

Diversity of Lichens along Elevational Gradients in Forest Ranges of ChamaraJanagar District, Karnataka State

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Abstract— The lichen species richness in ChamaraJanagar district in Karnataka, India were assessed using altitudinal gradient, in order to compare distribution patterns of different growth forms, dominant families and diversity index. Four major forest ranges, Biligiriranga Hills, Himavad Gopalswamy Hills, Malay Mahadeshwara Hills, and Shivanasamudra Falls were surveyed and a total of 97 lichens, belonging to 47 genera and 25 families were recorded. Physciaceae was found to be dominant family by 18 species under 8 genera, followed by Parmeliaceae with 16 species under 4 genera. Crustose type was dominated with 51%, followed by foliose type with 38%. Malay Mahadeshwara hills had highest lichen species richness and harboured 67 species, of which, 36 species were crustose type and 28 species were foliose type. Shannon-weiner index ranged from 3.85- 2.45 and Simpson index of diversity ranged from 0.02-0.09. Luxuriant growth of lichens was recorded at the altitude of mid elevation with degree of abundance, density, frequency and distribution of the lichen species compared to other elevation. The present study provided baseline data of lichen diversity, which helps in understanding the relationship between distribution of lichen species along different elevation bands and vegetation types.

Keywords— Biodiversity, Deciduous forest, Physciaceae, Corticolous, MM Hills

I. INTRODUCTION

Lichens, one of the most successful symbiotic associations of a fungus, a green and/ or blue green alga, are known to inhabit nearly all the terrestrial domains of the planet [1]. Lichens are the early land colonizers of terrestrial habitats and perhaps the oldest living creatures on the Earth [2]. To know the spatial patterns in biodiversity along environmental gradients, is a central theme in ecology [3]. Elevation gradients distributed across the globe are a powerful test system for understanding biodiversity [4]. Elevation gradient studies on diversity and distribution of lichens has been undertaken across the world [5- 8]. In Karnataka, diversity and distribution pattern of lichens was studied only in mid-elevation wet Evergreen forest of Southern Western Ghats [9]. Southernmost part of Karnataka state lies ChamaraJanagar district. The forest regions in this district run east from the Western Ghats to the river Cauvery and forms a forest ecological corridor that connects the Eastern Ghats and Western Ghats. This district is unique because it has scrub, dry deciduous, moist deciduous, semi-evergreen, evergreen and shola forests. It is also known for its many endemic species of plants including valuable medicinal ones. Forests in this district have been conserved to protect habitats like flora, fauna and cryptogamic forms like algae,

bryophytes, pteridophytes and lichens. Lichens can provide valuable information about medicinal values and environmental conditions around the forest area. Enumeration of lichens in this region is not reported. Hence, in the present study forest ranges with different elevation gradients has been undertaken in ChamaraJanagar district, with particular reference to understand the species richness, diversity, abundance, frequency, growth form and ecological adaptation of lichens.

II. METHODOLOGY

Topography of the Study Area

ChamaraJanagar is the southernmost district in the state of Karnataka, India. ChamaraJanagar district is divided into 3 taluks: Yelandur taluk, Kollegal taluk and Gundlupet taluk (Figure 1). Major and popular mountain ranges from each taluk has been selected for the study. Sampling sites were distributed at various elevations in the district.



Fig 1: Map of Chamarajanagar District showing location of Collection sites (Source: Google map and Google earth)

Biligiriranga Hills also known as BRT Wildlife Sanctuary (Yelandur Taluk) is one of the famous Biodiversity and Hill station in the world and is rarest wildlife sanctuary. Male Mahadeshwara Hills (Kollegal Taluk) popularly called as MM Hills. It is a Holy place believed to have 777 wide hills, 77 important hills, 7 lively hills around. Shivanasamudra Falls (Kollegal Taluk), the Kaveri with its numerous branches falls down from 75 to 100 feet. All round falls one can see a number of hillocks. Himavad Gopalswamy Hills (Gundlupet Taluk). It is an important Hill Station and Pilgrim Centre (Table 1).

