RESEARCH ARTICLE

Biodiversity, substrate relationship and distribution of Lichens from Telangana and Andhra Pradesh, India

C. MANOHARACHARY^{1*} and D. NAGARAJU²

¹Department of Botany, Osmania University, Hyderabad 500 007, Telangana, India

²Department of Botany, Government Degree College, Eturnagaram 506 165, District Jayashankar, Telangana, India

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ABSTRACT: Lichens are one of the important most viable and successful alliances of photobiont and Mycobiont in nature. Lichens exist in three different growth forms and are distributed throughout the world including in Polar Regions. There is little or no information on lichen floristics, their distribution and substrate relationship from Telangana and Andhra Pradesh states. The survey (2010-13) of different forest localities resulted in the collection of 65 Lichens which have been identified upto species level. The data pertaining to their substrate relationships, growth forms and distribution has been presented.

Keywords: Diversity, distribution, growth, lichen, substrate

Nature maintains a number of organisms in its specialized ecological niches. One such symbiotic association of fungus and alga in lichens are nature's most remarkable alliances. A lichen is an association of a fungus and photobionts i.e., algae may be either green algae or cyanobacteria. The mycobiont belongs mostly to Ascomycotina and a few either to Basidiomycotina or Deuteromycotina. However, fungal partners may be necrotrophic or mutualistic. It is also observed that the two fungi may be associated with a single photobiont. There may be 300 genera and 22000 species of obligately lichenicolous fungi with a wide range of biological relationship. Around 2000 lichens are reported from India (Nayaka and Upreti, 2013). It is evidenced that a number of mycobionts are involved in lichens. The number of lichenized fungi is about 14000 and 98 percent of these belong to Ascomycotina. The lichenized members of Ascomycotina are of Graphidales, Gyalectales, Peltigerales, Pertusariales and Teloschistales. The fungi belonging to Hymenomycetes and Deuteromycetes also contribute for the lichen formation.

Awasthi (1965, 1960, 1988), Awasthi and Joshi (1977, 1978, 1979), Awasthi and Mathur (1987), Awasthi and Singh (1977), Awasthi and Srivastava (1989), Awasthi and Upreti (1980), Pant and Awasthi (1989), Patwardhan and Kulkarni (1977) and Sinha and Singh (2005) have reported lichens covering Himalayas, Sikkim, Madhya Pradesh, Dehra Dun, Andaman areas, Tamil Nadu, Cochin, Bangalore and other areas of India. No attempt is made to understand the floristics of lichens from Telangana and Andhra Pradesh except for rare reports by Awasthi and Srivastava (1989);

Manoharachary (1979) and Venugopal Rao and Manoharachary (1980), Oksanen (2006), Karatygin *et al.* (2007) and Shyamkumar *et al.* (2011) have elaborated the biology, symbiosis, ecology and biotechnological aspects of lichens. Hariharan (2011) has dealt with conservation of lichens and associated epiphytes to shield the habitats in a changing environment. The above workers emphasized more on the lichen morphology and their taxonomy neglecting substrate relationship, concept of communities and distribution patterns.

The present work forms a significant and an original contribution on the lichen flora associated with some forest localities, their morphology, taxonomy, classification and substrate relationship besides paving the way of exploring the lichen flora from new geographical regions covering some forests of Telangana and Andhra Pradesh. (Ananthagiri Hills (Vikarabad), Yacharam Forest, Nallamalai forest (Srisailem), Tirumala Hills, Ramannapet Hills, Araku valley and Sringavarapu Kota). Type of forests include dry deciduous and scrub jungle forms. Telangana receives 53% of rainfall and Andhra Pradesh gets around 60-70%.

Topography and climate

The new State of Telangana has come into existence on June 2, 2014 after nearly six decade long relentless struggle. The state Telangana has an area of 1,14,840 Sq. Km, bounded by N latitudes 15° 46' and 19° 47' and E longitudes 77° 16' and 81° 43'. The State's geographical area of 1,14, 840 sq.km holds a population of 351.49 lakhs (2011 Census). Andhra Pradesh, a linguistic state formed in November 1956, ranks fifth in terms of area (1, 60, 205 Sq. Km) in India and lies in between 1240'

*Corresponding author: cmchary@gmail.com

and 1950' North longitude with a population of around six crores, Mainly six types of soils manifest in these two states viz: alluvial soils, black-cotton soils, red soils, laterite soils, arenaceous soils and sandy loam soils.

