International Journal of Biodiversity and Conservation

Volume 6 Number 6, June 2014
ISSN 2141-243X

Academic Journals

ABOUT IJBC

The **International Journal of Biodiversity and Conservation (IJBC)** (ISSN 2141-243X) is published Monthly (one volume per year) by Academic Journals.

International Journal of Biodiversity and Conservation (IJBC) provides rapid publication (monthly) of articles in all areas of the subject such as Information Technology and its Applications in Environmental Management and Planning, Environmental Management and Technologies, Green Technology and Environmental Conservation, Health: Environment and Sustainable Development etc.
The Journal welcomes the submission of manuscripts that meet the general criteria of significance and scientific excellence. Papers will be published shortly after acceptance. All articles published in IJBC are peer reviewed.

Submission of Manuscript

Please read the **Instructions for Authors** before submitting your manuscript. The manuscript files should be given the last name of the first author

Click here to Submit manuscripts online

If you have any difficulty using the online submission system, kindly submit via this email ijbc@academicjournals.org.

With questions or concerns, please contact the Editorial Office at ijbc@academicjournals.org.

Editorial Board

Instructions for Author

Electronic submission of manuscripts is strongly encouraged, provided that the text, tables, and figures are included in a single Microsoft Word file (preferably in Arial font).

The **cover letter** should include the corresponding author's full address and telephone/fax numbers and should be in an e-mail message sent to the Editor, with the file, whose name should begin with the first author's surname, as an attachment.

Article Types
Three types of manuscripts may be submitted:

Regular articles: These should describe new and carefully confirmed findings, and experimental procedures should be given in sufficient detail for others to verify the work. The length of a full paper should be the minimum required to describe and interpret the work clearly.
Short Communications: A Short Communication is suitable for recording the results of complete small investigations or giving details of new models or hypotheses, innovative methods, techniques or apparatus. The style of main sections need not conform to that of full-length papers. Short communications are 2 to 4 printed pages (about 6 to 12 manuscript pages) in length.

Reviews: Submissions of reviews and perspectives covering topics of current interest are welcome and encouraged. Reviews should be concise and no longer than 4-6 printed pages (about 12 to 18 manuscript pages). Reviews are also peer-reviewed.

Review Process

All manuscripts are reviewed by an editor and members of the Editorial Board or qualified outside reviewers. Authors cannot nominate reviewers. Only reviewers randomly selected from our database with specialization in the subject area will be contacted to evaluate the manuscripts. The process will be blind review.
Decisions will be made as rapidly as possible, and the journal strives to return reviewers' comments to authors as fast as possible. The editorial board will re-review manuscripts that are accepted pending revision. It is the goal of the AJFS to publish manuscripts within weeks after submission.

Regular articles

All portions of the manuscript must be typed double-spaced and all pages numbered starting from the title page.

The Title should be a brief phrase describing the contents of the paper. The Title Page should include the authors' full names and affiliations, the name of the corresponding author along with phone, fax and E-mail information. Present addresses of authors should appear as a footnote.

The Abstract should be informative and completely self-explanatory, briefly present the topic, state the scope of the experiments, indicate significant data, and point out major findings and conclusions. The Abstract should be 100 to 200 words in length.. Complete sentences, active verbs, and the third person should be used, and the abstract should be written in the past tense. Standard nomenclature should be used and abbreviations should be avoided. No literature should be cited.
Following the abstract, about 3 to 10 key words that will provide indexing references should be listed.

A list of non-standard **Abbreviations** should be added. In general, non-standard abbreviations should be used only when the full term is very long and used often. Each abbreviation should be spelled out and introduced in parentheses the first time it is used in the text. Only recommended SI units should be used. Authors should use the solidus presentation (mg/ml). Standard abbreviations (such as ATP and DNA) need not be defined.

The Introduction should provide a clear statement of the problem, the relevant literature on the subject, and the proposed approach or solution. It should be understandable to colleagues from a broad range of scientific disciplines.

Materials and methods should be complete enough to allow experiments to be reproduced. However, only truly new procedures should be described in detail; previously published procedures should be cited, and important modifications of published procedures should be mentioned briefly. Capitalize trade names and include the manufacturer's name and address. Subheadings should be used. Methods in general use need not be described in detail.

Results should be presented with clarity and precision. The results should be written in the past tense when describing findings in the authors' experiments. Previously published findings should be written in the present tense. Results should be explained, but largely without referring to the literature. Discussion, speculation and detailed interpretation of data should not be included in the Results but should be put into the Discussion section.

The Discussion should interpret the findings in view of the results obtained in this and in past studies on this topic. State the conclusions in a few sentences at the end of the paper. The Results and Discussion sections can include subheadings, and when appropriate, both sections can be combined.

The Acknowledgments of people, grants, funds, etc should be brief.

Tables should be kept to a minimum and be designed to be as simple as possible. Tables are to be typed double-spaced throughout, including headings and footnotes. Each table should be on a separate page, numbered consecutively in Arabic numerals and supplied with a heading and a legend. Tables should be self-explanatory without reference to the text. The details of the methods used in the experiments should preferably be described in the legend instead of in the text. The same data should not be presented in both table and graph form or repeated in the text.

Figure legends should be typed in numerical order on a separate sheet. Graphics should be prepared using applications capable of generating high resolution GIF, TIFF, JPEG or Powerpoint before pasting in the Microsoft Word manuscript file. Tables should be prepared in Microsoft Word. Use Arabic numerals to designate figures and upper case letters for their parts (Figure 1). Begin each legend with a title and include sufficient description so that the figure is understandable without reading the text of the manuscript. Information given in legends should not be repeated in the text.

References: In the text, a reference identified by means of an author‘s name should be followed by the date of the reference in parentheses. When there are more than two authors, only the first author‘s name should be mentioned, followed by ’et al‘. In the event that an author cited has had two or more works published during the same year, the reference, both in the text and in the reference list, should be identified by a lower case letter like ’a‘ and ’b‘ after the date to distinguish the works.

Examples:

Abayomi (2000), Agindotan et al. (2003), (Kelebeni, 1983), (Usman and Smith, 1992), (Chege, 1998; 1987a,b; Tijani, 1993,1995), (Kumasi et al., 2001)
References should be listed at the end of the paper in alphabetical order. Articles in preparation or articles submitted for publication, unpublished observations, personal communications, etc. should not be included in the reference list but should only be mentioned in the article text (e.g., A. Kingori, University of Nairobi, Kenya, personal communication). Journal names are abbreviated according to Chemical Abstracts. Authors are fully responsible for the accuracy of the references.

Examples:

Chikere CB, Omoni VT and Chikere BO (2008). Distribution of potential nosocomial pathogens in a hospital environment. Afr. J. Biotechnol. 7: 3535-3539.

Moran GJ, Amii RN, Abrahamian FM, Talan DA (2005). Methicillinresistant Staphylococcus aureus in community-acquired skin infections. Emerg. Infect. Dis. 11: 928-930.

Pitout JDD, Church DL, Gregson DB, Chow BL, McCracken M, Mulvey M, Laupland KB (2007). Molecular epidemiology of CTXM-producing Escherichia coli in the Calgary Health Region: emergence of CTX-M-15-producing isolates. Antimicrob. Agents Chemother. 51: 1281-1286.

Pelczar JR, Harley JP, Klein DA (1993). Microbiology: Concepts and Applications. McGraw-Hill Inc., New York, pp. 591-603.

Short Communications

Short Communications are limited to a maximum of two figures and one table. They should present a complete study that is more limited in scope than is found in full-length papers. The items of manuscript preparation listed above apply to Short Communications with the following differences: (1) Abstracts are limited to 100 words; (2) instead of a separate Materials and Methods section, experimental procedures may be incorporated into Figure Legends and Table footnotes; (3) Results and Discussion should be combined into a single section.
Proofs and Reprints: Electronic proofs will be sent (e-mail attachment) to the corresponding author as a PDF file. Page proofs are considered to be the final version of the manuscript. With the exception of typographical or minor clerical errors, no changes will be made in the manuscript at the proof stage.

Fees and Charges: Authors are required to pay a $550 handling fee. Publication of an article in the International Journal of Biodiversity and Conservation is not contingent upon the author's ability to pay the charges. Neither is acceptance to pay the handling fee a guarantee that the paper will be accepted for publication. Authors may still request (in advance) that the editorial office waive some of the handling fee under special circumstances

Submission of a manuscript implies: that the work described has not been published before (except in the form of an abstract or as part of a published lecture, or thesis) that it is not under consideration for publication elsewhere; that if and when the manuscript is accepted for publication, the authors agree to automatic transfer of the copyright to the publisher.

International Journal of Biodiversity and Conservation

Table of Contents: Volume 6 Number 6 June, 2014

ARTICLES

academicJournals

Vol. 6(6), pp. 428-435, June 2014
DOI: 10.5897/IJBC2014.0711
Article Number: 9841ED645308
ISSN 2141-243X

http://www.academicjournals.org/IJBC

International Journal of Biodiversity and Conservation

Full Length Research Paper

The impacts of human activities on tree species richness and diversity in Kakamega Forest, Western Kenya

Vuyiya Esther[1], Konje Martha[1], Tsingalia Harrison[3], Obiet Lenard[1], Kigen Charles[1], Wamalwa Stella[1] and Nyongesa Humphrey[2]

[1]Biological Sciences Department, Masinde Muliro University of Science and Technology, P.O. Box 190-50100, Kakamega, Kenya.
[2]Department of Sugar Technology, Masinde Muliro University of Science and Technology, P.O. Box 190- 50100, Kakamega, Kenya.
[3]Biological Sciences Department, Moi University, P.O Box, 3900.-30100, Eldoret, Kenya.

Receive 08 April, 2014; Accepted 24 April, 2014

Tropical rain forests are species rich ecosystems that are being depleted at very high rates through human encroachment. Kakamega forest is one of the heavily fragmented and disturbed tropical rain forests due to the high human population densities that surround the forest. The purpose of this study was to investigate the impact of human activities on tree species richness, diversity, canopy surface area and seedling density in Kakamega forest. The study was conducted in four sites within Kakamega forest: Handidi, Lukusi, Isecheno and KWS as a control site. The data was collected between June and December, 2011. Vegetation sampling was done in randomly selected sites within each study site using belt transects and quadrants. Within each transect, the number of tree species and seedlings were counted and the intensity of human disturbances assessed. Vegetation data were analyzed by two-way analysis of variance. Correlation and regression analysis were done between dependent and independent variables. Simpson's diversity index was used to calculate tree species diversity in each study site. There were significant differences between species diversity, richness, canopy surface area and seedling density with distance from the forest edge. The study showed that there was negative impact of human activities (logging, grazing, debarking and charcoal burning) on tree species in the three study sites as compared to the control site. The results revealed a negative influence on the forest by human activities. The study recommended strict enforcement of the existing conservation laws concerning forest use by the local communities as well as formulating more integrated approach to the needs of local communities for natural resource use.

Key words: Canopy area, seedlings, debarking, logging, disturbances.

INTRODUCTION

Tropical forests are species rich ecosystems that are being depleted at very high rates (Myers, 2000). As a result, many initiatives of conserving tropical forests and enhancing the economic wellbeing for communities living around these forests have been put in place to reduce the dependence on them. In Kenya, the most documented initiatives are around protected forest areas (PFAs). These initiatives aim at reducing pressure on the protected

areas by providing alternative livelihoods to the surrounding local communities (Miller, 1982). Tropical rainforests are mainly exploited by man for economic, political and social reasons (Soper, 1995). Poor farmers trying to make a living on marginal lands cause a significant portion of deforestation (Myers, 1988). In addition to subsistence agriculture, activities like logging, clearing for cattle pasture and commercial agriculture contribute significantly to deforestation on a global scale (Anderson, 1990). Agricultural fires used in land clearing are increasingly spreading outside cultivated areas and into the degraded forest regions.

Studies have shown that countries with significant rainforest cover generally have the poorest local people living in and around forests, who depend almost entirely on the forest resources (Myers, 1992). Their poverty costs their country and the world through loss of biodiversity and ecosystem services like erosion prevention, flood control, water and fisheries protection (Myers, 1992). This scenario applies to Kakamega Forest in western Kenya. Majority of families living around the Kakamega Forest are poor and rely heavily on forest resources to earn their living (Nambiro, 2000). Most families own very small farm plots for growing household staple foods like maize, beans, cassava and bananas.

The primary contemporary drivers of tropical forest biodiversity loss include direct effects of human activities such as habitat destruction and fragmentation (land use change), invasive species and over-exploitation as well as indirect effects of human activities such as climate change (Millennium Ecosystems Assessment, 2005). Over- exploitation of a particular species can result in species or group of species driven to local extinction or even global extinction. The most well known example of overexploitation of tropical forest species involves large mammals for bush meat (Miller Gulland et al., 2003) and tropical hardwoods for timber (Asner et al., 2005). The over exploitation of large mammals has consequences for the structure and species composition of tropical plant communities by affecting their interactions with seed predators, seed dispersers, herbivores and browsers (Wright, 2005).

Kakamega forest is one of the heavily fragmented and disturbed forests (Kokwaro, 1988) due to the high human population densities that surrounds the forest most of which is involved in small-scale agriculture. Anthropogenic disturbances like selective logging, grazing, debarking and charcoal burning can reduce the diversity of plant and animal species, thereby reducing seedling species richness and hence the forest ecosystem in the long-term. This is because the germination and establishment of seedlings of many species in rain forests depends on the events on the forest floor below the canopy (Chazdon, 2008). The purpose of this study was to quantitatively assess and determine how human activities are affecting plant species diversity, richness, canopy area and seedling density with reference to Kakamega forest; specifically to (i) determine the effect of logging, debarking, grazing and charcoal burning on the tree species diversity and richness between study sites with distance from forest edge, (ii) determine the effect of logging, debarking, grazing and charcoal burning on the tree canopy surface area and seedlings density between study sites with distance from forest edge and (iii) assess the relationship between tree species diversity and canopy area.

MATERIALS AND METHODS

Study area

Kakamega forest is located in Kakamega East District in Kakamega County, Western Kenya. It lies between longitudes 34° 40' and 34° 57' 30" East and 0° 15" South. The entire population of Kakamega East District was projected at 159475 by 2009, according to 2009 population census and a population density of 358 persons per km square (Mars Group Kenya, 2009). The forest has a varied topography with altitudes ranging from 1250 to 2000 m above sea level (Tsingalia, 1988). The forest has a warm and wet climate and experiences two rainy seasons: the long rains which start in March and end in June; and the shorter rains begin in July and end in October with a peak in August. Annual rainfall averages between 1500-2000 mm (Tsingalia, 1988). The vegetation of the forest includes closed indigenous forest, grasslands and open forest. The area surrounding the forest is densely populated and intensively used for farming (Sharp, 1993; Emerton, 1994; Nambiro, 2000). There is widespread dependence on the forest by the local people who obtain their livelihood by mainly harvesting firewood, thatch grass and medicinal plants (Emerton, 1994; Sharp, 1993; Nambiro, 2000). They also use the forest grasslands as traditional grazing grounds. There are incidences of illegal logging, charcoal burning and hunting of small mammals in the forest (Kokwaro, 1988). The study sites selected within this forest include Handidi, Lukusi, Isecheno and KWS. Three of these sites, Handidi, Lukusi and Isecheno were chosen based on the fact that some human activities are allowed in these sites while KWS site was used as a control because it is well protected from any human disturbance.

Identification of human activities

To identify the main human activities that take place in Kakamega forest, questionnaires were administered to 300 households within 5 km stretch from the forest. Households were randomly selected from the community around the forest. A population of 2000 persons was obtained from the households from which the respondents were picked.

Measurement of trees species richness and diversity

Belt transects were used in vegetation sampling in randomly

*Corresponding author. E-mail: konjemartha@gmail.com. Tel: +254 711259863.

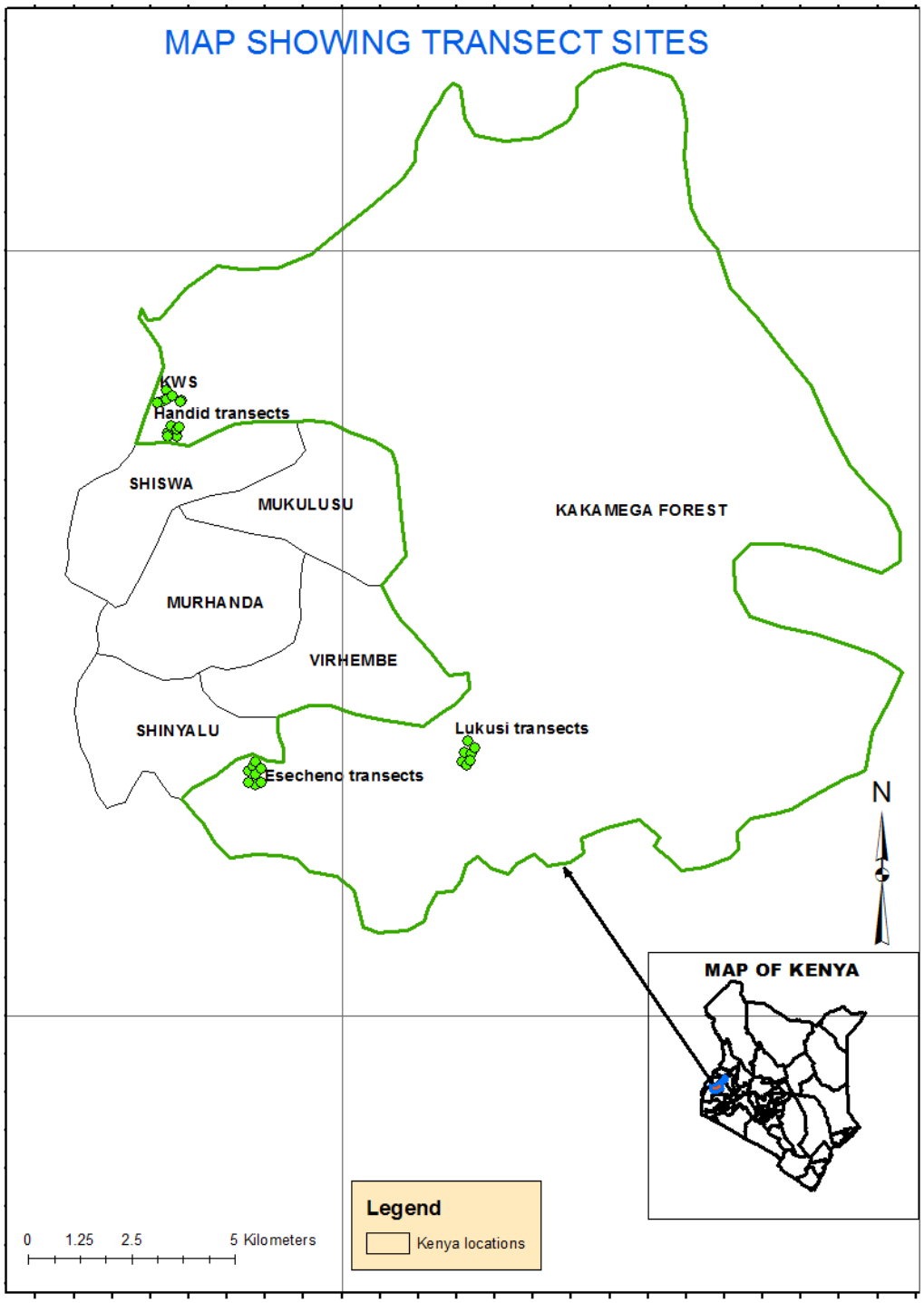


Figure 1. Map of Kakamega forest showing study sites (Source: BIOTA Africa).

selected regions within the forest, in the four study sites shown in Figure 1. The regions were chosen based on their location in the forest, that is, they were adjacent to the NTZ making it easy to assess the impact of human activities on the forest species diversity and species richness. The transects were laid from the edge of the forest adjacent to the tea zone to the interior of the forest (Figure 1). Two belts transects measuring 2 km long and 10 m wide were established in each of the four study sites using a global positioning system (GPS) and a compass. Another transect was laid at Kakamega National Reserve at Buyangu (KWS site) that acted as a control, since the area is effectively managed by Kenya Wildlife Service (KWS) as a protected area. Five quadrates of 10 by 10 m were set up along each transect at 500 m interval. Within each quadrant/plot, tree species richness was assessed where the

Table 1. Pearson's correlation coefficient between dependent variables and human activities (marked correlations * are significant at p<0.05. N=35).

Variable	Logging	Grazing	Debarking	Charcoal burning
Species richness	R= -0.2872	R= -0.0372	R= -0.283	R= -0.378
	P= 0.028*	P= 0.099	P= 0.025*	P= 0.094
Species diversity	R= -0.280	R= -0.244	R=-0.250	R=-237
	P= 0.0102	P= 0.157	P=0.147	P= 0.169
No. of seedling	R=-0.504	R= -0.412	R=-0.618	R= -0.422
	P= 0.002*	P= 0.014*	P=0.000*	P= 0.012*
Canopy volume	R= -0.49	R= -0.471	R=-0.545	R= -0.404
	p= 0.002*	p= 0.004*	p=0.001*	p= 0.016*

different tree species were identified, counted and noted. This was used to assess the species diversity of trees within each quadrant. The Shannon diversity index was used to calculate the species diversity of the vegetation samples in the different plots (Shannon and Weiner, 1948).

Measurement of seedling density and disturbance

Within each transect, canopy area and numbers of seedlings were identified. Canopy diameter was obtained using a tape measure on the ground by taking the longest diameter of tree canopy on the ground. The seedlings in each quadrant were also identified on the basis of their stem diameters and counted. All plant tree species with a diameter of 10 cm and below are regarded as seedlings hence counted and recorded. Incidences of forest disturbance were also assessed within each transect. Logging was assessed by noting the number of tree stumps within each plot along the transect and expressing it as a percentage of the total number of mature trees in each transect. Debarking was assessed by noting the number of trees debarked within each plot along the transect and expressed as a percentage. Grazing was assessed by number of grazed sites within each plot along the transect and expressed as a percentage while charcoal burning was assessed by noting the number of charcoal burnt sites within each plot along the transect and expressing it as a percentage.

Data analysis

Quantitative data from vegetation sampling was analyzed by two-way analysis of variance (ANOVA) to test any significant difference in the dependent variables (species diversity, richness, number of seedlings and canopy area) with distances from the forest edge and between sites ($p \leq 0.05$). Correlation analysis was also done between dependent (species diversity, richness and seedling density) and independent variable (canopy surface area) to determine the factors responsible for the patterns in species diversity, richness, seedling density and canopy surface area in the study sites.

RESULTS

Correlation between human activities and the dependent variables

The human activities that were identified in the four study sites included logging, debarking, grazing and charcoal burning. All the dependent variables (logging, grazing, debarking and charcoal burning) were negatively correlated with human activities. They also show that species richness was significantly affected by logging and debarking but not by grazing and charcoal burning, number of seedlings and canopy surface area were significantly influenced by all the human activities while there was only significant different in species diversity with logging with P-value less than 0.05 but not with the other human disturbances (Table 1).

Variation of dependent variables with distance from edge of forest and between study sites

The distance from forest edge affected the dependent variables significantly and the variables were also significantly different between the study sites. There was a significant difference in canopy surface area at the forest edge at 100, 500 and 1000 m, but no significant difference at 1500 and 2000 m in the interior of the forest. The number of seedlings significantly increased with distance from forest edge; and was also significantly different at each distance as shown in Table 2.

Regression analysis between seedling density, species richness and diversity and canopy area

There were significant relationships between the different dependent variables and distance from the forest edge (Table 3). Of greater significance was the effect of distance on species diversity, canopy surface area and seedling density, all of which were highly significant. This suggests that forest disturbance, most likely from the local people decrease significantly with distance from the forest edge. Seedling density, canopy surface area and species diversity can be predicted fairly well by distance from the forest edge. Regression analysis between canopy area and seedling density, species richness and diversity reveals a linear regression between the predictor

Table 2. Variation of dependent variables with distance from forest edge and between study sites.

Variable	Interaction	DF	ANOVA SS	Mean sq.	F-value	P-value
Species richness	Site	3	17301.17	5767.06	70.76	< 0.0001
	Distance	4	7912.88	1978.22	24.27	< 0.0001
	Site*Distance	12	4679.84	389.99	4.79	0.0028
Species Diversity	Site	3	0.39	0.13	18.83	< 0.0001
	Distance	4	0.15	0.04	5.24	0.0076
	Site*Distance	12	0.086	0.07	1.13	0.4700
Seedling density	Site	3	9282.51	3094.2	46.07	< 0.0001
	Distance	4	3970.32	992.58	14.78	0.0001
	Site*Distance	12	860.24	7199	1.07	0.4454
Canopy area	Site	3	12848.51	4282.84	39.56	< 0.0001
	Distance	4	5053.84	1263 46	11.67	0.0002
	Site*Distance	12	81.23	6.77	0.06	1.0000

Table 3. Regression of dependent variables with distance from forest edge (p≤ 0.05).

Interaction	N	P- Value	R^2	F- Value
Sp. Richness vs. distance	35	0.0003	0.56	$F_{(4,30)} = 10.033$
Sp. diversity vs. distance	35	0.0001	0.68	$F_{(4,30)} = 30.135$
Canopy area vs. distance	35	0.0001	0.81	$F_{(4,30)} = 40.744$
Seedling density vs. distance	35	0.0001	0.83	$F_{(4,30)} = 38.622$

variable (canopy surface area) and the dependent variables (seedling density, species richness and diversity). The regression equation between seedling and canopy area was y = 44ln(x) - 107.5, with R^2 value of 0.72. The regression equation between species diversity and canopy surface area was y = 0.122ln(x) + 0.234 with R^2 of 0.32 while regression equation between species richness and canopy surface area was y = 38.85ln(x) - 92.84 with R^2 of 0.75. This clearly shows that canopy surface area had a great influence on species richness and seedling density in Kakamega forest.

Variations of canopy area, seedling density, species richness and diversity in different study sites

The dependent variables were compared in the different study sites. Table 4 shows ANOVA results that compare the means of dependent variables among the four study sites. Species richness was significantly different between sites being highest at KWS site and lowest at Lukusi. There was no significant difference in species richness between Isecheno and Handidi. Species diversity was significantly different between sites being highest in KWS followed by Handidi. There was no significant difference in species diversity between Lukusi and Isecheno. Seedling density and canopy area were higher in KWS site and lowest in Lukusi. There was no significant difference in seedling density between Handidi and Lukusi while canopy surface area did not differ significantly between Handidi, Lukusi and Isecheno.

From the results, KWS had a higher mean in the dependent variables, that is, species richness, diversity, canopy area and seedling seedling density in all the four study sites. This could be attributed to the fact that some human activities take place in the other three regions as opposed to the KWS site, which is under strict management that does not allow any human activity in the reserve. A significant difference in species diversity was observed in the different study sites, with KWS having the highest species diversity. This is attributed to the fact that it is highly protected from any human disturbance. Canopy area was significantly higher in KWS but did not differ significantly in Lukusi, Handidi and Isecheno. Species richness differed significantly between Lukusi and KWS but did not differ significantly between Handidi and Isecheno. The number of seedlings did not differ significantly between Lukusi, Handidi and Isecheno, but was significantly higher in KWS (control) site.

DISCUSSION

Logging had a negative correlation with species richness, seedling density and canopy surface area as these were found to be low in areas where logging had occurred.

Table 4. Mean values of dependent variables in the four study sites (means of same letters are not significantly different at 95% confidence limit).

Site	Specie richness	Specie diversity	Seedling density	Canopy area
Handidi	52.1b	0.73b	28.8c	46.4b
Lukusi	22.1c	0.61c	28.3c	43.7b
Isecheno	47.5b	0.56c	39.8b	47.1b
KWS site	86.7a	0.85a	70.9a	93.4a
Mean	52.2	0.68	39.8	57.65
LCD (<0.05)	9.3	0.09	8.4	0.42
CV	18.2	12.2	20.7	18.8

LCD = Least common denominator; CV = coefficient of variation.

This is attributed to large open gaps within the forest that create a dry climate which interferes with seedling density and seedling establishment. This reduces species richness and canopy area in the long run. Logging leads to total removal of some mature tree species from the forests, which are important in providing cool climate under the canopy for seedling germination. The tree species exploited for logging in Kakamega forest included the hardwoods like *Olea carpensis*, *Prunus africanus* and *Celtis africana.* Logging also causes habitat destruction and a general decline in forest species abundance and diversity (Lawton et al., 1998). Moreover, Asner (2005) noted that selective logging reduces plant species diversity thereby reducing seedling species richness and hence forest seedling density in the long-term. Deforestation and logging have the greatest impact on biodiversity in tropical forests (Sala et al., 2000). Further, the new habitat that results from logging determines the biodiversity. For instance, secondary forest regenerating after the natural forest has been cleared may never reach the same species and composition as the primary forest (Chazdon, 2008)

Debarking correlated negatively with canopy surface area and seedling density. It occurred in three of the four study sites: Lukusi, Handidi and Isecheno but not KWS site. The three sites are not effectively protected from human activities and hence paving way for detrimental activities like debarking, logging, charcoal burning and grazing. KWS site is under strict surveillance and does not allow any human activity from taking place within the forest. Debarking was mainly practiced by herbalists from the community around the forest .The tree species exploited for medicinal purposes in Kakamega forest include *P. africana* and *Gravillea* ssp. and *Mondia whytei.* This leads to death of mature trees with big canopies that provide a cool climate on the floor necessary for seedling density. It also leads to slow growth rate in trees since removal of the bark interferes with translocation of manufactured food. To counter this, the Kenya Forest Service has developed a conservation strategy that provides herbalists with seeds of the medicinal trees to grow on their farms. This is an ongoing project that is yet to take root and is beset by the rising demand of herbal medicines and the slow growth rate of indigenous trees (KIFCON, 1994).

Grazing had a negative impact on seedling density. Grazing was noted in three study sites, Handidi, Lukusi and Isecheno where some extractive use was allowed in the forest hence interfered with seedling density. This was done illegally within the forest and penalties were given to the offenders. However, the ineffective surveillance of the forest and inadequate resources for management pave way for destructive activities. KWS site does not allow human activities from taking place and offenders face hash penalties. The grazing animals also stumble on young seedlings making them unable to establish themselves (Tsingalia, 2009). Even limited grazing can cause significant shifts in vegetation and damage to the soil crusts. Kleiner and Harper (1997) found that seven plant species that were common in the un-grazed area were absent or insignificant in comparable grazed sections of Canyon lands National Park. This was attributed in part to changes to cryptobiotic soil crust which decreased from 38% cover in the un-grazed area to 5% in the lightly grazed area.

Charcoal burning had a negative correlation with tree species richness, diversity, canopy surface area and seedling density and significantly affected seedling density and canopy area. Charcoal burning is detrimental to both species diversity and richness due to overexploitation of certain species for charcoal production. It also interferes with seedling density as mature trees are eliminated resulting to poor dispersal of seeds. This also interfered with canopy provided by mature trees. Tree species exploited for charcoal burning in Kakamega forest included hard woods such as *C. africana* and *P. africana*. These are known to produce finest charcoal. This was noted to be taking place in the interior remote areas inside the forest in three study sites, that is, Handidi, Lukusi and Isecheno, where the local community

does not adhere to the rules and regulations. This kind of disturbance was noted to be most detrimental especially in the sites where extractive use was allowed.

There was a positive correlation between all the dependent variables with distance from the forest edge. This shows that there is low species diversity, richness, canopy surface area and number of seedlings at the forest edge and increases towards the interior. This is because forest edges have greater impacts of human activities such as logging and grazing due to easy accessibility as compared to the interior areas. At the forest edge there are microclimate changes (Harper, 2005). Edge areas in forest are typically warmer, more exposed to light and wind and are drier than the interior areas. Gradients of these microclimate conditions extend into the interior approximately 15 to 75 m (Kapos, 1989; Lawrence and Bierregaad, 1997). Microclimate changes along forest edges often have secondary effects such as altering vegetation structure and eventually plant and animal communities (Matlack, 1993). Increased wind along the edge physically damages trees causing stunted growth and tree falls (Essen, 1994). Furthermore, wind tends to dry out the soil, decrease air humidity and increase water loss from leaf surfaces creating a drier microclimate. Increased light along the edges affects both the rate and type of plant growth, favoring fast growing light loving species at the expense of slower growing shade loving ones (Harper, 2005). Edges are also more susceptible to invasion by generalized or 'weedy' species that are better adapted to handle disturbance and new microclimate, for example lianas, vines, creepers and exotic weeds.

Species diversity, richness, number of seedlings and canopy surface area were found to be relatively high in the protected site (KWS) than in the areas where extractive use occurs (Handidi, Lukusi and Isecheno). As noted earlier, human activities have a negative impact on the species diversity, richness, canopy surface area and seedling density. KWS site does not allow any extractive use and is under strict management that does not allow any destructive human activities. There are also harsh penalties to law offenders and this keeps off people from the reserve and hence no human interference with the forest. This explains the high species diversity, richness, canopy surface area and seedling density in this site as compared to the other three sites. The indigenous forest area including grasslands/glades and open forest, is under multiple management strategies enforced by different institutions. The Forest Department manages 20,000 ha of which 11,000 ha is indigenous forest in which three of the four study sites (Handidi, Lukusi and Isecheno) occur. Some extractive forest uses such as collection of dead fuel wood, medicinal plants and thatching grass are permitted in much of the forest, but logging, debarking and charcoal burning are illegal. Cattle grazing are only allowed in the open glades. The Isecheno forest block has been established as a nature reserve by the forest department and all extractive use is forbidden in this region. However, the study established that some destructive human activities like grazing, charcoal burning and debarking take place within the forest leading to relatively low species diversity, richness, canopy surface area and seedling density as compared to KWS site. This is attributed to ineffective surveillance on the forest by the guards. Kakamega Wildlife Service (KWS) has a small area of 4,000 ha as compared to the area managed by the forest department (Isecheno, Handidi and Lukusi), that is, 20,000 ha, hence maximum surveillance on the reserve by the guards. This means all sections of the reserve is effectively guarded from any destructive human activities and hence the surrounding community cannot access the forest. This leads to a more intact forest with relatively high species diversity, richness, canopy surface area and seedling seedlings density, as compared to areas where extractive use and human disturbance occurred.

The canopy surface area greatly influenced the tree species richness and seedling density. An increase in canopy surface area would lead to an increase in the number of seedlings. Large canopies limit light penetration and may lead to a decrease in seedling density and species richness as well. Seeds in tropical forests require a cool climate at the canopy floor for germination and this can be provided by closed canopies (Whitmore, 1998). Open canopies allow too much heat to the forest floor interfering with seedling establishment, and hence dry up (Whitmore, 1998).

The human activities noted within three study sites namely, Handidi, Lukusi and Isecheno included logging, charcoal burning, debarking and grazing. There was no human disturbance noted in Kenya Wildlife Service (KWS) site at Buyangu since extractive use is forbidden in this site and harsh penalties given to offenders. In Handidi, Lukusi and Isecheno regions, some human disturbance was noted since extractive use is allowed though in a controlled manner. For instance, an interview with one of the forest guides revealed that the Forest Department office gives licenses for allowed extractive use like grazing, thatching grass collection, firewood collection and seed collection. However some illegal activities were noted within the forest areas managed by the forest department like charcoal burning, debarking and logging. This impacted negatively on the forest tree species diversity, richness, canopy surface area and seedling density. As noted earlier, these human activities reduce plant species diversity, interfere with seedling germination and establishment due to open canopies and also interfere with soil properties. The forest is generally highly degraded and fragmented and the composition of the plant communities has been greatly influenced by past commercial logging activities and other anthropogenic disturbances (Mitchel, 2004). A high abundance of middle aged individuals of *Funtumia africana* observed indicates past and recent human disturbances in the forest.

Conclusions and recommendations

The study found that the human activities (logging, debarking, grazing and charcoal burning) identified within the forest impacted negatively to the forest tree species as depicted by the relatively low tree species richness and diversity in the sites where human disturbances occurred as compared to the control site (KWS).The human activeties had a negative impact on seedling density and canopy surface area. This is evidenced by the relatively low seedling density and canopy surface area in the three study sites where human disturbances were recorded as compared to the control site (KWS). The Nyayo Tea Buffer zone around the forest did not effectively prevent the local communities from carrying out destructive activities within the forest. The national natural resource management bodies therefore should enforce strict penalties to law offenders concerning forest use by the local community. The government and other conservation stakeholders should device alternative source of livelyhood for the local community rather than rely fully on the forest resource. The government should device a more integrated approach to forest conservation. There is need for further research to look at the effect of other factors like climate change on the forest species diversity and richness.

Conflict of Interests

The author(s) have not declared any conflict of interests.

REFERENCES

Anderson AB (1990). *Alternatives to Deforestation*: Steps towards Sustainable use of the Amazon Rain Forests: Colombia University Press, London.

Asner GP, David K, Paulo B, Michael K, Jose S (2005). Selective logging in the Brazilian Amazon *Science* 310:410-482.

Chazdon RL (2008). Chance and determinism in tropical forest succession. In Tropical forest community ecology. Wiley-Blackwell, Oxford, UK

Emerton L (1994). Summary of the current value use of Kakamega Forest. KIFCON, Nairobi.

Essen PA (1994). True mortality patterns after experimental fragmentation of old- growth conifer forest. Biol. Conser. 68(3):19-29.

Harper KA, MacDonald SE, Barton PJ, Chen J, Brosoffske KD (2005). Edge Influence of forest Structure and composition in fragmentation landscapes, Conserv. Biol. 19:1-15.

Kapos V (1989). Effects of isolation on the water status of forest patches in the Brazilian Amazon. J.. Trop. Ecol. 5:73-85.

KIFCON (1994). Kenya Indigenous Forest Conservation Programme in Kakamega Forest: The official grid, forest dept. Nairobi, Kenya.

Kleiner EF, Harper KT (1997). Soil properties in relation to cryptogamic groundcover in Canyonlands National park. J. range manag. 30:202-205.

Kokwaro JO (1988). Conservation Status of Kakamega forest in Kenya. The eastern-most relic of the equatorial rain forests of Africa. Missouri Botanical Garden 25:471-489.

Lawrance WF, Bierregaard RO (1997). Tropical Forest Remnants: Ecology, Management and Conservation of fragmented communities. Ecology 79(6):2032-2040.

Lawton JH, Bignell DE, Bolton GF (1998). Biodiversity inventories, indicator taxa and effects of habitat modification in tropical forest. Nature 391:72-76.

Mars Group Kenya (2010). Kenya 2009 population data- Population distribution by sex, number of households, area density and district. Nairobi, Kenya.

Matlack GR (1993). Microenvironment variation within and among forest edge sites in the Eastern United States. Biol. Conser. 66:185-194.

Millenium Ecosystem Assessment (2005). Ecosystems and human well being, biodiversity synthesis, World Resource Institute, Washington DC

Miller KR (1982). Parks and protected Areas: Considerations for the Future. *Ambio* 11:315-317.

Miller-Gullard EJ, Rowcliffe M, Wilkie D (2003). Wild meat; The bigger picture. *Trends Ecol. Evol.* 18: 351-357.

Mitchell N (2004). The explanation and disturbance history of Kakamega forest, Western Kenya. BIOTA Report No. 1- BIElefelder Okologische BEtrage

Myers N (2000*)*. Biodiversity hotspots for conservation priorities. Nature 403: 853- 858.

