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Research Article

Diversity of Macrolichens in Bolampatti II Forest Range (Siruvani Hills), Western Ghats, Tamil Nadu, India

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An annotated checklist of 103 macrolichen species is provided based on identification of specimens collected from three different vegetation types within the Bolampatti II forest range, Western Ghats, India. Among them, the dominant order is Lecanorales with 47 species, while the dominant family is Parmeliaceae with 40 species. The foremost genus is *Usnea* with 15 species.

1. Introduction

Nearly 80,000 species of fungi are available in nature [1]. Of these, approximately 17% are lichenized, forming symbioses with green algae (Chlorophyta, Viridiplantae) or the so called blue-green algae (Cyanobacteria, Bacteria). These relationships produce symbiotic organisms commonly called lichens [2]. Lichens are an outstandingly successful group of symbiotic organisms exploiting a wide range of habitats throughout the world. About 20,000 species of lichens are so far recorded across the globe, among which the Indian subcontinent harbours 2450 (12.25%) species [3]. Tropical forests, because of their complexity and variety of microhabitats, usually harbour a rich diversity of lichens. Even though they are often small and inconspicuous, especially in the lowland forest, they may play a significant role in the forest ecosystem [4]. It has been estimated that 50% of the Indian lichen biota are currently undescribed [5]. In India, the comprehensive regional treatments (both ecological and systematic) on lichens are still not available, and a few cover areas like portions of Western Ghats (Nilgiri and Palni Hills, Himalayas, and North Eastern regions) [6, 7]. Still, many of the pristine Western Ghats ecosystems remain unexplored to list out the extent and type of distribution of lichens [8]. In view to explore such important organisms, the present study has studied the macrolichens from Bolampatti II forest range, Western Ghats. The primary objective of this paper is to enumerate the macrolichens and their distribution within the forest types of the Bolampatti II forest range.

2. Materials and Methods

2.1. Study Area. Bolampatti II forest range, Coimbatore district, Tamil Nadu (part of Western Ghats—76° 33″ to 76° 46″ E and 11° 2″ to 10° 54″ N), is a part of the Nilgiri Biosphere Reserve, is commonly known as Siruvani Hills (Figure 1), and is one of the biodiversity hotspots of the world. The study site is located west to Coimbatore city and north of the Walayar valley, is shaped like a horse-shoe opening eastwards, and covers an area of 197.66 km^2. The Bolampatti valley consists of vegetation types progressively from lower to higher altitudes (east to west) dry deciduous forest (DDF) (4a/C2), moist deciduous forest (MDF), and western tropical evergreen forest (WTEF) (1a/C3) [9, 10]. This valley drains eastwards into the Noyilar and its tributaries. The elevation ranges from 458 m (Noyilar base) to 1,986 m on Periyakunjiramalai at the southwest corner and 1,800 m on Vellingiri peak at the northwest. This hill receives a rainfall of 75–200 cm from the northeast monsoon during September to November, with a dry period of six months. The temperature ranges between 10°C during December and January and 40°C

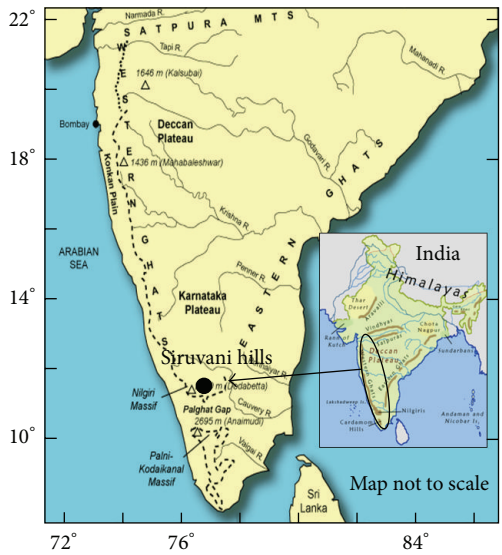

FIGURE 1: Map of Bolampatti II forest range (Siruvani Hills), Western Ghats.

during March to May. The older rock is of Precambrian origin with the formation of mainly Charnockite or Nilgiri gneiss. Soil is mainly of red type in the hills. The foothills generally have sandy loam. The Vellingiri peak is barren and rocky.

