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Diversity of Epiphytic Lichens and Evaluation of Important Host Species Exploited by Them in Tropical Semi-Evergreen and Deciduous Forests of Koppa, Central Western Ghats, India

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ABSTRACT

This paper deals with epiphytic lichen flora in semi-evergreen and deciduous forests of Koppa taluk, central Western Ghats. A total of 36 lichen species belonging to 15 genera and 9 families were documented. The Shannon-Winner diversity value was 3.34 and Simpson's richness value was 0.031. Deciduous forests have more lichens (27 spp.) than semi-evergreen forests. More epiphytic lichens grow on the main trunk (25 spp.) than branches and fallen twigs. Twenty four different host trees were recorded from the study area. Trees < 25 cm GBH (girth at breast height) sustained the growth of more lichens (33) than the other girth classes. *Randia dumetorum*, which has moderate bark texture, supported *Graphina* sp., *Graphis celata*, *Heterdermia incana*, *H. pseudospeciosa*, *Lecanora indica*, *Porina americana*, and *Leptogium burnetiae*. The assemblage of distinct species at different sites indicates restrictive species distribution and signifies the need for protecting large areas for lichen conservation.

Keywords: epiphytic, foliose lichen, malnad, photobiont, Western Ghats
Abbreviations: GBH, girth at breast height; **GPS**, global positioning system; **MSL**, meters above sea level; **RH**, relative humidity; **SIV**, species importance value

INTRODUCTION

Lichens are complex organisms involving in a symbiotic relationship between a photobiont and a mycobiont (Pinokiyo *et al*. 2006). Epiphytic lichen communities are diverse, their richness may be greater or equal to that of vascular plants (Pipp *et al*. 2001). In a heterogeneous forest land, the diversity of lichen is variable, as the supporting host trees provides space for different types of lichens (Sequiera and Kumar 2008). These epiphytic lichens commonly cover the bark of trees (corticolous) as well as leaf surfaces (follicolous). Thus, in tropical forests, lichens show characteristic distribution patterns related to their growth forms (Lakatos *et al*. 2006). Knowledge of the degree of host specificity of lichens serves a useful purpose in the estimation of their diversity and conservation (Sequiera and Kumar 2008). Dead and decaying trees are the favorite habitat of many epiphytic lichens; lichen diversity is often higher on living trees, hence the trees are vital as a habitat (Hauck 2005). Macrolichen species in low-land rainforests are restricted to the canopy (Cornelissen and Ter-Steege 1989), whereas information on vertical microlichen distribution in tropical forests is virtually lacking. The epiphytic lichens dwelling in forests have a long generation time as well as poor dispersal and colonization abilities (Juriado *et al*. 2009). They are sensitive to climatic stress because of their location in the canopy and because they are dispersed by wind (Esseen and Renhorn 1998). Hence these are actively used in monitoring air quality (Saipunkaew *et al.* 2005; Pande *et al*. 2006; Hazarika 2011). Epiphytic lichens may also be affected by altered forest microclimate (Esseen and Renhorn 1998) and serve as indicators of forest health (Pipp *et al*. 2001). The trees benefit from the input of lichens. For example, oaks (*Quercus* sp.) colonized by lichens received an increased deposition of nitrogen, phosphorous, and water from local rainfall and fog dripping (Werth and Sork 2008). Epiphytic lichen assemblage and their host specifications have been intensively studied throughout the world (Esseen and Renhorn 1998; Pipp *et al*. 2001; Hauck 2005; Saipunkaew *et al*. 2005; Werth and Sork 2008; Juriando *et al*. 2009; Öztürk *et al*. 2010). However, only scanty information is available for Indian lichens (Upreti and Chatterjee 1999; Pande *et al*. 2006; Sequiera and Kumar 2008; Rout *et al*. 2010; Rawat *et al*. 2011). Hence the main objective of this paper is to elucidate the host specificity of epiphytic lichens and to evaluate the important host species exploited by them.