Myers N (1992). The Primary Source: Tropical Forests and Our Future. New York. USA

Myers N (1988). Threatened Biotas: Hotspots in Tropical Forest. New York, USA.

Nambiro E (2000). Socio-economic baseline Survey of households around Kakamega Forest (Unpublished report, ICIPE library, Nairobi, Kenya).

Sala OE, Stuart FC, Armesto JJ, Berlow E, Bloomfield J, Dirzo R (2005). Global biodiversity sceneries for the year 2100. *Science* 287:1770-1774.

Shannon CF, Weiner W (1948). The Mathematical theory of communication. University of Illiois press, Urbarn.

Sharp AFG (1993). *Kakamega Forest Rural Development Report*. Nairobi; KIFCON and Natural Resources Institute.

Soper K (1995). What is Nature? Culture, Politics and the Non-Human. Oxford: Blackwell.

Tsingalia HM (2009). Habitat distribution severity and patterns of abundance in Kakamega Forest, Western Kenya: Afro. J. Ecol. 28: 213-226.

Tsingalia HM (1988). *Animals and Regeneration of a Canopy Tree in an African Tropical Forest:* PhD Thesis. Berkely, University of California.

Whitmore TC (1998). An Introduction to Tropical Rain Forest. Oxford University Press. Oxford, UK

Wright SJ (2005). Tropical forests in a changing environment. Trends. Ecol. Evol. 20:553-560.

academicJournals

Vol. 6(6), pp. 436-443, June 2014
DOI: 10.5897/IJBC2014.0713
Article Number: 28D56BF45309
ISSN 2141-243X

http://www.academicjournals.org/IJBC

International Journal of Biodiversity and Conservation

Full Length Research Paper

Medicinal plants in the high mountains of northern Jordan

Sawsan A. Oran and Dawud M. Al- Eisawi

Department of Biological Sciences, Faculty of Sciences, University of Jordan, Amman, Jordan.

Receive 10 April, 2014; Accepted 24 April, 2014

The status of medicinal plants in the high mountains of northern Jordan was evaluated. A total of 227 plant species belonging to 54 genera and 60 families were recorded. The survey is based on field trips conducted in the areas that include Salt, Jarash, Balka, Amman and Irbid governorates. Line transect method was used; collection of plant species was done and voucher specimens were deposited. A map for the target area was provided; the location of the study area grids in relation to their governorate was included.

Key words: Medicinal plants, high mountains of northern Jordan, folk medicine.

INTRODUCTION

Human beings have always made use of their native flora, not just as a source of nutrition, but also for fuel, medicines, clothing, dwelling and chemical production. Traditional knowledge of plants and their properties has always been transmitted from generation to generation through the natural course of everyday life (Kargıoğlu et al., 2008).

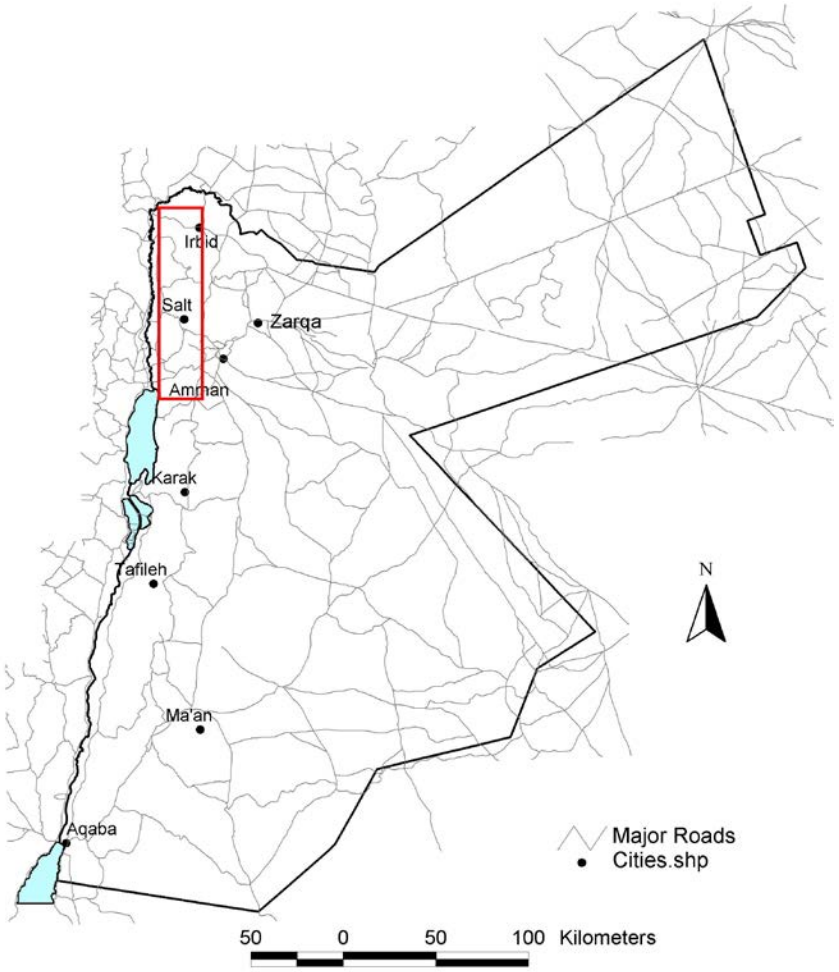
Documentation of the indigenous knowledge through ethnobotanical studies is important for the conservation and utilization of biological resources (Muthu et al., 2006). Therefore, establishment of the local names and indigenous uses of plants has significant potential societal benefits (Bağcı, 2000).

In this study, a total of 227 plant species were recorded in the target areas which includes Salt, Amman, Jarash, Ajloun and Balka which represent Mediterranean phytogeographical area (Al- Eisawi, 1996) (Map 1). The recorded plant species are reported and identified as medicinal plant out of 670 flowering plant species identified in the same area in Jordan. Recent studies are published on the status of medicinal plants that are used fofolk medicine by the local societies (Oran, 2014).

Medicinal plants in Jordan represent 20% of the total flora (Oran et al., 1998). The local Bedouins and villagers know many plant species; 363 species of medicinal vascular plants were recorded in Jordan (Oran et al., 1998).

Previous related studies where done on medicinal plant species in Jordan (Afifi et al., 2000; Abu-Irmaileh et al., 2003; Khalil et al., 1995, 2005; Al- Qura'n, 2009). Several studies were done to examine the different medicinal potentials of medicinal plants in Jordan (Al- Khalil, 1995; Oran et al., 1999; Aburjai, 2000; Elbetiha et al., 2000; Abu-Irmaileh et al., 2003; Aburjai et al., 2007; Alzweri et al., 2011; Issa et al., 2011; Bzour et al., 2011; Qunais et al., 2013; Zeidan et al., 2013). Also morphological,

*Corresponding author. E-mail: oransaw@ju.edu.jo



Map 1. Jordan map showing the study area.

taxonomic and chemical studies has increased in the last few years (Khatun et al., 2011; Erdogan et al., 2012, 2014; Mert Gönenç at al., 2014; Selvi et al., 2014).

In this study, the status of medicinal plants in the high mountains of northern Jordan was evaluated.

MATERIALS AND METHODS

Plant collections

Plant specimens were sampled from the high mountains of 5 governorates (Amman, Irbid, Ajloun, Balka and Jerash) as shown in Map 1.

Plants classifications

Plants were classified by plant taxonomists (Prof. Sawsan Oran and Prof. Dawud Al- Eisawi, University of Jordan).

Voucher specimens were deposited at the herbarium, AMM at the Department of Biological Sciences, University of Jordan, Amman, Jordan.

A list of the medicinal plants recorded in the study area is tabulated.

RESULTS

A list of medicinal plants is provided in Table 1. Rare plant species are reported and indicated in the list prepared. A map for the study area as well as the location of the study area grids in relation to their governorate is included (Figure 1).

DISCUSSION

It is shown from this study that the diversity of medicinal plants in the study area is relatively high; 227 plant species are recorded. The area surveyed is characterized by its high mountains, high altitudes (900 – 1700 m), and the climatic and the phytogeographical area is the characteristics of the Mediterranean area with rich fertile soil and rainfall. In this study, a total of 71 species were recorded as rare species that reflects the difficult situation

Table 1. The total recorded number of medicinal plants in the study area.

S/N	Name	Family	Recorded
1.	*Acanthus syriacus*	Acanthaceae	
2.	*Achillea aleppica*	Asteraceae	
3.	*Achillea biebersteinii*	Asteraceae	
4.	*Achillea santolina*	Asteraceae	R
5.	*Adiantum capillus-veneris*	Adiantaceae	
6.	*Adonis aestivalis*	Ranunculaceae	
7.	*Adonis palaestinus*	Ranunculaceae	
8.	*Ajuga chia*	Lamiaceae	R
9.	*Ajuga orientalis*	Lamiaceae	
10.	*Alcea acaulis*	Malvaceae	
11.	*Alcea setosa*	Malvaceae	R
12.	*Alkanna orientalis*	Boraginaceae	
13.	*Alkanna tinctoria*	Boraginaceae	
14.	*Allium erdelii*	Liliaceae	
15.	*Allium neapolitanum*	Liliaceae	
16.	*Allium orientale*	Liliaceae	
17.	*Allium pallens*	Liliaceae	
18.	*Allium stamineum*	Liliaceae	
19.	*Allium truncatum*	Liliaceae	
20.	*Amygdalus communis*	Rosaceae	
21.	*Anagallis arvensis*	Primulaceae	
22.	*Anchusa aegyptiaca*	Boraginaceae	
23.	*Anchusa italica*	Boraginaceae	
24.	*Anchusa strigosa*	Boraginaceae	R
25.	*Anchusa undulata*	Boraginaceae	
26.	*Androcymbium palaestinum*	Liliaceae	
27.	*Anemone coronaria*	Ranunculaceae	R
28.	*Anthemis bornmuelleri*	Asteraceae	R
29.	*Anthemis palaestina*	Asteraceae	R
30.	*Apium graveolens*	Apiaceae	
31.	*Apium nodiflorum*	Apiaceae	
32.	*Arbutus andrachne*	Ericaceae	
33.	*Aristolochia billardieri*	Aristolochiaceae	
34.	*Aristolochia parvifolia*	Aristolochiaceae	
35.	*Arum hygrophilum*	Araceae	
36.	*Arum palaestinum*	Araceae	R
37.	*Arundo donax*	Poaceae	
38.	*Asparagus aphylla*	Liliaceae	R
39.	*Asphodelus aestivus*	Liliaceae	R
40.	*Astragalus annularis*	Fabaceae	
41.	*Astragalus beershabensis*	Fabaceae	
42.	*Astragalus bethlehemiticus*	Fabaceae	
43.	*Astragalus callichrous*	Fabaceae	
44.	*Astragalus cruciatus*	Fabaceae	
45.	*Astragalus deinacanthus*	Fabaceae	
46.	*Astragalus fruticosus*	Fabaceae	
47.	*Astragalus oocephalus*	Fabaceae	
48.	*Astragalus palaestinus*	Fabaceae	
49.	*Astragalus sanctus*	Fabaceae	
50.	*Ballota undulata*	Lamiaceae	R
51.	*Bifora testiculata*	Apiaceae	R

Table 1. Contd.

52.	*Blepharis ciliaris*	Acanthaceae	
53.	*Bongardia chrysogonum*	Berberidaceae	R
54.	*Bryonia cretica*	Cucurbitaceae	
55.	*Bryonia syriaca*	Cucurbitaceae	
56.	*Calamintha incana*	Lamiaceae	
57.	*Calendula palaestina*	Asteraceae	
58.	*Calendula tripterocarpa*	Asteraceae	
59.	*Calycotome villosa*	Fabaceae	R
60.	*Capparis spinosa*	Capparaceae	R
61.	*Capsella bursa-pastoris*	Brassicaceae	
62.	*Centaurea iberica*	Asteraceae	R
63.	*Ceratonia siliqua*	Fabaceae	R
64.	*Chrysanthemum coronarium*	Asteraceae	R
65.	*Chrysanthemum segetum*	Asteraceae	
66.	*Cichorium pumilum*	Asteraceae	R
67.	*Cistus creticus*	Cistaceae	R
68.	*Cistus salvifolius*	Cistaceae	R
69.	*Clematis cirrhosa*	Ranunculaceae	
70.	*Consolida scleroclada*	Ranunculaceae	
71.	*Convolvulus scammonia*	Convolvulaceae	
72.	*Coronilla scorpioides*	Fabaceae	
73.	*Crataegus aronia*	Rosaceae	
74.	*Crocus hyemalis*	Iridaceae	
75.	*Cupressus sempervirens*	Cupressaceae	
76.	*Cyclamen persicum*	Primulaceae	R
77.	*Cynodon dactylon*	Poaceae	
78.	*Cynoglossum creticum*	Boraginaceae	
79.	*Cyperus longifolium*	Cyperaceae	
80.	*Daucus carota subsp. maximus*	Apiaceae	
81.	*Delphinium peregrinum*	Ranunculaceae	
82.	*Ecballium elaterium*	Cucurbitaceae	R
83.	*Echinops polyceras*	Asteraceae	
84.	*Eminium spiculatum*	Araceae	R
85.	*Ephedra alte*	Ephedraceae	R
86.	*Ephedra campylopoda*	Ephedraceae	R
87.	*Epilobium hirsutum*	Onagraceae	
88.	*Eremostachys laciniata*	Lamiaceae	
89.	*Erodium acaule*	Geraniaceae	
90.	*Erodium malacoides*	Geraniaceae	
91.	*Erodium moschatum*	Geraniaceae	
92.	*Eruca sativa*	Brassicaceae	
93.	*Eryngium creticum*	Apiaceae	
94.	*Eryngium glomeratum*	Apiaceae	
95.	*Erysimum crassipes*	Brassicaceae	
96.	*Euphorbia aleppica*	Euphorbiaceae	
97.	*Euphorbia helioscopia*	Euphorbiaceae	
98.	*Euphorbia hierosolymitana*	Euphorbiaceae	R
99.	*Euphorbia macroclada*	Euphorbiaceae	
100.	*Euphorbia oxyodonta*	Euphorbiaceae	
101.	*Euphorbia peplis*	Euphorbiaceae	
102.	*Ficus carica*	Moraceae	R
103.	*Foeniculum vulgare*	Apiaceae	R

Table 1. Contd.

104.	*Fumaria densiflora*	Fumariaceae	R
105.	*Fumaria parviflora*	Fumariaceae	R
106.	*Galium aparine*	Rubiaceae	
107.	*Geranium dissectum*	Geraniaceae	
108.	*Geranium molle*	Geraniaceae	
109.	*Geranium tuberosum*	Geraniaceae	
110.	*Glaucium arabicum*	Papaveraceae	
111.	*Gundelia tournefortii*	Asteraceae	
112.	*Helichrysum sanguineum*	Asteraceae	
113.	*Heliotropium europaeum*	Boraginaceae	
114.	*Herniaria hirsute*	Caryophyllaceae	
115.	*Hyoscyamus aureus*	Solanaceae	
116.	*Hypecoum imberbe*	Fumariaceae	
117.	*Hypericum triquetrifolium*	Hypericaceae	
118.	*Inula viscose (Dittrichia viscosa)*	Asteraceae	R
119.	*Lactuca serriola*	Asteraceae	
120.	*Lactuca tubersoa*	Asteraceae	
121.	*Lagoecia cuminoides*	Apiaceae	
122.	*Lamium amplexicaule*	Lamiaceae	
123.	*Lamium moschatum*	Lamiaceae	
124.	*Leontice leontopetalum*	Berberidaceae	R
125.	*Lonicera etrusca*	Caprifoliaceae	R
126.	*Mandragora autumnalis*	Solanaceae	R
127.	*Marrubium vulgare*	Lamiaceae	
128.	*Matricaria aurea*	Asteraceae	R
129.	*Medicago sativa*	Fabaceae	R
130.	*Melilotus indicus*	Fabaceae	
131.	*Mentha longifolia*	Lamiaceae	R
132.	*Mercurialis annua*	Euphorbiaceae	
133.	*Micromeria nervosa*	Lamiaceae	R
134.	*Myosotis uncata*	Boraginaceae	
135.	*Nasturtium officinale*	Brassicaceae	
136.	*Nepeta curviflora*	Lamiaceae	
137.	*Nerium oleander*	Apocynaceae	R
138.	*Neslia apiculata*	Brassicaceae	
139.	*Nigella ciliaris*	Ranunculaceae	
140.	*Olea europaea*	Oleaceae	R
141.	*Ononis natrix*	Fabaceae	R
142.	*Ononis spinosa subsp. Antiquorum*	Fabaceae	
143.	*Onopordum alexandrinum*	Asteraceae	
144.	*Onopordum cynarocephalum*	Asteraceae	
145.	*Onopordum macrocephalum*	Asteraceae	
146.	*Ophrys carmeli*	Orchidaceae	
147.	*Orchis anatolica*	Orchidaceae	
148.	*Origanum syriacum*	Lamiaceae	R
149.	*Osyris alba*	Santalaceae	
150.	*Papaver subpiriforme*	Papaveraceae	R
151.	*Papaver syriaca*	Papaveraceae	
152.	*Paronychia argentea*	Caryophyllaceae	R
153.	*Paronychia sinaica*	Caryophyllaceae	
154.	*Phagnalon rupestre*	Asteraceae	R
155.	*Phoenix dactylifera*	Palmae	

Table 1. Contd.

156.	*Phragmites australis*	Poaceae	
157.	*Pimpinella cretica*	Apiaceae	
158.	*Pimpinella eriocarpa*	Apiaceae	
159.	*Pimpinella olivieri*	Apiaceae	
160.	*Pimpinella peregrine*	Apiaceae	
161.	*Pinus halepensis*	Pinaceae	
162.	*Pistacia atlantica*	Anacardiaceae	R
163.	*Pistacia palaestina*	Anacardiaceae	R
164.	*Plantago afra*	Plantaginaceae	
165.	*Plantago lanceolata*	Plantaginaceae	
166.	*Plantago major*	Plantaginaceae	
167.	*Plantago ovata*	Plantaginaceae	
168.	*Plumbago europaea*	Plumbaginaceae	R
169.	*Polygonum equisetiforme*	Polygonaceae	
170.	*Psoralea bituminosa*	Fabaceae	
171.	*Punica granatum*	Punicaceae	R
172.	*Quercus coccifera*	Fagaceae	R
173.	*Ranunculus asiaticus*	Ranunculaceae	
174.	*Reseda lutea*	Resedaceae	R
175.	*Retama raetam*	Fabaceae	R
176.	*Rhus coriaria*	Anacardiaceae	R
177.	*Rhus tripartite*	Anacardiaceae	
178.	*Ridolfia segetum*	Apiaceae	
179.	*Roemeria hybrida*	Papaveraceae	
180.	*Rubus tomentosus*	Rosaceae	
181.	*Rumex crispus*	Polygonaceae	R
182.	*Rumex cyprius*	Polygonaceae	R
183.	*Rumex pulcher*	Polygonaceae	R
184.	*Ruta chalepensis*	Rutaceae	
185.	*Salix acmophylla*	Salicaceae	
186.	*Salix alba*	Salicaceae	R
187.	*Salix pseudo-safsaf*	Salicaceae	
188.	*Salvia dominica*	Lamiaceae	
189.	*Salvia multicaulis*	Lamiaceae	
190.	*Salvia triloba*	Lamiaceae	R
191.	*Sanguisorba minor*	Rosaceae	
192.	*Sarcopoterium spinosum*	Rosaceae	R
193.	*Scrophularia xanthoglossa*	Scrophulariaceae	R
194.	*Scutellaria subvelutina*	Lamiaceae	
195.	*Scutellaria tomentosa*	Lamiaceae	
196.	*Sedum nicaeense*	Crassulaceae	
197.	*Senecio vernalis*	Asteraceae	
198.	*Silybum marianum*	Asteraceae	
199.	*Sinapis alba*	Brassicaceae	R
200.	*Sinapis arvensis*	Brassicaceae	R
201.	*Smilax aspera*	Liliaceae	
202.	*Solanum dulcamara*	Solanaceae	
203.	*Solanum luteum*	Solanaceae	
204.	*Sonchus oleraceus*	Asteraceae	
205.	*Stellaria media*	Caryophyllaceae	
206.	*Styrax officinalis*	Styracaceae	
207.	*Symphytum palaestinum*	Boraginaceae	

Table 1. Contd.

208.	*Taraxacum officinale*	Asteraceae	
209.	*Tetragonolobus palaestinus*	Fabaceae	R
210.	*Teucrium polium*	Lamiaceae	R
211.	*Thymus capitatus*	Lamiaceae	R
212.	*Tordylium aegyptiacum*	Apiaceae	R
213.	*Trigonella foenum-graecum*	Fabaceae	
214.	*Tulipa agenensis*	Liliaceae	
215.	*Typha domingensis*	Typhaceae	
216.	*Urginea maritime*	Liliaceae	
217.	*Urtica pullulans*	Urticaceae	R
218.	*Vaccaria pyramidata*	Caryophyllaceae	
219.	*Varthemia iphionoides*	Asteraceae	R
220.	*Verbascum fruticulosum*	Scrophulariaceae	R
221.	*Verbascum sinuatum*	Scrophulariaceae	
222.	*Veronica anagallis-aquatica*	Scrophulariaceae	
223.	*Veronica syriaca*	Scrophulariaceae	
224.	*Vicia sativa*	Fabaceae	
225.	*Xanthium spinosum*	Asteraceae	
226.	*Ziziphus lotus*	Rhamnaceae	R
227.	*Ziziphus nummularia*	Rhamnaceae	

R: Rare

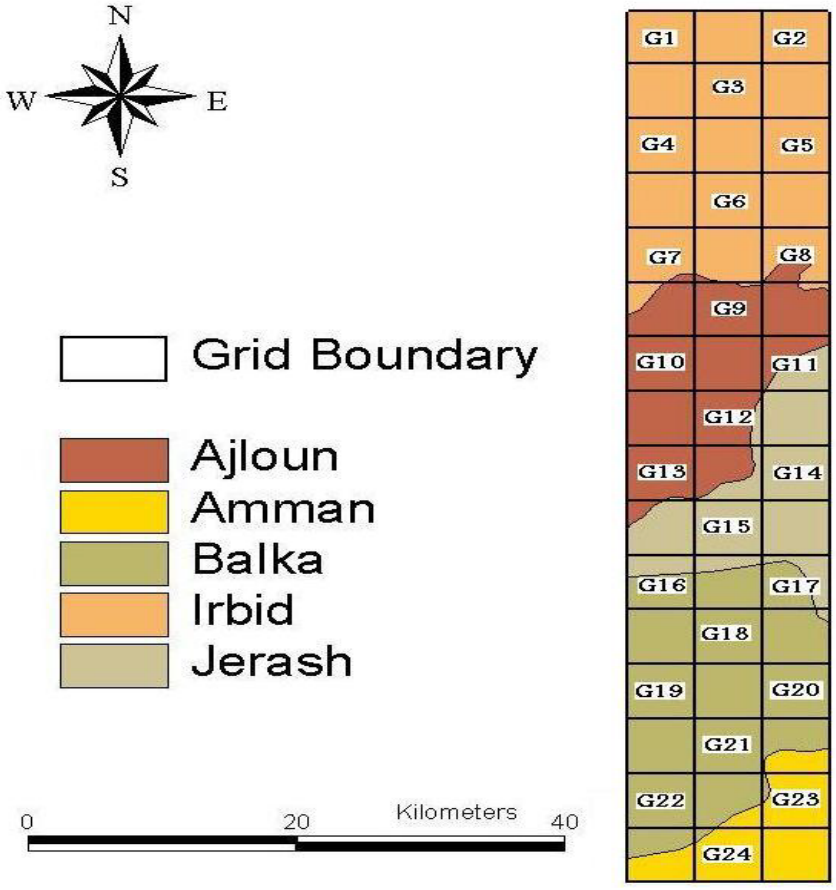


Figure 1. The location of the study area grids in relation to their governorate.

of the survival of many plant species recorded.

Therefore, more efforts are required for the conservation and protection of the medicinal plant species in that rich area; the laws for the conservation of nature are to be seriously enforced.

It was also shown from this study, the use of medicinal herbs in folk medicine which is declining in most of the investigated areas as a result of the following:

1. Degradation of the wild plants resources amongst the medicinal plants.
2. Grazing.
3. Urbanizations.
4. Construction of roads.
5. Forest destructions
6. Lack of elders in most of the study localities, hence the youth comprising the large number of the population from where one could learn about the tradition medicine most.

Finally, collaborative scientific research is needed at local and global level; some of the medicinal plants recorded are rare and threatened wild genetic resources. Priorities in research should be given to those endangered plant species.

Conflict of Interests

The author(s) have not declared any conflict of interests.

ACKNOWLEDGEMENTS

The authors are indebted to the Deanship of Scientific Research at the University of Jordan for their continuous financial support and Miss Asma Bzour for technical assistance.

REFERENCES

Aburjai T (2000). Anti- platelet stilbenes from aerial parts of *Rheum palaestinum*, Phytochemistry, 55(5):407-410.

Aburjai T, Hudaib M, Tayyem R, Yousef M, Qishawi M (2007). Ethnopharmacological survey of medicinal herbs in Jordan, the Ajloun Heights region. J. Ethnopharmacol. 110:294- 304.

Abu-Irmaileh B, Afifi F (2003). Herbal medicine in Jordan with special emphasis on commonly used herbs. J. Ethnopharmacol. 89(2–3):193–197.

Al- Eisawi DM (1996). Vegetation of Jordan. UNESCO (ROSATAS), Cairo, Egypt, p.284.

Al- Khalil S (1995). A Survey of Plants Used in Jordanian Traditional Medicine. Pharmaceutical Biology. 33(1):317-323.

Al- Qura'n A (2009). Ethnopharmacological survey of wild medicinal plants in Shawbak, Jordan, J. Ethnopharmacol. 123:45- 50.

Alzweri M, Sarhan A, Mansi K, Hudaib M, Aburjai T (2011). Ethnopharmacological survey of medicinal herbs in Jordan, the Northern Badia region, J. Ethnopharmacol. 1:137(1):27-35.

Bağcı Y (2000). Ethnobotanical features of Aladağlar (Yahyalı, Kayseri) and its vicinity. The Herb Journal of Systematic Botany 7:89–94.

Bzour JF, Oran SA, Khaleel M, Mashallah S, Bustanji Y (2011). Inhibitory effects of methanolic extract of *Salvia fruticosa* Mill. on pro-inflammatory cytokines production in RAW 264.7 *in vitro* cellular model and in Balb/c mice *in vivo* animal model. J. Med. Plants Res. 5(30):6662–6671.

Erdogan T, Kıvçak B, Önür MA, Braca A (2012). Chemical constituents and Cytotoxic Activity of *Ranunculus pedatus* subsp. *pedatus.* Chemistry of Natural Compounds, 48(3):486-488.

Erdogan T, Gonenc T, Demirci B, Kivçak B, Baser KCH (2014). Determination of fatty acid and essential oil constituents and biological activities on *Ranunculus pedatus subsp. pedatus.* Asian J. Chem. 26(7):2156-2160.

Issa A, Mohammad M, Hudaib M, Tawah K, Abu Rjai T, Oran S, Bustanji Y (2011). Potential role of *Lavandula angustifolia* in the management of diabetic dyslipidemia. J. Med. Plants Res. 5(16):3876-3882.

Kargıoğlu M, Cenkci S, Serteser A, Evliyaoğlu N, Konuk M, Kök MŞ, Bağcı Y (2008). An ethnobotanical survey of inner-West Anatolia, Turkey. Human Ecology 36:763–777.

Khatun S, Cakilcioglu U, Chatterjee NC (2011). Pharmacognostic value of leaf anatomy and trichome morphology for identification of forskolin in a novel medicinal plant *Coleus forskohlii* Briq. Biol. Divers. Conserv. 4(2):165-171.

Muthu C, Ayyanar M, Raja N, Ignacimuthu S (2006). Medicinal plants used by traditional healers in Kancheepuram district of Tamil Nadu, India. J. Ethnobiol. Ethnomed. 2:43.

Oran SA, Al-Eisawi DM (1998). List of Medicinal Plants in Jordan. *Dirasat* (Medical and Biology Sciences) 25(29):84-112.

Oran SA (1999). Potato Disc Bioassay of Some Jordanian Medicinal Plants. Pharmaceutical Biology, 37(4):296-299.

Oran SA (2014). The status of medicinal plants in Jordan. Accepted

Qunais E, Abdalla F, Kaddumi E, Abdalla S (2013). Evaluation of the antidiarrheal activity of *Laures nobilis* leaf extract in rats, J. Medicinal Food, 15(1):51-57.

Selvi S, Paksoy MY, Polat R, Cakilcioglu U (2014). Micromorphological and anatomical characteristics of the Genus *Chrysophthalmum* Schultz Bip. (Asteraceae) growing in Turkey. Proceedings of the National Academy of Sci, India Section B: Biological Sci. 4:431-438.

Zeidan R, Oran S, Khleifat K, Matar S (2013). Antimicrobial activity of leaf and fruit extracts of Jordanian *Rubus sanguineus* Friv. (Rosaceae). Afr. J. Microbiol. Res. 7(44):5114-5118.

academicJournals

Vol. 6(6), pp. 444-451, June 2014
DOI: 10.5897/IJBC2011.132
Article Number: F71F2AF45311
ISSN 2141-243X

http://www.academicjournals.org/IJBC

International Journal of Biodiversity and Conservation

Full Length Research Paper

Phenological patterns among the vegetation of Ganga Chotti and Bedori Hills in a moist temperate to alpine forests

Z. H. Malik* and N. Z. Malik

Department of Botany, University of AJ&K, Muzaffarabad (A.K), Pakistan.

Received 30 May, 2011; Accepted 12 February, 2014

There were 206 plant species of 47 families consisting of 10 trees, 18 shrubs, 140 herbs and 38 grasses harbouring Ganga Chotti and Bedori Hills during 1999 and 2000. The investigated area had two flowering seasons. In the first spell, 111 species (54%) flowered while in the second spell, 46% species flowered. Majority of the herbaceous, shrubby trees species flowered from May to June and the flowering reached the peak during July and August. Most species produced fruits during the first spell

Key words: Phenology, climate, environmental changes, rainfall.

INTRODUCTION

Phenology is a periodic phenomenon in plants that is tied to periodic environmental changes. This type of study investigates the relationship between climate and growing periods of plants of an area. The studies are essential for planning, regeneration, forestation and conservation in rangeland and forestry. Some work has been done on phenology of plants in different areas of the world (Morellato, 1995; Wright and Calderon, 1995; Kim, 1996; Stranghetti and Ranga, 1997; Shrestha et al., 1998; Zhanghe et al., 1999; Kimkim and Yadava, 2001; Osada et al., 2003; Marques et al., 2004; Malik, 2005, 2007).

The investigated area lies in moist temperate to alpine zone. The annual rainfall is 705.12 mm. The minimum rainfall occurs during the month of June to August with 76-167 mm, respectively. The maximum temperature from January to March ranges between 11 and 16°C. From May to August, the temperature ranges between 25 and 29°C. Snow falls frequently at altitude above 2000 m during November to January which melts during the month of May. However, there is no permanent snow cover.

MATERIALS AND METHODS

The phenological observations were recorded every month for two consecutive years from May to November, 1999 and then again from May to November, 2000. The data was averaged. The plants were classified into the following three stages.

1. Prereproductive (vegetatively young and pre-flowering)
2. Flowering (only flowers seen)
3. Fruiting (when fruiting can be seen)
4. Dormant (life cycle completed or fruiting completed).

RESULTS

There were two flowering seasons in the investigated area. One from May to August followed by the second from September to November. From December to April the entire area is covered by snowfall.

In the first periods 111 species (53.88%) flowered, which included 6.89% trees, 10.34% shrubs, 62.06% herbs and 13.79% grasses. There were 6.89% ferns in

*Corresponding author. E-mail: malikzh51@yahoo.com.

Table 1. Phenology of plants recorded from Ganga Chotti and Bedori hills during 1999-2000.

S/N	Specie	Seedling	Flowering	Fruiting	Dormant
	Tree layer				
1	*Abies pindrow* Royle	Mar	Apr	May	July
2	*Ficus palmata* Forssk	Throughout the year	May	Aug	Sep
3	*Picea smithiana*(Wallich) Boiss	Mar	Apr	May	July
4	*Pinus roxburghii S*argent	Mar	Apr	May	July
5	*Pinus wallichiana* A.B.Jackson	Mar	Apr	June	July
6	*Punica granatum* L.	Throughout the year	July	Aug	Sep
7	*Pyrus pashia* Buch	Apr	May	July	Aug
8	*Quercus dilatata* Royle	Mar	Apr	June	July
9	*Machilus odoratissima* Nees	May	July	Aug	Sep
10	*Astragalus floridus* L	June	Aug	Sep	Oct
Shrub layer					
11	*Berberis lycium* Royle	Mar	Apr	June	July
12	*Cotoneaster acuminatus* Lindley	May	June	July	Sep
13	*Desmodium multiflorum* DC	June	July	Sep	Oct
14	*Indigofera heterantha* Wallich	June	July	Sep	Oct
15	*Jasminum officinale* L.	Throughout the year	June	July	Aug
16	*Juniperus communis* L.	Mar	May	June	July
17	*Myriactus nepalensis* Bth	Aug	Sep	Oct	Nov
18	*Myrsine africana* L.	Mar	May	June	July
19	*Rosa ellipticus* Smith	May	June	July	Sep
20	*Rosa macrophylla* Lindley	May	June	July	Sep
21	*Rosa webbiana* Wallich ex Royle	May	July	Aug	Sep
22	*Rubus niveus* Wallich	May	July	Aug	Sep
23	*Salix albeda* Anderson	June	July	Aug	Oct
24	*Salix denticulata* Anderson	May	June	July	Aug
25	*Salix grandiflorum* L.	May	July	Aug	Sep
26	*Sarcococca saligna* (D.Don) Muel	Throughout the year	Apr	May	june
27	*Viburnum grandiflorum* Wallich ex DC	Oct	Nov	May	June
28	*Zanthoxylum armatum* DC	Mar	Apr	May	June
Herb layer					
29	*Achillea millefolium* L.	May	July	Aug	Sep
30	*Aconitum chasmenthum* Stapf	July	Aug	Sep	Oct
31	*Aconitium laeve* Royle	July	Aug	Sep	Oct
32	*Aconitum violaceum* jacquem ex Stapf	July	Aug	Sep	Oct
33	*Ajuga bracteosa* Wallich	Apr	June	July	Oct
34	*Allium humile* Kunth	May	July	Sep	Oct
35	*Amaranthus viridus* L.	May	July	Aug	Sep
36	*Anaphalis margaritacea* (L.) Bth	July	Sep	Oct	Nov
37	*Anaphalis nepalensis* Spreng. *Hand*	May	July	Aug	Sep
38	*Anaphalis timmua* D. Don	May	July	Sep	Oct
39	*Androsace rotundifolia* Hardw	Mar	Aug	Sep	Oct
40	*Aquilegia pubiflora* Wallich	May	July	Sep	Oct
41	*Arenaria neel* Wight and Arn	Mar	Apr	Aug	Sep
42	*Arenaria orbiculata* Royle	June	Aug	Sep	Oct
43	*Arisaema intermedium* Blume	May	June	July	Aug
44	*Arisaema jacquemontii* Blume	May	June	July	Aug
45	*Artemisia wallichiana* Besser	June	July	Aug	Sep

Table 1. Contd.

46	*Artemisia scoparia* Waldst and Kit	Apr	July	Aug	Sep
47	*Artemisia herba-alba* Asso	May	July	Sep	Oct
48	*Aster alpinus*(Clarke) Hutch	May	June	Aug	Sep
49	*Bergenia ciliata* (Haw) Sternb	Apr	June	July	Aug
50	*Bergenia ligulata* (Str) Hot	Apr	May	June	July
51	*Biden bipinnata* L.	Apr	May	July	Sep
52	*Bistorta amplexicaulis*(D.Don) Greene	May	July	Aug	Sep
53	*Brunella vulgaris.*L	May	June	Aug	Sep
54	*Bupleurum longicaule* Wall Ex DC	May	July	Sep	Oct
55	*Calamintha umbrosum* (M.Bieb) K.Koch	May	July	Aug	Sep
56	*Caltha palustris* L.	May	July	Aug	Oct
57	*Cannabis sativa* L.	May	June	July	Aug
58	*Chenopodium ambrosiodes L.*	May	June	July	Sep
59	*Circaea alpina* Asch&Mag	June	July	Aug	Sep
60	*Circium arvense* (L).Scop	June	July	Aug	Oct
61	*Clematis grata* Wallich	Throughout the year	July	Aug	Sep
62	*Clinopodium alpinum* Cass	Oct	June	July	Aug
63	*Codonopsis ovata* Bth	June	July	Aug	Oct
64	*Convolvulus arvensis Var.linearifolius* Choisy	Throughout the year	July	Aug	Sep
65	*Conyza canadensis* L.	May	June	July	Aug
66	*Cotoneaster acuminatus* Lindley	May	June	July	Aug
67	*Cynoglossum lanceolatum* Forssk	Apr	June	July	Aug
68	*Cynoglossum glochidiatum* Wallich ex Benth	May	July	Aug	Sep
69	*Cyperus niveus* Retz	May	June	July	Sep
70	*Cyperus panicoides* L.	June	July	Aug	Sep
71	*Cypripedium cordigerum* D.Don.Prod	May	June	July	Sep
72	*Dipsacus inermis* Wall	June	July	Aug	Sep
73	*Elsholtzia strobilifera* Bth	Throughout the year	July	Sep	Oct
74	*Epilobium cylindricum* D.Don	May	July	Sep	Oct
75	*Epilobium hirsutum* L.	May	July	Sep	Oct
76	*Erigeron alpinus* L.	Apr	June	Aug	Sep
77	*Erigeron bellidioides* Buch	Apr	June	Aug	Sep
78	*Euphorbia helioscopia* L.	Apr	July	Aug	Sep
79	*Euphorbia wallichii* HK..f	Apr	May	Sep	Oct
80	*Euphorbia prostrata* Ait	Throughout the year	Aug	Sep	Oct
81	*Fragaria nubicola* Lindl.	Apr	June	July	Aug
82	*Fritillaria roylei* Hook	May	July	Aug	Sep
83	*Galium elegan* Wall	June	July	Aug	Sep
84	*Gentiana cachmerica* DC	July	Aug	Sep	Oct
85	*Gentiana decumbens* L.P Clarke	July	Aug	Sep	Oct
86	*Gentiana kurroo* Royle	July	Aug	Sep	Oct
87	*Geranium rotundifolium* L.	Mar	May	June	Aug
88	*Geranium wallichianum* D.Don	June	July	Sep	Oct
89	*Gerbera gossypina* Royle	Oct	May	July	Aug
90	*Geum elatum* Wall	May	June	Aug	Sep
91	*Hedra nepalensis* K. Koch	Throughout the year	Aug	Nov	Oct
92	*Impatiens edgeworthii* H.K.f	June	Sep	Oct	Nov
93	*Impatiens glandulifera* Royle	July	Aug	Sep	Oct
94	*Ipomoea perforatum* L.	May	June	Aug	Sep

Table 1. Contd.

