A Review of Bryophytes; Evolution, Value and Threats

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Abstract-Bryophytes are the first dwellers of land plant history. The global context of bryophytes species is comparatively obtained much greater concern with the emergence of the concept of conservation biology. Literature from 1860 to 2017 was used along with e-resources for the review. Literary evidence revealed a rate of destruction or degradation of bryophytes has increased. The unawareness of people regarding the value of bryoflora has increased the rate of destruction. Considering both the ecological and economic value of bryophytes this review emphasized the necessity of conservation measures to protect bryophyte species.

Index Terms- Bryophyte, Bryogeography, Conservation, Ecological and economic value, Threats

1. INTRODUCTION

1.1 What are bryophytes?

Bryophytes (commonly referred to as mosses) are the first dwellers of the land plant history, play a spirited role in ecosystems. Land plants evolved 480 million years ago. First land plants evolved from freshwater algae like ancestors (Sakakibara, 2016). The term 'bryophyte' has its origin in the Greek language, referring to plants that swell upon hydration. The occurrence of bryophytes takes place in wet, humid or boggy areas such as damp rocks, damp land area, forests and tree trunks. With the development of the concept of conservation biology which is closely related to biodiversity, conservation of bryophytes initially and completely overlooked by least amount of scientists and researchers. Bryophytes were first studied centuries ago. And also, nobody has understood the plant life cycle so the conversation among the researchers was disorganized. As a result, the meaning of some of the many terms that have been coined over the years to explain bryophytes is confusing and overlapping. Bryophytes have gained considerable publicity in the past fifteen years at least among scientists. Literary evidence prove the negligence of bryophyte studies;

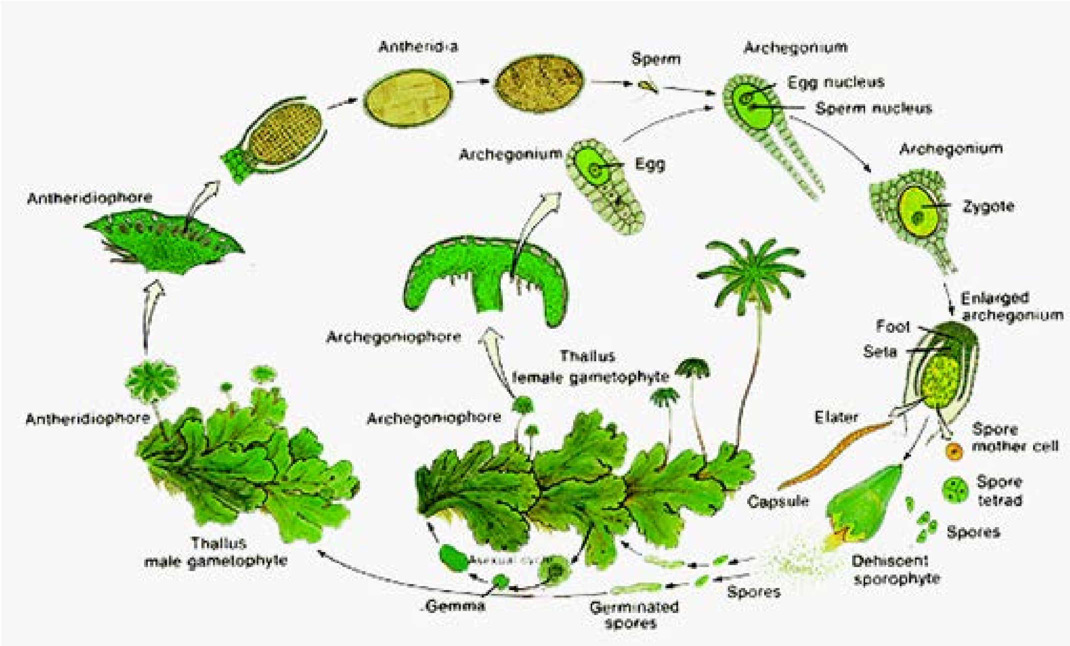
"a lot of time has passed since and most certainly a vast corpus of bryophytes research did not receive the proper attention it deserved, but ever since the publication and availability of the Physcmitrella patens genome(as the fourth genome of land plant after Arabidopsis thaliana (the Arabidopsis genome initiative, 2000), Oryza sativa(Goff et al, 2002; Yu et al, 2002) and Populus trichocarpa (Tuskan et al, 2006) and as the first nonvascular plant genome(Rensing et al, 2008) bryophytes and mosses in particular, again serve as focal points of plant and genome research".

