

DIVERSITY IN INDIAN HORNWORTS (BRYOPHYTA) :
A STATE OF THE ART REPORT

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A B S T R A C T

The hornworts, comprising a small, phylogenetically significant group of plants, are represented in India by 5 genera, viz. *Anthoceros* L. emend. Prosk., *Folioceros* Bharad. (Anthocerotaceae); *Notothylas* Sull. (Notothylaceae); *Megaceros* Campb. and *Phaeoceros* Prosk. (Phaeocerotaceae), 35 species and 2 subspecies. Anthocerotaceae and Phaeocerotaceae show greater manifestation in the Himalayas, whereas the Western ghats abound in maximum members of Notothylaceae. Fifty eight percent (or 21 species) of the total Indian hornworts are endemic, of which only *Anthoceros bharadwajii* Udar et Asthana, *A. erectus* Kash. and *Notothylas himalayensis* Udar et Singh have an extended range of distribution in more than one bryogeographical territories. The high incidence of primitive *Notothylas* taxa coupled with the highest endemism encountered in the Western ghats makes this region Cradle of the genus. The other phytogeographical elements discernible amongst Indian hornworts are : Cosmopolitan (4), Disjuncts (4) and Eastern Asiatics (7). The rich and phytogeographically unique hornwort flora of its own, notwithstanding, about 28% of the Indian anthocerototes could never be located again since their original collection. Certain biotic influences, on the other hand, are threatening a few other species of their survival. The paper epitomizes the causes of threats and rarity of such taxa and discusses the strategies to salvage the situation.

Hornworts, a popular colloquium for Anthocerototes, embrace a small yet distinctly defined, homogeneous and phylogenetically significant group of plants. It occupies a synthetic position between rest of the bryophytes on one hand and pteridophytes on the other (Proskauer, 1960; Renzaglia, 1978; Udar & Singh, 1978, 1979). The group is characterised by the presence of true dichotomous branching; usually a single large chloroplast in each cell with a distinct pyrenoid; mucilage/schizogenous cavities in the thallus; endogenously developed antheridium; completely embeded archegonium; cylindrical, mostly columellate, partially photosynthetic and stomatiferous sporophyte with usually indeterminate growth; usually amphithecial archesporium; and nonsynchronous development of sporogenous tissue because of the basal meristematic activity of the sporophyte. Based on these unique morphogenetic traits, the hornworts are considered to constitute an isolated bryophytic taxon and have generated immense speculation with regards to their systematic position (see Renzaglia, 1978; Hasegawa, 1979, 1988;

Bharadwaj, 1981; Hässel de Menendez, 1988; Asthana & Srivastava, 1991). Accordingly the group has been assigned different taxonomic status ranging from an Order (Anthocerotales) within Hepaticae; Class (Anthocerotae) coordinate with Hepaticae and Musci; division (Anthocerotophyta) coordinate with Hepatophyta (liverworts) and Bryophyta (mosses). Sometimes, they are even sought to be excluded from bryophytes (Schuster, 1977).

Hornworts are invariably terriicolous; except the genus *Dendroceros* which is always cortiicolous or foliicolous in nature. Majority of them prefer cool, humid mesic conditions to not only facilitate sexual reproduction but to also accomplish asexual propagation and the dispersal of species as a whole through the dispersal of spores and gemmae.

Hornworts, like the liverwort *Blasia*, harbour blue-green algae or the *Nostoc* Colonies in their thallus, which symbiotically helps in atmospheric nitrogen fixation (Ridgway, 1967). This symbiotic association of Cyanobacteria render them a potential biofertiliser (Saxena, 1981).

Studies on Anthocerotales date to pre-Linnaean era when Merret (1667) first described 'Anthoceros' type plants, under the phrase description '*Lichen capillaceus ex plurimis capillamentis nigris constans*' now referable to *Anthoceros punctatus* L. Later Dillenius (1718) described specimens, presently referable to *Phaeoceros* Prosk. under 'genus' *Lichen* and transferred 'Anthoceros punctatus type' plants to the 'genus' *Lichenastrum* (Dillenius, 1724). However, it was Micheli (1729) who first coined the name 'Anthoceros' to include the two species of hornworts known till then, and which was later adopted by Linnaeus (1753). Today the group has worldwide distribution comprising 8 genera, viz. *Anthoceros* L. emend. Prosk., *Notothylas* Sull., *Dendroceros* Nees, *Megaceros* Campb; *Phaeoceros* Prosk., *Folioceros* Bharad., *Leiosporoceros* Hässel and *Sphaerosporoceros* Hässel, and over 250 species. The monotypic *Leiosporoceros* and the *Sphaerosporoceros* (with only two species) have a highly circumscribed distribution being usually confined to only tropical North America (Hässel de Menendez, 1986, 1988).

