

Epiphytic lichen diversity in a Reserve Forest in southern Assam, northeast India

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Abstract: The present work describes lichen diversity in a Reserve Forest in southern Assam, northeast India, situated in the Indo-Burma biodiversity Hotspot. A total of 55 species distributed in 26 genera and 15 families were enumerated during the study. Two growth forms, crustose and foliose, were found. The crustose and foliose forms contributed 89 and 11 % of total species, respectively. Graphidaceae and Pyrenulaceae were the dominant families, which together constituted more than 50 % of populations. *Pyrenula*, *Sarcographa* and *Graphis* were the genera, which together accounted for approximately 30 % of the total lichen species. A total of 46 new species were encountered which were hitherto not reported from Assam state. Two species were found to be endemic to the Eastern Himalayan region and another four to the Indian region. The rich lichen diversity in a small forested area indicates the need for more such exploration in the region.

Resumen: El presente trabajo describe la diversidad de líquenes en una reserva forestal en el sur de Assam, noreste de la India, situada en el Punto Caliente de Biodiversidad Indo-Birmanio. Durante el estudio se enumeraron en total 55 especies distribuidas en 26 géneros y 15 familias. Se encontraron dos formas de crecimiento, costrosos y foliosos. Las formas costrosas y las foliosas contribuyeron con 89 y 11 % del total de especies, respectivamente. Graphidaceae y Pyrenulaceae fueron las familias dominantes y en conjunto constituyeron más de 50 % de las poblaciones. Los géneros *Pyrenula*, *Sarcographa* y *Graphis* representaron en conjunto alrededor de 30 % del total de las especies de líquenes. Se encontró un total de 46 nuevas especies que hasta la fecha no habían sido reportadas del estado de Assam. Se encontró que dos especies son endémicas de la región Himalaya Oriental y otras cuatro de la región India. La rica diversidad de líquenes en un área forestal pequeña indica la necesidad de aumentar este tipo de exploración en la región.

Resumo: O presente trabalho descreve a diversidade dos líquenes numa Reserva Florestal no Sul de Assam, nordeste da Índia, situado no ponto focal de biodiversidade Indo-Birmânia. Um total de 55 espécies distribuídas por 26 géneros e 15 famílias foram enumeradas durante o estudo. Duas formas de crescimento, crostosa e foliosa, foram encontradas. As formas crostosas e foliosas contribuíram com 89 e 11 % do total das espécies, respectivamente. As Graphidaceae e Pyrenulaceae foram as famílias dominantes, que no seu conjunto, contribuíram com mais de 50 % das populações. Os géneros *Pyrenula*, *Calenia* e *Graphis* foram os que juntos representaram cerca de 30 % do total de espécies de líquenes. Foram encontradas um total de 46 novas espécies, que até então não se encontravam identificadas no Estado de Assam. Duas espécies foram consideradas endémicas da região Leste dos Himalaias e outras quatro para a região Indiana. A rica diversidade de líquenes numa pequena área florestada indica a necessidade de mais explorações deste género na região.

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Key words: Eastern Himalaya, endemic species, Innerline Reserve Forest, lichen flora.

Introduction

The northeast region of India, situated at the confluence of Indo-Malayan, Indo-Chinese and Indian bio-geographical realms, is one of the richest biodiversity zones of India. It serves as a geographical gateway for much of India's flora and fauna and is also part of the Indo-Burma Hot spot (Myers *et al.* 2000). The region has been able to retain a significant proportion of its biodiversity owing to long years of isolation and the difficult terrain. Information about the lichen biodiversity in this region is far from complete and there may be still many undiscovered species. Deforestation is a major environmental issue which may cause disappearance of many lichen species without being studied. India is home to an estimated 89,450 described species of all living organisms, accounting for about 7.3 percent of the global biodiversity. However, data on most of these is highly scattered and not easily accessible. The lack of readily accessible information on 'how much' of 'what' bioresources occur 'where' has become a limiting factor in conservation planning and converting our biowealth into economic wealth. The present study attempts to gather baseline information about the lichens within the Innerline Reserve Forest in southern Assam, northeast India, where deforestation and other anthropogenic pressures are causing the degradation of important plant resources including lichens.

