MAN-MADE, DISTURBED HABITATS AND THEIR BRYOPHYTIC ASSOCIATIONS OF NAINITAL AND ENVIRONS, WESTERN HIMALAYA

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Abstract

Bryophytic colonization on various man-made, disturbed habitats in and around Nainital was studied. A total of 12 liverworts and 20 mosses were recorded. Their peculiarities of distribution in such habitats/microhabitats and niches are discussed. The status of *Funaria hygrometrica* Hedw. as a pyrophilous species and a pioneer invader of many bare, unstable surfaces has also been emphasized.

Introduction

Bryophytes form an important and striking part of the cool, humid Himalayan scenario. They impart a lush greenery—a verdant cover in every possible shade of green tinged with hues of brown, red and yellow to almost all kinds of habitats like rocks, boulders, stones, hillsides, tree trunks, forest floors and various artificial substrates in/around Nainital. In the present study, an attempt has been made to find out the distribution of bryophytes in such man-made and disturbed habitats. Due attention was paid to the importance of habitat, microhabitat and niche of these small plants.

It is a well-known fact that bryophytes occupy preferentially or exclusively certain habitats such as rock of preferred kind, bark of a specific nature, logs and stumps at certain stages of decomposition or soil or humus under appropriate conditions of moisture, exposure and hydrogen ion concentration (Crum, 1972). The bryofloras of calcareous and siliceous rock surfaces differ considerably (Schofield, 1985). Not only the habitat but also the subtle differences of microhabitat and niche may be of crucial importance to bryophytes.

Bryophytes are also able to grow on substrata initially unsuitable for most higher plants and therefore emerge as primary colonizers on barren, disturbed or even unstable surfaces. In the colonization of each such habitat/microhabitat/niche, the emergence of a particular bryophyte species/community is favoured by shade, available moisture, texture of the surface, altitude and local climate.

Material and methods

During the collection of bryophytes from diverse habitats in district Nainital and vicinity, we came across different types of bryo-colonizations over various man-made and disturbed substrates. These included building blocks of old and new retaining walls (stones), cementing material used as a filler in-between the gaps of adjoining stones; trampled sites: scattered bricks and brickworks of pavements, cement-walks/blocks, gravel foot paths; accumulated lime wastes around lime kilns; roof tops; road-cuts and cut-ends of hill slopes and burnt soils and ashes left by fires. The fresh material was brought to the laboratory for microscopic study. Slides were prepared in Gum chloral mounting medium. Bryophytes were duly identified in the Lab. All the voucher specimens are lodged in the Bryophyte Herbarium, Department of Botany, Kumaun University, Nainital.

This preliminary assessment of bryophytic vegetation on man-made, disturbed habitats is based upon visual field observa-

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tions-mainly the physical characteristics of of the habitat/microhabitat/nichè on which the species/community grows.

Observations

Man-made and disturbed substrates

1. *Retaining walls*

Retaining walls are conspicuous feature of hill areas. A rich wall-flora lends colour to outdoor scenes and one notices and passes by an array of bryophytes, ferns and herbs everyday. The distinct types of retaining walls were recognized in this study—the old and the new ones. Over the former (old retaining walls) two clearcut niches can be seen, each having its own bryoflora.

1.1. *Old retaining walls*

(i) Over the moist surfaces of the constituent stones, species of *Asterella*, *Plagiochasma*, *Frullania*, *Lejeunea*, *Brachythecium*, *Entodon*, *Herpetineuron* and *Hyophila* prevail in a lush expansion. At places, the succession has already progressed to a considerable extent up to the moss-fern-herbaceous stages.

(ii) The cementing material used as a filler in-between the gaps of adjoining stones, provides the second nichè where *Hymenostylium recurvirostrum* vár. *cylindricum* (Bartr.) Zand. (Pl. 1, fig. 2) has established itself. The moss is a known calcicole that thrives well over a calcareous substrate.

