval stages could not be differentiated based only on the general external morphology.

c. Batocera rufomaculata (Coleoptera: Cerambycidae)

The larvae of B. rufomaculata (Plate 4) were encountered generally in cashew trees which were previously infested by Plocaederus spp.. Various stages of B. rufomaculata could be collected from the field during September to November.

Adults of B. rufomaculata (4-5 cm long) were dull ash coloured beetles with two red/orange crescent shaped markings and a few lateral spots on the elytra, the antenna was longer than the body in males and slightly equal to body length in females.

The larvae were robust, apodus, with prognathus mouth parts and varied from 3.0 to 8.0 cm, depending on their age. The nature of feeding was typical, wherein the bark fibres removed were more coarse and profuse in comparison to Plocaederus feeding. The larvae developed into an exarate pupa (7.0 -8.0 cm) which pupated in a cavity without formation of cocoon. Adult emergence and sex ratio were found to differ in a year seasonally. Sex ratio was female biased in July, October and November.

d. Glenea multiguttata (Cerambycidae: Lamiinae)

Larva was apodus, collected from a secondarily infested tree from DCR Kemminje plot, mean body length was 1.2 cm and body width was 0.2 cm. The field larvae were reared on cashew bark. The larvae developed into exarate pupa in 15 days. The pupa moulted in 9 days into a pale coloured spotted beetle (imago) which after two days, became dark yellow coloured with four rectangular spots on the thorax and nine black spots on each elytra and body dimensions were 1.4 cm in length and 0.3cm in width (Plate 5).

e. Pterolophia (?) paralosipes (Coleoptera: Cerambycidae)

The larvae of this species were flat ovate, with hood like anterior end having the mouth parts. They were apodus, 0.5 -1.5 cm in length and non cannibalistic. Different age groups of larvae were collected from cashew trees which were severely infested by CSRB. The larvae fed beneath the partly dried cashew bark. They were reared on cashew bark under laboratory and the larvae developed into exarate pupae in 15-30 days. The adults emerged after 7-9 days of pupal period and had a mean body length of 1.2 cm and 0.3 cm body width. Two unidentified species of Pterolophia were collected from cashew plantations (Plate 6).

f. Olenecamptus bilobus (Coleoptera: Cerambycidae)

The species was collected as quiescent adult, 1.1cm long, 0.3cm wide with a considerably elongate antenna in male. The beetle was collected from seriously infested cashew trees. The beetle was brown coloured with 4-6 red spots on the elytra. The pest has been reported to be polyphagous in different Oriental countries, including India (Plate7).

g. Aeolesthes species (Coleoptera: Cerambycidae)

The larva resembled the larva of Batocera rufomaculata and had prognathus mouth parts and was apodus. The adult beetles (3.1 cm length; 1.0 cm width) had brownish velvety, patchy cuticle with creamy pubescence. Antennae filiform. (Plate8).

h. Apomecyna saltator (Coleoptera: Cerambycidae)

The pest was collected as quiescent adult from severely infested cashew tree. Adult beetle was a slate-gray beetle with several white spots arranged in four V shaped markings across the elytra. The adult measured 10.75 mm in length and 3.45 and 3.04 mm in breadth across thorax and abdomen, respectively; with a long antennae measuring 6.95 mm about two-thirds the length of the body (Plate9).

i. Neocerambyx paris (Coleoptera: Cerambycidae)

This was recorded as a secondary borer of cashew. Dark brown, covered with golden pubescence, which is denser on the elytra. Head with a deep groove; above, between the eyes. Prothorax feebly rounded at the sides. Elytra separately rounded at the apex, armed each with a short spine in the suture. Antennae, twice as long as he body i n the male; first joint stout. Body length 55-78mm and width 17-23 mm (Plate10).

j. Coptops aedificator (Coleoptera: Cerambycidae)

It was recorded as a secondary borer of cashew, encountered in a severely infested cashew tree. The body was pitted with dark pubescence and had dark bands on the legs, with filiform antennae. Body length measured 1.5-2.0 cm, breadth 0.5 cm. (Plate11).

k. Schizotrachelus intermedius Senna (Coleoptera: Brentidae)

It was recorded as a dead wood borer in cashew plantations in the present study. The abdomen tapered towards the end. This species was commonly encountered in dying cashew trees. The adults were chestnut coloured, lean and had a straight snout, with antennae on each side; Body length ranged from 1.2-1.3 cm (Plate12).

Apart from the above species, two unidentified species, of Anthribidae, (length 0.5 cm) were collected in their larval stage from dead bark of cashew tree infested by Plocaederus species. An unidentified larva (weevil species) (Plate 14) was collected from already infested cashew tree, which developed into adult (length 1.0cm). The root grubs (Plate 15) which were collected from one year old cashew plants, could form pupae, but failed develop into adults under laboratory conditions. Among the species collected and identified, 10 species were cerambycids; whereas weevil, anthribids and Brentid were also recorded as minor pests infesting cashew tree (Table 1).

