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Species Diversity and Host Specificity of Epiphytic Lichens: A Case Study in Two Forest Stands of Central India

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ABSTRACT

This paper describes the species diversity and host specificity of epiphytic lichens in two forest stands of Central India. The Amarkantak Hills supported 96 species, belonging to 30 genera and 18 families, from 18 sites, while the Achanakmar Wildlife Sanctuary supported 24 species, belonging to 14 genera and 11 families form 6 sites. In Amarkantak Hills with high altitudes and a heterogenous, moist climate is responsible for higher alpha and beta diversity, while the deciduous forests in the Achanakmar Wildlife Sanctuary generally have a lower altitude and a drier climate which limit the lichen growth. Both forests exhibit luxuriant growth of crustose lichens: the Amarkantak Hills Forest area has 59.79% crustose, 38.14% foliose and 2.06% leprose species, while the Achanakmar Wildlife Sanctuary has 83% crustose, by 12.5% leprose and 4.16% foliose species. Comparison of species richness showed that the bark of *Shorea robusta* supports the highest lichen diversity among all the phorophytes in both forest stands. Most lichen communities have a wide range of host preference, while few individual species were host specific. Climatic factors, such as moist and dry condition, together with pH, substrate texture, and forest types appear to be responsible for host specificity and luxuriant growth of lichens.

Key Words: Epiphytic Lichens; Host Specificity; Species Diversity; Forests; Climatic Factors; Vegetation; India.

INTRODUCTION

Lichens are vital components of the ecosystem, in terms of substrata, shelter, food, nutrient cycles and succession (Gradstein 1992). Since lichens are sensitive, and widely accepted as indicators of air quality, climate change, etc., large-scale data on lichens and environmental variables that determine their distribution are an integral component of many global conservation programmes.

The physical and chemical nature of the substratum/host is important for the establishment of lichens, and markedly influences their survival. The lichens are relatively more sensitive to their immediate surroundings, living within a microenvironment on a specific substratum/host. Several studies have demonstrated the host specificity of corticolous lichen communities on a range of tree species, enumerating their vertical distribution and succession (Barkman 1958, Hale 1955, Beals 1965, Culberson 1955). Several environmental factors, such as light conditions (Palmqvist and Sundberg 2000), water availability (Lange 1980) and bark proper-ties (Gauslaa and Holien 1998), are important for the growth of epiphytic lichens.

Only a few studies of lichen distribution on different phorophytes have been made in India (Upreti 1996, Upreti and Chaterjee 1999a, 1999b, Satya et al. 2005). Dudgeon (1923) studied the succession of epiphytic lichens on *Quercus leucotricophora* in the Mussoorie area of the Himalayas. Other studies on the ecology of Indian lichens have been carried out (Upreti 1995, 1997, 1998, Negi and Gadgil 1996a, Negi and Upreti 2000, Negi and Gadgil 1996b, 2002, Negi 2000, Nayaka and Upreti 2002, Balaji and Hariharan 2004).

Ecological studies in India have been mostly concerned with lichens of the temperate and alpine Himalayan regions. The present investigation deals with the lichen diversity and host specificity in a tropical region of central India in the 14th Biosphere Reserve of India with the objectives of (1) determining alpha and beta diversity in two different forest stands of the Biosphere Reserve, (2) understanding the pattern of abundance, diversity and distribution of species in two forests, (3) determining data whether individual species of epiphytic lichens show host specificity on dominant tree species in both forest areas, (4) determining whether communities or co-occurring groups of epiphytic lichens show host specificity on different trees in both forest areas, 5) comparing species richness of lichen epiphytes on different trees in both forest areas, and 6) comparing and constrasting the epiphytes – phorophytes in both forest areas.

MATERIALS AND METHODS

Study Area

The Achanakmar Amarkantak Biosphere Reserve (AABR) lies between 22˚ 15' to 22˚ 58' N and 81˚ 25' to 82˚ 5' E, and is sp;read over 3835.51 sq. km area. The Achanakmar Wildlife Sanctuary (AWLS) of AABR is the core zone with 551.15 sq km. Amarkantak Hills (AHs) are located at 22º 67º N 81’75º E with altitudes in the range of 303-808 m (Figure 1). The area is comprised of bauxite and laterite soil dominated by *Shorea robusta* forest along with *Mallotus philippensis*, *Ficus glomerata*, *Grewia* sp., and *Mangifera indica*. The AWLS lies in the eastern flank of the Maikal range of Satpura Mountain between 22º23' - 22˚35' N and 81˚ 34'-81˚ 55' E at an elevation of 439-488 m (Figure 1), it is an ‘Indus-Ganges Monsoon’ forest (Udvardy 1975) and dominated by *Mallotus phillipensis*, as well as *Shorea robusta*, mixed forest and bamboo forest.

Data Analysis

The frequency distributions of lichen species was computed from the presence / absence in sampling units. Alpha diversity was calculated by the Shannon Weaver Index (H') (Shannon Weaver, 1949) $H' = \sum_{pi} 1n_{pi,}$ where, *pi* = density of the i^{th} species / density of all species. The beta diversity was calculated followng Whittaker (1960) as:

BD = Number of species exclusive to the locality A + Number of species exclusive site B / S.

Jaccard’s similarity index and PCA were analyzed by statistical software INDOSTAT for both study sites. Jaccard’s similarity index was used to compare epiphytes on different host trees in the two forest areas. In both areas, three 10x10 m quadrats were laid randomly. The lichen species on different phorophytes within the quadrat were analysed from base up to chest height.

The collected specimens were identified by their morphological, anatomical, and chemical characters and are preserved in the lichen herbarium of National Botanical Research Institute Lucknow (LWG), India. Specimens were identified with the help of Awasthi (1988, 1991) Upreti et al. (1991) and Divakar (2001). Some lichens were identified with the help of aliphatic and phenolic metabolites which were analysed by thin-layer chromatographic methods as described by Walker and James (1980).

Habitat Analysis

For pH analysis of the bark, small pieces of bark (0.5 g) were removed from the tree trunk with a knife or chisel. The bark samples were placed in a 10 mL beaker with 5 mL of deionized water, and sealed to prevent carbon dioxide contamination. The samples were left for four hours with occasional shaking. The mixture was then filtered and the pH was measured with a Digital pH meter - model 111. To assess water holding capacity, bark samples of similar size (triplicates for each tree) were oven dried at 105˚C for 24 hours, weighed, and stored in deionized water for one hour. Samples were weighed again after removal of excess water with a paper towel. The water holding capacity was expressed as:

WHC = (Wet weight-Dry weight / Wet weight) x 100.

