A Study on Diversity and Conservation of Lichens in Shettihalli Wildlife Sanctuary, Western Ghats, India

Final Technical Report

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Vinayaka K.S

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2) **The title of the project**: A Study on Diversity and Conservation of Lichens in Shettihalli Wildlife Sanctuary, Western Ghats, India

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4) **Location of the project**: Shettihalli WLS, Western Ghats

i) **Name of the town or village**: Shimoga, Karnataka
Country: India

ii) **The latitude and longitude of this location**: 13°51'11.66"N 75°22'51.06"E

5a) **Two line summary of the project aims**:
This project mainly focus on the diversity, distribution, ecology and the conservation of lichen in the Shettihalli WLS.

5b) **Description of the project**:

Lichens are a unique group of plants that consist of two different groups of organism's fungi and algae, living in a close symbiotic association. The study of Lichens is quite neglected throughout India. The total number of species that are recorded in India is quite small in comparison with world average. The rapid destruction of habitats, increasing atmospheric pollution, over-exploitation, grazing, frequent forest fires and other anthropogenic disturbances are responsible for a decrease in population of lichens worldwide, so also in the Western Ghats. In the rich ecosystem of Western Ghats of Karnataka, there is a lack of knowledge regarding lichen diversity, ecology and their distribution patterns. Therefore, inventerization is valuable to understand the status of lichens in the Western Ghats. This project proposal is aimed at the systematic survey, identification and documentation of the lichen flora followed by studies on distribution and conservation of lichens in different habitats type of Shettihalli Wildlife Sanctuary in Western Ghats. For the present investigation we will follow the random sampling techniques by placing transects in different vegetation types. The identification of lichens by studying their

morphology, anatomy, colour tests and also by using TLC techniques. The TLC for identification of secondary metabolites will be performed by Culberson (1972) and Walker and James (1980), finally we confirm the specimen by referring the available standard floras Awasthi (2000). Ecological studies on lichens will be carried out by using standard ecological parameters.

INTRODUCTION

Lichens are the complex organisms involve a symbiotic relationship between phycobionts and a mycobiont and have attracted considerable attention because they perceived position in the ladder of evolution to land plants. They are often observed as the most significant bio indicators. They are universal in distribution and grow at an average rate of 1-5 mm per annum. India's plant resources are well known with rich diversity distributed in different ecological habitats. Therefore it is important to understand the ecology & distribution of this diversity. The status of the lichen communities are severely threatened due to manmade activity that includes deforestation, denudation and over exploitation of forest produce. Present investigations have been undertaken to inventorying the lower life forms like lichens. The present study aims at the detailed analysis of lichen diversity and distribution pattern and their conservation in the Shettihalli Wildlife Sanctuary located at central Western Ghats of South India.

Earlier works in India and Western Ghats

The highlights of the research scenario of lichens in India are being studied as follows. Linnaeus mentioned the occurrence of *Lichen fuciformis* (L.) DC. (*Roccella montagnei* Bél.) from India. In his masterpiece '*Species Plantarum*' *Eric Acharius* (1810, 1814) the father of Lichenology describes lichens in his classical works '*Lichenographia Universalis*' and '*Synopsis Methodica Lichenum*'. There after the Indian lichens have been described by various lichenologists. Bélanger (1838) was the first person to study the lichens of Western Ghats, who described a total of 40 taxa from Pondicherry and Coromandel Coast of which six were new to science. Jatta (1902, 1905, 1911), Smith (1926), Choisy (1931), Santesson (1952), Moreau and Mme (1952) were the important European lichenologists who studied lichens of Western Ghats. Awasthi (1965) and Singh (1964) compiled lichens described by various researchers till 1960s including that of Western Ghats. Awasthi had published so many monographs and new discoveries form Western Ghats. Awasthi (1970, 1973, 1975, 1976, 1982, 1983, 1985, 1986, 1987, 1991 and 1998), Awasthi and Akhtar (1977 and 1979), Awasthi and Singh (1971, 1972 a&b, 1973, 1975 and 1980), Awasthi and

Upreti (1980, 1981 and 1985). In the mean time Ajay Singh worked on pyrenocarpous lichens (1969, 1970 a and b, 1971, 1973, 1978, 1980), Upreti (1985, 1987, 1988, 1991, 1994, 1997 and 1998), Patwardha, Makhija and Kulkarni worked on microlichens of Western Ghats in Agharkar Research Institute, Pune (1977, 1979, 1980). Recently Upreti and Sanjeeva Nayaka worked a lot on lichen diversity (1995, 2001, 2002, 2004, and 2008).

The crustose lichen dominates in Western Ghats represented by 618 taxa followed by foliose and fruticose lichens, which are represented by 269 and 62 taxa respectively. The highest number 253 species of endemic lichens (26.7%) are present of which, 210 are found only in Western Ghats while remaining 43 occur in other licheno-geographical region. Lichens are self supporting symbiotic associations of a fungus and one or several algal or cyanobacterial components. Lichens and lichen products have been used in traditional medicines for centuries and still hold considerable interest as alternative treatments in various parts of the world. In various systems of traditional medicine worldwide, including the Indian system of medicine, these lichen species are said to effectively cure dyspepsia, bleeding piles, bronchitis, scabies, stomach disorders, and many disorders of blood and heart (Saklani and Upreti, 1992; Lal and Upreti, 1995; Negi and Kareem, 1996). They produce characteristic secondary metabolites that are unique with respect to those of higher plants (Lawrey, 1986). Lichen metabolites exert a wide variety of biological actions including antibiotic, antimycobacterial, antiviral, anti-inflammatory, analgesic, antipyretic, antiproliferative and cytotoxic effects (Muller, 2002). The utility of lichens is due of range of secondary compounds produced by them. A wide range of secondary metabolites of lichens were characterized. According to their chemical structure, most lichen substances are phenolic compounds, dibenzofuranes, Usnic acids, depsidones, depsones, lactones, quinines and pulvunic acid derivatives (Boustie and Grube, 2005). About 320 tons of lichens are annually utilized for different purpose in Nepal and adjoining regions of India (Moxham, 1986). Approximately 250 metric tons of lichens are brought in annually from Uttaranchal hill and 800 metric tons from other regions of India, including Himachal Pradesh, Sikkim and Assam of this, about 50-80 metric tons are exported (Shah, 1997). A survey on lichen samples available in local markets of Maharashtra, Karnataka and Tamil Nadu found 11 species of lichens (Upreti *et al.,* 2005). Quantitative studies have not been carried out in Western Ghats to assess the amount of lichen collected, utilized, exported and its effect on particular lichen species or whole lichen diversity of the region.

Objectives

- To survey and collect the lichens from different localities of the Shettihalli WLS, Karnataka
- To quantify the existing levels of lichen diversity in Wildlife sanctuary
- To study the lichen distribution pattern in different substrates
- To conduct ecological studies utilizing different ecological parameters
- To assess the threat to the lichen community and propose the conservation measures to the lichens of the Wildlife Sanctuary
- To document the information on uses of lichens by different ethnic groups.

MATERIALS AND METHODS

Study area

Wildlife sanctuary is situated 10 km from the Shimoga district head quarter. These forests harbour an impressive assemblage of wildlife form the large and imposing elephant and tiger to lesser known fauna like birds, lizards, snakes, frogs, insects and more. This Sanctuary is important both from the point of its unique location and biological diversity. It is very compact and unique in its formation.