In India, the first record of hornworts comes through Mitten's (1861) 'Hepaticae Indiae Orientalis' wherein he reported *Aspiromitus glandulosus* L. et L. [now *Folioceros glandulosus* (L. et L.) Bharad.] and *Anthoceros punctatus* L. from Khasi hills in Meghalaya. Eversince, the various aspects of anthocerotales have received considerable attention in Indian Bryology (Udar, 1976; Singh, 1979, 1984, 1993; Asthana & Srivastava, 1991). And in the present state of our knowledge the group is represented in India by 36 taxa spreading over to three families and five genera, which accounts for ca 15% of the total hornwort flora of the world.

DIVERSITY, DISTRIBUTION AND AFFINITIES

The diverse physiographic and ecoclimatic conditions met within India have not only adequately expressed itself by supporting a rich bryoflora, both in luxuriance and species diver-

sity, but have also shaped their distributional pattern in different bryogeographical regions of the country (Pande, 1958; Singh, 1993). Hornworts, usually inhabiting regions with high annual precipitation and humidity, show their maximum manifestation in the Himalayas and the peninsular India. While they are mostly the components of tropical-subtropical bryo-vegetation, the species like *Anthoceros alpinus*, *A. angustus*, *Folioceros indicus*, *F. glandulosus*, *Megaceros tjobodensis*, *M. flagellans*, *Notothylas khasiana*, *N. levieri*, *Phaeoceros kashyapii*, etc. attain almost temperate to sometimes alpine altitudes in the Himalayas.

ANTHOCEROTACEAE

Comprising three genera, the family Anthocerotaceae accounts for about half of the total hornwort taxa in the world, with the genus *Anthoceros* widely distributed across the globe. Among the remaining genera while *Sphaerosporoceros* does not occur in India, the genus *Folioceros* is restricted to Africa, Asia and Indo-Pacific regions alone. The family is represented in India by the genera *Anthoceros* and *Folioceros* only.

Anthoceros L. emend. Prosk.

This is the largest genus amongst the anthocerotales, but in India it is so far known to be represented by 9 species only, distributed in all the bryogeographical regions of the country, except the Andaman and Nicobar Islands (Table-I). It shows maximum differentiation in the Eastern Himalayan territory, which harbours 6 species, followed by the Western Himalayas and the Western ghats, with 5 species each. Of the 9 species known to occur in the country *Anthoceros crispulus* (Mont.) Douin. and *A. punctatus* L. are cosmopolitan, whereas *A. alpinus* St., *A. bharadwajii* Udar et Asthana, *A. erectus* Kash., *A. macrosporus* St. and *A. pandei* Udar et Asthana are endemic to India. The other two taxa, viz. *A. angustus* St. and *A. subtilis* St. show Eastern Asiatic affinity (Table-I).

