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# An Initiatory Review on Bryophytes Diversity

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**Abstract:** *The varied group of terrestrial plants known as bryophytes is tiny in stature but has significant ecological effects. The biggest group of terrestrial plants, excluding flowering plants, they have over 23,000 known species worldwide. Mosses, hornworts, and liverworts are among the three phylogenetically separate lineages that make up the category. Mosses are typically regarded as a "key group" in our comprehension of the phylogenetically relatedness and origin of contemporary land plants (embryophytes). Bryophytes are able to live in a wide range of settings and have various growth habits. Although, mosses exhibit high species diversity, a major limitation in using mosses as study organisms has been the lack of basic floristic, ecological, and alpha-taxonomical knowledge of plants in many regions.*

**Keywords:** *Bryophytes, plants, Diversity, mosses, liverworts, hornworts etc.*

## I. INTRODUCTION

Bryophytes are spore-producing, non-vascular terrestrial plants. They are the second largest plant genus after the flowering plants, but are less well known due to their size (Chandra et al., 2017). Mosses include a very separate group in the vegetation of land plants. They comprise around 23,000 species and form the most species-rich group of land plants. They have evolved to be an incomparable variety in size and structure. In India, mosses are represented by about 2850 taxa (Singh and Hajra 1996) and the Western Himalayas, Eastern Himalayas and Western Ghats represent biodiversity hotspots and acquire numerous endemic mosses. They can grow in extreme conditions. Most mosses are small, but some reach heights of up to half a meter or a little more. They can store large amounts of water, nutrients and carbon in their biomass. In most ecosystems, especially in peatlands, mosses act as carbon sinks, which is of great importance given the increasing levels of carbon dioxide around the world. Most mosses are ectohydric; they have the ability to absorb water, inorganic nutrients and mineral elements directly from the atmosphere rather than from the soil and substrate. Bryophytes are widely considered to be the oldest living land plants (Shaw and Renzaglia 2004). The properties of mosses relate them to green algae and both seem to have a common ancestor. Bryophytes have a short-lived dominant sporophytic and gametophytic phase. Bryophytes have a basal phylogenetic position among extant land plants, remnants of lineages that survived the spectacular radiation of land plants in the Devonian period (400 million years ago). Recent phylogenetic reconstructions of family relationships suggest that toadstools are the basic group of higher land plants; Moss and liverwort form a monophyletic sister group. By adapting to the irregular subaerial water supply, mosses in generally employed the alternative strategy of developing drought tolerance, photosynthesizing and growing during wet periods, and suspending metabolism during dry periods. Growth and sexual reproduction of mosses depend on external water and are therefore favored by a humid microclimate. They have a remarkable ability to regenerate from any plant fragment. Various reproductive modes play an important role in the life cycle of mosses, particularly in heavily disturbed stands (during 1997). Small, short mosses move their sperm with the help of early morning dewdrops. Moss spores travel long distances even with the help of the wind moving between continents by jet streams. The spore walls are highly protective and some spores are reported to remain viable for up to 40 years. Bryophytes can survive under stressful conditions such as cold, dry, shady. Bryophytes play an efficient role in filtering the nutrients that enter the soil by absorbing them directly from the atmosphere in the liquid phase. Bryophytes protect soil from erosion due to their interconnected, convoluted protonemata and gametophores, which cover exposed substrates and help increase the soil's water-holding capacity. The role of mosses in an ecosystem is determined by four properties: their ability to form soils, trap and retain moisture, exchange cations, and tolerate desiccation. These qualities are enhanced by its ability to multiply through frequent branching. Mosses such as *Atrichum*, *Nardia*, *Pogonatum*, *Pohlia* and *Trematodon* are soil erosion inhibitors due to their rigid structure and ability to regenerate. Bryophytes have an ecological association with microorganisms, protozoa, rotifers, Nematodes, earthworms, mollusks, insects, spiders and many other invertebrates (Gerson, 1982), as well as mosses in the ecosystem of 281 other plants and fungi.