MATERIALS AND METHODS

The investigations were conducted primarily on Lichen collections during 2010-2013, which were deposited with accession numbers (OULH) in Mycology and Plant Pathology, Department of Botany, Osmania University. Lichenological methods were employed for the identification of lichens. The crystal tests and colour reactions on the thallus and apothecia were tested by 10% aqueous solutions of potassium hydroxide (K), bleaching powder (calcium hypochlorite-C), iodine (I) and Steiner's paraphenylenediamine (P) (Hale, 1969). Lichen samples were also analysed for their mineral contents (Prasad and Manoharachary, 1993; Hale, 1983; Sinha and Singh, 2005; Nayaka and Upreti, 2013).

RESULT AND DISCUSSION

Distribution and indicator lichens

Distribution data of lichens with reference to forest localities have been represented in Table 2. Altogether 65 lichens were collected and were found maximum in A.P. The remaining localities such as Scrub Jungle Forest of Ananthagiri Hills (Vikarabad), Nallamalai Forest Range of Srisaillam and Mannanur and also few Scurb Jungle Forest localities of Telangana areas were poorly represented. This data clearly indicates direct correlation between the thickness of vegetation, altitude, rainfall and relative humidity with that of lichen populations. It is also interesting to note that the following are the lichen indicators for different forest localities investigated (Table 1).

Distributions, dominance, quantity of Lichens are dependent on rainfall, temperature, vegetation, Lichen propagule dissemination and growth period.

It is pertinent to mention here that lichens such as *Dirinaria applanata* D.consimilis, *D. picta*, *Heterodermia dissecta*, *Lecanora amorpha*, *Parmelia andina*, *P. glabra*, *P. hababiana*, *P. praesorediosa*, *Physia alba*, *Pyxine cocoas*, *P. petricola* and *Ramalina confusa* have shown greater abundance in the forest localities investigated. These lichens can be considered as bio-indicators. Ecology in modern times has been variously defined. It is the study of reciprocal relations between the organisms and the environment. In an ecological niche, the most tangible element of a plant's environment is its substrate, the material on or in which the lichen grows. In the mycological sense, the substrate often interpreted to mean the nutritive material used by the fungus. However, among lichens, the material supporting lichen thalli is a complex one. Terms such as rock lichens (saxicolous), bark lichens (corticolous) and ground lichens (terricolous) are generally accepted and understood. Identification keys are often based on the substrate classification. The substrate factors such as texture, water relations, chemistry, organic material and temperature affect the lichen substrate ecology. Similar conclusions were drawn earlier by Sinha and Singh (2005) and Tehler (1996).

Substrate relationship

From the present data (Table 2) it is evident that lichens representing diversified genera namely *Buellia*, *Cladonia*, *Dirinaria*, *Graphina*, *Graphis*, *Heterodermia*, *Hyperphyscia*, *Lecanora*, *Lecidea*, *Lecanora*, *Parmelia*, *Pertusaria*, *Physcia*, *Pyxine*, *Ramalina*, *Tylophoran* and *Usnea* were found to be corticolous. It is interesting to note that the saxicolous and terricolous lichens have been poorly represented with rare distribution. Saxicolous

Table 1. Forest localities and lichen indicators

Sl. No.	Forest locality	Name of the Lichen
Telangana		
1.	Ananthagiri Hills, Vikarabad	<i>Dirinaria picta</i> (Sw.) Clem.& Shear
2.	Yacharam Forest	<i>Pyxine cocoas</i> Nyl.
3.	Nallamalai Forest	<i>Pyxine cocoas</i> Nyl.
4.	O.U Campus, Hyderabad	<i>Pyxine cocoas</i> Nyl.
5.	Nallamalai Forest Range, Srisaillam	<i>Parmelia andina</i> Mull.Arg. <i>Physcia alba</i> (Fee.) Mull.Arg.
Andhra Pradesh		
6.	Tirumala Hills	<i>Dirinaria consimilis</i> (Stirton) Awasthi. <i>Parmelia glabra</i> (Schaeerer) Nyl.
7.	Karampudi Hills	<i>Lecanora amorpha</i> Poelt
8.	Kondapalli Hills	<i>Ramalina confuse</i> Awasthi <i>Pyxine petricola</i> Nyl.
9.	ArakuValley	<i>Parmelia hababiana</i> Gyelnik <i>Parmelia praesorediosa</i> Nyl. <i>Heterodermia dissecta</i> (Kurok.) Awas.
10.	Sringavarapukota	<i>Pyxine cocoas</i> Nyl.