Table 1: Geographical Parameters of lichen collection sites in Chamarajanagara district

Site	Locality	Altitude	Latitude	Longitude
1	Biligiriranga Hills	1500 m	11°59'43.74"N	77°08'33.79"E
2	Himavad Gopalaswamy Hills	1450 m	11°43'26.72"N	76°35'21.40"E
3	Malay Mahadeshwara Hills	1300 m	12°01'30.87"N	77°33'54.87"E
4	Shivanasamudra Falls	700 m	12°17'37.03"N	77°10'05.50"E

Lichen Sampling

Field trips were executed to collect lichen growing on different substrata were sampled by belt transect method. Each transect measuring 50x10 m laid in different locations of the study area. A total of 20 transects was laid in 4 different locations in the study area. All species of lichens found in sampling area were harvested and species that are tightly adhered to bark or rock were collected with the help of chisel and hammer. Immediately after collection, samples were cleaned and wrapped in a tissue paper and stored in paper bags. Collected specimens were numbered and preserved in lichen herbarium packet (17cmX10mm) with details of the locality and deposited in the herbarium of the

Department of studies in Botany, Manasagangotri, University of Mysore, Karnataka, India.

Identification of Lichen Species

The external morphology was studied using a stereomicroscope. The anatomy of the thallus and apothecia were studied under a compound microscope. The anatomical structures were studied after taking the section of dry material with the help of safety razor blade and the sections were mounted in water or on cotton blue in lactophenol. The colour of medulla, epithecium, hypothecium and ascus were recorded. The shape and size of the asci, ascospores and conidia were measured. The measurements of the thallus, medulla, epithecium and hymenium were generally recorded from the sections mounted on cotton blue. The thallus size was measured in centimeter, lobe size and ascocarps in millimeter and thallus medulla, epithecium, hymenium thickness, asci and ascospores size in millimicron. Chemical test of the specimens includes- colour spot tests (K, C, KC and P test) and thin layer chromatography (TLC) test through cold extraction method. Identification was carried out by consulting suitable keys to identify lichens [10- 13].

Data Analysis and Interpretation

Lichen assemblages were quantitatively analyzed for density and frequency. Relative frequency (RF) and relative density (RD) were determined [14]. $RF = 100 \times (\text{frequency of species } I / \text{sum of frequency values of all species})$, and $RD = 100 \times (\text{density of species } I / \text{sum of density values of all species})$. The importance value index (IVI) used here is the sum of the relative frequency and relative density. Frequency distribution, alpha diversity - Shannon-Weiner diversity index (H') and Simpson diversity index (D') have been used to assess species diversity [15]. Alpha diversity (H') was estimated as the Shannon-Wiener index: $H' = -\sum pi \ln pi$, Where, pi =density (number of thalli) of the species, i /density of all species. All statistical analyses were performed using SPSS.

III. RESULTS

The present study deals with the systematic survey of lichens in forest ranges along with elevational gradient in Chamarajanagar district in Karnataka state which is bordering with Kerala and Tamil Nadu states. A total of 97 lichens, belonging to 47 genera and 25 families were recorded from 35 transects of 4 localities namely; Biligiriranga Hills, Male Mahadeshwara Hills, Shivanasamudra Falls and Himavad Gopalaswamy Hills (Table 2).