RESULTS

Diversity

Amongst the 96 lichen species recorded from 18 sites of the AHs forest area, 58 are crustose, 37 foliose and two leprose. Maximum diversity (30 species) was found at site 10, representing 30.92% of all the species recorded from this area (Figure 2A). Amongst the 24 species recorded from six sites in the AWLS forest area, 20 were

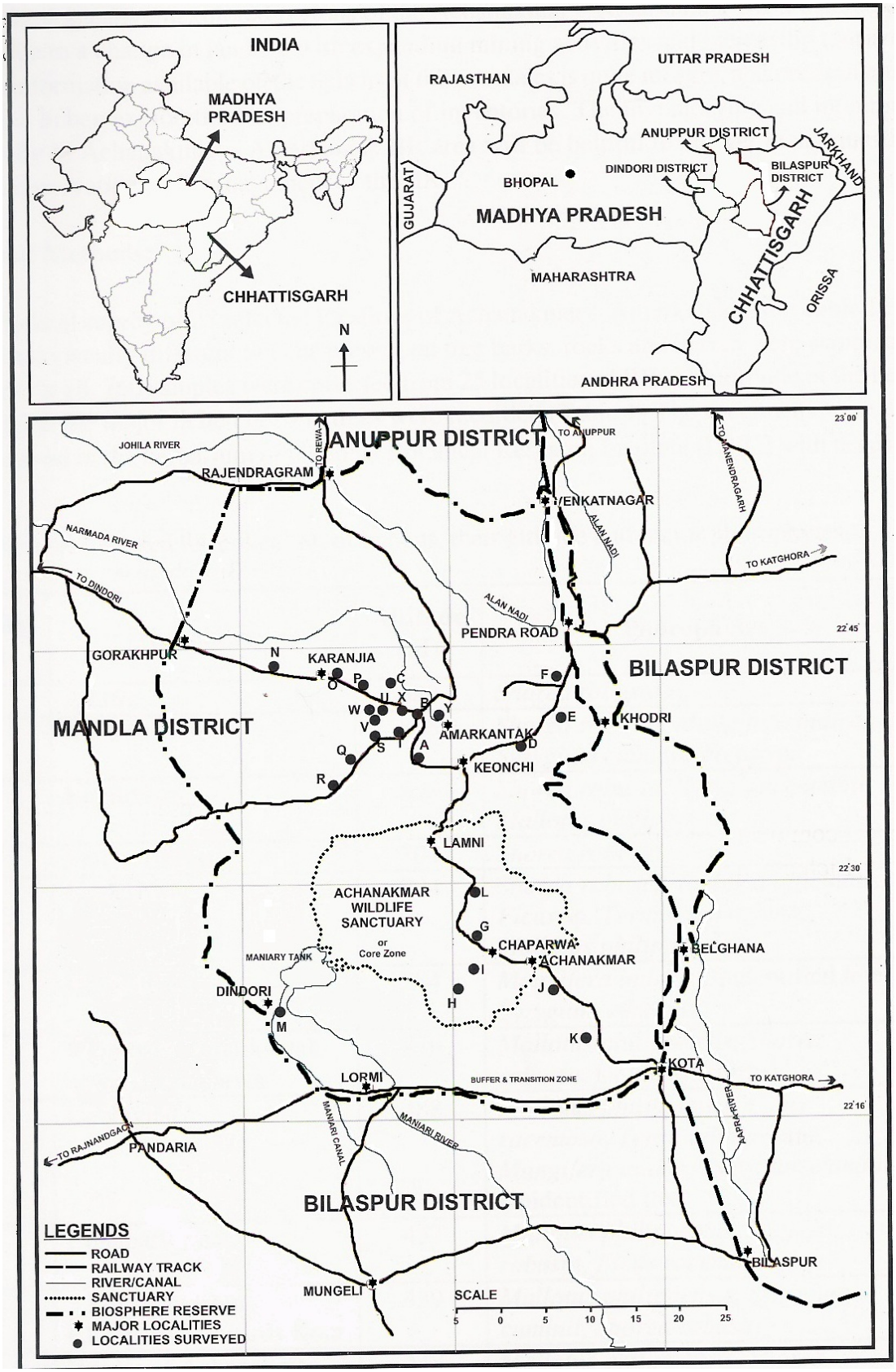

Figure 1. Map showing sites of Amarkantak Hills and Achanakmar Wildlife Sanctuary explored for lichens within India

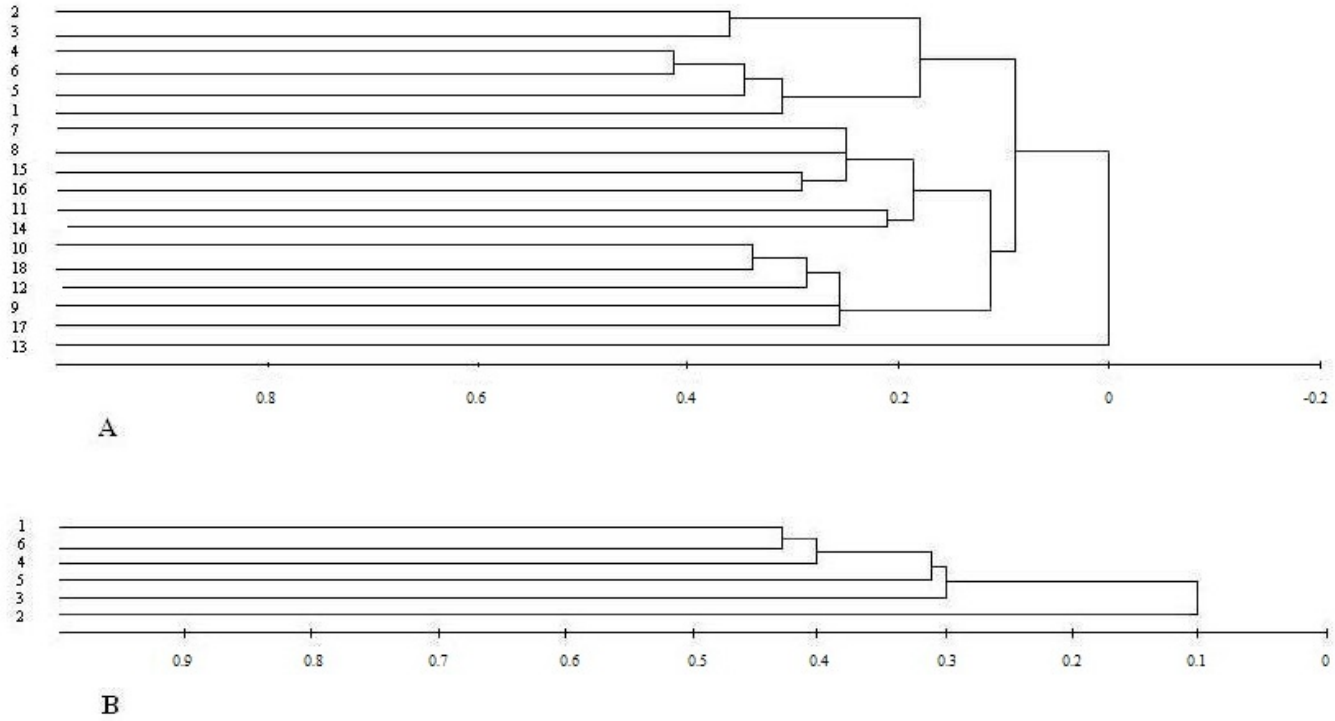

Figure 2. Complete linkage clusters for 18 sites of AHs (A) and 6 sites of AWLS (B), based on Jaccard's Similarity Index. For sites 1-18, refer to Tables 1A and B

crustose, three leprose and one foliose. Here, maximum diversity (15 species) was recorded at site 5,that is 62.50% of all the species recorded from this area (Figure 2 B).

Comparing alpha diversity expressed by the species richness in both forest areas, site 10 (3.11) undoubtedly has the highest species richness followed by site 18 (3.08) and 12 (2.85) in AHs forest area (Table 1 A). Site 10 with dense and large tracts of *Shorea robusta* trees has a higher species richness than the sites (12 and 18) with a mixed forest of *Mangifera indica*, *Eucalyptus* sp., *Grewia* sp. and *Shorea robusta*. The AWLS forest area in general has a poor lichen diversity. Site 5 has the highest species richness (2.52), followed by site 6 (2.34, Table 1 B). Localities in the periphery of the AWLS were richer in corticolous lichens in comparison to the central areas at sites 2 and 3. The presence of lichens favoring the dominant phorophytes *Mallotus philippensis* and *Shorea robusta*, in lesser proportion in the central area seems to be the major cause for the poor representation of corticolous lichens in site 2. A rocky area under the shade of trees provides a suitable habitat for saxicolous lichens at site 3.