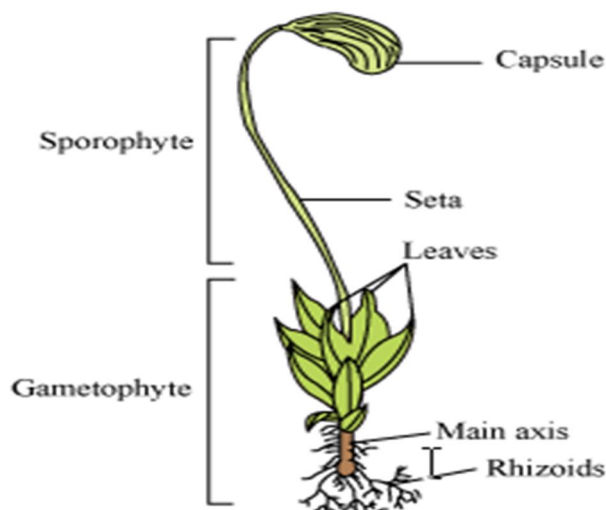


Fig 1: Sporophytic and Gametophytic body of Bryophytes

## II. DIVERSITY IN MORPHOLOGICAL FORMS

Bryophytes are divided into three groups, namely liverworts, hornworts and musci. Cell ultrastructure and molecular biology confirmed that mosses themselves have three separate evolutionary patterns crowning liverworts (Hepaticopsida), tomentosum (Anthocerotopsida), and mosses (Bryopsida) (Shaw and Goffinet 2000).

### A. Liverworts

The estimated number of hepatica species ranges from 6000 to 8000. Hepaticas are represented by about 850 species belonging to 141 genera and 52 families (Singh 2001). The leaf forms (young Maniopsid) are represented by almost 85% of liverwort species exhibit enormous morphological, anatomical and ecological diversity. Plants with leaf shoot systems are the most common habit in this class, *S...*, *Cololejeunea*, *Frullania*, *Jubulopsis* and *Radula* thalloid forms, e.g., *Metzgeriales* and *Marchantiales* are widely distributed in moist, shady, terrestrial, semiaquatic locations, especially in high altitude, dense subalpine and moist temperate forests. The spores are spread by the rotating movement of the wing blades and by the division of the sporophyte into four segments.



Fig 2: Mosses, Liverworts and Hornworts

### B. Hornwort

Hornwort consists of about 100-150 species in the world (Renzaglia and Vaughn 2000). They resemble some hepaticas only in the case of unspecialized thalloid gametophytes. Hornwort, they have colonies of *Nostoc* ventrally on their thallus. This alga exhibits a symbiotic nature that provides organic nitrogen for the metabolism of the toadstool thallus and provides nourishment (carbohydrates) and protection to the thallus. They possess a Cylindrical, horn-shaped sporangia (sporophyte). The release of the spores from the sporophyte occurs gradually over a long period of time. Its spores are spread by the movement of the water and not by the wind.

### C. Mosses

Mosses show the highest biodiversity with species number estimates between 10,000 and 15,000. In India, mosses are represented by 2,300 species in 330 genera. Peat mosses are one of the most important groups of mosses from an ecological and economic point of view.

### III. HABIT AND HABITAT DIVERSITY

Moss plants are typically smaller than maximum different vascular plants. *Dawsonia superba* is the tallest moss, reaching a height of up to 70 cm; *Polytrichum commune* grows in humid conditions and can reach a height of 50 cm. Other hanging mosses such as *Meteoriopsis* spp. and the water moss *Fontinalis* spp. They can reach a height of up to 1 meter. Some of the Bryophytes are quite small; the smallest tiny *Cephalooziella* plants are visible only under the microscope and some mosses such as *Micromitrium* species. Moist evergreen forests have a variety of microhabitats. Bryophytes are important components of temperate and tropical forests where they are found as carpets on damp soil, boulders, living and dead trunks, hanging from branches and on leaves. The distribution of mosses is first influenced by microclimatic factors, i.e., precipitation and temperature, latitude and altitude (Sveinbjörnsson and Oechel 1992), and by micro-environmental conditions such as shade, moisture, humus and temperature (Alpert 1991). The moss vegetation can be influenced by additional factors, e.g. soil age, rock, forest soil composition, moisture content (Silleet and Neitlich 1996) and by substrate such as pH and humus status (Batty et al.).2003). Bryophytes have a special nature to grow in specific habitats such as B. preferred rocks, special barks, rotted logs and stumps, in soils that have adequate moisture and humus, exposure and pH. The moss carpet on the forest floor provides a suitable substrate for seed germination and seedling growth of higher plants. Many *Sphagnum* species are aquatic and will eventually form swimming pairs. *Riccia fluitans* is also an aquatic moss. The special thing about mosses is that they absorb water in a short time and become fresh when they dry out under unfavorable conditions, which is why they are also called "resurrection plants". Mosses like *Sphagnum* species are able to change their environment and thus influence the life of other organisms.