Table 2. Substrate relationship and growth forms in Lichens

Name of the lichen	Foliose	Fruticose	Crustose	Substrate	Accession No. (OULH)	Forest locality
<i>Arthrothelium awasthi</i> Patw. & Makhija	-	-	+	Bark	41	6,7
<i>Buellia</i> sp.	+	-	-	Bark	42	1,8,9
<i>Cladonia furcata</i> (Huds.) Schrader	-	+	-	Bark	43	6,7,10
<i>C. gracilis</i> (L.) Willd.	-	+	-	Bark	44	1,2,3,9
<i>C. mitis</i> Sandst.	-	+	-	Bark	45	1,4,5,8
<i>C. rangiferina</i> (L.) Weber ex F.H. Wigg	-	+	-	Bark	46	1,6,7,9
<i>C. tenuis</i> (Florke) Harm	-	+	-	Bark	47	1,3,5,10
<i>Coccocarpia erythroxyli</i> (Spreng.) Swinscow & Krog.	+	-	-	Bark	48	6,7,8
<i>Dirinaria applanata</i> (Fee.) Awas.	+	-	-	Bark	49	7,10
<i>D. confluens</i> (Fr.) Awas.	+	-	-	Bark	50	1,2,3,9
<i>D. consimilis</i> (Stirton)	+	-	-	Bark	51	6,7,8
<i>D. picta</i> (Sw.) Clem. & Shear	+	-	-	Bark	52	4,5,6,9
<i>Diorygma megasporum</i> Kalb. Staiger & Elix	-	-	-	Bark	53	1,9,10
<i>Dyplolabia afzelii</i> (Ach.) A. Massal	+	-	-	Bark	54	1,2,3,10
<i>Glyphis cicatricose</i> Ach.	+	-	-	Bark	55	6,7,8,10
<i>Graphina</i> sp.	+	-	-	Bark	56	3,9,10
<i>Graphis capillacia</i> Stirt.	-	-	+	Bark	57	5,6,7,9
<i>Graphis cocarctata</i> Stirt.	-	-	+	Bark	58	1,2,3,9
<i>Graphis nigroglaucula</i> Leight.	-	-	+	Bark	59	4,6,8
<i>Graphis polystriata</i> Makhija <i>et al.</i>	-	-	+	Bark	60	7,8,9
<i>Hemithelium nakanishianum</i> Patw. & C.R. Kulkarni	-	-	+	Bark	61	1,4,9,10
<i>Heterodermia boryi</i> (Fee) Kr. P. Singh	+	-	-	Leaf	62	6,7,10
<i>Heterodermia diadermata</i> (Taylor) D.D.A	+	-	-	Leaf	63	1,2,3,9
<i>H. dissecta</i> (Kurok) Awas.	+	-	-	Leaf	64	6,7,9
<i>H. leucomela</i> (L.) Poelt.	+	-	-	Leaf	65	3,8,9,10
<i>H. podocarpa</i> (Bel.) D.D. Awasthi	+	-	-	Leaf	66	1,4,5,8
<i>H. pseudospepcicosa</i> (Kurok.) W.L. Culb.	+	-	-	Leaf	67	6,7,9
<i>Hyperphyscia adglutinata</i> (Florke) H. Mayrhofer & Poelt	+	-	-	Bark	68	4,8,9,10
<i>Lecanora alphoplaca</i> (Wahlend.) Ach.	-	-	+	Bark	69	1,2,6,01
<i>L. fimbriatula</i> Stirt.	-	-	+	Bark	70	4,5,6,01
<i>L. indica</i> Zahlbr.	-	-	+	Bark	71	2,8,10
<i>L. muralis</i> (Schreber) Rabenh.	-	-	+	Bark	72	3,9,10
<i>Lecidia</i> sp.	-	-	+	Bark	73	1,4,5,01
<i>Leptogium javanicum</i> Mont.	-	-	+	Bark	74	4,8,9,10
<i>Letrouitia domengensis</i> (Pers). Haf. and Bellem	-	-	+	Bark	75	1,2,3,9
<i>L. subazureum</i> Dube & Makhija	-	-	+	Bark	76	1,5,6,7,8
<i>Parmelia andina</i> Mull. Arg.	+	-	-	Bark	77	3,9,10
<i>Parmelia caperata</i> (L.) Ach.	+	-	-	Bark	78	8,9,10
<i>P. crinata</i> Ach.	+	-	-	Bark	79	1,2,3,9
<i>P. formosana</i> Zalbr	+	-	-	Bark	80	5,6,7,8
<i>P. glabra</i> (Schaerer) Nyl.	+	-	-	Bark	81	1,2,3
<i>P. hababiana</i> Gyelink	+	-	-	Bark	82	4,5,6,9
<i>P. mussorensensis</i> Awas.	+	-	-	Bark	83	1,2,3,10
<i>P. prasorediosa</i> Nyl.	+	-	-	Bark	84	1,2,3,10
<i>P. sancte-angelii</i> Lynge	+	-	-	Bark	85	5,6,7,10
<i>P. tinctorum</i> Despr. Ex Nyl.	+	-	-	Bark	86	4,6,7,9