95	*Iris lactea* L.	May	June	Aug	Sep
96	*Lactuca dissecta* L.	May	July	Aug	Sep
97	*Lavaetra cachemiriana* Camb	May	July	Aug	Sep
98	*Leontopodium alpinum* Cass	Apr	June	Aug	Oct
99	*Lepidium sativum* L.	May	June	July	Aug
100	*Lespedeza sericea* (Thunb) Miq	June	July	Aug	Sep
101	*Malva sylvestris* L.	Apr	June	Aug	Sep
102	*Malva verticillata* L.	Apr	June	July	Sep
103	*Medicago falcata* L.	May	July	Aug	Sep
104	*Medicago leciniata* (L) Mill	May	July	Aug	Sep
105	*Melilotus indica* (L) All	May	July	Aug	Sep
106	*Mentha longifolia* (L.)Hudson	May	June	July	Sep
107	*Micromeria biflora* (Ham) Bth	May	June	July	Aug
108	*Morina coulteriana* Royle	May	July	Aug	Oct
109	*Myriactus nepalensis* Bth	Aug	Sep	Oct	Nov
110	*Nepeta podostachys* Bth	July	Aug	Sep	Oct
111	*Oenanthe javanica* (Blume) DC	Apr	July	Aug	Sep
112	*Oenothera rosea* (L). Her	May	July	Aug	Oct
113	*Oxalis corniculata* L.	Apr	May	June	July
114	*Phlomis bracteosa* Royle ex Bth	May	June	July	Aug
115	*Plantago lanceolata* L.	Apr	Aug	Sep	Oct
116	*Plantago major* L	July	Aug	Sep	Nov
117	*Plantago ovata* Forssk	May	July	Aug	Nov
118	*Plectranthus rugosus* Wall	July	Sep	Oct	Nov
119	*Pleurospermum govanianum (*DC) Clarke	May	July	Aug	Oct
120	*Podophyllum hexandrum* Royle	Apr	May	June	July
121	*Polygonum album* Ham	May	July	Aug	Sep
122	*Polygonum amplexicaulis* D.Don	May	July	Aug	Sep
123	*Polygonum alpinum* All	May	June	July	Aug
124	*Potentilla cuneata* Wallich	June	July	Aug	Sep
125	*Potentilla eriocarpa* Wallich	June	July	Aug	Sep
126	*Potentilla gelida* C.A. Meyer	May	July	Sep	Oct
127	*Potentilla geradiana* L.	June	July	Aug	Sep
128	*Primula denticulata* Smith	Apr	July	Aug	Sep
129	*Pseudomertensia echioides(* Bth) Riedl	May	July	Aug	Sep
130	*Pseudomertensia moltkioides* (Royle) Kazmi	May	July	Aug	Sep
131	*Ranunculus repens* L.	May	June	July	Aug
132	*Ranunculus laetus* Wallich	May	June	July	Aug
133	*Rubia tinctorum* L.	May	June	July	Aug
134	*Rumex hastatus* D. Don	May	June	July	Sep
135	*Rumex dentatus* L.	May	Aug	Sep	Oct
136	*Rumex nepalensis* D.Don	May	July	Aug	Nov
137	*Saussurea lappa* Clark	Apr	June	July	Sep
138	*Saxifraga ciliata* Royle	July	Aug	Sep	Oct
139	*Scutellaria chamaedrifolea* Bth	Apr	June	Aug	Sep
140	*Senecio ligularia* Hook	July	Aug	Sep	Oct
141	*Senecio chrysanthemoides* DC	July	Aug	Sep	Oct
142	*Senecio graciliflorus* DC	July	Aug	Sep	Oct
143	*Senecio nudicaulis* DC	July	Aug	Sep	Oct

Table 1. Contd.

144	*Senecio quadriflorum* Pall	July	Aug	Sep	Oct
145	*Selinum tenuifolium* Wall	July	Aug	Sep	Oct
146	*Sibbaldia cuneata* Hornem	June	July	Aug	Oct
147	*Solanum nigrum* L.	Throughout the year	July	Sep	Nov
148	*Sonchus arvense L.*	Apr	July	Sep	Nov
149	*Sonchus asper* Hill	Apr	July	Sep	Nov
150	*Spiraea canescens* D.Don	June	July	Aug	Sep
151	*Stellaria media* (L) Vill	May	July	Aug	Sep
152	*Stellaria monosperma* Buch	May	July	Aug	Sep
153	*Strobilanthes attenuata* Nees	May	July	Aug	Sep
154	*Swertia petiolata* D.Don	June	July	Aug	Sep
155	*Taraxacum officinales* Weber	Apr	June	July	Aug
156	*Thlaspi arvense* L.	May	June	July	Aug
157	*Thymus serphyllum* L.	May	July	Aug	Sep
158	*Trifolium repens* L.	May	June	July	Aug
159	*Trifolium resupinatum* L.	May	June	July	Aug
160	*Trillidium repen* L	May	June	July	Aug
161	*Trilidium govanianum* (D. Don) Kunth	May	June	July	Aug
162	*Tussilogo farfara* L.	June	July	Aug	Sep
163	*Urtica dioica* L.	June	Aug	Sep	Oct
164	*Valeriana pyrolifolia* Dcne	Apr	May	June	Aug
165	*Verbascum thapsus* L.	June	July	Aug	Oct
166	Veronica m*elissaefolia* Royle	May	June	July	Aug
167	Viola odorata L.	Mar	Apr	June	Aug
168	Viola serpen Wallich	Mar	May	July	Sep
	Grasses				
169	*Agrostis alba* auct	May	July	Aug	Sep
170	*Agrostis canina* auct	May	July	Aug	Sep
171	*Agrostis gigantea* Roth	May	July	Aug	Sep
172	*Andropogon munroi* C.B.Clarke	Mar	Apr	Aug	Sep
173	*Arundo donax* L.	May	June	Oct	Nov
174	*Avena barbata* Pott ex Link	Mar	Apr	May	June
175	*Brachiaria ramosa* (L) Stapf	May	July	Oct	Nov
176	*Bromus tectorum* L.	May	June	July	Aug
177	*Cenchrus biflorus* Roxb	Aug	Sep	Nov	Dec
178	*Cenchrus uniflorus* Ehr	July	Aug	Jan	Feb
179	*Chrysopogon aucheri* (Boiss) Stapf	Feb	Apr	May	June
180	*Cynodon dactylon* (L.) Pers	Feb	Mar	Sep	Oct
181	*Dactylis glomerata* L.	June	July	Aug	Sep
182	*Desmostachya bipinnata* (L) *S*tapf	Sep	Oct	Dec	Jan
183	*Dichanthium annulatum* (Forssk).Stapf	Feb	Apr	Sep	Oct
184	*Elymus repens* (L.)Gould	June	July	Aug	Sep
185	*Festuca modesta* Nees	Mar	Apr	Aug	Sep
186	*Imperata cylindrica* (L.)	Mar	Apr	June	July
187	*Koeleria macrantha* (Ledeb) Schult	Mar	Apr	Sep	Oct
188	*Phalaris minor* Retz	Feb	Apr	Aug	Sep
189	*Phleum alpinum* L.	June	July	Sep	Oct
190	*Poa annua* L.	Feb	Apr	Sep	Oct
191	*Poa bactriana* Rozhev	Mar	Apr	May	June
192	*Polypogon monspeliensis* (L.) Desf	Mar	Apr	July	Aug
193	*Saccharum spontaneum* L.	June	July	Sep	Oct

Table 1. Contd.

194	*Sorghum halepense* (L)Pers	Apr	May	Oct	Nov
195	*Themeda anathera* Ness ex Steud	May	June	Oct	Nov
196	Vetiveria zizanioides (L) Nasch	Aug	Sep	Oct	Nov
197	**Ferns**				
	Adiantum venustum D.Don	June	July	Aug	Sep
	Adiantum capilus veneris L.	June	July	Aug	Oct
	Asplenium adiantum nigrum L.	June	Aug	Sep	Oct
	Athyrium mackinnoni (Hope) C. Chr	June	Aug	Sep	Oct
	Cystopteris fragilis (L) Bth	May	June	July	Aug
	Dryopteris stewartii Fress	May	July	Aug	Sep
	Onychium japonicum (Kunze) Wall	May	June	July	Oct
	Pteris cretica L.	May	June	Aug	Sep
	Pteris vitata L.	May	June	Sep	Oct
	Thelypteris levinger Clark	May	June	Sep	Oct

Table 2. Comparison of phenological phases between spring and monsoon vegetation.

Season	Total flowering species	Flowering (%)	Trees (%)	Shrub (%)	Herbs (%)	Grasses (%)	Ferns (%)
1	111	53.80	6.89	10.34	62.06	13.79	6.89
2	95	46.11	1.12	2.25	74.15	16.85	5.61

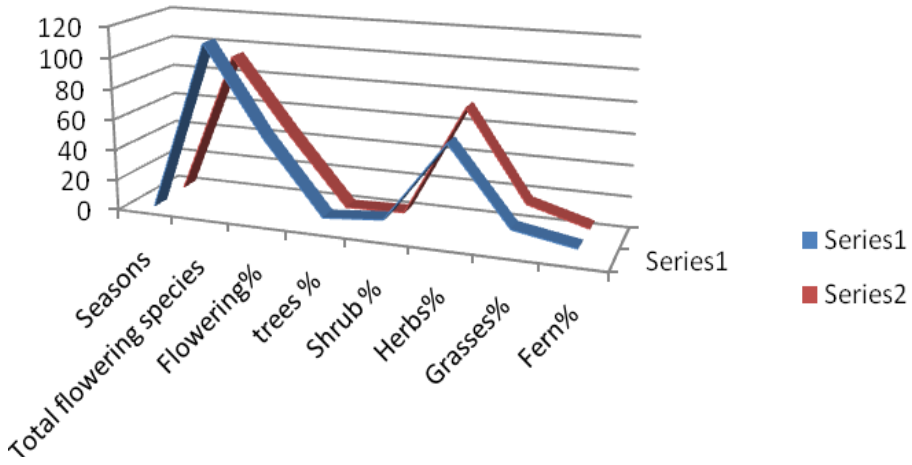


Figure 1. Comparison of phenological phases between spring and monsoon vegetation.

reproductive phase (sori were prominent) (Tables 1 and Table 2; Figure 1).

During the second flowering spell, 95 species (46.11%) were blooming. Out of these, 1.12% were trees, 2.25% were shrubs, 74.15% were herbs, 16.85% were grasses and 5.61% were ferns (in reproductive phase). There were 1% shrubs, 15% herbs and 2% grasses, which exhibited continuous flowering during growing season.

The months of May and June and then July and August appeared to be the peak flowering seasons as 36 (18%), 53 (26%), 81 (39%) and 28 (14%) species were in the flowering stage. The flowering percentage declined to 6 (3%) to 1(.5%) from September to November. Majority of species (55%) became dormant during September while the remaining 45% also become dormant in November.

Trees such as *Abies pindrow, Quercus dilatata, Picea smithiana*, *Pinus wallichiana* and *Ficus palmata* flowered in April and May and thereafter cones of conifers started maturing within the next 2-3 years. During this time cones remain intact on parent trees. Shrubby species had maxi-

mum flowering around May and June, which decreased to 20% towards the end of September. Thus, during September 80% species became dormant. From there onward with the onset of winter most (80%) species remain dormant till next April.

There were 38 herbaceous species in flowering stage in May, 46 in June and 83 in July, which decline to 27 in August. There was a tendency of declining flowering from September to October. Of the total 127 recorded herbaceous species, only 33% completed their life cycle at the end of June.

Maximum flowering of grass species (46.63%) was observed in May, followed by 28.5% in July. In the remaining months grasses flowered less than 10%.

DISCUSSION

The present study showed that the growing season started at the end of April whereby only few herbaceous and shrubby plants initiated vegetative growth. The blooming of few plants occurred during early May. Plants such as Ficus, Pyrus, Juniperus, Myrsine, Bergenia, Biden, Euphorbia, Geranium, Gerbera, Oxalis, Podophyllum and Valeriana, etc were active during this period.

The majority of herbaceous, shrubby and tree species flowered from May to August. The flowering reached the peak during July and August. The first spell of flowering started at the beginning of spring (May to June), while fructification occurred during July and August. Most species produced fruits during the first spell.

In the first spell, 111 species (53.88%) flowered, which included 7% trees, 10% shrubs, 26% herbs, 4% grasses and 6.89% ferns. During the second flowering spell, lasting from September to November 95 species (46%) were blooming. Of them, there were 1% trees, 2% shrubs, 21% herbs, 17% grasses and 5% ferns. The month of June and July appeared to be the peak flowering season. The flowering declined from September to November. Most trees and shrubs flowered during April to May. The fructification however can be observed in July - August. Shrestha et al. (1998) reported that majority of the plants flowers during April/May in Riyale, Nepal. Similarly, Zhanghe et al. (1999) also reported that peak of flowering occurred during May in different parts of China. Stranghetti and Ranga (1997) stated that in Brazil shrubs exhibited continuous flowering throughout the year. But in our case, majority of shrubs flowered from May to August. Our finding are in line with those of Kim (1996) and Stranghetti and Ranga (1997) who also reported two flowering seasons into their areas. Durrani (2000) also reported two flowering seasons in Harboi range, Kalat. The fruiting occurring during the dry period is probably related to the fact that the beginning of the next rainy period will offer favorable condition for seed germination (Morellato et al., 1989).

Another study in Brazil (Morellato, 1995) indicated that the flowering starts at the end of dry season and beginning of wet period. Fruiting was more intense during dry season. Most species were in flowering session between July to September and fruiting in December, which is the end of dry and beginning of rainy seasons. Morellato and Leitao-Filho (1992) pointed out that this period (December) has the advantage of providing the seeds with more intense luminosity and thus greater probability to germinate. Foster (1982) mentioned that the phenology of fructification is strongly related to the seasons which offer better condition for seed germination. In our case seeds are deposited in November and December that remain dormant during the cold season and are subjected to natural treatments such as chilling, stratification and moisture treatment before they could germinate in the next spring, whereby climate becomes warmer.

Kikim and Yadava (2001) stated that majority of the species exhibited peak of leaf drop in cool dry period January to February and leaf flushing in the beginning of warm dry period (March to April) and another in rainy season (August) of the year. Both over-storey and understorey species showed a sharp flowering peak in April. The peak period of fruit maturation occurred during September - October. This is what happened in this study. Leaf flush and flowering were simultaneous in over and under storey tree species. While the fruiting of under - storey tree species was one month earlier than that of over-storey tree species. In this study, trees such as *Abies pindrow, Picea smithiana, Pinus roxburghii* flowered and produced fruits in April and May when temperature was low. *Ficus palmata* flowered in May - August, *Pinus wallichiana* in April – June, *Pyrus pashia* in May – July, *Quercus dilatata* from April to June in low rainfall area, while Machilus and Astragalus in July-August and August-September during rainy seasons. In cool temperate forest, the proportion of flowerings tree species is small in early spring; this proportion increases around June, and then decreases again (Rathcke, 1988; Inoue et al., 1990; Kato et al., 1990). In the present study, a similar situation was seen because of similarity in climatic factor. The investigated area is of cool temperate type with low temperature in winter that restricts the reproductive timing of woody plants. Wright and Calderon (1995) indicated the importance of phenology in determining the flowering season of a species. The flowering sequence of several genera e.g. *Rhododendron a*nd *Viburnum* was conducted in cool temperate forest in North America (Rathcke, 1988). This suggests the phenological patterns might not change significantly through the data of one year.

Some trees on Yakushima Island flower even in winter (Yumoto, 1987), probably because of difference in latitude. Evergreen in typical warm tropical forest flower throughout the year, although the proportion of flowering tree is small in winter.

Osada et al. (2003) stated that various tree species bloomed sequentially from the middle of February to the end of October and flowering tree species were particu-

larly abundant around May. This corresponds to the season of leaf emergence, as flowers of most species were produced at the same time. In our case, too, the season started from the month of May whereby some species flowered in May such as *Abies, Picea* and *Pinus roxburgii* and shrubs such as *Juniperus, Myrsine, Bergenia, Biden, Euphorbi, Geranium, Gerbera, Oxalis, Podophyllum, Valeriana* and *Viola* flowered sequentially.

During, year 2000, the climate was comparatively moist due to rainfall while in 1999 climate was dry. The phonological activities were almost similar in both years from April to August. Species of spring aspect completed their life cycle one month earlier during 2000 as compared to 1999. The major vegetation elements remained dormant from November onward. Morellato and Leitao-Filho (1992) stated that lack of nutrients during transition from dry to wet season might be an important factor in controlling phonological activities. In the investigated area, low precipitation rate and fall of the leaves of many species during dry season offer a good chance with climatic cycle. Normally plants disperse seeds/fruits after completing the life cycle. During winter, seeds receive cold treatment which the triggers germination and sprouting from below ground parts or shoots during early monsoon.

The grazing period was coordinated with phenological cycle. Grazing was allowed in most plants or in vegetative fall. Once the shrubs shed the seeds, they may be allowed for grazing. Grazing of annual and herbaceous plants before flowering will slowly decreases their production as seeds are the only source of survival and regeneration. Seed collection can be achieved after fruiting seasons for storage as a gene bank. The crucial grazing period which is coordinated with flowering can be avoided to ensure a good seed bank for future generation. The annuals usually flush flowering during early spring or during monsoon season. Rainfall in the investigated area is uncertain for the last few years, therefore the amount of seed produced and emergence of seedling might be invariable during different years.

REFERENCES

Durrani MJ (2000). Ecological evaluation of some rangeland plants of Harboi Hills, Kalat,Balochistan. Ph.D, Thesis University of Peshawar.

Foster RB (1982). The seasonal rhythum of fruitfall on Barro Colorado Island, In: E.G. Leigh. Jr., A.S. Rand and D.M. Windsor (eds). The ecology of a tropical forest, Smithsonian Institution Press, Washington.

Inoue T, Kato M, Kakutani T, Suka T, Itino T (1990). Insect-flower relationship in the temperate deciduous forest of Kibune, Kyoto, an overview of the flowering phenology and the seasonal pattern of insect visits. Contributions from the Biological Laboratory, Kyoto University, 27: 377-463

Kato M, Kakutani T, Inoue T, Itino T (1990). Insect –flower relationship in the primary beech forest of Ashu, Kyoto; an overview of the flowering phenology and the seasonal pattern of insect visits. Contributions from the biological laboratory, Kyoto University, 27:309-375.

Kikim A, Yaadava PS (2001). Phenology of tree species in sub tropical forests of Manipur in North eastren India. Trop. Ecol. 42:269-276.

Kim AC (1996). Lianas da Mata Atlantica do estado de Sao Paulo. Campinas, UNICAMP. Dissertacao (Mestradoem Biologia).

Malik NZ (2007).Vegetation structure and diversity of moist temperate rangelands of Pir-Chinasi hills,District Muzaffarabad.Ph.D Thesis University of Arid Agriculture Rawalpindi.

Malik ZH (2005). Comparative study on the vegetation of Ganga chotti and Bedori hills District Bagh, Azad Jammu and Kashmir with special reference to Range conditions. Ph.D Thesis University of Peshawar.

Marques MCM, Roper JJ, Salvalaggio APB 2004. Phenological patterns among plant life-form in a subtropical forest in Southern Brazil. Plant Ecol. 173:203-213.

Morellato LPC (1995). As estacoes do anon a floresta. Pp 37-41. in: L.P.C. Morellato and H.F. Leitao Filho (orgs.). Ecologia e preservacao deuma floresta tropical urbana. Reserva de Santa Genebra. Editora da UNICAMP-Campinas.

Morellato LPC, Leitao-Filho HF (1992). Padroes de frutificacao e dispersao na Serra doo Japi. 112-139. In : L.P.C. Merellato (org.) Historia natural da Serra do Japi: Ecologia e preservacao de uma area florestal no sudeste do Brasil. Editora da UNICAMP –FAPESP. Campinas.

Morellato LPC, Rodrigues RR, Filho HFL, Joly CA (1989). Estudo comparitivo dafenologia de especies arboreas de floresta de altitude floresta mesofila semidecidua na serra Japi; Junidia, Sao Paulo. Rev. Bras. Bot. 12: 85-98.

Osada N, Shinji S, Kawamura K, Cho M, Takeda H (2003). Community level flowering phenology and fruit set: Comparative study of 25 woody species in a secondary forest in Japan. Ecol. Res. 18: 711-723.

Rathcke B (1988). Interactions for pollinations among co-flowering shrubs. Ecology 69: 446-457.

Shrestha S, Jha PK, Shrestha KK (1998). Vegetation of degraded, regenerating and natural forests in Riayle, Kavrepalanchok, Nepal. Pak. J. PIant Sci. 4:13-28.

Stranghetti V, Ranga T (1997). Phenological aspect of flowering and fruiting at the Ecological station of Paulo de Faria-Sp-Brazil. Trop. Ecol. 38: 323-327

Wright SJ, Calderon O (1995). Phylogenetic patterns among tropical flowering phenologies. J. Ecol. 83: 937-948.

Yumoto T (1987). Pollination systems in a warm temperate evergreen broad- leaved forest on Yaku Island. Ecol. Res. 2:133-145.

Zhanghe C, Jieyuan C, Yunlong Z (1999). Flowering and fruiting phenologies of the woody plants in three floras in China. J. Trop. Subtrop. Bot. 7:102-108.

academicJournals

Vol. 6(6), pp. 452-458, June 2014
DOI: 10.5897/IJBC2012.141
Article Number: D9A774C45312
ISSN 2141-243X

http://www.academicjournals.org/IJBC

International Journal of Biodiversity and Conservation

Full Length Research Paper

Environmental factors influencing structure and distribution of east African green heart (*Warburgia ugandensis* Sprague) in Mt. Kenya Forest

Anne Kairu[1]*, Nathan Gichuki[2], James Kanya[2] and Roeland Kindt[3]

[1]Embu University College, P.O Box 6-60100, Embu, Kenya.
[2]University of Nairobi P.O Box 30197, G.P.O, Nairobi, Kenya.
[3]World Agroforestry Centre, United Nations Avenue, Gigiri, P.O Box 30677, Nairobi 00100, Kenya.

Received 20 November, 2012; Accepted 9 May, 2014

Effects from past climate, natural disturbances and human activities are significantly impacting negatively on current day processes in tropical indigenous trees forests. Most of the indigenous trees mostly hard woods have been logged by human activities. *Warburgia ugandensis* is a tree that is highly valued for its medicinal properties, timber, poles and fuel wood. Consequently, its population and distribution has been on the decline due to environmental and anthropogenic impacts. There is no documentation on how environmental factors affect distribution and population structure of *W. ugandensis* in Mt. Kenya forest and without which conservation strategies may be impossible. This study purposes to determine the present distribution and population structure of *W. ugandensis* in Mt. Kenya forests. Study area was stratified into four blocks based on potential natural vegetation: moist montane, moist intermediate, dry montane and dry intermediate natural vegetation types. Dry montane was the only vegetation type with *W. ugandensis* and therefore four forest blocks were selected for this study: Kangaita, Kahurura, Ontulili and Gathioro forests. Belt transects measuring 25 m wide and 500 m long were marked and subdivided into 20 sub-plots of 25 by 25 m from which four sub-plots were systematically selected for sampling. Rainfall data for all the sampled blocks were obtained from meteorological records while altitude data was obtained by use of geographical positioning system (GPS). Data was analyzed by SPSS 11.0 (2001) statistical software. There was a significant negative correlation between rainfall and the population structure of *W. ugandensis*. The species was concentrated in the drier parts of dry montane forests while none existed in the other three potential natural vegetation types.

Key word: Distribution, population, structure, *Warburgia ugandensis*, diameter at breast height, canopy, height.

INTRODUCTION

Forests play a vital role in water catchment, improve soil fertility, regulate local climate and are vital carbon sinks and reservoirs. Assessing the distribution and structure of a particular forest plant species forms an important part

*Corresponding author. E-mail: kairuanne1@gmail.com. Tel: +254-0722679081.

of forest conservation. Climate change effects on forests include changes in the geographic range of certain tree species. According to Intergovernmental Panel on Climate Change (IPCC) 2007, there are significant transitions associated with shifts in forest locations and composition due to climate change.

Warburgia ugandensis is an indigenous tree species whose distribution as studied by Trapnell et al. (1966) indicated its presence in Eastern and South Eastern parts of Mt. Kenya forest. Issues of climate change and human exploitation of forest through logging, clearing for cultivation and forest farming through shamba system and PELIS contributed to a general decline of some specific indigenous tree species. The species has been rated 2nd among the highly threatened species after *Prunus africana*. Although a lot of information has been documented on deforestation of natural forests, information on the distribution and population structure of individual tree species and effects of environmental factors is lacking. Without such information, it would be difficult to apply appropriate conservation strategies to protect such species from disappearing. This study therefore investigated the current status of some of the most valuable species for the purpose of conservation. The results from this research are necessary in introducing the species into cultivated landscapes using PNVT as a criterion for ecological suitability (Mueller-Dombois and Ellenberg, 1974).

MATERIALS AND METHODS

This study was conducted in several forests around Mount (Mt.) Kenya (Figure 1) forests. The mountain is 5,199 m above sea level and lies on latitude 0° 9' 00'' S and longitude 37° 18' 00" E. The lower limit of the forest is between 2,000 and 2,500 m above sea level (Young, 1991). These altitudes are believed to affect the temperature and amounts of rainfall received in a given locality. There are differences in the vegetations on different aspects of the mountain (Figure 1). On the northern slopes, the dominant species is the East African juniper *Juniperus procera* (EWP, 2007), Podo, *Podocarpus milanjianus*, African Olive *Olea europaea* common in drier forest and at lower elevations. Precipitation commonly comes in two seasons in a year, the long rainsis in March to May and the short rains in October to November. Mount Kenya is underlain by Quaternary (less than 2 million years old) trachytic and basaltic lavas.

In addition, the lavas are covered by different strata of volcanic ashes, pyroclastics and fluvial-lacustrine sediments all of which are of variable ages (Jaetzhold and Schmidt, 1982).

Study area was stratified into four blocks based on potential natural vegetation types (Kindt et al., 2007); moist montane, moist intermediate, dry montane and dry intermediate natural vegetation type. Mapping of roads and foot paths used within Mt. Kenya forests was done by use of Global Positioning System (GPS) together with vegetation and climatic maps (Trapnell et al., 1966). *W. ugandensis* was sampled in dry montane forests in Kangaita, Kahurura, Ontulili and Gathioro. In each forest, base transects were either an established road, foot path or animal track cutting across altitudinal gradient as described by Caratti et al. (2006). Length of base transects varied depending on the terrain. At each sampling site, data was collected at a distance of 50 m from the forest edge into the forest to reduce edge effects from neighbouring farms. Belt transects measuring 25 m wide and 500 m long were marked with the starting points being 50 m from the base transect. Direction of the first belt transect was determined randomly by tossing a coin, where a head represented the left hand side of the base transect and the tail represented the right hand side. The rest of the belts were selected systematically by alternating left and right sides of base transect spaced at altitudinal intervals of 100 m above sea level. The belt transect was subdivided into twenty plots of 25 by 25 m from which four sub-plots were systematically selected for sampling starting from the 2nd sub-plot and then the others after a distance of every 100 m. The entire sub-plot was used in sampling *W. ugandensis* which has more than 5 cm diameter at breast height (Kindt et al., 2007). Rainfall data for all the sampled blocks was obtained from Nanyuki meteorological station, while altitude data was obtained by use of GPS. In each plot, data for number of trees, DBH, height and canopy diameter was collected along altitude and rainfall gradients. In the four sub-plots, all *W. ugandensis* with a height of more than 1.5 m was sampled for diameter at a breast height of 1.3 m. Tree height was determined by use of Suunto clinometer. Data was analyzed for analysis of variance and correlations between different plots, belts and between the dependent and independent variables.

RESULTS

W. ugandensis structure based on diameter at breast height (DBH) in different forests

The sizes of *W. ugandensis* trees varied in different forests in Mount Kenya ecosystem. Kangaita forest had a mean DBH of 0.23 m and was therefore larger than the same species in other forests studied. However trees found in the high altitude Ontulili forest were slightly smaller (mean DBH of 0.21 m) than those found in Kangaita forest but higher than those of Kahurura (mean DBH 0.14 m) and Gathioro (mean DBH 0.17 m) forests. There was no significant difference in DBH of this species among the four forests ($F_{[3, 214]} = 6.67$, $p = 0.077$).

W. ugandensis height in different forests

Ontulili and Kangaita forest had the tallest *W. ugandensis* trees with mean heights of 12.6 and 12.2 m, respectively. Kahurura and Gathioro forests had shorter trees with mean heights of 7.3 and 6.025 m, respectively (Table 1). There was a significant difference in height of trees of this species among different forests ($F_{[3, 214]} = 9.92$, $p = 0.046$).

Canopy diameters of *W. ugandensis* in different forest reserves

Canopy diameter of *W. ugandensis* averaged between 2.5 to 4.5 m in all the forests. Kangaita recorded the greatest canopy diameter of 4.5 m, Ontulili 3.9 m, Kahurura 3.1 m and Gathioro 2. 5 m (Table 1). The third belt in Kangaita had only two individual trees and

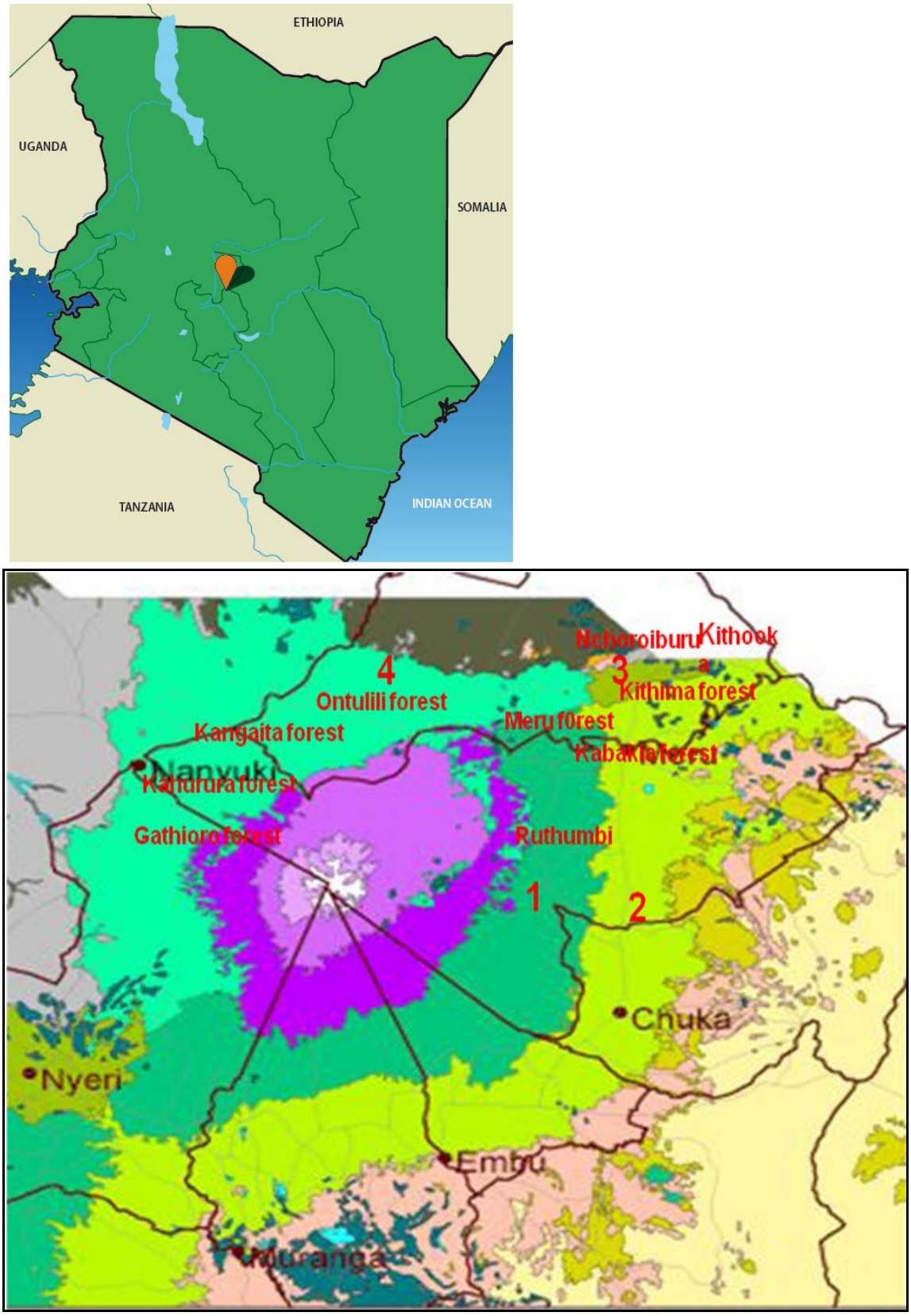


Figure 1. Mt. Kenya potential natural vegetation types adopted from Directorate of Overseas Survey (L.R.) 3006, Kenyan Government 1976. The lines on the map show road network. 1, Moist montane; 2, moist intermediate; 3, dry intermediate; 4, dry montane.

Table 1. Mean DBH, height and canopy diameter in different forests, altitudes and rainfall amounts.

Forest	Altitude (m)	Rainfall (mm)	Height (m)	DBH (m)	Canopy (m)
Kangaita	2080	72.9	12.7	0.26	5.1
	2171	74.6	11.7	0.19	3.8
Kahurura	2058	74.8	9.5	0.18	3.9
	2156	74.5	8.2	0.15	2.9
	2234	77.1	4.3	0.10	2.4
Ontulili	2155	71.3	15	0.26	4.3
	2254	72.8	10.1	0.15	3.5
Gathioro	2117	78.1	6.4	0.08	2.3
	2221	81.5	5.65	0.09	2.6

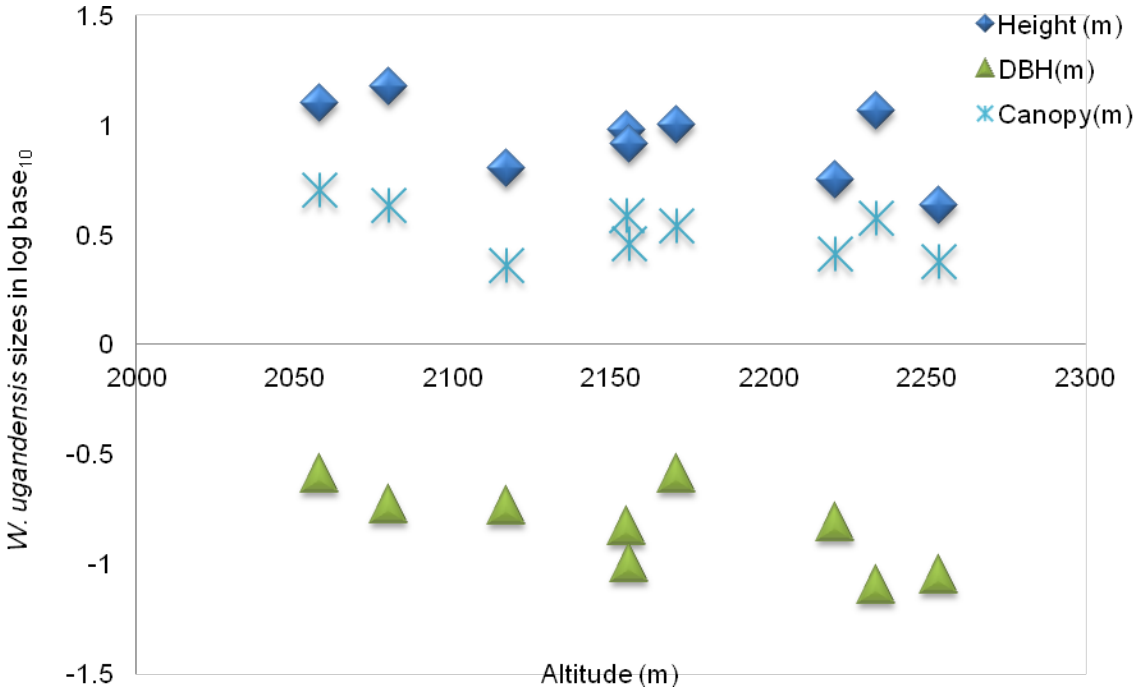


Figure 2. Sizes of *W. ugandensis* in relation to altitude ranging from about 2000-2300m asl.

therefore not included in the analysis since they were not representative of the real situation. Ontulili (2354 m asl) and Gathioro's (2321 m asl) belt three lacked *W. ugandensis*.

There was no significant difference in canopy diameter of this species among different forests ($F_{[3, 214]} = 5.932$, p= 0.089). The canopy diameter appeared to have been influenced by the location of the tree among other associated forest tree species. *W. ugandensis* trees located in open areas tended to have larger canopies than those with tree neighbours of other species.

Trends in *W. ugandensis* sizes found in different altitudes

The findings of this study revealed that DBH of *W. ugandensis* decreased with increasing altitude in all the four forests (Figure 2).

The largest DBH was 0.26 m at 2080 m and 2155 m above sea level (asl) while the lowest was 0.08 m at 2117 m asl. To reduce the variation of height values, DBH and canopy diameter, the values were converted into log base ten. There was no significant correlation (r = -0.447,

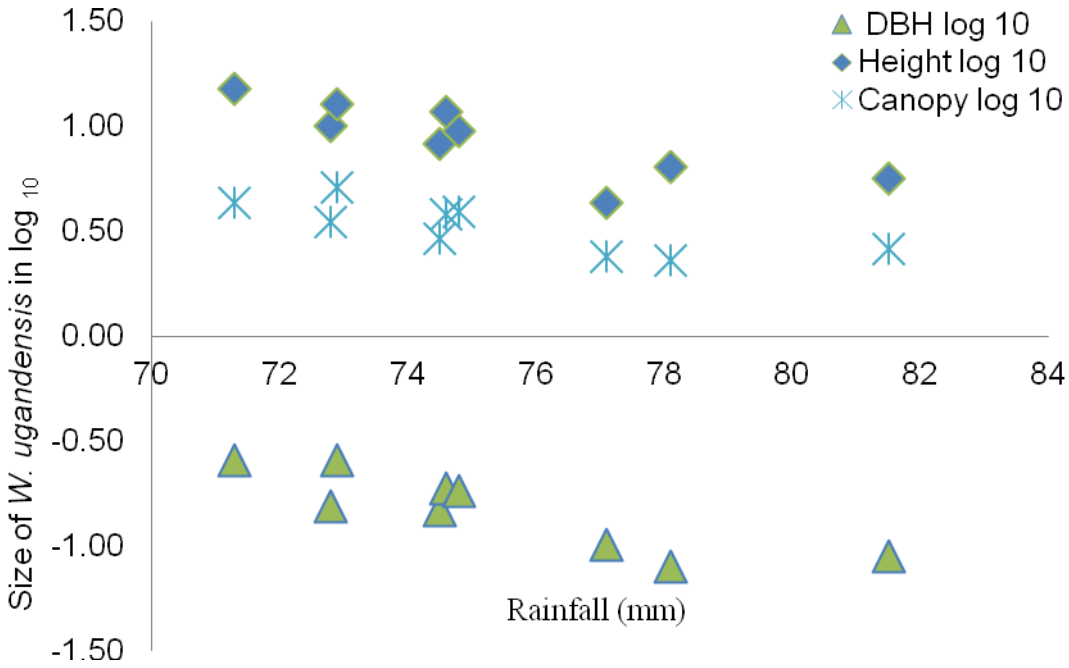


Figure 3. Tree sizes in relation to rainfall.

n=214, p= 0.228) between DBH and altitude.