Location of the Sanctuary

It spread over parts of three taluks of Shimoga district they are Shimoga, Hosanagara and Thirthahalli covering 369.60 sq km. It covers dry deciduous, moist deciduous and semi evergreen forests of Sahydri hills of Western Ghats. The important tree species were teak, Sandal, Lagstromia, Pteriocarpus etc. and important wild animals are Elephant, Bison, spotted deer, tiger, panther also rich in reptiles and avifauna population. Hilly area forms the catchment basin for Kummudwathi river has enumerated herbs, shrubs, ferns and grasses some of which are yet to be surveyed and listed. Tourist attraction spots Elephant camp of Sacrebyle, Mandagadde bird sanctuary, tiger and lion safari Thyavarekoppa Wildlife Sanctuary is situated in the Malnad region of Karnataka, north from Ayanur along the southern portion of Ayanur Hosanagara road up to Ripenpet running from east to west. West from Rippenpet along eastern portion of Rippenpet- Thirthahalli road including Kuugudthi state forest up to Konandur runs north to south. South from Konandur along the boundaries of Rippenpet, Hanagere and Thirhahalli range forest area up to Manda. Extending between

13°40′ and 14°05′ N and longitudes 75°10′ and 75°35′ E latitude the area comprises the forests of Western Ghats and its fringes (Fig.1).

Sl. No.	Location	Latitude	Longitude	Altitude (in Meters)
1	Arasalu	14° 00'.18″	75° 19'.27″	667
2	Anupinakatte	13° 56'.15″	75° 29'.46″	642
3	Ayanur	14° 00'.28″	75° 26'.04″	675
4	Belur	13° 53'.08″	75° 21'.26″	816
5	Chitrashettihalli	13° 51'.27″	75° 27'.59″	679
6	Gajanur	13° 50'.26″	75° 30'.35″	612
7	Hanagere	13° 46'.19″	75° 19'.25″	648
8	Harakere	13° 53'.34″	75° 33'.37″	585
9	Harohitalu	13° 58'.06″	75° 20'.30″	713
10	Hosahalli	13° 52'.47″	75° 33'.30″	589
11	Kaggudi	13° 51'.44″	75° 15'.17″	715
12	Kammachi	13° 53'.35″	75° 15'.21″	688
13	Karakunji	13° 51'.02″	75° 22'.04″	880
14	Mallur	13° 43'.55″	75° 20.02″	665
15	Mandagadee	13° 43'.49″	75° 27'.38″	614
16	Mandaghatta	14° 01'.19″	75° 20'.11″	703
17	Puradal	13° 54'.45″	75° 28'.52″	705
18	Sakkarebylu	13° 48'.46″	75° 30'.28″	609
19	Shettihalli	13° 52'.25″	75° 25'.31″	781
20	Tavarekoppa	13° 58'.27″	75° 75'.29″	695

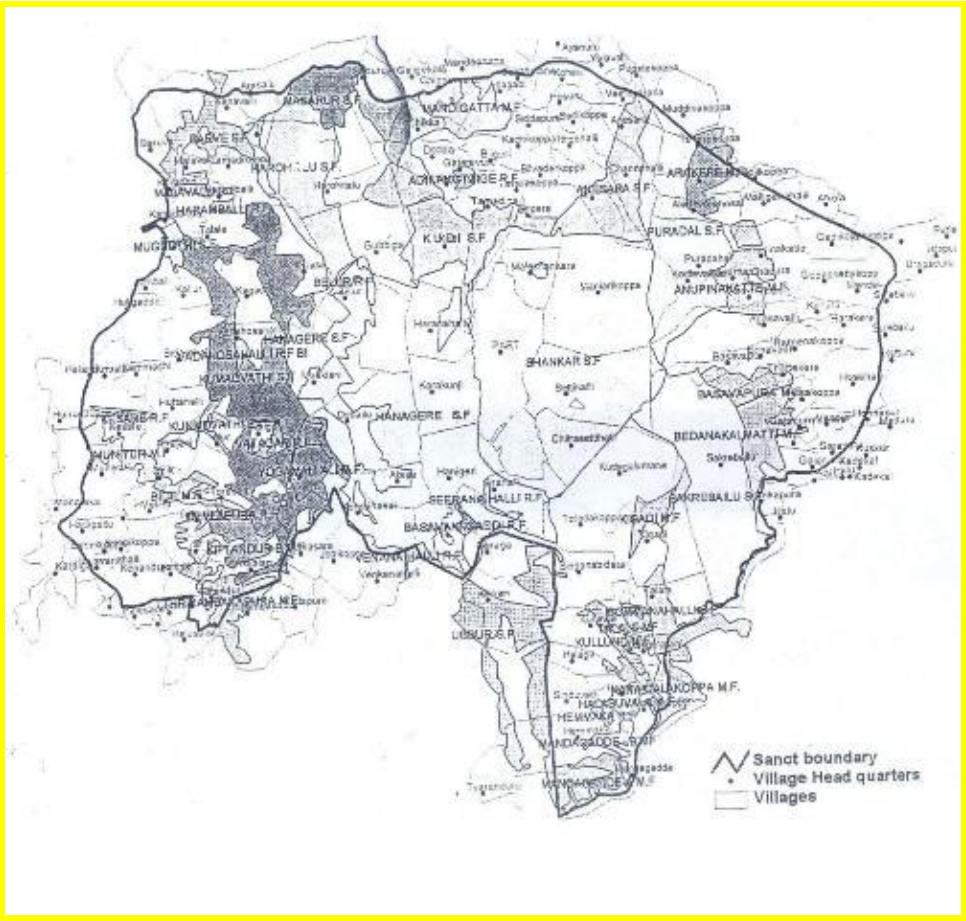

Fig 1. Map showing study areas

History of the Sanctuary

The forest covering under the Shettihalli sanctuary was previously under the control of the primarily state of Mysore. The Mysore kingdom had been showing keen enters in the protection of forest. For better management of forest and wildlife. These forest areas were declared protected forest during 1905-1920. Since then these forest have been managed in a systematic was for fulfilling the needs of people. During 1960-1965, Linganamaki reservoir was constructed in Sharavathi river valley. This led to Submersions of many villages. The people affected by this Hydro-electric project were shifted from the projected area and allowed to settle in the present Shettihalli sanctuary. In this way more settlements of rehabilitated villages came into entrance in the sanctuary leading to encroachments and cleaning of forests. After the declaration of Shettihalli wildlife sanctuary with govt. Order No AEd FwL 74 dated 23-11-1974. Protection and development activities towards better management of wildlife had been estimated by the wildlife wing of the forest department with the handling over of the sanctuary to the wildlife wing by the territorial wing these activities have been further intensified.

Topography

Area is plain to understudying with a few pockets consisting of very steep and undulating terrains and hillocks. The area consists of perennial Nalas and a number of small streams. The forest is rich with mostly deciduous to semi-evergreen species and dense undergrowth the highest peak is Shankaragudda (1031m). Underlying geological formulation is of gneissic origin. The Ghats forests are principally of gneissic composition interspersed occasionally by quartzite, masochist and granite. In Shankaragudda region the rock forms a lanticular mass of laterite covers ferruginous and magniferous rocks intimately associated with bands of limestone, dolomite, manganese and a few quartz in south west Gajanur border shows scrubby forests. Manganese ore are also found in some parts of this sanctuary. Loamy towards hills, valleys middle slopes and lower slopes. Yunga and Kumaduathi are the main rivers flowing in the sanctuary and they are perennial. Tributes are seasonal. Irrigation water tanks Gajanur, Hailde, Barehalla, and Segehalla waterholes are spread all over the sanctuary

Climatic factors

It is having tropical climate. Rainfall sanctuary receives rain fall from south west monsoon and exposed to showers staring from April to May and September to October. Heavy to very heavy showers in June, July and August the erosion action of the torrential rains can be noticed in open areas on hill rocks or forest clearings due to deforestry activities. In areas benefit of vegetation the top soil gets washed away resulting in open blanks incapable of supporting any vegetations. The average rainfall of the area is 2000mm some time northeast monsoon is received during November. The two monsoon winds that blow over the parks are the south westerly wind between June and September. The North Easterly wind between September to December. Dry wet and cold seasons are recognized. Cold season from December to February and hot season from March to May. Climate is humid and wet with average minimum and maximum temperature being about 15°c to 38°c respectively. Water supply is adequate during rainy season but not so during summer small check dams to streams in the catchment may help in solving the problem.

