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Research Article

A Bryofloristic Ecological Assessment of Assam, India

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ABSTRACT

Bryophytes, an interesting group of non-vascular cryptogams, constitute one of the important components of phytodiversity of Assam. The present paper deals with an ecological assessment of bryophytes with particular reference to their habitat preferences of Assam, India. In the present investigations a total of 162 taxa of bryophytes (Liverworts, Hornworts & Mosses) under 90 genera and 39 families have been recorded with their proper habitat which reveals an exquisite variety of habitats for their luxuriant growth and spread with an interesting and characteristic bryo-vegetation in Assam. Accordingly, attempt was made to gain an insight into the peculiarities of distribution of the taxa of Bryoflora in different microhabitats such as river bank, river bed, earth cutting slopes, termite mound; tree trunks, knotholes of tree trunks, rotten wood logs; fruit bodies of wood rotting fungi, birds' nest, old historical monuments etc., which will be considered as noteworthy contributions towards the Bryoflora of Assam considering both taxonomical and ecological aspects.

Key Words: Bryoflora, Microhabitat, Epilithic, Non-Epilithic, Corticolous, Non-Corticolous.

INTRODUCTION

Bryophytes, comprising liverworts, hornworts and mosses are the first invaders of land habit occupying an intermediate position between the lower vascular plants, the Pteridophytes on one hand and Thallophyta especially the aquatic green algae, the Chlorophyceae on the other hand. They are considered as very ecosensitive organisms having a rather sharply defined and narrow ecological range. Recently, they can be effectively used as "Biomonitors" and "Bioaccumulators" as well as an "Exploratory tools" in geobotanical and biogeochemical prospecting.

The history of Bryophytes ecology, which is common with other branches of ecology, shows an increasing tendency towards the use of an objective of a particular environment by quantitative approach. The ecological studies on Bryophytes have led to detailed investigation into the relationships between the plants and their environment in the European countries. However, in our country, more particularly from the North Eastern Region of India, the ecological studies exclusively on Bryophytes are very infancy (Barukial and Gogoi, 1998; Barukial, Gogoi and Borua, 2002b). It is evident that, despite their relative insignificance in other respects of economic importance, they play an important ecological role especially in extreme environments. They constitute an important element of diverse vegetation complex which play an important role in terrestrial ecosystems such as modification of habitat, nutrient cycling and the maintenance of nutrient status of the soil, primary production etc. Bryophytes are also potential sources of new antibiotics and anticancerous substances (Chopra and Vasishtha, 1994). The recent upsurge of interest in monitoring atmospheric pollution has revealed a new aspect of the relevance of this elegant group of plant kingdom. They have been more rationally used in pollution detection, environmental monitoring and as climatic indicator which can be helpful to management of a particular environment.

The present study deals with main objective of finding the habitat preferences of different genera and species of bryophytes along with the peculiarities of their distribution in diverse habitat and very narrow ecological niches. For the sake of convenience the different ecological niches have been classified into habitat and sub-habitat and it is further subdivided into very narrow units as locations **(Table 1).** Ecologists have often used the term habitat both in general as well as more limited sense. In the present study the term "Habitat" has been used to indicate the kind of place or places in which Bryophytes or its associations lives.

MATERIALS AND METHODS

Thorough year round, collections of bryophytes from various diverse habitats and locations along with the proper ecological data were made during the period extending from 1993 to 2003 in several trips covering all the seasons and brought them to the laboratory in blotting paper bags. The collected fresh materials were

examined and fixed in 70 % alcohol as well as mosses were air dried, pressed and stored in suitable well labeled standard sized paper packets as per the internationally accepted herbarium methodology with proper field notes. They were deposited in the Bryological section of Botany Department of Debraj Roy College Herbarium, Golaghat, Assam, India. The identification of taxa has been done in the laboratory by studying the specimens and consulting with various standard literatures.