Fig 3: Thalloid body of Bryophytes

### IV. BRYOPHYTES OF SPECIEAL HABITATS

- 1) *Epiliths (Saxicolous)*: Some mosses that only grow on rocks have some adaptation and special requirements, perhaps for a more permanent habitat, need less water and their adaptability to grow on such substrates.
- 2) *Xerophytic Mosses*: They are able to colonize moving sand. Under unfavorable conditions they remain buried in the ground and can reappear shortly after a rain or humidity shower.

### A. Bryophytes Association With Animals

The extent to which different taxonomic groups share similarities in diversity patterns has attracted increasing attention, but such studies of stream biota are lacking. The environment correlates patterns of species richness of mosses, micro-invertebrates and fish in streams. Bryophytes and micro-invertebrates showed the highest degree of similarity, but even this relationship had relatively weak predictive power. The growth forms of the mosses play an important role as a shelter for other organisms. Therefore, they form an attractive habitat for many invertebrates that get shelter, sustenance from them even in adverse conditions, e.g., *Frullania* and *Herbertus* harbor a range of rotifers, nematodes, invertebrates and algae in their lobes. Some, aquatic mosses are the best habitats for snails to lay eggs. Insects suck the sap from the cells of gametophores and sporangia. Spiders, mites, centipedes, centipedes and ants find shelter here within these mosses. This invertebrate activity within the moss supports the circulation of minerals that fuel the growth of this vegetation. Some insects transport the spores from the mature sporangia to the nitrogen substrate, where this spore can germinate and grow. Many birds use mosses to build their nests. Shoots of pleurocarp moss collected by birds to build their nests because these mosses are lighter compared to others Vegetation and are easy to weave and isolate into the desired pattern. In relation to alpine regions, mosses are a suitable habitat for lichens.

### B. Ecological Importance

Bryophytes have a variety of uses. Some of the important uses of mosses are listed below:

**Pioneer colonizers in succession** Mosses colonize dry soils that are poor in nutrients and where no other plant can grow. After a long rest, these moss colonies have accumulated an organic layer on this sterile soil that supports the growth of microorganisms. These microbes change the mineral state of the substrate and the site becomes suitable for the establishment of other vegetation. This creates a new sequence with the change of humidity, lighting regime and with the decomposition of the wood.

**Pollution and Heavy Metals Indicators** Bryophytes are bioindicators of air and water pollution and heavy metal accumulators. Under such disturbed environmental conditions (air pollution), moss, lichen and liverwort communities decrease over a period of time.

### C. Threats To Bryophytes

Developmental activities result in habitat loss at both macro and micro levels. The root cause these lower plants threaten the clearing of the forest to convert it to agricultural land and other means such as shelter, sanitation, road, dam, etc. All these activities are entirely responsible for the habitat loss of the mosses. Global warming is making the climate arid, moisture loss and a drier microclimate are responsible for the loss of mosses. Unplanned forest management further increases the loss of these valuable lower plants by knowledge.

The wildfire, whether natural or man-made, causes a subsequent drought that affects the growth of mosses and other plants. According to Hilton-Taylor (2000), 36 species of Bryopsida, 2 of Anthocerotopsida and 42 of Marchantiopsida are threatened and 2 species of Bryopsida and 1 Marchantiopsida species are extinct.

Some of the causes threatening moss diversity are listed below:

- 1) Land use Change.
- 2) River Valley Projects.
- 3) Invasion of exotic species.
- 4) Climate change.
- 5) Road construction.

## V. CONCLUSION

Mosses, liverworts, and hornworts are the three types of non-vascular plants that make up the bryophytes, an unofficial division of plants. The absence of actual roots, stalks, and leaves is one of mosses' distinguishing characteristics. The rhizoids also act as roots, ultimately holding the plants to the ground. Rhizoids do not, however, absorb nutrients like conventional plant roots. For mosses to flourish and spread, a high humidity climate or closeness to a body of water is crucial. However, several moss species are known to thrive in deserts and other arid and semi-arid conditions.

They may entirely dry up and enter a state of suspended animation in such circumstances. They resurrect and carry on growing when they come into contact with water once more.