Vegetation

The biotic factors and edifice variation have played a dominant role in determining the nature of the forests growing in the sanctuary. The eastern portion of the sanctuary comprises dry deciduous forests and it gradually changing to moist deciduous type as wet goes towards the west. The following two types of forests are mainly found in the sanctuary.

1. The southern tropical dry deciduous type

This type is seeing in Puradal, Anesara, Sacrebyle, Shakaraghudda, Kudi and parts of Hanagere state forests. The top canopy consists of *Terminalia tomentosa*. *T. Belarica*, *Gmelina arborea, Tectona grandis, Anogessus latifolia* and *Lagerstroemia lanceolata.* second canopy *Wrightia tictoria, Zizphus rugos, Cassia fistula, Emblica officanalies, Randia dumatorium* and Bamboos. Ground floor grass patches ferns and there eupatorium has come up in many open patches.

2. Southern tropical moist deciduous type

See on the western side of the sanctuary i.e part of Hanagere SF, Kumaduti SF, Mugudthi SF etc. *Bambusa arundianacea* and *Dendrocalamus strictus* occurs throughout the area *Terminalia tomentosa, Tectona grandis, Lagerstromiea, Xylia, Grewia* and Kydia.

3. Semi evergreen types

See in parts of Hanagere SF and Kumadvathi SF. The important trees were Dipterocarpus, *Hopea, Schlichaers, Xylia, Michelia* and Bambus species.

Timber harvesting

The sanctuary has got a number of good timber species viz. Teak, Rosewood, *Lagasromia, Terminalia, Artocurpus,* etc. At present timber harvesting is extremely limited and is mainly conservation oriented. Previously these areas were worked by clear felling and for raising of Teak and Eucalyptes plantation now only dead and fallen trees near side's demarcation line fire lines and inspection plats were removed. Plantations were raised by Mysore paper mills, Karnataka forest development corporation and also departmentally. Thinning is teak plantations were taken during 1995-1996 to 1999-2000 for better management of protected area. Thinning of remaining teak plantation is prepared. It has been boosted natural regeneration and improvement the habitat substantially.

Tourism and tourism development

Shettihalli WLS has got mainly attractions including panoramic view since spots dense forest, diversified flora and fauna. The Mandagadde bird sanctuary, elephant camp at Sacarebyle are some of the most important spots located in the sanctuary. The sanctuary offers ample opportunities to tourists. Specially bird watchers, nature lovers and adventurous trekkers. Keeping this in view it is necessary to develop within the sanctuary in a limited and

modest scale. Basic infrastructures to provide facilities for the tourists. Here the approach will have to be environment friendly and all activities aimed at development of tourism will have to be implemented in conserve with nature surroundings.

Fire play very critical role in the habitat management of the main forestry that has cleared the deep rooted of forest cover is the occurrence of fire which has almost become an annual feature the grazer's fire wood and NTFP collectors and tourists tend to set fire deliberately or by accident. Smugglers and poachers also set fire to the forest fire to divert the attention to field staff due to forests fire the natural regenerators is lost and the forests are deprived at rich humas wild animals practically harbourers are the worst suffers for worst of green foliages while innumerable soil fauna will be destroyed which play a very important role in maintaining the ecologically balance by decomposing and releasing energy from dead plant and animals hence preventive and fire control measures have been given much importance in the habitat development considering all these aspects the following suggestions.

Surveying and Sampling

Survey was done regularly in the different habitats and particularly sensitive to timing and location of observation. Survey was carried out by using transect method. Each transects measuring 50x10 m laid in different forest locations of study site. A total of 20 transects were laid in different types of vegetations. In each transect all substrates were thoroughly searched for the occurrence of lichens. All the stems surveyed for lichens on the basis of presence or absence of lichens up to the breast height. The altitude was recorded with a hand-held GPS, (Garmin etrex, USA) relative humidity (RH) (digital thermo-hygrometer, 288CTH Euro lab), temperature, microhabitat data were recorded in each transect. The pH of the tree bark was estimated (Kricke, 2000) and also recorded the bark texture they grouped as rough, smooth and moderate. The host tree species were identified with the help of published floras (Gamble 2000, Neginhal, 2004).

Collection and Identification

The representative lichen specimens were collected along with their substratum irrespectively of their growth form. Only the lichens that were very loosely attached to substratum was scraped out and collected. The corticolous lichens growing on tree trunk at reachable height usually collected and canopy lichens found fallen on ground was collected. Superficial bark was removed with the help of chisel by knife in order to avoid damage to the trees. In case of saxicolous lichens smaller pieces of the rock substrate was collected.

The collected specimens were made to dry under sun. During winter and rainy season, the material was dried with the help of a hot air oven. The lichen herbarium packets were made with a thick white or brown handmade acid free paper. The herbarium packet dimension was maintained at 13.5 x 11.5 cm. The process of identification of lichens was done on the basis of the morphology, anatomy and chemical test (Colour and TLC test). All lichen specimens were preserved in the herbarium of the Department of Applied Botany, Kuvempu University, Shankaraghatta, Shimoga, Karnataka.

Colour tests

Colour test has been performed by chemical reagents by applying it on thallus and medulla resulting change in colour. A positive change is denoted by a positive (+) symbol followed by the colour produced and no change in colour is denote by a negative (-) symbol. The chemical reagents used are as follows.

K test (Potassium): 10-25% aqueous solution of potassium hydroxide, applied to cortex, medulla and part of apothecium.

C test (Calcium hypochlorite): A freshly prepared aqueous solution of calcium hypochlorite or bleaching powder or modern commercial bleaching fluid containing active chlorine. It is prepared by dissolving calcium hypochlorite in distilled water in 2% ratio.

KC test (Potassium and Calcium hypochlorite): At a particular spot of thallus, potassium hydroxide is applied first and immediately followed by calcium hypochlorite.

Pd test (Paraphenylenediamine): Solution of paraphenylenediamine is prepared in ethanol in a small quantity for the use of a day. It is unstable and cannot be used for the next day. A more stable solution called Steiner's PD is prepared by dissolving 1 gm of paraphenylenediamine and 10 gm of sodium sulphite in 100 ml of distilled water with 1 ml of a liquid detergent. This reagent keeps well for about a month.

I test (Iodide): 2-5 gm of iodine is dissolved in water with 0.5 gm of potassium iodide. The reagent keeps well for several days and is to be renewed when colour fades.

Other colour tests: A dilute aqueous solution of nitric acid and an aqueous solution of ferric chloride are some time used for identification of *Melanelia* and *Buellia* species. The spot tests can be done on any part of the thallus but younger parts give better results. Colour test is done to a small fragment of the desired lichen thallus part or thallus or ascocarp. A definite colour comes showing the presence of any lichenic acid.