It is clear from Table 2 A and B that there is a huge turn-over of (unshared) species between all sites studied. Whittaker's measure of beta diversity is >0.4 in AHs and >0.3 in the AWLS forest area. Site 13 has the highest beta diversity or unshared species in the AHs area. A similar result is also demonstrated with the Jaccard similarity index (Figures 2 A and B). All the sites in AHs exhibit very less similarity (<0.4). Figure 2A illustrates the clustering of 18 studied sites of AHs forest on the basis of species composition and Jaccard similarity index. Four clusters can be discerned, the maximum similarity occurring at 0.35% which includes sites 2, 3, 4, 6, 5 and 1 (cluster 1), while clusters 2 and 3 show similarities at 0.21 and 0.25% and include sites 7, 8, 15, 16, 11 and 14, and 10, 18, 12, 9 and 17 respectively, but cluster 4, including site 13, does not show any similarity with others (Figure 2A). In the AWLS forest area, site 2 has a high beta diversity, the maximum similarity occurred again in cluster 1 at 0.4% which includes sites 1, 6 and 4, followed by cluster 2 (sites 5 and 3) and cluster 3 (site 2) at 0.3% and 0.1% respectively (Figure 2 B).

Table 1. Sites selected for lichen collection along with number of species encountered and species richness (Shannon Weaver index): **(A)** Amarkantak Hills **(B)** Achanakmar Wildlife Sanctuary

Locality code	Name of locality	Species number	Species richness
A: Amarkantak Hills			
1 / A	Attaria	12	2.03
2 / B	Kabirchabutra	4	1.21
3 / C	Kapildhara	11	2.15
4 / D	Mai ki Bagia	9	1.87
5 / E	Jwaleshwar	17	2.61
6 / F	Durgadhara	15	2.26
7 / M	Dindori forest rest house	8	1.92
8 / N	7 km before Karanjia from Gorakhpur	7	1.67
9 / O	Karanjia forest rest house	13	2.31
10 / P	Jagatpur forest rest house	30	3.11
11 /Q	Chauradader	11	2.32
12 /R	Tarwartola	27	2.85
13 /S	13 km before Kabirchabutra from Chauradader	5	1.56
14 /T	8 km before Kabirchabutra from Chauradader	6	2.09
15 /U	Khurkhuridader VALCO mining site plantation area	7	1.86
16 / V	Khurkhuridader VALCO mining site virgin forest	15	2.45
17 / W	Khurkhuridader	13	2.47
18 / X	Near Kabirchabutra	28	3.08
B: Achanakmar Wildlife Sanctuary			
1 / G	5 km before Chaparwa from Amarkantak	10	1.98
2 / H	Gabhighat	5	1.49
3 / I	Chaparwa naala	7	1.72
4 / J	5 km away from Chaparwa towards Kota	8	1.79
5 / K	Border of Achanakmar Wildlife Sanctuary	15	2.52
6 / L	22 km before Keonchi from Chaparwa	14	2.34

The lichen species of AHs forest area were relatively restricted in distribution, while a few taxa in AWLS are widespread. *Lecanora tropica,* frequently occurred in AHs while *Cryptothecia lunulata* and *Letrouitia transgressa* are frequently found in the AWLS forest area. The value of the IVI differed from site to site in AHs forest. The maximum IVI was recorded at site 14 in AHs (Table 3 A), while the AWLS forest areas generally contribute a similar IVI value (Table 3 B). It can be concluded from Figure 3A that the PCA vector I explains 17% of the variation, followed by PCA vector II with 11% variation, in AHs forest area. In the AWLS forest area, the PCA vector I contribute 32.46% variation, followed by PCA vector II with 21.85% variation (Figure 3 B). The PCA of AHs forest area is related to its heterogeneity, while that of the AWLS forest is related to the homogeneity of the climatic conditions.

Species Richness on Phorophytes

Out of 521 trees, analyzed for the study a total of 369 (70.82 %) exhibit the growth of lichen thalli. Amongst these 369 trees, about 60 trees of *Acacia nilotica* investigated, total 45 (75 %) trees of *A. nilotica* exhibit occurrence of lichens thalli followed by 227 (69. 63 %) out of 326 trees of *Shorea robusta* in AHs forest (Table 4A). All of the 12 *Pongamia pinnata* trees and six *Mallotus philippensis* trees exhibit 100% of lichen growth in AHs. Among the various trees of the forest, *Shorea robusta*, one of the commonest phorophytes of Ahs, supports the maximum growth of 73 lichen species, followed by *Mangifera indica* and *Mallotus philippensis* with 15 and 14 species respectively. *Prosopis* bears a single species, while *Bauhunia* sp., *Eucalyptus* sp. and *Syzygium cuminii* have only two species on each area. The Shannon diversity index also shows that the bark of *Shorea robusta* supports the highest lichen species richness (3.94), followed by *Mangifera indica* (2.52) (see Table 4A).

The AWLS forest contains different phorophyte species along with the dominant phorophyte of *Mallotus phillipensis*. Of the 126 trees surveyed, only 86 (68.25%) support lichen growth. Amongst 49 trees of *Mallotus phillipensis*, 46 (93.88%) show the presence of lichens, followed by 26 (63.41%) out of 41 trees of *Shorea robusta* (Table 4B). *Shorea robusta* supports the highest diversity (17 species), followed by *Mallotus philippensis* with 11 species. The Shannon diversity index also shows that *Shorea robusta* has the highest species richness (2.58), followed by *Mallotus philippensis* (2.15) (see Table 3B). Both *Prosopis* sp. (1.03) and *Syzgium cuminii* (1.01) trees support a low diversity of lichen species.

Species Similarity Between Phorophytes

The similarity index compares only the quantity of each species found in both forest areas. When similarity for epiphytes is compared between tree species, it is clear

Table 2. Whittaker's measure of Beta diversity between pair of sites in Amarkantak Hills forest **(A)**, and Achanakmar Wild Life Sanctuary forest (B). For sites 1-18, refer to Table 1A and B

A. AH Forest

	Sampling Sites																	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
1		0.62	0.57	0.52	0.53	0.65	0.9	1	0.9	0.95	0.91	0.85	0.88	1	0.89	0.93	1	0.85
2			0.47	0.69	0.64	0.68	0.83	1	0.88	0.94	0.87	0.94	1	1	0.82	0.89	1	0.94
3				0.5	0.59	0.46	0.89	1	0.92	0.9	0.82	0.84	1	0.88	0.89	0.92	1	0.85
4					0.48	0.42	1	1	0.91	1	1	0.94	1	1	1	1	0.91	0.89
5						0.52	0.92	1	0.94	0.88	0.93	0.82	1	1	0.92	0.88	0.94	0.74
6							1	1	0.93	1	1	0.95	1	1	1	1	1	0.91
7								0.6	0.71	0.79	0.68	0.89	0.85	0.71	0.6	0.74	0.81	0.82
8									0.8	0.89	1	1	0.83	0.85	0.86	0.91	0.9	0.94
9										0.59	0.75	0.85	0.89	0.68	0.6	0.64	0.69	0.71
10											0.71	0.55	0.94	0.78	0.79	0.61	0.59	0.49
11												0.63	0.88	0.65	0.67	0.69	0.67	0.74
12													0.94	0.88	0.88	0.76	0.7	0.56
13														0.82	0.83	0.9	0.89	0.94
14															0.69	0.81	0.79	0.71
15																0.55	0.6	0.77
16																	0.57	0.63
17																		0.66

