ON SOME AQUATIC BRYOPHYTE COMMUNITIES OF NAINITAL AND ITS ENVIRONS (WESTERN HIMALAYAS)*

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ABSTRACT

A preliminary study of the bryophytes confined to the aquatic habitats of Naini Tal was taken and a check-list made. A total of eighteen Hepaticae and twenty-eight Musci were recorded, out of them nine liverworts and ten mosses were collected from eutrophic tufaceous, aquatic habitats forming consolidated masses of calc-tufa or travertine. Two mosses, *Distichophyllum schmidtii* Broth. and *Thammobryum latifolium* (Bosch & Lac.) Nieuwl., are new records for India and two liverworts and four mosses are new records for Kumaun Himalayas.

INTRODUCTION

Bryophytes are important components of mountain ecosystems. In a cool, temperate region, like Naini Tal (alt. 1936 m) in the Western Himalayas, one comes across a mosaic of bryophytic communities ranging from relatively xeric to hydric habitats. One may wonder to what extent bryophytes differ among different habitats and microhabitats with respect to taxa composition and what is their preference to the particular niche' as the specificity of this group of plants is now too well known. In seeking answers to these questions a preliminary study of the bryophytes confined solely to the aquatic habitats of this area was taken and a check list made (also PANT & TEWARI, 1982).

OBSERVATION

Naini Tal and its surroundings offer a wide variety of aquatic habitats abounding in lakes, ponds, naulas, streams ditches, marshes, springs, waterfalls, gadhs, canal, nalis and gules that could help to place on record the distribution of bryophytes (See Table 1). In this assessment of bryophytic vegetation on aquatic habitats, the present analysis is based on visual field observations mainly upon the physical characteristics of the habitat or microhabitat on which the community occurs. The aquatic bryophytic species are categorised into two main groups.

I. *Tufaceous Aquatic habitat*—In this type of aquatic habitats only those liverworts and mosses are included which directly or indirectly receive highly calcareous water from underground seepage, springs or streams and form solid porous masses of calcium carbonate called tufa or travertine. Four important sites were taken into consideration for the study of such incrusting algal-bryophytic communities of calcareous spring waters, viz. at Bhujia Ghat, Dogaon, Khurpa Tal and Kuligadh (Suyalbari). High calcium content in water apparently does not inhibit the growth of bryophytes and many species thrive well in this eutrophic environment. These are *Asterella* sp.,

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Table 1—Aquatic Bryophytic communities of Naini Tal & its environs.

S. No.	Aquatic Habitats	Colonizing Bryo-flora
		(Forming 'fossil casts')
A	Tufaceous, aquatic habitat	*Dumortiera hirsuta*, *Pellia endiviaefolia*, *Chiloscyphus polyanthus* *Plagiochila* sp. *Atrichum obtusulum*, *Barbula gracienta*, *Eurhynchium riparioides*, *Fissidens grandifrons*, *F. taxifolius*, *Hydrogonium javanicum*, *Philonotis ealcarea*, *Vesicularia montagnei*,
		(Not forming 'fossil casts')
		Asterella sp., *Marchantia palmata*, *M. polymorpha*. *Plagiochasma appendiculatum*, *Jungermannia gollanii*, *Cratoneuron commutatum*, *Mnium cuspidatum*.
B	Non-Tufaceous, aquatic habitats	
	1—Lakes	*Riccia fluitans*, *Ricciocarpus natans*, *Ectropothecium cyperoides*, *Eurhynchium striatum* , *Hydrogonium consanguineum*.
	2—Ponds	*Riccia curtisii*, *R. fluitans*, *Barbula indica* var. *gregaria*, *Cratoneuron commutatum*, *Drepanocladus exannulatus*, *Fissidens sylvaticus*, *Physcomitrium pyriforme*..
	3—Naulas	*Pellia endiviaefolia*, *Chiloscyphus argutus*, *C. polyanthus*, *Ectropothecium cyperoides*, *Eurhynchium riparioides*, *Fissidens bryoides*, *Rhynchostegium vagans*.
	4—Streams	*Dumertiera hirsuta*, *Marchantia nepalensis*, *Pellia endiviaefolia*, *Chiloscyphus polyanthus*, *Anomobryum filiforme*, *Barbula gracilenta*, *Cratoneuron filicinum*, *Eurhynchium riparioides E. striatum*, *Fissidens grandifrons*., *F. nobilis*, *Hydrogonium consanguineum*, *Philonotis fontana*.
	5—Ditches	*Eurhynchium riparioides*, *Mnium cuspidatum*.
	6—Marshes	*Marchantia polymorpha*, *Pellia endiviaefolia*, *Riccardia pinguis*, *Mnium cuspidautum*, *Philonotis fontana*, *Vesicularia montagnei*.
	7—Perennial springs	*Conocephalum conicum*, *Dumortiera hirsuta*, *Anthoceros* sp. *Pellia endiviaefolia*, *Chiloscyphus polyanthus*, *Plagiochila* c.f. *orientalis*, *Anomobryum filiforme*, *Distichoplyllum schmidtii*, *Eurhynchium striatum*, *Fissidens bryoides*, *Hydrogonium consanguineum* *Mnium cuspidatum*, *Plagiomnium rostratum*, *Philonotis fontana*, *Thamnobryum latifolium*.
	8—Waterfalls	*Asterella wallichiana*, *Dumortiera hirsuta*, *Pellia endiviaefolia*, *Chiloscyphus polyanthus*, *Barbula gracilenta*, *Cratoneuron commutatum*, *Eurhynchium striatum*, *Fissidens grandifrons*, *Philonotis fontana*.
	9—Gadheras & Gadhs	*Dumortiera hirsuta*., *Marchantia palmata*, *M. polymorpha*, *Pellia endiviaefolia*, *Barbula graeilenta*, *Fissidens bryoides*, *F. sylvaticus*, *Philonotis fontana*.
	10—Canals	*Asterella wallichiana*, *Marchantia palmata*, *Chiloscyphus polyanthus*, *Barbula gracilenta*, *Eetropothecium cyperoides*, *Eurhynchium striatum*, *Hydrogonium pseudo-ehrenbergii*, *Philonatis fontana*, *Rhynchostegium vagans*.
	11—Nalis	*Asterella wallichiana*, *Marchantia palmata*, *Chiloscyphus polyanthus*, *Barbula graeilenta*, *Fissidens bryoides*, *Philonotis fontana*.
	12—Gules	*Marchantia palmata*, *Barbula indica*, *Fissidens sylvaticus*, *Mnium cuspidatum*, *Taxiphyllum taxirameum*.