2.2. Research Methods. The lichen samples (approximately. 3000 specimens) were collected from various vegetation types, namely, dry deciduous forest (DDF), moist deciduous forest (MDF), and western tropical evergreen forest (WTEF) during 2001–2005 by the authors based on ocular survey on all possible lichen occurring substrates, such as tree bark, rocks, leaves, and soil. Lichens on fallen twigs were collected, since they represent the species that occur on canopy. Each sample was given a field number. The specimens were dried and incorporated into a reference collection that is preserved in the Lichen Ecology and Bioprospecting Laboratory, M. S. Swaminathan Research Foundation (MSSRF), Chennai. The specimens were identified based on the internal and external morphological, reproductive, and chemical features following recent literature [11–18], and lichen taxa are classified based on the systematic arrangement provided by Hawksworth et al. [19]. For each of the lichen species collected, their distribution with respect to growth form, substratum preference, and forest types were provided.

3. Results and Discussion

A total number of 103 species of macrolichens under 27 genera in 9 families in 3 fungal orders were recorded within the Siruvani hills (Table 1; Figures 2(a)–2(f)). Fungal order Lecanorales dominate with 47 species followed by Teloschistales (35) and Peltigerales (21). Out of 9 families of lichens, Parmeliaceae (40 species) is the largest family followed by Physciaceae (20), Collemataceae (16), Caliciaceae (14), Ramalinaceae (6), and Lobariaceae (4), and three families were with single species each. The largest genus was *Usnea* with 15 species followed by *Heterodermia* and *Parmotrema* with 13 species each, *Leptogium* and *Pyxine* with 11 and 10 species, respectively.

Fourteen (14) genera were with single species each. Among the forest types studied, MDF contain 55 lichens followed by WTEF with 51 and DDF with 48 species, in which, 21 lichen species were specific to DDF while 24 to MDF and 21 to WTEF. Thirty-seven (14) lichen species were common to all the forest types. Seven (7) species were shared between DDF and MDF, while 6 species between DDF and WTEF, and 24 species between MDF and WTEF.

Among the species recorded, 92.2% of lichens were colonized on bark (corticolous), followed by 6% on rock (saxicolous), 0.8% on soil (terricolous), and a single lichen species both on bark and rock substratum. Bark colonizing lichens were maximum in both MDF & WTEF (47% each) followed by DDF (43%). Rock colonizing lichens were maximum in MDF (4) followed by DDF (3) and WTEF (1). Single soil colonizing lichen *Cladonia* sp. was found in MDF. Lichen *Parmotrema praesorediosum* was found colonizing both on bark as well as on rock in DDF type.

The photobiont distribution showed 80% of lichens with *Trebouxia* and 20% of lichens with *Nostoc* sp. *Trebouxia* containing lichens were maximum in WTEF and MDF with 34% each, followed by DDF (32%). *Nostoc*-containing lichens were maximum in MDF (44%) followed by WTEF and DDF (28% each).

Lichens with *Trebouxia* as photobiont dominate tropical regions with an alternating wet and dry period and include macrolichens in Parmeliaceae and macrolichens and crusts in Bacidiaceae (syn. Ramalinaceae), Physciaceae, and Pertusariaceae [20]. The *Trebouxia* containing macrolichens in DDF are also equally present in WTEF and MDF, prevailing in our study sites. It includes lichen families such as Parmeliaceae, Physciaceae, and Caliciaceae. Wolseley and Hawksworth [20] reported that the *Trebouxia* dominated families may occur with increasing dryness and/or disturbance as caused by fire in Thailand.

The *Nostoc*-containing lichens were found dominant in MDF, while there was equal distribution of *Trebouxia* containing lichens in all the forest types studied. Lichen taxa with cyanobacteria are more common in the moister forests; species of *Collema* and *Parmeliella* were found in DDF as well as SEF, and *Leptogium cyanescens* was found in all forest types [21]. The lichen species such as *Collema actinoptychum, Collema flaccidum,* and *Collema furfuraceum* are confined only to DDF, while *Collema subflaccidum* is found both in DDF and WTEF. The lichens *Leptogium cyanescens* and *Leptogium denticulatum* are found in all forest types as in the case of lichens of northern Thailand forests [21].