Table 2: List of lichen flora enumerated from Chamaraajanagar district

Sl No	Lichen samples (* new record to Karnataka)	Family	Growth form	Substratum	Collection sites Values in Importance Value Index (IVI)				Frequency distribution
					BRH	HGH	MMH	SSF	
1	<i>Anaptychia kaspica</i> Gyelnik*	Physciaceae	Foliose	Bark	3.46	-	3.01	-	50%
2	<i>Arthonia medusula</i> (Pers.) Nyl.	Arthoniaceae	Crustose	Bark	-	2.06	1.91	2.3	75%
3	<i>Arthonia radiata</i> (Pers.) Ach*	Arthoniaceae	Crustose	Bark	3.30	3.95	-	-	50%
4	<i>Bacidia alutacea</i> (Krempel.) Zahlbr.	Bacidiaceae	Crustose	Bark	-	4.06	-	-	25%
5	<i>Bacidia incongruens</i> (Stirton) Zahlbr	Bacidiaceae	Crustose	Bark	3.80	-	3.51	-	50%
6	<i>Bacidia rosella</i> (Pers.) de Not.*	Bacidiaceae	Crustose	Bark	3.96	-	-	-	25%
7	<i>Bacidia</i> sp.	Bacidiaceae	Crustose	Bark	-	-	1.77	-	25%
8	<i>Brownliella cinnabarina</i> (Ach.) S.Y. Kondr., Karnefelt, A. Thell, Elix, J.Kim, A.S. Kondr. & J.S. Hur.*	Teloschistaceae	Crustose	Rock	5.31	7.14	-	-	50%
9	<i>Buellia indica</i> S.R. Singh & D.D. Awasthi	Physciaceae	Crustose	Rock	3.46	6.41	4.47	7.61	100%
10	<i>Buellia hemispherica</i> S.R. Singh & D.D. Awasthi	Physciaceae	Crustose	Bark	-	5.89	-	-	25%
11	<i>Buellia</i> sp.	Physciaceae	Crustose	Rock	-	-	4.11	-	25%
12	<i>Bulbothrix goebelii</i> (Zenker) Hale*	Parmeliaceae	Foliose	Bark	-	2.97	3.44	-	50%
13	<i>Bulbothrix setschwanensis</i> (Zahlbr.) Hale*	Parmeliaceae	Foliose	Bark	-	1.66	2.41	-	50%
14	<i>Caloplaca abuensis</i> Y. Joshi & Upreti*	Teloschistaceae	Crustose	Bark	-	-	-	5.67	25%
15	<i>Caloplaca atosanguinea</i> (G. Merr.) Lamb*	Teloschistaceae	Crustose	Bark	1.78	2.43	5.63	-	75%
16	<i>Caloplaca flavorubescens</i> (Huds.) J.R. Laundon	Teloschistaceae	Crustose	Bark	1.01	3.49	-	-	50%
17	<i>Caloplaca bassiae</i> (Ach.) Zahlbr *	Teloschistaceae	Crustose	Bark	2.12	-	-	-	25%
18	<i>Caloplaca poliotera</i> (Nyl.) J. Steiner*	Teloschistaceae	Crustose	Rock	-	-	1.91	-	25%
19	<i>Caloplaca suboahuensis</i> Y. Joshi & Upreti*	Teloschistaceae	Crustose	Rock	-	-	3.58	-	25%
20	<i>Caloplaca subnigricans</i> Magnusson*	Teloschistaceae	Crustose	Bark	3.63	-	3.44	4.24	75%
21	<i>Caloplaca subsoluta</i> (Nyl.) Zahlbr*	Teloschistaceae	Crustose	Bark	4.40	-	4.33	-	50%
22	<i>Candelaria concolor</i> (Dicks.) Stein	Candelariaceae	Foliose	Bark	6.49	4.63	5.62	4.52	100%
23	<i>Canoparmelia texana</i> (Tuck.) Elix & Hale*	Parmeliaceae	Foliose	Bark	-	-	1.91	-	25%
24	<i>Catillaria cervinofusca</i> (Nyl.) Zahlbr.*	Catillariaceae	Crustose	Bark	-	-	1.98	-	25%
25	<i>Chrysothrix candelaris</i> (L.) Laundon	Chrysothricaceae	Leprose	Bark	4.07	5.20	5.40	-	75%
26	<i>Collema rugosum</i> Kremp	Collemataceae	Foliose	Rock	2.78	-	2.70	-	50%
27	<i>Crespona</i> sp.	Roccellaceae	Crustose	Bark	-	-	3.53	-	25%
28	<i>Cryptothecia culbersonae</i> Patw. & Makh.	Arthoniaceae	Crustose	Bark	7.48	6.91	6.57	-	75%
29	<i>Dimerella nepalensis</i> G. Thor & Vezda*	Gyalectaceae	Crustose	Bark	-	-	6.81	-	25%
30	<i>Diorygma hieroglyphicum</i> (Pers.) Staiger & Kalb*	Graphidaceae	Crustose	Bark	-	-	1.10	-	25%
31	<i>Diorygma pruinatum</i> (Eschw.) Kalb, Staiger & Elix*	Graphidaceae	Crustose	Bark	1.95	-	-	-	25%
32	<i>Diploschistes cinereoaeisus</i> (Sw.) Vain	Thelotremataceae	Crustose	Rock	-	-	4.47	-	25%
33	<i>Diploschistes scruposus</i> (Schreber) Norman	Thelotremataceae	Crustose	Rock	3.46	-	2.20	-	50%
34	<i>Dirinaria appanate</i> (Fee) Awas.	Physciaceae	Foliose	Bark	4.54	5.32	5.47	6.16	100%
35	<i>Dirinaria confluens</i> (Fr.) Awas.	Physciaceae	Foliose	Bark	5.64	4.63	4.09	-	75%
36	<i>Dirinaria papillulifera</i> (Nyl.) D. D. Awasthi*	Physciaceae	Foliose	Bark	-	1.31	-	-	25%
37	<i>Flavoparmelia caperata</i> (L.) Ach.	Parmeliaceae	Foliose	Bark	5.31	9.21	4.16	11.45	100%
38	<i>Graphis homichlodes</i> Redinger	Graphidaceae	Crustose	Bark	-	-	2.20	-	25%
39	<i>Graphis script</i> (L.) Ach.	Graphidaceae	Crustose	Bark	2.61	1.54	-	-	50%
40	<i>Haemotaemna puniceum</i> (Sm. Ex Ach.) Massal.	Haematommataceae	Crustose	Bark	2.78	-	2.34	-	50%
41	<i>Hemithecium nakanishiana</i> (Patw. & kulk.) Makhija & Dube	Graphidaceae	Crustose	Bark	1.26	1.66	-	-	50%
42	<i>Heterodermia comosa</i> (Eschw.) Follmann & Redón	Physciaceae	Foliose	Bark	2.89	3.95	-	-	50%
43	<i>Heterodermia hypocaecia</i> (Yasuda) D.D. Awasthi	Physciaceae	Foliose	Bark	-	5.20	3.51	-	50%
44	<i>Heterodermia obscurata</i> (Nyl.)	Physciaceae	Foliose	Rock	3.22	-	4.52	-	50%
45	<i>Heterodermia podocarpa</i> (Bèl.) Awas.	Physciaceae	Foliose	Bark	5.75	-	-	-	25%