RESULTS

In the present investigations a total of 162 taxa of Bryophytes distributed under 90 genera and 39 families have been recorded with their proper microhabitats. Among them are 32 species of Liverworts under 17 genera and 10 families; 3 species of Hornworts under 2 genera and 2 families and 127 species of Mosses under 71 genera and 27 families. Although the main objective of this study was ecological assessment, keeping in view of Bryophytes Systematics, we arranged the taxa phylogenetically based on Schuster (1979) system of classification for Hepaticopsida (Liverworts) and Anthocerotopsida (Hornworts) and for Bryopsida (Mosses), Brotherus (1924 – 25) system of classification modified by Chopra (1975) have been followed. Genera and species are alphabetically listed under each family (**Table 2**). The different microhabitats (Locations) preferred by the collected taxa have revealed that some species of Bryophytes occur in a wide range of habitats which indicate broad ecological amplitudes. In sharp contrast to it some Bryophytes have been preferred single microhabitats *i.e.* narrow ecological amplitudes. In our investigation, it has been revealed that out of 162 taxa, 51.85 % have shown single microhabitats, 37.03% of 2 microhabitats , 07.4% of 3 microhabitats and 03.7% of more than 4 microhabitats **(Table 3).** Besides, in our present investigations, 162 taxa were collected from 275 different microhabitats considering the different locations preferred by them. It has been revealed that 52.3 % of microhabitats under Terrestrial habitat, 35.27 % under Epiphytic habitat and 8.72% under Aquatic habitats **(Table 4).**

DISCUSSION

In our present heterogeneous collections of Bryophytes covering the diverse microhabitat(s), the result reveals that the 51.85 % of species have preferred single microhabitat *i.e.* narrow ecological amplitude which indicates that they are highly ecosensitive organisms. If their habitat(s) once disturbed they will certainly be dwindled in their both diversity and abundance. The frequencies of diverse microhabitat(s) preferred by the taxa have revealed 52.3%, 35.27% and 08.72% of Terrestrial, Epiphytic and Aquatic habitat respectively. It indicates that the present environment of the study area is to be considered as an ideal home for luxuriant growth of bryo- vegetation pattern.

In our throughout insight investigation it has been revealed that the 35.27% of epiphytic bryophytes are highly ecosensitive than the 52.3% of Terrestrial habitat because among the taxa in our investigation, most of the epiphytic bryophytes preferred only single microhabitats which were collected from the deep thick different remote forest areas. We have collected some rare species of corticolous mosses *viz. Brotherella falcata, Ectropothecium buitenzorgii, Eriopus lucidus, Foreauella orthothecia, Herpetineuron toccoae, Leucophanes octoblepharoides, Macromitrium moorcroftii, Octoblepharum albidum, Sematophyllum subhumile, Taxithelium cilatum, Thuidium philiberti and Vesicularia pereticulata* in felling age old tree in the interior of proposed Joydihing Wildlife Sanctuary which indicates the species diversity considering the number of species richness related to other community properties such as productivity and stability by providing different amount of direct or indirect light and heat radiations, availability of water and nutrients from direct rainfall, stem flow, mist, dew, humidity; physical and chemical characters of the bark of the tree.

The luxuriant growth of the epiphytic bryophytes has been seen to be thriving well only in certain niches. The mosses *Calymperes tenarum, Leucophanes octoblepharoides, Octoblepharum albidum,* etc. prefer to grow on vertical tree trunk; probably these species have a greater competitive ability on a vertical trunk than on an inclined or horizontal branches of the tree.

The finding of certain mosses like *Aerobryopsis longissima, Neckera crenulata* in the birds' nest indicates the correlation with Avifauna. The finding of an ephemeral genus *Trematodon* in the drying up river bed which has shown luxuriant growth during winter seasons is interesting from ecological point of view, considering pollution indicator. In our critical observation it has been revealed that the *Trematodon ceylonensis* has never been luxuriantly grown at the point in the river bed where municipal sewerages drains meet. On the other hand this species grown luxuriantly like a valvate carpet in the river bed and streams of less polluted sites. It indicates that the distribution of bryophytes life-form types appears to be controlled by the P^H and other chemical features of the edaphic substrates.

Table 1: Classification of Diverse Habitats Preferred by Bryophytes

Habitats ⇒	**I :Terrestrial**		**II: Epiphytes**		**III: Aquatic**	
Sub Habitats ⇒	**IA: Epilithic**	**IB: Non Epilithic**	**IIA: Corticolous**	**IIB: Non Corticolous**	**IIIA: Drying (periodic)**	**IIIB: Constantly Wet.**
L O C A T I O N S	i. On bare exposed surface of rocks and boulders. ii. Moist stones where soil has accumulated . iii. In between chinks and crevices of bricks walls. iv. Over the roof of buildings. v. On the historical temples and monuments. vi. In between gaps of bricks work pavement.	i. On shady moist loose soils. ii. On humus soils. iii. On sandy soils. iv. Roadside earth cutting soils v. Termite mound.	i. Adpressed to bark of the trees. ii. Over exposed roots of trees. iii. Hanging from the branch of trees.	i. Making thin layer over the thalli of the liverworts. ii. Over fruit bodied of wood rotting fungi. iii. Over half decomposed leaf litters. iv. knotholes v.Over dead wood logs. vi. Birds' nest.	i. River bed. ii. small and artificial drains (Non-concrete	i. submerged. ii. Wet rocks crevices near waterfalls// water channel