Chromatography

Earlier in chromatography, paper was used for spotting the lichen substances. Use of paper has been substituted by thin layer chromatographic plates. Glass sheets either used in the laboratory by coating with silica gel or pre-coated aluminium plates were purchased from the market for this purpose. Chromatographic plates were prepared in the laboratory by taking ordinary smooth glass plates of 20x20 cm size. They were thoroughly leaned by keeping them in glass tank, dried in a low temperature in (30-35º C) oven. About 30gm of silica gel G is made into a paste in 80 ml of distil water in a conical flask and stirred vigorously. About 9-10 ml of the silica gel paste has set the plates were dried at 35º C and left at that temperature till they are needed for chromatographic purposes.

Generally *Parmelinella wallichiana* is used for atranorin and salazinic acid and *Usnea baileyi* or *Pyxine phillipina* for Norstictic acid have been used when the silica gel plate has been fully spotted with the desired number of extracts (Divakar and Upreti, 2005). It is placed in a jar, internally lined by filter paper and containing a specific solvent, level of which is about 1 cm below the spotting places of the lichen extracts. The solvent gradually use up in the silica gel coating and is allowed to rise up to 14 cm mark. The plates is taken out dried in air and observed under ultra violet lamp any fluorescence observed is marked or noted. For spotting the different fatty acid, distilled water is sprayed on the plates and spots are marked with pencil. A 10% aqueous solution of sulphur was sprayed over the coated surface of the plate then placed in an oven at a temperature of 110º C for about 5-15 minutes or until the differently coloured spots at different levels become clear. The plate then taken out, allowed to cool. Colour of the spots their position for each extract were noted and again observed under ultra violet light and finally R_f value calculated. Identification was made of the spots by comparison with the charts published by Culberson & Christenson (1970); Culberson (1972); Walker & James (1980) and White & James (1985).

The R_f value is calculated by using the formula

$$R_f \text{ value} = \frac{\text{Distance travelled by lichen substance}}{\text{Distance travelled by solvent}}$$

The following three solvent systems usually used for the chromatography are:

Solvent A (BDA) - Benzene 90ml: 1, 4 dioxine 25ml: acetic acid 4ml.

Solvent B (HEF) - Hexane130ml: di-ethyl-ether 100ml: Formic acid 20 ml.

Solvent C (TA) - Toluene 85ml: acetic acid 15 ml.

The most common solvent system used for chromatography is:

TOA- Toluene 180 ml: dioxiane 60 ml: acetic acid 8ml.

Data analysis and interpretation

The data recorded from the every field survey was maintained in the data sheet, after that they were enter into Microsoft excel data sheets. Finally, the data used to calculate the density, frequency and abundance, the relative frequency, relative density index were calculated by referring Cottam and Curtis (1956) and Importance Value (IVI) was calculated by summing the relative values for species (Species Importance Value- SIV) (Ganesh *et al*., 1996). The alpha diversity Shannon-Weiner diversity index (H') was calculated according to the formula $H' = \Sigma$ pi x lnpi to asses species richness and Simpson diversity index (D') was calculated according to the formula $D' = 1/\Sigma (pi)^2$ (Pielou, 1975). Beta diversity was calculated by Sorenson's similarity coefficient (Cs) was calculated according to the formula $Cs = 2j/ (a+b)$ (Magurran, 1988).

Frequency and relative frequency is calculated by

$$\text{Frequency} = \frac{\text{No. of transect in which species studied}}{\text{Total no. of transect studied}}$$

$$\text{Relative frequency} = \frac{\text{Frequency of a species}}{\text{Total frequency of all species}} \times 100$$

Density and relative density is calculated by

$$\text{Density} = \frac{\text{Total no. of individual species}}{\text{Total no. of transect studied}}$$

$$\text{Relative Density} = \frac{\text{Total no. of individuals of the species in all the transect}}{\text{Total no. of individuals of all the species in all the transect}} \times 100$$

Abundance is calculated by

$$\text{Relative dominance} = \frac{\text{Total no. of basal area of all the species in the transect}}{\text{Total basal area at the species in all the transect}}$$

Importance Value Index (IVI) is calculated by

IVI = Relative frequency + Relative density + Relative dominance

Ethno-botanical study of lichen

Periodic ethno botanical surveys were carried out in some remote villages of central Western Ghats of Karnataka. Before undertaking the field work, a rapport was established with the chief or well-known persons of the village as the selection of informants from an important aspect of ethno-botanical study in the field. During the study, ethno-botanical information on lichen species was collected through interviews with tribes and knowledgeable elder people of the study area using the modified questionnaires of Sinha (1996). During the study collected the information about age, sex, personal information,

collection of crude drug, method of formulation preparation, mode of dosage, etc. The collected information was confirmed by discussion with practitioners and knowledgeable persons of the study area. Data were cross checked and also compared with the already existing literature on ethno-botany (Upreti, 2000; Lal, 1990). Voucher specimens were photographed and collected, for the preparation of herbarium and numbered. Herbarium specimens were deposit at the Department of Botany, Kuvempu University, Karnataka.

RESULTS AND DISCUSSION

A total of 1809 individuals belongs to 111 species were encountered in all the surveyed localities of Shettihalli Wildlife Sanctuary, Karnataka. These were belongs to 41 genera placed among 22 families. The cortcolious lichens were found luxuriantly as they represented by 101 species, followed by nine saxicolous and one terricolous lichen species.

Among the eight lichenogeographic regions of India, Western Ghats secures first position in terms of higher lichen diversity with 800 species and occupy second in terms of endemism with 140 species (Singh and Sinha, 1997). Out of the species known so far from Indian subcontinent, about 50 percent belongs to the crustose forms most of which have not been collected at second time. A great majority of these are corticolous Pyrenocarpus, Graphidaceous and Thelotremataceous lichens which are widely distributed in the tropical countries (Awasthi, 1977) distributional. The lichen flora shows strong correlation with the climatic conditions and arboreal elements of the flora of the regions. Present study also show the same results that the distribution of the lichens are mutually varies with climatic variation in the deciduous forest regions had maximum number of macrolichens and shola forests showed more number of microlichens. Similar studies conducted in Garwal Himalaya region reported 85 species from 15 genera and 13 families (Negi, 2000). Our study results in rich diversity with a total of 111 species from 41 genera. Tropical dry evergreen forest of Guindy National Park (GNP) Chenni, showed distribution of 31 lichens from 26 genera (Balaji and Hariharan, 2004). Shettihalli Wildlife Sanctuary has different types of forests where, these are also harbouring high species richness of lichens. The forest of Shettihalli Wildlife Sanctuary dominated by moist and dry deciduous forests as these types of vegetation supports the growth of macrolichens. The important macrolichen species growing in these forests such as *Dirinaria, Pyxine, Lecanora, Heterodermia, Parmotrema, Usnea, Ramalina* and several other species (Negi and Gadgil, 1996; Balaji and Hariharan, 2004). Macrolichens were documented in similar habitats of costal Brazial (Marcelli, 1991) and in South Eastern Australia (Pharo and Beattie, 1997).

The members of families Parmeliaceae (21), Physciaceae (22), Graphidaceae (16) and Thelotremataceae (10) exhibited the maximum diversity in the area. The families like Roccellaceae, Strigulaceae, Lobariaceae and Biotraceae represented by single species each. The genera *Parmotrema tinctorum* (Parmeliaceae) is represented by 44 individuals with IVI of 4.18 with relative density of 2.4 & relative frequency of 1.75 followed by *Heterodermia dissecta, Parmotrema reticulatum, Parmotrema cristiferum* with IVI of 3.96, 3.52, 3.41 respectively. The *Pertusaria limbata* and *Pertusaria leucosora* showing lower IVI of 0.93 and 0.99 respectively (**Table. 1**).