Lichen communities of the seasonal evergreen forest (SEF) and tropical mixed deciduous forest (TMDF) are moisture-dependent and shade-adapted, whereas lichen communities of the DDF are adapted to xerophytic conditions and photophilous [21]. This pattern of distribution can be attributed to the sensitivity of the lichen photobiont to drought or high temperatures, which determines the

Table 1: List of lichen species found within the Bolampatti II forest range (Siruvani Hills), Western Ghats, Tamil Nadu, India.

S. no.	Species name	Family	Order	Growth forms	Substratum	Forest types		
						DDF	MDF	WTEF
1	*Bulbothrix isidiza* (Nyl.) Hale	Parmeliaceae	Lecanorales	G	1	+	–	–
2	*Bulbothrix tabacina* (Mont. & Bosch) Hale	Parmeliaceae	Lecanorales	G	1	–	+	–
3	*Canoparmelia aptata* (Krempelh.) Elix et Hale	Parmeliaceae	Lecanorales	G	1	–	+	–
4	*Cladonia* sp.	Cladoniaceae	Lecanorales	F	3	–	+	–
5	*Coccocarpia palmicola* (Spreng.) Arv. & D.J. Galloway	Coccocarpiaceae	Peltigerales	A	1	–	+	–
6	*Collema actinoptychum* Nyl.	Collemataceae	Peltigerales	B	1	+	–	–
7	*Collema flaccidum* (Ach.) Ach.	Collemataceae	Peltigerales	B	1	+	–	–
8	*Collema furfuraceum* (Arnold) Du Rietz	Collemataceae	Peltigerales	B	1	+	+	+
9	*Collema rugosum* Kremp.	Collemataceae	Peltigerales	B	1	–	+	–
10	*Collema subflaccidum* Degel.	Collemataceae	Peltigerales	B	1	+	–	+
11	*Dirinaria applanata* (Fée) D.D. Awasthi	Caliciaceae	Teloschistales	C	1	+	–	+
12	*Dirinaria confluens* (Fr.) D.D. Awasthi	Caliciaceae	Teloschistales	C	2	–	+	–
13	*Dirinaria consimilis* (Stirt.) D.D. Awasthi	Caliciaceae	Teloschistales	C	1	+	–	–
14	*Dirinaria picta* (Sw.) Schaer. ex Clem.	Caliciaceae	Teloschistales	C	1	+	+	+
15	*Everniastrum cirrhatum* (Fr.) Hale ex Sipman	Parmeliaceae	Lecanorales	E	1	–	+	–
16	*Heterodermia angustiloba* (Müll. Arg.) D.D. Awasthi	Physciaceae	Teloschistales	D	1	+	+	–
17	*Heterodermia comosa* (Eschw.) Follmann & Redón	Physciaceae	Teloschistales	D	1	–	–	+
18	*Heterodermia diademata* (Taylor) D.D. Awasthi	Physciaceae	Teloschistales	D	1	+	+	+
19	*Heterodermia dissecta* (Kurok.) D.D. Awasthi	Physciaceae	Teloschistales	D	1	+	+	+
20	*Heterodermia hypocaesia* (Yasuda) D.D. Awasthi	Physciaceae	Teloschistales	D	1	–	+	+
21	*Heterodermia isidiophora* (Vain.) D.D. Awasthi	Physciaceae	Teloschistales	D	1	–	+	+