Old retaining walls

↓ Nichè i. (stones)

Asterella wallichiana (Lehm.) Groll.
Plagiochasma appendiculatum L. et L.
Frullania squarrosa (Nees) Mont.
Lejeunea tuberculata Steph.
Brachythecium buchananii (Hook.) Jaeg.
Entodon plicatus C. Muell.
Herpetineuron toccoae (Sull. et Lesq.) Card.
Hyophila involuta (Hook.) Jaeg.
H. rosea Wiliams
Asplenium dalhousiae Hook.
Cheilanthes albomarginata Clarke.
Arthraxon lancifolius (Trin.) Hochst.
Erigeron karvinskianus DC.
Geranium nepalense Sweet.
Viola canescens Wall. ex Roxb.

↓ Nichè ii. (cementing material)

Hymenostylium recurvirostrum

1.2. *New retaining walls*

The newly constructed retaining walls are equally interesting in terms of their bryocover and colonization.

(i) The exposed faces of stones remain barren for a long time and the process of succession is extremely slow. *Frullania squarrosa*, *Lejeunea tuberculata* and *Hyophila involuta* are the pioneers.

(ii) In contrast, the cementing material as a filler is at once colonized by a thick population of *Funaria hygrometrica* Hedw. (Pl. 1, fig. 1) even in the very first season after construction. The dense and copiously fruiting tufts of the "ephemeral-annual",

F. hygrometrica referred by During (1979) as the species with a "fugitive life strategy", are quickly stripped off along with a surfacial crust of the underlying soil. Thus, once again the substratum remains bare and the recolonization by the same moss starts anew. This process is repeated at least twice or thrice in a year. Next seral stage is followed by a moss-liverwort mingled community of *Bryum argenteum* Hedw. *Didymodon recurvus* (Mitt.) Broth. *Hydrogonium amplexifolium* (Mitt.) Chen-*Asterella wallichiana-Plagiochasma appendiculatum*. Finally this community is superseded in turn by the lone expansion of the well known Pottiaceous calcicole, *Hymenostylium recurvirostrum*. This moss population holds the fort for a long time. In this way the cementing material of the entire wall is capped with a beautiful green mossy covering forming a distinct pattern. The moss extends itself in a very characteristic way, following contours of the cementing material (Pl. 1, fig. 2).

Bryophyte succession on newly constructed stony walls

Nichè i (Fresh faces of stones).

Nichè ii (Cementing material)

Frullania squarrosa

Lejeunea tuberculata

Hyophila involuta

Recolonization

I. *Funaria hygrometrica*

II. Liverwort—moss community
Asterella wallichiana-Cyathodium tuberosum Kash.-*Plagiochasma appendiculatum-Bryum argenteum-B. bicolor* Dicks.-*Didymodon recurvus-Hydrogonium amplexifolium*

II. *Hymenostylium recurvirostrum var. cylindricum*

2. *Trampled sites*

Common "weeds" like *Bryum argenteum* and *Funaria hygrometrica* (Pl. 1, Fig. 3) appear immediately over scattered bricks and brickworks of pavements; cement-walks/blocks, gravel foot paths. The silver moss, *Bryum argenteum* spreads abundantly over all such regularly trampled sites in the form of a green line. The regenerating potential of this "hardy voyageur of the cement canal" is remarkable. The tiny fragments of leaves carried from one place to another on the soles of shoes regenerate into new plants upon falling to the ground again (Ketchledge, 1961; Studlar, 1980), enabling it to become a "truly colonizing species" (During, 1979).