Saxicolous lichens were representing by *Dirinaria applanata, Lecanora* sp., *Parmotrema grayanum, Leptogium* sp. Some macrolichen species showed specificity to a particular host tree which could be attributed to various ecological conditions. *Rocella montagnei* were specific to host *Mangifera indica*. *Usnea stigmatoides* were corticolous species reported from deciduous forests only. *Coccocarpia erythroxyli* and *Heterodermia speciosa* hosted by *Litsea floribunda* and some *Usnea* species were supported by branches of *Tectona grandis* and *Syzygium* species. *Pyxine coccifera* and *Dirinaria applanata* were resistant to pollutions and they grow in almost open areas and scrubby forests and dry regions of study area. *Parmotrema tinctorum, P. cristiferum, Parmelinella wallichiana, Haterodermia diademata, H. dissecta* and *Leptogium burnetiae* were commonly distributed in deciduous and semi-evergreen forests. *Parmotrema tinctorum* and *Leptogium burnetiae* were most common genera growing both in deciduous and semi-evergreen forests. *Parmotrema reticulatum and Ramalina pacifica, Ramalina conduplicans and Usnea galbinifera* were rich in deciduous forests and semi-evergreen forests were dominated by Thelotremataceae and Graphidaceaeous members.

Negi (2000) found that over 64% species of lichens occurred on woody component in two landscapes of Chopta-Tungnath and Nanda Devi Biosphere reserve in India. The highest diversity in evergreen forests is associated with an increase in crustose species and decrease in foliose species. In the dry deciduous forests, diversity in crustose species varies with fire and forest history, but foliose diversity is lowest in regularly burnt plots variation with tree species (Wolsely & Hudson, 1997b).

The corticolous taxa in the seasonal tropics of Southeast Asia can be used to indicate, areas of long ecological continuity, areas of high biodiversity and areas where degradation of forests is occurring (Wolsely & Hudson, 1997a). Shettihalli Wildlife Sanctuary represents more number of corticolous lichens (90.9%) and also results that the higher altitude contains

less percentage of lichens when compare to lower altitudes. A total of 76 species of macrolichens were recorded from 16 transects in Nanda Devi Biosphere and suggest that deforestation, fuel wood collection, grazing and forest fires are major threat to the lichen diversity in the region (Negi & Gadgil, 1996). Wolsely and Hudsonn (1991) found that above 1500m contains more number of macrolichen species. Pinakiyo *et al.* (2008) studied the diversity and distribution of lichen in relation to altitude where they reported 177 species from 71 genera. They also reported the corticolous lichen (133 species) was dominated in nature in relation with that present study recorded 111 species from 41 genera.

Association of the algal partner in the distribution of lichen is *Trebouxia* is the dominant algal partner followed by *Nostoc* and *Trentephollia*. The evergreen forests were supported large number of cyano-lichens than deciduous forests (**Table 2**).

Table 2. Association of some algal species in macrolichens identified in the Shettihalli WLS

Sl. No.	Lichen genus	Algal partner
1	*Bulbothrix*	*Trebouxia*
2	*Caloplaca*	*Pseudotrebouxia*
3	*Canoparmelia*	*Trebouxia*
4	*Candelaria*	*Trebouxia*
5	*Cladonia*	*Pseudotrebouxia*
6	*Coccocarpia*	*Scytonema*
7	*Collema*	*Nostoc*
8	*Dirinaria*	*Trentepholia*
9	*Endocarpon*	*Trebouxia*
10	*Everniastrum*	*Trebouxia*
11	*Evernia*	*Trebouxia*
12	*Flavopunctelia*	*Trebouxia*
13	*Heterodermia*	*Trebouxia*
14	*Hypotrachyna*	*Trebouxia*
15	*Lepraria*	*Stichococcus*
16	*Lecanora*	*Trebouxia*
17	*Leptogium*	*Nostoc*
18	*Lobaria*	*Myrmecia*
19	*Nephroma*	*Nostoc*
20	*Parmeliella*	*Scytonema*
21	*Parmotrema*	*Trebouxia*
22	*Peltigera*	*Coccomyxa*
23	*Peltula*	*Nostoc*
24	*Physciea*	*Trebouxia*
25	*Phaeophyscia*	*Trebouxia*
26	*Physma*	*Nostoc*
27	*Pseudocyphellaria*	*Chlorella*

28	*Pyxine*	*Nostoc*
29	*Ramalina*	*Trebouxia*
30	*Rimelia*	*Trebouxia*
31	*Roccella*	*Trentepholia*
32	*Sticta*	*Myrmecia*
33	*Usnea*	*Trebouxia*
34	*Xantoria*	*Trebouxia*

Alpha diversity index, i.e., shannon-winner and simpson index was found to be 4.65 and 0.99 respectively. The lichen species are varies with altitude in the study area. In lower altitude i.e., 585 m 20 species of lichens were and in higher altitude i.e., 880 m six species of lichens were reported. The higher altitudes contributing more number of fruticose lichens and in lower altitude more number of foliose and crustose lichens were found.

Microhabitat preference of particular lichens is responsible for their differential distribution. However, in spite of their abundance in the vegetation only a small fraction of trees actually harboured lichens on trunk. Many of these trees have somewhat smooth, medium and rough bark textured. We studied the texture, pH and moisture content of barks of different host trees in different forest types. In case of altitudinal gradient, the higher altitude support for more number of fruticose lichens. The data showed in Ayanur represented by *Usnea* and *Ramalina* species. In low land areas most of foliose species like *Parmotrema*, *Heterodermia*, *Leptogium* and *Pyxine* species were present. Parmeliaceae and Physciaceae were either attach to the upper canopy branches or on rocks with sufficient canopy openings that regions will receives more lights and wind in this region.

Table 3. Showing bark texture, moisture, pH and number of colonies on different host tree species distribution in Shettihalli WLS

Sl. No.	**Host tree**	**Bark texture**	**Bark moisture**	**Bark pH**	**No of colonies**	**Dominant genera**
1	*Anogeissus latifolia* (Roxb. ex DC.) Wall. ex Guill. and Perr.	Smooth	17.4	4.9	2	-
2	*Bauhinia malabarica* Roxb.	Moderate	21.2	5.5	9	*Parmotrema*
3	*Butea monosperma* (Lam.) Taub.	Moderate	12.9	5.5	5	-
4	*Canthium* sp.	Moderate	12	6.8	12	-
5	*Cassia siamea* Lamk.	Rough	11.5	5.5	11	*Heterodermia*
6	*Cassine glauca* (Rotth.) Kuntze	Rough	9.6	4.8	14	*Parmotrema* and *Pyxine*
7	*Dalbergia latifolia*	Moderate	21	5.6	9	*Parmotrema*