Mean heights in relation to altitude

The findings of this study revealed that height of *W. ugandensis* decreased with increasing altitude in all the forests (Figure 2 and Table 1). In Kangaita, the mean heights were 12.7 and 11.7 m at altitudes 2,080 m and 2,171 m, respectively. This trend was also reflected in Kahurura where mean heights were 9.5 and 4.3 m at altitudes 2,058 and 2,234 m respectively. Equally for Ontulili the mean heights were 15 and 10.1 m at altitudes 2,155 and 2,254 m and in Gathioro, mean height were 6.4 m at 2,117 m and 5.65 m at 2,221 m asl. There was no significant correlation (r = -0.359, n =214, p=0.343) between height of trees and altitudes.

Canopy diameter in relation to altitude

The highest canopy diameter of 5.1m was recorded at an altitude of 2080 m asl while the lowest was 2.3 m at 2117m asl (Table 1). However, there was no significant correlation (r = -0.49, n=214, p=0.183) between canopy diameter and altitude.

Variation in sizes of *W. ugandensis* found in different rainfall regimes

Mean monthly rainfall ranged from 71 to 81 mm in all forests where *W. ugandensis* occurred (Table 1). DBH of *W. ugandensis* decreased with increasing rainfall in all the forests (Figure 3). Highest DBH was 0.26 m at 71.3 and 72.9 mm of rainfall and the lowest was 0.08 m at rainfall of 78.1 mm. There was a highly significant negative correlation (r = -0.840, n=214, p= 0.005) between rainfall and tree diameter at breast height. Diameter at breast height was higher in trees in lower rainfall range and as the rainfall increased the DBH decreased (Figure 3).

Tree height in relation to rainfall

Height of *W. ugandensis* decreased with increasing rainfall in all the forests (Figure 3). The tallest trees averaging 15 m were found at 71 mm of rainfall while the shortest trees with an average 4.3 m occurred at 77 mm of rainfall. There was a strong negative correlation (r = -0.84, n=214, p=0.005) between rainfall and tree heights. When the mean DBH, height and canopy diameter were converted to log base ten to reduce their variation, a general trend was noted where all sizes decreased with increasing rainfall (Figure 3).

Effect of rainfall on canopy size

The largest canopy diameter was 5.1 m occurring at 72.9 mm of rainfall and the smallest canopy diameter was 2.3 m at 81.5 mm of rainfall per month (Figure 3). Data

collected indicated that areas with higher rainfall had smaller canopy diameter than areas with low rainfall (Figure 3). There was significant negative correlation (r = -0.75, n=214, p=0.02) between canopy diameter and rainfall.

DISCUSSION

The objective of this study was to determine the distribution and population structure of *W. ugandensis.* The study found that *W. ugandensis* did not occur in moist montane, dry intermediate and moist intermediate natural vegetation types and all sampled plants were obtained from dry montane forests, particularly in north west of Mount Kenya. This may be attributed to the uniqueness of dry montane's type of annual rainfall which ranges from 650 to 1500 mm in altitude of 1800 to 2500 m above sea level (Kindt et al., 2007).

Climate is the major determinant of distribution of vegetation types and plants species in the world as stated by Woodward (1987). Rainfall has affected the distribution of this species in that the species grows in areas with less rainfall and fail to exist in areas with a lot of it. Moist montane forest is probably too wet while intermediate forests are in lower altitude zones where forests have already been converted into agricultural land. This has affected the distribution of *W. ugandensis* by limiting it only to the forest reserves where its distribution is also limited by altitude up to about 2200 m asl. The variation in distribution of *W. ugandensis* in different forests may be due to variations in rainfall.

W. ugandensis structure has been described in relation to diameter at a breast height of 1.3 m, height of the tree and canopy diameter (Ogden, 1970). There was a trend with the tree DBH decreasing as the altitude increased in Kangaita, Kahurura and Ontulili. This may be attributed to decrease in temperature and water holding capacity of air and decrease in soil nutrients which decline with increase in altitude. This concurs with the work of Kapelle et al. (1995) which showed stem diameter of the different species of trees decreased with increase in altitudinal zonation of Quercus montane forest. Kitayama and Aiba (1994) and Priceton (1997) reported that plant stature declined with increase in altitude but no significant correlation between DBH and altitude. Rainfall, soil water and temperature are important in determining DBH increment (Chidumayo, 2005). In this study, the DBH declined significantly with increase in rainfall. Possible cause of this decline could be attributed to high levels of leaching and erosion of essential nutrients like nitrate and organic compounds from the soil by heavy rainfall. High levels of leaching and water logging reduce soil pH as described by Macintire et al. (1938). Impeded drainage causes water logging which influences plant structure development (Frankham et al. 1996) due to reduced aeration limiting the microbial activities and reducing nutrients availability. These results are consistent with findings of Soethe et al. (2008) who found that plant growth, correlates with nutrients availability.

Mean tree height decreased with increase in altitude and this was possibly caused by low soil nutrients and low temperatures which cause decreased rate of microbial decomposition and nutrients release for plant use. Reduced microbial activity could be linked to the decreasing temperatures as altitude increased. Decrease in tree height with increasing altitude was also reported by Kofidis and Bosabalidis (2008) whose work on *Nepeta nuda* L. and found that height decreased with altitude. Decrease in tree height could be explained by the shortening of tree stems at high elevations as reported by Smith (1980) who found that stem height decreases with increase in altitude in plant species occurring above tree line (ecotone containing upright trees more than 3 m tall). Decrease in plant height may also be associated with decreased solar radiation and sunshine which decreases the photosynthetic rate (Frankham et al., 1996). Shorter plants are able to obtain warmth from the ground for the purpose of photosynthesis.

Tree height decreased with increasing rainfall amount. There was a strong negative correlation between rainfall and tree heights. These findings are supported by Longino (1986), in their study on tropical liana which indicated a negative correlation between rainfall and height of shoot. This may be attributed to waterlogging of the soils which limit availability of nitrogen compounds, enhancing accumulation of phosphorus, loss of organic matter through erosion and low levels of pH (Longino, 1986).

Mean canopy diameter had a negative correlation with altitude. Higher altitudes had trees with smaller canopy diameter. Decrease in canopy diameter with increasing altitude is linked to decrease in nutrients and increase of phosphate compounds which tie up micronutrients like iron, copper and zinc (Busman et al., 2002).

There was strong significant negative correlation between canopy diameter and rainfall. Canopy diameter was also found to correlate with DBH and plant height. According to Chidumayo (2005), if DBH decreases with increase in rainfall, then canopy diameter would also decrease with rainfall increase. However, the possible cause of decline of canopy size with increase in rainfall amount may also be linked to the leaching, waterlogging, unavailability of nutrients and eroding levels of essential nutrients. Moreover, impeded drainage has negative influence on canopy development (Frankham et al., 1996). This may be due to poor root hair development and hence low absorption of essential nutrients, causing reduced growth.

Conclusions

This study shows that *W. ugandensis* exist in dry montane

forests and population structure was mainly dependent on the amount of rainfall. However, changes observed in relation to altitude did not correlate with population structure. Changes in rainfall and corresponding changes in temperature, which are also linked to altitude variation, appeared to limit the distribution of *W. ugandensis* in Mt. Kenya forests.

Conflict of Interests

The author(s) have not declared any conflict of interests.

REFERENCES

Busman L, Lamb J, Randall G, Rehm G, Schmitt M (2002). The nature of phosphorus in the soil. Minnesota University. p. 112.

Caratti J, Duncan C, Keane E, Key C, Benson C, Sutherland S, Gangi J (2006). FIREMON: Fire effects monitoring and inventory system. Gen. Tech. Rep.RMRS-GTR-164-CD. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. pp. DE-1-15.

Chidumayo EN (2005). Effects of climate on growth of exotic and indigenous trees in Central Zambia. J. Biogeogra. 32:111-120.

EWP (2007). Mount Kenya Map and Guide (Map). 1:50,000 with 1:25,000 inset. EWP Map Guides. Cartography by EWP (4th ed.)

Frankham R, Ballou J, Briscoe D (1996*).* Primer conservation genetics. Cambridge University Press.

Kapelle M, Uffelen JG, Cleef AM (1995). Altitudinal zonation of montane Quercus forest along two transects in Chirripo National Park, Costa Rica. Plant Ecol. 119:119-153.

Kindt R, Lilleso JPB, Breugel VP (2007). Potential natural vegetation of South Western Kenya for the selection of indigenous tree species. World Agroforestry Centre. Kenya.

Kindt R, Lilleso JPB, Breugel VP (2011). Potential natural vegetation maps for Western and Central Kenya. Presently under utilized tools for the selection of indigenous tree species and their seed sources. World Agroforestry Centre. Kenya.

Kitayama K, Aiba SI (1994). Structure, composition and species diversity in an altitude-substrate matrix of rain forest tree communities on Mt. Kinabalu, Borneo. Plant Ecol. 140:139-157.

Kofidis G, Bosabalidis AM (2008). Effects of altitude and season on glandular hair and leaf structural traits of *Nepeta nuda* L. Bot. Stud. 49:362-372.

Longino JT (1986). A negative correlation between growth and rainfall in a tropical liana. The association for tropical biology and conservation. Biotropica 18:195-200.

Macintire WH, Shaw WM, Brooks R (1938). The leaching action of rain water upon dolomite and limestone separates incorporated with quartz in outdoor lysimetres. Soil Sci. 46:9-20.

Ogden J (1970). Plant population structure and productivity. Department of botany and zoology, Massey University, Palmerson North. p.72.

Smith AP (1980). The paradox of plant height in an Andean giant rosette species. British ecology society. J. Ecol. 68:63-73.

Soethe N, Wilcke W, Homier J, Lehmann J, Engels C (2008). Gradient in a tropical Mountain of Ecuador. Ecological studies 198:259-266.

Trapnell CG, Birch WR, Brunt MA (1966). Kenya 1:250,000 vegetation sheet 1. Results of a vegetation land use survey of south western Kenya. British Government's Ministry of Overseas Development (Directorate of overseas Surveys) under the Special Commonwealth African Assistance Plan p.15

Woodward FI (1987). Climate and plant distribution. Press syndicate of the University of Cambridge. p.167.

Young T (1991). Flora and Fauna, in: Guide to Mount Kenya and Kilimanjaro (I. Allan, ed.). Nairobi: Mountain Club of Kenya.

academicJournals

Vol. 6(6), pp. 459-467, June 2014
DOI: 10.5897/IJBC2014.0719
Article Number: C40FFE345313
ISSN 2141-243X

http://www.academicjournals.org/IJBC

International Journal of Biodiversity and Conservation

Full Length Research Paper

Factors affecting local ecological knowledge and perceived threat to the kori bustard (*Ardeotis kori struthiunculus*) in the Serengeti Ecosystem, Northern Tanzania

Emmanuel Clamsen Mmassy[1] and Eivin Røskaft[2]*

[1]Tanzania Wildlife Research Institute (TAWIRI), PO Box 661, Arusha, Tanzania.
[2]Department of Biology, Norwegian University of Science and Technology (NTNU), N-7491, Trondheim, Norway.

Received 21 April, 2014; Accepted 23 May, 2014

This study examines local tribal knowledge regarding the ecology of the kori bustard (*Ardeotis kori struthiunculus*) and assessed threats to this species in Northern Serengeti communities. A picture of an indigenous kori bustard was presented to survey participants in villages in the study area. General knowledge on the kori bustard was tested in relation to the bird's general habitat, nesting habitat, food and number of individuals in groups. Of the survey respondents, 56.7% knew the name of the kori bustard and were therefore included in further analyses. The Maasai tribe showed the greatest knowledge of the species, with 98% of individuals identifying the species correctly. Additionally, male survey participants were generally more knowledgeable than females. No differences among age groups or individuals with different education levels were found, suggesting that there is a local knowledge transfer of the species to all age groups regardless of educational level of respondents and that education is not an obstacle to the local knowledge. The study concludes that nature of activities e.g. nomadic and social life, gender and tribes were contributing factors to the knowledge of the kori bustard in the northern Serengeti.

Key words: Local knowledge, kori bustards, Serengeti ecosystem.

INTRODUCTION

The study of local ecological knowledge (LEK) has been growing as a scientific field in recent years, partly due to the recognition that such knowledge can contribute to the management of various ecosystems and ecological processes, the conservation of biodiversity and rare and threatened species, and the sustainable use of natural resources (Berkes, 1999; Colding, 1998; Johannes, 1998). LEK is the informal, often explicit knowledge held by a specific group of people about their local ecosystems and includes the interplay between organisms and their environment (Olsson and Folke, 2001). LEK differs from 'traditional' ecological knowledge

*Corresponding author. E-mail: Eivin.roskaft@ntnu.no.

(TEK) in the sense that the former has been derived from more recent human-environment interactions (e.g. those occurring within a few generations) rather than being embedded in deeper cultural practices (Ohmagari and Berkes, 1997).

Analyses of many LEK systems have identified various components of LEK, including a component related to local observational knowledge of species and other environmental phenomena, a practical component related to resource use activities, and a belief component related to how people fit into or relate to ecosystems (Berkes et al., 2000). The understanding of LEK plays a major role in aiding and promoting the improvement of scientific research and the management of ecosystems (Berkes et al., 2000).

The study of LEK began with species identification and classification (ethnobiology) and evolved to include the study of people's understanding of ecological processes and their relationships with the environment (Berkes, 1999; Williams and Baines, 1993). Not all traditional practices and belief systems are ecologically adaptive, and they can change with time. Acknowledging the importance of LEK is commonly assumed, incorrectly, that indigenous peoples sustainably conserve natural resources (Redford and Sanderson, 2000). Local traditional knowledge has showed an intergenerational decline and may vary with age and gender (Gómez-Baggethun et al., 2010; Law et al., 2010; Quinlan and Quinlan, 2007).

Local ecological knowledge about medicinal plants and the identification of traditional foods appears to decrease with increasing formal education (Giovannini et al., 2011; Wester and Youngvanit, 1995). Thus, formal education may contribute to the loss of local traditional knowledge because it reduces the time and number of opportunities that children have to attain local traditional knowledge and skills from their elders (Heckler, 2002; Luoga et al., 2000).

Local knowledge and its applications seem to be declining owing to a combination of factors, including loss of local language, land use change, inaccessibility to traditional resources due to conservation programmes, industrialization and globalization, and the transition to market economies (Benz et al., 2000; Kingsbury, 2001; Turner and Turner, 2008). Because this loss of knowledge affects local communities in developing countries, the remaining local ecological knowledge must be safeguarded through a number of methods, including environmental policies designed to protect its pools (Montes, 2010).

Local ecological knowledge can be maintained in traditional communities by controlling and monitoring access to certain sites and resource use. This may result in improvements of the knowledge base, which can then be used to respond adaptively to change in certain environments. Through the use of particular local knowledge, a community may benefit by securing employment and education through conservation experiments and/or natural resource management in a specific project area that is related to local ecosystem conservation (Drew and Henne, 2006). Indigenous people are frequently experts on their local ecosystems and can have a broad spectrum of indigenous knowledge. Rapid local language shift to the global language might however, make them lose this intellectual knowledge. Many cultures have disappeared as a result of indigenous people exhausting the environment's ability to sustain their population (Mazzocchi, 2006). Further-more, such disappearance of indigenous culture has been exacerbated by European colonization, which has eroded and destroyed much traditional knowledge by replacing it with Western educational and cultural systems (Mazzocchi, 2006); economic development and the transition to market economies (Godoy et al., 2005); loss of access to traditional resources due to conservation policies; and more generally, the forces of industrialization and globalization (Turner and Turner, 2008). Local and traditional ecological knowledge is increasingly recognized as an important component of scientific research, conservation, and resource management, especially where LEK and TEK fill gaps in the scientific literature or offer a critical source of basic environmental data (Thornton and Scheer, 2012).

Gathering scientific information regarding local ecological knowledge of kori bustard has never been carried out in the Serengeti ecosystem. In this study we found that 1) illegal hunting among local people for food exists, 2) kori bustards are rarely observed indicating a low population size, and 3) that their nesting habitat outside the national park has been turned into agricultural land and human settlements. Thus it is obvious that the species is in unimaginable threat. The outcome of our study has provided us an image that the species needs to be closely monitored and that local communities/tribes who are more knowledgeable on kori bustards are to be fully involved in conservation of the species to provide their ideas to the management authority on how to conserve this species in the future.

Study species

Although kori bustards are used by tribes in the Serengeti ecosystem as a source of food in household diets (Magige et al., 2009), there is no clear evidence that the species is used in other social cultural, or economic contexts. In Tanzania, the current range of the kori bustard is restricted to the northern plains of the Serengeti and the Tarangire-Manyara ecosystems. The range of this sub-species where it was historically found (in parts of East Africa, Somalia, Sudan and Ethiopia) has been shrinking, such that its current range is much smaller than its historical range (Hallager and Boylan, 2004).

The kori bustard is listed by CITES (Appendix II) as near threatened (Birdlife-International, 2009; 2013) and faces many threats. The main threats to the kori bustard are human-induced, including habitat destruction through agricultural development, as well as shrub encroachment caused by overgrazing and subsistence hunting (Magige et al., 2009; Senyatso et al., 2013). The poison used to control locusts is toxic to birds and may also be affecting the kori bustard populations (Barnes, 2000). The kori bustard is an omnivorous species, and its food sources are expected to be quite diverse. However, according to Arlott (1996), kori bustards consume mostly insects and plant material in their grassland habitat. The population status of this species and its population trends remain unknown, both in Tanzania and the entire East Africa. Thus, local understanding of ecology and threat of the kori bustard may provide inputs that management authorities can apply for sustainable management of areas where the small range of species occurs.

Since people in the northern Serengeti live a traditional life style that includes hunting wildlife for food and as a source of income, we hypothesised that people in our study area might have LEK of the kori bustard *(Ardeotis kori struthiunculus)*. We also hypothesised that there would be differences in local knowledge of this species' ecology among different tribes. We further hypothesised that the threats faced by the kori bustard are well understood by the people of the northern Serengeti because they live in the villages adjacent to the Serengeti National Park where the species is found. Scientific information about this species' ecology and the factors influencing the major threats to the species is limited. The goal of our study was to provide information on whether the species needs to be monitored, which includes the possibility of local community-based monitoring because the species utilizes habitat found on communal lands. The outcomes of the study could also help management authorities consider impacts to this species when developing various conservation programs in the communities surrounding protected areas. Local knowledge could provide broad insights into kori bustard conservation that could be used by management authorities when developing management plans.

METHODOLOGY

Study area

The mean temperatures in the study area range between 15 and 27°C, while the mean annual seasonal rainfall varies from 1,050 to 1200 mm (Sinclair et al., 2000). According to United Republic of Tanzania (URT) (2003, 2013), the study area has a total population of approximately 40,000 people.

The Serengeti ecosystem covers an area of 25,000 km^2 and straddles the border of northern Tanzania and southern Kenya. The ecosystem comprises several different conservation areas (Figure 1) that harbour a variety of animals such as wildebeests (*Connochaetes taurinus*), antelopes, carnivores and birds. A yearly migration of animals including wildebeests occurs in the area (Maddock, 1979) of which during the northern migration, the wildebeests often travel out of the protected area and enter unprotected areas with comparatively high human population densities. During the migration season, kori bustards are associated with the migrating animals and may be vulnerable to snares used by poachers to catch large animals. The villages found along the Serengeti ecosystem are fairly typical of the region, in that, hunting of wildlife for food is still a common practice (Holmern et al., 2007).

Study communities

The Northern Serengeti is highly diverse in terms of ethnicity. Over 20 tribes live in the area. We were able to interview individuals from the major and the largest tribes, including migrants. Individuals from the Meru, Chaga, Iraq, Mbulu and Sonjo tribes are immigrants to the northern Serengeti. Agro-pastoralism plays a major role in the livelihoods of these tribes. Although we interviewed people from 18 tribes in the selected villages, we used only the data from the three largest tribes (Maasai, Kurya and Ikoma) in our analyses because these tribes had sufficient number of survey respondents. There are no inter-tribal conflicts among the interviewed tribes; however, the health of the ecosystem suffers due to conflicts between conservationists and local communities. The conflict stems from the conservation and management authority prohibition of access to natural resources for many tribes living in the area (Kideghesho et al., 2007). The Maasai are nomadic, herding their livestock to green pastures and water. The Ikoma have traditionally hunted wild animals as a source of income and food, while the Kurya have traditionally been primarily farmers, but practice hunting activities to some degree.

Generally, the people in the region are poor (US $150-200 per annum). Their annual incomes, which are generally earned through agro-pastoralism, are far lower than Tanzania's average per capita income of US $280 (WB, 2003). To compensate for the hardship of earning a low income, many communities in the area engage in illegal hunting and charcoal burning (Kideghesho, 2010). With the increasing rates of human and livestock population growth in the region, these activities have caused ecosystem fragmentation, natural resource depletion and habitat destruction (Kideghesho, 2010), including the extinction of bird species of conservation concern.

Data collection using questionnaires

The study site was selected as an example of the type of socio-ecological context that occurs where communal areas are adjacent to protected areas. However, the site was also selected because of the conflict between local communities and management authorities towards access to wildlife resources.

Fieldwork was conducted in 13 villages of the northern Serengeti that were selected prior to beginning of the survey in October, 2011. The villages were selected based on their proximity to protected areas (Loliondo Game Controlled Area, Ikorongo Game Reserve, Ikona Open Area, and Serengeti National Park), where we expected the kori bustard to be frequently observed.

The closed-ended question interviews (Newell, 1993) were conducted in Kiswahili with the aid of well-trained local translators who translated Kiswahili into the local tribal languages because most elders knew only their tribal language. The use of local translators increased the number of people who could be interviewed, because the translators could communicate with respondents in their local language. Furthermore, because the respondents live adjacent to the protected areas and illegal subsistence hunting of wildlife still occurs, they were initially concerned about talking with us because they thought we were

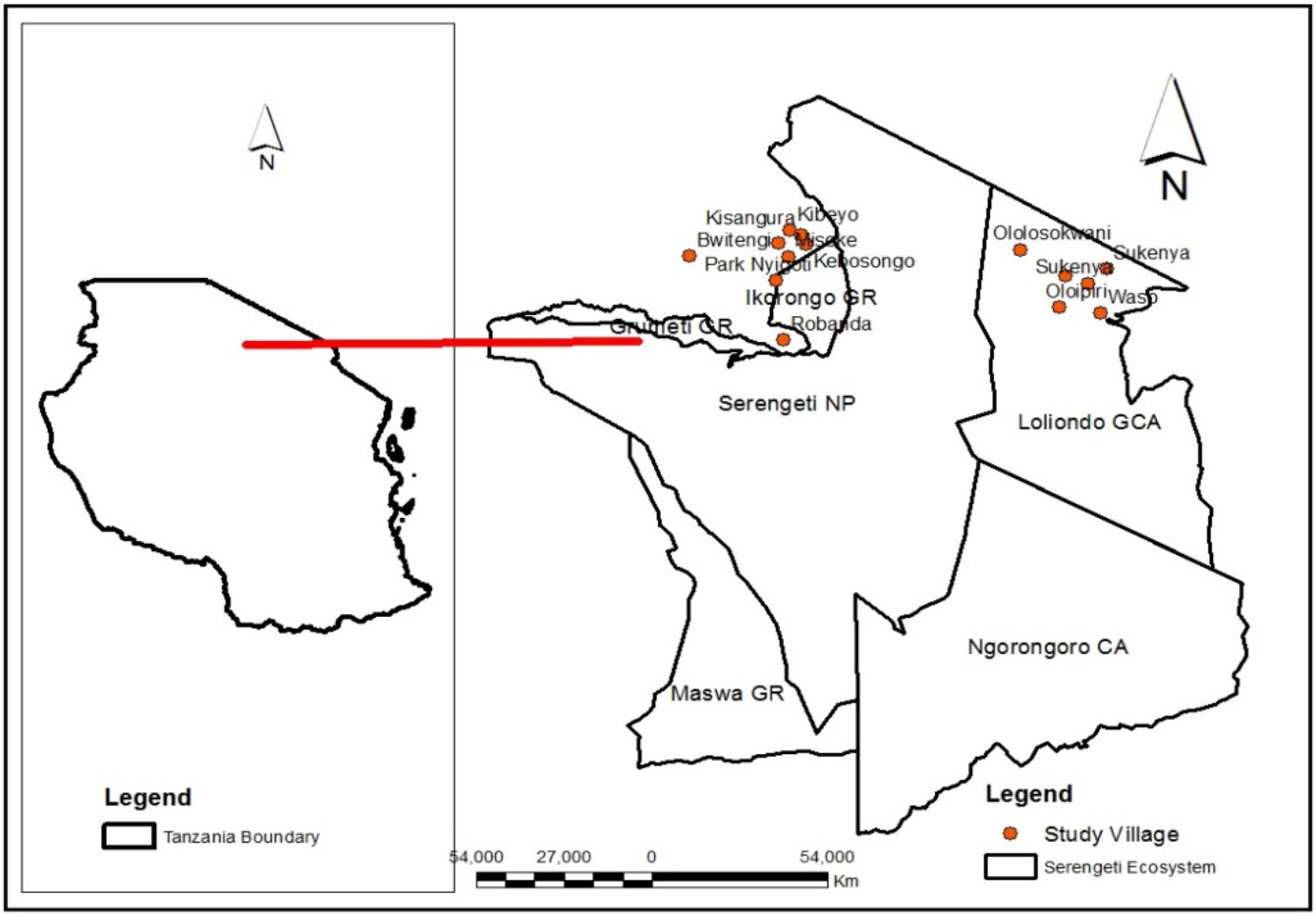


Figure 1. Map of the Serengeti ecosystem showing the locations of surveyed villages in the northern Serengeti.

Figure 2. Kori bustard on the Serengeti plains (photo: E. Røskaft).

wildlife officers who wanted to investigate poaching including the kori bustard. The current proposed road construction from Mto wa Mbu to Musoma town (Fyumagwa et al., 2013) was another barrier to recruiting survey participants, as some people thought we were environmentalists or conservationists who wanted to convince the local people to oppose the proposed road construction. This problem was resolved by the village leaders who convened a village meeting where he expressed our aim to interview people in the area.

During the survey, a picture of the indigenous kori bustard (Figure 2) was shown to the participants. All respondents were between 18 and 85 years of age and were able to recognise the picture as a bird. However, not all respondents were able to identify the species. Face-to-face interviews were conducted in which the respondents were asked different questions after identifying the picture of the bird as kori bustard (Mmassy and Røskaft, 2013). A total of 330 individuals were randomly picked from households in the selected villages, of which 197 individuals (Table 1) were able to identify the kori bustard by looking at the picture. We stratified our sample of interview respondents based on tribe, gender, age and education level to test for species knowledge.

In our analyses, we included only the three most common tribes (Maasai, Ikoma and Kurya) and 25 individuals from a combination of other smaller tribes (Luo, Chaga, Jita, Iraq, Mbulu, Meru, Natta, Maragoti, Mungurumi, Zanaki, Ikizu, Mwira, Sukuma, Isenye, Sonjo) who identified the kori bustard correctly.

Table 1. Knowledge variables related to kori bustard biology derived from the responses of interview participants and the validation of their knowledge using literature.

Variable	Correct knowledge	Incorrect knowledge	No. of respondents
How often do you see the species	Rarely: 80.6%	Frequently: 19.4%	191
Population size	Small: 91.0%	Large: 9.0%	162
Group size	1-2 individuals: 66.8%	>3 individuals: 33.2%	129
Nesting habitat	Open grasslands 90.5%	Mixed woodlands 9.5%	137
Food	insects, reptiles, small mammals, seeds, and roots 90%	insects, reptiles, small mammals, seeds, and roots 10%	190
Threats	Illegal hunting 77.6%	Other, such as accidents, 22.4%	98

Sources: Birdlife-International, 2008; Hallager, 2012; Harrison et al., 1997. Respondents who provided a correct answer were designated as having correct knowledge.

Table 2. Analysis of the general knowledge of the kori bustard among people of the northern Serengeti in relation to gender, tribe, educational level and age groups.

Constant/independent		Dependent variable/general knowledge (%)						
		Poor	Week	Average	Good	Very good	Total	χ^2 =; *p* =
Gender	Male	35.7	7.1	22.0	24.7	10.6	255	19.17; 0.002
	Female	62.7	4.0	14.7	14.7	4.0	75	
Tribe	Kurya	83.5	5.8	4.9	4.9	1.0	103	184.1; 0.000
	Maasai	2.8	5.6	27.1	38.3	26.2	107	
	Ikoma	36.8	8.4	31.6	23.2	0.0	95	
	Others	56.0	4.0	12.0	24.0	4.0	25	
Education	No or primary education	40.7	7.0	20.5	22.3	9.5	273	2.298; 0.807
	Secondary education	47.4	3.5	19.3	22.8	7.0	57	
Age	14-45 years	42.9	5.1	19.8	23.0	9.2	217	6.118; 0.295
	Above 45 years	39.8	8.8	21.2	21.2	8.8	113	

The respondents were asked various questions about the species, such as how often the bird was observed, the habitats in which it was most frequently observed, the species' population size, why the bird preferred to live in the habitat where it is observed, how many individuals were observed at a time per group, where it placed its nests, why it uses a particular breeding habitat, the food source of the species, and threats to the species.

Local people in the Serengeti ecosystem could identify the species to the genus level (bustard). The identification to the genus level, that is, bustard, was done following Balmford et al. (2002), since mammals and birds need genus level identification (e.g., 'rabbit'). We grouped some items of knowledge that varied among only a small number of respondents. For example, rodents and other small mammals listed as food sources were recorded as mammals, while all types of reptiles (snakes and lizards) were recorded as reptiles. Seeds, flowers, leaves, fruits and roots were recorded in a single category as plant materials. All woodland, forest and shrub land habitats were combined and designated as mixed woodlands, while open grassland was retained as a separate category. Frequency of observation of the species was recorded as two categories: observed daily (at least once per week or more) and observed rarely (less than once per week). Information on food availability, safety from predators and the use of different habitats was separated into two categories: food availability and safety from non-human predators and hunters. Species occurrence was categorised as a single individual, two individuals, or greater than two (3-20) individuals.

The information provided by the respondents was assessed/analyzed and compared to information from various literature sources (Table 1) to validate the respondents' knowledge as correct or incorrect (Table 1). Respondents who provided correct answers were designated having correct knowledge and those who could not provide correct answer were designated providing incorrect knowledge (Table 1). The six knowledge variables were thereafter pooled and varied between 0 and 6. Individuals with knowledge for 0 or 1 of the variables were given a value of 1 (poor), followed by those who had knowledge of 2 variables (weak), those who had knowledge of 3 (average), those who had knowledge of 4 (good), and those who had knowledge of 5-6 variables (very good) (Table 2).

Statistical analysis

The information included in the analyses was collected through questionnaire surveys that were coded and entered into a computer. Statistical Package for the Social Sciences (SPSS), version 16, manufactured by SPSS Inc., was used for the analyses. Chi square analyses were primarily used to calculate the percentages of respondents at a significance level of $p = 0.05$.

RESULTS

Of the individuals interviewed, 59.7% (N = 330) correctly identified the picture as a kori bustard, while 40.3% (N = 133) were unable to identify the species. The Maasai tribe was the tribe with the highest level of knowledge of the species, with 97% of individuals identifying the species correctly (N = 107). However, only 66% of the interviewed individuals from the Ikoma tribe (N = 95) and 18% from the Kurya tribe (N = 103) were able to identify the kori bustard from the picture. Among the other surveyed tribes, 44% of the individuals surveyed were able to identify the kori bustard correctly (N = 25). The difference among tribes in identifying the kori bustard was highly significant ($\chi^2 = 139.7$, df = 3, $P < 0.001$). There was a highly significant difference between the genders, with males correctly identifying the bird more often than females ($\chi^2 = 17.88$, df = 1, $P < 0.000$). In contrast, there were no significant differences in ability to identify the bird among age groups or individuals with different education levels ($\chi^2 = .848$, df= 1, $P = .357$; $\chi^2 = .477$, df = 1, $P = .490$, respectively).

Generally, most of the interviewed individuals knew the kori bustard well, and they displayed a high level of knowledge of the species with regards to frequency of observation, population size, group size, nesting habitat, food sources and threats to the species (Table 1). The Maasai tribe showed a high level of knowledge of the biology of the kori bustard overall, with 74.5% of the respondents showing good to very good knowledge of the bird. The second most knowledgeable tribe was the Ikoma, where 54.8% of individuals exhibited good to very good knowledge. The Kurya tribe was the least knowledgeable, with only 5.9% of the respondents having good to very good knowledge (Table 2; $\chi^2 = 46.8$, df = 12, $P < 0.000$). Men had significantly more knowledge than women (Table 2), but there were no detected differences in knowledge with regards to the age or education level of the respondent (Table 2).

A linear regression analysis with general knowledge as the dependent variable and gender and tribe (the two variables that were significant in the analyses described above) as independent variables explained 8.8% of the variation in knowledge ($r^2 = 0.088$). The results showed that, in general, tribe (Beta = 0.194, T = 3.611, $P < 0.0001$) and gender (Beta = 0.191, t = -3.558, $P < .0001$) independently explained some of the variation in knowledge of kori bustard ecology (ANOVA; F = 15.685, $P < 0.000$).

DISCUSSION

The majority of the interview participants from tribes in the northern Serengeti knew the kori bustard and showed good knowledge of the bird's general ecology. The overall good knowledge of members of the Maasai and Ikoma tribes on the biology of and threats to the kori bustard may be due to the nature of the activities (hunting and nomadic migration) that have been practiced by these tribes since historical times. Given that the Maasai tribe is pastoralist and nomadic in nature, its members are likely to encounter this species frequently (Mmassy and Røskaft, 2013). The knowledge and understanding of kori bustard ecology within the Ikoma tribe may be due to their hunting practices and the inheritance of hunting knowledge from their ancestors, because hunting has been an integral part of life in Serengeti for thousands of years (Holmern, 2010). The Ikoma have traditionally been a hunting tribe that collects eggs from game birds (Magige et al., 2009) and hunts wild animals for food and income (Barnett, 2000). This type of practice could have increased their knowledge of a species like the kori bustard.

Male respondents generally showed better knowledge of kori bustard biology and were better able to identify the bird from a picture. This result may reflect the division of household tasks in the villages in this study. Males conduct outdoor activities, while females practice more indoor activities (Mmassy and Røskaft, 2013; Røskaft et al., 2004). According to Pfeiffer and Butz (2005), Maasai women are responsible for taking care of domestic animals in small confined areas around their homes, while males graze herds of cattle across large geographical areas.

Females are frequently less knowledgeable about wildlife, including birds around the world (Kideghesho et al., 2007; Mmassy and Røskaft, 2013; Røskaft et al., 2007). However, ethnobiological research suggests that women are more knowledgeable about medicinal plants and small mammals because they are more engaged in healing practices and the collection of food (Letsela et al., 2003). This type of knowledge can, on the other hand, vary with geographical location, social status, ethnicity, occupation and experience (Heckler, 2002). Therefore, we suggest that the different societal roles of the two genders in our study may have resulted in greater knowledge of birds among men (Røskaft et al., 2004).

Formal education is not necessarily a prerequisite for having local knowledge of a certain place. In fact, research in the fields of ethnobiology, natural food identification and ornithology has revealed variation in local knowledge between people with a formal education and those without education. In this respect, educated people might be less knowledgeable than uneducated ones (Giovannini et al., 2011; Mmassy and Røskaft, 2013). In our study, we found that the ability of respondents to identify the kori bustard was similar without considering the level of education. This suggests

that LEK of kori bustard has been shared among the indigenous people of all age groups and education levels in the study area. Again if the kori bustard has been used as food source in the study area it is possible for almost every individual to acquire some knowledge of the species. The yearly association of the kori bustard with the animal migration (wildebeest) may also have contributed to the increased identification knowledge of the inhabitants.

Most respondents displayed correct knowledge (according to our comparison with literature sources) of the kori bustard by stating that it was rarely observed in the Serengeti ecosystem. These infrequent observations of the species may indicate a declining population or low population density or both. According to respondents, the rarity of this species might be due to habitat loss as also stated by Hallanger and Boylan (2004) and/or being hunted for food (Magige et al., 2009). According to Hallager and Boylan (2004), both subspecies of kori bustards are facing an uncertain future and birds are absent in areas where they were previously found. However, a population trend for this species was not available at the time of this study because the species' population has not yet monitored in the study area. The range of the kori bustard is much smaller than it was a few years ago due to the fact that the kori bustard is presently declining throughout its range (Hallager and Boylan, 2004). This trend is occurring in the northern Serengeti, where people reported that the species is rarely observed, as there is an increase in human population and the demand of resources in the area. As has been reported in other parts of southern Africa (Hallager, 2012), the rarity of the species in the study area may probably be due to rapid human population growth and activities associated with development.

Given that the gathering of eggs from most large grassland birds, including kori bustards, is tradition among tribes living close to Serengeti National Park (Magige et al., 2009), it would be possible for the tribes to develop accurate knowledge of the decline of the species, even though there are no existing data for the Serengeti population.

In our study area, there was a high level of knowledge on the nesting and feeding habitats of the kori bustard. Local knowledge was consistent with the literature, which shows that the kori bustard nests in grasslands (Harrison et al., 1997). It is clear that LEK can strengthen conservation programs by providing information on a given species (Drew, 2005). Some studies have suggested that local people's knowledge have been used as input for designing and applying management plans for sustainable development, especially in protected areas (Agrawal, 2000; Papageorgiou and Vogiatzakis, 2006). In the case of the kori bustard in the Serengeti, management authorities must work with local people in order to achieve successful conservation of the kori bustard (Ghimire and Pimbert, 1997).

The most serious threat to the kori bustard in the northern Serengeti, according to the respondents in this study, is illegal hunting. This result may act as a challenge to management authorities to take appropriate action because the management authority has never been informed about the presence of illegal hunting of kori bustards. The threats to the kori bustard may be more serious than previously thought, given that its population size is not known and, according to this study, the bird is now rarely seen in the Serengeti ecosystem. The respondents claimed that the greatest threats to the kori bustard are from the hunting of these birds for food.

Bird conservation has been strongly dependent on the available biological information (Filion, 1987). The LEK presented by respondents will largely help in the development of conservation priority strategies and implementation of the species conservation program. The outcome of a study of the species will give information whether the species needs to be monitored, including local community-based monitoring as the species utilize communal lands. It might also help the management authority to take into account this important species when developing various conservation programs on communities surrounding protected areas. Such local knowledge might provide broad insight into management authorities when developing aspects of the species management plan. LEK of a species matters as different local knowledge can be shared between stakeholders which might lead to an extensive knowledge of a species in its surroundings

Conclusion

Local ecological knowledge can help traditional community-based systems control and monitor access to sites and resources, thereby protecting natural resources. To conserve *A. kori struthiunculus* for future generations, we recommend additional research on this species. In particular, information is needed on population status, threats (apart from hunting for food) and ecological requirements. Additionally, public education would help prevent degradation of this species' habitat and minimize illegal hunting, and could be effective measures for preventing further population declines.