Despite harbouring a rich lichen diversity, the northeast region of India is grossly under explored. The region has a humid climate and plenty of rain in most of the areas. The mountainous topography and the moisture-laden monsoon winds blowing across the Bay of Bengal appear to be congenial for the luxuriant growth of lichens. The topography and varied altitude also contributes towards the rich lichen diversity and its endemism. The region is exceedingly rich in lichens, mosses and liverworts (Ramakantha *et al.* 2003).

Materials and methods

Study area

The study area is situated in the Barak valley in southern Assam. The state of Assam can be

divided into three major physiographic divisions: the Brahmaputra valley, the hills of Karbi Anglong and North Cachar, and the Barak Valley. The Brahmaputra valley supports famous vegetation association like *Dipterocarpus macrocarpus* - *Shorea assamica* - *Mesua ferrea* and the Barak valley supports the *Mesua ferrea* - *Dipterocarpus turbinatus* - *Palaquium polyanthum* vegetation association (Chatterjee *et al.* 2006). The Barak Valley is a swampy plain interspersed with low hills. The two major valleys are separated from each other by the watershed of the Shillong plateau and the Barail ranges.

The present study was performed during the winter of 2005 in a selected forest patch of about 50 km² near Loharbond, about 30 km from Silchar town (Fig. 1). The forest patch is a part of Innerline Reserve Forest covering a total area of about 920 km² in Assam-Mizoram border under Cachar and Hailakandi Forest Divisions. The selected study area is about 5 % of the total stretch of the reserve forest in Assam. It is situated at an altitude of 112 m and is located between 24° 30' N and 24° 35' N latitude, and between 92° 45' E and 92° 50' E longitude. The topography consists entirely of sporadic hillocks and associated valleys. Important host tree species include *Artocarpus chama*, *A. heterophyllus*, *Palaquium polyanthum*, *Kayea floribunda*, *Castanopsis hystrix*, *Eugenia jambolina* and *Terminalia chebula*.

The forest is surrounded by local Bengali and Hindi-speaking people and tribal communities (mainly Mizo, owing to the vicinity of border areas of Mizoram state). These people are dependent on the forest for collection of fuel wood and other non-timber forest products. Innerline Reserve Forest is among the proposed network of protected areas (wild life sanctuary) in northeast India. The reserve forest, along with Kathakal and Barak Reserve Forests, is one of the 46 important bird areas of Assam (Chatterjee *et al.* 2006). Further, the presence of Phayre's leaf monkey (*Trachypithecus phayrei*) along with other important fauna has been reported from this forest (Bose 2003).

Climate

The region has subtropical, warm and humid climate with three principle seasons - summer, mon-