	Roxb.					
8	*Delonix regia* (Bojer ex Hook.) Raf.	Moderate	18	5.4	8	*Parmotrema*
9	*Diospyros melanoxylon* Roxb.	Very Rough	14.6	6.4	17	*Pyxine* and *Dirinaria*
10	*Diospyros montana* Roxb.	Rough	11.6	6.5	12	*Pyxine*
11	*Ficus racemosa* L.	Moderate	23.7	5.7	14	*Parmotrema*
12	*Grewia tiliifolia* Vahl.	Rough	9.8	6.1	10	*Pyxine*
13	*Lagerstroemia microcarpa* Wight	Smooth	18.3	4.9	4	-
14	*Maduca latifolia* (Roxb.) Macbride	Moderate	16.4	6.4	9	-
15	*Polyalthia cerasoides* (Roxb.) Bedd.	Rough	13.4	6.3	15	*Parmotrema*
16	*Polyalthia longifolia* (Sonn.) Thw.	Moderate	17.3	6.1	13	*Drineria*
17	*Pterocarpus marsupium* Roxb.	Rough	20.2	6.2	12	-
18	*Radermachera xylocarpa* (Roxb.) K. Schum.	Moderate	15.3	5.7	11	-
19	*Randia dumetorum* (Retz.) Poir.	Moderate	15.4	6.1	19	*Parmotrema*
20	*Santalum album* L.	Moderate	17	5.9	12	*Ramalina*
21	*Schefflera oleosa* (Lour.) Oken.	Rough	12.8	5.6	10	-
22	*Syzygium cumini* (L.) Skeel	Rough	16.2	4.8	7	*Parmotrema*
23	*Tectona grandis* L. f.	Rough	12.8	4.6	6	*Hetrodremia*
24	*Terminalia bellirica* (Gaertn.) Roxb.	Moderate	14.7	4.8	6	-
25	*Terminalia paniculata* Roth	Rough	13.8	5.6	15	*Parnotrema*
26	*Terminalia tomentosa* (Roxb. ex DC.) Wight and Arn.	Very Rough	15	5.8	8	-
27	*Wrighitia tomentosa* Roem. And Sch.	Moderate	15.3	5.1	12	-
28	*Xylia xylocarpa* (Roxb.) Taub.	Rough	14.3	5.1	10	*Ramalina*
29	*Ziziphus xylopyrus* (Retz.) Willd.	Moderate	9.8	5.8	9	*Bulbothrix*
30	*Ziziphus rugosa* Lam.	Rough	18.5	5.1	11	*Heterodermia*

Epiphytic lichens change hosts in different climatic regimes, even when the same host trees are present. Hale (1955) also reported similar host specificity pattern of lichens in the upland forests of Wisconsin. Macro and micro climatic conditions and bark characteristics of trees vary depending on the forest types and altitude. Although, light factor

is important in the distribution of lichens, the availability of light is low inside evergreen forests when compare to deciduous forests. Bruiteg (1993) observed that frequency, duration and form of precipitation are important for the distribution of lichens. In addition to precipitation, mist and fog may cause humid condition even where precipitation is low.

Most of the practitioners collect lichen from forest when they necessary. Among the interviewed people, 70 percent people used *Parmotrema* species for medicine and 20 percent people used *Usnea* for medicinal use and only 10 percent people used *Ramalina* and *Heterodermia* species for medicine. The lichen thalli are used for different purposes by local community in different parts of the sanctuary.

The ethno-lichenological survey of Shettihalli WLS of Karnataka revealed that local people are using eight species of macrolichens belonging to five genera in the region. These lichens were locally used as spices and for treating wounds. The tribal communities like Kudabi, Golias are used these lichens mixed with some plants as adjective in local medicines. Among eight species, 50 percent were used as food, 40 percent used as medicine and 10 percent used for other purposes. Among the reported species, most of them belong to Parmeliaceae (75%) it was followed by Physciaceae and Ramalinaceae. The foliose covers 62.5% and fruticose covers 37.5%. Most of them were corticolous (87.5%) and remaining were saxicolous (12.5%). The descriptions of the species which were collected and identified are as follows.

Species name	Family	Voucher specimen	Description	Chemical present in TLC	Uses
Everniastrrum cirrhatum (Fr.) Hale	Parmeliaceae	KU01035	Lichen thallus in foliose lobes gray to green in colour, linear, dichotomously branched, cilia is simple marginal, rhizines absent, lower surface brown to black in colour	Salazinic acid	They are used with the mixtures of *Parmotrema* species. It is used as spice and flavouring agent for meat and vegetables.
Usnea pseudosinensis Asahina	Parmeliaceae	KU00673	Thallus fruticose, filaments very long thread like cylindrical, branched apically directed, colour greenish pale.	Usnic acid and barbatic acids	It is used for the treatment of children suffering from common ills
Usnea	Parmeliaceae	KU00341	Thallus fruticose,	Usnic	These species are

galbinifera Asahina			filaments very long thread like cylindrical, branched apically directed, colour greenish pale	acid and barbatic acids	mixed with *Parmotrema* and used as flavouring agent and also used to make pillows in Mysore regions. It locally used as locket for those suffering from some phobias.
Heterodermia diademata (Taylor) Awasthi	Physciaceae	KU00043	Foliose, lichen Thallus corticolous, branched, lower side pale brown colour lacking isidia and soredia.	Zeorin	They are mixed with *Parmotrema* and used as flavouring agent for meat and other food items. This species is used to heal cuts and wounds and used as plaster to protect from infection.
Parmotrema tinctorum (Nyl.) Hale	Parmeliaceae	KU00173	Lichen with foliose membranaceous to coriaceous, saxicolous, larger thallus with upper dark grey in colour.	Lecanoric acid and orsellinic	These species are mixed with calcium carbonate to prepare a paste and this is being used for healing cuts and wounds
Ramalina pacifica	Ramalinaceae	KU00131	Lichen thallus fruticose, corticolous gray in colour. It is pendulous bushy in nature, photobiotic is green alga, chondroid tissue is present		Used as spices and curry powder also used in flavouring agent for meat and vegetables
Parmotrema reticulate Tayl	Parmeliaceae	KU00161	Lichen thallus foliose wide lanciniatelobate, ashy grey upper side reticulately white maculate and minutely cracked, soralia globular along the margin, separate or confluent, underside	Salazinic and consalazinic acids	Local people used this as spices and flavouring agent in food to increase the taste and fragrance of meat, pulse and special dishes

			rhizinate		
Parmotrema cristiferum	Parmeliaceae	KU00187	Lichen thallus foliose with narrow lanciniate, grey colour, upper side is smooth, esorediate		It is used is masala ingredient and it is mixed with jaggary and other plant products and prepare and leha used in increase the energy. It is also used against ringworms.

Threats and Conservation of lichens

The factors responsible for loss of lichen diversity in the study area include change in the ecological conditions, forest cover, loss of habitat and increase of the urban and industrial areas. The anthropogenic activities in hilly regions such as 'Jhoom' cultivation, agriculture, mineral extraction, tourism, hydroelectric and road building projects are leading to the rapid deterioration of lichen rich habitats. Over exploitation and selective removal of economically important lichens by local people. The raw material required for the various uses of lichens is quite high. The weight of lichens were very little when dry, thus a vast bulk of these plants are harvested for utilization. In the global scenario of evidences show that many lichen rich sites are facing threats mainly associated with human activities such as air pollution, habitat destruction, unsystematic forestry practices, forest fire, tourism, over exploitation and illegal collections.

RECOMMENDATION FOR CONSERVATION OF LICHENS IN THE SANCTUARY

Shettihalli Wildlife Sanctuary is a magnificent piece of beautiful and valuable forest tract of the Western Ghats. Because of its unique location and comparatively lesser biotic interference, the sanctuary has been able to retain much of its pristine and diverse vegetation and Wildlife. It is therefore absolutely essential to conserve these valuable resources sustainable and to initiate appropriate steps to further develop these resources. The sanctuary must also be put to multiple use viz., educative, recreate, scientific etc., for the benefit of mankind. As the sanctuary is in its preliminary stage of development, establishment of systematic and scientific management of habitat, conservation of flora and the wildlife are

not going in full pledge. So there is an urgent need to protect and manage the fragile ecosystem of the sanctuary. On the basis of a very brief span of our inventories we have recorded certain lacunae in the management of the sanctuary. Following are the some of the threats causing damage to the sanctuary that we have observed and possible remedial measures for the same.