MATERIALS AND METHODS

Study area

Koppa taluk, a part of Western Ghats that comprises an eclectic collection of lichens, falls under the Malnad region (hilly area with dense forest) of Chickmaglur district, Karnataka, located at 75º15' to 72º20' E and 13º30' to13º35' N, 700-844 masl. The study area enjoys generally cool climate throughout the year and remains pleasant during summer. The temperature of this region varies between 18 and 31°C, whereas the annual rainfall is nearly 1600-3400 mm. For the present study, two types of forests (semi-evergreen and deciduous) were selected at random.

Surveying and sampling

Frequent field visits were undertaken from November 2007 to June 2008. A random sampling method was used to document the lichen diversity by laying two belt transects (10 m × 50 m) in each type of selected forest. In each transect all substrates were tho-

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Research Note

Table 1 Frequency, density, abundance and species importance value of lichen species with their growth form and host plant in the different vegetation types.

Species name	G	Fre	Den	A	SIV	Host species	VT
Bulbothrix isidiza (Nyl.) Hale (Parmeliaceae)	F	0.33	0.33	1	4.17	*Syzygium cumini*	SE
Chrysothrix sp. (Chrysothrixacae)	C	0.33	0.33	1	4.17	*Sapium insigne*, *Croton caudatus*	DD
Dirinaria confluens (Fr.) D.D. Awasthi (Physciaceae)	F	0.33	0.33	1	4.17	*Syzygium cumini*	DD
D. applanata (Fee) D.D. Awasthi (Physciaceae)	F	0.33	0.33	1	4.17	*Hopea ponga*	SE
Graphis celata Stirton (Graphidaceae)	C	0.33	0.33	1	4.17	*Gnetum ula*	DD
Graphis sp. (Graphidaceae)	C	0.33	2.33	7	12.5	*Terminalia tomentosa*, *Erithrina superba*, *Calyptoterics florigunda*, *Randia dumetorum*	DD/SE
Graphis aphanes Mont & v.d.Bosch (Graphidaceae)	C	0.33	1.00	3	6.94	*Ficus tsjahela*, *Symplocos racemosa*, *Terminalia tomentosa*	DD
G. celata Stirton (Graphidaceae)	C	0.33	0.33	1	4.17	*Randia dumetorum*	DD
G. longiramea (Graphidaceae)	C	0.33	0.33	1	4.17	*Gnetum ula*	*DD*
Heterodermia diademata (Taylor) D.D. Awasthi (Physciaceae)	F	0.67	0.67	1	8.33	*Calyptoterics florigunda*, *Terminalia paniculata*	DD
H. dissecta (Kurok.) D.D. Awasthi (Physciaceae)	F	0.67	0.67	1	8.33	*Calycopteris floribunda*, *Terminalia paniculata*	DD
H. incana (Stirton) D.D. Awasthi (Physciaceae)	F	1.00	2.00	2	16.67	*Croton caudatus*, *Ligustrum gamblei*, *Randia dumetorum*	DD/SE
H. obscurata (Nyl.)Trevis. (Physciaceae)	F	0.33	0.67	2	5.56	*Hopea ponga*, *Sapium insigne*	DD
H. pseudospeciosa (Kurok.) W. Culb. (Physciaceae)	F	0.33	0.33	1	4.17	*Randia dumetorum*	DD
H. speciosa (Wulf.) Trevis. (Physciaceae)	F	0.67	1.33	2	11.11	*Sapium insigne*, *Terminalia paniculata*	DD
H. albidiflava (Kurok.) D.D. Awasthi (Physciaceae)	F	0.33	0.33	1	4.17	*Croton caudatus*	DD
Lecanora indica Zahibr. (Lecanoraceae)	F	0.33	0.33	1	4.17	*Randia dumetorum*	DD
Leptogium burnetiae Dodge (Collemataceae)	F	0.33	1.00	3	6.94	*Clausena dentata*, *Mappia foetida*, *Randia dumetorum*	SE
L. chloromelum (Sw.) Nyl. (Collemataceae)	F	0.33	0.67	2	5.56	*Syzygium cumini*	DD
Leptogium sp. (Collemataceae)	C	0.67	2.00	3	13.89	*Clausena dentata*, *Paramignya monophylla*	SE
Ocellularia diacida Hale (Thelotremataceae)	C	0.33	0.33	1	4.17	*Schleichera oleosa*	DD
Parmotrema cristiferum (Taylor) Hale (Parmeliaceae)	F	0.33	0.33	1	4.17	*Symplocos racemosa*	SE
P. hababianum (Gyeln.) Hale (Parmeliaceae)	F	0.33	0.33	1	4.17	*Sapium insigne*	DD
P. reticulatum (Taylor) Choisy (Parmeliaceae)	F	0.33	0.33	1	4.17	*Paramignya monophylla*	DD
P. stuppeum (Taylor) Hale (Parmeliaceae)	F	0.33	0.33	1	4.17	*Clausena dentata*	DD
P. tinctorum (Despr. ex Nyl.) Hale (Parmeliaceae)	F	0.33	0.67	2	5.56	*Paramignya monophylla*, *Terminalia paniculata*	DD
Parmotrema sp. (Parmeliaceae)	F	0.67	0.67	1	8.33	*Eliocarpus serratus*	DD
Porina americana Fee (Trichotheliaceae)	C	0.33	1.33	4	8.33	*Hopea ponga*, *Randia dumetorum*	SE/DD
P. innata (Nyl.) Mull. Arg. (Trichotheliaceae)	C	0.33	0.33	1	4.17	*Hopea ponga*	SE
Pyxine coccifera (Fee) Nyl. (Physciaceae)	F	0.33	0.33	1	4.17	*Terminalia paniculata*	DD
P. minuta Vain. (Physciaceae)	F	0.33	0.33	1	4.17	*Mappia foetida*	DD
Ramalina divericata (Ramalinaceae)	Fr	0.33	0.33	1	4.17	*Ziziphus xylopyrus*	DD
Thelotrema canarense Patw. & Kulk. (Thelotremataceae)	C	0.33	0.67	2	5.56	*Hopea ponga*, *Aporosa lindliana*	SE
Thelotrema sp. (Thelotremataceae)	C	0.33	0.33	1	4.17	*Paramignya monophylla*	DD
Usnea ghattensis G. Awasthi (Parmeliaceae)	Fr	0.33	1.00	3	6.94	*Dimocarpus longan*, *Gordonia obtusa*, *Myristica doctyloides*	DD