Dumortiera hirsuta (Sw.) Nees., *Marchantia palmata* Nees., *M. polymorpha* L., *Plagiochasma appendiculatum* L. et L., *Pellia endiviaefolia* (Dicks.) Dum., *Chiloscyphus polyanthus* (L.) Cord., *Jungermannia gollanii* (St.), *Plagiochila* sp., *Atrichum obtusulum* (C. Muell.) Jaeg., *Barbula gracilenta* Mitt., *Cratoneuron commutatum* (Hedw.) Roth., *Eurhynchium riparioides* (Hedw.) Richs., *Fissidens taxifolius* Hedw., *F. grandifrons* Brid., *Hydrogonium javanicum* (Doz. & Molk.) Hilp., *Mnium cuspidatum* Hedw., *Philonotis calcarea* (B. S. G.) Schimp., *Vesicularia montagnei* (Bel.) Broth. The thick algal felts of some blue-green algae, like *Chroococcus, Nostoc, Petalonema alatum* Berk. var. *indicum* Rao. together with many diatoms and a desmid like *Cosmarium* sp. together with the dense moss polsters and liverwort thalli seem to induce the development of a biogenic rock, like calc-tufa or travertine by providing spongy surfaces which can absorb, retain and expose copious thin films of water for effective evaporation and consequent diffusion of CO_2 from the calcareous spring waters thus causing the precipitation of $CaCO_3$ in the form of travertine. The mineral matter (calcite) hardens round the mosses and liverworts taking the mould of their forms and these plants act as nuclei or 'frame work' around which travertine is deposited (Emig, 1917; Wilson & Guest, 1961; Parihar & Pant, 1977).

In our observations from the above mentioned three sites around Naini Tal, calcite impregnated specimens were collected in various stages of travertine formation ranging from bright green cushions and mats of *Barbula, Fissidens, Hydrogonium, Vesicularia, Chiloscyphus* and *Plagiochila* to partly incrusted or porous, crumbling plant masses and finally the compact limestone. All these plants were also seen in various stages of gradual decay of their rhizoids as well as older parts of the leafy shoots or thalli as they go on being incrusted and buried in calcareous mud or tufa, while young, green shoots arise at the tips. The vigorous growth rate of these organisms (algae and bryophytes) seems to exceed the rate of carbonate deposition so that the process of getting cemented below and growing above is continued and the tufa also "grows up".

II. *Non-Tufaceous Aquatic habitat*—All those bryophytes are included in this category which are seen growing on other than tufaceous aquatic habitats.