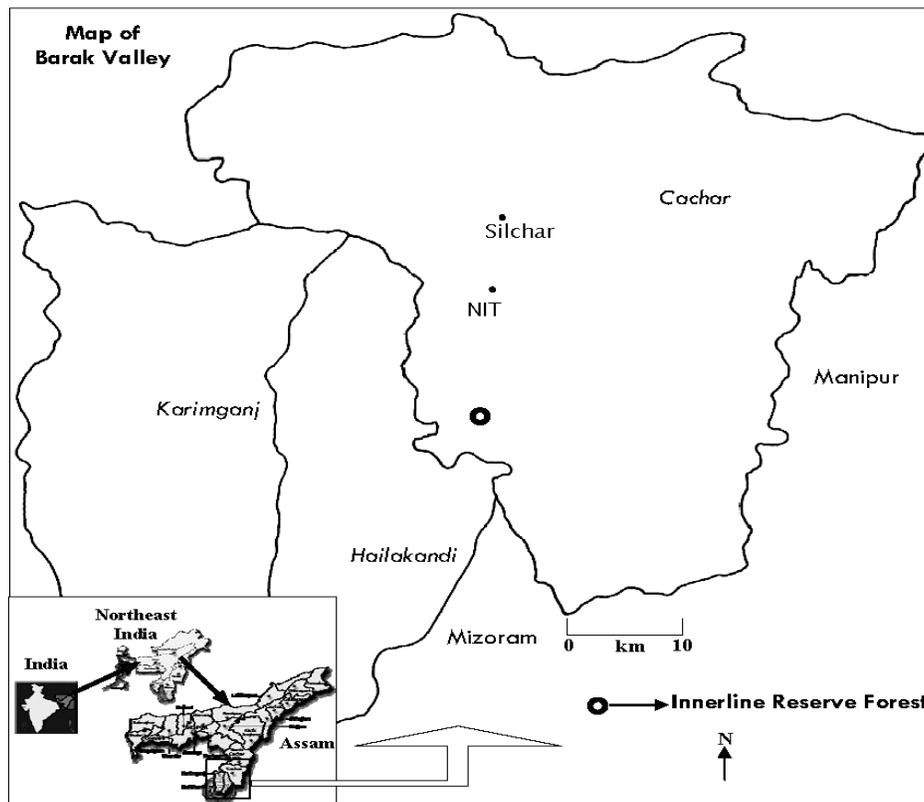


Fig. 1. Location of the study site in southern part of Assam and adjoining areas.

soon and winter. Summer is severe, extending from April to September-October while monsoon coincides with summer and starts from early May extending up to September-October. Winter is short and mild from December to February. The months of March and April witness severe storms with strong winds, thunder and hail. The humidity is high throughout the year, with an average of 80 % during morning and 70 % during evening, with minor recess during the months of March and April. Rainfall, however, varies considerably, being lowest in January and February and highest in July and August. The average annual rainfall of the region in last five years preceding 2005 was observed to be 3200 mm (Statistical Handbook, Cachar District, 2004).

Sampling

The study was carried out in the month of February 2005, during which the average maximum and minimum temperature was 29 °C and 16 °C, respectively and the average relative humidity

was 70 %. The survey was conducted and lichens across a variety of habitats in the region were searched. The samples were collected from different trees up to a height of about 2 m and from dried twigs and stems from the forest floor with well-colonized lichens. Specimens were collected in paper bags and brought to the laboratory for identification using standard keys (Awasthi 1988, 1991, 2000a, b) as well as through chemical tests following Walker and James (1980). Specimens are preserved in the herbarium of the National Botanical Research Institute, Lucknow (LWG) and of the Department of Ecology and Environmental Science, Assam University, Silchar, India.

Results

The study revealed 55 species belonging to 15 families and 25 genera (Table 1) from Innerline Reserve Forest. The forest is dominated by the Graphidaceae family with 21 species (38 %), followed by Pyrenulaceae with 8 species (15 %)

(Fig. 2 A); the two families account for more than 50 % of the lichen flora in the area. The families Trypetheliaceae, Thelotremataceae, Pertusariaceae, Opegraphaceae and Arthoniaceae had three species each, and together constituted 25 % of lichens, followed by Tricotheliaceae, Coccocarpiaceae and Parmeliaceae, with two species each. One species from each of the families Biatoraceae, Brigantiaceae, Catillariaceae, Collemataceae, Pannariaceae were found. The genus (Fig. 2 B), *Pyrenula* was dominant with 8 species (15 %) followed by *Graphis* and *Sarcographa* with 4 species each (7 %). The genera *Trypethelium*, *Phaeographis*, *Pertusaria*, *Opegrapha*, *Myriotrema*, *Fissurina* and *Arthothelium* each had three species. The lichen flora of the forest was represented by two growth forms; crustose and foliose (Fig. 3). Out of the

total 55 species identified, 6 (11 %) (distributed among 4 families and 5 genera) have a foliose growth form; the remaining 89 % are crustose lichens.