Among the different species of stem borers, the incidence of P. ferrugineus was found to exceed all the other species of CSRB in all the localities surveyed. P. obesus was recorded to be the next major pest species infesting cashew, followed by B. rufomaculata, which was found to occur only as a secondary borer (Fig 2).

In general, it was noticed that the stem and root borer species encountered in the cashew trees in all locations surveyed comprised of coleopteran species only.

Table 1: List of various species of CSRB collected from infested cashew trees.

No.	Species of the pest	Order and Family	Area of collection
1	Plocaederus ferrugineus L	Coleoptera :Cerambycidae	All the cashew plantations surveyed
2	Plocaederus obesus Gahan	Coleoptera :Cerambycidae	All the cashew plantations surveyed
3	Batocera rufomaculata De Geer	Coleoptera: Cerambycidae	All the cashew plantations surveyed
4	Glenea multiguttata Guérin-Méneville	Coleoptera: Cerambycidae	DCR., Kemminje
5	Aeolesthes sp	Coleoptera : Cerambycidae	DCR., Kemminje
6	Pterolophia paralosipes ?.	Coleoptera :Cerambycidae	DCR., Kemminje
7	Neocerambyx paris Wiedemann	Coleoptera :Cerambycidae	DCR., Kemminje
8	Apomycena saltator L.	Coleoptera: Cerambycidae	DCR., Kemminje
9	Olenecamptus bilobus Fabricius	Coleoptera :Cerambycidae	DCR., Kemminje
10	Coptops aedificator	Coleoptera :Cerambycidae	DCR., Kemminje
11	Schizotrachelus intermedius Senna	Coleoptera : Brenthidae	DCR., Kemminje
12	Fungus weevil *	Coleoptera : Anthribidae	DCR., Kemminje
13	Fungus weevil *	Coleoptera : Anthribidae	DCR., Kemminje
14	Stem Weevil *	Coleoptera: Curculionidae	DCR., Kemminje
15	Scarabid root grub**	Coleoptera: Scarabidae	DCR., Kemminje