Contd....

Name of the lichen	Foliose	Fruticose	Crustose	Substrate	Accession No. (OULH)	Forest locality
<i>Parmelinella simplicitor</i> (Hale) Elix & Hale	+	-	-	Bark	87	6,8,9,10
<i>Parmotrema tinctorum</i> (Nyl.) Hale	+	-	-	Bark	88	6,7,8
<i>Pertusaria</i> sp.	-	-	+	Bark	89	5,6,7,9
<i>Pertusaria quassiae</i> (Fee) Nyl.	-	-	+	Bark	90	
<i>Phaeophyscia hispidula</i> (Ach.) Moberg	-	+	-	Bark	91	5,8,9,10
<i>Phaeophyscia pyrrophora</i> (Poelt) D.D. Awasthi & Joshi	-	+	-	Bark	92	6,7,8,9
<i>Physcia alba</i> (Fee.) Mull. Arg.	-	+	-	Bark	93	6,7,8,10
<i>Physcia clementei</i> (Sm. in Sm. & Sow.) Lynge	-	+	-	Bark	94	6,7,8,10
<i>P. stellaris</i> (L.) Nyl.	+	-	-	Bark	95	1,9,10
<i>P. tribacia</i> (Ach.) Nyl	+	-	-	Bark	96	3,9,10
<i>Pyxine cocoas</i> Nyl.	+	-	-	Rock	97	1,2,3,9
<i>P. consocians</i> Vain.	+	-	-	Rock	98	1,5,6,7,9
<i>P. petricola</i> Nyl.	+	-	-	Rock	99	1,9,10
<i>Ramalina confuse</i> Awas.	-	+	-	Leaf	100	9,10
<i>Trepethelium eluteriae</i> Spreng.	+	-	-	Bark	101	9,10
<i>Tylophoron moderatum</i> Nyl.	+	-	-	Bark	102	8,9,10
<i>Usnea</i> sp.	-	+	-	Branch	103	8,9,10
<i>Usnea complanata</i> (Mull. Arg.) Motyka	-	+	-	Branch	104	8,9,10
<i>Usnea ghattensis</i> G. Awasthi	-	+	-	Branch	105	8,9,10

1=Ananthagiri hills; 2=Yacharam; 3=Nallamalai Forest Range, Mannanoor; 4=Osmania University Campus; 5=Srisaillam; 6=Tirumala hills; 7 =Karampudi; 8=Kondapalli; 9=Rannapet hills; 10=Araku valley; 11=Sringavarapukota; +=Present; - =Absent; OULH= Osmania University Lichen Herbarium

lichens were represented by *Lecanora hellmichiana*, *Parmelia praesorediosa* and *Pyxine petricola*, *Cladonia furcata*, *C. mitis* and *C. rangiferina* were recognized as terricolous.