46	<i>Heterodermia pseudospeciosa</i> (Kurok.) Culb.	Physciaceae	Foliose	Bark	2.12	-	-	-	25%
47	<i>Hyperphyscia granulate</i> (Poelt) Moberg	Physciaceae	Foliose	Rock	-	4.98	2.12	8.59	75%
48	<i>Hyperphyscia minor</i> (Fee.) Awas.*	Physciaceae	Foliose	Bark	-	-	3.15	-	25%
49	<i>Lecanora argentata</i> (Ach.) Malme*	Lecanoraceae	Crustose	Bark	-	5.89	2.34	-	50%
50	<i>Lecanora carpinea</i> L.	Lecanoraceae	Crustose	Bark	2.20	-	4.09	-	50%
51	<i>Lecanora chlarotera</i> Nyl.	Lecanoraceae	Crustose	Bark	8.15	10.06	6.69	10.91	100%
52	<i>Lecidella enteroleucella</i> (Nyl. In Nyl. Scrombie Hertel)*	Lecanoraceae	Crustose	Rock	-	4.75	5.19	-	50%
53	<i>Lepraria lobificans</i> Nyl.*	Stereocaulaceae	Leprose	Soil & rock	2.20	-	1.02	-	50%
54	<i>Leptogium wilsonii</i> Zahlbr.	Collemataceae	Foliose	Bark	-	5.77	1.17	-	50%
55	<i>Leptogium chloromelum</i> (Swartz ex Ach.) Nyl.	Collemataceae	Foliose	Rock	4.2	-	-	-	25%
56	<i>Ocellularia</i> sp.	Thelotremataceae	Crustose	Bark	-	-	3.34	-	25%
57	<i>Ochrolechia pallescens</i> (L.) Massal.	Pertusariaceae	Crustose	Bark	1.34	-	2.27	-	50%
58	<i>Opegrapha inaequalis</i> Fee*	Roccellaceae	Crustose	Bark	-	-	1.95	-	25%
59	<i>Opegrapha varia</i> Pers.	Roccellaceae	Crustose	Bark	-	-	2.03	-	25%
60	<i>Parmeliella triptophylla</i> (Ach.) Müll. Arg	Pannariaceae	Squamulose	Rock	4.40	-	-	-	25%
61	<i>Parmelinella wallichiana</i> (Taylor) Hale	Parmeliaceae	Foliose	Bark	2.20	2.97	-	-	50%
62	<i>Parmotrema austrosinensis</i> (Zahlbr.) hale	Parmeliaceae	Foliose	Bark	4.62	10.92	7.43	13.81	100%
63	<i>Parmotrema crinitum</i> (Ach.) Choisy	Parmeliaceae	Foliose	Bark	-	3.95	3.73	-	50%
64	<i>Parmotrema grayanum</i> (Hue) Hale	Parmeliaceae	Foliose	Bark	3.80	5.72	3.23	-	75%
65	<i>Parmotrema hababianum</i> (Gyelnik) Hale	Parmeliaceae	Foliose	Bark	3.71	-	2.41	-	50%
66	<i>Parmotrema indicum</i> Hale	Parmeliaceae	Foliose	Bark	-	-	1.81	-	25%
67	<i>Parmotrema margaritata</i> (Hue) Hale	Parmeliaceae	Foliose	Bark	3.63	5.20	-	-	50%
68	<i>Parmotrema mesotropum</i> (Müll. Arg.) Hale	Parmeliaceae	Foliose	Bark	-	-	2.12	-	25%
69	<i>Parmotrema praesorediosum</i> (Nyl.) Hale.	Parmeliaceae	Foliose	Bark	4.24	2.97	2.34	-	75%
70	<i>Parmotrema reticulatum</i> (Taylor) M. Choisy	Parmeliaceae	Foliose	Bark	2.45	-	3.30	-	50%
71	<i>Parmotrema saccatilobum</i> (Taylor) Hale	Parmeliaceae	Foliose	Rock	4.32	3.20	3.23	-	75%