Conflict of Interests

The author(s) have not declared any conflict of interests.

Acknowledgements

We express our sincere thanks to the Government of Norway, Ministry of Foreign Affairs for their financial support through an IPBES (Intergovernmental Platform of Biodiversity and Ecosystem Services) grant, without which

this study would not have been possible. We are very grateful to Dr. Robert Fyumagwa, Director of the Serengeti Wildlife Research Centre, for logistic support and to Mr. Noel Massawe for field assistance during the questionnaire survey. Thanks are also due to the Director General of TAWIRI, Dr. Simon Mduma, and to the Commission for Science ant Technology, Tanzania (COSTECH) for granting permission to conduct such a unique type of study. Finally we want to acknowledge two anonymous reviewers who's commends improved this paper.

REFERENCES

Agrawal A (2000). Adaptive management in transboundary protected areas: The Bialowieza National Park and Biosphere Reserve as a case study. Environ. Conserv. 27(4):326-333.

Arlott N (1996). Family Otidadae (Bustards). Handbook of the Birds of the World. Vol 13. Hoatzins to Auks. Del Hoyo J, Elliot A, Saragatal J. Barcelona, Lynx Edicions. Vol. 13: p.240-273.

Balmford A, Clegg L, Coulson T, Taylor J (2002). Why conservationists should heed Pokémon. Science 295(5564): 2367.

Barnes KN, Ed. (2000). The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland, Birdlife South Africa.

Barnett R (2000). Food for thought: the utilization of wild meat in eastern and southern Africa. Trade review. Nairobi, Kenya, TRAFFIC/WWF/IUCN: p. 264.

Benz BF, Cevallos J, Santana F, Rosales J, Graf S (2000). Losing knowledge about plant use in the Sierra de Manantlan biosphere reserve, Mexico. Econ. Bot. 54(2):183-191.

Berkes F (1999). Sacred ecology. Traditional ecological knowledge and resource management. Philadelphia and London, UK, Taylor and Francis.

Berkes F, Colding J, Folke C (2000). Rediscovery of traditional ecological knowledge as adaptive management. Ecol. Appl. 10(5):1251-1262.

Birdlife-International (2008). *Otis tarda*. IUCN Red List of Threatened Species. Version 2011. IUCN, IUCN.

Birdlife-International (2009). *Ardeotis kori*. IUCN Red List of Threatened Species, Version 2010. IUCN, IUCN.

BirdLife-International (2013). Ardeotis kori, IUCN.

Colding J (1998). Analysis of hunting options by the use of general food taboos. Ecol. Model. 110(1):5-17.

Drew JA (2005). Use of traditional ecological knowledge in marine conservation. Conserv. Biol. 19(4):1286-1293.

Drew JA, Henne AP (2006). Conservation biology and traditional ecological knowledge: integrating academic disciplines for better conservation practice. Ecol. Soc. 11(2):34.

Filion FL (1987). Birds as a socio-economic resource a strategic concept in promoting conservation. Diamond AW, Filion FL, International Council for Bird Preservation Technical Publication. No. 6: pp. 7-14.

Fyumagwa RD, Gereta EJ, Hassan S, Kideghesho JR, Kohi EM, Keyyu J, Magige F, Mfunda IM, Mwakatobe A, Ntalwila J, Nyahongo JW, Runyoro V, Røskaft E (2013). Roads as a threat to the Serengeti Ecosystem. Conserv. Biol. 27(5):1122-1125.

Ghimire KB, Pimbert MP, Eds (1997). Social change and conservation: Environmental politics and impacts of national parks and protected areas. London, Earthscan.

Giovannini P, Reyes-Garcia V, Waldstein A, Heinrich M (2011). Do pharmaceuticals displace local knowledge and use of medicinal plants? Estimates from a cross-sectional study in a rural indigenous community, Mexico. Soc. Sci. Med. 72(6):928-936.

Godoy R, Reyes-Garcia V, Byron E, Leonard WR, Vadez V (2005). The effect of market economies on the well-being of indigenous peoples and on their use of renewable natural resources. Ann. Rev. Anthropol. 34:121-138.

Gómez-Baggethun E, Groot Rd, Lomas PL, Montes C (2010). The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes. Ecol. Econ. 69: 1209-1218.

Hallager S (2012). Kori Bustard, Biology and natural history. Retrieved 30.05.2012, 2012, from http://nationalzoo.si.edu/SCBI/TropicalEcosystems/KoriBustards/biology.cfm.

Hallager S, Boylan J, Eds (2004). Kori bustard species survival plan (*Ardeotis kori*) husbandry manual. Washington DC, National Zoological Park.

Harrison JA, Allan DG, Underhill LG, Herremans M, Tree AJ, Parker V, Brown CJ, Eds (1997). The Atlas of Southern African Birds; Volume 2: Passerines. Avian Demography Unit, Department of Statistical Sciences, University of Cape Town BirdLife South Africa.

Heckler S (2002). Traditional ethnobotanical knowledge loss and gender among the Piaroa. Ethnobiology and biocultural diversity: Proceedings of the 7th International Congress of Ethnobiology, October 2000 2002, Athens, Georgia, USA.

Holmern T (2010). Bushmeat hunting in Western Serengeti: Implications for community-based conservation. Conservation of natural reources; Some African & Asian examples. Gereta E, Røskaft E. Trondheim, Tapir academic press. pp. 211-236.

Holmern T, Muya J, Røskaft E (2007). Local law enforcement and illegal bushmeat hunting outside the Serengeti National Park, Tanzania. Environ. Conserv. 34(1):55-63.

Johannes RE (1998). The case for data-less marine resource management: examples from tropical nearshore finfisheries. Trends Ecol. Evol. 13:243-246.

Kideghesho JR (2010). Wildlife conservation in Tanzania: Whose interests matter? Conservation of natural resources; Some African and Asian examples. Gereta E, Røskaft E. Trondheim, Tapir academic press. pp. 82-110.

Kideghesho JR, Røskaft E, Kaltenborn BP (2007). Factors influencing conservation attitudes of local people in Western Serengeti, Tanzania. Biodiv. Conserv. 16(7):2213-2230.

Kingsbury N (2001). Impacts of land use and cultural change in a fragile environment: Indigenous acculturation and deforestation in Kanavayén, Gran Sabana, Venezuela. Interciencia 28: 327-336.

Law W, Salick J, Knight TM (2010). The effects of pollen limitation on population dynamics of snow lotus (*Saussurea medusa* and *S. laniceps*, Asteraceae): Threatened Tibetan medicinal plants of the eastern Himalayas. Plant Ecol. 210:343-357.

Letsela T, Witkowski ETF, Balkwill K (2003). Plant resources used for subsistence in Tsehlanyane and Bokong in Lesotho. Econ. Bot. 57:619-639.

Luoga EJ, Witkowski ETF, Balkwill K (2000). Economics of charcoal production in miombo woodlands of eastern Tanzania: some hidden costs associated with commercialization of the resources. Ecol. Econ. 35(2):243-257.

Maddock L (1979). The migration and grazing succession. Serengeti: dynamics of an ecosystem. Sinclair ARE, Norton-Griffiths M. Chicago, Ill, The University of Chicago Press. pp. 104-129.

Magige FJ, Holmern T, Stokke S, Mlingwa C, Røskaft E (2009). Does illegal hunting affect density and behaviour of African grassland birds? A case study on ostrich (*Struthio camelus*). Biodiv. Conserv. 18(5):1361-1373.

Mazzocchi F (2006). Western science and traditional knowledge: Despite their variations, different forms of knowledge can learn from each other. EMBO Rep. 7(5):463-466.

Mmassy EC, Røskaft E (2013). Knowledge on birds of conservation interest among the people living close to protected areas in Serengeti, Northern Tanzania. Int. J. Biodivers. Sci. Ecosyst. Services Manage. 9(2):114-122.

Montes G (2010). The problems of disadvantaged youth: An economic perspective. J. Econ. Issues 44(3):843-845.

Newell R (1993). Questionnaires. Researching social life. Gilbert N. London, UK, SAGE Publications Ltd. pp. 95-115.

Ohmagari K, Berkes F (1997). Transmission of indigenous knowledge and bush skills among the Western James Bay Cree women of subarctic Canada. Hum. Ecol. 25(2):197-222.

Olsson P, Folke C (2001). Local ecological knowledge and institutional dynamics for ecosystem management: a study of Lake Racken

watershed, Sweden. Ecosysytems 4:85-104.
Papageorgiou K, Vogiatzakis IN (2006). Nature protection in Greece: An appraisal of the factors shaping integrative conservation and policy effectiveness. Environ. Sci. Policy 9:476-486.
Pfeiffer JM, Butz RJ (2005). Assessing cultural and ecological variation in ethnobiological research: the importance of gender. J. Ethnobiol. 25(2):240-278.
Quinlan RJ, Quinlan MB (2007). Parenting and cultures of risk: A comparative analysis of infidelity, aggression & witchcraft. Am. Anthropol. 109:164-179.
Redford KH, Sanderson SE (2000). Extracting humans from nature. Conserv. Biol. 14(5):1362-1364.
Røskaft E, Hagen ML, Hagen TL, Moksnes A (2004). Patterns of outdoor recreation activities among Norwegians: an evolutionary approach. Ann. Zool. Fennici. 41(5):609-618.
Røskaft E, Händel B, Bjerke T, Kaltenborn BP (2007). Human attitudes towards large carnivores in Norway. Wildl. Biol. 13(2):172-185.
Senyatso KJ, Collar NJ, Dolman PM (2013). Assessing-range wide conservation status change in an unmonitered widespread African bird species. Divers. Distrib. 19(2):106-119.
Sinclair ARE, Mduma SAR, Arcese P (2000). What determines phenology and synchrony of ungulate breeding in Serengeti? Ecology 81(8):2100-2111.
Thornton TF, Scheer AM (2012). Collaborative engagement of local and traditional knowledge and science in marine environments: A review. Ecol. Soc. 17:3.
Turner NJ, Turner KL (2008). Where our women used to get the food: cumulative effects and loss of ethnobotanical knowledge and practice; case studies from coastal British Columbia. Botany 86(1):103-115.
URT (2003). Population and housing censuses. Bureau of Statistics PsOPC. Dar es Salaam, Tanzania, United Republic of Tanzania, Government Printer.
URT (2013). Population and housing census counts 2012. http://www.nbs.go.tz, Tanzania, National Bureau of Statistics.
WB (2003). World Development Indicators. from http://devdata.worldbank.org.
Wester L, Youngvanit S (1995). Biological diversity and community lore in northeastern Thailand. J. Ethnobiol. 15(1):71-87.
Williams NM, Baines G, Eds (1993). Traditional ecological knowledge: wisdom for sustainable development. Canberra, Australia, Centre for Resource and Environmental Studies, Australian National University.

academicJournals

Vol. 6(6), pp. 468-487, June 2014
DOI: 10.5897/IJBC2013.0657
Article Number: 743231B45314
ISSN 2141-243X

http://www.academicjournals.org/IJBC

International Journal of Biodiversity and Conservation

Full Length Research Paper

Fungi from submerged plant debris in aquatic habitats in Iraq

Abdullah H. Al-Saadoon and Mustafa N. Al-Dossary*

Department of Biology, College of Science, University of Basrah, Iraq.

Received 22 November, 2013; Accepted 9 May, 2014

An annotated checklist and table of the substrate type for the past and updated fungal species recorded from various submerged plant debris in aquatic habitats of Iraq are provided. Sixty seven (67) species of freshwater and marine fungi occurring in different types of plant debris collected from various locations of Iraq were registered. These include: 46 species of ascomycota, 19 species of hyphomycetes and two species of coelomycetes. Of these, 11 species were reported for the first time in Iraq. Brief descriptions of the new records are presented.

Key words: Fungi, aquatic habitat, Iraq.

INTRODUCTION

The role of fungi associated with plant debris in aquatic habitats is immense and they are responsible for most of the decomposition of organic materials, thus contributing in nutrient regeneration cycles (Rani and Panneerselvam, 2009; Wong et al., 1998). Noteworthy, fungal taxa have been isolated from submerged woody substrata in freshwater habitats (Shearer, 1993; Goh and Hyde, 1996; Hyde and Goh, 1998; Tsui et al., 2003; Fallah and Shearer, 2003; Vijaykrishna et al., 2006; Raja et al., 2011, 2012, 2013; Hu et al., 2012; Vasilyeva et al., 2013; Zhang et al., 2014) and marine habitats (Kohlmeyer and Kohlmeyer, 1979; Kohlmeyer, 1984; Cuomo et al., 1985; Hyde and Jones, 1989; Jones, 2000; Kohlmeyer and Kohlmeyer, 2002; Alias et al., 2010; Khan and Manimohan, 2011; Sakayaroj et al., 2011; Borse et al., 2013). Little attention has been given so far to fungi colonizing submerged substrates in aquatic habitats in Iraq. Our knowledge on the occurrence of such fungi has been confined to the work of Abdullah (1983). There are a few isolated records by Abdullah and Abdulkadir (1987), Abdulkadir and Muhsin (1991), Abdullah and Al-Saadoon (1994a, b, 1995), Muhsin and Abdulkadir (1995), Guarro et al. (1996, 1997a, b), Al-Saadoon and Abdullah (2001), Muhsin and Khalaf (2002) and Al-Saadoon and Al-Dossary (2010). This work provides a checklist and describes some fungal species from submerged wood substrates in aquatic habitats in Iraq.

MATERIALS AND METHODS

Submerged plant debris (leaves, small branches, stems and wood of deciduous and herbaceous plants) were collected from several locations in south Iraq, these materials were placed in plastic bags and brought to the laboratory, rinsed with tap water, placed on moist filter papers in glass chambers and incubated at 25°C. Samples were examined periodically for any fungal growth.

*Corresponding author. E-mial: mustaffanjm@yahoo.com.

Cultures of fungi were obtained where possible from single spores; overall emphasis was placed on direct examination of fungi for morphological characterization. For ascomycetes, squash mounts of fungal fruiting bodies were prepared on slides mounted with water and then covered with cover slips for initial examination, water was replaced with lactophenol cotton blue for measurement and photography. India ink in distilled water was used to reveal gelatinous sheaths or appendages on or around ascospores. Permanent slides, dried specimens and/or living cultures were deposited at the Department of Biology, College of Science, University of Basrah.

RESULTS AND DISCUSSION

Taxonomy

Ascomycota

***Aniptodera chesapeakensis* Shearer and Miller, Mycologia 69: 887(1977):** Specimen examined: On submerged dead stem of *Arundo donax* and *Phragmites australis,* Khor Al-Zubair estuary, Basrah, Iraq, March, 1992. On submerged dead stem of *A. donax* and *P. australis* Shatt Al-Arab River near University campus, Basrah September 1995. On unidenitified dead twigs submerged in Shatt Al-Arab river near Abu-AlKhasib, Basrah, November 1998. On submerged dead stem of *Typha australis* and leaf bases of date palm (*Phoenix dactylifera* L.) in brackish water, Al-Kahla`a river, Missan, Southern Iraq, March 2009. On submerged dead stem of *P. australis* and unidentified wood, Shatt Al-Arab river near University campus, Basrah, April 2010.

This species was originally described by Shearer and Miller (1977) on Balsa wood submerged in Patuxent River, U.S.A. Subsequent reports of this species have been made by Minoura and Muroi (1978) on Balsa wood submerged in freshwater lake in Japan, from United States on *Juncus roemerianus* and *Spartina alterniflora* by Kohlmeyer and Kohlmeyer (1979), on submerged wood in India Ocean near Sri Lanka by Koch (1982), on drift wood collected from Karala coast, India by Khan and Manimohan (2011) and from west and east coast of India by Borse et al. (2013).

This species has been isolated from submerged dead stem and floating dead leaves of *T. australis* in southern marshes of Iraq (Abdullah and Abdulkadder, 1987) (Table 1 shows the presence of each fungal species).

***A. fusiformis* Shearer, Mycologia 81: 139(1989):** Specimen examined: On dead stem of *P. australis* and unidentified twigs submerged in water near Qurna, Basrah, Iraq, November, 2010.

The fungus was originally described from submerged woody materials in freshwater habitats in USA (Shearer, 1989).

The Iraqi collections were reported from brackish habitat on submerged wood and stem of *T. australis* in Al-Kahla`a river, Missan, southern Iraq (Al-Saadoon and Al-Dossary, 2010).

***A. mauritaniensis* Hyde, Ho and Tsui Mycoscience 40: 172(1999):** Specimen examined: On submerged dead leaf base of date palm, Al-Kahla`a river, Missan, March 2009. On unidentified wood submerged in Shatt Al-Arab River near University campus, Basrah, April 2010.

The type of species was originally described from submerged wood in Black river in Mauritius (Hyde et al., 1999). This species has been described from submerged dead leaf base of date palm tree in Shatt Al-Arab River near University campus, Basrah, Iraq (Al-Saadoon and Abdullah, 2001).

***A. palmicola* Hyde, Ho and Tsui Mycoscience 40: 171(1999):** Specimen examined: On submerged dead stem of *P. australis*, Al-Kahla`a river, Missan, March 2009. On unidentified wood submerged in Shatt Al-Arab River near Abu-Al-Khasib, Basrah, March 2009. On submerged dead leaf base of date palm, Shatt AL-Arab River near University campus, Basrah, April 2010.

This species was originally described from South Africa on submerged rachis of *Raphia australis* in 1999 (Hyde et al., 1999). *A. palmicola* has been isolated from stem of *A. donax* and unidentified wood immersed in water of Shatt Al-Arab river near University campus, Basrah, southern Iraq (Al-Saadoon and Abdullah, 2001).

***Arxiomyces campanulatus* Horie, Udagawa and Cannon. Mycotaxon 25: 231 (1986):** This type of species was found parasitizing *Stachybotrys chartarum* isolated from cultivated soil in Japan (Horie et al., 1986). The Iraqi collection was found parasitizing *Stachybotrys* sp. developed on dead stem of *A. donax* floating in water of Khor Al-Zubair channel, Basrah, southern Iraq (Al-Saadoon and Abdullah, 2001).

***Arxiomyces zubairiensis* Abdullah and Al-Saadoon. Marina Mesopotamica 9:245(1994):** Specimen examined: On submerged dead stem of *P. australis*, Al-Kahla`a river, Omara, March 2009. On submerged dead stem of *A. donax* in Shatt Al-Arab River near Abu-AlKhasib, Basrah, November 2010.

A. zubairiensis was originally described in Iraq by Abdullah and Al-Saadoon (1994b) parasitizing *Stachybotrys* sp. on *P. australis* dead stem collected from tidal zone of Khawr Al-Zubair canal, southern Iraq. Recently, it was isolated from sugarcane plant in Iraq. *A. zubairiensis* differs from two other known species in the genus (*Arxiomyces vitis* (Fuckel) P.F. Cannon and Hawksworth and *Arxiomyces campanulatus* Horie, Udagawa and Cannon) by its globose to

Table 1. List of fungal species and substrate type from water habitats in Iraq.

Fungal species	Substrate type											
	Arundo donax	*Cyperus rotundus*	*Halocneumum strobilaceum*	*Phoenix dactylifera*	*Phragmites australis*	*Salicornia europea*	*Salsola baryosma*	*Suaeda* sp.	*Tamarix aphylla*	*Typha australis*	Unidentified wood	U. twigs
Ascomycota												
Aniptodera chesapeakensis	+			+	+					+	+	+
A. fusiformis					+					+		+
A. mauritaniensis				+	+						+	
A. palmicola	+			+	+						+	
Arxiomyces campanulatus	+											
A. zubairiensis	+				+							
Canariomyces notabilis						+						
Chaetomium globosum	+				+							
Coniochaeta saccardoi				+								
Corollospora maritima				+								
C. pseudopulchella				+								
Decorospora gaudefroyi								+				
Didymosphaeria futilis										+		
Jahnula bipileata				+							+	
Kirschsteiniothelia maritima *	+			+	+							
*Leptosphaeria agnita**					+							
*Lignicola laevis**	+				+							
Lulworthia grandispora											+	
L. medusa											+	
*Marinosphaera mangrovei**											+	
Monosporascus eutypoides			+									
Mycosphaerella pneumatophorae											+	
*Nais aquatica**											+	
N. inornata	+			+							+	
Natantispora retorquens	+									+		
Ophiobolus australiensis				+								
Phaeosphaeria albopunctata										+		
P. orae-maris										+		
P. typharum										+		
Pleospora herbarum										+		
Podospora dolichopodalis					+							
P. inquinata											+	
Preussia aquilirostrata				+								
P. dispersa										+		
Pseudoallescheria desertorum											+	
*Pseudohalonectria phialidica**	+				+							
*Pseudolignincola siamensis**					+							

Table 2. Contd.

Pyrenophora typhaecola										+		
Savoryella lignicola					+							
Sphaerulina orae-maris											+	
Syspastospora tetraspora	+											
Verruculina enalia	+				+						+	
Zopfiella cephalothecoidea	+										+	
Z. karachiensis					+					+		+
Z. latipes	+		+	+	+	+						+
Z. submerse	+				+							
Hyphomycetes												
Alternaria alternata	+				+							
Aureobasidium pullulans					+			+			+	
Bactrodesium linderi										+		
Beltrania rhombic										+		
Cirrenalia macrocephala	+			+	+					+		
Clavatospora bulbosa				+							+	
Cumulospora marina	+	+			+							
Cylindrocladium camelliae	+				+							
*Dendryphiella arenaria**					+						+	
Exserohilum rostratum	+	+			+							
Halenospora varia	+				+						+	
*Halosigmoidea parvula**												+
*Moromyces varius**											+	
Monodictys pelagica			+	+		+						
Periconia prolific					+						+	
Stachybotrys atra	+			+	+						+	
*Trichocladium alopallonellum**				+								
Virgariella atra											+	
Zygosporium masoni											+	
Coelomycetes												
Camarosporium roumeguerii			+			+	+					
Coniothyrium obiones									+			

*: New record.

subglobose ascospores, whereas the former two species are characterized by ovoid to ellipsoidal ascospores.

Canariomyces notabilis **v. Arx. Persoonia 12: 185(1984):** This type of species was originally isolated from palm litter from Gran Canaria (Arx et al., 1988). This species has been collected from Khor Al-Zubair channel, Basrah, southern Iraq, on stem of *Salicornia europea* submerged in saline

water (Al-Saadoon and Abdullah, 2001). This collection represents the first report for the species from marine habitat.

Chaetomium globosum Kunze, Mykol. Hefte 1:16(1817) (For the synonyms see von Arx et al., 1986): Specimen examined: On submerged dead stem of *P. australis*, in Shatt Al-Arab river near Abu-AlKhasib, Basrah, November 1998. On submerged dead stem of *A. donax*, in Shatt Al-Arab river near University campus, Basrah, April. 2010.

C. globosum is a variable species, especially in the pigmentation of the colonies and the colour of the ascomatal hairs reflected light (von. Arx et al., 1986). This species is associated with decomposing plant debris and has been reported from both terrestrial and aquatic habitats. It was isolated from submerged dead stems of *Carex oligosperma* in freshwater habitat, USA (Fallah and Shearer, 2001). The fungus has been reported from different habitats in Iraq.

***Coniochaeta saccardoi* (Marchal) Cain, Univ. Toronto stud. Biol. Ser. 38:65(1934):** Five species of *Coniochaeta* viz. *Coniochaeta leucoplaca, Coniochaeta lignaria, Coniochaeta kellermania, Coniochaeta velutina* and *Coniochaeta renispora* were isolated from freshwater habitats (Shearer, 1993; Crane and Shearer, 1995), however, *C. saccardoi* has been reported on dung, soil and decaying plant materials (Checa et al., 1988). This species has been isolated from dead date palm leaf submerged in Euphrates River, Nassiryia city, Iraq (Al-Saadoon and Abdullah, 2001). This finding represents the first report of the species from freshwater habitats.

***Corollospora maritima* Werderman. Notizbl. Bot. Gart. u. Museum 2u Berlin 8:284(1922):** *Arenariomyces cinctus* Höhnk, Veröff. Int. Meeresforsch. Bremerhaven 3:28(1954); *Peritrichospora integra* Linder, Farlowia 1:414(1944).

Kohlmeyer (1984) considers this fungus as tropical one. Zainal and Jones (1984) reported this fungus on drift wood in coastal waters of Kuwait. It was the most frequently reported in southern Thialand (Sakayaroj et al., 2011). The species has been encountered from west and east coast of India (Borse et al., 2013)

The species was found on leaves of *Phoenix dactylifera* submerged in Shatt Al-Arab River near University campus, Basrah, Iraq (Abdulkadir and Muhsin, 1991).

***Corollospora pseudopulchella* Nakagiri and Tokura, Trans. Mycol. Soc. Jpn. 28:428(1987):** Ascospore of *C. pseudopulchella* is similar to that of *Corollospora pulchella* in size and septation, however, in the former species, the ascospore is attenuated toward both ends and sometimes seems to have terminal appendages, but *Corollospora pulchella* has ascospores with rounded ends. Most recently this species has been recorded from Kerala and Tamil Nadu state, India (Borse et al., 2013). It was recovered from submerged wood and leaf bases of date palm (*Phoenix dactylifera* L.) in brackish water of Al-Kahla`a river, Missan, southern Iraq (Al-Saadoon and Al-Dossary, 2010). This species is a typical marine taxon and to our knowledge, there is no report from the literature on this species from brackish water, thus it was for the first time to be recorded from brackish water in Al-Kahla`a river located faraway 200 km from the Arabian Gulf and this is typical marine taxon which has been reported from sea-foam in Japan (Nakagiri and Tokura, 1987).

***Decorospora gaudefroyi* (Pat.) Inderb., Kohlm. And Volkm-Kohlm., Mycologia 94: 657(2002):** *Pleospora gaudefroyi* Pat. Tabulae Analticae Fungorum, Paris 2:40 (1886).

The genus differs from *Pleospora* at the molecular and morphological level, especially the well developed gelatinous sheath drawn into 2-4 subconical extensions (Yusoff et al., 1994). It has been reported on *Salicornia* spp. (Kohlmeyer and Kohlmeyer, 1979). This fungus was found on dead stems of *Suaeda* sp. submerged in coastal waters of Umm Qasr, north of Arabian gulf, Iraq and reported under the synonyms of *Pleospora gaudefroyi* (Abdulkadir and Muhsin, 1991).

***Didymosphaeria futilis* (Berk and Br.) Rehm, Hedwigia 18: 167(1879):** In this monograph, Aptroot (1995) regarded *D. futilis* as one of the seven accepted species in the genus *Didymosphaeria.* This fungus is cosmopolitan and it has been found in and on stems of various plants, also on dead leaves, wood and even linoleum (Aptroot, 1995). This species was isolated from decaying leaves of *T. australis* collected from Um-Al-Shwech, southern marshes of Iraq (Abdullah and Abdukadir, 1987).

***Jahnula bipileata* Raja and Shearer, Mycologia 98:321(2006):** *J. bipileata* is morphologically closest to *J. aquatica*, however, the former species differs clearly from *J. aquatica* as it has ascomata with a long cylindrical neck and irregularly striated rough-walled ascospores with a hyaline cap at both apices, features not observed in *J. aquatica* (Raja and Shearer, 2006). This species was recently recovered from USA on submerged decorticated wood in freshwater (Raja and Shearer, 2006). It was reported on submerged leaf bases of date palm in Hamadan tributary, Abu-Alkhasib and submerged

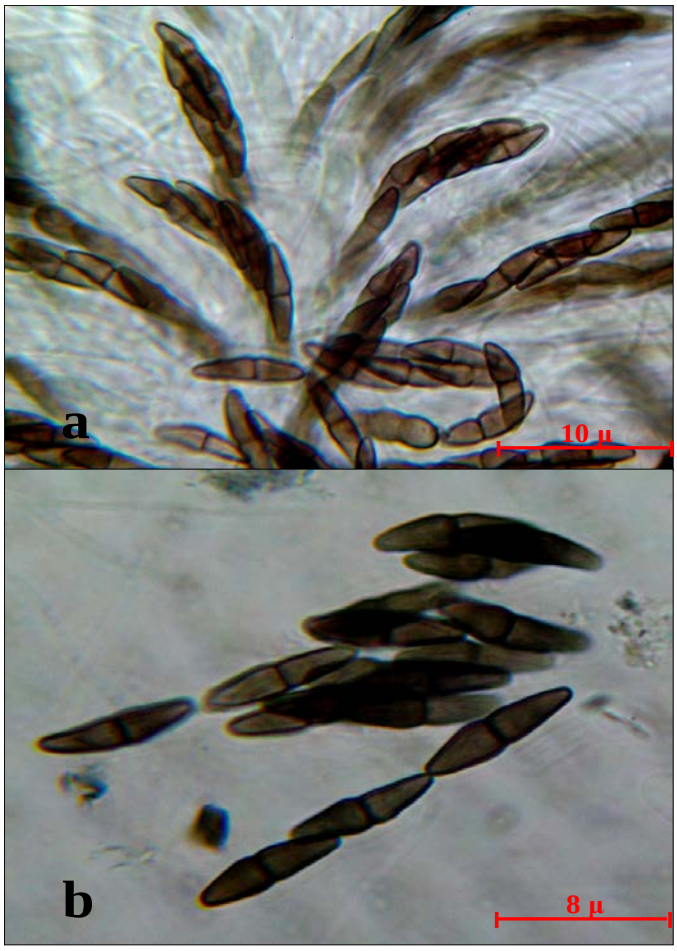


Figure 1. *Kirschsteiniothelia maritima* a: asci and ascospores; b: ascospores.

wood in Al-Kahla`a river, Omara, southern Iraq (Al-Saadoon and Al-Dossari, 2010). This finding represents the first report of the species from brakish habitat and dead leaf of date palm is perhaps a new substrate.

***Kirschsteiniothelia maritima* (Linder) D. Hawksw., Bot. J. Linn. Soc. 91:183 (1985) (Figure 1):** *Amphisphaeria maritima* Linder, Farlowia 1:411(1944). *Microthelia maritima* (Linder) Kohlm., Nova Hedw. 2:322(1960). *Microthelia Linderi* Kohlm. Trans. Mycol. Soc. 57: 483(1971).

Ascomata on natural substrate semiglobose, superficial, ostiolate, short papillate, carbonaceous, black and gregarious, 57-128 µm high and 104-268 µm diameter. Asci clavate to elongate-ellipsoidal, pedunculate, thick walled, lacking an apical apparatus, 38-52 × 8-13 µm. Ascospores brown, 1-septate, constricted at the septum, 15-20 × 6-8 µm.

Specimen examined: On dead stem of *A. donax, P. australis* and leaf bases of *Phoenix dactylifera* submerged in Euphrates river, near Qurna, Basrah, Iraq, November 2010.

The genus *Kirschsteiniothelia* was established by Hawksworth (1985) using *Kirschsteiniothelia aethiops* (Berk. and Curtis) D. Hawksworth as the type species. *Kirschsteiniothelia maritima* (Linder) D. Hawksworth, has been collected from an aquatic habitat (Hawksworth, 1985). The fungus was found on drift wood, bark and coniferous wood (Jones et al., 2009). It was isolated from only one sample for the first time in Kerala state, India (Khan and Manimohan, 2011), most recently it was recorded from Kerala and Pradesh states, India (Borse et al., 2013). Three new plant substrates were investigated for this fungus in this study, and probably the first time to be recorded from brackish water.

***Leptosphaeria agnita* (Desm.) Ces and de Not., Schema Sfer. Ital. 236(1863) (Figure 2):** *Sphaeria agnita* Desm., Annls Sci nat. (Bot. ser. 3) 313(1851). Ascomata on natural substrate, papillate, subglobose, ostiolate, immersed and later becoming almost superficial, 275-340 µm diameter.

Asci cylindrical to clavate, shortly stalked, bitunicate, 8-spored, 100-130 x 10-12 µm, separated by filamentous pseudoparaphyses. Ascospores cylindrical, 5-6 septate, the 3rd cell from the apex is wider than the rest, straight or slightly curved, golden brown, 30-37 x 5-6 µm. Specimen examined: On dead culms of *Phragmites australis* submerged in Shatt Al-Arab river near Al-Karma tributary, Basrah, February 2010.

More than 1.600 taxa have been described in *Leptosphaeria* Ces. and de Not. (Crane and Shearer, 1991). *Leptosphaeria* sensu stricto, as accepted by Barr (1987). Eriksson (1967), Hedjaroude (1969), Holm (1957), Shoemaker (1984) and von Arx and Muller (1975), includes species with scleroplectenchymatous ascomata that occur on dicotyledonous plants. The fungus was collected on *Eupatorium cannabium, Scuttellaria galericulata* and *Senecio jacobaea* (Lucas and Webster, 1967). This is the first record of *L.agnita* from Iraq.

***Lignincola laevis* Höhnk, veroeff, Inst. Meereforsch. Bremerhaven 3: 216 (1955) (Figure 3):** Ascomata on natural substrate subglobose or ellipsoidal, superficial or immersed, ostiolate, papillate, light brown to black with long neck120-320 µm high. Asci 8-spored, clavate to subfusiform, short pedunculate without apical apparatus, thin walled, unitunicate, persistent, whole asci and ascospores released through the ostiole into the water later central part of ascus swelling in water, then break up, 46-55 x 9.5-17 µm.

Ascospores 20-26 x 6-9 µm, biseriate, ellipsoidal, one-septate, hyaline, slightly constricted at the septum, without appendages. Specimen examined: On submerged dead culms of *A. donax* collected in shore line, near Umm Qasr, Basrah, March 2009. On submerged

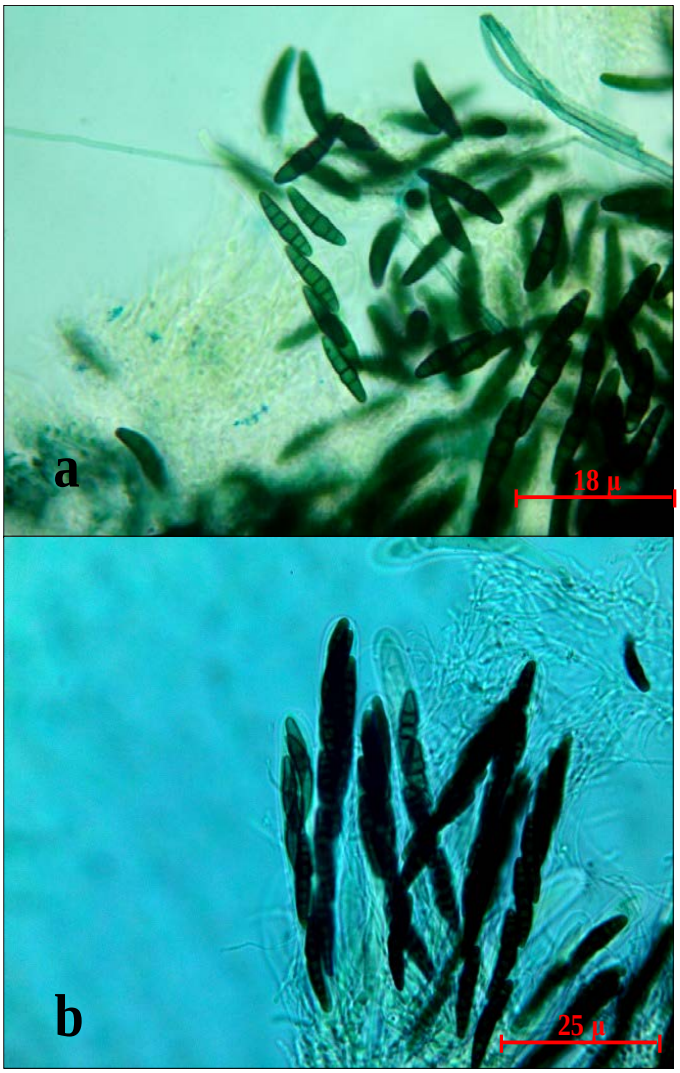


Figure 2. *Leptosphaeria agnita* a: ascospores; b: asci and ascospores.

dead culms of *P. australis* in Khor Al-Zubeir channel, Basrah, February 2009. On submerged dead culms of *P. australis* collected in Qarma tributary, Shatt Al-Arab river Basrah, April 2010.

The genus *Lignincola* has only one unifying character, the hyaline, 1-septate ascospores, lacking appendages (Jones et al., 2009). *Lignincola laevis* (type species) is characterized by hyaline or dark ascomata, semi-persistent fusiform asci, which swell in the middle when mounted in water, and small, thin walled ascospores without appendages (Höhnk, 1955).

This fungus was isolated from mangrove plants in Malaysia (Elias et al., 2010). It was recorded on driftwood collected from Kerala, India from southern Thialand (Sakayaroj et al., 2011) and from west and east coasts of India (Borse et al., 2013), the Iraqi collections are in agreement with the description given for the species by Hohnk (1955) and Pang et al. (2003). The collections were found in brackish and saline water, Basrah, southern Iraq.

***Lulworthia grandispora* Meyers, Mycologia 49: 513(1957):** Many *Lulworthia* species were originally described by Barghoorn and Linder (1944) as *Halophiobolus*, but transferred to earlier taxon *Lulworthia* (Sutherland, 1916) by Cribb and Cribb (1955). The genus has been shown to be polyphyletic based on 18S and 28S sequences analysis and two new genera erected to accommodate species that do not group within the genus *Lulworthia* sensu stricto (Campbell et al., 2005).

Anamorphs of different *Lulworthia* spp. include: *Anguillospora marina (Lindra obtusa), Cirrenalia pygmea, Cirrenalia tropicalis, Cumulospora varia* and *Orbimyces spectabilis* (Jones et al., 2008). It has been stated that this lignicolous species appeared to be restricted to tropical and subtropical waters (Johnson and Sparrow, 1961; Kohlmeyer and Kohlmeyer, 1979). The fungus has been isolated from twigs in eastern Thialand (Dethoup and Manoch, 2009), from mangrove plants in Malaysia (Alias et al., 2010), from southren Thialand (Sakayaroj et al., 2011) and from west and east coasts of India (Borse et al., 2013), this species was isolated from wood submerged in Qarma tributary, Basrah, southern Iraq (Muhsin and Khalaf, 2002).

***L. medusa* (Ellis and Everh.) Cribb and J.W. Cribb, Pap. Dept. Bot. Univ. Qd. 3:80(1955):** *Halophiobolus medusa* (Ellis and Everh.) Linder, Farlowia 1:419(1944); *Linocarpon medusa* (Ellis and Everh.) Petr., Sydowia 6:388(1952); *Ophiobolus medusae* Ellis and Everh., Journal of Mycology 1: 150(1885).

This fungus is closely related to other members of the genus however, the only differentiated character can be made based on the ascospore measurements. The species generally found on culms of *Spartina* species (Jones et al., 2009). This species has been isolated from submerged wood in brackish water, Abu-Alkhasib, Basrah, southern Iraq (Muhsin and Khalaf, 2002).

***Marinosphaera mangrovei* K.D. Hyde, Can. J. Bot. 67: 3080(1989) (Figure 4):** Ascomata on natural substrate ellipsoidal, globose, subglobose, elongate, immersed, ostiole, papillate, membranous, light to dark brown, solitary or gregarious, 840-1120 µm high, parpaphyses wide, simple, septate.