## REFERENCES

- [1] Babita (2021); ROLE OF MEDICINAL PLANTS IN RURAL SOCIETY OF INDIA Int. J. of Adv. Res. **9** (Jun). 403-409] (ISSN 2320-5407).
- [2] Acebey, A., Gradstein, S. R. & Kromer, T. (2003) Species richness and habitat diversification of bryophytes in submontane rain forest and fallows of Bolivia. *Journal of Tropical Ecology*, 19, 9–18. [CrossRefGoogle Scholar](#)
- [3] Adams, D. G. & Duggan, P. S. (2008) Cyanobacteria–bryophyte symbioses. *Journal of Experimental Botany*, 59, 1047–1058. [CrossRefGoogle ScholarPubMed](#)
- [4] Ah-Peng, C. & Rausch De Traubenberg, C. R. (2004) Aquatic bryophytes as pollutant accumulators and ecophysiological bioindicators of stress: bibliographic synthesis. *Cryptogamie Bryologie*, 25, 205–248. [Google Scholar](#)
- [5] Alpert, P. & Oechel, W. C. (1985) Carbon balance limits microdistribution of *Grimmia laevigata*, a desiccation-tolerant plant. *Ecology*, 66, 660–669. [CrossRefGoogle Scholar](#)
- [6] Alpert, P. & Oliver, M. J. (2002) Drying without dying. In *Desiccation and Survival in Plants: Drying Without Dying*, eds. Black, M. & Pritchard, H. W.. Wallingford: CAB International, pp. 3–43. [CrossRefGoogle Scholar](#)
- [7] Alpert, P. (2000) The discovery, scope, and puzzle of desiccation tolerance in plants. *Plant Ecology*, 151, 5–17. [CrossRefGoogle Scholar](#)
- [8] Alpert, P. (2005) The limits and frontiers of desiccation-tolerant life. *Integrative and Comparative Biology*, 45, 685–695. [CrossRefGoogle ScholarPubMed](#)
- [9] Alpert, P. (2006) Constraints of tolerance: why are desiccation-tolerant organisms so small or rare? *Journal of Experimental Biology*, 209, 1575–1584. [CrossRefGoogle ScholarPubMed](#)
- [10] Andelman, S. J. & Fagan, W. F. (2000) Umbrellas and flagships: efficient conservation surrogates or expensive mistakes? *Proceedings of the National Academy of Sciences of the USA*, 97, 5954–5959. [CrossRefGoogle ScholarPubMed](#)
- [11] Ayres, E., Wal, R., Sommerkorn, M. & Bardgett, R. (2006) Direct uptake of soil nitrogen by mosses. *Biology Letters*, 2, 286–288. [CrossRefGoogle ScholarPubMed](#)
- [12] Bakken, S. (1993) Effects of simulated acid rain on the morphology, growth and chlorophyll content of *Hylocomium splendens*. *Lindbergia*, 18, 104–110. [Google Scholar](#)
- [13] Barkman, J. J. (1958) *Phytosociology and Ecology of Cryptogamic Epiphytes*. Assen: van Gorcum. [Google Scholar](#)
- [14] Barthlott, W., Fischer, E., Frahm, J. P. & Seine, R. (2000) First experimental evidence for zoophagy in the hepatic *Colura*. *Plant Biology*, 2, 93–97. [CrossRefGoogle Scholar](#)
- [15] Bates, J. W. & Duckett, J. G. (2000) On the occurrence of rhizoids in *Scleropodium purum*. *Journal of Bryology*, 22, 300–302. [CrossRefGoogle Scholar](#)
- [16] Bates, J. W. & Farmer, A. M. (1990) An experimental study of calcium acquisition and its effects on the calcifuge moss *Pleurozium schreberi*. *Annals of Botany*, 65, 87–96. [CrossRefGoogle Scholar](#)
- [17] Bates, J. W. (1982) The role of exchangeable calcium in saxicolous calcicole and calcifuge mosses. *New Phytologist*, 90, 239–252. [CrossRefGoogle Scholar](#)
- [18] Bates, J. W. (1988) The effect of shoot spacing on the growth and branch development of the moss *Rhytidiadelphus triquetrus*. *New Phytologist*, 109, 499–504. [CrossRefGoogle Scholar](#)
- [19] Bates, J. W. (1989) Growth of *Leucobryum glaucum* cushions in a Berkshire oakwood. *Journal of Bryology*, 15, 785–791. [CrossRefGoogle Scholar](#)