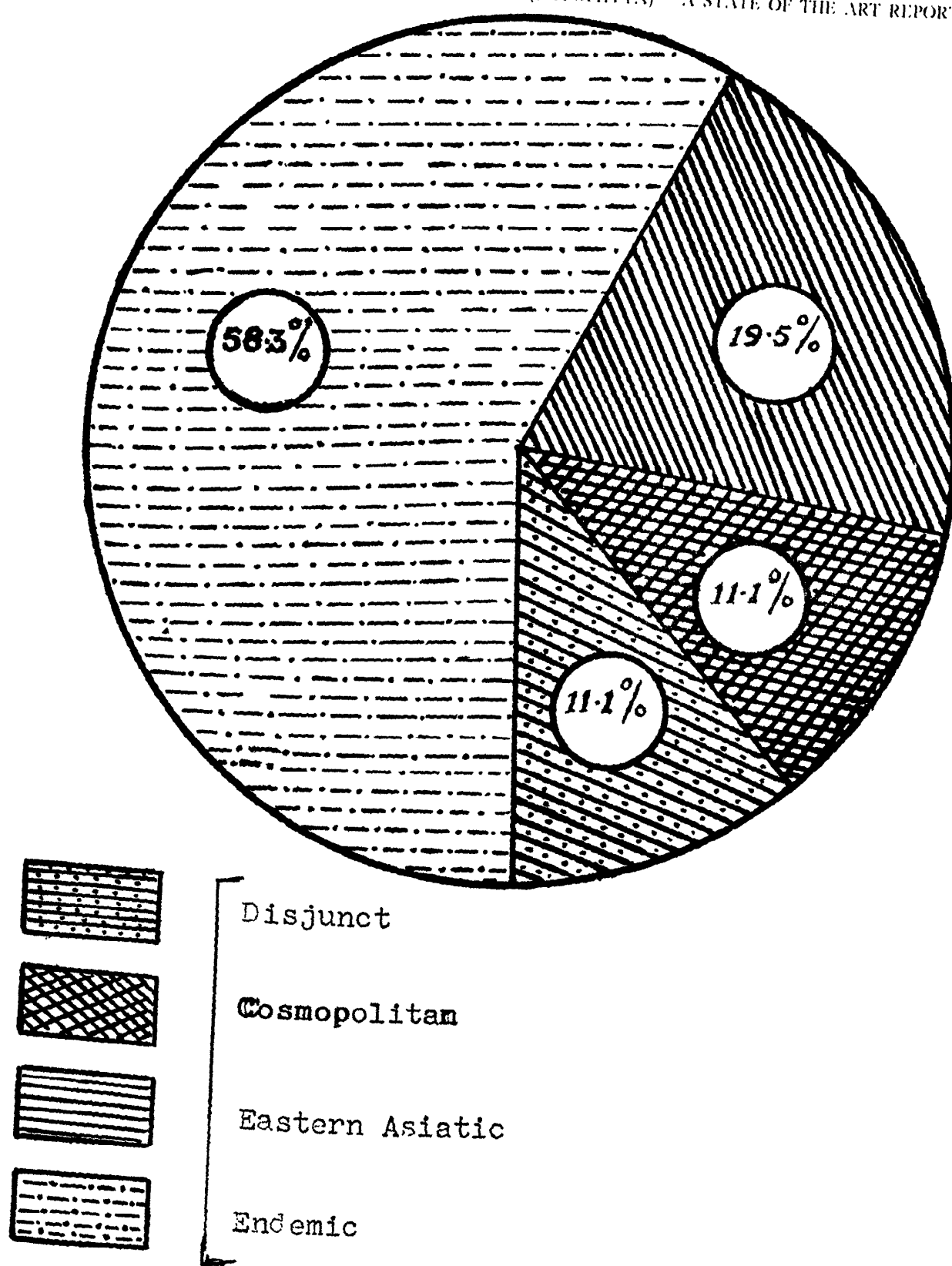


Fig. 1. Schematic representation of phytogeographical affinities of Indian Hornwort Flora.

Table - I : Distribution and Phytogeographical Affinities of Indian hornworts.

Name of the Species	DISTRIBUTION																REMARKS
	INDIA								East- ern Asia	Aus- tra- lia	N.Am- erica	C. Am- erica	S.Am- erica	Afr- ica	Eu- rope		
	Eas- tern Him- alayas	W. Him- alayas	Pun- jab & West Raja- sthan	Gange- tic Plain	Cent- ral India	Wes- tern Ghats	Eas- tern Ghats & Deccan Plateau	Anda- man & Nico- bar Islands									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
ANTHOCEROTACEAE																	
<i>Anthoceros alpinus</i> St.		+														Endemic	
<i>A. angustus</i> St.	+	+							+							Eastern Asiatic	
<i>A. bharadwajii</i> Udar et Asthana	+	+				+	+									Endemic	
<i>A. crispulus</i> (Mont.) Douin	+	+		+		+					+				+	Cosmopolitan	
<i>A. erectus</i> Kash	+	+	+		+	+	+									Endemic	
<i>A. macrasporus</i> St						+										Endemic	
<i>A. pandei</i> Udar et Asthana	+															Endemic	
<i>A. punctatus</i> L.	+	+			+				+		+		+	+	+	Cosmopolitan.	
<i>A. subtilis</i> St.						+			+							Eastern Asiatic	
<i>Folioceros appendiculatus</i> (St.) Udar et Singh	+								+							Eastern Asiatic	
<i>F. assamicus</i> Bharad.	+															Endemic	
<i>Folioceros divitiamus</i> (Mahabale) Bharad.						+										Endemic	
<i>F. indicus</i> Bharad.		+														Endemic	
<i>F. glandulosus</i> (L. et L.) Bharad.	+									+						Disjunct	

Contd.