Some bryophyte species sprout on cattle-trodden soils particularly over the footprints or hoofprints of animals. As stated by During (1979) these particular spots may disappear within a short period, i.e. become unsuitable for the species. However, the species reappear over similar other spots in the same area. The most notable of such "annual shuttle species" are *Bryum argen-*

teum, *Riccia* sp. and *Notothylas* spp. The common 'weed' *B. argenteum* grows abundantly on animal footprints together with *Notothylas indica* Kash. in *Bhabar region and *N. levieri* Schiffn. particularly in the hills. A few others, viz., *Riccia frostii* Aust., *Aneura pinguis* (L.) Dum., *Funaria hygrometrica* and *Philonotis fontana* (Hedw.) Brid. colonize the damp, animal drinking places near the margins of tempotary ponds.

3. *Accumulated lime wastes around lime kilns*

Lime kilns are very frequent in the lowlying foot-hills and Bhabar (300-500 m.) areas of district Nainital. Here, limestone is brought down from the limestone quarries. The rock pieces are broken into smaller pieces and baked in a kiln. Enough waste material is left all around containing powdery ash of lime. After sometime, this lime-enriched mass becomes a suitable thriving substrate for some mosses like *Barbula indica* (Hook.) Spreng. and *Hyophila involuta*. The moss population is very conspicuous all around wherever the spray of powdery lime-ash reaches and gets deposited. In the lime kiln sites of the hills particularly in Nainital and Khurpa Tal (1700-2000 m.) areas, we have observed dense colonization of another calcicole moss, *Hymenostylium recurvirostrum* around the accumulated lime wastes. On such lime-enriched habitats these mosses reach a luxuriant expansion and their repeated occurrence seems to go well with their preference to calcareous substrate.

4. *Roof tops*

Roof tops, especially in regions with extended periods of wet weather, are often colonized by mosses. Substrata that retain moisture particularly favour bryophyte colonization, with thatched roof tops sometimes harbouring a rich moss mat. Slate, wooden and pebble-impregnated shingles all favour moss colonization (Schofield, 1985). Mosses thriving on roof tops made-up of slate, asbestos, cement mixed with pebbles in our hilly areas deserve attention. Thick, easily detachable cushions of *Bryum capillare* Hedw., interspersed with *B. argenteum* and *Herpetineuron toccoae* accumulate large quantities of of soil or humus and become so much rounded and massive (Pl. 1, figs. 4, 5, 6) that they can easily slide down the slopy roofs of the building by strongly blowing winds. The moss cushions act as efficient "traps" and accumulate enough dust especially over the roofs of roadside buildings. Such moss cushions are spread over slaty and asbestos roofs in patches (Pl. 1, figs. 4, 5). Even on drying and incorporating enough soil and humus in-between, they retain their spheroidal shape, get detached from their substratum and are carried away by the violent gusts of wind. Like the "unattached moss polsters" of Shacklette (1966); these cushions also assume a typically spheroidal form because of nearly equal growth in all directions made possible by the frequent change in orientation of the polsters.

Bryum capillare is a common colonizer of a variety of substrates in this region. Besides roof tops, this acrocarp commonly grows on tree-barks, decomposed leaf litter, soil covered rocks and boulders and even over an almost negligible, inconspicuous soil-layer accumulated over joints of telephone poles and corners of iron window frames. This illustrates the ability of this moss to become "a specialist in frugality" making very little demand upon its habitat.

5. *Road-cuts/cut-ends of hill slopes*

The freshly cut-ends of exposed hillslopes and various sites prone to landslides in the hilly areas are interesting, because a new section of soil is brought to the surface each time. Here, one is reminded of Schuster's (1969) remark that "hepaticae and to some degree other bryophytes are essentially pioneer species, which..... invade bare sites and prepare such habitats for the eventual succession of higher plants, i.e., they form a matrix in which higher plants can undergo ecesis. Liverworts, therefore, occur most abundantly in restricted sites where they do not have to compete with other plants. Among such sites are rock walls and their crevices, the surface of decorticated logs, moist, loamy or sandy soil of mud-slides and road-cuts, where the succession of higher plants is limi