B. AWLS Forest

	1	2	3	4	5	6
1		0.60	0.41	0.33	0.44	0.33
2			0.50	0.69	0.60	0.68
3				0.33	0.55	0.43
4					0.39	0.45
5						0.38

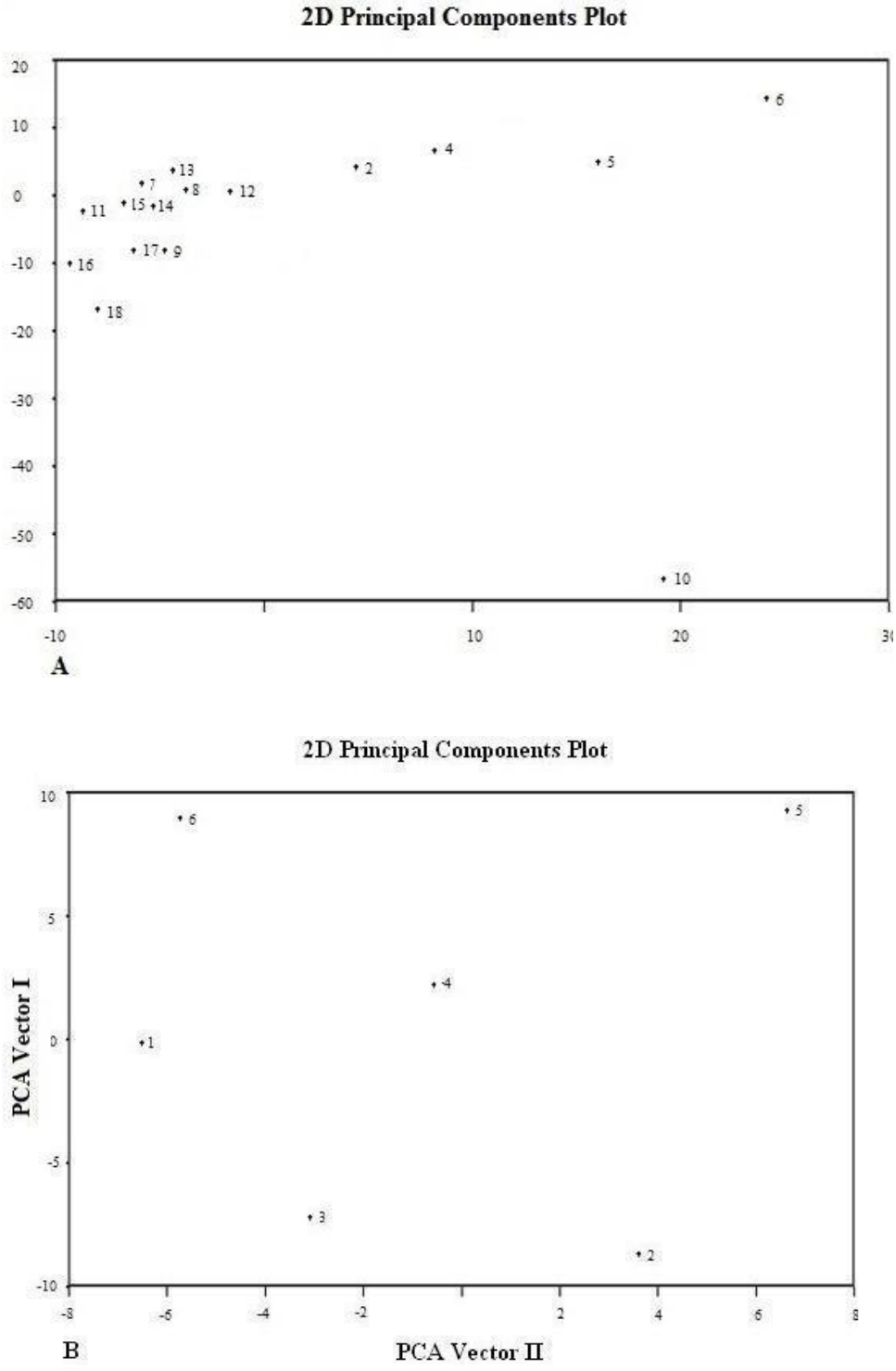

Figure 3. PCA of lichen species composition between all sites of AHs (A) and AWLS (B). For sites 1-18, refer to Table 1 A and B.

that lichen epiphytes distinguish clearly among some tree species but not all (Table 5). Figures 4A and B illustrate the similarity of all 14 and 8 phorophytes on the basis of species abundance in both the forest areas. According to Euclidean distance similarity, three clusters were found in AHs (Figure 4A): cluster 1 has the largest number of phorophytes, including *Syzygium cuminii*, *Pongamia pinnata*, *Cassia fistula*, *Phyllanthus emblica* and *Acacia*

Table 3. Importance Value Index (IVI) of all lichen species in AHs **(A)** and AWLS forest area (**B)**, For sites 1-18, refer to Table 1A and 1B

Lichen Taxa	Collection Sites																	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Arthothelium nigrodiscum Patw. & Makh.					6.12													
Cryptothecia culbersoniae Patw.& Makh.					6.12													
C. lunulata (Zahlbr.) Makh. & Patw.											14.08							
C. involuta Stirton			13.25	11.82		8.57												
C. sp.		34.22	4.96	23.48	13.3	45.94												
Bacidia millegrana (Taylor) Zahlbr.										3.32								
B. rubella (Hoffm.) Massal.										3.32								
B. alutacea (Krempleh.) Zahlbr.	7.94												50					
B. psorina (Nyl. In Hue) Pant & Awasthi													100					
Collema subflaccidum Degel.																		4.05
Leptogium denticulatum F. Wilson												3.78						
L. cyanescens (Ach.) Körber												3.78						
Leptogium victorianum F. Wilson																8.83		
L. furfuraceum (Harm.) Sierk																		
L. austro-americanum (Malme) Dodge			19.68	11.82														
L. marginellum (Swartz) Gray												3.78						8.10
Chrysothrix candelaris (L.) Laundon	7.94																	
C. chlorina (Ach.) Laundon														33.33				8.21
Schadonia indica Upreti & Nayaka										15.5							12.9	8.21
Graphis proserpens Vainio										6.64								
G. schizograpta Müll. Arg.	18.68		19.68	6.31	23.3	8.57												
Graphina panhalensis Patw. & C.R. Kulk.						8.57												
G. platycarpa (Eschw.) Zahlbr.						11.21												
Lecanora tropica Zahlbr						55.93	45.36	21.62	11.37			100	33.33	16.67	34.26	12.9	15.77	
L. coronulans Nyl.								26.44										
L. sulphurescens Fée																		8.10
L. flavidofusca Müll.Arg.									7.555									
L. achroa Nyl.							32.02	26.44										
L. alba Lumbsch										3.323								
L. iseana Räsänen						8.57												
L. perplexa Brodo	7.94		19.68	6.31	12.85	8.57												
Lecanora leproplaca Zahlbr.					6.12													
Lecidella sp.						8.57												
Lepraria lobificans Nyl.					6.12					12.74								4.05
Phyllopsora corallina (Eschw) Müll.Arg.					6.12					12.74								4.05

Table 3 (continued)