22	*Heterodermia japonica* (K. Satô) Swinscow & Krog	Physciaceae	Teloschistales	D	1	–	+	–
23	*Heterodermia leucomela* (Fée) Swinscow & Krog	Physciaceae	Teloschistales	D	1	–	–	+
24	*Heterodermia microphylla* (Kurok.) Skorepa	Physciaceae	Teloschistales	D	1	–	+	+
25	*Heterodermia obscurata* (Nyl.) Trevis.	Physciaceae	Teloschistales	D	1	–	+	+
26	*Heterodermia pellucida* (D.D. Awasthi) D.D. Awasthi	Physciaceae	Teloschistales	D	1	+	+	+
27	*Heterodermia pseudospeciosa* (Kurok.) W.L. Culb.	Physciaceae	Teloschistales	D	1	+	+	+
28	*Heterodermia speciosa* (Wulfen) Trevis.	Physciaceae	Teloschistales	D	2	+	+	+
29	*Hypotrachyna coorgiana* Patw. & Prabhu	Parmeliaceae	Lecanorales	A	1	–	–	+
30	*Leptogium austroamericanum* (Malme) C.W. Dodge	Collemataceae	Peltigerales	B	1	+	+	–
31	*Leptogium azureum* (Sw. ex Ach.) Mont.	Collemataceae	Peltigerales	B	1	–	+	–
32	*Leptogium cyanescens* (Pers.) Körb.	Collemataceae	Peltigerales	B	1	+	+	+
33	*Leptogium denticulatum* F. Wilson	Collemataceae	Peltigerales	B	1	+	+	+
34	*Leptogium isidiosellum* (Riddle) Sierk	Collemataceae	Peltigerales	B	1	+	+	–
35	*Leptogium marginellum* (Sw.) Gray	Collemataceae	Peltigerales	B	1	–	–	+
36	*Leptogium millegranum* Sierk	Collemataceae	Peltigerales	B	1	–	–	+
37	*Leptogium moluccanum* (Pers.) Vain.	Collemataceae	Peltigerales	B	1	–	+	+
38	*Leptogium phyllocarpum* (Pers.) Mont.	Collemataceae	Peltigerales	B	1	–	+	–
39	*Leptogium pichneum* (Ach.) Nyl.	Collemataceae	Peltigerales	B	1	+	–	–
40	*Leptogium ulvaceum* (Pers.) Vain.	Collemataceae	Peltigerales	B	1	–	–	+
41	*Lobaria japonica* (Zahlbr.) Asahina	Lobariaceae	Peltigerales	A	1	–	+	–
42	*Myelochroa aurulenta* (Tuck.) Elix & Hale	Parmeliaceae	Lecanorales	A	1	+	+	–
43	*Parmelia direagens* Hale	Parmeliaceae	Lecanorales	G	1	+	–	–
44	*Parmelina muelleri* (Vain.) Hale	Parmeliaceae	Lecanorales	G	1	–	–	+
45	*Parmelinella simplicior* (Hale) Elix & Hale	Parmeliaceae	Lecanorales	G	1	–	+	+
46	*Parmelinopsis expallida* (Kurok.) Elix & Hale	Parmeliaceae	Lecanorales	G	1	+	–	–
47	*Parmelinopsis microlobulata* (Awas.) Elix and Hale	Parmeliaceae	Lecanorales	G	1	–	–	+
48	*Parmotrema andinum* (Műll. Arg.) Hale	Parmeliaceae	Lecanorales	G	1	+	–	–
49	*Parmotrema austrosinense* (Zahlbr.) Hale	Parmeliaceae	Lecanorales	G	1	–	+	–