Asci clavate, short pedunculate, persistent, unitunicate, thin-walled, J-subapical plate and pore, 8-spored, 100-140 x 10-12 µm. Ascospores broad ellipsoidal to fusiform, initially 0-septate but becoming distinctly 3-septate, hyaline to yellow color, smooth-walled and lacking a sheath or appendages, 29-33 x 7-8 µm. Specimen examined: On unidentified wood submerged in Shatt Al-Arab river near Qarma tributary, Basrah, April 2010. The

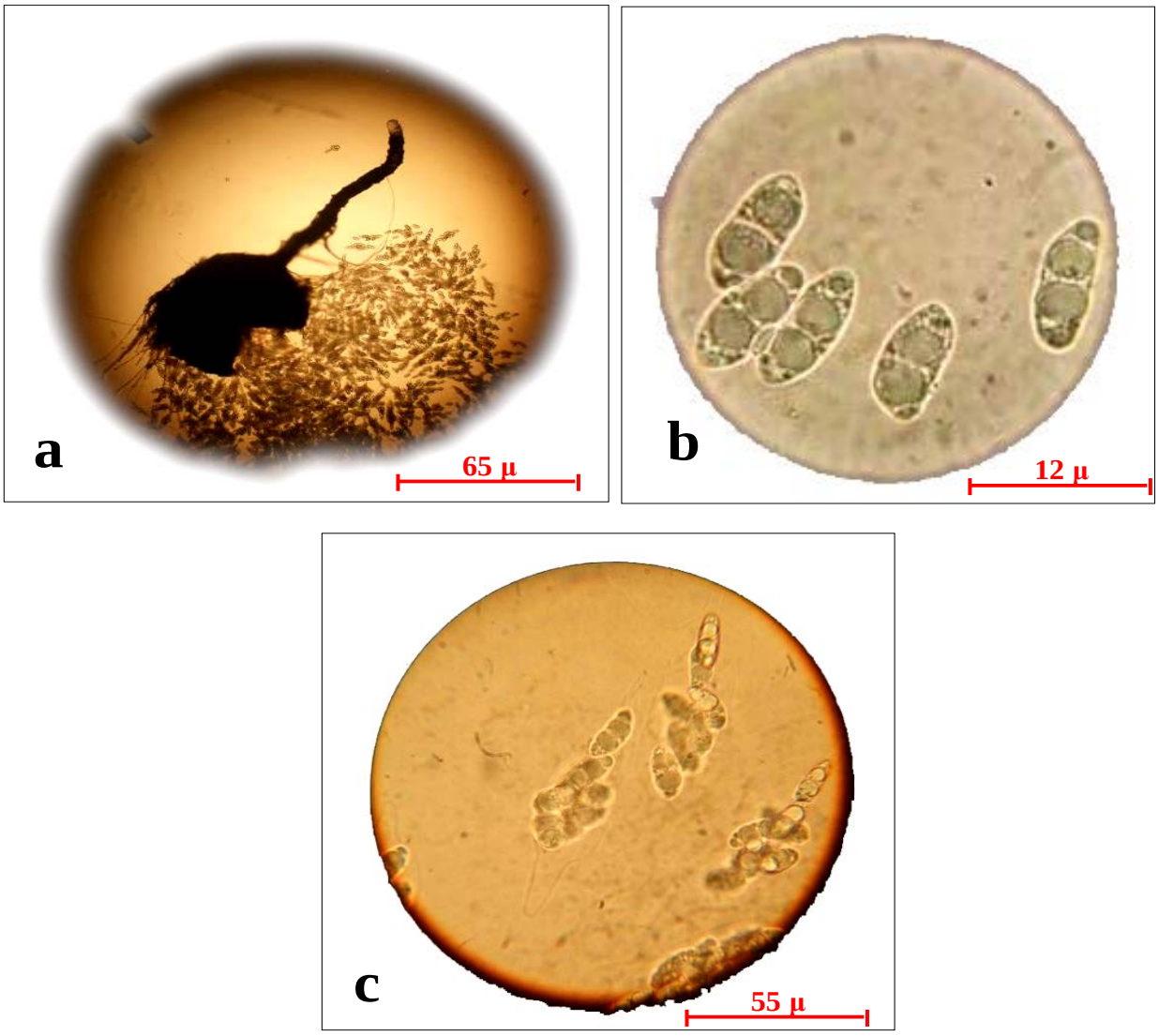


Figure 3. *Lignincola laevis.* a: ascoma and asci; b: ascospores; c: asci.

species is easily identified by its wide, regularly septate paraphyses (Jones et al., 2009). This is a common species, often found on an early colonizer of mangrove wood (Alias, 1996).

It was isolated from twigs collected from beach of Rayong province eastern Thiland (Dethoup and Manoch, 2009), from southern Thiland (Sakayaroj et al., 2011), on driftwood collected from Kerala state, India (Khan and Manimohan, 2011) and from west coasts of India (Borse et al., 2013). This is the first record and new substrate for the fungus from Iraq.

***Monosporascus eutypoides* (Petrack) vonArx, Kavaka 3:34(1975):** *Rechingeriella eutypoides* Petrack, Sydowia 8:170(1954); *Bitrimonospora indica* Sivanesan, Talde and Tilak, Trans. Br. Mycol. Soc. 63:595(1974). The fungus was originally described by Sivanesan et al. (1974) as *Bitrimonospora indica* found on *Achyranthes aspera* from India. von Arx (1975) considered *B. indica* and *Rechingeriella eutypoides* are cospecific. The latter species was described by Petrak and Ahmed (1954) from decaying roots of unidentified plant in Pakistan. von Arx (1975) transferred *R. eutypoides* Petrak to the genus *Monosporascus.* This fungus was found on stem bases of *Halocneumum strobilaceum* collected from shoreline of Khor Al-Zubair canal, Basrah, southern Iraq (Abdullah and Al-Saadoon, 1995).

***Mycosphaerella pneumatophorae* Kohlmeyer, Ber. Dtsch. Bot. Ges. 79:32 (1966):** A well characterized genus, primarily of circa 500 terrestrial species causing leaf spot disease of a wide range of hosts. Marine taxa

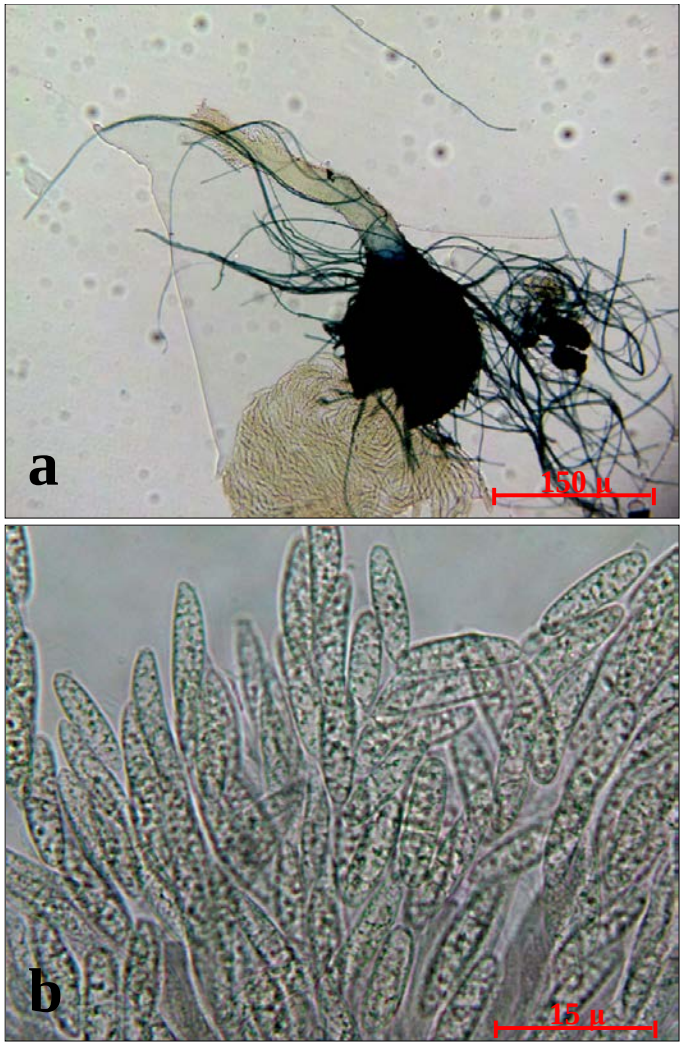


Figure 4. *Marinosphaera mangrovei*; a. ascoma and asci; b. asci and ascospores.

are generally on the salt marsh plants *Armeria, Limonium, Salicornia* and *Suaeda. M. pneumatophorae* occur on the bark of pneumatophores of *Avicennia* species, with recent records from Asian mangroves (Jones et al., 2009), and from Tamil Nadu state, India (Borse et al., 2013).

This species was reported from submerged wood in saline water of Khor Al-Zubair canal, Basrah, southern Iraq (Muhsin and Khalaf, 2002). The taxonomic relegation of species within the genus is based on the substrate type, however, Muhsin and Khalaf (2002) had filded this isolated fungus under this taxon.

Nais aquatica **K.D. Hyde, Aust. Syst. Bot. 5: 117(1992):** Ascomata on natural substrate globose to ampulliform, partly immersed or superficial, black membraneous, ostiolate, papillate, periphysate, 120-390 µm high. Asci, 8-spored, 80-82.4 x 45-46.6 µm thin walled, lacking an apical pore or thicking, deliquescent. Ascospores 31.9-34.2 x 15.6-16.3 µm, hyaline, broadly ellipsoidal, bicelled, not constricted at the septum, relatively thin-walled, with oil droplets forming inner wall ornamentations at the septum. Specimen examined: On unidentified wood submerged in Shatt Al-Arab River near Qarma tributary, Basrah February, 2010.

A genus characterized by hyaline bicelled ascospores with a characteristic arrangement of the internal wall ornamentation along the septum where small oil globules aggregate and lacking appendages. *N. aquatica* is similar to *Nais inornata*, but the former differs in that ascospores develop appendages on release from the ascomata (Hyde, 1992). This is the first record of *N. aquatica* from Iraq.

N. inornata **Kohlm. Nova Hedw. 4:409(1962):** Specimen examind: On submerged dead stem of *P. australis*, Qarma tributary, Shatt Al-Arab River, Basrah, April 2011.

The data from DNA sequence analysis is by Pang et al. (2003) have shown that *N. inornata* is closely related to *Aniptodera*. *N. inornata* is a marine taxon (Dethoup and Manoch, 2009), however, it has been reported from brackish lake in Italy (Grasso and Laferla, 1985). This species has been isolated from submerged wood in brackish water southern Iraq (Muhsin and Khalaf, 2002). Recently, it has been isolated from brackish water, but on submerged leaf bases of date palm in Omara city, this fungus seems to extend its distribution to Missan province, North-East Basrah (Al-Saadoon and Al-Dossary, 2010).

Natantispora retorquens **(Shearer and Crane) J. Campb., J.L. Anerson and Shearer, Mycologia 95: 543(2003):** *Halosarpheia retorquens* Shearer and J.L. Crane, Bot. Mar. 23: 608(1980). Specimen examind: On submerged dead stem of *P. australis*, Qarma tributary, Shatt Al-Arab River, Basrah, April 2011.

Campbell et al. (2003) segregated this species from *Halosarpheia* based on sequence data, although distinguishing morphological features at the generic level are not established. From combined 18S and 28S sequences *Natantispora* species are distantly placed from *Halosarpheia* (Abdel-Wahab et al., 2001).

This species was originally described only from freshwater habitats (Shearer and Crane, 1980), although it has been reported frequently from brackish and marine habitats (Kohlmeyer and Volkmann-Kohlmeyer, 1991). It is among the very few species of Halosphaeriales that occur in both freshwater and marine habitats (Campbell et al., 2003). This fungus has been isolated from submerged dead stem of *Typha australis,* Abu Al-Khasib, Basrah, Southern Iraq (Al-Saadoon and Al-Dossary, 2010).

***Ophiobolus australiensis* Johnson et Sparrow. Fungin in oceans and estuaries. Weinheim, p. 419(1961):** This species was reported on dead leaves of *Phoenix dactylifera* submerged in Umm Qasr saline waters, Basrah, southern Iraq (Abdulkadir and Mahsin, 1991).

***Phaeosphaeria albopunctata* Shoemaker and Babcock, Can. J. Bot. 67:1566 (1988):** *Leptosphaeria albopunctata* (Westendorp) Sacc., Syll, Fung. 2: 72(1883).

This species has also recently been transferred from *Leptosphaeria* to the genus *Phaeosphaeria* (Khashnobish and Shearer, 1996). It has a world wide distribution and reported as a saprophyte on a variety of salt marsh plants such as *Juncus maritimus, Spartina alterniflora, Spartina townsendii* and *Phragmites communis* (Kohlmeyer and Kohlmeyer, 1979). Kumar (1973) reported on the species on the driftwood submerged in sea water near Madras, India. This fungus is found on *T. australis* in southern marshes of Iraq (Abdullah and Abdulkadir, 1987).

***Phaeosphaeria orae-maris* (Linder) Khashn and Shearer, Mycol. Res. 100: 1351(1996):** *Leptosphaeria oraemaris* Linder, Farlowia 1: 413(1944).

The delimitation between *Phaeosphaeria* and *Leptosphaeria* has been obscure, however, based on morphological data and ITS2 and partial 28S rRNA sequences, Khashnobish and Shearer (1996) supported the monophyly of *Phaeosphaeria* and suggested that the genus is delimited by the relatively thin peridium composed of thin-walled pseudoparenchyma with 2-4 cell layers. This species has recently been transferred from *Leptosphaeria* to the genus *Phaeosphaeria* (Khashnobish and Shearer, 1996). It has been recorded from west and east coasts of India (Borse et al., 2013). This species was isolated on dead leaves of *T. australis* submerged in water, southern marshes of Iraq (Abdullah and Abdulkadir, 1987). This collection seem to be the first record from a warm region.

***Phaeosphaeria typharum* (Desm.) L. Hdm., Symb. Bot. Ups. 14: 126(1957) (For the synonyms see Jones et al., 2009):** This species has been reported from marshes and marine habitats in Europe and North America (Apinis and Chester, 1964; Gessner and Goos, 1973b). It has also been reported from freshwater habitats on different species of *Typha* plants in Europe by Muller (1950); Munk (1957) and Pugh and Mulder (1971). Kohlmeyer and Kohlmeyer (1979) considered this species as facultative marine fungus. Abdullah and Abdulkadir (1987) reported the species on decomposing leaves of *T. australis* submerged in water, southern marshes of Iraq.

***Pleospora herbarum* (Fr.) Rabenh. Ex Ces. And de Not. Comm. Soc. Critt. Ital. I. 217(1863):** This species has been previously reported on a variety of salt marshes plants from Brition by Apinis and Chester (1964). It has been isolated from dead leaves and stems of *T. australis* submerged in water, southern marshes of Iraq (Abdullah and Abdulkadir, 1987).

***Podospora dolichopodalis* Mirza and Cain, Can J. Bot. 47: 2018(1969):** This fungus has been reported from dung of herbivorous animals in USA and Brazil (Mirza and Cain, 1969; Lundqvist, 1973). This species was found on *P. australis* submerged in Shatt Al-Arab river, near Basrah University, Basrah, Iraq (Al-Saadoon, 2000). *P. australis* was considered a new substrate.

***P. inquinata* Udagawa and Ueda, Mycotaxon 22: 399(1985):** *P. inquinata* is the only species exclusively recorded from marine sediment collected in the Nagasaki Bay, Japan (Udagawa and Ueda, 1985). It was isolated from freshwater habitat on unidentified wood submerged in the Euphrates River near Battha town, DeQar governorate, south of Iraq (Al-Saadoon, 2000). It was the second kind of the species and unidentified substrate collected from freshwater habitat considered as new substrate.

***Preussia aquilirostrata* Guarro, Abdullah, Gene and Al-Saadoon, Mycol. Res. 101: 305(1997):** It was described from leaf bases of date palm tree (*Phoenix dactylifera* L.) submerged in Shatt Al-Arab River, Basrah, Iraq (Guarro et al., 1997).

***P. dispersa* (Clum.) Cain, Can. J. Bot. 39: 1645(1961):** The species was isolated from water and sediment from pool in USA by W.B. Cooke (Cain, 1961). It was isolated from decomposing leaves of *T. australis* plant submerged in water, southern marsh, Iraq (Abdullah and Abdulkadir, 1987).

***Pseudoallescheria desertorum* (Arx and Mustafa) McGinnis, Mycotaxon 14: 98(1982):** It was isolated from submerged wood in freshwater, Garma, Basrah, Iraq (Muhsin and Khalaf, 2002).

***Pseudohalonectria phialidica* Shearer, Can. J. Bot. 67:150(1989) (Figure 5):** Ascomata on natural substrate immersed, partially immersed or superficial, bright yellow, becoming greyish yellow, globose to flattend globose, 132-350 × 256-400 µm. Asci pale yellow, cylindrical, straight or sigmoid, 8-spored in a single fascicle, short stalked, 106-133 x 10.6-11.9 µm. Ascospores hyaline, yellow in mass, 3-4 septate, filiform, slightly curved or

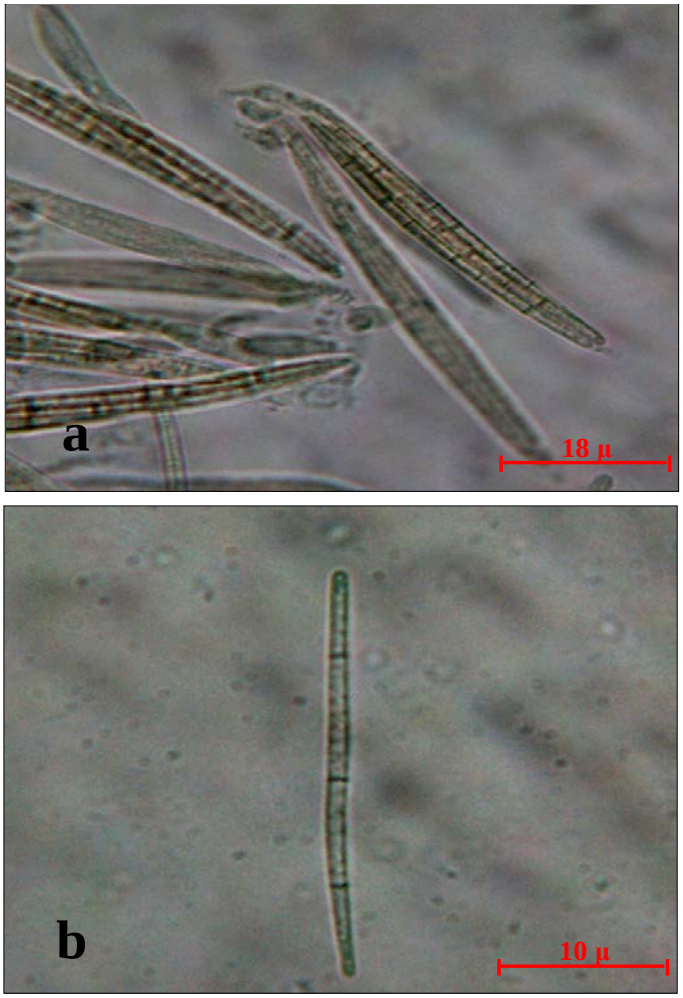


Figure 5. *Pseudohalonectria phialidica*; a. asci; b. ascospore.

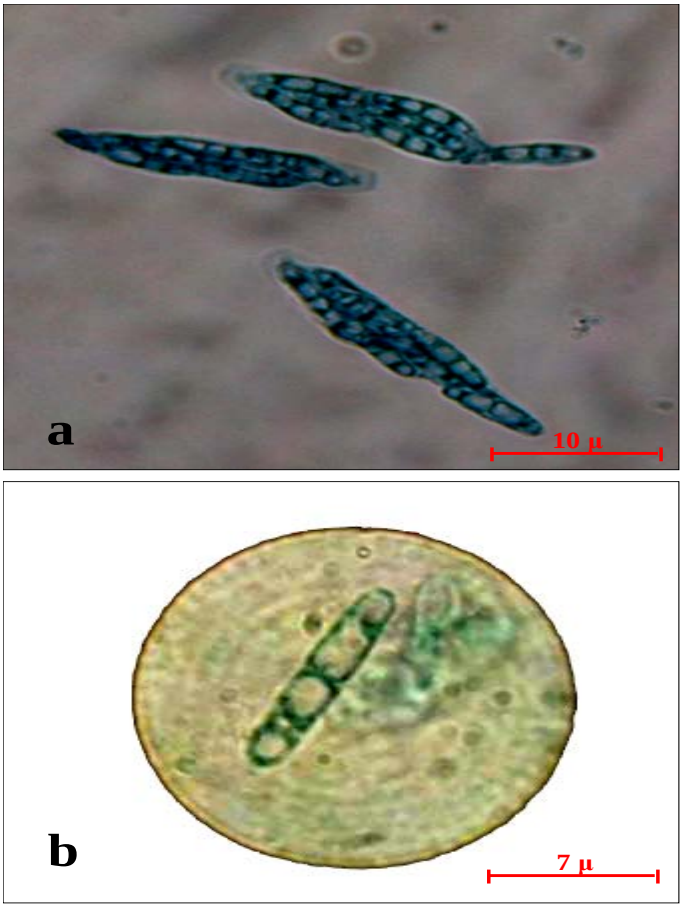


Figure 6. *Pseudolignincola siamensis*; a. asci; b. ascospore.

sigmoid with oil droplets interrupted at regular intervals by non refractile regions 60-65 × 3.9-4.6 µm. Specimen examined: On submerged dead stems of *Arundo donax* and *P. australis*, Qarma tributary, Shatt AlArab, Basrah Iraq, April 2010.

Pseudohalonectria Minoura and Muroi was established in 1978 for *P. lignicola*, an ascomycete found on balsa wood submerged in Japanese lake (Minoura and Muroi, 1978). *P. phialidica* was originally isolated from submerged woody debris in the Salt Fork of the Virmilion river, USA (Shearer, 1989). This fungus has been isolated from freshwater (Shearer, 1989), however, at the present study, it was found on submerged dead culms of *A. donax* and *P. australis* in brackish water and a new substrates were found.

***Pseudolignincola siamensis* Chatmala and E.B.G. Jones, Nova Hedw. 83: 226(2006) (Figure 6):** Anamorph: *Humicola siamensis* Chatmala and E.B.G. Jones. Ascomata globose, dark brown, deeply immersed in the wood, coriaceous with long neck, solitary, catenophyses, 700-1150 µm.

Asci clavate to slightly cylinhdrical, long pedicellate, unitunicate, thin-walled, truncate at the apex with a refractive thicking and retraction of the plasmalemma at the apex, 46.6-56.8 x 9.8-13.3 µm, ascospores cylindrical, 1-4-septate, hyaline, smooth-walled, lacking a sheath or appendages, 20-21-25 x 4-5 µm. Specimen examined: On dead stem of *P. australis*, submerged in water near Qurna, Basrah, Iraq.

April 2010. *P. siamensis* was isolated from plant substrata in Thailand mangroves. It is characterized by having clavate asci with a truncate, thickened apex, a pore, the ascus plasmalemma is retracted and ascospores are 1-4 septate, hyaline, cylindrical and lacking appendages (Jones et al., 2006). *P. siamensis* has only been cited once for Iraq and a new substrate was found.

***Pyrenophora typhaecola* (Cke.) Mull. Sydowia 5: 256(1951):** This species has a world wide distribution and

has been repeatedly collected on *Typha* (Munk, 1957; Wehmeyer, 1961; Pugh and Mulder, 1971). It was reported on dead stem and leaves of *T. australis* submerged in water southern marshes of Iraq (Abdullah and Abdulkadir, 1987).

***Savoryella lignicola* Jones et Eaton, Trans. Br. Mycol. Soc. 52: 161(1969):** The species is known from freshwater, brackish water and marine water habitats and appears to have a wide distribution and wide salinity tolerance (Eaton and Jones, 1971; Hyde, 1993, 1994; Hyde and Jones, 1988; Kohlmeyer and Kohlmeyer, 1979). *Savoryella lignicola* was observed on the collections from Lakshadweep island and noticed on drift wood from Kerala, India (Khan and Manimohan, 2011), and recorded from west and east coasts of India (Borse et al., 2013). It was reported from fresh water habitat on *P. australis* stem submerged in a stream in Nineva province, north of Iraq (Al-Saadoon and Abdullah, 2001).

Sphaerulina orae-maris* Linder, Farlowia 1:413(1944):** This species can be separated from the other marine fungus ***Sphaerulina *albispiculata* Tubaki by its ascomata with a short papillae neck and the number of ascospore septa (Jones et al., 2009). *S. orae-maris* is accepted as an obligate marine fungus (Kohlmeyer and Volkmann-Kohlmeyer, 1991), nevertheless, it was isolated from submerged wood in freshwater, Basrah, Iraq (Muhsin and Khalaf, 2002).

***Syspastospora tetraspora* Adbullah and Al-Saadoon, Marina Mesopotamica 9:83(1994):** The species was isolated from decaying dead stem of *Arundo donax* L. collected from Khor Al-Zubair channel southern Iraq (Abdullah and Al-Saadoon, 1994a).

The genus *Syspastospora* was erected by Cannon and Hawksworth (1982) to accommodate *S. parasitica* (Tul.) P.F. Cannon and D. Hawksworth (1982). The second species of the genus is *S. boninensis* Horie, Udagawa and P.F. Cannon (1986). *S. tropicalis* D. Garcia, Stachigel and Guarro has recenthy been isolated from tropical soils (Garcia et al., 2002).

Syspastospora tetraspora can be distinguished from *Syspastospora parasitica*, *Syspastospora boninensis* and *Syspastospora tropicalis* by its four-spored asci and cylindrical to doliform ascospores, with two large terminal, slightly sunken germ pores.

***Verruculina enalia* (Kohlm.) Kohlm. And Volkm-Kohlm., Mycol. Res. 94:689(1990):** *Didymosphaeria enalia* Kohlm., Ber. Deutsch. Bot. Ges. 79: 28(1966); *Lojkania enalia* (Kohlm.) M.E. Barr, N. Amer. FL. Ser. 2. 13:56(1990). Specimen examined: On stems of *A. donax* submerged in Qarma tributary, Shatt Al-Arab river, Basrah, Dec. 1994; on dead stems of *P. australis* submerged in Shatt Al-Arab river near Abu-Alkhasib, Basrah, Nov 1999; on unidentified wood submerged in Qarma tributary, Shatt Al-Arab river, Basrah, April 2010.

The species was originally described as a *Didymosphaeria enalia* Kohlm., but accepted by Barr (1990) as *Lojkania enalia* (Kohlm.) M.E. barr and by Kohlmeyer and Volkmann-Kohlmeyer (1990) as a type of monotypic *V. enalia* (Kohlm.) Kohlm. and Volkm.-Kohlm. Initially referred to the Didymosphaeriaceae, Melanommatales by Kohlmeyer and Volkmann-Kohlmeyer (1990), sequence data place it in the Testudinaceae as the most basal clade of the pleosporales (Schoch et al., 2006). *V. endia* was one of the most common species isolated from twigs collected from beaches in eastern Thialand (Dethoup and Manoch, 2009) and it has been recorded from southern Thialand (Sakayaroj et al., 2011). It was one of the frequently encountered taxon for all states and union territories investigated in India (Borse et al., 2013), this species has been isolated from submerged dead rhizomes of *A. donax*, Shatt Al-Arab river, Basrah (Abdulkadir and Muhsin, 1991). *A. donax, P. australis* and unidentified wood were considered as new substrates for this fungus.

***Zopfiella cephalothecoidea* Guarro, Abdullah, Al-Saadoon et Gene, Mycotaxon 59:179(1996):** Specimen examined: On submerged dead stems of *A. donax,* Shatt Al-Arab river near Abu Al-Khasib, Basrah, May 1999; on submerged dead stem of *A. donax,* Shatt Al-Arab, Hamdan tributary, Abu Al-Khasib, April 2000; On unidentified dead twigs submerged in Al-Kahla`a river, Missan, southern Iraq, Nov. 2009.

This fungus has been isolated from unidentified dead twig collected from the Euphrates near Battha town DeQar governorate, southern Iraq (Guarro et al., 1996).

This contributions extend its distribution to the provinces of Basrah and Omara. *A. donax* is considered as a new substrate for this fungus.

***Zopfiella karachiensis* (Ahmed and Asad) Guarro, Trans. Br. Mycol. Soc. 91:589(1988):** *Strattonia karachiensis* Ahmed and Asad, Sydowia 21: 281(1967); *Triangularia karachiensis* (Ahmed and Asad) Udagawa, Trans. Mycol. Soc. Japan 20: 362(1979); *Podospora faurelii* Mouchacca, Rev. Mycol. 38: 109(1973). Specimen examined: On submerged dead stems of *P. australis*, Shatt Al-Arab River near Abu Al-Khasib, Basrah, February 1994. On submerged dead stems of *P. australis*, Qarma tributary, Basrah, Dec. 1999. On submerged unidentified twigs, Shatt Al-Arab River near Abu Al-Kasib, Basrah, April 2010.

Z. karachiensis appears to be reasonably widely distributed (Guarro et al., 1991). There are records of it

from Egypt (Mouchacca, 1973), Japan, Thailand (Udagawa et al*.,* 1979), Kenya, Tanzania and India (Khan and Krug, 1990). The species was originally described by Ahmed and Asad (1967) from sheep dung collected from Pakistan. It was changed to *Zopfiella* because its ascospores are not conical as in *Triangularia* (Guarro and Cano, 1988). It has been isolated from decaying *Typha* stem in water, Al-Hammar marshes, near Basrah, Iraq (Abdullah, 1983).

***Z. latipes* (Lundq.) Malloch and Cain, Can. J. Bot. 49: 876(1971):** *Tripterospora latipes* Lundq, Bot. Notiser 122: 592 (1969). Anamorph: *Humicola*- like. Specimen examined : On submerged dead culms of *A. donax* and *P.australis,* Khor Al-Zubair channel, Basrah, Iraq, March 1992. On dead stems of *Halocneumum strobilaceum* and *Salicornia europea* submerged in water, Khor Al-Zubair channel, Basrah, March 1992. On unidentified twigs submerged in Euphrates River, DeQar governorate, June 1994. On *P. australis* submerged in Shatt Al-Arab River, near Basrah University, Basrah, Iraq, Feb. 1995. On submerged leaf bases of date palm, Al-Kahla`a river, Omara, southern Iraq, April 2009. On dead stems of *A. donax* and *Phragmites australis* submerged in Tigris River, near Qurna, Basrah, Nov. 2010. On dead stems of *A. donax* submerged in Shatt Al-Arab River near Qarma, Basrah, April 2011.

This is a fairly common and wide spread species isolated from various herbaceous and woody submerged in both terrestrial and marine ecosystems, as well as from dung (Guarro et al*.*, 1991). It was recorded from Chile, Denmark, India, Japan, South Africa, USA and India (Lundqvist, 1969; Shearer, 1972; Furuya and Udagawa, 1973; Tubaki and Ito, 1973; Borse et al., 2013). It has been isolated on decaying *Typha* plant in water, AL-Hammar marshes, near Basrah, southern Iraq (Abdullah, 1983).

***Z. submersa* Guarro, AL-Saadoon, Gene and Abdullah, Mycologia 89:955(1997):** Specimen examined: On submerged dead stems of *P. australis,* Shatt Al-Arab river, near Qarma, Basrah, December 1999. On submerged dead stems of *A. donax,* Shatt Al-Arab river, near Abu-Al-Khasib, Basrah, southern Iraq, April 2009.

Z. submersa has been isolated from submerged dead culms of *Phragmites* sp. and *A. donax* in Euphrates River, DeQar, Iraq (Guarro et al*.*, 1997).

Anamorphic fungi

Hyphomycetes

***Alternaria alternata* (Fr.) Keissler, Beih. Bot. Zbl. 29: 434(1912):** Specimen examind: On submerged dead stems of *A. donax* and *P. australis*, Shatt Al-Arab river, near Qarma and Abu-Al-khasib, Basrah, June 2009. On submerged dead stems of *P. australis* Shatt Al-Arab River, near Qarma and Qurna, Basrah, April 2011.

This species was reported on *Spartina alterniflora* (Gessner and Goos, 1973a, b; Gessner, 1977, 1978) and *Salicornia* (Reidle and Ershad, 1977). It has been isolated from *P. australis* submerged in water near Basrah University Campus, Basrah (Muhsin and Abdulkadir, 1995).

***Aureobasidium pullulans* (DeBary) Arnaud, Ann. Ec. Agric. Montpellier New Ser. 16: 39(1918):** Specimen examined: On unidentified wood submerged in water, Hamdan tributary, Abu-Al-Khasib, Basrah, Dec. 1999. On dead stems of *Suaeda* sp. submerged in water of Khor Al-Zubair channel, Basrah, Jan 2009. On submerged dead stems of *P. australis*, Shatt Al-Arab, near Qarma, Basrah, April 2011.

This species has been recorded from various halophytes (Pugh and Buckley, 1971; Lindsey, 1976). It was isolated from dead stems of *P. australis* submerged in water, Shatt Al-Arab, near Basrah University campus, Basrah (Muhsin and Abdulkadir, 1995).

***Bactrodesmium linderi* (Crane and Shearer) M.E. Palm and E.L. Stewart, Mycotaxon 15:319(1982):** *Trichocladium linderi* Crane and Shearer, Mycologia 70: 866(1978). The fungus has been transferred to *Bactrodesmium* based on the presence of compact sporodochia (Palm and Stewart, 1982), and not a feature of *Trichocladium* which has mononematous and scattered conidiophores (Ellis, 1971). The species was originally isolated from balsa wood submerged in esturine water, USA (Crane and Shearer, 1978). Most recently it has been reported from west and east coasts of India (Borse et al., 2013). It has been reported on dead leaves of *T. austeralis* submerged in Shatt Al-Arab river, near University campus, Basrah southern Iraq (Abdulkadir and Muhsin, 1991).

***Beltrania rhombica* Penzig, Nouvo G. Bot. Ital. 14: 72(1882):** This species was recorded from dead leaves of many tropical plants and isolated from air, seeds and stems in many countries all over the world (Ellis, 1971), from pineapple field soil in Okinawa, Japan (Watanabe, 1971). This fungus has been isolated from submerged dead stem of *T. austeralis* in Shatt Al-Arab River, near Abu- Al-Khasib, Basrah southern Iraq (Al-Saadoon and Al-Dossary, 2010).

***Cirrenalia macrocephala* (Kohlm.) Meyers and R.T. Moore, Am. J. Bot. 47:347(1960):** *Helicoma macrocephala* Kohlm., Ber. Dtsch. Bot. Ges. 71: 99(1958).

Specimen examined: On submerged dead stems of *Aruond* donax in Khor Al-Zubair channel, Basrah, March 1999. On dead stems of *P. australis*, submerged in Shatt Al-Arab river, near Abu- Al-Khasib, Basrah, April 2010. On unidentified wood submerged in Shatt Al-Arab, near Qarma, Basrah, December 2011.

This fungus was reported on drift wood in coostal waters of Kuwait (Zainal and Jones, 1984), on decayed intertidal wood of *Avicennia marina* (Forssk.) Vierh, *Rhizophora mangle* L., *Rhizophora mucronata* Lamk. and driftwood, decayed leaves (Abdel-Wahab et al., 2010). This species has been isolated from dead date palm (*Phoenix dactylifera*) leaves submerged in Shatt Al-Arab River, near University campus, Basrah, Iraq (Abdulkadir and Muhsin, 1991).

***Clavatospora bulbosa* (Anast.) Nakagiri et. Tubaki, Bot. Mar. 28: 489(1985):** *Clavariopsis bulbosa* Anastasiou, Mycologia 53: 11(1962). In culture, the bulbous basal cells may be absent and conidia develops a single raw of brown cells (Jones et al., 2009). Kohlmeyer and Kohlmeyer (1979) referred to these as chlamydospores. This species has been reported from freshwater and marine habitats (Kohlmeyer and Kohlmeyer, 1979; Dethoup and Manoch, 2009; Borse et al., 2013) as a state of *Corollospora pulchella* Kohlm. Schmidt and Nair. *C.bulbosa* has been described from wood submerged in freshwater in Basrah, southern Iraq (Muhsin and Khalaf, 2002)/ Most recently Al-Saadoon and Al-Dossary (2010) isolated this species from drift wood and leaf bases of date palm (*Phoenix dactylifera* L.) in brackish water, Al-Kahla`a, Omara, north east Basrah.

***Cumulospora marina* I. Schmidt, Mycotaxon 24: 421(1985):** *Vesicularia marina* I. Schmidt, Natur Naturschutz Mecklenberg 12: 117(1974). *Basramyces marinus* (I. Schmidt) Abdullah, Abdulkadir and Goos, Intern. J. Mycol. and lichenol. 4: 183(1989).

Cumulospora is a monotypic genus described by Schmidt (1985) to accommodate a dematiaceous marine hyphomycete, initially referred to as *Vesicularia marina*. The generic name *Vesicularia* was illegitimate and subsequently *Cumulospora* was erected to accommodate this fungus (Schmidt, 1985). The fungus was originally found on decayed wood and rhizomes of *Phragmites communis* in the Baltic sea (Schmidt, 1974). Abdullah et al. (1989) described an identical fungus as *Basramyces marinus* from dead, submerged and floating culms of *P. australis* (Cav.) Trin. ex Steud (Syn. *Phragmites communis*) in southern marshes of Iraq.

C. marina is widely distributed from temperate to tropical locations, and is often common on mangrove bark (Chatmala et al., 2004). It has been recorded from west and east coasts of India (Borse et al., 2013).

This fungus was found on dead culms of *Cyperus rotundus* L. and *A. donax* L. submerged in Shatt Al-Arab River, Basrah, southern Iraq and two substrates were considered as new for this fungus (Abdulkadir and Muhsin, 1991).

***Cylindrocladium camelliae* Venkataramani and Ram, Current Science 30: 186(1961):** This species was isolated from root of *Phellodendron amurense* in Japan (Watanabe, 1994). *C. camelliae* was isolated from submerged leave bases of date palm and stem of *A. donax*, Abu-Al-Khasib, Basrah, southern Iraq, (Al-Saadoon and Al-Dossary, 2010). It was the first report for the species from water habitat.

***Dendryphiella arenaria* Nicot., Rev. Mycol., Paris 23: 93(1958) (Figure 7a and b):** Colonies on PCA growing rapidly, effuse, dark blackish brown, velvetly, reverse grey to black; hyphae pale to mid brown, smooth, 2-5 µm thick, septate and branched. Conidiophores macronematous simple or branched, straight or flexuous, pale to mid brown to olive brown, cylindrical 1-3 septate apically swollen up to 90 µm long, conidia straight, ellipsoidal, cylindrical or obpyriform, mostly 1-3 septate, rarely with 4-septa, pale brown to olivaceous, often with dark septa and dark spot at one end 7-20 x 4-6 µm. Specimen examined: On submerged dead stem of *P. australis and* unidentified wood, Shatt Al-Arab, near Qarma, Basrah, southern Iraq, November 2010.