Contd.

Table - I : Contd.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
<i>Folliceros kashyapii</i> Srivastava et Asthana	+															Endemic
<i>F. mangaloreus</i> (St.) Bharad.						+										Endemic
<i>F. paliformis</i> Singh	+															Endemic
<i>F. pandei</i> Udar et Shaheen						+										Endemic
<i>F. physocladus</i> (Schiff. et Pande) Bharad.	+															Endemic
<i>F. spinisporus</i> (St.) Bharad.						+		+	+							Eastern Asiatic
<i>F. satpurensis</i> (Sriv.) Bharad. et Siv.					+											Endemic
<i>F. udarii</i> Asthana et Srivastava						+										Endemic
NOTOTHYLACEAE																
<i>Notothyas anaporata</i> Udar et Singh						+										Endemic
<i>N. dissecta</i> St.	+					+						+				Disjunct
<i>N. himalayensis</i> Udar et Singh		+	+													Endemic
<i>N. indica</i> Kash.				+	+		+		+							Eastern Asiatic
<i>N. khasiana</i> Udar et Singh	+															Endemic
<i>N. levieri</i> Schiff. ex St.	+	+			+				+				+			Disjunct
<i>N. pandei</i> Udar et Chandra						+										Endemic
<i>N. pfeidereri</i> Udar et Singh						+										Endemic

Contd.

Table - I : Contd.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
PHAEOCEROTACEAE																
<i>Megaceros flagellaris</i> (Mitt.) St.		+							+							Eastern Asiatic
<i>M. tibodensis</i> Campb.	+								+							Eastern Asiatic
<i>Phaeoceros himalayensis</i> (Kash.) Prosk.	+	+				+					+					Disjunct
<i>P. kashyapii</i> Asthana et Srivastava		+														Endemic
<i>P. laevis</i> (L.) Prosk. ssp. <i>Carolinianus</i> Prosk.	+	+			+	+			+	+	+		+	+	+	Cosmopolitan
<i>P. laevis</i> (L.) Prosk. ssp. <i>laevis</i> Prosk.	+	+	+			+				+	+				+	Cosmopolitan

Folioceros Bharad.

The genus is represented by 22 species in the tropical and subtropical regions of the world, of which 13 species are hitherto known to occur in the country (Udar & Shaheen 1982; Singh, 1987; Asthana & Srivastava, 1991). This is the highest representation of the genus in any geographical region of the world. Like *Anthoceros*, this genus too shows maximum diversity in the Eastern Himalayas, with 6 species known to occur here, followed by the Western ghats with 5 species, and Western Himalayas, Central India and the Andaman and Nicobar Islands with 1 species each (Table-I).

Among the Indian taxa 10 species, viz. *Folioceros assamicus* Bharad., *F. dixitianus* (Mahabale) Bharad., *F. indicus* Bharad., *F. kashyapii* Srivastava et Asthana, *F. mangalorens* (St.) Bharad., *F. paliformis* Singh, *F. pandei* Udar et Shaheen, *F. physocladus* (Shiffn et Pande) Bharad., *F. satpurensis* (Sriv.) Bharad. et Sriv. and *F. udarii* Asthana et Srivastava are endemic to the country, whilst *F. glandulosus* (L. et L.) Bharad. shows a bicentric, trans-oceanic disjunct distribution between India and Australia. And *F. appendiculatus* (St.) Udar et Singh and *F. spinisporus* (St.) Bharad. represent Eastern Asiatic Phytogeographical element. It is rather interesting to note that all the Indian species of the genus are curiously confined to their respective bryogeographical regions, except *F. spinisporus* which is common between the Western ghats and the Andaman and Nicobar Islands (Table-I). Interestingly, this is the only hornwort to be so far recorded from this island territory.