G: growth form, F: foliose, Fr: fruticose, C: crustose, Fre: frequency, Den: density, Ab: abundance, SIV: species importance value, VT: vegetation type, SE: semi-evergreen, DD: deciduous

roughly checked for the occurrence of lichens. Only representative lichen specimens were collected and packed in brown paper bags, brought in polythene bags to the laboratory. The altitude was recorded with a hand-held GPS (Garmin e-trex, USA). RH (digital thermo-hygrometer, 288CTH Euro lab), temperature and micro-habitat data were recorded for each transect.

Identification and preservation

Collected lichen specimens were dried (at 30-35°C) for 1-2 weeks to remove all moisture content from the sample and identified on the basis of their morphology, type of fruiting bodies, anatomy and chemistry according to the following standard literature (Walker and James 1980; Awasthi 2000). All lichen specimens were preserved in the herbarium of the Department of Applied Botany, Kuvempu University, Shankaraghatta, Shimoga, Karnataka and voucher specimens were submitted to the herbarium of National Botanical Research Institute, Lucknow (LWG), India.

Calculations

The frequency, density, abundance and diversity indices were calculated using respective formulas (Cottam and Curtis 1956; Magurran 1988):

Frequency = the number of transects in which a species occurs / total number of transects studied.

Relative frequency = (the number of transects in which a species occurs / the total number of all species in all transects) × 100.