Discussion

The Eastern Himalayan region (northeast India, Sikkim and Darjeeling) is the richest area (Singh 1999) for lichen species in the country and contains 843 of the 2030 species known in India, consisting of 457 crustose, 243 foliose and 143 fruticose forms falling within 150 genera. Parmeliaceae, with 115 species, is the largest family in the Eastern Himalayan region, followed by Graphidaceae, Physciaceae, Cladoniaceae and Usneaceae. Out of the 199 species of Parmeliaceae known from

Table 1. List showing 55 species of lichens with their genus and family, found in a reserve forest in southern Assam.

| Family | Genus | S. No. | Species | Family | Genus | S. No. | Species |
|------------------|----------------------|--------|----------------------|--------------|---------------------------|--------|-----------------------|
| Biatoraceae | <i>Phyllopsora</i> | 1. | <i>buettneri</i> | Pyrenulaceae | <i>Pyrenula</i> | 27. | <i>anomala</i> |
| Brigantiaceae | <i>Brigantiaea</i> | 2. | <i>leucoxantha</i> | | | 28. | <i>brunnea</i> |
| Catillariaceae | <i>Catillaria</i> | 3. | <i>pulverea</i> | | | 29. | <i>coactella</i> |
| Collemataceae | <i>Leptogium</i> | 4. | <i>cyanescens</i> | | | 30. | <i>costaricensis</i> |
| Pannariaceae | <i>Pannaraceous</i> | 5. | spp. | | | 31. | <i>immisa</i> |
| Coccocarpiaceae | <i>Coccocarpia</i> | 6. | <i>palmicola</i> | | | 32. | <i>introducata</i> |
| | | 7. | <i>pellita</i> | | | 33. | <i>leucotrypa</i> |
| Parmeliaceae | <i>Parmotrema</i> | 8. | <i>tinctorum</i> | | | 34. | <i>mamillana</i> |
| | <i>Relicinopsis</i> | 9. | <i>malaccensis</i> | Graphidaceae | <i>Graphis</i> | 35. | <i>intermediella</i> |
| Tricotheliaceae | <i>Clathroporina</i> | 10. | <i>anoptella</i> | | | 36. | <i>nakanishiana</i> |
| | <i>Porina</i> | 11. | <i>dolichophora</i> | | | 37. | <i>proserpens</i> |
| Arthoniaceae | <i>Arthothelium</i> | 12. | <i>abnorme</i> | | | 38. | <i>subserpentina</i> |
| | | 13. | <i>chiodectoides</i> | | <i>Sarcographa</i> | 39. | <i>cinchonarum</i> |
| | | 14. | <i>subruanum</i> | | | 40. | <i>leprieurii</i> |
| Opegraphaceae | <i>Opegrapha</i> | 15. | <i>prosodea</i> | | | 41. | <i>subtriosa</i> |
| | | 16. | <i>subvulgata</i> | | <i>Sarcographina</i> | 42. | <i>subtorquescens</i> |
| | | 17. | <i>vulgata</i> | | <i>Phaeographis</i> | 43. | <i>albolabiata</i> |
| Pertusariaceae | <i>Pertusaria</i> | 18. | <i>amara</i> | | | 44. | <i>dendritica</i> |
| | | 19. | <i>coccodes</i> | | | 45. | <i>leightonii</i> |
| | | 20. | <i>quasiae</i> | | <i>Fissurina</i> | 46. | <i>columbina</i> |
| Thelotremataceae | <i>Myriotrema</i> | 21. | <i>albocinctum</i> | | | 47. | <i>comparilis</i> |
| | | 22. | <i>anamalaiense</i> | | | 48. | <i>humilis</i> |
| | | 23. | <i>reclusum</i> | | <i>Platygramme</i> | 49. | <i>muelleri</i> |
| Trypetheliaceae | <i>Trypethelium</i> | 24. | <i>eluteriae</i> | | | 50. | <i>pudica</i> |
| | | 25. | <i>inamoenum</i> | | | | Var. <i>platyloma</i> |
| | | 26. | <i>tropicum</i> | | <i>Acanthothecis</i> | 51. | <i>leucoxantha</i> |
| | | | | | | 52. | <i>albescens</i> |
| | | | | | <i>Hemithecium</i> | 53. | <i>chryseron</i> |
| | | | | | <i>Dyplolabia</i> | 54. | <i>afzelii</i> |
| | | | | | <i>Carbacanthographis</i> | 55. | <i>marcescens</i> |