Lakes—Naini Tal lake itself has no bryophytic element, either in free-floating or in a submerged state. However, the periodically inundated, wavy lake margin, on careful examination shows a few mosses like *Hydrogonium consanguineum* (Thwait & Mitt.) Hilp., and *Eurhynchium striatum* (Hedw.) Schimp. The growth of these mosses is confined only to the exposed surfaces of partly underlying dolomitic rocks and boulders liable to be flooded by discontinuous water currents of the lake. The two mosses seem to be the chief colonizers of a microhabitat of their own. By contrast, the nearby Bhim Tal and Naukuchia Tal lakes harbour the floating species of *Riccia fluitans* L. The liverwort grows in abundance over the stagnant waters throughout the shallower portions of the lake margin. On the muddy shores of these lakes, *Ricciocarpus natans* (L.) Corda. is found associated with a moss *Ectropothecium cyperoides* (Hook.) Jaeg.

Ponds—Temporary ponds having no underlying source of water that come up seasonally during the rains are generally devoid of any bryophytic colonization. The latter only begins when the pond starts drying up. A study of some such dried up ponds made at Chaurgalia (foot-hills) on Haldwani-Tanakpur road (alt. 348 m) revealed the presence of ****Riccia curtisii*** (Aust.) James.—*Riccia fluitans—Fissidens sylvaticus* Griff.—*Physcomitrium pyriforme* (Hedw.) Hamp.—****Barbula indica*** var. *gregaria* (Mitt.) Zond. community. *Riccia curtisii* happens to be an interesting species, collected for

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****New records for Kumaun Himalaya.**

the first time from Kumaon Himalayas (TEWARI & PANT, 1983). Previously a few thalli of this species were once collected by PANDE AND AHMAD (1944) by the sides of a lake in Mohanlalganj (Lucknow) and reported for the first time from India. They had noted that some spores of this plant were perhaps brought to the site of its occurrence from somewhere in the hills but somehow the species could not get stabilized in the plains. Curiously enough the plant has not been gathered from any other spot in the country (UDAR, 1961). In contrast, the permanent ponds (having a continuous source of water) showed a different bryophytic flora. Pleurocarpous mosses like *Cratoneuron commutatum* (Hedw.) Roth. and ***Drepanocladus exannulatus* (B. S. G.) Warnst. grow submerged to slightly emergent all along the margins of the ponds. *Riccia fluitans* (sterile) is also associated with aquatic weeds.

"*Naulas*"—Naula is a local term used by hill people for a type of closed spring water reservoir. Bryophytes growing luxuriantly over the constituent stones of this water reservoir in an extremely moist, dark environment are: *Pellia endiviaefolia, Chiloscyphus argutus* Nees., *C. polyanthus, Ectropothecium cyperoides, Eurhynchium riparioides, Fissidens bryoides* Hedw. and *Rhynchostegium vagans* Jaeg. Here the growth of the pleurocarpous moss *Rhynchostegium* is specially noteworthy as it forms a lush green turf over the stones which are completely bathed in water. The wiry, yellow-green glossy tufts of this moss are coated with diatoms too. The attachment of the epiphytic algae is in part related to the structure of the surface layer of the plants (ROUND, 1965) and the thin long, wiry, moss shoots of *Rhynchostegium* serve as a rough surface. Accordingly it is not surprising to find *Rhynchostegium* skeins at such sites heavily epiphytized with diatoms. It is interesting to note in this connection that the moss—(*R. vagans*)-diatom association is a constant feature of all the "naulas" studied.

Streams—Perennial spring waters flow down at different speed rates. The downward flow of stream water depends upon the mountain slope. Our observations reveal that the fast flowing steams are chiefly colonized by a thick mossy-felt of *Cratoneuron filicinum* and *Eurhynchium striatum* while the slow-moving steams support a rich assemblage of liverworts and mosses, like *Dumortiera hirsuta, Marchantia nepalensis* L. et L., *Petlia endiviaefolia, Chiloscyphus polyanthus, Anomobryum filiforme* (Dicks.) Solms., *Barbula gracilenta, Eurhynchium riparioides, Fissidens grandiforns, F. nobilis* Griff., *Hydrogonium consanguineum* and *Philonotis fontana* (Hedw.) Brid.

Ditches—These are small, open water bodies densely colonized by mosses, like *Eurhynchium riparioides* and *Mnium cuspidatum.*

Marshes—Marshes are not very common in Naini Tal. For the present study only two marshy sites were observed, viz. at Ghorakhal (Bhowali) and Kuligadh (Suyalbari) 15 and 36 km respectively from Naini Tal. Here bryophytes are well adjusted with Angiosperms, like species of *Mentha* and *Polygonum.* At various levels of the marshy habitat, yellowish-green, dense patches of *Riccardia pinguis* (L.) Gray are seen flourishing well. Besides this interesting liverwort, *Marchantia polymorpha, Pellia endiviaefolia, Mnium cuspidatum, Philonotis fontana* and *Vesicularia montagnei* form a close-knit community.