Ellis (1976) referred to the species as *Scolecobasidium*, however, in the marine *Dendryphiella* species conidiogenous cells are enteroblastic and denticles are absent. Ellis (1976) described pegs on the conidiogenous cells but these may be confused with extensions from the conidia as seen in SEM micrographs. *D. arenaria* is frequently reported from saline environments (Kohlmeyer and Kohlmeyer, 1979) and it is known from various salt-marsh halophytes (Gessner and Goos, 1973b; Kohlmeyer and Kohlmeyer, 1979; Muhsin and Booth, 1987). Our collection represents the first report of the species from Iraq.

***Exserohilum rostratum* (Drechsler) Leonard and Suggs., 66: 290(1974):** *Drechsler halodes* (Drechsler) Subram. and Jain, Curr. Sci. 35:354(1966). Specimen examined: On submerged dead stem of *A. donax* and *P. australis,* Shatt Al-Arab river, near Qarma, Basrah, April. 2010. The fungus was reported on the aerial parts of *Spartina alterniflora* (Gessner, 1977) and halophytic plants from an inland salt marsh at Delta, Man, Manitoba, Canada (Muhsin and Booth, 1987). The species has been described as *Drechslera halodes* on dead culms of *Cyperus rotundus* submerged in Shatt Al-Arab River near Al-Khora tributary, Basrah, southern Iraq (Abdulkadir and Muhsin, 1991).

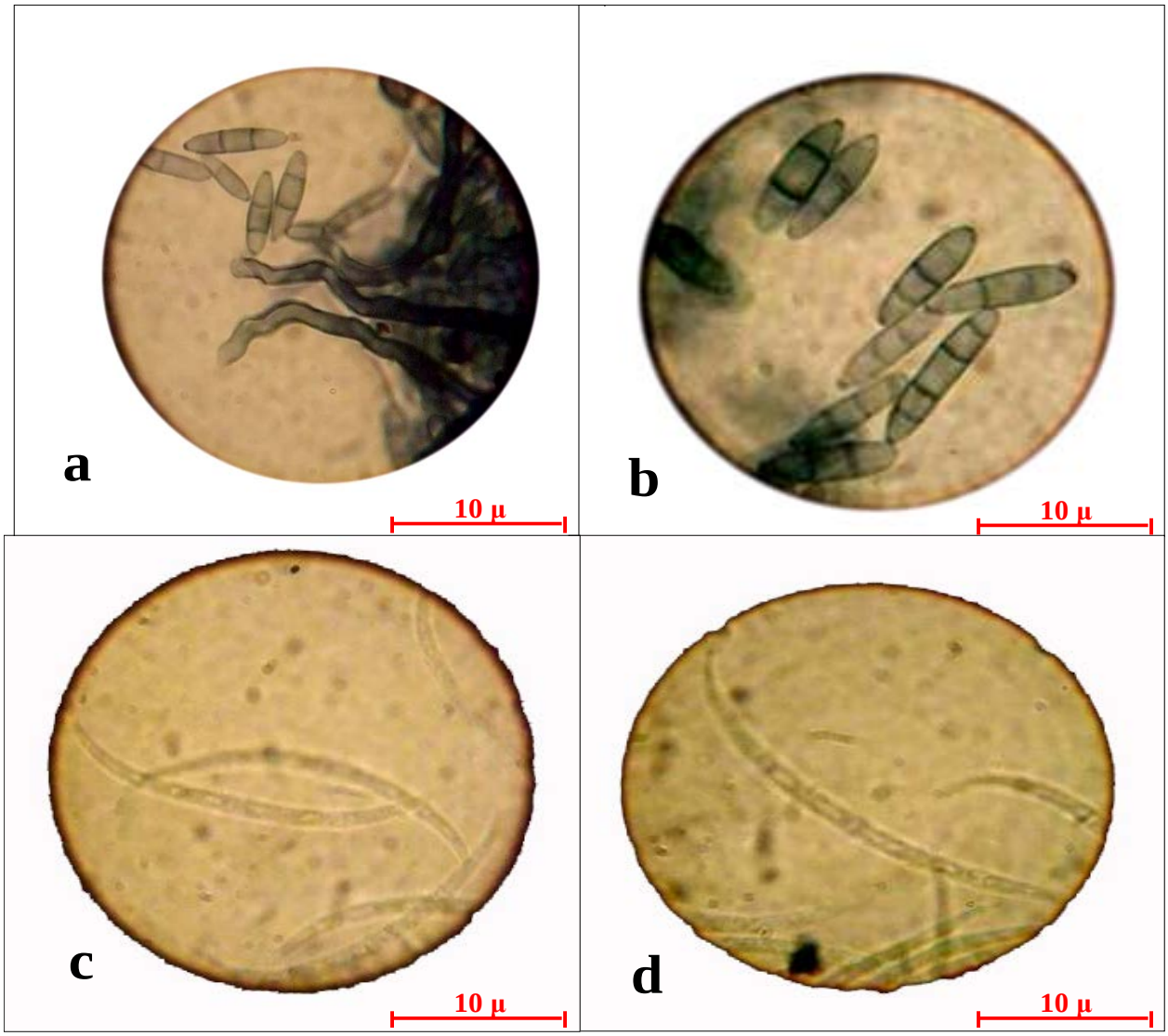


Figure 7. *Dendryphiella arenaria*; a. hyphae and conidia; b. conidia and *Halosigmoidea parvula*; c and d. conidia.

***Halenospora varia* (Anastasiou) E.B.G. Jones, Fungal Diversity 35: 154(2009):** *Zalerion varium* Anastasiou, Can. J. Bot. 41: 1136(1963). Specimen examined: On submerged dead stems of *A. donax, P. australis* and unidentified wood, Khor Al-Zubair channel, Basrah, March 1994. On dead stems of *A. donax,* submerged in Shatt Al-Arab River, near Abu- Al-Khasib, Basrah, April 2009.

Changed to *Halenospora* because its conidia produce a lateral rather than a terminal spiral as in *Z. maritima*. The indiridual cells in *H. varia* are narrower than those of *Z. maritima*, and form knot-like structures (Jones et al., 2009). Records in adjacent areas was by RaghuKumar (1973) from Indian Ocean by Koch (1982), from Srilanka by Khan and Manimohan (2011), from lakshadweep Island and kerala stat in India, by Sakayaroj et al. (2011), from Southern Thialand and by Borse et al. (2013) from west and east coasts of India.

This fungus seems to be cosmopolitan as reported by Kohlmeyer (1984), occurring on intertidal wood, submerged leaves, seedling of *Rhizophora* mangle (Jones et al., 2009). It has been isolated from dead rhizomes of *A. donax* submerged in Shatt Al-Arab River near Nashwa village and Al-Khora tributary, Basrah (Abdulkadir and Muhsin, 1991).

***Halosigmoidea parvula* Zuccaro, J.I. Mitch. and Nakagiri, Bot. Mar. 52: 349-359 (2009) (Figure 7c and d)**

Hyphae branched, septate, hyaline. Conidiophore hyaline, initially short and simple then becoming longer and septate. Conidiogenous cells holoblastic, terminal,

symbodial. Conidia aleuriospores, C to U-shaped, rarely sigmoid, solitary, septate, hyaline, terminal and basal cells of mature conidia, devoid of cytoplasm, 4-5 septate 56.2-68.7 × 2.5-3.2 µm. Specimen examined: On unidentified twigs, submerged in Tigris near Qurna, Basrah, Iraq, November 2010.

Predominantly on decaying seaweeds, especially members of the Fucales (Jones et al., 2009). Mature conidia are generally not constricted at the septa, but before germination each conidial cell becomes rounded and septate into individual cells or several cell clusters, from which hyphae germinate. This is the first reference of *H. parvula* from Iraq.

***Moromyces varius* (Chatmala and Somrith.) Abdel-Wahab, K.L. Pang, Nagahama, Abdel-Aziz and E.B.G. Jones, Mycol. Prog. 9: 555 (2010) (Figure 8a):** *Cumulospora varia* Chatmala and Somrith., Fungal Diver. 17: 3(2004). Specimen examined: On unidentified wood submerged in Shatt Al-Arab river near Qurna, Basrah, Nov. 2010.Colonies on PCA growing rapidly at 25°C, black; reverse black; hyphae septate, branched. superficial or immersed, pale brown. Conidiophores absent. Conidiogenous cells holoblastic, terminal. Conidia 20-80 x 18-48µm, dark grey to fuscous, solitary, scattered or gregarious, muriform. Conidia initially spiral, but cell division in several planes, leads to a tangled knot of cells.

C. varia was transferred to the new genus *Moromyces* by Abdel-Wahab et al. (2010). *M. varius* is different from *Cumulospora marina* by having a muriform, irregularly helicoid conidia, while the latter fungus has rosette-like conidia, globose conidial cells that form pseudo-chains. *C. marina* have conidia that are differentiated into small basal cells which form a filament and larger rounded apical cells, while conidia in *M. varius* form a knot of cells that are more or less similar in shape and size (Abdel-Wahab et al., 2010). It was isolated from decayed driftwood and mangrove seeds in the intertidal zone, Egypt, Japan and Thailand (Chatmala and Somripthipol, 2004; Abdel-Wahab et al., 2010). This is the first record of the species from Iraq.

Monodictys pelagica (Johnson) E.B.G. Jones, Trans. Br. Mycol. Soc. 46: 138(1963): Piricauda pelagica T.W. Johnson, J. Elisha Mitchell Sci. Soc. 74:42(1958). Piricauda arcticoceanorum R.T. Moore, Rhodora 61: 95(1959). Specimen examined: On dead stems of *Salicornia europea* and *Halocnemum strobilaceum* submerged in Khor Al-Zubair channel, Basrah, March 1999. On dead stems laef bases of date palm submerged in Shatt Al-Arab River, near Abu- Al-Khasib, April 2009 and Qarma, November 2010. A cosmopolitan species occurring on a wide range of substrata, largely with a temperate distribution (Jones et al., 2009). It is known from submerged wood and drift Spartina and salt-marsh halophytes (Jones, 1963; Gessner and Goos, 1973a, b; Davidson, 1974; Muhsin and Booth, 1987). The species has been isolated from the soil and mud of the tidal zone of Khor Al-Zubair canal southern Iraq.

***Periconia prolifica* Anastasiou, Nova Hedw. 6: 260(1963):** Specimen examined: On dead stems of *P. australis* submerged in Shatt Al-Arab river, near Abu- Al-Khasib, Basrah, January 1999; on dead stems of *P. australis* submerged in Shatt Al-Arab river, near Qarma, April 2009, November 2010.

P. prolifica is a very common on tropical wood (Vrijmoed et al., 1994) occurring on a wide range of substrata. This species is considered as a marine inhabitant fungus and can be separated from the releated species *P. abyssa* Kohlm. by the conidial size (Kohlmeyer and Kohlmeyer, 1979). It represents the anamorph of *Okeanomyces cucullatus* (Kohlm.) K.L. Pang and E.B.G. Jones, however, the later species has been isolated during this survey, also was recently isolated from southern Thialand (Sakayaroj et al., 2011), and from west and east coasts of India (Borse et al., 2013). This species has been isolated from submerged wood in saline water, of Khor Al-Zubair estuary, Basrah, southern Iraq (Muhsin and Khalaf, 2002).

***Stachybotrys atra* Corda, Icon. Fung. (Prague) 1:21 (1837):** Specimen examined: On dead stems of *A. donax, P. australis,* unidentified wood and dead leaf bases of *Phoenix dactylifera* submerged in water, Shatt Al-Arab, near Abu- Al-Khasib and Qarma, Basrah, April 2009, November 2010.

Stachybotrys has been reported from marine habitats (Meyers and Reynolds, 1959). *S. atra* was reported from submerged twigs of *Tamarix aphylla* in Salton Sea (Anastasiou, 1963). This species was isolated from soil, aquatic sediments, southern Iraq (Muhsin and Al-Helfi, 1981).

***Trichocladium alopallonellum* (Meyers and Moore) Kohlm. and Volkm.-Kohlm., Mycotaxon 53: 392(1995) (Figure 8b):** *Humicola alopallonella* Meyers and Moore, American Journal of Botany 47: 346(1960). Specimen examined: On dead leaf bases of *P. dactylifera* submerged in Shatt Al-Arab near Qarma, November 2010. Hyphae sub-hyaline to light brown, septate and branched. Conidiophores 3-6 x 2.5-5.5 µm, macronematous, simple, smooth, subhyaline to light brown, 0-1 septate, lateral, short, sometimes indistinct, conidiogenous cells usually remaining connected to the conidium. Conidia 9-30 x 7-15 µm, fucous, obpyriform, ovoid or subglobose, 0-1 septate, apical cell large, 8-14 × 7-12 µm, ovoid, fuscous, basal cell smaller, abconical to cylindrical, light brown, distal cell subglobose, small,

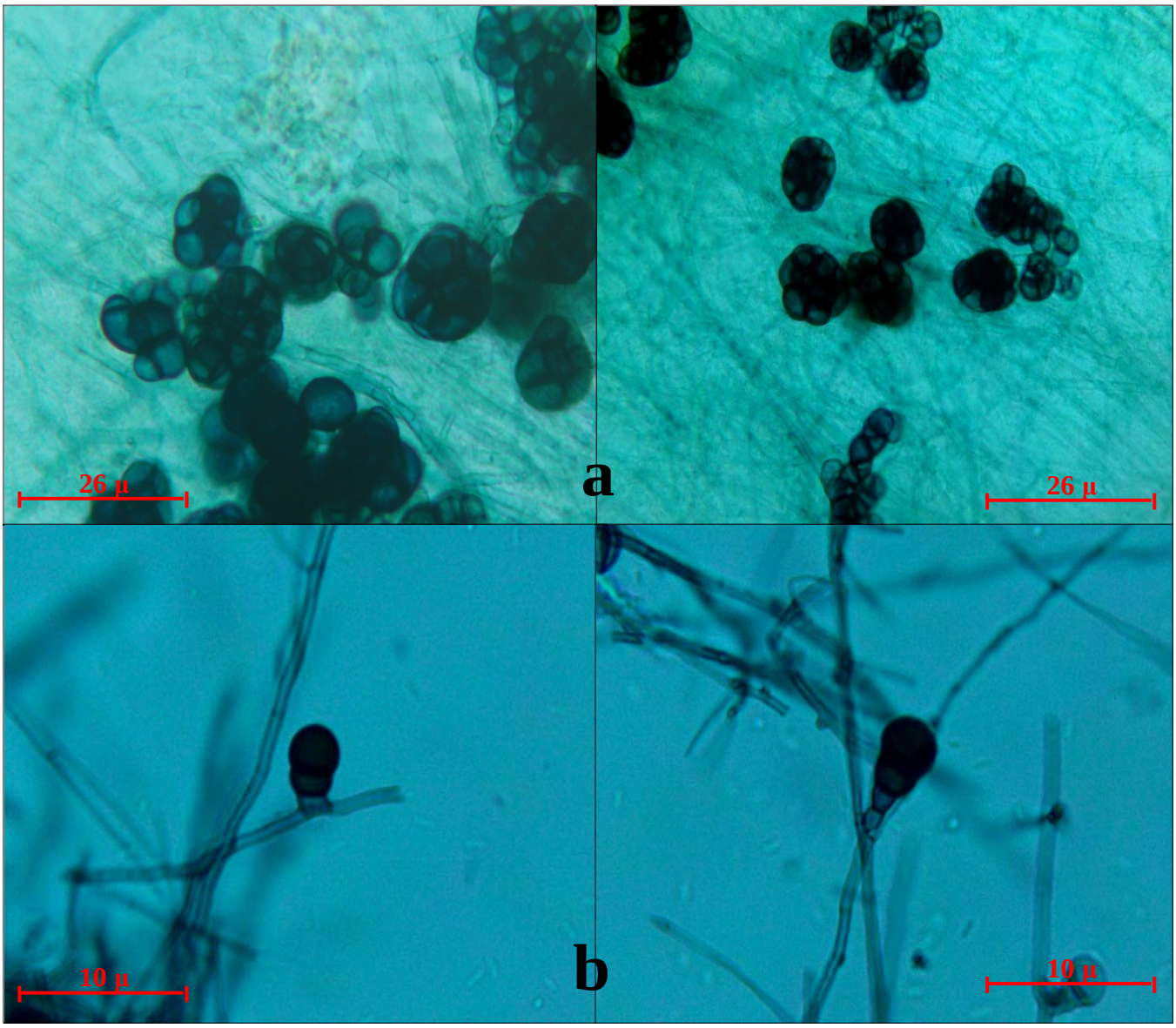


Figure 8. *Moromyces varius;* a. conidia and *Trichocladium alopallonellum*; b. hyphae and conidia.

hyaline.

T. alopallonellum is a marine species (Meyers and Moore, 1960; Kohlmeyer and Volkmann-Kohlmeyer, 1995; Alias et al., 2010; Borse et al., 2013) with conidia that are mostly 2-sptate and pyriform, with fuscous, subglobose distal cell (Goh and Hyde, 1999). *T. alopallonellum* closely resemble *Trichocladium melhae*, however, it differ in having fuscous pyriform conidia that are moderately constricted at the septa and larger. This is the first record of the species from Iraq.

***Virgariella atra* Huges, Can. J. Bot. 31: 653(1953):** This species has been found on rotten wood of *Fagus, Fraxinus* and *Quercus* from Great Britain (Ellis, 1971). From the literature, this species has not been reported from marine environment, thus it was the first time to be recorded from saline water on wood submerged in Khor Al-Zubair estuary, Basrah, southern Iraq (Muhsin and Khalaf, 2002).

***Zygosporium masoni* Hughes, Mycol. Pap. 44:15(1951):** This fungus has been commonly isolated from dead leaves and occasionally other parts of different plants and soil (Ellis, 1971), and from mangroves (Newell, 1976), however, it was found on submerged wood in freshwater in Qrama tributary, Basrah, Southern

Iraq (Muhsin and Khalaf, 2002).

Coelomycetes

***Camarosporium roumeguerii* Saccardo, Michelia 2: 112(1880):** *Camarosporium obiones* Jaap, bot. Ver. Prov. Brandenburg 47: 97(1905). Specimen examined: On dead stems of *Halocneumum strobilaceum* and *Salicornia europea* submerged in Khor Al-Zubair channel, Basrah, January 1994, February 1999.

This species occur on the salt marsh plants *Halimione portulacoides* and various *Salicornia* species (Kohlmeyer and Kohlmeyer, 1979). Only one record for this fungus in the Arabian Gulf was reported by Zainal and Jones (1984) from driftwood in coastal waters of Kuwait. Most recently it has been reported from west and east coasts of India (Borse et al., 2013).

C. roumeguerii was found on dead shoots of *Salsola baryosma* Forrsic submerged in saline water of Khor Al-Zubair estuary, Basrah, Iraq (Abdullkadir and Muhsin, 1991).

***Coniothyrium obiones* Jaap, Schr. Naturw. Ver. Schlesing-Holstein 14: 29(1907):** Occurs on the salt marsh plant *H. portulacoides* (Jones et al., 2009). it has been recorded from Orissa coasts of India (Borse et al., 2013), this species has been isolated on dead twigs of *Tamarix aphylla* (L.) kars. submerged in Al-Khora tributary, Basrah, Iraq (Abdullkadir and Muhsin, 1991).

Conflict of Interests

The author(s) have not declared any conflict of interests.

ACKNOWLEDGEMENTS

We are indebted to Professor Dr. Samir K. Abdullah, Biology Department, Faculty of Science, Zakho University, Iraq, for his continuous support and reviewing this paper. We thank Professor Dr. Mohamed Ahmed Abdel-Wahab, Deptartment of Botany, Faculty of Science, Sohag University, Egypt, for his suggestions and help with identification of several species. We also thank Dr. Huzefa Raja, Department of Plant Biology, University of Illinois, USA, for advice and confirmation of the identification of some species.

REFERENCES

Abdel-Wahab MA, Pang KL, EL-Sharouney HM, Jones EBG (2001). *Halosarpheia unicellularis* sp. nov. (Halosphaeriales Ascomycota) based on morphological and molecular evidence. Mycoscience 42:638-642.

Abdel-Wahab MA, Pang KL, Nagahama T, Abdel-Aziz F, Jones EBG (2010). Phylogenetic evaluation of anamorphic species of *Cirrenalia* and *Cumulospora* with the description of eight new genera and four new species Mycol. Prog. 9:537-558.

Abdulkadir MA, Muhsin TM (1991).Marine fungi from Iraq. Mar. Mesop. 6:193-207.

Abdullah SK (1983). New and noteworthy ascomycetes from Iraq. Trans. Br. Mycol. Soc. 81:592-395.

Abdullah SK, Abdulkadder MA, Goos RD (1989). *Basramyces marinus* nom. Nor. (hyphomycete) from southern marshes of Iraq. Int. J. Mycol. Lichen. 4:181-186.

Abdullah SK, Abdulkadir MA (1987). Freshwater and marine ascomycotina from the southern-marshes of Iraq. Mari. Mesopot. 2:65-74.

Abdullah SK, Al-Saadoon AH (1994a). *Syspastospora tetraspora* sp. nov. a new ascomycete from the khawr Al-Zubair estuary, southern Iraq. Mar. Mesop. 9:83-89.

Abdullah SK, Al-Saadoon AH (1994b). *Arxiomyces zubariensis sp. nov*. from the Khawr Al-Zubair estuary, southern Iraq. Mar. Mesop. 9:245-250.

Abdullah SK, Al-Saadoon AH (1995). On occurrence of *Monosporascus eutipoides* in arid region of Iraq. Bas. J. Sci. 13:113-118.

Ahmed SI, Asad F (1967). *Strattonia karachiensis* sp. nov. from West Pakistan. Sydowia 21:282-284.

Alias SA (1996). Ecological and taxonomic studies of lignicolous marine fungi in Malaysian mangroves. PhD. Thesis, University of Portsmouth.

AliasSA, Zianuddin N, Jones EBG (2010). Biodiversity of marine fungi in Malaysian mangroves. Bot. Mar. 53:545-554.

Al-Saadoon AH (2000). Additions to *Podospora* of Iraq. Bas. J. Sci. 18:27-38.

Al-Saadoon AH, Abdullah SK (2001). Some interesting ascomycete from Iraq. Iraqi J. Biol. 1:125-134.

Al-Saadoon AH, Al-Dossary MAN (2010). Some fungi isolated from submerged plant debris in southern Iraq. Marsh Bullet. 5:207-221.

Anastasiou CJ (1963). Fungi from salt lakes II. Ascomycetes and fungi imperfecti from the Salton Sea. Nov. Hidw. 6:243-276.

Apinis AE, Chester CGC (1964). Ascomycetes of some salt marshes and sand dunes. Trans. Br. Mycol. Soc. 47:419-435.

Aptroot A (1995). A monograph of *Didymosphaeria.* Stud. Mycol. 37:1-160.

Arx JA von (1975). On *Thielavia angulata* and some recently described *Thielavia* species. Kavaka 3:33-36.

Arx JA von, Figueras MJ, Guarro J (1988). Sordariaceous Ascomycetes without ascospore ejaculation. J. Cramer, Berlin-Stuttgart. 101pp.

Arx JAvon, Guarro J, Figueras MJ (1986). The Ascomycete genus *Chaetomium*. Beihefte zur. Nov. Hedw. 84:1-162.

Arx JAvon, Muller E (1975). A re-evaluation of the bitunicate ascomycetes with keys to families and genera. Stud. Mycol. 9:1-159.

Barghoorn ES, Linder DH (1944). Marine fungi: their taxonomy and biology. Farlow. 1:395-467.

Barr ME (1987). Prodromus to class Loculoascomycetes. Amherst, Massachusetts: Hamilton I. Newell, Inc. 168p.

Barr ME (1990). North American flora. Series11, part 13, Melanommatales (Loculoascomycetes). New York Botanical Garden, New York.

Borse BD, Borse KN, Pawar NS, Tuwar AR (2013). Marine fungi from India – XII Arerised check list . Ind. J. Geo-Mar. sci. 42:110-119.

Cain RF (1961). Studies on coprophilous ascomycetes VII. Preussia. Can. J. Bot. 39:1633-1666.

Campbell J, Anderson JL, Shearer CA (2003). Systematics of *Halosarpheia* based on morphological and molecular data. Mycol. 95:530-552.

Campbell J, Volkmann-Kohlmeyer B, Grafenhan T, Spataofora JW, Kohlmeyer J (2005). A re-evaluation of Lulworthiales: relationships based on 18S and 28S rDNA. Mycol. Res. 109:556-568.

Cannon PF, Hawksworth DL (1982). Are-evaluation of *Melanospora* Corda and similar pyrenomycetes, with a revision of the British species. Bot. J. Linn. Soc. 84:115-150.

Chatmala I, Sakayaroj J, Somrithipol S, Phongpaichit S (2004). Marine hyphomycetes of Thailand and *Cumulospora varia sp. nov*. Fung. Diver. 17:1-9.

Checa J, Barras JM, Moreno G, Fort F, Guarro J (1988). The genus

Coniochaeta (Sacc.) Cooke (Coniochaetaeae: Ascomycotina) in Spain. Cryptogamic Mycol. 9:1-34.
Crane JL, Shearer CA (1978). Two new species of *Trichocladium* (Hyphomycetes) from submerged wood. Mycol. 70:866-874.
Crane JL, Shearer CA (1991). A nomenclator *Leptosphaeria* V. Cesati and G. DeNotaris. Illinois Nat. Hist. Survey, Biol. Notes 34:1-355.
Crane JL, Shearer CA (1995). A new *Coniochaeta* from freshwater. Mycot. 54:107-110.
Cribb AB, Cribb JW (1955). Marine fungi from Queensland-1.University Queensland Papers. Department of Botany 3:77-81.
Cuomo V, Vanzanella F, Fresi EC, Cinelli F, Mazzella L (1985). Fungal flora of *Posidonia oceanica* and its ecological significance. Trans. Br. Mycol. Soc. 84:35-40.
Davidson DE (1974). Wood-inhabiting and marine fungi from a saline lake in Wyoming. Trans. Br. Mycol. Soc. 63:143-149.
Dethoup T, Manoch L (2009). Diversity of marine fungi in Eastern Thialand . Kasetsart. J. 43:100-106.
Eaton RA, Jones ENG (1971). The biodeterioration of timber in water cooling towers I. Fungal ecology and the decay of wood at Connahs Guay and the Inc. Mat. Organ. 6:51-80.
Ellis MB (1971). Dematiaceous hyphomycetes. CMI. Kew. 608pp.
Ellis MB (1976). More dematiaceous hyphomycetes. Common. Mycol. Instit. Kew, England.
Eriksson O (1967). On graminicolous pyrenomycetes from Fennoscandia I, II, III. Phragmosporous and scolecosporous species. Arkiv. Bot. Ser. 2:381-440.
Fallah PM, Shearer C (2003). Freshwater ascomycetes: new or noteworthy species from north temperate lakes in Wisconsin. Mycol. 93:566-602.
Furuya K, Udagawa S (1973). Coprophilous ascomycetes from Japan III. Trans. Mycol. Soc. Japan 14:7-30.
Garcia D, Stchigel AM, Guarro J (2002). A new species of *Syspastospora* from tropical soils. Mycol. 94:862-865.
Gessner RV (1977). Seasonal occurrence and distribution of fungi associated with *Spartina alterniflora* from a Rhode Island estuary. Mycolo. 69:477-491.
Gessner RV (1978). *Spartina alterniflora* seed fungi. Can. J. Bot. 56:2942-2974.
Gessner RV, Goos RD (1973a). Fungi from decomposing *Spartina alterniflora*. Can. J. Bot. 51:51-55.
Gessner RV, Goos RD (1973b). Fungi from *Spartina alterniflora* in Rhode Island. Mycol. 65:1296-1301.
Goh TK, Hyde KD (1996). Biodiversity of freshwater fungi. J. Ind. Microb. 17:328- 345.
Goh TK, Hyde KD (1999). A synopsis of *Trichocladium* species, based on the literature. Fung. Diver. 2:101-118.
Grasso S, Laferla R (1985). Further investigations on the occurrence of lignicolous fungi in the brackish lake of faro (Messina Italy). Memorie dibiologia marina e di occanografia, 7:233-243.
Guarro J, Abdullah SK, Al-Saadoon AH, Gene J (1996). A new *Zopfiella* (Lasiosphaeriaceae) from Iraq. Mycot. 59:197-202.
Guarro J, Abdullah SK, Gene J, Al-Saadoon AH (1997a). A new species of *Preussia* from submerged plant debris. Mycol. Res. 101:305-308.
Guarro J, Al-Saadoon AH, Gene J, Abdullah SK (1997b). Two new cleistothecial ascomycetes from Iraq. Mycol. 89:955-961.
Guarro J, Cannon PF, van der HA (1991). A synopsis of the genus *Zopfiella* (Ascomycetes, Lasiosphaeriaceae). Syst. Ascomy. 10:79-112.
Guarro J, Cano J (1988). The genus *Triangularia*. Trans. Br. Mycol. Soc.91:587-591.
Hawksworth DL (1985). *Kirschsteiniothelia*, a new genus for the *Microthelia incrustans*-group (Dothideales). Bot. J. Linn. Soc. 91:181-202.
Hedjaroude GA (1969). Etudes taxonomiques sur Les *Phaeosphaeria* Miyake et Leurs formes voisines (Ascomycetes). Sydow. 22:57-107.
Holm L (1957). Etudes taxonomiques sur les Pleosporacees. Symb. Bot. Ups. 14:1-188.
Horie Y, Udagawa S, Cannon PF (1986). Four new species of the Ceratostomataceae (Ascomycetes). Mycot. 25:229-245.
Hyde KD (1992). Tropical Australian freshwater fungi-II. *Annulatascus velatispora gen. et. sp. nov*., *A. bipolaris sp. nov*. and *Nais aquatica sp. nov*. (Ascomycetes). Aust. Syst. Bot. 5:117-124.
Hyde KD (1993). Tropical Australian freshwater fungi V. *Bombardia* sp. *Jahnula australiensis sp. nov*. *Savoryella lignicola* and *S. aquatica* sp. nov. Aust. Syst. Bot. 5:161-167.
Hyde KD (1994). The genus *Savoryella* from freshwater habitats including *S. grandispora sp. nov*. Mycosc. 35:59-61.
Hyde KD, Goh TK (1998). Fungi on submerged wood in Lake Barrine, North Queensland, Australia. Mycol. Res. 102: 739-749.
Hyde KD, Ho WH, Tsui KM (1999). The genera *Aniptodera, Halosarpheia, Nais* and *Phaeonectriella* from freshwater habitats. Mycosc. 40:165-183.
Hyde KD, Jones EBG (1988). Marine mangrove fungi. Mar. Ecol. (Berlin) 9:15-23.
Hyde KD, Jones EBG (1989). Marine fungi from Seychelles. VIII. *Rhizophila marina*, a new ascomycetes from mangrove prop roots. Mycot. 34:527-533.
Höhnk W (1955). Studien zur Brack-und Seewassermykologie. V. Hohere Pilze des submersen Holzes. –Veroff. Inst. Meeresforsch. Bremer. 3:199-227.
Hu DM, Chen H, Cai L, Bahkali AH, Hyde KD (2012). *Aquapeziza* anew genus from freshwater and its morphological and phylogenetic relationships to Pezizaceae. Mycologia. 104:540-546.
Johnson TW, Sparrow FK (1961). Fungi in oceans and estuaries. J. Cramer Pub. Weinheim.
Jones EBG (1963). Marine fungi 2.Ascomycetes and Deuteromycetes from submerged wood and drift *Spartina*. Trans. Br. Mycol. Soc. 46:135-144.
Jones EBG (2000). Marine fungi: some factors influencing biodiversity. Fung. Diver. 4:53-73.
Jones EBG, Chatmala I, Pang KL (2006). Two new genera of the Halosphaeriaceae isolated from marine habitats in Thailand: *Pseudolignincola* and *Thalespora.* Nov. Hedw. 83:219-232.
Jones EBG, Eaton RA (1969). *Savorylla lignicola* gen. et. sp. nov., from water cooling towers. Trans. Br. Mycol. Soc. 52:161-174.
Jones EBG, Klaysuban A, Pang KL (2008). Ribosomal DNA phylogeny of marine anamorphic fungi: *Cumulospora varia, Dendryphiella* species and *Orbimyces spectabilis*. Raffl. Bullet. Zool. suppl. 19:11-18.
Jones EBG, Sakayaroj J, Suetrong S, Somrithipol S, Pang KL (2009). Classification of marine ascomycota, anamorphic taxa and basidiomycota. Fung. Diver. 35:1-187.
Khan RS, Krug JC (1990). New records of the Sordariaceae from East Africa. Mycol. 81:862-869.
Khan SS, Manimohan P (2011). Diversity and abundance of marine fungi on driftwood collected from Keralas state and Lakshadweep Island. Mycosphere 2:223-229.
Khashnobish A, Shearer CA (1996). Phylogenetic relationships in some *Leptosphaeria* and *Phaeosphaeria* species. Mycol. Res. 100:1355-1363.
Koch J (1982). Some lignicolous marine fungi from Sri Lanka. Nord. J. Bot. 2:163-169.
Kohlmeyer J (1984). Tropical marine fungi. Mar. Ecol. 5:329-378.
Kohlmeyer J, Kohlmeyer E (1979). Marine Mycology. The higher fungi. Academic Press. New York.
Kohlmeyer J, Volkmann- Kohlmeyer B (1990). Revision of marine species of *Didymosphaeria* (Ascomycotina). Mycol. Res. 94:685-690.
Kohlmeyer J, Volkmann- Kohlmeyer B (1991). Illustrated key to the filamentous marine fungi. Bot. Mar. 34:1-61.
Kohlmeyer J, Volkmann- Kohlmeyer B (1995). Fungi on *Juncus roemerianus* 1. *Trichocladium medullare* sp. nov. Mycot. 53:349-353.
Kohlmeyer J, Volkmann- Kohlmeyer B (2002). Fungi on *Juncus* and *Spartina*: New marine fungi known from *Spartina.* Mycol. Res. 106:365-374.
Kumar S (1973). Marine lignicolous fungi from India. Kava. 1:73-85.
Lindsey BI (1976). Saprophytes on plant surfaces in maritime areas. In Microbiology of aerial plant surfaces. Edited by C.H. Dickinson and T.F. Preece. Academic Press, London, pp.391-399.
Lucas-Maria T, Webster J (1967). Conidial states of British species of *Leptosphaeria.* Trans. Br. Mycol. Soc. 50:85-121.
Lundqvist N (1969). *Tripterospora* (Sordariaceae s. lat., Pyrenomycetes). Botan. Not. 122:589-603.
Lundqvist N (1973). Studia fungorum firmi: I. New records of Podosporae and a new species *P. papilionacea*. Sven. Bot. Tidsk.