Lichen Taxa	Collection Sites																	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Phyllopsora sp.																		
Letrouitia transgressa (Malme) Haf. & Bellem.										3.32								
Pyxine cocoes (Swartz.) Nyl.	50.96	97.32	33.78	52.53	30.65	45.94			25.97									
P. berteriana (Fée) Imsh.	32.03		26.5	23.65	20.87	32.47												4.05
P. subcinerea Stirton								13.22		3.32								
P. petricola Nyl.											12.49							
Buellia stillingiana Steiner							16.01		29.18	3.32	12.49			33.33				8.10
B. sp.																		
B. curtisii (Tuck.) Imsh.in Brodo						8.57												
B. pusillula (Nyl.) Malme .	7.94																	
B. almorensis S. Singh & Awasthi	26.59	34.22			18.45	8.57												
Heterodermia diademata (Taylor) Awas.										6.65	12.49			33.33				
H. speciosa (Weelfen) Trevis.														33.33				4.05
H. angustiloba (Müll. Arg.) Awasthi																		4.05
H. hypocaesia (Yasuda) Awasthi																8.83		
H. pseudospeciosa (Kurok.) Culb.																		8.10
H. obscurata (Nyl.) Trevisan																		
Physcia tribacia (Ach.) Nyl.					20.87													
P. dimidiata (Arn.) Nyl.																8.83		
Phyaeophyscia hispidula (Ach.) Moberg					6.12													4.05
Dirinaria aegialita (Afz. ex. Ach.) Moore										6.65							32.24	17.61
D. consimilis (Stirton) Awas.	7.94																	
Rinodina sophodes (Ach.) Massal.							16.01	13.22										
Pyrenula subglabriuscula Vainio	7.94																	
Pertusaria acuta Müll. Arg.			19.68	11.82	6.12												12.9	
P. amarkantakana Sriv. Awasthi									12.74						8.83		4.05	
P. amara (Ach.) Nyl.														16.67				
P. concinna Erichsen								7.55	8.05						8.83		8.10	
P. coronata (Ach.) Th. Fr.								7.55	6.65						8.83		4.05	
P. cinchonae Müll. Arg.									7.55	3.32								
P. dehiscens Var. *depressior* Müll.Arg.										3.32								
P. quassiae Fée						16.01		32.48	11.37					33.29	25.43	12.9	8.10	
P. leioplacella Nyl.										3.32						8.83	12.9	
P. melastomella Nyl.										3.32								
P. pustulata (Ach.) Duby									7.55	3.32								

Table 3 (continued)

Lichen Taxa	Collection Sites																	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
P. subdepressa Mull.arg.	32.03		45.49	41.22	12.25	27.18												8.10
P. subochracea Stirton											12.49		50					
P. rigida Müll.Arg.									7.55	6.65	12.49						25.81	
P. rimosa Awsathi & Sriv.													50					
P. coccoed (Ach.) Nyl.						8.57												
P. himalayensis Awasthi & Srivastava					6.12	8.57												
P. punctata Nyl.																8.83		
P. splendens Awasthi & Sri																	12.9	
P. sp.										3.32								
Bulbothrix setschwanensis (Zahlbr.) Hale										3.32							12.9	4.05
B. isidiza (Nyl.) Hale									3.32	24.98					8.83	12.9	15.77	
B. tabacina (Mont. & Bosch) Hale																		
Canoparmelia texana (Tuck.) Elix & Hale																		
C. aptata (Kremp.) Elix & Hale										3.32								
Parmotrema crinitum (Ach.) Choisy																		4.05
P. praesorediosum (Nyl.) Hale	7.94				28.23		32.02				24.98				16.67	8.83		
P. tinctorum (Despr. ex Nyl.) Hale								22.76	14.14	37.66			33.33	50.19	30.43	12.9	4.05	
P. andinum (Müll. Arg.) Hale								28.61	7.55									
P. kamatii Patw. & Prabhu										3.32								
P. mesotropum (Müll. Arg.) Hale							16.01											
P. upretii Divakar																		4.05
Parmelinella wallichiana (Taylor) Elix & Hale							16.01				24.98							11.72
Hypotrachyna infirma (Kurok.) Hale																		
Protoblastenia russula (Ach.) Räsänen									15.11						33.29			
Calolaca bassiae (Ach.) Zahlbr.										24.98				33.29	30.43	25.81		
C. citrina (Hoffm.) Th. Fr.								13.22										

Table 3 (continued)
Table B.

Lichen Taxa	Collection Sites					
	1	2	3	4	5	6
Arthothelium abrorme (Ach.) Müll. Arg.					9.151	
A. pycnocorpoid Müll. Arg.					9.151	
Arthonia recedens Stirton			16.2	19.07		
Cryptothecia lunulata (Zahlbr) Makh. and Patw.	16.86	28.57	39.73	19.07	9.151	10.09
Bacidia alutacea (Krempelh.) Zahlbr.	8.43					
B. rubella (Hoffm.) Massal.		28.57				
Chrysothrix chlorina (Ach.) Laundon.	28.83					
Graphina penhalensis Pat. and Kulkarni	8.43		16.2	19.07	9.151	10.09
G. platycarpa (Eschw.) Zahlbr.						20.18
Haematomma puniceum (Sm. Ex Ach.) Massal.			16.2			10.09
Lecanora leproplaca Zahlbr.					9.151	
L. imshaugii Brodo						10.09
L. perplexa Brodo	16.86			19.07	22.58	20.18
Letrouitia transgressa (Malme) Haf. Bellem	16.86	57.14	16.2	19.07	9.151	10.09
Pyrenula fuscoolivacea Vainio	8.43					10.09
P. subglabriscula Vainio	8.43					
Buellia almorensis S. Singh and Awasthi	8.43	28.57	32.41		9.151	10.09
B. curtisii (Tuck.) Imsh. in Brodo.					9.151	10.09
Pyxine cocoes (Swartz.) Nyl.	35.79		63.05			10.09
Pertusaria acuta Müll. Nyl.				38.13	27.58	
P. himalayensis Awasthi and Srivastava					13.3	10.09
P. subdepressa Müll. Arg.	42.65			66.54	35.88	48.67
Lepraria sp.						10.09
Lepraria lobificans Nyl.		57.14			13.3	

Table 4. Total number of trees observed for each phorophyte species, the number of encountered lichen species and species richness
(A): Amarkantak Hills (AHs) and (B): Achanakmar Wild Life Sanctuary

Phorophytes species	Number of trees observed	Number of lichen bearing trees	Diversity index
A			
Shorea robusta	326	227	3.94
Mangifera indica	14	6	2.52
Syzygium cuminii	3	2	1.37
Ficus sp.	5	4	2.09
Mallotus philippensis	6	6	2.47
Acacia nilotica	60	45	1.43
Pongamiya pinnata	12	12	1.42
Grewia sp.	30	28	1.40
Eucalyptus sp.	10	17	1.36
Delonix sp.	12	4	1.38
Caccia fistula	16	8	2.12
Phyllanthus emblica	20	7	2.19
Prosopis sp.	4	1	1.39
Bauhunia sp.	3	2	1.34
B			
Shorea robusta	41	26	2.58
Mallotus philippensis	49	46	2.15
Acacia nilotica	8	2	1.16
Delonix sp.	5	3	1.67
Prosopis sp.	5	3	1.03
Syzgium cuminii	7	2	1.01
Ficus sp.	3	1	1.49
Mangifera indica	8	3	1.37

nilotica, and species of *Prosopis*, *Bauhinia*, *Eucalyptus*, *Delonix*, *Ficus*, and *Grewia* with a very low similarity at a distance of 7, while clusters 2 and 3 include only one phorophyte, with distances of 13 and 32, respectively.