Density = the total number of individuals of a species / total number transects studied.

Relative density = (the total number of individuals of a species / total number of specimens collected in all transects) × 100.

Abundance = total number of individuals of a species / the total number of transects in which species occur.

Species importance value (SIV) = relative frequency + relative density.

Shannon-Weiner's diversity index (H') = -Σ piln pi.

Simpson's value (D) = [Σni X (ni-1)] / N (N-1)

where pi= (ni/N); N = total number of individuals collected, ni = number of individual species.

RESULTS AND DISCUSSION

Diversity and distribution pattern

A total of 36 lichen species belonging to 15 genera and 9 families were found in the tropical semi-evergreen and deci-

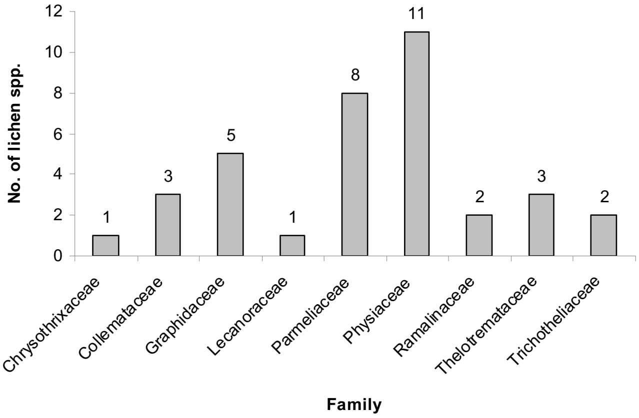

Fig. 1 Different lichen family composition in the study area.

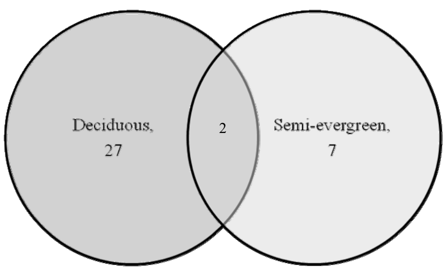

Fig. 2 Species composition of lichens in different forests.

duous forests of Koppa taluk (**Table 1**). As many as 67 colonies were sampled over a 3000 m^2 area. Physciaceae was the largest family in the study area with 11 species; both Chrysotrixaceae and Lecanoraceae were represented by a single species (**Fig. 1**). The foliose lichens were dominant in the study area (59%) followed by crustose (33%) and fruticose (8%). These numbers changed depending on the vegetation type (**Fig. 3**). *Heterodermia incana* was the most frequent species and also had the highest SIV value (16.67) followed by *Graphina* sp. with an SIV of 12.5 (**Table 1**). Highest density was shown by *Graphina* sp. (2.33). *Graphina* sp. was also the most abundant (7) lichen species. The recorded lichen species in different vegetation types in the study area showed a Shannon-Winner diversity value (H') of 3.34 and a Simpson's richness value (D) of 0.031.

There were considerable differences in species composition and abundance between the two forest types. The semi-evergreen forests harbored 27 species while 7 species were exclusive to the deciduous forests and 2 species of lichens were common in both forest types (**Fig. 2**). However, microlichens accounted for 42.86% in semi-evergreen forests and for 29.63% in deciduous forests; the remainder was macrolichens. Fruticose lichens were not found in semi-evergreen forests.

Lichen-host specificity

As many as 25 species were found on the main trunk, whereas 4 and 9 species were found on branches and fallen twigs, respectively (**Fig. 4**). A total of 24 different host trees were recorded in the study area. The girth at breast height (GBH) of the trees documented in the transect area ranged from 4 to 150 cm. They were divided into 5 girth classes. Most lichens (33) grew on plants with a girth < 25 cm (**Fig. 5**). The main trunk supported the maximum number of lichens (**Fig. 4**). Trees with rough bark such as *Schleichera oleosa*, *Myristica doctyloides* and *Terminalia tomentosa* supported more fruticose and foliose lichens whereas plants with a smooth bark supported more crustose lichens. *Randia dumetorum*, which has a moderate bark texture, supported seven lichen species (**Table 2**).