Table 1: Continued.

S. no.	Species name	Family	Order	Growth forms	Substratum	Forest types		
						DDF	MDF	WTEF
50	*Parmotrema crinitum* (Ach.) M. Choisy	Parmeliaceae	Lecanorales	G	1	+	–	–
51	*Parmotrema dilatatum* (Vain.) Hale	Parmeliaceae	Lecanorales	G	1	–	+	–
52	*Parmotrema grayanum* (Hue) Hale	Parmeliaceae	Lecanorales	G	2	–	+	–
53	*Parmotrema indicum* Hale	Parmeliaceae	Lecanorales	G	1	–	–	+
54	*Parmotrema melanothrix* (Mont.) Hale	Parmeliaceae	Lecanorales	G	1	+	–	+
55	*Parmotrema mesotropum* (Müll. Arg.) Hale	Parmeliaceae	Lecanorales	G	1	+	–	–
56	*Parmotrema permutatum* (Stirt.) Hale	Parmeliaceae	Lecanorales	G	1	–	+	–
57	*Parmotrema praesorediosum* (Nyl.) Hale	Parmeliaceae	Lecanorales	G	1 & 2	+	–	–
58	*Parmotrema saccatilobum* (Taylor) Hale	Parmeliaceae	Lecanorales	G	1	+	–	+
59	*Parmotrema tinctorum* (Nyl.) Hale	Parmeliaceae	Lecanorales	G	1	+	–	–
60	*Parmotrema xanthinum* (Müll. Arg.) Hale	Parmeliaceae	Lecanorales	G	1	–	–	+
61	*Phaeophyscia hispidula* (Ach.) Moberg	Physciaceae	Teloschistales	C	1	+	–	–
62	*Phyllopsora corallina* (Eschw.) Müll. Arg.	Ramalinaceae	Lecanorales	A	1	+	+	+
63	*Phyllopsora parvifolia* (Pers.) Müll. Arg.	Ramalinaceae	Lecanorales	A	1	+	+	+
64	*Physcia aipolia* (Ehrh. ex Humb.) Fürnr.	Physciaceae	Teloschistales	C	1	+	–	+
65	*Physcia caesia* (Hoffm.) Fürnr.	Physciaceae	Teloschistales	C	1	–	–	+
66	*Physcia dilatata* Nyl.	Physciaceae	Teloschistales	C	2	+	–	–
67	*Physcia dimidiata* (Arnold) Nyl.	Physciaceae	Teloschistales	C	1	+	+	–
68	*Physcia tribacia* (Ach.) Nyl.	Physciaceae	Teloschistales	C	1	+	+	+
69	*Physcia tribacioides* Nyl.	Physciaceae	Teloschistales	C	1	+	–	–
70	*Pseudocyphellaria aurata* (Ach.) Vain.	Lobariaceae	Peltigerales	A	1	–	+	–
71	*Pyxine cocoës* var. *cocoës* (Sw.) Nyl.	Caliciaceae	Teloschistales	C	1	+	+	–
72	*Pyxine cocoës* var. *prominula* (Stirt.) D.D. Awasthi	Caliciaceae	Teloschistales	C	1	+	–	–
73	*Pyxine cognata* Stirt.	Caliciaceae	Teloschistales	C	1	+	–	–
74	*Pyxine consocians* Vain.	Caliciaceae	Teloschistales	C	2	+	–	–
75	*Pyxine himalayensis* D.D. Awasthi	Caliciaceae	Teloschistales	C	1	+	–	–
76	*Pyxine meissneriana* Nyl.	Caliciaceae	Teloschistales	C	1	+	–	–
77	*Pyxine nilgiriensis* D.D. Awasthi	Caliciaceae	Teloschistales	C	2	–	+	–
78	*Pyxine petricola* Nyl.	Caliciaceae	Teloschistales	C	1	+	+	–
79	*Pyxine sorediata* (Ach.) Mont.	Caliciaceae	Teloschistales	C	1	+	+	+
80	*Pyxine subcinerea* Stirt.	Caliciaceae	Teloschistales	C	1	+	–	–
81	*Ramalina baltica* Lettau	Ramalinaceae	Lecanorales	I	1	–	–	+
82	*Ramalina pacifica* Asahina	Ramalinaceae	Lecanorales	I	1	+	+	+
83	*Ramalina roesleri* (Hochst. ex Schaer.) Hue	Ramalinaceae	Lecanorales	I	1	–	+	+
84	*Ramalina* sp.2	Ramalinaceae	Lecanorales	I	1	–	+	–
85	*Rimelia reticulata* (Taylor) Hale and Fletcher	Parmeliaceae	Lecanorales	G	1	+	–	+
86	*Sticta filicina* Ach.	Lobariaceae	Peltigerales	G	1	–	+	–
87	*Sticta weigelii* Isert	Lobariaceae	Peltigerales	G	1	–	+	+
88	*Teloschistes flavicans* (Sw.) Norman	Teloschistaceae	Teloschistales	I	1	–	–	+
89	*Usnea albopunctata* Nyl. apud Crombie	Parmeliaceae	Lecanorales	H	1	–	+	–
90	*Usnea bornmuelleri* J. Steiner	Parmeliaceae	Lecanorales	H	1	–	–	+
91	*Usnea corallina* Motyka	Parmeliaceae	Lecanorales	H	1	–	+	–
92	*Usnea dendritica* Stirt.	Parmeliaceae	Lecanorales	H	1	–	+	+
93	*Usnea galbinifera* Asahina	Parmeliaceae	Lecanorales	H	1	–	–	+
94	*Usnea orientalis* Motyka	Parmeliaceae	Lecanorales	H	1	–	+	+
95	*Usnea pangiana* Stirt.	Parmeliaceae	Lecanorales	H	1	–	–	+
96	*Usnea pectinata* Stirt.	Parmeliaceae	Lecanorales	H	1	–	+	–
97	*Usnea picta* (J. Steiner) Motyka	Parmeliaceae	Lecanorales	H	1	–	–	+
98	*Usnea pictoides* G. Awasthi	Parmeliaceae	Lecanorales	H	1	–	+	–