In the AWLS, three clusters can be recognized: cluster 1 includes phorophytes of *Acacia nilotica*, *Prosopis* sp., *Mangifera indica*, *Syzygium cuminii*, *Delonix* sp. and *Ficus glomerata*, at a distance of 25. Cluster 2 includes only one phorophyte *Mallotus philippensis* at a distance of 43, while cluster 3 includes *Shorea robusta* at a distance of 116 (Figure 4B).

Table 5 shows the occurrence of epiphytic lichen species on host trees in both forest areas. Each phorophyte varied greatly in its nature and texture of bark which thus supported some characteristic lichen species.

A total of 14 common epiphytic lichen species occurring on *Shorea robusta* tree trunks in both forest are: *Cryptothecia lunulata, Bacidia rubella, B. alutacea, Chrysothrix chlorina, Lecanora perplexa, Lepraria lobificans, Letrouitia transgressa, Pyxine cocoes, Buellia almorensis, B. curtisii, Pyrenula subglobriscula, Pertusaria acuta, P. subdepressa* and *P. himalayensis.* 55 species were found only on *Shorea robusta* trees in AHs, while two species were found in AWLS only.

Only one species, *Pertusaria acuta,* was common to both the forests. A total of 12 species, *Leptogium cyanescens, Graphis schizograpta, Lecanora tropica, Buellia stillingiana, Heterodermia diademata, Pertusaria cinchonae, P. quassiae, P. rimosa, P. punctata, Parmotrema tinctorum, P. praesorediosum* and *P. andinum*, were characteristic of *Mangifera indica* in AHs forest area. While the AWLS forest show a single species *Pertusaria acuta*. *Graphis shizograpta, Pertusaria cinchonae, P. rimosa* and *P. punctata* were restricted to *Mangifera indica.*

Graphina penhalensis and *Lepraria lobificans* are the only two species common on *Syzygium cumini* in both areas. In addition, *Arthothelium pycnocarpoides* was found only in AWLS. *Syzygium cuminii* has only one species, *Graphina penhalensis,* in AHs area exhibit total absence of lichens.

Six common epiphytic lichen species found on *Ficus glomerata* trunks in both forest area are: *Graphina penhalensis, Letrouitia transgressa, Pyxine cocoes, Pertusaria himalayensis, Cryptothecia lunulata* and *Graphina platycarpa.* Only two species, *Haematomma puniceum* and *Arthonia recedens,* were restricted to *Ficus glomerata* in AWLS, while in AHs forest area *Ficus glomerata* is devoid of lichens

Ten epiphytic lichen species common in both AHs and the AWLS on *Mallotus philippensis* are: *Cryptothecia lunulata, Graphina penhalensis, Lecanora perplexa, L. leproplaca, Letrouitia transgressa, Pyxine cocoes, Buellia almorensis, Pertusaria acuta, P. subdepressa* and *P. coccoed.*

Cryptothecia sp., *Lecanora iseana* and *Physcia tribacia* are restricted to AHs forest, while *Arthonia recedens, Lecanora imshaugii* and *L. subimmersa* were found only in the AWLS forest area. *Cryptothecia* sp., *Lecanora iseana, L. imshaughii, L. leproplaca, L. subimmersa, Pertusaria coccoed* and *Physcia tribacia* growing only on *Mallotus philippensis* trunks.

Table 5. Distribution patter of epiphytic lichens on different phorophytes in both forest areas. X= species occurrence, 0= species are absent, Sh ro= *Shorea robusta, Ma in=Mallotus philippensis, Sy cu= Syzygium cuminii, Fig glo=Ficus glomerata, Ma ph= Mallotus philippensis, Ac ni=Acacia nilotica, Po pi= Pongamia pinnata, Gr* sp.= *Grewia* sp., *Eu* sp.= *Eucalyptus* sp., *De* sp.= *Delonix* sp., *Ca fi=Caccia fistula, Ph em=Phyllanthus emblica, Pr* sp.= *Prosopis* sp., *Ba* sp.= *Bauhinia* sp.

Lichen taxa	Forest Area		Host species													
	AH s	AWLS	*Sh ro*	*Ma in*	*Sy cu*	*Fi glo*	*Ma ph*	*Ac ni*	*Po pi*	*Gr* sp	*Eu* sp	*De* sp	*Ca fi*	*Ph em*	*Pr* sp	*Ba* sp
Arthothelium abnorme (Ach.) Müll.Arg.	0	X	0	0	0	0	0	0	0	0	0	0	0	X	0	0
A. pycnocarpoides Müll.Arg	0	X	0	0	X	0	0	0	0	0	0	0	0	0	0	0
A. nigrodiscum Patw. & Makh.	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
Arthonia recedens Stirton	0	X	0	0	0	X	X	0	0	0	0	0	0	0	0	0
Cryptothecia culbersoniae Patw. & Makh.	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
C. lunulata (Zahlbr.) Makh. & Patw.	X	X	X	0	0	X	X	0	0	0	0	0	0	0	0	X
C. involuta Stirton	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
C. sp.	X	0	0	0	0	0	X	0	0	0	0	0	0	0	0	0
Bacidia millegrana (Taylor) Zahlbr. Arg.	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
B. rubella (Hoffm.) Massal.	X	X	X	0	0	0	0	0	0	0	0	0	0	0	0	0
B. alutacea (Krempleh.) Zahlbr.	X	X	X	0	0	0	0	0	0	0	0	0	0	0	0	0
B. psorina (Nyl. In Hue) Pant & Awasthi	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
Collema subflaccidum Degel.	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
Leptogium denticulatum F. Wilson	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
L. cyanescens (Ach.) Körber	X	0	X	X	0	0	0	0	0	0	0	0	0	0	0	0
L. victorianum F. Wilson	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
L. furfuraceum (Harm.) Sierk	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
L. austro-americanum (Swartz) Gray	X	0	0	0	0	0	0	0	0	0	0	0	0	X	0	0
L. marginellum (Swartz) Gray	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
Chrysothrix candelaris (L.) Laundon	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
C. chlorina (Ach.) Laundon	X	X	X	0	0	0	0	0	0	0	0	0	0	0	0	0
Schadonia indica Upreti & Nayaka	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
Graphis proserpens Vainio	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
G. schizograpta Müll. Arg.	X	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0
Graphina penhalensis Pat. Kulkarni	X	X	0	0	X	X	X	0	0	0	0	0	0	0	0	0
G. platycapa (Eschw.) Zahlbr.	X	X	0	0	0	X	0	0	0	0	0	0	0	X	0	0
Haematomma puniceum (Sm ex Ach) Massal.	0	X	X	0	0	X	0	0	0	0	0	0	0	0	0	0
Lecanora tropica Zahlbr	X	0	0	X	0	0	0	X	X	0	X	0	X	X	0	0
L. coronulans Nyl.	X	0	0	0	0	0	0	X	0	0	0	0	0	0	0	0
L. sulphurescens Fée	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
L. flavidofusca Müll.Arg.	X	0	0	0	0	0	0	0	X	0	0	0	0	0	0	0

Table 5 (continued)