NOTOTHYLACEAE

A monogeneric family, comprising the genus *Notothylas* Sull., Notothylaceae occupies a significant phylogenetic position as a 'Synthetic taxon' between liverworts and rest of the hornworts (Udar & Singh, 1978, 1979). The distribution pattern shown by various species of this

family vis-a-vis their phylogenetic status suggests the evolution of Notothylaceae in Western ghats (Singh, 1979).

The genus *Notothylas* is represented in the world by 18 species, mostly exhibiting circumtropical distribution, with the sole exception of *N. orbicularis* (Schw.) Sull. which is a Pan-boreal element. In India the genus is represented by 8 Species (Udar & Singh, 1981) which is highest for any geographic region in the world.

Among the Indian taxa of the genus, 5 species, viz. *N. anaporata* Udar et Singh, *N. himalayensis* Udar et Singh, *N. khasiana* Udar et Singh, *N. pandei* Udar et Chandra and *N. psleidereri* Udar et Singh are endemic to the country, whereas *N. dissecta* St. and *N. levieri* Schiffn., show a bicentric, transoceanic disjunction of considerable phytogeographical interest. On the other hand *N. indica* Kash. shows a very limited range of distribution being confined only to Indian sub-continent (India, Burma and Pakistan).

Unlike the general distributional pattern displayed by liverworts and other hornworts, in its regional distribution in India the genus *Notothylas* shows maximum representation in Western ghats, which hosts a total of 6 species including 4 persistently columellate, primitive species. This is followed by East and West Himalayan territories, with 3 species each; Central Indian territory, with 2 species; and the Gangetic plains, Punjab & West Rajasthan and the Eastern ghats and Deccan Plateau sharing one species each (Table-I). Phytogeographically, therefore, the Western ghats are quite significant and are regarded as cradle of the genus *Notothylas* which might have originated and differentiated here prior to physical separation of continents. It is interesting to note that though *Anthoceros* and *Notothylas* do not show identical habitat preferences, the latter is represented in all the Bryological territories of the country, except of course the Andaman and Nicobar Islands, much like the former (Table-I).

PHAEOCEROTACEAE

The family comprising 4 genera, viz. *Megaceros*, *Phaeoceros*, *Dendroceros* and *Leiosporoceros*, constitutes the second largest family of hornworts, and accounts for bulk of the taxa in Southern Hemisphere and tropical-subtropical regions of Northern Hemisphere. In India, however, only *Megaceros* and *Phaeoceros* are found to occur, together having 6 species including 2 subspecies.

Megaceros Campb.

The genus is represented in India by 2 species, viz. *M. flagellaris* (Mitt.) St. from Himachal Pradesh (Dalhousie) in Western Himalayas (Vishwakarma & Kaul, 1989) and *M. tjbodensis* Campb. from West Bengal (Darjeeling) and Arunachal Pradesh (Srivastava *et al.*, 1990; Singh, 1993) out of a world population of *ca* 40 species. Both are clearly temperate species and show Eastern Asiatic affinity (Table-I).

Phaeoceros Prosk.

The genus shows extreme "somatic plasticity" in a number of species, especially *Phaeoceros laevis* (L.) Prosk. And like *Anthoceros*, it also shows a worldwide distribution, and is represented in India by 3 species and 2 subspecies. The West Himalayan territory accounts for all the 4 taxa, within the genus recorded from the country so far, followed by the Western ghats and the East Himalayan region with 3 taxa each, and Punjab and West Rajasthan and the Central Indian territory, with 1 taxon each (Table-I). Whilst *P. kashyapii* Asthana *et* Srivastava is endemic to India and is confined to just an isolated mountain peak in the Western Himalayas, *P. himalayensis* (Kash.) Prosk. exhibits a bicentric, trans-oceanic disjunction between India and North America (Table-I). The other two taxa viz. *P. laevis* (L.) Prosk. ssp. *laevis* Prosk. and *P. laevis* ssp. *carolinianus* Prosk. are cosmopolitan (Table-I).