-Lang et al, 2016

Thus the vocabulary of bryophytes has developed recently than the early times.

Extant bryophytes belong to either liverwort (Marchantiophyta), mosses (Bryophyta in the strict sense) or hornworts (Anthocerotophyta) (Wellman and Gray, 2000). Liverworts are the earliest diverged lineage of land plants, their origin dates back to the Silurian period (Kenrick and Crane, 1997 a, b; Wellman *et al*, 2003 and Heinrichs *et al*, 2006). The vegetative gametophyte is either thalloid i.e. ribbon-like plants or composed of a leafy stem, with leaves arranged in two or three parallel rows. Specialized water-conducting cells account for endohydric transport in the gametophytes of some taxa (Edwards et al. 2003) but are always lacking in the sporophyte. The sporophyte produces a single sporangium elevated, at maturity, on a seta that grows primarily by cell elongation rather than extensive cell divisions. The mode of dehiscence of the sporangium varies but typically, the capsule wall splits along four vertical lines. Stomata are always lacking in the sporangial wall. The capsule holds spores and elaters, elongated cells with spiral wall thickenings that are thought to promote spore release. An axial columella is lacking in the sporangium (Vanderpoorten and Goffinet, 2009). Spores typically develop into a single, branched gametophyte (Figure1).

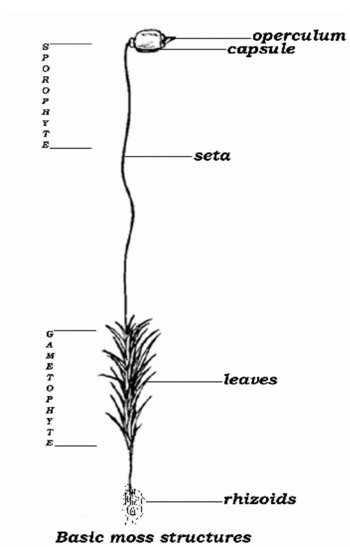
Figure 1. Marchantia life cycle



Source: https://www.pinterest.com/pin/340514421800127878/ , 2019

Hornworts are the species composed of the least diverse lineage of bryophytes, which never bears leaves where the thallus may be dissected. Their name refers to the horn like sporophyte that lacks seta and dehisces along one or two vertical lines. The vegetative gametophyte is always thalloid (Vanderpoorten and Goffinet, 2009). The thallus may be dissected but never bear leaves. These species lack water-conducting cells in both generations of the life cycle. The sporophyte is linear and composed of the long sporangium. The long sporangium cannot be seen in the foot. A seta is thus completely lacking. A basal meristem adds new cells to the base of the sporangium, which consequently matures basipetally. Dehiscence follows two longitudinal lines, extending downward much like a zipper, gradually exposing a spore mass surrounding an axial columella. Pseudo-elaters facilitate the dispersal of spores. Stomata are present on the sporangial walls of some taxa. All hornworts harbour endosymbiotic colonies of *Nostoc*, which form globular or channelled clusters throughout the thallus (Vanderpoorten and Goffinet, 2009).

Figure 2.Basic moss structure



Source: http://bryophytes.science.oregonstate.edu/page3.htm, 2019

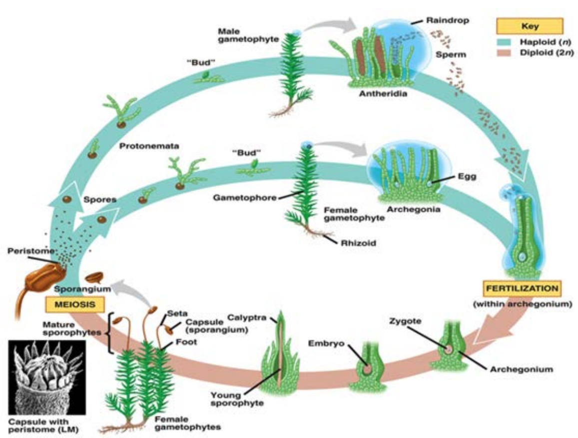
Mosses are the species generally seen as small plants confined to humid habitats avoiding exposure to direct sunlight. The vegetative body is always composed of a stem bearing leaves, typically arranged in spiral rows. Axial water conducting strands occur in both generations of many taxa. The activity of an intercalary meristem, located immediately below the presumptive capsule gives rise to the seta, which completes its development prior to sporogenesis. This stalk is almost never branched, although in very rare cases two capsules may be found on the same seta (Leitgeb 1876). The sporangium is always terminal. In the majority of mosses, the capsule sheds an operculum (Figure2). Stomata may occur in the capsule wall but are always lacking on the seta. The columella typically extends beyond the sporogenous layer. In most taxa, the spore sac surrounds an axial columella, rarely does it also arch over it. Cells of the sporogenous tissue never divide to form elaters. Spore germination results in a filamentous or, in some basal lineages including Sphagnum and Oedipodium, a thalloid sporeling called a protonema, which subsequently develops into one to several gametophytes thalloid (Vanderpoorten and Goffinet, 2009). The bryophytes include a small number of species with a smaller stature and more mellowed colours and of less obvious ecological significance with less evolutionary stories. However, this aspect was changed due to frequent studies on bryophytes.