Growth forms

A number of lichenologists have segregated lichens based on growth forms. Growth form means the overall shape and configuration of the lichen thallus. There are three major types of growth forms: foliose (leaf-like), fruticose (shrubby or hair-like) and crustose (crust-like). Detailed investigations have been made on the collected lichens with special reference to growth forms (Table 2). Altogether 65 lichens were encountered. Out of which 38 are foliose lichens, 12 are fruticose lichens and 15 are crustose lichens. It is interesting to find that the foliose lichens representing *Dirinaria*, *Heterodermia*, *Hyperphyscia*, *Parmelia*, *Physcia* and *Pyxine* formed the dominant lichen flora. Interestingly the lichens have existed mostly in one growth form.

Taxonomy

Lichen classification seems to be an unsolved problem and needs an indepth analysis and critical evaluation. Though substantial literature has accumulated on lichens from all over the world, the Indian literature is fragmentary. In India, some workers (Awasthi, 1961, 1965, 1973, 1975a,b, 1976, 1980, 1981a,b, 1988; Awasthi and Joshi 1977, 1978; Awasthi and Singh 1973, 1975; Awasthi

and Uperti 1980; Patwardhan and Kulkarni 1977a,b; Roychoudhury 1977 and Singh (1973) have surveyed the forest localities and prepared a checklist of lichens for limited geographical regions. Awasthi (1973, 1975a, b, 1976, 1980, 1981a,b, 1986, 1988) has been an active researcher in the field of lichenology and contributed significantly to the lichen flora of some areas in India and Nepal. His contributions have been outstanding for lichen genera such as *Pyxine*, *Dirinaria*, *Anaptychia*, *Heterodermia*, *Lepogium*, *Phaeographana* and *Rhizocarpon*. It is pertinent to mention here that the study of lichen flora has been neglected in Telangana and Andhra Pradesh but for randomised reports (Manoharachary, 1979; Venugopalrao and Manoharachary, 1980). Therefore, an attempt has been made to survey the lichen flora existing in some forest localities of Telangana and Andhra Pradesh. Three years survey (2010-2013) revealed the richness of 65 lichens collected from eleven forest localities. The collected lichens were represented by seventeen genera viz., *Buellia*, *Cladonia*, *Dirinaria*, *Graphina*, *Graphis*, *Heterodermia*, *Hyperphyscia*, *Lecanora*, *Lecidea*, *Letrouitia*, *Parmelia*, *Pertusaria*, *Physcia*, *Pyxine*, *Ramalina*, *Tylophoron* and *Usnea* of which, *Parmelia* was the dominant genus followed by *Cladonia*, *Lecanora*, *Physcia*, *Dirinaria*, *Heterodermia*, *Graphis* and *Pyxine*. All the collected lichens from new additions to the lichen flora of Telangana and Andhra Pradesh.

The earlier lichenologists have identified the lichens based on spore types, structure of fruit bodies and type

Fig. 1. (A). *Dirinaria applanata* (Fee.) Awas., (B). *Parmelinella simplicitor* (Hale) Elix & Hale., (C). *Phaeophysciapyrophora* (Poelt), D. Awasthi & Joshi, (D). *Usnea ghattensis* G. Awasthi., (E). *Lecanora fimbriatula* Strirt., (F). *Glyphis cicatricose* Ach.

of alga. Most of the lichen systematists were not familiar with the fungal groups. There is voluminous literature dealing with the vascular plants but much to be gained with references to lichens. Chemical tests, crystal tests, morphology, anatomy, growth form and reproductive structures were the parameters used by different workers (Awasthi 1980; Culberson and Kristinsson 1970; Hale 1969; Hawksworth and Hill 1988) in identifying the lichens. In the present investigation, similar criteria was also used in the identification of forty eight lichen species. Though a number of classifications are proposed (Hale, 1983; Hale and Culberson, 1970; Poelt, 1973a,b; Zahbruckner, 1926), no commonness was observed for foliose, fruticose and crustose growth forms, respectively.

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