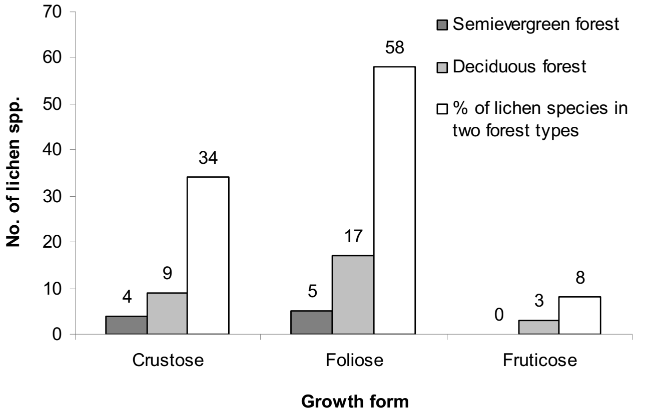

Fig. 3 Number of lichens in different forest types and their growth form.

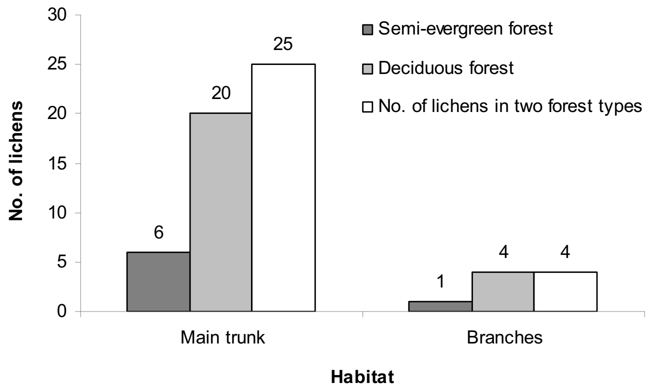

Fig. 4 Relationship between substratum and number of lichens.

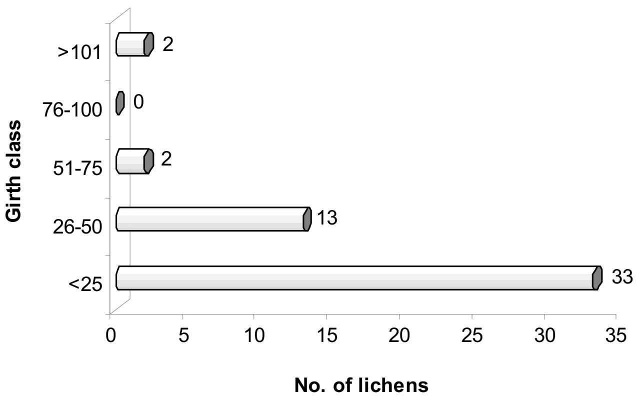

Fig. 5 Diversity of lichens according to the GBH of host trees.

A forest is a habitat with complex ecological gradients and is an important habitat for a rich assemblage of lichens (Sequiera and Kumar 2008). The number of species or any other ranks of taxonomic organization at a site (species richness) and their compositional change across different habitat types (species turnover) within a landscape are important parameters of biodiversity that have wide applications such as environmental monitoring and conservation evaluation (Negi 2000). In this study, epiphytic lichen groupings varied depending on the type of habitat under various external pressures (such as disturbance by humans and livestock grazing) in both tropical semi-evergreen and deciduous forests. Lichen abundance also varies within tree crowns because of exposure (Esseen and Renhorn 1998). Competition for light is an important factor than moisture for the growth of lichens (Upreti and Chatterjee 1999). These facts are emphasized by the fact that deciduous forests are comprised of more lichens than semi-evergreen forests. The open canopy forest and widely branched deci-

Table 2 Host plants and lichen relationship.