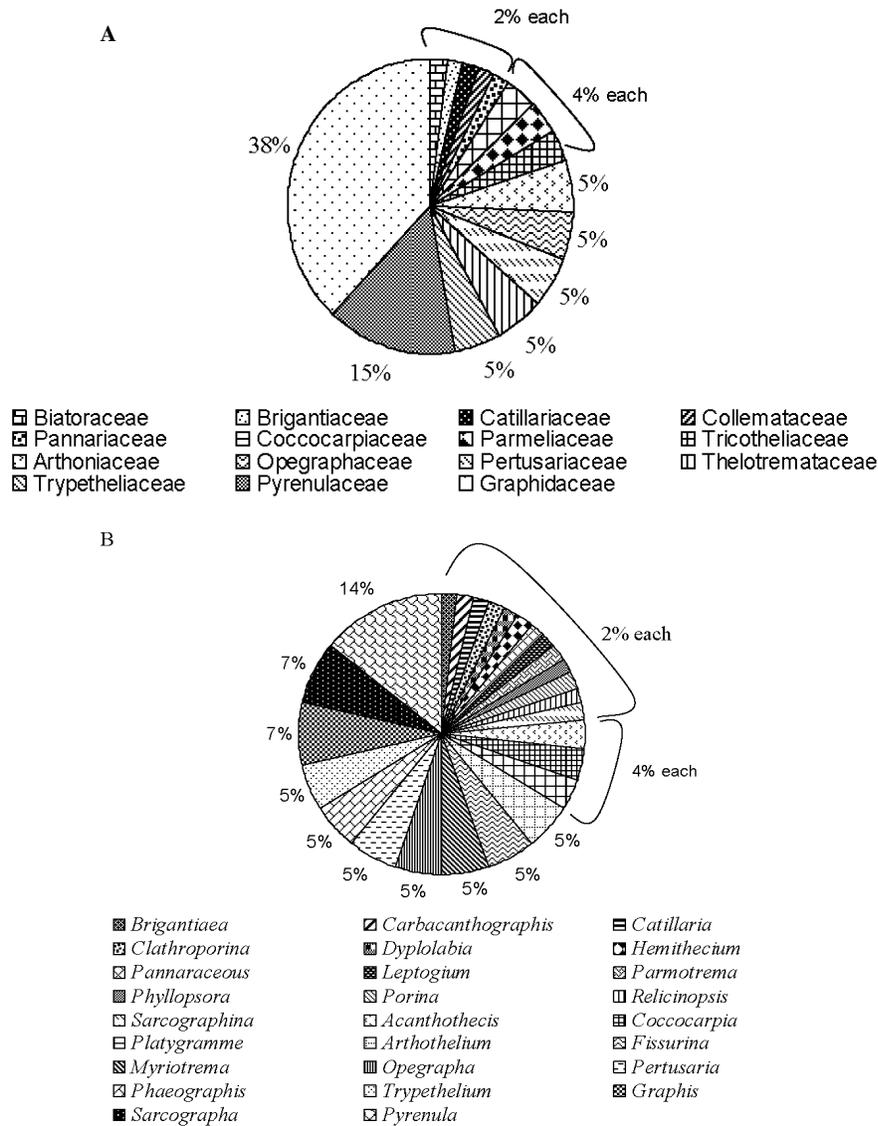


Fig. 2. Percentage of lichen species consisted by each family (A) and each genus (B) in a reserve forest in southern Assam.