Lichen taxa	Forest Area		Host species													
	AH s	AWLS	*Sh ro*	*Ma in*	*Sy cu*	*Fi glo*	*Ma ph*	*Ac ni*	*Po pi*	*Gr* sp	*Eu* sp	*De* sp	*Ca fi*	*Ph em*	*Pr* sp	*Ba* sp
L. achroa Nyl.	X	0	0	0	0	0	0	0	0	0	0	0	X	0	0	0
L. alba Lumbsch	X	0	0	0	0	0	0	0	0	0	0	0	X	0	0	0
L. iseana Räsänen	X	0	0	0	0	0	X	0	0	0	0	0	0	0	0	0
L. perplexa Brodo	X	X	X	0	0	0	X	0	0	0	0	0	0	X	0	0
L. imshaugii Brodo	0	X	0	0	0	0	X	0	0	0	0	0	0	0	0	0
L. leproplaca Zahlbr.	X	X	0	0	0	0	X	0	0	0	0	0	0	0	0	0
L. subimmersa	0	X	0	0	0	0	X	0	0	0	0	0	0	0	0	0
Lecidella sp.	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepraria lobificans Nyl.	X	X	X	0	X	0	0	0	0	0	0	0	0	0	0	0
L. sp. 0	X	X	0	0	0	0	0	0	0	0	0	0	0	0	0	
Phyllopsora corallina (Eschw.)Müll. Arg.	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
P. manipurensis (Müll.Arg.) Gotth	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
Letrouitia transgressa (Malme) Haf. & Bellem.	X	X	X	0	0	X	X	0	0	0	0	0	0	0	0	X
Pyxine cocoes (Swartz.) Nyl.	X	X	X	0	0	X	X	0	0	0	0	0	0	0	0	0
P. berteriana (Fée) Imsh.	X	0	X	0	0	0	0	X	0	0	0	0	0	0	0	0
P. subcinerea Stirton	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
P. petricola Nyl.	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
Buellia stillingiana Steiner	X	0	X	X	0	0	0	0	X	X	0	0	X	0	0	0
B. albatrior (Nyl.) Szat.ex.Awasthi	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
B. curtisii (Tuck.) Imsh. in Brodo	X	X	X	0	0	0	0	0	0	0	0	0	0	0	0	0
B. pusillula (Nyl.) Malme.	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
B. almorensis S. Singh & Awasthi	X	X	X	0	0	0	X	0	0	0	0	0	0	0	0	0
Heterodermia diademata (Taylor) Awas.	X	0	X	X	0	0	0	0	0	0	0	0	0	0	0	0
H. speciosa (Weelfen) Trevis.	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
H. angustiloba (Müll. Arg.) Awasthi	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
H. hypocoesia (Yasuda) Awasthi	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
H. pseudospeciosa (Kurok.) Culb.	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
H. obscurata (Nyl.) Trevisan	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
Physcia tribacia (Ach.) Nyl.	X	0	0	0	0	0	X	0	0	0	0	0	0	0	0	0
P. dimidiata (Aru.)Nyl.	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5 (continued)

Lichen taxa	Forest Area		Host species													
	AH s	AWLS	*Sh ro*	*Ma in*	*Sy cu*	*Fi glo*	*Ma ph*	*Ac ni*	*Po pi*	*Gr* sp	*Eu* sp	*De* sp	*Ca fi*	*Ph em*	*Pr* sp	*Ba* sp
Phyaeophyscia hispidula (Ach.) Moberg	X	0	0	0	0	0	0	0	0	0	0	0	0	X	0	0
Dirinaria aegialata (Afz. in Ach.) Moore	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
D. consimilis (Stirton) Awas.	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
Rinodina sophodes (Ach.) Massal.	X	0	0	0	0	0	0	X	0	0	0	0	X	0	0	0
Pyrenula subglobriscula Vainio	X	X	X	0	0	0	0	0	0	0	0	0	0	0	0	0
P. fuscoolivacea Vainio	0	X	X	0	0	0	0	0	0	0	0	0	0	0	0	0
Pertusaria acuta Müll. Arg.	X	X	X	X	0	0	X	0	0	0	0	0	0	X	0	0
P. amarkantakana Sriv. Awasthi	X	0	X	0	0	0	0	0	0	0	X	0	0	0	0	0
P. amara (Ach.) Nyl.	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
P. concinna Erichsen	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
P. coronata (Ach.) Th. Fr.	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
P. cinchonae Müll. Arg.	X	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0
P. dehiscens Var. *depressior* Müll.Arg.	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
P. quassiae (Fée)	X	0	X	X	0	0	0	0	X	0	0	X	0	0	0	0
P. leioplacella Nyl.	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
P. melastomella Nyl.	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
P. pustulata (Ach.) Duby	X	0	X	0	0	0	0	0	0	0	0	X	0	0	0	0
P. subdepressa Mull.Arg.	X	X	X	0	0	0	X	0	0	0	0	0	0	0	0	0
P. subochracea Stirton	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
P. rigida Müll.Arg.	X	0	X	0	0	0	0	0	X	0	0	0	0	0	0	0
P. rimosa Awsathi & Sriv.	X	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0
P. coccoed (Ach.) Nyl.	X	X	0	0	0	0	X	0	0	0	0	0	0	0	0	0
P. himalayensis Awasthi &Srivastava	X	X	X	0	0	X	0	0	0	0	0	0	0	X	0	0
P. punctata Nyl.	X	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0
P. splendens Awasthi & Sri	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
P. sp.	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
Bulbothrix setschwanensis (Zahlbr.)Hale	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
B. isidiza (Nyl.) Hale	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
B. tabacina (Mont. & Bosch) Hale	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
Canoparmelia texana (Tuck.) Elix & Hale	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5 (continued)

Lichen taxa	Forest Area		Host species													
	AH s	AWLS	*Sh ro*	*Ma in*	*Sy cu*	*Fi glo*	*Ma ph*	*Ac ni*	*Po pi*	*Gr* sp	*Eu* sp	*De* sp	*Ca fi*	*Ph em*	*Pr* sp	*Ba* sp
C. aptata (Kremp.) Elix & Hale	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
Parmotrema crinitum (Ach.) Choisy	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
P. praesorediosum (Nyl.) Hale	X	0	X	X	0	0	0	0	0	X	0	0	0	0	X	0
P. tinctorum (Despr. ex Nyl.) Hale	X	0	X	X	0	0	0	0	0	X	0	X	0	0	0	0
P. andinum (Müll. Arg.) Hale	X	0	0	X	0	0	0	X	0	0	0	0	0	0	0	0
P. kamatii Patw. & Prabhu	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
P. mesotropum (Müll. Arg.) Hale	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
P. upretii Divakar	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
Parmelinella wallichiana (Taylor) Elix & Hale	X	0	X	0	0	0	0	0	0	0	0	0	X	0	0	0
Hypotrachyna infirma (Kurok.) Hale	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0
Protoblastenia russula (Ach.) Räsänen	X	0	0	0	0	0	0	0	0	X	0	0	0	0	0	0
Caloplaca bassiae (Ach.) Zahlbr.	X	0	X	0	0	0	0	0	0	0	0	0	0	X	0	0
C. citrina (Hoffm.) Th. Fr.	X	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0