- [20] Bates, J. W. (1992) Influence of chemical and physical factors on *Quercus* and *Fraxinus* epiphytes at Loch Sunart, western Scotland: a multivariate analysis. *Journal of Ecology*, 80, 163–179. [CrossRefGoogle Scholar](#)
- [21] Bates, J. W. (1995) A bryophyte flora of Berkshire. *Journal of Bryology*, 18, 503–620. [CrossRefGoogle Scholar](#)
- [22] Bates, J. W. (1997) Effects of intermittent desiccation on nutrient economy and growth of two ecologically contrasted mosses. *Annals of Botany*, 79, 299–309. [CrossRefGoogle Scholar](#)
- [23] Bates, J. W. (1998) Is 'life-form' a useful concept in bryophyte ecology? *Oikos*, 82, 223–237. [CrossRefGoogle Scholar](#)
- [24] Bates, J. W. (2000) Mineral nutrition, substratum ecology, and pollution. In *Bryophyte Biology*, 1st edn, eds. Shaw, A. J. & Goffinet, B.. Cambridge: Cambridge University Press, pp. 248–311. [CrossRefGoogle Scholar](#)
- [25] Bates, J. W. (2009) Mineral nutrition and substratum ecology. In *Bryophyte Biology*, 2nd edn, eds. Goffinet, B. & Shaw, A. J.. Cambridge: Cambridge University Press, pp. 299–356. [Google Scholar](#)
- [26] Bates, J. W., Proctor, M. C. F., Preston, C. D., Hodgetts, N. G. & Perry, A. R. (1997) Occurrence of epiphytic bryophytes in a 'tetrad' transect across southern Britain. 1. Geographical trends in abundance and evidence of recent change. *Journal of Bryology*, 19, 685–714. [CrossRefGoogle Scholar](#)
- [27] Bates, J. W., Thompson, K. & Grime, J. P. (2005) Effects of simulated long-term climatic change on the bryophytes of a limestone grassland community. *Global Change Biology*, 11, 757–769. [CrossRefGoogle Scholar](#)
- [28] Batty K., Bates J.W. and Bell J.N.B. 2003. A transplant experiment on the factors preventing lichen colonization of oak bark in southeast England under declining SO<sub>2</sub> pollution. *Canad J. Bot.* 81: 439-451.
- [29] Beaugelin-Seiller, K., Baudin, J. P. & Brotter, D. (1994) Use of aquatic mosses for monitoring artificial radionuclides downstream of the nuclear power plant of Bugey (river Rhone, France). *Journal of Environmental Radioactivity*, 24, 217–233. [CrossRefGoogle Scholar](#)
- [30] Beckett, R. P., Marschall, M. & Laufer, Z. (2005) Hardening enhances photoprotection in the moss *Atrichum androgynum* during rehydration by increasing fast- rather than slow-relaxing quenching. *Journal of Bryology*, 27, 7–12. [CrossRefGoogle Scholar](#)
- [31] Bencotter, B. W. & Vitt, D. H. (2007) Evaluating feathermoss growth: a challenge to traditional methods and implications for the boreal carbon budget. *Journal of Ecology*, 95, 151–158. [CrossRefGoogle Scholar](#)
- [32] Berbee, M. L. & Taylor, J. W. (2007) Rhyne chert: a window into a lost world of complex plant-fungus interactions. *New Phytologist*, 174, 475–479. [CrossRefGoogle ScholarPubMed](#)
- [33] Berendse, F. (1999) Implications of increased litter production for plant biodiversity. *Trends in Ecology and Evolution*, 14, 4–5. [CrossRefGoogle ScholarPubMed](#)
- [34] Berendse, F., Breemen, N., Rydin, H., et al. (2001) Raised atmospheric CO<sub>2</sub> levels and increased N deposition cause shifts in plant species composition and production in Sphagnum bogs. *Global Change Biology*, 7, 591–598. [CrossRefGoogle Scholar](#)
- [35] Berg, A., Gärdenfors, U., Hallingbäck, T. & Noren, M. (2002) Habitat preferences of red-listed fungi and bryophytes in woodland key habitats in southern Sweden: analyses of data from a national survey. *Biodiversity and Conservation*, 11, 1479–1503. [CrossRefGoogle Scholar](#)