72	<i>Parmotrema subarnoldiides</i> Abb.	Parmeliaceae	Foliose	Bark	4.40	-	3.08	-	50%
73	<i>Parmotrema subinctorum</i> (Zahlbr.) Hale	Parmeliaceae	Foliose	Bark	2.12	2.97	-	-	50%
74	<i>Parmotrema tinctorum</i> Nyl.	Parmeliaceae	Foliose	Bark	7.98	4.98	5.26	-	75%
75	<i>Pertusaria albescens</i> (Huds.) Choisy & Wern.	Pertusariaceae	Crustose	Bark	2.28	6.52	-	-	50%
76	<i>Pertusaria concinna</i> Erichsen	Pertusariaceae	Crustose	Bark	1.10	-	2.41	-	50%
77	<i>Pertusaria leioplacella</i> Nyl	Pertusariaceae	Crustose	Bark	3.38	-	-	-	25%
78	<i>Pertusaria leucosorodes</i> Nyl.	Pertusariaceae	Crustose	Bark	-	-	1.02	-	25%
79	<i>Pertusariamelastomella</i> Nyl.	Pertusariaceae	Crustose	Bark	-	-	1.10	-	25%
80	<i>Pertusaria pustulata</i> (Ach.) Duby	Pertusariaceae	Crustose	Bark	4.0	2.97	-	9.77	75%
81	<i>Physcia aipolia</i> (Ehrh. ex Humb.) Furnr.	Physciaceae	Foliose	Bark	5.8	10.69	6.4	12.5	100%
82	<i>Porina subinterstes</i> (Nyl.) Müll. Arg	Trichotheliaceae	Crustose	Bark	-	-	0.88	-	25%
83	<i>Pyxine petricola</i> Nyl.	Physciaceae	Foliose	Bark	6.58	9.49	5.47	12.07	100%
84	<i>Ramalina baltica</i> Lettau*	Ramalinaceae	Fruticose	Bark	-	2.63	2.12	-	50%
85	<i>Ramalina subpusilla</i> (Nyl.) Krog & Swinscow*	Ramalinaceae	Fruticose	Bark	2.03	-	-	-	25%
86	<i>Ramboldia griseococcinea</i> (Nyl.) Kalb, Lumbsch & Elix	Ramboldiaceae	Crustose	Rock	-	-	1.17	-	25%
87	<i>Reminitzia santensis</i> Tuck.	Graphidaceae	Crustose	Bark	-	-	1.98	-	25%
88	<i>Rinodina oxydata</i> (A. Massal.) A. Massal.*	Physciaceae	Crustose	Rock	-	-	2.05	-	25%
89	<i>Roccella montagnei</i> Bel. Emend. Awas.	Roccellaceae	Foliose	Bark	3.55	-	3.01	-	50%
90	<i>Tephromela atra</i> (Huds.) Hafellner	Tephromelataceae	Crustose	Rock	-	2.69	3.01	-	50%
91	<i>Teloschistes flavicans</i> (Swartz) Norm.	Teloschistaceae	Fruticose	Bark	1.01	-	-	-	25%
92	<i>Trypethelium ochroleucum</i> (Eschw.) Nyl. Var. <i>Pallescens</i> (Fée) Müll. Arg.	Trypetheliaceae	Crustose	Bark	2.64	-	2.87	-	50%
93	<i>Usnea baileyi</i> (Stirt.) Zahlbr*	Usneaceae	Fruticose	Bark	-	1.20	-	-	25%
94	<i>Usnea subflorida</i> (Zahlbr.) Mot.	Usneaceae	Fruticose	Bark	2.80	1.77	-	-	50%
95	<i>Usnea subfloridana</i> Stirton	Usneaceae	Fruticose	Bark	2.72	-	-	-	25%
96	<i>Usnea stigmatoides</i> G. Awasthi	Usneaceae	Fruticose	Bark	3.22	-	-	-	25%
97	<i>Verrucaria margacea</i> (Wahlenb.) Wahlenb.	Verrucariaceae	Crustose	Rock	-	-	-	6.93	25%