It is thus apparent that the general distribution of hornworts, within the present political

boundary of the country, almost fully conforms to the one discernible in the case of rest of the hepatics. The group as a whole shows maximum diversity in the Eastern Himalayas (including the states of North Eastern India) which harbours 19 of the 36 taxa reported to be growing in the country. Among them while 9 taxa are exclusively confined to this territory in Indian bryology, 9 taxa are common with the Western Himalayas; 7 with the Western ghats; 4 with Central Indian territory; 2 each with Punjab and West Rajasthan and Eastern ghats and Deccan Plateau; and 1 with the Gangetic plains. The Western Himalayas host 14 taxa, of which 4 are confined to this region alone in Indian bryology. And of the 10 taxa with extended range of distribution 5 are common with Western ghats; 3 each with Central India, and Punjab and West Rajasthan; 2 with Eastern ghats and Deccan Plateau; and 1 with the Gangetic plains. The Western ghats, with 9 out of 16 taxa, confined to its territory alone in Indian bryoflora, shares 2 species each with Central Indian territory, the Punjab and West Rajasthan, and the Eastern ghats and Deccan Plateau and one species each with the Gangetic plain, and the Andaman and Nicobar Islands. Of the 6 species recorded from Central Indian territory, while 1 is restricted to this region only, 1 species each is common with the Punjab and West Rajasthan and the Gangetic plain; and 2 with Eastern ghats and the Deccan Plateau. Similarly the Punjab and West Rajasthan, with 3 taxa, share 1 species each with the Gangetic plain and the Eastern ghats and Deccan plateau. And the territory of Eastern ghats and Deccan plateau, having 3 species, has one species common with the Gangetic plain.

Endemism :

The endemism in the flora of a country or a particular geographical region provide an insight into the biogeography of the region, centres of diversity, vicariance, and adaptive evolution of the floristic components of that particular region. It may arise either by gradual biotic extinction of the floristic components, once wide-spread, over

Table - II : Regional Distributional Relationship of Endemic Hornworts in India

Bryogeographical Regions of India	Total No. of Species	Distributional formulae	COMMON WITH / CONFINED TO									
			Eastern Himalayas		Western Himalaya		Punjab & West Rajasthan	Gangetic plain	Central India	Western Ghats	Eastern Ghats & Deccan Plateau	Andaman & Nicobar Islands
Eastern Himalayas	8	Aer Fph Abh Fks Apn Fpl Fas Nkh	Apn Fph Fpl	Fas Fks Nkh	Aer Abh	Aal Pks	Fin Nhl		Aer	Aer Abh	Aer Abh	
Western Himalayas	6	Aer Nhl Abh Pks Aal Fin	Aer	Abh	Aal Pks	Fin Nhl		Aer	Aer	Abh	Aer Abh	
Punjab & West Rajasthan	2	Aer Nhl	Aer		Aer	Nhl		Aer	Aer		Aer	
Gangetic Plains	0											
Central India	2	Aer Fsp	Aer		Aer		Aer		Fsp	Aer	Aer	
Western ghats	10	Aer Fud Aih Fml Amc Fpn Fdx Nap Npi Npf	Aer	Abh	Aer	Abh	Aer	-	Aer	Amc Fud Fdx Npi	Fpn Fml Nap Npf	Aer Abh
Eastern ghats & Deccan Plateau	2	Aer Abh	Aer	Abh	Aer	Abh						
Andaman & Nicobar Islands	0											

Aer = *Anthoceros erectus*; Abh = *Anthoceros bharadwajii*; Aal = *Anthoceros alpinus*; Amc = *Anthoceros macrosporus*; Apn = *Anthoceros pandei*; Fas = *Folioceros assamicus*; Fdx = *Folioceros dixitianus*; Fin = *Folioceros indicus*; Fks = *Folioceros kashyapii*; Fml = *Folioceros mangaloreus*; Fpl = *Folioceros paliformis*; Fph = *Folioceros physocladus*; Fsp = *Folioceros satpurensis*; Fud = *Folioceros udarii*; Nap = *Notothylas anaporata*; Nhl = *Notothylas himalayensis*; Nkh = *Notothylas khasiana*; Npi = *Notothylas pandei*; Npf = *Notothylas pfeidereri*; Pks = *Phaeoceros kashyapii*.

most of its range of distribution, during the millions of years, or consequent to physical isolation of their habitat, usually associated with climatological influences during the Pleistocene glaciation, that enhanced the selection pressure leading to the evolution of new taxa (Pande, 1958; Schuster, 1982).

The Indian hornwort flora, with as many as 21 endemic species, is thus considerably interesting from the biogeographical point of view. The bryogeographical territory of Western ghats has a maximum of 10 endemics followed by Eastern Himalayas (8), Western Himalayas (6) and the Eastern ghats and Deccan Plateau, Central India, and the Punjab and West Rajasthan (2 each). The regional distributional relationships of endemic taxa amongst various bryogeographical regions are summarised in Table-II.