- [36] Bergamini, A. & Pauli, D. (2001) Effects of increased nutrient supply on bryophytes in montane calcareous fens. *Journal of Bryology*, 23, 331–339. [CrossRefGoogle Scholar](#)
- [37] Bergamini, A., Pauli, D., Peintinger, M. & Schmid, B. (2001a) Relationships between productivity, number of shoots and number of species in bryophytes and vascular plants. *Journal of Ecology*, 89, 920–929. [CrossRefGoogle Scholar](#)
- [38] Bergamini, A., Peintinger, M., Schmid, B. & Urmi, E. (2001b) Effects of management and altitude on bryophyte species diversity and composition in montane calcareous fens. *Flora*, 196, 180–193. [CrossRefGoogle Scholar](#)
- [39] Berglund, H. & Jonsson, B. G. (2001) Predictability of plant and fungal species richness of old-growth boreal forest islands. *Journal of Vegetation Science*, 12, 857–866. [CrossRefGoogle Scholar](#)
- [40] Bidartondo, M. I., Bruns, T. D., Weiß, M., Sérgio, C. & Read, D. J. (2003) Specialized cheating of the ectomycorrhizal symbiosis by an epiparasitic liverwort. *Proceedings of the Royal Society of London B*, 270, 835–842. [CrossRefGoogle ScholarPubMed](#)
- [41] Biermann, R. & Daniels, F. J. A. (1997) Changes in a lichen-rich dry sand grassland vegetation with special reference to lichen synusia and *Campylopus introflexus*. *Phytocoenologia*, 27, 257–273. [CrossRefGoogle Scholar](#)
- [42] Billings, W. D. & Drew, W. B. (1938) Bark factors affecting the distribution of corticolous bryophytic communities. *American Midland Naturalist*, 20, 302–330. [CrossRefGoogle Scholar](#)
- [43] Bisang, I. & Ehrlen, J. (2002) Reproductive effort and cost of reproduction in female *Dicranum polysetum*. *Bryologist*, 105, 384–397. [CrossRefGoogle Scholar](#)
- [44] Bisang, I. (1992) Hornworts in Switzerland: endangered? *Biological Conservation*, 59, 145–149. [CrossRefGoogle Scholar](#)
- [45] Bisang, I. (1996) Quantitative analysis of the diaspore bank of bryophytes and ferns in cultivated fields in Switzerland. *Lindbergia*, 21, 9–20. [Google Scholar](#)
- [46] Bisang, I. (1998) The occurrence of hornwort populations (*Anthocerotales*, *Anthoceropisa*) in the Swiss Plateau: the role of management, weather conditions and soil characteristics. *Lindbergia*, 23, 94–104. [Google Scholar](#)
- [47] Bobbink, R., Hornung, M. & Roelofs, J. G. M. (1998) The effects of air-borne nitrogen pollutants on species diversity in natural and semi-natural European vegetation. *Journal of Ecology*, 86, 717–738. [CrossRefGoogle Scholar](#)
- [48] Boisselier-Dubayle, M.-C., Lambourdière, J. & Bischler, H. (2002) Molecular phylogenies support multiple morphological reductions in the liverwort subclass *Marchantiidae* (Bryophyta). *Molecular Phylogenetics and Evolution*, 24, 66–77. [CrossRefGoogle Scholar](#)
- [49] Boudier, P. (1988) Différenciation structurale de l'épiderme du sporogone chez *Sphagnum fimbriatum* Wilson. *Annales des Sciences Naturelles, Botanique*, 8, 143–156. [Google Scholar](#)
- [50] Boudreault, C., Gauthier, S. & Bergeron, Y. (2000) Epiphytic lichens and bryophytes on *Populus tremuloides* along a chronosequence in the southwestern boreal forest of Quebec, Canada. *Bryologist*, 103, 725–738. [CrossRefGoogle Scholar](#)
- [51] Bragazza, L., Siffi, C., Iacumin, P. & Gerdol, R. (2007) Mass loss and nutrient release during litter decay in peatland: the role of microbial adaptability to litter chemistry. *Soil Biology & Biochemistry*, 39, 257–267. [CrossRefGoogle Scholar](#)
- [52] Brown DH and House K.L. 1978. Evidence of a copper tolerant ecotype of the Hepatic, *Solenostoma crenulata*. *Ann. Bot.* 42: 1383-1392.
- [53] Brown, D. H. & Wells, J. M. (1990) Physiological effects of heavy metals on the moss *Rhytidiadelphus squarrosus*. *Annals of Botany*, 66, 641–647. [CrossRefGoogle Scholar](#)