1. Fire Protection

One of the primary factors that have adversely affected the status of habitat management and biodiversity conservation in the sanctuary is the occurrence of fire, which has almost become an annual affair. Due to forest fires, which are sometimes deliberate, the natural regeneration either lost of retarded and the forest floor is deprived of rich humus, so essential for growth of lichen. Fires cause irreparable damage to the microfauna besides affecting the normal life, growth, propagation and movement of many larger animals and birds. Hence, fire control measures have to be given top priority in the habitat development and lichen conservation in the sanctuary. The Fire Protection Force and fire extinguishing vehicles could be deployed at the major fire prone areas of the sanctuary well in advance during fire risk days.

2. Management of Natural Deciduous forests

In the past, the forests were heavily logged under a prescription for removal of dead and fallen trees. In combination with intensive selection felling carried out even earlier, all such forestry operations have considerably degraded the old forest growth structure, eliminated very large old trees and lianas and caused major gaps in which invasive exotics like *Chromolaena odorata* and *Lantana camara* are thriving out of the cost of local species. These alien species are suppressing the regeneration of original species and without the natural enemies these plants are occupying the ground of the native species. Hence, these invasive species should be controlled. The old trees more support for rich lichen diversity, hence removal of these trees causing threat to lichen diversity in the sanctuary. So it should be recommended to avoid the cutting of trees and removing the invasive species.

4. Illegal grazing

There are large numbers of livestock belonging to the villagers residing in and around the sanctuary. Apart from grazing with in the villages the cattle enter even to the core zones of the sanctuary. The trampling effects of their foot in many areas, this will effect on the some terricolous lichen diversity in the sanctuary.

5. Collection of wood

Most of the nearby villagers depend on the sanctuary for their daily need of the fuel wood. Many a time this human intervention has been the major factor behind the fire outburst and collection of fire wood indirectly affects on the lichen diversity and propagation. Therefore collection of firewood should be strictly controlled. Efforts should be made by the forest department to reduce the dependence of the people of adjacent village people by providing LPG gas stoves to many families as alternative source of fuel.

6. Smuggling and Poaching or Hunting

Shettihalli Sanctuary is the natural habitat of some of the prized timber species such as *Tectona grandis, Dalbergia latifolia, Lagerstroemia microcarpa, Santalum album* and others. This has made a very active smuggling lobby in the Gajanur and Hanagere range limits, especially across the back water of the Tunga River. Even though, the authentic data on these act not obtained many press releases have covered the devastating smuggling lobby along the Shimoga district. The trenches were digged all along the sanctuary still depth seems to be insufficient or reduced due to overlaying plant or soil debris. Therefore the depth of trenches should be increased and debris to be cleared. These smuggling of tree indirectly cause the loss of epiphytic lichen diversity in the sanctuary. In some parts of the sanctuary the lichens was harvested illegally and commercially exporting in local markets but now a day it is prohibited.

7. Research Program Support

For developing any management strategies research is a strong tool used worldwide. It's with many sanctuaries and other protected areas within Karnataka and India that co-operation and support by the staff of concerned office bearers are very much lacking in field. Same with the Shettihalli Sanctuary also. Except for the certain areas, co-operation of the staff of the Forest Department is such a neglected that several times our entry in to the forest was either denied or delayed. This type of attitude of the staff is certainly a draw back to the effective field research. It is necessary to give importance to research programs.

All the above said management actions can be summarized as following recommendations for strategy to effective conserve the biodiversity of lichens.

- Forests fire should be prevented at any cost.

- Old growth forest structure to be restored effectively by controlling invasion of allied species.
- Alternative fuel sources should be made available to the villagers to stop the collection of firewood.
- Prohibit illegal harvesting of lichens for commercial purposes.
- The feasibility of the developmental projects affecting a protected area balance should be reviewed before it is implemented.
- The researchers should be invited and encouraged to work on lower plants like lichens.
- Establish some long-term plot for bio monitoring study of lichens.
- Many a time meteorological data is insufficient in the areas of the districts, hence it is suggested that meteorological stations can be established for having regular weather data.
- Establish some lichen gardens in the rich diversity areas.
- Conservation should be attributing to rock, soil or wood specialist taxa of macrolichens.

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Annexure : Check list of lichens

Sl. No.	Species	Family	Growth forms	Substrate
MACROLICHENS				
1.	*Bulbothrix isidiza* (Nyl.)Hale	Parmeliaceae	F	Cor
2.	*Coccocarpia palmicala* (Spreng.) Arvidss. & D.J. Galioway	Coccocarpiaceae	F	Cor
3.	*C.erythoxyli* (Spreng.) Swinsc.& Krog	Coccocarpiaceae	F	Cor/Sax
4.	*Dirinaria applanata* (Fee) D.D.Awasthi	Physciaceae	F	Sax
5.	*D. confluens* (Fr.) D.D. Awasthi	Physciaceae	F	Cor
6.	*Heterodermia albidiflava* (Kurok.) D.D. Awasthi	Physciaceae	F	Cor
7.	*H. angustiloba* (Mull. Arg.) D.D. Awasthi	Physciaceae	F	Cor
8.	*H. dendritica* (Pers.)	Physciaceae	F	Cor
9.	*H. diademata* (Taylor) D.D.Awasthi	Physciaceae	F	Cor/Sax
10.	*H. dissecta* (Kurok.) D.D.Awasthi	Physciaceae	F	Cor
11.	*H. firmula* (Nyl.) Trevis.	Physciaceae	F	Ter/Sax
12.	*H. incana* (H.Magn.) D.D.Awasthi	Physciaceae	F	Cor
13.	*H. microphylla* (Kurok.) Skorepa	Physciaceae	F	Sax
14.	*H. obscurata* (Nyl.)Trevis	Physciaceae	F	Cor
15.	*H. pseudospeciosa* (Kurok.) W.Culb	Physciaceae	F	Cor/Sax
16.	*H. speciosa* (Wulf.) Trevis.	Physciaceae	F	Cor
17.	*H. tremulans* (Mull.Arg.) W.Culb.	Physciaceae	F	Cor
18.	*Hypotrachyna awasthii* Hale & Patwardhan	Parmeliaceae	F	Cor
19.	*H. crenata* (Kurok.) Hale	Parmeliaceae	F	Cor
20.	*Lecanora indica* Zahibr.	Lecanoraceae	F	Sax
21.	*Leptogium burnetiae* Dodge	Collemataceae	F	Cor/Sax
22.	*L. chloromelum* (Sw.) Nyl.	Collemataceae	F	Cor
23.	*L. denticulatum* Nyl.	Collemataceae	F	Cor
24.	*L. ulvaceum* (Pers.) Vain.	Collemataceae	F	Cor
25.	*Myelochroa xantholepis* (Mont.& Bosch) Elix&Hale	Parmeliaceae	F	Cor/Sax
26.	*Parmelinella wallichiana* (Taylor) Elix and Hale	Parmeliaceae	F	Cor/Sax
27.	*Parmotrema austrosinese* (Zahlbr.) Hale	Parmeliaceae	F	Cor
28.	*P. cristiferum* (Taylor) Hale	Parmeliaceae	F	Cor