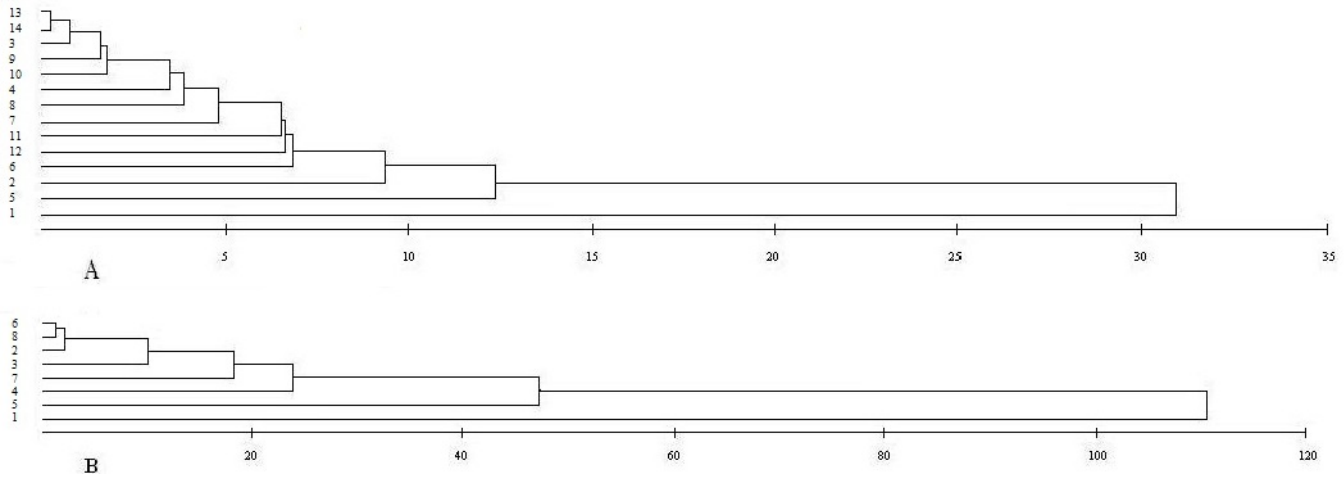

Figure 4. Complete linkage clusters between all phoropytes of AHs (A) and AWLS (B)

Acacia nilotica which only grows in AHs forest area bears *Lecanora tropica, L. coronulaus, Pyxine berteriana, Rinodina sophodes* and *Parmotrema andinum.* The crustose lichen *Lecanora coranulaus* was the only characteristic species found on *Acacia nilotica.*

Pongamia pinnata has five lichen species, *Lecanora tropica, L. flavidofusca, Buellia stillingiana, Pertusaria quassiae* and *P. rigida,* in AHs area only. *Lecanora flavidofusca* is restricted to *Pongamia pinnata* trunks. *Grewia* sp. in AHs area only supports *Buellia stillingiana, Parmotrema praesorediosum*, *P. tinctorum*, and *Protoblastenia russula*, the latter restricted to this phorophyte.

Eucalyptus trees, found only in AHs, support *Pertusaria amarkantana* and *Lecanora tropica* near the bases of their trunks.

Delonix sp., known only in AHs forest, supports the following characteristic lichen species: *Pertusaria quassiae*, *P. pustulata* and *Parmotrema tinctorum.*

Cassia fistula supports *Lecanora tropica, L. achroa, L. alba, Buellia stillingeana, Rinodina sophodes* and *Parmellinella wallichiana* in AHs area only, with *Lecanora alba* and *L. achroa* restricted to this tree.

Graphina platycarpa, *Lecanora perplexa*, *Pertusaria acuta* and *P. himalayensis* were common on *Phyllanthus emblica* in both forests areas. *Arthothelium abnorme* is restricted to the AWLS area, while *Leptogium austro-americanum*, *Lecanora tropica*, *Phaeophyscia hispidula* and *Caloplaca bassiae* were found in AHs forest area.

Prosopis sp. supports only *Parmotrema praesorediosum* in AHs forest area. *Bauhinia* sp. supports *Cryptothecia lunulata* and *Letrouitia transgressa* in both the forest area.

DISCUSSION

The higher alpha diversity in the moist deciduous forest of AHs area is due to the favourable environmental conditions, moist habitat and higher altitude. Pinokiyo et al. (2008) also concluded that altitude and humidity were the key factors controlling the diversity and distribution of lichens within the climatically heterogenous and altitudinally varied landscape of the Mehao Wildlife Sanctuary in north-east India. In addition, the substratum particularly the bark of deciduous trees is a more attractive substratum for lichen species than the bark of pine (Barkman 1958). In contrast, the dry deciduous forests, particularly the Achanakmar Wildlife Sanctuary, have lower altitudes and a drier climate which are limiting factors for lichen growth in the sanctuary.

The number of species (or any other higher ranks of taxonomic organization) in a site (species richness or alpha diversity) and their change in composition across different habitat types (species turnover or beta diversity) within a landscape are important parameters of biodiversity that have wide applications in, for example, environmental monitoring and conservation evaluation (Magurran 1988, Pressey et al. 1994, Negi 1999). In the present study, lichen assemblages depend upon the host specificity and climatic condition.

Both forest areas studied have high alpha diversity on *Shorea robusta* (Table 2 A and B) together with high species richness. *S. robusta* is a suitable phorophyte for the luxuriant growth and development of crustose lichens. Out of 64 species recorded from this tree in various forests sites of India, 42 are crustose (Satya et al. 2005). This study clearly indicates the influence of microclimatic condition, altitude and vegetation on the diversity of lichens.

The present study revealed that the AHs forest area has much varied phorophyte flora in comparison to the AWLS forest area. It is also experimentally determined that the, carrier phorophytes is of primary importance since the properties of the tree can strongly influence the lichen vegetation, and different tree species can support different lichen assemblages (Barkman 1958, Bates and Brown 1981, Hawksworth and Rose 1970). Phorophytic preference and bark properties are important factors for the growth of epiphytic lichens (Gauslaa and Haien 1998, Loppi et al. 2002a, Loppi and Frati 2004).

The pH of bark may influence the distribution of lichens on a tree. Du Rietz (1945) reported that the number of species on a tree is correlated with pH (acidic bark having fewer species than alkaline bark). In the present study, all epiphytic lichens were collected from the acidic bark having a pH range of 4.5 to 5.5. The pH differences were not significant when comparison of lichen diversity were made between the two study areas. The water holding capacity of bark ranges of both the forest trees were also not significant. The interactions of water relations with pH and bark texture (hardness and roughness) are important in determining species composition of epiphytic communities of bryophytes and lichens (Culberson 1955, Hale 1965). This study has determined that rough barked trees support many more epiphytic species of lichens than smooth bark. Rough bark provides more microhabitats, and places for humus and water to accumulate. The proportionately high representation of lichens on *Shorea robusta* is probably due to its rough fissured bark.

There are few species of lichens which were present in both areas but only occur on a given species of tree in one area or the other area. Schmitt and Slack (1990) compared the specificity of epiphytic lichens and bryophytes in two USA forest types and concluded that very few species were host specific, but that most communities of lichens, of bryophytes, and of both combined, were specific to particular tree species. Exceptionally, there is evidence that the epiphytes change hosts in different climatic regimes even when the same host trees are presents (Hale 1955).

The frequency-based study revealed that *Parmotrema praesorediosum*, *P. tinctorum* and *Pertusaria amrkantakana* occurred frequently on *Shorea robusta* in AHs, while *Cryptothecia lunulata*, and *Letrouitia transgressa* were frequent on *Mallotus philippensis* in the AWLS area. Therefore these lichens can be considered as indicator species for these phorophytes in the studied forests. According to Barkman (1955) and Almborn (1948), trees that are "rich" in one area or under certain conditions may be "poor" when the area or conditions are different.

The shade demanding cyanolichens, such as *Leptogium cyanescens*, *L. denticulatum*, *L. chloromelum*, *L. furfuraceum*, *L. austroamericanum* and *L. marginellum*, are indicative of the moist and shady condition in AHs forest at a higher altitude range (400-808 m). While the lower altitude (303-488 m) in the AWLS forest is devoid of these lichens. Wolseley and Hudson (1997a) [not in refs.] also reported such species changed above 1500m altitude in the montane Fagaceous forest in Thailand.

The comparative studies of common and uncommon species in both the forests on different phorophytes showed that the texture of bark and forest type together with climatic conditions play a major role for host specificity and species richness for lichens in both forest areas studied. As with the studies of Studlar (1982), it is clear from the above observations that climate and geography play important roles in determining the make-up of epiphytic communities in the study areas.

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