Table 2: Diverse Microhabitats preferred by the Bryophytes

TAXA OF BRYOPHYTES	DIFFERENT MICROHABITATS**
HEPATICOPSIDA	
Family:-Calypogeiaceae	
Calypogeia arguata Mont. & Nees	IB.v
Family-Jungermanniaceae	
Jungermannia confertissima Nees	IA.ii
J. subulata Evans	IIB.ii & v
Plectocolea infusca Mitt.	IIIA.ii
Family :- Geocalycaceae	
Chiloscyphus argutus Nees.	IIA.ii, IIB.v
C. polyanthus (L.) Card.	IIIA. i &ii
Family :- Plagochilaceae	
Plagiochila chinensis Steph.	IA i , IIIA.ii
P. nepalensis Lindb.	IA ii, IIIA ii
P. spinulosa (Dicks.) Dum	IIIB i & ii
Family :- Porellaceae	
Porella caespitans (St.) Hatt.	IA. iii & iv
P. gracillima Mitt.	IA. v & vi
Family :- Jubulaceae	
Frullania hampeana Nees.	IIA.i
F. muscicola St.	IIA.i
F. subclavata Steph	IIA.i
Family-Lejeuneaceae	
Archilejeunea mariana (Gottsche.) Steph.	IIA. i & ii
Brachiolejeunea sandvicensis (Gottsche.) Evans.	IIA.i
Cololejeunea goeblii (Gottsche & Schiffn.) Schiffn.	IIA.ii
C. himalaensis (pande *et* Mishra) schuster	IIA.i &ii
C. lanciloba Steph.	IIA.i & ii
Drepanolejeunea follicola Horikawa.	IIA.i &ii
Lejeunea boninensis Horikawa.	IA.i, IB.i
L. longifolia Mitt.	IA.i
L. uliciana *(Tayl.) Tayl.*	***IIA.i***
Leptolejeunea subacuta Evans.	IIA.i
Family :- Pelliaceae	
Pellia endaevifolia Dicks.	IIIA.ii
P. epiphylla (L) Corda	IIIB.iii
Family-Marchantiaceae	
Dumortiera hirsuta (Sw.) Nees.	IA.ii, IB.i & iii
D. nepalensis (Tayl) Nees.	IA.ii, IB.iii, IIIA.ii, IIIB.ii.
Marchantia polymorpha L.	IA.iii &v, IIB.ii
M. nepalensis Lehm. & Lindb.	IA.iii &iv, IB.iii, IIIB. ii
Family- Ricciaceae	

Riccia discolor Lehm. *et* Lindb.	IB.i & ii
R. frostii Aust	IB.i & ii
ANTHOCEROTOPSIDA	
Family- Anthocerotaceae	
Anthoceros glandulosus Lehm.& Lindb.	IIIA. ii, IIIB.ii
A. Punctatus L.	IB.iv, IIIA.ii, IIIB.ii
Family :- Notothylaceae	
Notothylus indica Kash	IIIB.ii
BRYOPSIDA	
Family- Polytrichaceae	
Lyellia crispa R. Br.	IB.iii, IIIA ii
Pogonatum aloides (Hedw.) Palis	IB.ii & iii
Polytrichum pilulifer (Hedw.) Pallis.	IB.ii & iii
Family :- Wilsoniellaceae	
Wilsoniella decipens (Mitt.) Alston.	IB.ii
Family – Ditrichaceae	
Ceratodon stenocarpus (Hedw.) Brid.	IA.iii & v
Distichium capillaceum (Hedw.) B.S.G.	IB.iii
Ditrichum heteromallum (Hedw.) E.G.B.	IB.iii
Garckea phascoides (Hook.) C. Muell.	IB.iv & v
Pleuridiella colei Robins.	IB. v
Family- Dicranaceae	
Campylopodium griffithii (Mitt.) Mitt. ex. Broth.	IB.i
Campylopus ericoides (Griff) Jaeg.	IA.i
C. laetus (Mitt.) Jaeg.	IB.i & v
C. richardii Brid.	IB.iii
C. subgracillis Ren. et. Card ex. Gang.	IB.iii & iv
Dichodontium pellucidum (Hedw.) Schimp.	IB.i
Dicranalla divericata (Mitt.) Jaeg.	IB.iv
. *D. heteromala*.(Hedw.) Schimp.	IA.ii
D. spiralis (Mitt.) Jaeg.	IB.i & ii
Dicranodontium caespitosum (Mitt.) Paris	IA.ii, IB.iii
Dicranum lorifolium Mitt.	IA.i
D. kashmirensis Broth.	IA.i
Trematodon ceylonensis C. Muell.	IIIA.i
T. hookeri C. Muell.	IB.iv , IIIA.ii
T. kurzii Hampe ex. Gangulee.	IB.ii
Family :- Leucobryaceae	
Lecobryum bowringii Mitt.	IB.i, ii, & iii
Leucophanes octoblepharoides Brid.	IIA.i
Octoblepharum albidum Hedw.	IIA.i
Family- Fissidentaceae	
Fissidens auriculatus C. Muller.	IB.i
F. bilaspurense Gangulee.	IB.iii