1.1 Evolutionary significance

Asakawa *et al* (2013) mentioned that the richness of endemic bryophyte genera in the southern hemisphere indicate that these plant species might have originated in the past landmass what is now Antarctica some 350,000,000 years ago and later these plant species introduced to the southern hemisphere during the evolutionary process. The extant embryophyte phylogeny dates back to the Ordovician period (Vanderpoorten and Goffinet, 2009) which was existed about 475 million years ago. Most recently Crandall-Stotler *et al* (2009) proposed a classification scheme to identify bryophytes which were based on both morphological and molecular data, accordingly the three groups of bryophytes; liverworts, hornworts and mosses were recognized as three phyla; Bryophyta (mosses), Marchantiophyta (liverworts) and Anthocerotophyta (hornworts) (Ruklani and Rubasinghe, 2013). The three major bryophyte lineages differ from one another in a variety of attributes, most conspicuously in the architecture of the vegetative (gametophyte) body and the sporophyte, to the extent that they are easily distinguished in the field.

This group of plants incorporate the earliest lineage of land plants derived from green algal ancestors (Goffinet and Shaw, 2009). The evolutionary history of bryophytes reveals early life on earth. Goffinet and Shaw (2009) and Shaw *et al* (2011) mentioned that this group of plant species do not constitute a single monophyletic lineage and share a basically similar life cycle (Figure3) with perennial and free-living, photosynthetic gametophyte alternating with a short-lived sporophyte. These species complete its entire development attached to the maternal gametophyte (Shaw *et al*, 2011). Critical aspects of life cycle evolution were involved in adapting bryophyte ancestors to life on land i.e. protection of the embryo in protective maternal tissue, elaboration of two distinct multicellular stages specialized for different functions, but the colonization of land also required structural and physiological adaptations to succeed in habitats with high solar radiation, high-temperature fluctuations, a drying atmosphere, and limited access to dissolved nutrients (Hanson and Rice, 2014). Although the primary structural design of the photosynthetic machinery was conserved from their algal ancestor, early land plants, as with contemporary bryophytes, likely facilitated carbon capture over short and long temporal scales in several years. These include the reduction of external water films on leaf surfaces, which impede the diffusion of carbon dioxide, the evolution of ventilated thalli or leaf structures, and the advancement of carbon concentrating mechanisms. In addition, these plant species evolved desiccation tolerance, which allowed plants to equilibrate with a drying atmosphere and retain metabolic function upon rehydration along with adaptations to achieve positive carbon balance during wet-dry cycles (Hanson and Rice, 2014).