- [54] Brown, D. H. & Whitehead, A. (1986) The effect of mercury on the physiology of *Rhytidiadelphus squarrosus* (Hedw.) Warnst. *Journal of Bryology*, 14, 367–374. [CrossRefGoogle Scholar](#)
- [55] Brundrett, M. C. (2002) Coevolution of roots and mycorrhizas of land plants. *New Phytologist*, 154, 275–304. [CrossRefGoogle Scholar](#)
- [56] Budke, J. M., Jones, C. S. & Goffinet, B. (2007) Development of the enigmatic peristome of *Timmia megapolitana* (Timmiaceae; Bryophyta). *American Journal of Botany*, 94, 460–467. [CrossRefGoogle Scholar](#)
- [57] Buitink, J. & Leprince, O. (2004) Glass formation in plant anhydrobiotes: survival in the dry state. *Cryobiology*, 48, 215–228. [CrossRefGoogle ScholarPubMed](#)
- [58] Burch, J. (2003) Some mosses survive cryopreservation without prior pretreatment. *Bryologist*, 106, 270–277. [CrossRefGoogle Scholar](#)
- [59] Büscher, P., Koedam, N. & Speybroeck, D. (1990) Cation-exchange properties and adaptation to soil acidity in bryophytes. *New Phytologist*, 115, 177–186. [CrossRefGoogle Scholar](#)
- [60] Cairney, J. W. G. (2000) Evolution of mycorrhiza systems. *Naturwissenschaften*, 87, 467–475. [CrossRefGoogle ScholarPubMed](#)
- [61] Campbell, D. R., Rochefort, L. & Lavoie, C. (2003) Determining the immigration potential of plants colonizing disturbed environments: the case of milled peatlands in Quebec. *Journal of Applied Ecology*, 40, 78–91. [CrossRefGoogle Scholar](#)
- [62] Carafa, A., Duckett, J. G. & Ligrone, R. (2003) Subterranean gametophytic axes in the primitive liverwort *Haplomitrium* harbour a unique type of endophytic association with aseptate fungi. *New Phytologist*, 160, 185–197. [CrossRefGoogle Scholar](#)
- [63] Carafa, A., Duckett, J. G., Know, J. P. & Ligrone, R. (2005) Distribution of cell wall xylans in bryophytes and tracheophytes: new insights into the basal interrelationships of land plants. *New Phytologist*, 168, 231–240. [CrossRefGoogle ScholarPubMed](#)
- [64] Carballeira, A., Diaz, S., Vazquez, M. D. & Lopez, J. (1998) Inertia and resilience in the responses of the aquatic bryophyte *Fontinalis antipyretica* Hedw. to thermal stress. *Archives of Environmental Contamination and Toxicology*, 34, 343–349. [CrossRefGoogle ScholarPubMed](#)
- [65] Carballeira, A., Fernandez, J. A., Aboal, J. R., Real, C. & Couto, J. A. (2006) Moss: a powerful tool for dioxin monitoring. *Atmospheric Environment*, 40, 5776–5786. [CrossRefGoogle Scholar](#)
- [66] Caron, J. (2001) La tourbe et les milieux artificiels. In *Ecologie des Tourbières du Québec-Labrador*, eds. Payette, S. & Rochefort, L.. Québec: Presses de l'Université Laval, pp. 399–410. [Google Scholar](#)
- [67] Chapman, S., Buttler, A., Francez, A. J., et al. (2003) Exploitation of northern peatlands and biodiversity maintenance: a conflict between economy and ecology. *Frontiers in Ecology and Environment*, 1, 525–532. [CrossRefGoogle Scholar](#)
- [68] Churchill, S. P. (1998) Catalog of Amazonian mosses. *Journal of the Hattori Botanical Laboratory*, 85, 191–238. [Google Scholar](#)
- [69] Churchill, S. P., Griffin, D. & Lewis, M. (1995) Moss diversity of the Tropical Andes. In *Biodiversity and Conservation of Neotropical Forests*, eds. Churchill, S. P., Balslev, H., Forero, E. & Luteyn, J. L.. New York: New York Botanical Garden, pp. 335–346. [Google Scholar](#)
- [70] Clark, K. L., Nadkarni, N. M. & Gholz, H. L. (1998) Growth, net production, litter decomposition, and net nitrogen accumulation by epiphytic bryophytes in a tropical montane forest. *Biotropica*, 30, 12–23. [CrossRefGoogle Scholar](#)
- [71] Cleavitt, N. (2005) Patterns, hypotheses and processes in the biology of rare bryophytes. *Bryologist*, 108, 554–566. [CrossRefGoogle Scholar](#)