* Adults yet to be identified

** Adult did not emerge

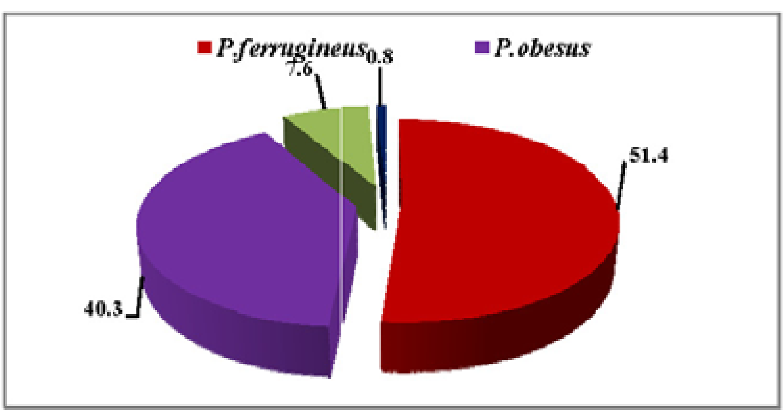

Fig 2: Percentage incidence of various CSRB species on cashew

Fig 2: Percentage incidence of various CSRB species on cashew

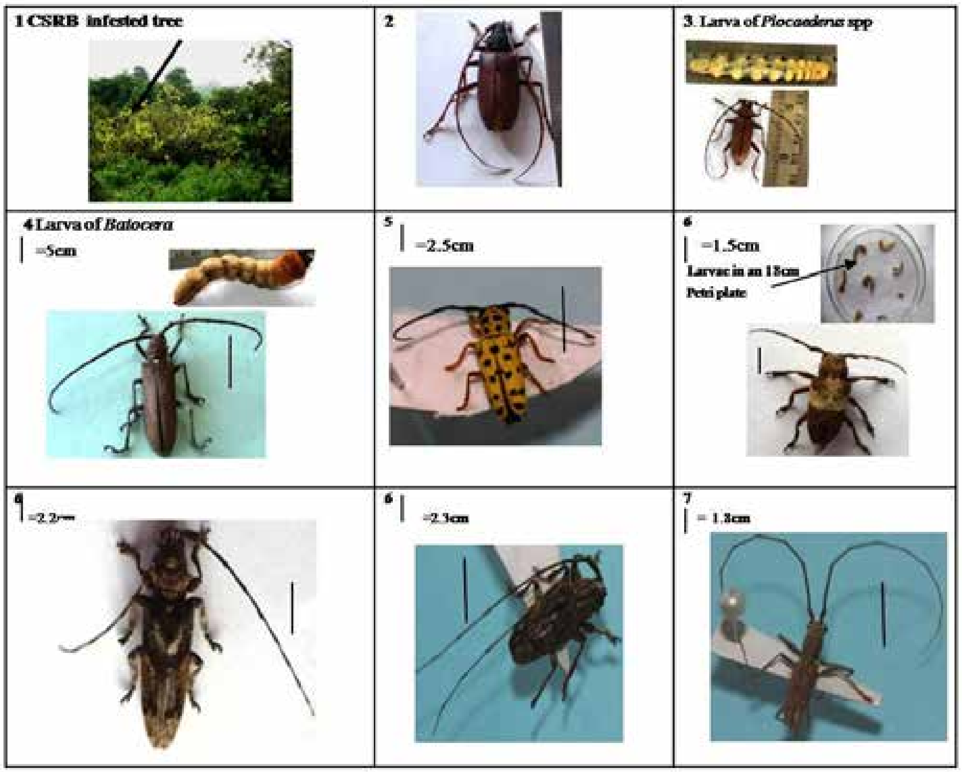

Plate 1-7

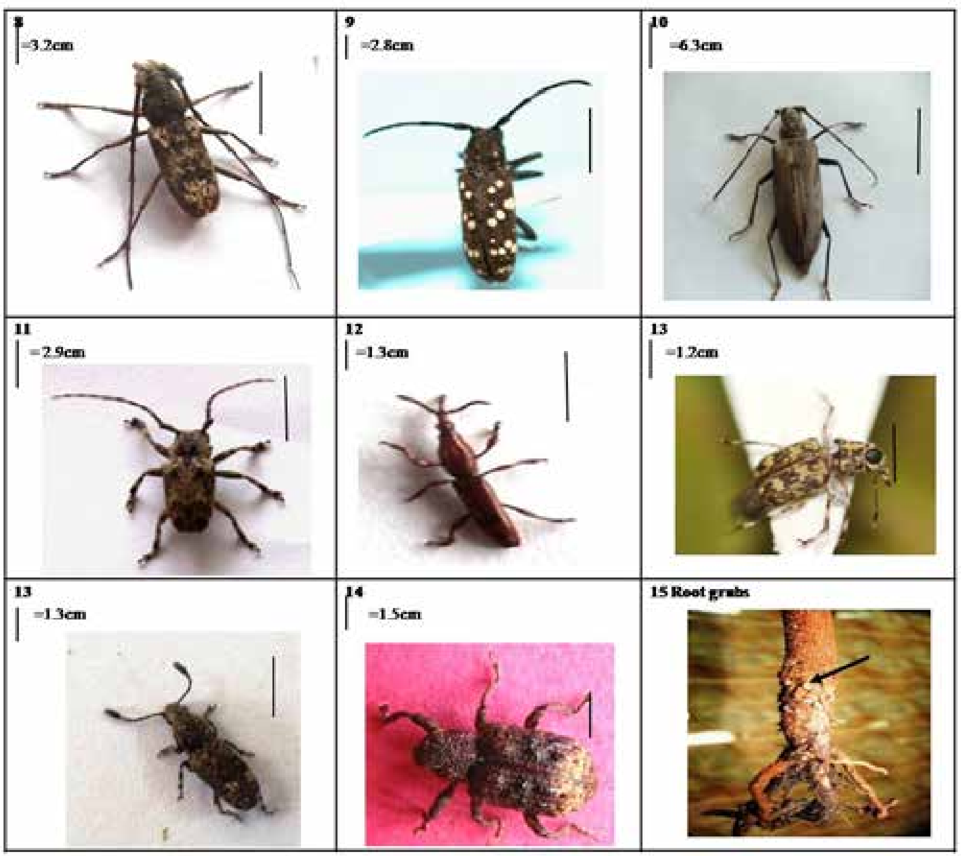

Plate 8-15

4. DISCUSSION

An infested cashew tree provides ample niche for proliferation of several phytophagous borer species. Beeson (1941) reported P. obesus and P. consocius Pascoe as the two borer species which infested cashew trees in India. Mathur and Chandra (1961) reported P. ferrugineus from logs of Boswellia serrata. Roxb. Ailanthus excels and Chochlospherum gossypium. Sundararaju (1984), Mariamma Daniel (1991), Senguttuvan (1998), Mohapatra (2004) reported Plocaederus spp. as a serious pest of cashew.

The mango stem borer, B. rufomaculata was reported to be a serious pest of forest trees and mango in many parts of India (Stebbing, 1914). It was reported to infest cashew tree (Beeson & Bhatia (1939), Abraham 1958) as a secondary borer. Pillai et. al. (1976) reported this pest from live cashew tree. Singh (1978) reported its occurrence on fig and apple trees in north India. Palaniswamy, et. al. (1979) reported the wide occurrence of mango stem borer, B. rufomaculata from all over the country while, Mariamma Daniel (1991), reported that, B. rufomaculata could breed on cut cashew logs, however the population of this species on cashew was low but, this pest was a potential major stem borer of cashew.

Present study documented 12 species of secondary borers which are opportunistic on already CSRB infested cashew trees. These secondary borers would be potential major pests of cashew if proper remedies are not taken. Destruction of the different stages of pests and the pest infested trees would be suggested to the farmers as a management strategy. However, proper monitoring of the CSRB is essential to detect the pest infestation.

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PERSPECTIVES ON BIODIVERSITY OF INDIA

Volume II – Part. 1

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