India, 115 spp. (57.8 %) occur in the Eastern Himalayan region. The Graphidaceae comprises about 51 percent of the total Indian Graphidaceous flora. Similarly, at the genus level, the *Cladonia* occupies the top position in the Eastern Himalayan region, followed by *Graphis* and *Usnea*. Out of the 59 species of the genus *Cladonia* known in India, 55 species (93 %) occur in the Eastern Himalayan region, followed by *Graphis* with 43 species (57.3 %) and *Usnea* with 36 species (64.3 %). It is notable that three of the dominant families, Cladoniaceae, Usneaceae and Physciaceae from the Eastern

Himalayan region are not represented in the present survey. Studies in the region indicate that the last two families are generally found at comparatively higher altitudes (Singh 1999). The Physciaceae is also found in the areas with anthropogenic interventions (Saipunkaew *et al.* 2005).

In a previous study carried out by us in the campus of the National Institute of Technology (NIT), Silchar, in the Barak valley, located at about 25 km from the present study site (Rout *et al.* 2005), 24 species distributed among 13 genera

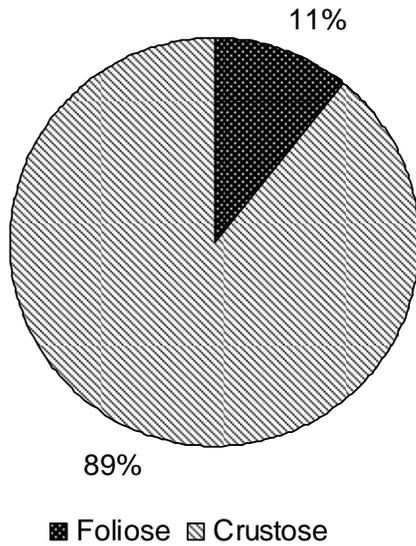


Fig. 3. Percentage of crustose and foliose growth forms of lichens in a reserve forest in southern Assam.

and 8 families were reported. The two dominant families were Graphidaceae and Physciaceae with 10 and 6 species, respectively, with the two dominant genera being *Phaeographina* (5 species) and *Pyxine* (4 species). The foliose growth form was demonstrated by 25 percent of the total lichen flora in the area. The lower species diversity of the NIT site is likely due in part to low to medium anthropogenic pressures like vehicular movement, human habitation in the vicinity etc., unlike the site of the present study, which experiences comparatively less disturbance. Another major factor constraining diversity may be the lower number of host tree species present in the NIT campus. It is noteworthy that the dominant lichen family in forests of the NIT campus is Physciaceae. Saipunkaew *et al.* (2005) found that *Pyxine cocoes* along with *Dirinaria picta* (both Physciaceae family) are tolerant of pollution in urban sites. Nayaka *et al.* (2002a, b) observed that the lichen flora is dominated by Physciaceae family in their studies in western Himalayan region, which is relatively free of air pollution.

Singh and Sinha (1994), in a study in the state of Nagaland in Northeast India, found Parmeliaceae (74 species), Physciaceae (45 species) and Graphidaceae (42 species) as the three dominant families, and *Heterodermia* (22 species), *Graphis* (20 species) and *Parmotrema* (18 species) as the three dominant genera. There are significant similarities in lichen

species from the Innerline Reserve Forest and those from Nagaland. These include *Pyrenula immisa*, *Graphis intermediella*, *G. proserpens*, *Leptogium cyanescens*, *Coccocarpia palmicola*, *C. pellita*, *Parmotrema tinctorum* and *Pertusaria quassiae*. However, the lichen flora of the present study is not limited to species characteristic of the Eastern Himalayan region. For example, Upreti and Divakar (2003) enumerated 108 species representing 35 genera of lichens in a Tiger Reserve in Uttaranchal, situated in the foot hills of Himalaya. The lichen species common to both sites include *Parmotrema tinctorum*, *Coccocarpia pellita*, *Clathroporina anoptella*, *Pyrenula immisa*, *P. introducta*, *P. brunneae*, *Pertusaria quassiae*, *Brigantiaea leucoxantha*. The distribution of species among growth forms (crustose and foliose) is also similar; 82 percent and 18 percent, respectively.