Collection sites: 1. HGH: Himadgopalaswamy hills, 2. BRH: Biligirirangana hills, 3. MMH: Malay mahadeshwara hills, 4. SSF: Shivanasamudra falls

Among the 97 species recorded from this region, 28 species are new reports from Karnataka state. Physciaceae was dominated by 18 species under 8 genera, Parmeliaceae with 16 species under 4 genera, followed by Teloschistaceae with 10 species under 2 genera, Pertusariaceae with 7 species under 2 genera and Graphidaceae with 6 species under 3 genera (Figure 2).

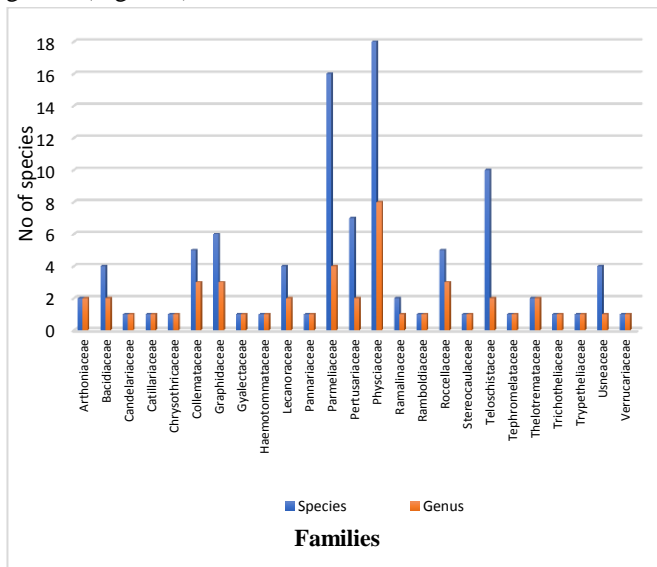


Fig 2: Dominant lichen families with respect to species richness in Chamaranjanagar district

Crustose type growth forms were abundant with 51%, followed by foliose type growth forms with 38%, fruticose type growth forms with 8% and squamulose type growth forms with 1% (Figure 3). High diversity of lichens was encountered in Male Mahadeshwara hills with 67 species, in which crustose growth form was more with 36 species and foliose with 28 species (Figure 4).