* The term Bhabar in Nainital District is applied to a narrow undulating belt of country at the foot of the hills. The terrain is of recent origin and characterised by boulders and shingle brought down by fast-flowing streams. The sub-montane zone is remarkable for absence of water as the drainage quickly percolates through the thin layer of alluvium and the upper soil is left arid and waterless.

ted by erosion.....With some restrictions, the less mature a site and the more extreme the physical conditions, the more diverse and conspicuous the bryophyte flora is likely to be". *Funaria hygrometrica* intially comes to colonize the freshly bare surfaces, subsequently followed by species of *Anthoceros*, *Anomobryum*, *Atrichum*, *Bryum*, *Pohlia* and *Pogonatum*. These are usually replaced by ferns or grasses and eventually by herbs, shrubs or trees if conditions are favourable.

6. *Burnt soils/ashes*

Initial plant colonization following burning of vegetation frequently consists of a highly characteristic assemblage of bryophyte species (Brown, 1982). *Funaria* and *Ceratodon* are recognized world wide as pyrophilous-"fire mosses" (Scott *et al.*, 1976). Southorn (1976) referred to *Ceratodon purpureus* (Hedw.) Brid. and *Bryum argenteum* as 'bonfire' species and emphasized upon the rapidly achieved dominance of *Funaria hygrometrica* over burnt soil surfaces.

We have observed *F. hygrometrica* on various burnt sites viz., forests, fallow fields and hillslopes in and around Nainital as the most conspicuous member of a post fire ground community. It is invariably associated with *Marchantia palmata* Nees, *M. polymorpha* L., *Riccia* sp. *Brachythecium buchananii*, *Bryum argenteum*, *Ceratodon purpureus* and *Pogonatum* sp. On burnt soil the initial plant colonization and dominance of *Funaria* is rapidly achieved. Higher plants probably fail to colonize initially on such inorganic mateials of accumulated ashes and burnt soils. This may be due to the high nutrient status because burning increases the nutrient content of the soil surfaces (Brown, 1982).

On burnt soil surfaces and accumulated wood ashes of dead stumps, old fallen trees and logs in *Pinus roxburghii* Sargent forest sites, the initial colonization of *F. hygrometrica* starts after 2 or 3 months following fire. Dense population of this species prevails around the areas where dead stumps, fallen trees and logs have been burnt and reduced to a substantial amount of ash. Large, more or less circular patches of *Funaria* are seen over the ground where ashes of the burnt stumps had accumulated. The burnt ash layer of fallen, dead trees and logs is beautifully colonized by the same moss, *Funaria* following the lengths of fallen trees and logs (which have been reduced to ashes). At such places in *P. roxburghii* forests, the mature, copiously fruiting population of *F. hygrometrica* becomes so very pronounced that one can easily locate the preburnt position of a stump, fallen tree or log by merely observing the moss colonization. This could be an aid to the trained forester for visually locating the position and number of stumps, fallen trees and logs by following the moss population.

During the course of our field studies, we have frequently noticed that *F. hygrometrica* not only invades the burnt soils but also appears on cemented ramshackled walls and collapsed debris; freshly cut-ends of muddy hill slopes as well as over unstable, slightly uplifted frozen soil that looks like pulverised soil seen around earthworm burrows.

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Explanation of Plate

Plate 1

1. Pioneers of vegetation-*Funaria hygrometrica* on cementing material of a newly constructed stony wall.
2. Dense tufts of a calcicole, *Hymenostylium recurviros*

trum var. *cylindricum* form a long lasting stage in the primary succession on a stony wall. Note that growth of the moss has followed the contours of cementing material, while the hard stony surfaces remain bare.

3. *Funaria hygrometrica* population on a dilapidated old cemented wall.
4. Thick cushions of *Bryum capillare* (arrows) over a cemented roof.
5. Thick, spheroidal, easily detachable cushions of *B. capillare* (arrows) over the slaty tiles of a slopy roof top.
6. A thick detached cushion of *B. capillare* intermixed with the silver moss, *B. argenteum*.