Although 110 species have been reported from the state of Assam to date, 46 out of a total of 55 species found in the present study are new records for this state (Das 2008). Considering that all previous work was confined to the Brahmaputra valley, this finding for the Barak valley is not surprising. Two species belonging to crustose growth form, *Arthothelium abnorme* and *Trypethelium inamoenum*, encountered in the present study are endemic to Eastern Himalayan region, and another four species *viz.* *Clathroporina anoptella*, *Graphis nakanishiana*, *Pyrenula immisa* and *P. introducta* are endemic to the Indian region (Singh 1999). None of these six endemic species could be found in a nearby NIT campus area.

Because lichens are key primary producers with important linkages to nutrient cycling and forest food webs (Jovan 2008), the rich generic and family diversity of lichens in the Innerline Reserve Forest is significant in this regard. Furthermore, the presence of the Thelotremataceae family is also noteworthy because, according to Hale (1974, 1978 & 1981) & Plata *et al.* (2007), lichens in the Thelotremataceae family are indicators of diverse and undisturbed tropical rain forests. In a study in semi-evergreen and deciduous forests of the Sharavathi river basin, situated in the middle of the Western Ghats of India, Nayaka and Upreti (2002) found Pyrenocarpous, Graphidaceous and Thelotremataceous lichens as common and dominant ones. It is important to observe that the Shrivati river basin lies in Western Ghats which is one of the two global biodiversity hot spots of the world found in India.

The presence of 55 species, 26 genera and 15 families of lichens in an area about 5 percent of the total forest cover is quite significant. This rich diversity indicates good forest health. Owing to close ecophysiological links, lichens are also recognized as promising candidates for air quality biomonitoring (Rout 2007). Anthropogenic pressures such as deforestation and encroachment of forested areas are major threats to the survival of many lichens which are yet to be identified, thus warranting intensive long term study. Moreover, the conservation aspects assume significance owing to the presence of tribal community inhabiting the surrounding area of the forests. Further research may reveal information regarding the ethnomedicinal use of lichens. Hence, it is urgently required to chalk out concrete plans for the conservation of lichens in this forest. The present lichen inventory will serve as baseline information for all future studies.