F. bryoides (L.) Hedw.	IB.i & v, IIIA.ii
F. diversifolioides Gangulee.	IB.i
F. incognitus Gangulee	IIIB.ii
F. involutus Wils et. Mitt.	IB.iii
F. lancifolius Hampe ex Gangulee.	IA.ii, IB.iii
F. nobilis Griff.	IIIB.ii
F. pulchellus Mitt.	IA.v & vi
F. ranchinensis Gangulee.	IB.iii
F. rubricaulis Dix.	IA.i, IB. iii
F. subpalmatus C. Muller.	IB.iii
F. teraicola C. Muller.	IA.ii, IB.i
F. titalyanus C. Muller.	IB.iii
Family- Calymperaceae	
Calymperes burmense Hampe.	IIA.i & ii
C. hampei Dozy et. Molk.	IIA.i
C. heterophyllum (Mitt. Bescherella.	IIA.i
C. tenerum C. Muell.	IIA.i
Syrhopodon gardneri (Hook.) Schw.	IIA.i
Thyridium fasciculatum (Hook.et Grev.) Mitt.	IIA.i
T. piluliferum (Dix.) Gangulee	IIA.i & ii
Family- Pottiaceae	
Anoectangium thomsonii Mitt.	IB.iii
Barbula constricta Mitt.	IA.ii, IB.iii
Hydrogonium arcuatum (griff.)Wijk. Et. Marg.	IA.iii,v & vi
H. inflexum(Dub in Moritzi)Chem.	IA.iv, v & vi
H. lecodontoides Gangulee.	IA.ii, IIIB. ii.
Hyophilla involuta (Hook.) Jaeg.	IA.iii,v, & vi, IIB.i & ii
Pseudosymblepharis pallidens Dix.	IA.iii & iv.
Tortella tortuosa (Hedw.) Limp.	IB.i
Family-Funariaceae	
Funaria diversinervis (C.Muell.) Broth.	IB.ii & iv
F. hygrometrica Hedw.	IB.ii & iv
F. wichurae (Fleisch.) Broth.	IBi & ii
Family :- Splachnobryaceae	
Splachnobryum synoicum Robins.	IA.iii & iv
Family- Bryaceae	
Bryum capillarae L. ex. Hedw.	IA.iv & vi
B. cellularae Hook. In Schwagr.	IA. iii & iv
B. coronatum Schw.	IA. iii, iv & vi
B. hemisphericarpum C. Muell.	IA. iii, v & vi
Pohlia ampulacea Gangulee.	IA.iii & iv
Family :- Bartramiaceae	
Philonotis revoluta Bosch & Lac.	IAii & IB.ii
Family :- Erpodiaceae	