67:34-53.
Malloch D, Cain RF (1971). New cleistothecial Sordariaceae and a new family, Coniochaetaceae. Can.J. Bot. 49:869-880.
Meyers SP (1957). Taxonomy of marine Pyrenomycetes. Mycol. 49:475-528.
Meyers SP, Moore RT (1960). Thalassiomycetes II. New genera and species of Deuteromycetes. Amer. J. Bot. 47:345-349.
Meyers SP, Reynolds ES (1959). Growth and cellulolytic activity of lignicolous Deuteromycetes from marine localities. Can. J. Microb. 5:493-503.
Minoura K, Muroi T (1978). Some freshwater Ascomycetes from Japan. Trans. Mycol. Soc. Japan. 19:129-134.
Mirza JH, Cain RE (1969). Revision of the genus *Podospora.* Can. J. Bot. 47:1999-2048.
Mouchacca J (1973). *Podospora faurelii* sp. nov. Revue de Mycol. 38:109-113.
Muhsin TM, Abdulkadir M (1995). Ecology of fungi associated with *Phragmites australis in Iraq.* Abh. Al-Yarm. 4:31-50.
Muhsin TM, Al-Helfi MA (1981). Hyphomycetes of Iraq-The Genus *Stachybotrys.* Sydow. 34:130-134.
Muhsin TM, Booth T (1987). Fungi associated with halophytes of an inland salt marsh, Manitoba, Canada. Can. J. Bot. 65:1137-1151.
Muhsin TM, Khalaf KT (2002). Fungi from submerged wood in aquatic habitats, southern Iraq. Iraq. J. Biol. 2:455-463.
Muller E (1950). Schweizerischen Arten der Gattung *Leptosphaeria* und ihrer Verwandten. Sydow. 4:185-319.
Munk A (1957). Danish Pyrenomycetes. A preliminary flora. Dan. Bot. Arkiv. 17:1-491.
Nakagiri A, Tokura R (1987). Taxonomic studies of the genus *Corollospora* (Halosphaeriaceae . Ascomycotina) with descriptions of seven new species. Trans. Mycol. Soc. Japan. 28:413-436.
Newell SY (1976). Mangrove fungi: The succession in the mycoflora of red mangrove (*Rhizophora mangle* L.) seedlings. In: Recent Advanced in Aquatic Mycology (ed, E.B.G. Jones). Wiley, N.Y. pp.51-91.
Palm ME, Stewart EL (1982). Two new combinations in *Bactrodesmium.* Mycot. 15:319-325.
Pang K, Vrijmoed LP, Kong, Richard YC, Jones EBG (2003). *Lignincola* and *Nais*, polyphyletic genera of the Halosphaeriales (Ascomycota). Mycol. Progr. 2:29-36.
Petrak F, Ahmed S (1954). Beitrage zur pilzflora Pakistans. Sydowia, 8:158-162.
Pugh GJF, Buckley NG (1971). *Aureobasidium pullulans,* an endophyte in sycamore and other trees. Trans. Br. Mycol. Soc. 57:227-231.
Pugh GJF, Mulder JL (1971). Mycoflora associated with *Typha latifolia*. Trans. Br. Mycol. Soc. 57:419-435.
Raghukumar S (1973). Marine lignicolous fungi from India. Kava. 1: 73-85.
Raja HA, Miller AN, Shearer CA (2012). Freshwater ascomycetes : Natipusillaceae, anew family of tropical fungi, including *Natipusilla bellaspora* sp .nov. from the Perurian Amazon. Mycol. 104:569-573.
Raja HA, Oberlies NH, El-Elimat T, Miller AN, Zelski SE, Shearer CA (2013). *Lindgomyces angustiascus* (Lindgomycetaceae, Pleosporales, Dothideomycetes), anew lignicolous species from freshwater habitats in the USA. Mycosci. 54:353-361.
Raja HA, Shearer CA (2006). *Jahnula* species from north and Central America, including three new species. Mycol. 98:319-332.
Raja HA, Tonaka K, Hirayama K, Miller AN, Shearer CA (2011). Fresh water ascomycetes: two new species of *Lindgomyces* (Lindgomycetaceae, Pleosporales, Dothideomycetes) from Japan and USA. Mycol. 103:1421- 432.
Rani C, Panneerselvam A (2009). Diversity of lignicolous marine fungi recorded from Muthupet Environs, Esat coast of India. ARPN J. Agri. Biol. Sci. 4:1-3.
Reidle H, Ershad D (1977). *Alternaria salicorniae* on dry stems of *Salicornia*.Sydow. 29:168.
Sakayaroy J, Supaphon O, Jones EBG, Phongpaichit S (2011). Diversity of n higher marine fungi at Hat Khanom-Muko Thale Tai National Park, Southern Thailand . Songklanakarin. J. Sci. Technol. 33:15-22.
Schmidt l (1974). Untersuchugen uber hohere Meerespilz an der Ostseekuste de DDR. Natur Naturs. Mecklen. 12:1-148.
Schmidt l (1985). Types and type collections of new higher marine and freshwater fungi from the Baltic coast. Mycot. 24:419-421.
Schoch CL, Sung GH, Volkmann-Kohlmeyer B, Kohlmeyer J, Spatafora JW (2006). Marine fungal lineages in the Hypocreomycetidae. Mycol. Res. 110:257-263.
Shearer CA (1972). Fungi of Chesapeake Bay and its tributaries. III. The distribution of wood-inhabiting ascomycetes and fungi Imperfecti of the Patuxent River. Amer. J. Bot. 59:961-969.
Shearer CA (1989). *Aniptodera* (Halosarpheriaceae) from wood in freshwater habitats. Mycol. 81:139-146.
Shearer CA (1989). *Pseudohalonectria* (Lasiosphaeriaceae), an antagonistic genus from wood in freshwater. Can. J. Bot. 67:1944-1955.
Shearer CA (1993). The freshwater ascomycetes. Nov. Hedw. 56:1-33.
Shearer CA, Crane JL (1980). Fungi of the Chesapeake Bay and its tributaries VIII. Ascomycetes with unfurling appendages. Bot. Mar. 23:607-617.
Shearer CA, Miller M (1977). Fungi of the Chesapeak Bay and its tributaries *Aniptodera chesapeakensis* sp. nov. Mycol. 69:887-898.
Shoemaker RA (1984). Canadian and some extralimital *Leptosphaeria* species. Can. J. Bot. 62:2688-2729.
Sivanesan A, Talde UK, Tilak ST (1974). *Bitrimonospora indica gen. et.* sp. nov., a new loculoascomycete from India. Trans. Br. Mycol. Soc. 63:595-596.
Sutherland GK (1916). Additional notes on marine pyrenomycetes. Trans. Br. Mycol. Soc. 5:257-263.
Tsui CKM, Hodgkiss IJ, Hyde KD (2003). Three new species of *Aquaticola*(Ascomycetes) from submerged freshwater habitats . Nov. Hedw. 77:161-168.
Tubaki K, Ito T (1973). Fungi inhabiting in brackish water, Report of Tottori Mycological Institute Japan 10:523-529.
Udagawa S, Tsuzaki Y, Uehada H (1979). Growth damage caused by ascospore dispersal of *Arnium macrotheca* from cultivated carnation. Trans. Mycol. Soc. Japan 20:357-369.
Udagawa S, Ueda S (1985). A new species of *Podospora* from marine sediment. Mycot. 22:399-406.
Vasilyeva LN, Chernysher AV, Stevenson SL, Hyde KD (2013).*Tortulomyces thailandicus* gen. et sp .nov. and *Nitschkia siamensis* sp. nov. (Coronophorales, Ascomycota) from Northen Thailand. Mycosc. 54:110-115.
Vijaykrishna D, Jeewon R, Hyde KD (2006). Molecular taxonomy, origins and evolution of freshwater ascomycetes. Fung. Diver. 23:351-390.
Vrijmoed LLP, Hyde KD, Jones EBG (1994). Observations on mangrove fungi from Macau and Hong Kong, with the description of two new ascomycetes: *Diaporthe salsuginosa* and *Aniptodera haispora.* Mycol. Res. 98:699-704.
Watanabe T (1971). Fungi isolated from the rhizosphere soils of wetland pineapple plants in Okinawa. Trans. Mycol. Soc. Japan. 12:35-47.
Watanabe T (1994). *Cylindrocladium tenue* comb. nov. and two other *Cylindrocladium* species isolated from *Phellodendron amurense* in Japan. Mycol. 86:151-156.
Wehmeyer LE (1961). A world monograph of the genus *Pleospora* and its segregates. University of Michigan Press.
Wong MKM, Goh TK, Hodgkiss IJ, Hyde KD, Ranghoo VM, Tsui CKM, Ho WH, Wong WS, Yuen TK (1998). Role of fungi in freshwater ecosystems. Biod. Conserv. 7:1187-1206.
Yusoff M, Moss ST, Jones EBG (1994). Ascospore ultrastructure of *Pleospora gaudefroyi* Patouillard (Pleosporaceae, Loculoascomycetes, Ascomycotina). Can. J. Bot. 72:1-6.
Zainal A, Jones EBG (1984). Observations on some lignicolous marine fungi from Kuwait. Nov. Hedw. 39:569-583.
Zhang Y, Zhang XD, Fournier J, Chen J, Hyde KD (2014). *Lindgomyces griseosporus,* a new aquatic ascomycetes from Europe including new records. Mycosc. 55:43-48.

academicJournals

Vol. 6(6), pp. 488-494, June 2014
DOI: 10.5897/IJBC2014.0698
Article Number: FBD477B45315
ISSN 2141-243X

http://www.academicjournals.org/IJBC

International Journal of Biodiversity and Conservation

Full Length Research Paper

Distribution of soil types, vegetation and tree species diversity in Eastern Ghats of Srikakulam District, Andhra Pradesh, India

Srinivasa Rao D.*, Prayaga Murthy P. and Aniel Kumar O.

Department of Botany, Andhra University, Visakhapatnam-530003, Andhra Pradesh, India.

Received 23 February 2014; Accepted 28 March 2014

The present investigation was carried out on distribution of soil types, vegetation and tree species diversity in Eastern Ghats of Srikakulam District, Andhra Pradesh, India. The inventory of tree species was done in 40 different forest areas of Srikakulam district. All the sample plots are tropical and moist thorny forest and dry thorny scrub forests of Srikakulam district. The soils of the study area are compressed red soils, loamy soils, sandy loams, with varying proportions of sand and clay and it constitute 96% of the total area; red sandy soil is the common type. Tree species richness varied according to the disturbance gradient in the different stands, a total of 4744 individuals, belonging to 129 species, 96 genera among 46 families from 40 line transects were recorded in the study area. Species richness ranging from 47 to 9 in a transect was recorded in the present study. Highest species richness of sizes 47 for 65-N/14 (SW-3, 65N-14 NW-3) was seen at Haddubanghi and lowest diversity 9 was seen at Korasanda 74-B/1(SE-1).

Key words: Soil types, vegetation, tree species diversity, Srikakulam district.

INTRODUCTION

Biodiversity is used in describing the diversity of life on earth, it includes all life forms and the ecosystem of which they are part. In the developing countries, biodiversity provides the assurance of food, many raw materials such as fibre for clothing, materials for shelter, fertilizers, fuel and medicines as well as sources of work energy in the form of animal traction. In addition, biodiversity maintains balance for planetary and human survival (Jafferies, 1997). Species diversity in the tropics varies dramatically from place to place, as compared to other tropical forest types, (Holdridge 1967). Dry deciduous forests are among the most exploited and endangered ecosystems of the biosphere (Murphy and Lugo, 1986; Gentry, 1992). Studies from forest survey of India showed that an average of 54% of forest is effected by fire and 72% of forest area is subjected to grazing annually, 3.73 million hectors of forest area are burnt resulting in economic losses of approximately 440 crores (MOE,1999). Dry deciduous forests are among the most exploited and endangered ecosystems of the biosphere (Janzen, 1988; Gentry, 1992). The world wide destruction of the natural environment by population explosion, urbanization,

*Corresponding author. E-mail: srinivas.duvvada@gmail.com.

industrialization and habitat fragmentation has led to a tremendous loss of biological diversity over the past few decades. Over exploitation is to severely reduce the population sizes below the critical level and consequently the survival of the species. Phyto-sociological investigation of vegetation serves as a pre-requisite for investigating the details of the primary productivity of an ecosystem. Tree species diversity, distribution and population structure of tropical forests of Eastern Ghats are poorly understood. We analyzed the structure of tropical deciduous forests in Srikakulam district of Eastern Ghats, Andhra Pradesh, India.

MATERIALS AND METHODS

Phytosociological studies carried out during July 2008 to June 2011 covered all spectrum of vegetation. The entire stretches of Eastern Ghats of Srikakulam district are divided into 6.25 x 6.25 km grid, based on the toposheets obtained. This expertise method of classification is obtained from UAS-ATREE team Bangalore (Jagadish et al., 2003). Each grid is from a sampling unit. The inventory of tree species was done in 40 different forest areas in Srikakulam district. In each forest area consider as one belt transect, one belt transect (Plot) of 5 x 1000 m in each of the 6.25 x 6.25 km (grid) is a sampling protocol with 0.01% of sampling intensity based on random sampling method. All the plots samples are from tropical dry deciduous forests, moist deciduous forests and scrub deciduous forests of Srikakulam district. In order to revisit these plots for seasonal sampling, latitude, longitude, altitude values were recorded by using a GPS (Garmen India) and other Geo-climatic features were identified and represented in Tables 1 and 2. The specimens were identified with the help of flora of Andhra Pradesh 3 Volumes (Pullaiah et al., 1997) and local floras like Flora of Srikakulam district (Rao R.S. and Hara Sreeramulu, 1986), studies on the vegetation and flora of Vizianagaram district (Venkaiah, 1980) and (Srinivasa *et al.,* 2012) phytosociological studies on tree diversity of Srikakulam districts of Andhra Pradesh, India.

Study area

The Srikakulam district lies on the east coast of India between 18°-20' and 19°-10'N and 83°-50' and 84°-50' E. The total geographical area is 2,254 sq km. This area is bounded by Orissa State on the North and West and Bay of Bengal on the East and North east on the south and west Visakhapatnam district. These area consist of 37 mandals of different types of soils like red soils, loamy soils, sandy loams, with varying proportions of sand and clay and they constitute 96% of the total area .Red sandy soils area the common type. The climate of the region is generally tropical. The temperature in the hill areas is cooler than in plains because hills receive heavier rainfall. The mean maximum temperature is 30-40°C in April-May and the mean minimum temperature is 17.4°C in December-January during the summer season till the on-set of the South-West monsoon the heat is oppressive and the day temperature may sometimes be about 43°C. The rainfall in the region is considerably more in the hilly areas as compared to the plains.

RESULTS AND DISCUSSION

A total of 129 tree species were recorded from 40 transects; the predominant species of this region are *Mangifera indica* which is the most important species followed by *Lannea coromandelica, Wrightia tinctoria, Dalbergia paniculata, Tamarindus indica, Diospyros sylvatica, Cleistanthus collinus, Xylia xylocarpa, Chloroxylon swietenia* and *Terminalia alata* were recorded. Density, frequency, relative density, relative frequency and relative abundance values were taken for the preparation of single link cluster analysis and results revealed that the majority of the species formed similar groups (Scale 0-25) except *M. indica* and *T.s indica* which forms the dissimilar groups in the study area (Figure 1). Latitude, longitude and altitude readings of the sampling areas and different soil types like sandy, black, red, loam and with different combinations were recorded and presented in Table 1. In the present investigation, the highest altitude was recorded in Laada followed by Polla, Kothakota, Samarillu, Sara, Sunnapugedda and lowest altitude was recorded in Sakipuram. Total study area was divided into 40 grids , the number of species that occurred in each grid was recorded; 47 species in Huddubanghi (65N-14,SW-3) followed by 45 species in near Chapara (74B-1 SE-4) and Sundarada (74B-2 NE-1), 43 species at Sobha (74B-1(SW-2), 42 species at Sunnapagedda (65N-10 NE-3), 41 species at Yetugada (65 N-13 NW-2) etc were recorded in the entire forest area (Table 2). Tree species richness varied according to disturbance gradient in different, a total of 4744 individuals, belonging to 129 species, 96 genera among 46 families from 40 line transects in the study area are recorded in Tables 1 and 2). Species richness ranges from 47 to 9 in a transect, as recorded in the present study. Species richness was more 47 for 65-N/14(SW-3, 65 N/14 NW-3) at Haddubanghi and has least species diversity 9 at Korasanda 74 B/1 (SE-1). Species area and species individual accumulation curve against equal-sized sampling area in different vegetation types showed that species heterogeneity was higher in vegetation types at mid elevations while their abundance was higher in vegetation types at higher elevations (Jayakumar and Nair, 2013). In tropical rain forests, the ranges of tree species count per hectare is about 20 to maximum of 223 (Parthasarathy and Sethi, 1997), 42-47 species ha^{-1} (Kadavul and Parthasarathy, 1998). In the present investigations, maximum of 47 tree species per 1000 m (one transect) was recorded, these results agree with earlier observations of Parthasarathy and Sethi (1997) and Kadavul and Parthasarathy (1998). In the present study, species richness in study sites are also correlated with the taxonomical studies, most of the trees show random distribution and was lowwhen compared with that of tropical forests of Indian Eastern Ghats and Western Ghats, that is, the number of species in Nallamalias, 69 (Sudhakar et al., 2008), Kolli hills, 25-56 (Chittibabu and Parthasaratthy, 2000), Kalarayan hills, 42-47 (Kadavul and Parthasarathy, 1999a). Shervarayan hills, 33-50 (Kadavul and Parthasarathy, 1999 b). The sacred grooves of Kerala 14-23, (Chandra Sekhar and

Table 1. Latitude, longitude and altitude of the sampling areas and soil types of the study area.

Location	Latitude		Longitude		Altitude		Soil type
	Starting	Ending	Starting	Ending	Starting (mts)	Ending (mts)	
Akkarajupeta	18° 43'223'' N	18° 43' 672'' N	83° 39' 523''E	83° 39' 848'' E	74	186	Black
Bethalapuram	18° 58' 923'' N	18° 59' 234'' N	84° 3°' °31'' E	84° 3°' 325'' E	86	121	Red
Bharani kota	18° 17' 479'' N	18° 17' 731'' N	84° 47' 2°1'' E	84° 47' 429'' E	35	86	Red
Degalakotturu	18° 43' 422'' N	18° 43' 631'' N	84° 42' 7°2'' E	84° 42' 873 ''E	78	89	Red
Haddubangi	18° 45' 326'' N	18° 45' 683'' N	83° 42' 231'' E	83° 42' 62°'' E	116	214	Red
Hannali	18° 53' 942 ''N	18° 54' 1°3 ''N	84° 28' 834'' E	84° 28' 625 ''E	35	86	Red
Haripuram	18° 35' 832'' N	18° 35' 643'' N	83° 47 '389 '' E	83° 47' 526'' E	58	110	Red
Hussanpuram	18° 4°' 279 ''N	18° 4°' 636'' N	83° 39' 8°3'' E	83° 39' 917'' E	78	96	Red
Irupeduguda	18° 42' 33° ''N	18 ° 42' 656'' N	83° 53' 175'' E	83° 53' 268 ''E	327	346	Black
Kalandinagaram	18° 56' 826 ''N	18° 56 '798 ''N	84° 26' 511'' E	84° 25' 838'' E	71	180	Black
Karakavalasa	18° 35' °°2'' N	18° 34' 733 ''N	83° 54' 762'' E	83° 54 ' 464'' E	53	80	Black
Korasanda	18° 49' 782 ''N	18° 49' 512'' N	84 °1°' 226'' E	84° 1°' 489'' E	72	89	Red
Kothakota	18° 44' 154 ''N	18° 44' 186'' N	83°39' 27°'' E	83° 39 ' 776 ''E	504	499	Red
Laada	18° 45' 233'' N	18° 45' 372'' N	83° 45' 434'' E	83° 45' 543'' E	667	739	Red
Labba	18° 43' 586 ''N	18° 43' 759 ''N	83° 52' 943'' E	83° 52' 625'' E	125	142	Red
Machannapeta	18° 32' 4°9 ''N	18° 32' 725'' N	83° 51' 969'' E	83° 51' 834'' E	101	199	Red
Manumakonda	18° 59' 423'' N	18° 59' °15'' N	83°46' 4°5'' E	83 ° 45' 997''E	108	186	Red
Masimguda	18° 45'883'' N	18 ° 45' 7°9 ''N	83° 51' 75°'' E	83° 51' 791'' E	125	169	Silt Red
Mukundapuram	18° 44' 152'' N	18 ° 43' 756 ''N	83° 51' 712'' E	83° 51' 3°4'' E	116	214	Red
Nallarayiguda	18° 51' °73'' N	18° 51' 24°'' N	83°5°'192'' E	83 ° 5°' 614'' E	196	69	Black
Nearchepara	18° 47' 782'' N	18° 47' 435'' N	84° 14' 2°1'' E	84° 14' 535'' E	55	63	Red
Pasukudi	18° 55' 628'' N	18° 55' 182'' N	83° 49' °°9'' E	83° 48' 922'' E	89	71	Red
Peddakedari	18° 39' 47°'' N	18° 39' 642'' N	84° 13 '221 '' E	84° 13' 535'' E	47	89	Red
Peddasankili	18 ° 42' 287'' N	18 ° 42' 556'' N	83 °55' 693 ''E	83 ° 55' 949'' E	61	109	Red
Polla	18° 45' 782 ''N	18 ° 45' 323'' N	83° 41' 198'' E	83 ° 41' 71°'' E	503	487	Black
Rayala	18 ° 48' °58'' N	18 ° 47' 823'' N	83° 59' °92 ''E	83 ° 59' 457'' E	69	193	Red
S.Narsipatnam	18 ° 44' 689'' N	18° 44 '987 '' N	83° 36' 446'' E	83° 36' 223'' E	93	106	Black
Sakipuram	18° 45' 793'' N	18° 45' 932'' N	84° 2°' 556'' E	84° 2°' 937 ''E	31	49	Red
Samarillu	18 ° 43' 77° ''N	18° 43'673'' N	83 °45' °15'' E	83 ° 45' 387'' E	475	484	Loam
Sambam	18° 38' 7°3 ''N	18° 38' 171'' N	83° 5°' 975'' E	83 ° 51' 235'' E	310	287	Silt black
Samparai guda	18 ° 45' 384'' N	18° 45' 789 ''N	83° 52' 262'' E	83 ° 52' 638 ''E	89	71	Red
Sara	18° 35' 6°6'' N	18° 35' 577'' N	83° 5°' 645'' E	83 ° 49' 785 ''E	353	372	Red
Saribujjili	18° 32' °12'' N	18° 32' 619 ''N	83° 54 '597 '' E	83° 54' 444 ''E	39	174	Red
Soba	18° 47' 436'' N	18 ° 47' 6°8 ''N	84° °1' 836'' E	84° °1' 52°'' E	86	110	Red
Sundarada	18° 44' 567'' N	18° 44' 998 ''N	84° °8' 634 ''E	84 ° °8' 935 ''E	80	124	Red
Sunnapugedda	18° 45' 624'' N	18° 46' 128'' N	83° 42' 449'' E	83° 42' 419'' E	325	336	Black
Temburu	18° 37' 538'' N	18° 37 '84° ''N	84° °7' 678'' E	84° °7' 937'' E	59	98	Red
Timedisala	18° 43' 325'' N	18° 43' 712'' N	84° 18' 235'' E	84° 18' 612'' E	56	74	Red
Vampaliguda	18° 44' 979 ''N	18° 45' 1°7'' N	83° 51' 356'' E	83° 51' 479 ''E	105	186	Red
Yatuguda	18° 53' 658'' N	18° 53 '655 '' N	83° 47' 761'' E	83° 47' 264 '' E	151	331	Black

Sankar, 1998), Thirumani Kuzhi sacred groove, 38 (Parthasarathy and Karthikeyan, 1997). The predominant forest areas of the study regions of Srikakulam district in Andhra Pradesh are tropical deciduous forests (Champion and Seth, 1968). Studies in this area reveal that the most abundant families were Rubiaceae and Mimosaceae (13), Moraceae (12), Euphorbiaceae (11), Fabaceae (9), Verbenaceae (9), Rutaceae, Anacardiaceae, Combretaceae and Ebenaceae with 6 species, respectively. An obvious variation in representation of tree species and the proportion of dominant species in the forests can directly be attributed to rainfall distribution and favorable topographic conditions. The present study also support the above fact that Euphorbiaceae, Fabaceae

Table 2. Details of the study area.

Toposheet number	Grid number	Location	District	Forest Division	Forest range	Type of vegetation	Families number	Genera number	Species number
65N-10	NE-4	Akkarajupeta	Srikakulam	Srikakulam	Palakonda	DD	18	31	35
74 B-9	NW-1	Bethalapuram	Srikakulam	Srikakulam	Pathapatnam	SCRUB	21	29	34
74 B-5	NE-2	Bharanikota	Srikakulam	Srikakulam	Srikakulam	SCRUB	20	22	25
74 B-2	NE-3	Degalakotturu	Srikakulam	Srikakulam	Pathapatnam	SCRUB	11	12	12
65N-14	SW-3	Haddubangi	Srikakulam	Srikakulam	Pathapatnam	SCRUB	30	43	47
74 B-5	NE-4	Hannali	Srikakulam	Srikakulam	Srikakulam	SCRUB	20	22	25
65N-14	SW-1	Haripuram	Srikakulam	Srikakulam	Palakonda	SCRUB	23	30	33
65N-10	NE-2	Hussanpuram	Srikakulam	Srikakulam	Palakonda	SCRUB	17	21	22
65N-14	NE-1	Irupeduguda	Srikakulam	Srikakulam	Palakonda	D D	18	23	23
74B-5	NE-3	KalandiNagaram	Srikakulam	Srikakulam	Pathapatnam	DD	22	31	33
65N-14	SE-1	Karakavalasa	Srikakulam	Srikakulam	Pathapatnam	SCRUB	21	32	36
74B-1	SE-1	Korasanda	Srikakulam	Srikakulam	Pathapatnam	SCRUB	9	9	9
65N-10	NE-1	Kothakota	Srikakulam	Srikakulam	Palakonda	MD	23	34	38
65N-13	SW-2	Laada	Srikakulam	Srikakulam	Palakonda	DD	21	30	33
65N-14	NE-1	Labba	Srikakulam	Srikakulam	Palakonda	D D	20	26	26
65N-14	SW-4	Machanna peta	Srikakulam	Srikakulam	Palakonda	DD	24	33	37
65N-13	NW-1	Manumakonda	Srikakulam	Srikakulam	Palakonda	DD	11	13	14
65N-13	SW-4	Masimguda	Srikakulam	Srikakulam	Palakonda	DD	21	31	32
65N-14	NW-3	Mukundapuram	Srikakulam	Srikakulam	Pathapatnam	SCRUB	30	43	47
65N-13	SW-3	Nallarayiguda	Srikakulam	Srikakulam	Palakonda	SCRUB	20	27	33
74 B-1	SE-4	Near Chapara	Srikakulam	Srikakulam	Pathapatnam	DD	22	39	45
65N-13	NW-4	Pasukudi	Srikakulam	Srikakulam	Palakonda	SCRUB	21	27	30
74B-2	NE-4	Peddakedari	Srikakulam	Srikakulam	Pathapatnam	DD	22	33	38
65N-14	NE-3	Peddasankili	Srikakulam	Srikakulam	Palakonda	D D	18	23	23
65N-9	SE-4	Polla	Srikakulam	Srikakulam	Palakonda	D D	22	34	36
65N-13	SE-4	Rayala	Srikakulam	Srikakulam	Pathapatnam	SCRUB	21	26	28
65N-10	NW-3	S.Narsipatnam	Srikakulam	Srikakulam	Palakonda	SCRUB	15	16	18
74 B-5	SW-4	Sakipuram	Srikakulam	Srikakulam	Srikakulam	SCRUB	11	12	14
65N-14	NW-1	Samarillu	Srikakulam	Srikakulam	Palakonda	DD	24	36	39
65 N-14	NW-4	Sambam	Srikakulam	Srikakulam	Palakonda	DD	21	35	38
65N-13	SW-1	Samparai guda	Srikakulam	Srikakulam	Palakonda	SCRUB	21	27	30
65N-14	NE-2	Sara	Srikakulam	Srikakulam	Palakonda	DD	21	32	33
65N-14	SE-2	Saribujjili	Srikakulam	Srikakulam	Pathapatnam	SCRUB	11	13	14
74B-1	SW-2	Soba	Srikakulam	Srikakulam	Pathapatnam	DD	22	35	43
74B-2	NE-1	Sundarada	Srikakulam	Pathapatnam	Srikakulam	SCRUB	30	41	45
65N-10	NE-3	Sunnapugedda	Srikakulam	Srikakulam	Palakonda	DD	25	38	42
74B-2	NE-2	Temburu	Srikakulam	Srikakulam	Srikakulam	SCRUB	24	35	39
74B-6	NW-1	Timedisala	Srikakulam	Srikakulam	Pathapatnam	SCRUB	23	32	37
65N-14	NW-3	Vampaliguda	Srikakulam	Srikakulam	Palakonda	DD	22	32	32
65N-13	NW-2	Yetuguda	Srikakulam	Srikakulam	Palakonda	DD	23	37	41

and Rubiaceae are dominant families in almost all type of forests as reported by Sudhakar et al. (2008) and Kadavul and Parthasarathy (1999a). In moist deciduous forests, the species composition comprise a mixture of both moist and dry elements; indicating transitional zone. In this forest, *Anogeissus latifolia, Garuga pinnata, Haldinia cordifolia, Lagerstroemia parviflora, Lannea coromandelica, Mangifera indica, Protium serratum, Pterocarpus marsupium, Syzygium cuminii, Terminalia alata* and *Xylia xylocarpa* are predominant species, some tree species like *Chloroxylon swietenia, Diospyros sylvatica, Schleichera oleosa*, etc. grow luxuriantly reaching more than 15-20 m in height. In dry deciduous forests, *Bombax ceiba, Bridelia retusa, Dalbergia paniculata, Gmelina arborea, Mitragyna parvifolia, Sterculia urens, Strychnos nux-vomica, Terminalia alata,*

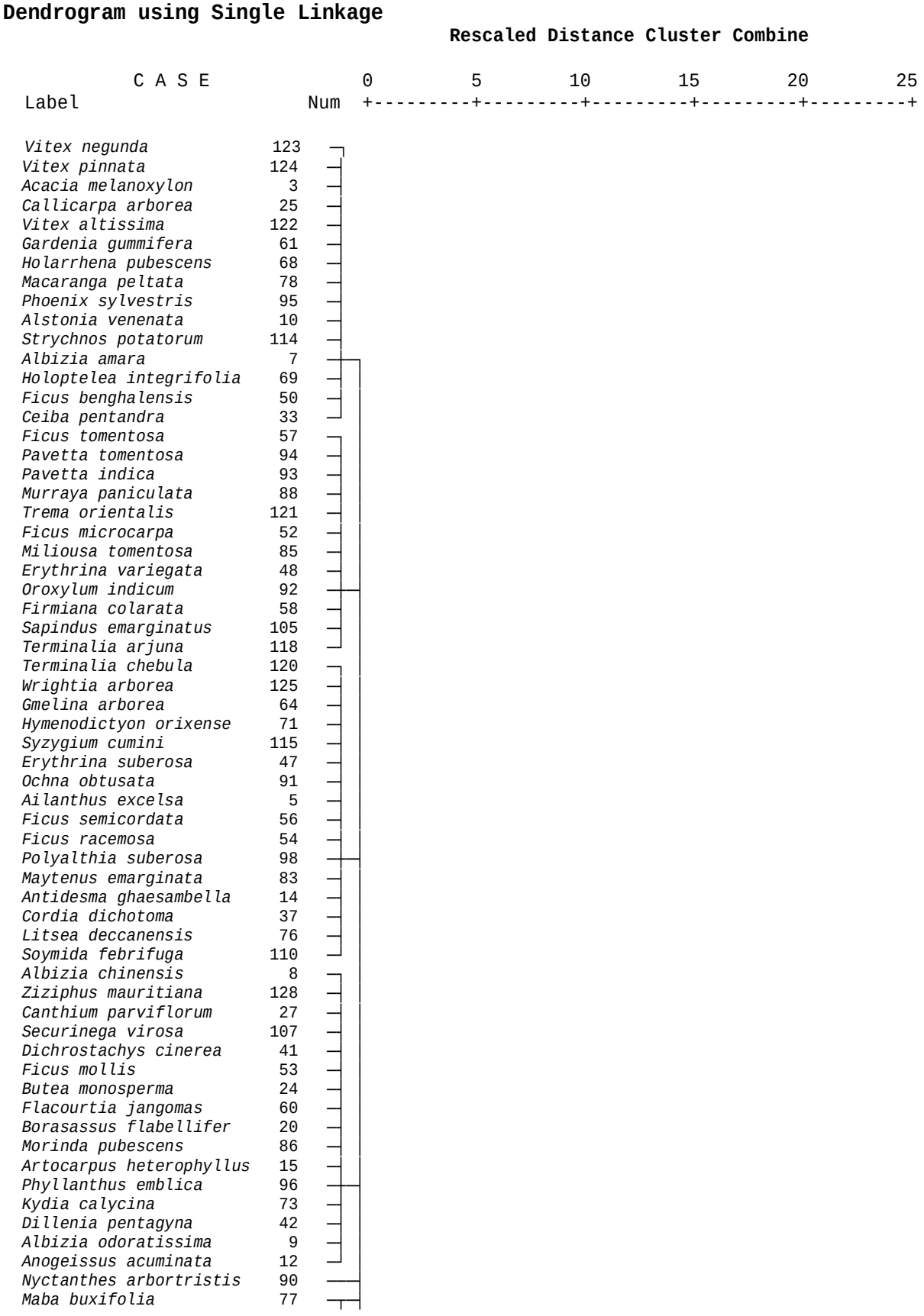


Figure 1. Hierarchical cluster analysis.

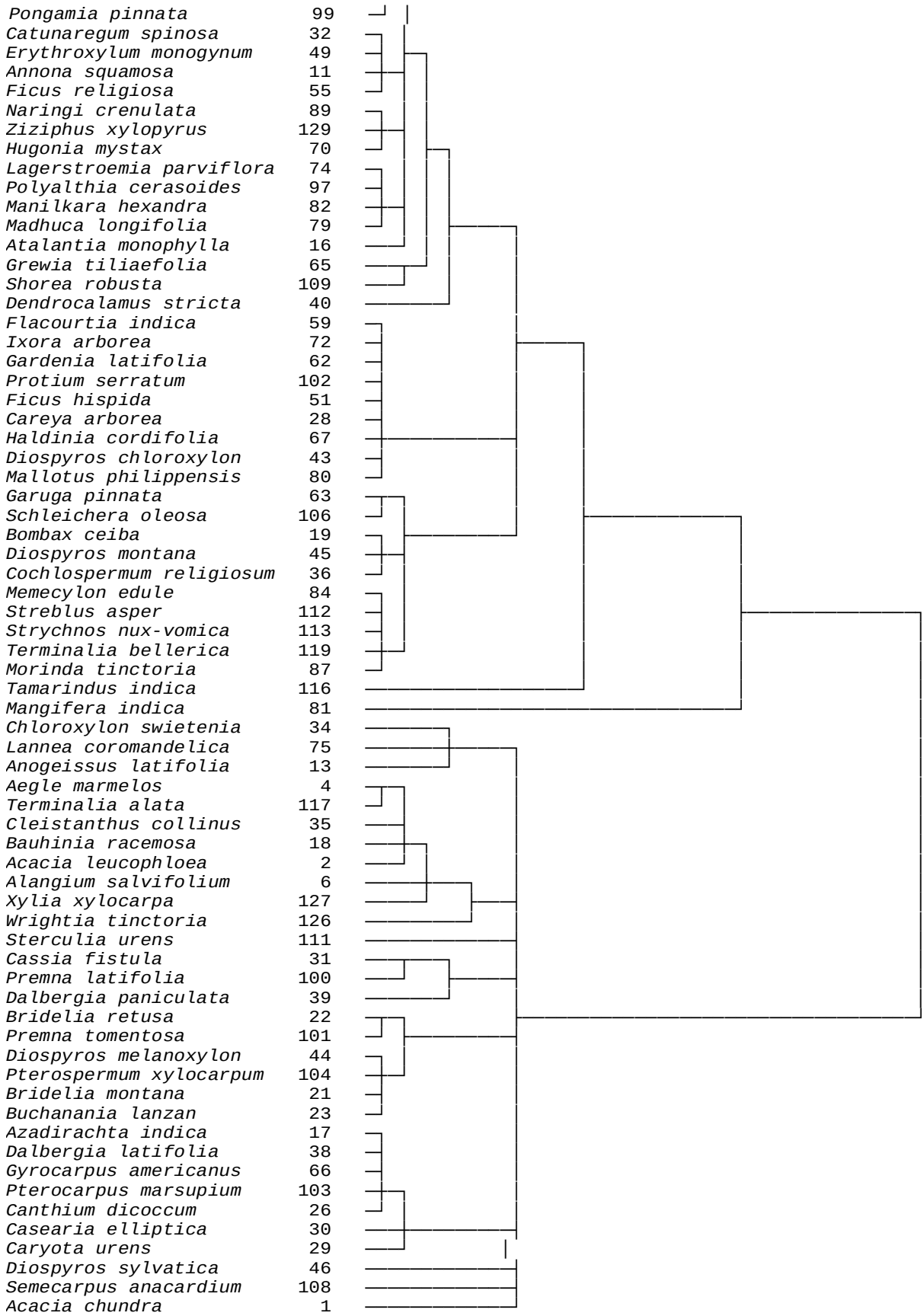


Figure 1 Contd.

Terminalia bellerica and *Xylia xylocarpa* are predominant tree species found in red sandy loam soils. Scrub deciduous forest is represented by *Diospyros melanoxylon, Diospyros chloroxylon, Strychnos potatorum, Zizyphus mauritiana, Wrightia tinctoria, Manilkara hexandra, Erythroxylum monogynum* species were reported because soils are characterized by red sandy types in study area. Studies revealed the presence of 4744 individuals in Srikakulam district when compared with Nallamalias, Seshachalam and Nigidi hills (1541-3ha^{-1}) (Sudhakara et al., 2008), Similipal Biosphere reserve (4819-8ha^{-1}) Sudhakara et al., 2007), Boudh district, Orissa (2364-4 ha^{-1}) (Sahu et al.,2007), inland and coastal tropical dry evergreen forest of Peninsular India (4676-10 ha^{-1}(Mani and Parthasarathy, 2006), the total individuals reported in the study area is less when compared with various sites in Eastern Ghats, revealing the degradation of forests due to cut stumps; ecological factors like forest fires are predominant hence we can conclude that some parts of the study area were under frequent fires, which is degradation to the vegetation.

Conclusion

The findings of the current study suggested that the species richness ranges from 47-9 in a transect. Species richness was more than 47 for 65N/14 (SW-3, 65N/14 NW-3) at Haddubanghi and has least species diversity of 9 at Korasanda 74B/1 (SE-1). Further research should focus on the diversity of the tree species from nearby Srikakulam forest area which will be beneficial to the ecological and taxonomical status of the plant species.

Conflict of Interests

The author(s) have not declared any conflict of interests.

ACKNOWLEDGEMENT

The authors are grateful to Department of Biotechnology (DBT) for giving financial assistance and also thank divisional forest officers, forest range officers, guards and beat officers for their help during the field survey.

REFERENCES

Champion HG, Seth SK (1968). Revised Survey of Forest Types of India. Oxford & IBH Publishers. New Delhi.

Chandra skhara UM, Sankar S (1998). Ecology and management of sacred groves in Kerala, India. For. Ecol. Manage, 112:165-177.

Chitti Babu CV, Parthasarathy N (2000). Attenuated tree species diversityin human-impacted tropical evergreen forest sites at Kolli-hills, Estern Ghats, India. Biod. Cons. 9:1493-1519.

Gentry AH (1992). Tropical forest biodiversity: Distributional patterns and their conservational significance. *Oikos*, 63:19-28.

Holdridge LR (1967). Life Zone Ecology. San Jose, Costa Rica: Tropical Science Center.

Janzen DH (1988). Tropical Dry Forests: The Most Endangered Major Tropical Ecosystem. Wilson, E.O. (Ed), Blod. Nat. Acad. Press, Washington DC., pp. 130-137.

Jayakumar R, Nair KKN (2013). Species diversity and Tree regeneration patterns in Tropical Forests of the Western Ghats, India ISRN Ecology Volume 2013(2013). http://dx.doi.org/10.1155/2013/890862

Jefferies M (1997). Biodiversity and Conservation London & NewYark

Kadavul K, Parthasarathy N (1998). Biodiversity of woody species and conservation of tropical semi-evergreen forest in the Kalrayan hills of Eastern Ghats, India.

Kadavul K, Parthasarathy N (1999a). Plant biodiversity and conservation of tropical semi-evergreen forest in the Shervarayan hills of Eastern Ghats, India, Biodiv. Cons. 8:421-439.

Kadavul K, Parthasarathy N (1999b). Structure and composition of woody species in tropical semi-evergreen forest of Kalrayan hills, Eastern Ghats, India. Trop. Ecol. 40:247-260.

Mani S, Parthasarathy N (2006). Tree diversity and stand structure in inland and Coastal tropical dry evergreen forests of Peninsular India. *Current Science,* 90(9):1238-1246.

Murphy PG, Lugo AE (1986). Ecology of tropical dry forests. Ann. Rev. Ecol. Syst. 17:67-88.

Parthasarathy N, Karthikeyan R (1997a). Biodiversity and population density of woody species in a tropical evergreen forest in Courtallum reserve forest, Western Ghats, India. Trop. Ecol. 38:297-306.

Parthasarathy N, Sethi P (1997). Tree and liana species diversity and population structure in a tropical dry evergreen forest in South India. Trop. Ecol. 38:19-30.

Pullaiah T (1997). *Flora of Andhra Pradesh,* Vol.3. Scientific Publishers, New Delhi.

Pullaiah T, Ali Moulali D (1997). *Flora of Andhra Pradesh,* Vol. 2. Scientific Publishers Jodhpur.

Pullaiah T, Chennaiah E (1997). Flora of Andhra Pradesh. Vol.1. Scientific Publishers Jodhpur.

Rao RS, Hara Sreeramulu S (1986). *The Flora of Srikakulam District*. Andhra Pradesh, India, Meerut

Sahu SC, Dhal NK, Sudhakar Reddy, Chiranjibi Pattanaik C, Brahman M (2007). Phytosociological Study of Tropical Dry Deciduous Forest of Boudh District, Orissa, India. Res. J. For. 1(2):66-72.

Srinivasa Rao D, Prayaga Murty P, Aniel Kumar O Srinivasa Rao D *et. al* (2012). Phytosociological studies on Tree diversity of Srikakulam and Vizianagaram Districts of Andhra Pradesh, India Ph.D. Thesis, Andhra University.

Sudhakar Reddy C, Shilpa Babar, Giriraj A, Reddy KN, Thulsi Rao (2008). Structure and Floristic Composition of Tree Diversity in Tropical Dry Deciduous Forest of Eastern Ghats, Southern Andhra Pradesh, India. Asian J. Sci. Res. 1:57-64.

Sudhakar Reddy P, Murthy MSR, Sudhakar S (2008). Quantitative structure and composition of tropical forests of Mudumalai Wildlife Sanctuary, Western Ghats, India. Taiwania, 53(2):150-156.

Venkaiah M (1980). Studies on the vegetation and flora of Vizianagaram district, Ph.D. Thesis, Andhra University, Visakhapatnam.

International Journal of Biodiversity and Conservation

Related Journals Published by Academic Journals

- *Journal of Ecology and the Natural Environment*
- *African Journal of Environmental Science and Technology*
- *African Journal of Biology and Environment*
- *Journal of Environmental Microbiology and Microbial Ecology*
- *International Journal of Marine Biology and Ecology*

academicJournals