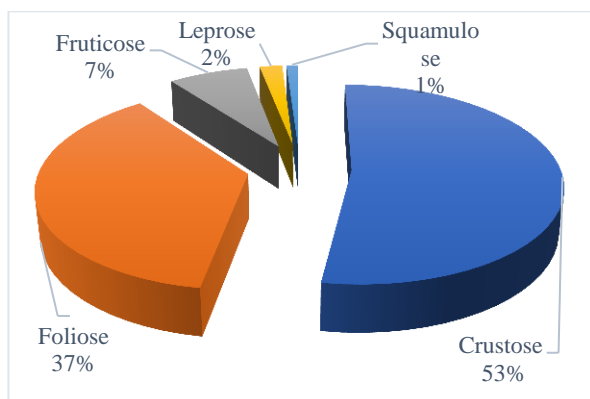


Fig 3: Percentage of different growth forms of lichens in Chamaranjanagar district

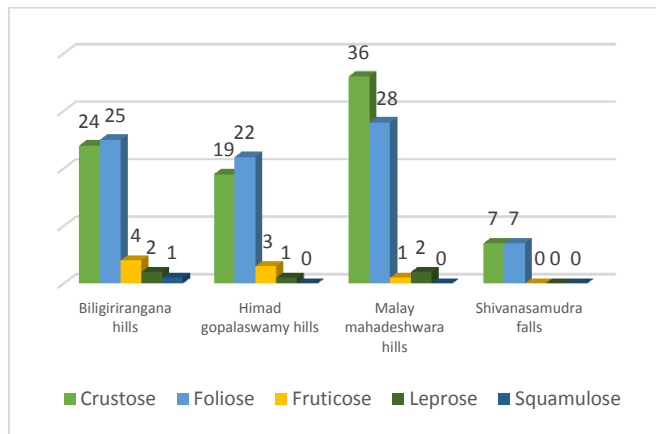


Fig 4: Number of lichen growth forms in each studied locality in Chamaranjanagar district

The different types of lichens recorded in this region were from the mid elevation level (950-1100). The forest type varies from evergreen forests to dry deciduous forests. The next richly dense place with lichen colonization of 55 species was Biligiriranga hills commonly called BR Hills. The forest vegetation types here were; scrub, deciduous, riparian, evergreen, sholas and grasslands. Among all the study sites, BR hills had the high range mountain peaks and at high altitude (1350-1450 m) only few lichens of *Heterodermia* and *Parmotrema* were recorded less density and abundance. Density of macrolichens was more compared to microlichens. But in mid elevation (1100- 1350m) abundance, density, frequency and distribution of lichens was recorded luxuriantly. At low elevation (800-1000m) density and abundance of crustose lichens was more. The next highest elevated region (1500m) is Himadgopaldaswamy hills which is situated in the core area of the Bandipur National Park and is frequented by wildlife. Dense fog predominates and covers the hills round the year, with moist deciduous forest type. In this forest range, density of macrolichens was found to be more with 25 species compared to the microlichens with 20 species at elevation of 1350-1450m). Shivanasamudra falls has a segmented water fall of river Kaveri with Scrub forest. Not much lichen colonization was found, density of lichens was very poor with 14 species.

Among the microlichens from all the regions *Buellia indica*, *Cryptothecia culbersonae*, *Chrysothrix candelaris* *Lecanora chlarotera*, *Graphis* sp., *Pertusaria pustulata* and macrolichens like *Candelaria concolor*, *Dirinaria applanata*, *Dirinaria confluens*, *Flavoparmelia caperata*, *Parmotrema*

austrosinensis, *Parmotrema grayanum*, *Parmotrema praesorediosum*, *Parmotrema tinctorum*, *Physcia aipolia* and *Pyxine petricola* had high Important Value Index. Shannon-Weiner index ranged from 3.85-2.45 and Simpson index of diversity ranged from 0.02-0.09. Among the four studied regions MM Hills harboured luxuriant growth of species with highest Shannon- Simpson index of 3.98 and 0.02 respectively, and less distribution was observed in Shivanasamudra falls with comparatively less Shannon-Simpson index of 2.45 and 0.09 respectively (Table 3).