The high endemism, coupled with the disjunction between the areas formerly part of the Gondwanaland, amongst the Indian anthocerotites is suggestive of the uniqueness and indigenous nature of its hornwort flora. The entire group apparently is archaic in nature and represents a 'relict' taxon.

STATUS AND CONSERVATION

Like other bryophytes the hornworts too have remarkably diversified themselves to endure the evolutionary limitations imposed by the narrow microenvironmental niches they usually inhabit. Still the extraneous stresses, caused by various anthropogenic practices and related biotic factors in recent times, have put their habitat under considerable strain. The recent investigations carried out on Indian hornworts have, while resulted into some interesting additions as well as extended range of distribution of some taxa, as e.g. *Folioceros appendiculatus*, *Megaceros flagellaris*, *Notothylas dissecta*, *N. levieri* etc., also brought to notice some alarming facts about the status of several other species. A cursory perusal of literature and herbarium records reveals that 10 species of hornworts, viz. *Anthoceros alpinus*, *A.*

macrosporus, *Folioceros assamicus*, *F. indicus*, *F. mangalorens*, *F. physocladus*, *F. satpurensis*, *Notothylas anaporata*, *N. khasiana* and *N. pandei* could never be collected again since their original collection. Ironically most of these species, known through single collection only, are reported from the regions quite extensively botanised from the bryological point of view. Few other species like *Anthoceros pandei*, *Folioceros glandulosus*, *F. kashyapii*, *Megaceros flagellaris*, *M. tjbodensis*, *Notothylas himalayensis*, etc., are either rare in nature or occur in only small, fragmented populations.

Two plausible reasons can be visualised for such phenomenon. First is the loss in diversity resultant from their habitat destruction due to the depletion of vegetal cover provided by macrophytes. Since the habitat requirements of the bryophytes as a whole are highly circumscribed because of their greater dependence on water/moisture to accomplish propagation, both sexual as well asexual, the hornworts too are highly susceptible to any degradation in their natural habitat caused by the indiscriminate clearance of forests and other biotic factors in recent times. As such in any scheme for *in-situ* conservation of rare or threatened bryophytes in general and the hornworts in particular of a given region, the conservation of indigenous macrophytes has also to be taken care of. For, 'environmental amelioration' is an essential prerequisite to create conducive conditions of growth for a group which inhabits narrow ecological niches. Besides, the biological diversity is vital for any stable ecosystem. The depletion of one component in such a system may lead to loss of several dependent species, both plants and animals.

Secondly, and not quite remote, the scant information on the listed species may also be due to lack of proper identification as there are only a few trained bryologists in the country today. This is largely because of their small, rather inconspicuous structure of plants that often escape attention in the field, the group has failed to

interest a common botanist or naturalist in the country. A proper representation of the group in the teaching syllabi of various universities, with judicious choice of representative taxa, is therefore suggested to inculcate interest in the younger generation about this little known yet curious group of plants.

In the meantime concerted efforts should be made to locate these critically rare species not only in their natural homes but in other ecoclimatically identical regions for their *ex-situ* conservation in 'Bryophyte gardens', first of which kind in India is being set up at Nainital (Pant & Tiwari, 1991). The Botanical Survey of India could be instrumental in establishing some more such 'Bryophyte gardens' in different bryogeographical regions of the country for effective *in-situ* as well *ex-situ* conservation of such taxa in their respective territories.