Erpodium mangiferae C. Muell.	IIA. i
Family :- Orthotrichaceae	
Macromitrium moorcroftii (Hook. & Grev.) Schw.	IIA. i
Family- Pterobryaceae	
Pterobryopsis auriculatus Dix.	IIA. i
P. crassicaulis (C. Muell.) Fleisch.	IIA. i
P. divergens (Mitt.) Jaeg.	IIA. i
Family-Meteoriaceae	
Aerobryoopsis longissima (Doz & Molk.) Fleisch.	IA.iv , IIB.vi
Barbella stevensii (Ren. Et. Card.)Fleisch	IIA. i & iii
Family- Neckeriaceae	
Neckera crenulata Harv.	IIA.i, IIB.vi
Thamnobryum fruticosum (Mitt.) Gangulee.	IIAi
Family- Hookeriaceae	
Calliostella papilata (Mont.) Mitt.	IB.i
Chaetomitrium papillifoloum Bosch.	IBi & ii
Eriopus lucidus Chwit & Mitt	IIA. i
Family :- Fabroniaceae	
Fabronia secunda Mont.	IIA.i
Family- Thuidiaceae	
Anomodon minor (Hedw.) Lindb. ssp. *integerrimus* (Mitt.) Iwats.	IIA.i
Clopodium assurgens (Sull et. Lesk.) Card.	IIA.i
Herpetineuron toccoae (Sull et. Lesk.) Card.	IIA.i
Thuidium brothari Salm	IIA.i & ii, IIB.ii & iii
T. kiasense Williums	IIA.i , IIB. I & ii
T. koelzi Robins.	IIAi, IIB.ii, iv & v
T. meyanianum (Hampe) Doz et. Molk.	IIA.i, IIB.iv & v
T. philbertii Limp.	IIA.i
T. subpellucens Dix.	IIAi, IIB. iv
Family :- Amblystegiaceae	
Campylium lacerulum (Mitt.) Broth.	IIA.ii
Family- Brachytheciaceae	
Brachythecium laevi-velutinum Dix.	IB.i & ii
B. rivulare B.S.G.	IIA.i
Eurhynchium dumosum (Mitt.) Jaeg.	IIA.i
Rhynchostegium celebicum (Bosch. & Lac.) Jaeg.	IA.i
R. hookeri Jaeg.	IA.i
Family :- Entodontaceae	
Erythodontium julacium (Schw.) Par.	IIA.i
Orthothecium intricatum (Hartm.) B.S.G.	IB.ii
Pterygynandrum decolor (Mitt.) Broth.	IIA.i
Trachyphyllum inflexum (Harv.) Gepp.	IIA.i
Family- Plagiotheciaceae	

Stereophyllum anceps (Bosch. & Lac.) Broth.	IIAi, IIB.iv
S. indicum (Bel.) Mitt.	IIA.i, IIB.iv
S. wightii(Mitt.) Jaeg.	IIAi
Family-Sematophyllaceae	
Acanthorrhyncium papilatum (Harv.in Hook.) Fleisch.	IIA.i & ii
Brotherella falcata (Doz. et. Molk.) Fleisch.	IIA.i
Foreauella orthothecia (Schw.) Dix. & Vard.	IIA.i
Meiothecium microcarpum (Hook.) Mitt.	IIA.i
Sematophyllum subhumile (C. Muell.)Fleisch.	IIA.i
Taxithellium cilatum (Mitt.) Broth.	IIA.iii & iv
T. kerianum (Broth.) Broth.	IIA.i
T. laeviusculum Dix.	
T. nepalensis (Schw.) Broth.	IIA.i
Family- Hypnaceae	
. *Ectropothecium buitenzorgii*(Bel) Mitt.	IA.ii, IB.i
E. ramuligerum Dix.	IA.ii
Hypnum cupressiforme Hedw.	IIA.i, IIB. vi
Isopterygium banacanum (Lac.) Jaeg.	IA.iii , IB.iii
I. disticaceum (Mitt.) Jaeg.	IB. iii
I. minutirameum (C. Muell.) Jaeg.	IB.i , IIA.i
I. pallidulum (Mitt.) Jaeg.	IIA.i
I. seligeri (Brid.) Dix.	IA.i , IIIB.ii
Ptilium crista-castrensis (Hedw.) De Not.	IA.iii & vi
Taxiphyllum taxirameum (Mitt.) Fleisch.	IIA.i
Vesicularia levieri Card.	IIA.i
V. montagnei (Bel.) Broth.	IB.i & ii
V. pereticulata Broth	IIA.i
V. reticulata (Doz. & Molk.) Broth.	IAi& v, IIA.i
V. selaginelloides Dix.	IA.ii, IB.i, IIA.ii
V. subpilicuspis Card & P. Vard.	IIA.ii
Family- Hylocomiaceae	
Macrothamnium macrocarpum (Reinw.& Hornch.) Fleisch.	IB.i

***Abbreviations cited under the column Different microhabitat corresponds with the Table -I*

Table 3: Frequency of Habitat (s) preferences by the collected taxa

Habitat (s) preferences by single species	No. of species occurrence	Frequency (%)
Single microhabitat	84	51.85
Two microhabitat	59	37.03
Three microhabitat	13	07.4
More than three microhabitat	6	03.7

Table 4: Frequency of diverse microhabitat (s) preferred by the taxa

Habitat(s)	Different microhabitats preferred by the taxa	Frequency (%)
Terrestrial	144	52.3
Epiphytic	97	35.27
Aquatic	24	8.72

Considering the above discussions, further works on bryophytes ecology of this area will be fruitful and encourage.

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