Table 3: Lichen richness in the study sites of Chamarajanagar district

Site	Locality	Shannon-weiner index	Simpson index of diversity	Total individual	Total number of species
1	Biligiriranga Hills	3.85	0.02	1231	57
2	Himavad Gopaldaswamy Hills	3.49	0.03	897	43
3	Malay Mahadeshwara Hills	3.98	0.02	1422	67
4	Shivanasamudra Falls	2.45	0.09	372	14

IV. DISCUSSION

In the present study, it was observed that, the species richness increased as elevation increases, up to a certain point, creating a "diversity bulge" at middle elevations [16]. Elevation was more important than forest structure in driving taxonomic and functional diversity. While the species richness with increase elevation, decrease in functional diversity revealed that community patterns shift with elevation from random to clustered, reflecting the selection for key shared traits. Higher elevations favoured species with a complex growth form (which takes advantage of high moisture) and asexual reproductive mode (facilitating establishment under low temperature conditions) [17].

As elevation increased, total area decreased; thus, there were more species present at middle elevations than at low and high elevations. There are generally three patterns of species richness; a monotonic decline in species richness from low to high elevation, a hump-shaped pattern with maximum at mid-elevations and a constant from the lowlands to mid elevations followed by a strong decline further up which indicates that the maximum number of species had been confined in the mid elevations [18]. The elevation was also clearly effective on both the number and the composition of

the epiphytic lichen communities. Climatic parameters like; temperature, rainfall, evaporation, are known to be closely related to altitude. For this reason, the number of species was more in the highest zone. The preferences of some species were reported to be concentrated in 1300-1600m and 1800-1900m elevation zones [19].

Families such as Graphidaceae, Thelotremataceae are generally observed to be found commonly in lowland forests [20] which corroborate our study in that, the population of crustose lichens was found to be more in low elevated areas, especially in BR hills and MM hills. Similar observation was reported from Chogoria, a wet forest type in Mt. Kenya forest, where high abundance of crustose micro lichens at lower elevation was observed and macro lichens were abundant at higher altitudes [21]. Further, it was apparent that, the numbers of foliose lichens are increasing with the increase of altitude. In most temperate and boreal forests, with light exposed trees, had richer lichen vegetation than the trees of the interior forest [22]. Mid-elevation peaks had a unimodal peak in diversity at intermediate elevations (4300m) with 25% or more species than at the base and the top of the mountain [23]. In a similar work, the effect of elevation was studied on lichen diversity in seven spatially separated sites of Zanskar valley, in Ladakh region of the Himalayan state of Jammu and Kashmir and found a significant linear relationship between total lichen diversity and elevation, where a gradual decrease in lichen diversity was observed with increase in elevation [24].

Elevational gradients of terricolous lichen species richness in the Western Himalaya and the total species richness showed a unimodal relationship with elevation, where the highest species richness was observed at mid elevations (3,200 m) [25], which is similar to our observation in the present study. Unimodal relationship of lichen species richness with elevation was also reported from Nepal [26], where the maximum modelled total richness occurred in 3100–3400m, whereas the observed maximum richness (144 species) was at approximately 4000m. The lichen diversity in the crowns of trees at mid elevation seems to be somewhat similar to that at lower elevation although tree species are different. At mid elevation, tree trunks get only diffused light while the canopy gets more direct light. The difference in distribution and diversity observed on barks could be mainly due to light condition prevailing at mid elevations [27]. The number of lichen species showed decline towards the high elevation gradient, in which rock

inhabiting species exhibit their dominance in higher altitude while, soil inhabiting lichens dominated in the lower altitude [28].

The majority of the parmelioid genera and species of Taiwan are distributed primarily in submontane-montane elevations (500–2,500 m) located in the meridional climatic zone [29]. Basic groundwork must be comprehended in order to meet the nation's needs and also to strive towards the biotechnology industry. Better lichen sample representation of the lichen should be collected. Furthermore, since the lichens can only be identified through its fruiting bodies, the task of collecting sterile lichens should be avoided [30].

V. CONCLUSION

The present study indicates the richness of lichen diversity in the Chamarajanagar district of Karnataka state. It had varied vegetation with different forest types namely; scrub, dry deciduous, moist deciduous, semi-evergreen, evergreen and shola forests. The study revealed that, as the elevation increased from lowland to mountain peak, the total area also decreased, leading to highest lichen species richness in terms of abundance, density, frequency and distribution at mid elevation, where luxuriant growth of lichen species was observed when compared to lowland and high elevation mountain peaks. The enumeration lichens species gave a baseline of lichen diversity of Chamarajanagar district of Karnataka, which is a lichenologically unexplored region and addition to Indian lichen inventory.

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