Table 1: Continued.

S. no.	Species name	Family	Order	Growth forms	Substratum	Forest types		
						DDF	MDF	WTEF
99	*Usnea pseudomontis-fuji* Asahina	Parmeliaceae	Lecanorales	H	1	–	+	–
100	*Usnea splendens* Stirt.	Parmeliaceae	Lecanorales	H	1	–	–	+
101	*Usnea stigmatoides* G. Awasthi	Parmeliaceae	Lecanorales	H	1	–	–	+
102	*Usnea undulata* Stirt.	Parmeliaceae	Lecanorales	H	1	–	–	+
103	*Usnea vegae* Motyka	Parmeliaceae	Lecanorales	H	1	–	–	+

Growth form code: A-foliose; B-foliose gelatinous; C-foliose laciniate; D-foliose ribbon like; E-foliose strap shaped; F-foliose two fold; G-foliose typical; H-fruticose cylindrical; I-fruticose strap shaped. Subsratum code: bark-1; rock-2; soil-3. DDF: dry deciduous forest; MDF: moist deciduous forest; WTEF: western tropical evergreen forest.

Figure 2: Examples of lichens examined during this study. (a) *Parmotrema praesorediosum,* an epiphytic macrolichen, (b) *Parmotrema mesotropum* (living in an open and dry condition with *Trebouxia* as photobiont), (c) *Ramalina pacifica,* a strap shaped lichen, (d) *Heterodermia isidiophora*, (e) *Pyxine cocoes* var. *cocoes* with black ascomata, and (f) *Leptogium denticulatum*, living in a shade and wet condition with *Nostoc* as photobiont (a cyanolichen).

survival of a lichen thallus [21], and the *Trebouxia* containing lichens are known to survive better in the open and dry [22, 23] condition prevailing in the DDF. The seasonal evergreen and tropical mixed deciduous forests of Thailand [24] were reported to contain more numbers of shade-tolerant *Trentepohlia* containing lichens compared to dry deciduous forests of Thailand. More number of shade-tolerant and moisture-dependent *Nostoc*-containing lichens were observed in MDF type in Bolampatti II forest range also. Lichen families with cyanobacteria and/or chlorococcoid algae include Lobariaceae and Collemataceae, and are more frequent in humid forests. The adaptations to tropical shaded moist conditions are the presence of cyanobacteria and *Trentepohlia* as photobionts [25].

Bergamini et al. [26] state that macrolichens may be good indicators of lichen species richness because of the highly significant relationships. The species turnover within the study sites was very similar for all lichens and macrolichens. The similar trend was also observed in our study sites. In northern Thailand, the lichen species characteristic of disturbance such as *Pyxine consocians* and *Dirinaria consimilis* is also observed in DDF of Bolampatti II forest range. The rate of colonization and growth of these species is an indication of the rate of change [24].

4. Conclusion

The present study revealing the occurrence of 103 macrolichens from 197.66 km^2 forest area indicates the lichen species richness of the study area and their availability for further ecological monitoring. It is desirable to develop location-specific and lichen-centric conservation strategies using this baseline data to protect the valuable and yet poorly studied ecologically-important group called lichens.

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