29	*P. hababianum* (Gyeln.)Hale	Parmeliaceae	F	Cor
30	*P. praesorediosum* (Nyl.) Hale	Parmeliaceae	F	Sax
31	*P. reticulatum* (Taylor) Choisy	Parmeliaceae	F	Cor
32	*P. stuppeum* (Taylor) Hale	Parmeliaceae	F	Cor/Sax
33	*P. tinctorum* (Despr.exNyl.) Hale	Parmeliaceae	F	Cor/Sax
34	*P. vartakii* Hale	Parmeliaceae	F	Cor
35	*Phaeophyscia orbicularis* (Neck.) Moberg	Physciaceae	F	Cor
36	*Phyllospsora corallina* (Eschw.) Mull.Arg.	Biotoraceae	F	Cor
37	*Pseudocyphellaria aurata* (Sm.ex Ach.) Vain.	Lobariaceae	F	Cor
38	*Pyxine coccifera* (Fee) Nyl.	Physciaceae	F	Cor
39	*P. cocoes* (Sw.) Nyl.	Physciaceae	F	Cor
40	*P. minuta* Vain.	Physciaceae	F	Sax
41	*P. reticulata* Vain.	Physciaceae	F	Cor
42	*P. sorediata* Ach.	Physciaceae	F	Cor
43	*Ramalina conduplicans* Vain.	Ramalinaceae	Fr	Cor
44	*R. hossei* Vain.	Ramalinaceae	Fr	Cor
45	*R. hossei var.* divericeta H.Magn. & G.Awasthi	Ramalinaceae	Fr	Cor
46	*R. pacifica* Asahina	Ramalinaceae	Fr	Cor
47	*R. pollinaria* (Westr.) Ach.	Ramalinaceae	Fr	Cor
48	*Rocella montagnei* Bel.em. D.D.Awasthi	Roccellaceae	Fr	Cor
49	*Teloschistes flavicans* (Sw.) Norm.	Teloschistaceae	Fr	Cor
50	*Usnea* sp.	Parmeliaceae	Fr	Cor
51	*U. aciculifera* Vain.	Parmeliaceae	Fr	Cor
52	*U. eumitrioides* Mot.	Parmeliaceae	Fr	Cor
53	*U. galbinifera* Asahina.	Parmeliaceae	Fr	Cor
54	*U. pictoids* G. Awasthi	Parmeliaceae	Fr	Cor
55	*U. stigmatoides* G.Awasthi	Parmeliaceae	Fr	Cor
56	*U. vegae* Mot.	Parmeliaceae	Fr	Cor
57	*Xanthoparmelia congensis* (B.Stein)Hale	Parmeliaceae	F	Sax
MICROLICHENS				
58	*Arthonia medusula* (Pers.)Nyl.	Arthoniaceae	C	Cor
59	*A. reniformis* (Pers.)Ach.	Arthoniaceae	C	Cor
60	*Brigantiaea leucoxantha* (Sprengel) R.Sant.	Brigantiaceae	C	Sax
61	*B. nigra* Awasthi & Srivastava	Brigantiaceae	C	Cor
62	*Buellia inornata* Nyl.	Physciaceae	C	Cor
63	*B.Punctata* (hoffm.) Massal.	Physciaceae	C	Cor
64	*Caloplaca flavorubescens* (Huda.) Laundon	Teloschistaceae	C	Sax
65	*Cryptothecia culbersonae* Patw. & Makh.	Arthoniaceae	C	Cor
66	*Diploschistes megalosporus*	Thelotremataceae	C	Cor

	Lumbsch			
67	*Graphina fissofurcata* (Leighton) Mull.Arg.	Graphidaceae	C	Cor
68	*G. junghunii* (Mont &v.d.Bosh) Mull. Arg.	Graphidaceae	C	Cor
69	*G. nylanderi* Patw. & Kulk.	Graphidaceae	C	Cor
70	*Graphis aphanes* Mont & v.d.Bosch	Graphidaceae	C	Cor
71	*G .celata* Stirton	Graphidaceae	C	Cor
72	*G. congesta* (Fee) Mull. Arg.	Graphidaceae	C	Cor
73	*G. dumastii* (Fee) Sprengel	Graphidaceae	C	Cor
74	*G. grammatis* Fee	Graphidaceae	C	Cor
75	*G. longiramea* Mull. Arg.	Graphidaceae	C	Cor
76	*G. pyrrhocheiloides* Zahlbr.	Graphidaceae	C	Cor
77	*G. scripta* (L.) Ach. Gr.	Graphidaceae	C	Cor
78	*Laurera aurantiaca* Makhija & Patw.	Trypetheliaceae	C	Cor
79	*Letrouitia domingensis* (Pers.) Half. & Bellem.	Letrouitiaceae	C	Cor
80	*Megalospora* sp. (Fee)Sipman	Megalosporaceae	C	Cor
81	*Myriotrema microporum* (Mont.) Hale	Thelotremataceae	C	Cor
82	*Ocellularia* sp.	Thelotremataceae	C	Cor
83	*O. arecae* (Vainio)Hale	Thelotremataceae	C	Cor
84	*O. canariana* Patw., Sethy & Nagarkar	Thelotremataceae	C	Cor
85	*O. karnatakensis* Hale	Thelotremataceae	C	Cor
86	*Opegrapha leptoterodes* Nyl.	Opheographeaceae	C	Cor
87	*O.longula* Nyl.	Opheographeaceae	C	Cor
88	*Pertusaria albescens* (Huds.) Choisy & Wern.	Pertusariaceae	C	Cor
89	*P. concinna* Erichsen	Pertusariaceae	C	Cor
90	*P. leucosora* Nyl.	Pertusariaceae	C	Cor
91	*P.leucosorodes* Nyl.	Pertusariaceae	C	Cor
92	*Phaeographina* sp.	Graphidaceae	C	Cor
93	*P. limbata* Mull. Arg.	Graphidaceae	C	Cor
94	*P. wattiana* Mull. Arg.	Graphidaceae	C	Cor
95	*Phaeographis nilgiriensis* K.Singh & Awasthi	Graphidaceae	C	Cor
96	*P. submarcescens* (Leighton) Zahlbr.	Graphidaceae	C	Cor
97	*Porina americana* Fee	Trichotheliaceae	C	Sax
98	*P. innata* (Nyl.) Mull. Arg.	Trichotheliaceae	C	Cor
99	*P. interestes* (Nyl.) Harm.	Trichotheliaceae	C	Cor
100	*P. subinterestes* (Nyl.) Mull. Arg.	Trichotheliaceae	C	Cor
101	*Pyrenula cayennensis* Mull. Arg.	Pyrenulaceae	C	Cor
102	*P. elegans* A.Singh & Upreti	Pyrenulaceae	C	Cor
103	*P. immersa* Mull. Arg.	Pyrenulaceae	C	Cor
104	*Strigula elegans* (Fee) Mull.	Strigulaceae	C	Cor

	Arg.			
105	*T. canarense* Patw. & Kulk.	Thelotremataceae	C	Cor
106	*T. confertum* Nagarkar, Sethy and Patw.	Thelotremataceae	C	Cor
107	*T. kamatii* (Patw. & Kulk.) Hale	Thelotremataceae	C	Cor
108	*T. leprocarpum* (Nyl.) Tuck	Thelotremataceae	C	Cor
109	*Trypethelium catervarium* (Fee) Tuck.	Trypetheliaceae	C	Cor
110	*T. eluteriae* Sprengel	Trypetheliaceae	C	Cor
111	*T. tropicum* (Ach.)Mull.Arg.	Trypetheliaceae	C	Cor