Host	B	No. of lichen spp.	GF	GBH (cm) of host
Calycopteris floribunda	M	1	C	20
Clausena dentata	S	2	F	50, 150
Terminalia paniculata	R	4	F	20, 20, 45, 18
Gnetum ula	M	2	C	18, 18
Schleichera oleosa	R	1	C	32
Terminalia tomentosa	R	2	C	15, 15
Aporosa lendlyana	M	1	C	23
Clausena indica	S	1	C	20
Xanthoxylum ovalifolium	M	1	C	5
Ficus tsjahela	S	2	C,F	25, 25
Hopea ponga	S	4	C,F	3, 18, 22, 45
Ligustrum gamblei	S	1	F	60
Mappia foetida	S	2	F	10, 15
Syzygium cumini	M	2	F	39, 45
Eliocarpus serratus	M	1	F	25
Croton caudatus	M	4	F,C	20, 32, 41, 7
Randia dumetorum	M	7	F,C	10, 15, 18, 20, 24, 25, 45
Symplocos racemosa	S	2	F,C	36, 12
Paramignya monophylla	M	4	F,C	12, 23, 45, 45
Sapium insigne	M	4	F,C	20, 20, 60, 4
Myristica doctyloides	R	1	Fr	42
Dimocarpus longan	M	1	Fr	51
Gordonia obtusa	S	1	Fr	15
Erythrina superba	S	1	Fr	110

B: bark type, S: smooth, R: rough, M: moderate, GF: growth form of the lichen hosted by the tree, C: crustose, F: foliose, Fr: fruticose, GBH: girth at brest height

duous trees are more favorable for epiphytic lichen growth. Although the evergreen and deciduous forests are found in a complex mosaic often at the same altitude, the lichen floras (corticolous) of the forests are different (Wolseley and Aguirre-Hudson 1997). Ozturk *et al.* (2010) showed that the distributions of epiphytic lichens were significantly related to altitude.

More lichens were found on tree bark than any other substrate, reflecting the importance of the woody component of the forest as a major lichen habitat (Pinokiyo *et al.* 2008). Bark texture and chemistry are probable factors determining host preference. Accurate measurements of bark texture and experiments of toxicity of bark to epiphytic species are needed to clarify the causes of host preference (Cornelissen and Ter-Steege 1989). Young trees supported lichen communities dominated by crustose forms, followed by a few foliose and fruticose forms (Upreti and Chatterjee 1999), while mature-trees (young tree have low GBH, where as mature trees has high GBH) sustain climax communities dominated by foliose and fruticose rather than crustose lichens (**Tables 1, 2**).

The effect of trunk size on lichen species richness on the tree bole is negative in boreo-nemoral forests (Juriado *et al*. 2009). With an increase in the diameter of the tree, the number of thalli decreased (*Parmelia cristifera* present on the tree with a GBH > 100 cm is an exception) (Pande 2006). The present study is evidence for the relationship between bole size and lichens: the number of lichens decreases with a rise in GBH. Pinokiyo *et al*. (2008) also showed that epiphytic lichen abundance and diversity were linked to their structural diversity. Since epiphytic lichen communities may be slow to become established (Pipp *et al*. 2001), they cannot grow in disturbed sites; thus the profusion of lichens in an area indicates that the place is not so disturbed. Consistent with the tested hypothesis epiphytic lichens have large potential as indicators of edge effects because of the frequent occurrence of more sensitive pendulous lichens like *Usnea* and *Ramalina* in a forest edge microclimate.

CONCLUSIONS

Epiphytic lichens may be strongly affected by specific environmental conditions. Distinct species assembles at different sites show restrictive species distribution, which signifies a need for protecting large areas for lichen conservation. Changes in environmental conditions are rapidly reflected in the lichen flora through quantitative sampling of individuals (Wolseley and Aguirre-Hudson 1997). Hence it is necessary to protect habitats before thinking of conserving and improving lichen diversity. Lichen abundance also varies depending on tree crowns because of exposure. Hence an open canopy forest shows higher diversity than a closed canopy forest.

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