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REFERENCES

- ASTHANA, A. K. AND S. C. SRIVASTAVA. Indian Hornworts. *Bryophyt. Biblioth.* 42 : 1-158. 1991.
- BHARADWAJ, D. C. Taxonomy of Anthocerotales. In *Recent Advances in Cryptogamic Botany*. 132-151. 1981.
- DILLENIUS, J. J. *Catalogus Plantarum Sponte Circa Gissam. Nascentium*, Frankfurt. 1718.
- . In Ray's *Synopsis Methodica Stirpium Britannicarum*, etc. 3rd. ed., London. 1724.
- HASEGAWA, J. Taxonomical studies on Indian Anthocerotae. 1. *Acta Phytotax. Geobot.* 30 : 15-30. 1979.
- . A proposal for a new system of Anthocerotae, with a revision of the genera. *J. Hattori Bot. Lab.* 64 : 87-95. 1988.
- HÄSSEL DE MENENDEZ, G.G. *Leiosporoceros* Hässel n. gen. and *Leiosporocetaceae* Hässel n. fam. of Anthocerotopsida. *J. Bryol.* 14 : 255-259. 1986.
- . A proposal for a new classification of the genera within the Anthocerotophyta. *J. Hattori Bot. Lab.* 64 : 71-86. 1988.
- LINNAEUS, C. *Species Plantarum*. Stockholm. 1753.
- MICHEL, P. A. *Nova Plantarum genera*, etc., Florence. 1753.
- MITTEN, W. *Hepaticae Indiae Orientalis— an enumeration of the Hepaticae of the East Indies*. *J. Proc. Linnaean Soc.* 5 : 109-128. 1861.
- MERRETT, C. *Pinax rerum naturalium britannicarum*, etc., London. 1667.
- PANDE, S. K. Some aspects of Indian Hepaticology. *J. Indian Bot. Soc.* 37 : 1-26. 1958.
- PANT, G. AND S. D. TEWARI. A moss garden in making at Nainital. *Bryol. News letter* 8 : 4. 1991.
- PROSKAUER, J. Studies on Anthocerotales. VI. On spiral thickenings in the columella and its bearing on phylogeny. *Phytomorphology* 10 : 1-19. 1960.
- RENZAGLIA, K. S. A comparative morphology and developmental anatomy of the Anthocerotophyta. *J. Hattori Bot. Lab.* 44 : 31-90. 1978.
- RIDGWAY, J. E. The biotic relationship of *Anthoceros* and *Phaeoceros* to certain Cyanophyta. *Ann. Mo. Bot. Gard.* 54 : 95-102. 1967.
- SAXENA, D. K. Role of *Anthoceros* as a bio-fertilizer. 13th Intern. Bot. Congr. 292. 1981.
- SCHUSTER, R. M. The evolution and early diversification of Hepaticae and Anthocerotae. In *Beiträge zur biologie der niederen Pflanzen*. 107-115. Stuttgart. 1977.
- . Generic and Familial endemism in the 'Hepatic flora of Gondwanaland; origin and causes. *J. Hattori Bot. Lab.* 52 : 3-35. 1982.
- SINGH, D. K. Studies in Indian Notothylaceae. Ph.D. Thesis, Lucknow University, Lucknow. 1979.
- . Bharat mein Pushpa-heen padap samooch 'Liverworts' Ki Vartamaan Sthiti. In *Bharat Ki Vanaspati*. 102-108. Howrah. 1984.
- . A new species of *Folioceros* Bharad. (Anthocerotaceae) from Arunachal Pradesh, India, *Bull. Bot. Surv. India* 29 : 176-180. 1987.
- . Liverwort (Hepaticae) diversity in Indian and its conservation. In *Status Report of Biodiversity Conservation*. New Delhi. 1993. (In Press).
- SRIVASTAVA, S. C., D. KUMAR AND A. K. ASTHANA. Genus *Megaceros* Campbell in India. *Beitr. Biol. Pflanzen*. 65 : 163-173. 1990.
- UDAR, R. *Bryology in India*. New Delhi. 1976.
- AND D. K. SINGH. Thickened bands in the Capsule wall of *Notothylas levieri*. *The Bryologist* 81 : 575-577. 1978.
- AND ———. On a new species of *Notothylas* Sull. from Western ghats, India. *Rev. Bryol. Lichen.* 45. 201-208. 1979.
- AND ———. Recent concept in the taxonomy of the genus *Notothylas*. In *Contemporary Trends in Plant Sciences*. 162-174. New Delhi. 1981.
- AND ———. *Folioceros appendiculatus* (Anthocerotaceae) An addition to Indian Bryoflora. *J. Econ. Taxon. Bot.* 8 : 224-228. 1988.
- AND F. SHAHEEN. A new *Folioceros* from South India. *Geophytology* 12 : 78-80. 1982.
- VISHWAKARMA, K. S. AND A. KAUL. *Megaceros flagellaris* (Mitt.) St. in the North-Western Himalayas. *J. Econ. Taxon. Bot.* 13 : 725-727. 1989.