- [72] Cowley M.J.R., Wilson R.J., Leon-Cortes J.L., Gutierrez D., Bulman C.R. and Thomas C.D. 2000. Habitatbased statistical models for predicting the spatial distribution of butterflies and day-flying moths in a fragmented landscape. *J. Appl Ecol.* 37: 60-72.
- [73] Crites S. and Dale M.R.T. 1998. Diversity and abundance of bryophytes, lichens and fungi in relation to woody substrate and successional stage in aspen mixed wood boreal forests. *Canad J. Bot.* 76: 641-651.
- [74] DuRietz G.E. 1931. Life forms of terrestrial flowering plants. *Acta Phytogeogr Suec* 3: 1. During H. 1997. Bryophyte diaspore banks. *Adv. Bryol* 6: 103-134.
- [75] Gerson U. 1982. Bryophytes and invertebrates. In: Smith A.J.E. (Ed.) *Bryophyte Ecology*. Chapman and Hall, London. pp. 291-330.
- [76] Gilbert O.L. 1968. Bryophytes as indicators of air pollution in the Tyne valley. *New Phytol* 67: 15-30.
- [77] Gimingham C.H. and Robertson E.T. 1950. Preliminary investigation on the structure of bryophytic communities. *Trans. British Bryol Soc.* 1: 330-344.
- [78] Gressitt J.L., Samuelson G.A. and Vitt D.H. 1968. Moss growing on living Papuans forest weevils. *Nature* 217: 765-767.
- [79] Groombridge B. (Ed.) 1992. *Global Biodiversity: Status of the Earth's Living Resources*. Chapman and Hall, New York.
- [80] Harmon M.E., Franklin J.F., Swanson F.J., Sollins P., Gregory S.V., Lattin J.D., Anderson N.H., Cline S.P., Aumen N.G., Sedell J.R., Lienkaemper G.W., Cromack K. and Cummins K.W. 1986. Ecology of coarse woody debris in temperate ecosystems. *Adv. Ecol. Res.* 15: 133-302
- [81] Heilmann-Clausen J. and Christensen M. 2003. Fungal diversity on decaying beech logs implications for sustainable forestry. *Biodivers Conserv* 12: 953-973.
- [82] Modi G., and Babita (2022). Study of Ethnobotanical Plants Found in Satrod Khurd and Dabra villages in Hisar. *International Journal of Research and Analytical review (IJRAR)*,9(3): 439-451
- [83] Paal J. 1998. Rare and threatened plant communities of Estonia. *Biodivers Conserv* 7: 1027-1049.
- [84] Pande S.K. 1958. Some aspects of Indian Hepaticology (Presidential address). *J. Ind. Bot. Soc.* 37: 1-26.
- [85] Singh D.K. 2001. Diversity in Indian Liverworts: their status, vulnerability and conservation. In: Nath V and Asthana A.K. (Eds.), *Perspectives in Indian Bryology*. Dehradun pp. 235-300.
- [86] Singh D.K. and Hajra P.K. 1996. Floristic diversity In: Gujral G.S. and Sharma V. (Eds.), *Changing Perspective of Biodiversity Status in the Himalayas*. New Delhi. pp. 23-38
- [87] Bhumika Arora, Babita, Gajanand Modi, Nivedan Bhardwaj (2023): Transgenic Approaches in the Improvement of Seed Oil and Quality in Oil Seed Crops- *IJFMR* Volume 5, Issue 1, January-February 2023. DOI 10.36948/ijfmr.2023.v05i01.1467
- [88] Babita, Gajanand Modi, Bhumika Arora, Nivedan Bhardwaj (2023): Zinc Oxide Nanoparticles in Alleviation of Toxicity Induced by Heat Stress in Plants - *IJFMR* Volume 5, Issue 1, January-February 2023. DOI 10.36948/ijfmr.2023.v05i01.1468





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