Perennial Springs—Abundant perennial springs of Naini Tal and its surroundings present a characteristic group of liverworts and mosses. The spring water seepage oozing out through the underlying slaty substrata at various places in Dhobighat was seen to be colonized by a *Conocephalum conicum* (L.) Neck., *Dumortiera hirsuta-Pellia endiviaefolia-Chiloscyphus polyanthus-Anthoceros* sp.-*Eurhynchium striatum* community. Inci-

dentally it may be mentioned here that Dhobighat is the only known station for *Conocephalum conicum* in Naini Tal.

Another aquatic bryophyte community consisting of *Chiloscyphus polyanthus*, ***Plagiochila* cf. *orientialis*, ****Distichophyllum schmidtii* Broch., *Mnium cuspidatum*, ***Plagiomnium rostratum* (Hook.) Kop. and ****Thamnobryum latifolium* (Bosch. & Lac.) Nieuwol. was seen at Hartola (Alt. 1750 m, distance 40 km) where the perennial spring water cascades over quartzite rocks (PANT & TEWARI, 1984). A bryophytic cover observed at Nathuakhan (alt. 1550 m) revealed an altogether different community consisting of *Anomobryum filiforme*, *Fissidens bryoides*, *Hydrogonium consanguineum* and *Philonotis fontana*.

Water falls—In the present study two water falls namely those of Kuligadh (Suyalbari, distance 32 km) and Bhujiaghat (distance 20 km) areas are taken into consideration. These descend down from a height of 15 m and 20 m, respectively. The central part of the main talus slope of the falls do not show any bryophytic colonization while the margin of the entire downward drop are lined with such mosses as *Barbula gracilenta* and *Eurhynchium striatum*. The neighbouring areas slightly away from the margins but coming in the spray zone are seen to be colonized by *Asterella-Dumortiera-Pellia-Chiloscyphus-Cratoneuron-Fissidens-Philonotis* community.

"Gadheras" and "Gadhs"—These two terms are commonly used by hill people. "Gadheras" are chasms of deep gullies in the hillside into which water flows through drainage and shows periodic drying. Due to the irregularity of water supply, this type of habitat does not show any peculiar aquatic bryophytic association. The water of the perennial streams, springs and seasonal "gadheras" ultimately mingle into a broad rivulet called "gadh". The water of the "gadh" never dries. Here the moss community of *Barbula gracilenta-Fissidens bryoides-Philonotis fontana* is very characteristic of the creeks and crevices of the partly submerged boulders and stones. The muddy banks of the "gadh" harbour *Dumortiera hirsuta*, *Marchantia palmata*, *M. polymorpha*. *Pellia endiviaefolia* and *Fissidens sylvaticus*.

Canals—Water from the rivulet is taken away by means of about 1.5 m to 2 m broad canals for the irrigation of cultivated lands. Canals are generally made up of stones and cementing material. Bryophytes, like *Asterella wallichiana* (Lehm.) Grolle, *Marchantia palmata*, *Chiloscyphus polyanthus*, *Barbula gracilenta* and *Philonotis fontana* are seen to be well adapted to grow in between the partitions or gaps of constituent stones throughout the length of the canal. This sort of microhabitat does not retain much water and the bryophytes seem to exist here as a 'catch-as-catch-can basis'. By contrast, a luxuriant mossy carpet comprising *Ectropothecium cyperiodes*, *Eurhynchium striatum*, ***Hydrogonium pseudo-ehrenbergii* (Fleisch.) Chen and *Rhynchostegium vagans* flourishes on the shallower portions of the canal where water flows slowly and the moss shoots are regularly bathed in water.

"Nalis"—Water is taken from the canals through about 0.5 m wide "nalis". These are made up of stones and cementing material. Here again the bryophytic colonization is selective of their niche being confined to only the tiny space in between the constituent stones. The chief invaders are *Asterella wallichiana*, *Marchantia palmata*, *Chiloscyphus polyanthus*, *Barbula gracilenta*, *Fissidens bryoides* and *Philonotis fontana*.

Gules—The only difference between "gules" and "nalis' lies in the fact that "gules" are always muddy while "nalis" are constructed of stones and cementing ma-

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***New records for India.

terials. Obviously the colonizing bryophytic flora receives an altogether different underlying substratum (mud). A *Marchantia-Barbula-Fissidens-Mnium-Taxiphyllum taxirameum* (Mitt.) Fleisch. community was observed throughout the length of such "gules" colonizing the bare mud.

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