References

- Awasthi, D.D. 1988. A key to macrolichens of India, Nepal and Srilanka. *Journal of the Hattori Botanical Laboratory* **65**: 207-232.
- Awasthi, D.D. 1991. A key to microlichens of India, Nepal and Srilanka. *Bibliotheca Lichenologica* **40**: 1-336.
- Awasthi, D.D. (ed.) 2000a. *A hand book of Lichens*. Bishen Singh Mahendra pal Singh, Dehradun, India.
- Awasthi, D.D. (ed.) 2000b. *Lichenology in Indian subcontinent*. Bishen Singh Mahendra pal Singh, Dehradun, India.
- Bose, J. 2003. 'Search for a Spectacle': *A conservation Survey of Phayre's Leaf Monkey (Trachypithecus phayrei) in Assam and Mizoram*. Wildlife Trust of India.
- Chatterjee, S., A. Saikia, P. Dutta, D. Ghosh, G. Pangging & A.K. Goswami. 2006. *Background Paper on Biodiversity Significance of Northeast India for the study on Natural Resources, Water and Environment Nexus for Development and Growth in North-eastern India*. Forest Conservation Programme, WWF-India, New Delhi.
- Das, P. 2008. *Lichen flora of Cachar district (Southern Assam) with reference to occurrence, distribution and its role as environmental bioindicators*. Ph.D. Thesis. Assam University, Silchar, India.
- Hale, M.E. Jr. 1974. Modern-Smithsonian expedition to Dominica: the lichens (Thelotremataceae). *Smithsonian Contributions to Botany* **16**: 1-46.
- Hale, M.E. Jr. 1978. A revision of the lichen family Thelotremataceae in Panama. *Smithsonian Contributions to Botany* **38**: 1-60.
- Hale, M.E. Jr. 1981. A revision of the lichen family Thelotremataceae in Sri Lanka. *Bulletin of the British Museum* **8**: 227-332.
- Jovan, S. 2008. *Lichen bioindication of biodiversity, air quality and climate: baseline results from monitoring in Washington, Oregon and California*. General Technical Report. PNW- GTR-737. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.
- Myers, N., R.A. Mittermier, C.G. Mittermier, G.A.B. da Fonseca & J. Kent. 2000. Biodiversity hotspots for conservation priorities. *Nature* **40**: 853-858.
- Nayaka, S. & D.K. Upreti. 2002. Lichens flora of Sharavati river basin, Shimoga district, Karnataka, India, with six new records. *Journal of Economic and Taxonomic Botany* **27**: 627-648.
- Nayaka, S., V. Yadav, R. Srivastava & D.K. Upreti. 2002a. An enumeration and new records of lichens from Solan District, Himachal Pradesh. *Indian Biological Memoirs* **28**: 25-33.
- Nayaka, S., D.K. Upreti & V. Yadav. 2002b. An enumeration and new records of lichens from Sirmaur District, Himachal Pradesh (H.P.), India. *Phytotaxonomy* **2**: 49-63.
- Plata, E.R., R. Lücking & H.T. Lumbsch. 2007. When family matters: an analysis of Thelotremataceae (Lichenized Ascomycota: Ostropales) as bio indicators of ecological continuity in tropical forests. *Biodiversity Conversation*. DOI 10.1007/s10531-007-9289-9.
- Ramakantha, V., A.K. Gupta & A. Kumar. 2003. Biodiversity of Northeast India: an overview. pp. 1-24. In: A.K. Gupta, A. Kumar & V. Ramakantha (eds.) *Envis Bulletin: Wildlife and Protected areas, Conservation of Rainforests in India*.
- Rout, J., R. Rongmei & P. Das. 2005. Epiphytic lichen flora of a pristine habitat (NIT campus) in Southern Assam, India. *Phytotaxonomy* **5**: 117-119.
- Rout, J. 2007. Air Pollution Biomonitoring: Lichen as an indicator species. pp. 13-54. In: P. Dwivedi, S.K. Dwivedi & M.C. Kalita (eds.) *Biodiversity and Environmental Biotechnology*, Scientific Publishers, Jodhpur.
- Saipunkaew, W., P. Wolseley & P.J. Chimonides. 2005. Epiphytic lichens as indicators of environment health in the vicinity of Chiang Mai city, Thailand. *The Lichenologist* **37**: 345-356.
- Singh, K.P. & G.P. Sinha. 1994. *Lichen flora of Nagaland*. Bishen Singh Mahendra Pal Singh, Dehradun.
- Singh, K.P. 1999. Lichens of Eastern Himalayan region. pp. 153-204. In: K.G. Mukerji, B.P. Chamola, D.K.

- Upreti & R.K. Upadhyay (eds.) *Biology of Lichens*. Aravali Books International, New Delhi.
- Upreti, D.K. & P.K. Divakar. 2003. Distribution of lichens in Corbett Tiger Reserve, Uttaranchal. *Journal of Economic and Taxonomic Botany* **27**: 1043-1060.
- Walker, F.J. & P.W. James. 1980. A revised guide to the microchemical technique for the identification of lichen products. *Bulletin of British lichen society* **46**: 13-29.