Figure 3. Bryophyte life cycle

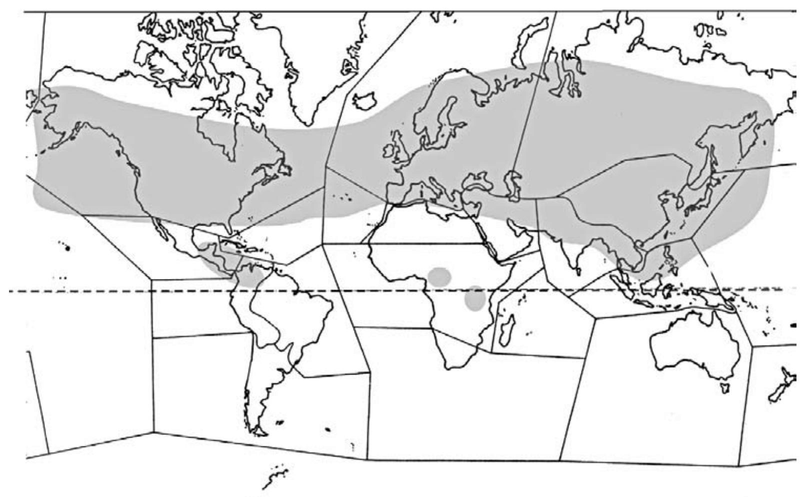


Source: https://www.pinterest.com/ahsapbio/, 2019

For a long time, bryophytes had a reputation of being "unmoving, unchanging sphinxes of the past" (Goffinet and Shaw, 2009). This aspect has proven inaccurate by scientists and researchers. These are species that show local adaptation to heterogeneous environments and exhibit their responsiveness to natural selection (Goffinet and Shaw, 2009). Bryophytes have barely been tapped as a resource for understanding photosynthesis and respiration on land despite the fact that the bryophyte life form has achieved ecological success in varied environments that span every continent, occur across dramatic gradients of temperature and water availability and were present at the early stage of the transition from aquatic habitats to land, potentially as early as the Cambrian (Hanson and Rice, 2014).

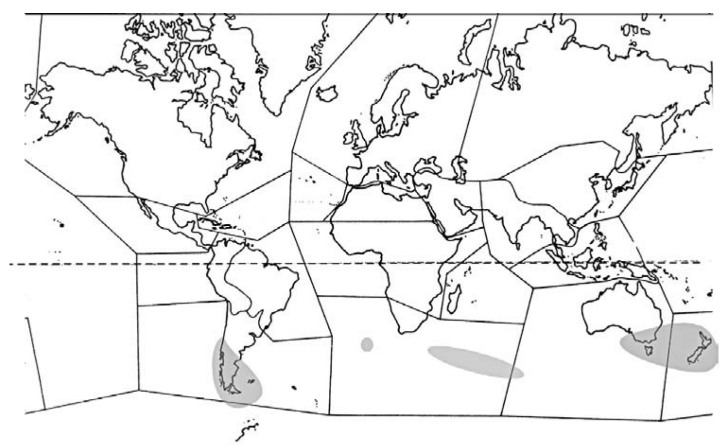
In general, bryophytes species have wide geographic ranges that often span more than one continent (Figure 4, 5 and 6). Vanderpoorten and Goffinet (2009) further stated that some termed as 'cosmopolitan', which are even widespread across all continents. Therefore, bryophytes species tend to show wider distributions than vascular plants. There are around 20,000 species of bryophytes have distributed throughout the world (Working list of all plant species, 2013). New Zealand, New Caledonia, Japan and Costa Rica are notable countries that displaying the highest species diversity of liverworts (Asakawa *et al*, 2013). Nepal, Bhutan, Taiwan, the Philippines, the islands of Borneo, Colombia, Ecuador and Sao Paulo in Brazil are the countries with more than 151 species per 10,000 km². Konrat *et al* (2008) stated the countries with rich areas of liverworts with 75-150 species per 10,000km² including French Guyana, Norway, the British Isles, Madagascar and the Iberian Peninsula. The distribution of a number of endemic genera of bryophytes throughout the world shows the importance of conservation of these small plant species (Figure 7).

Figure 4. Holarctic distribution of the liverwort Lepidozia reptans



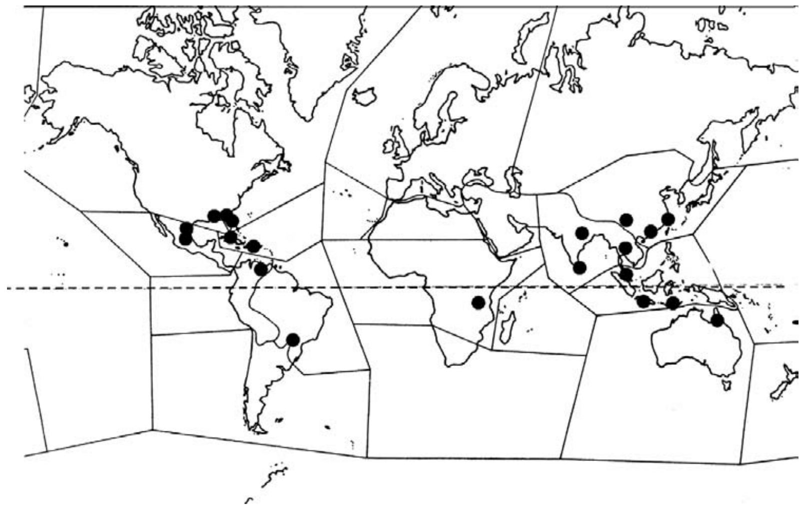
Source: Vanderpoorten and Goffinet, 2009

Figure 5. Circum-Subantarctic range of the liverwort genus Herzogobryum



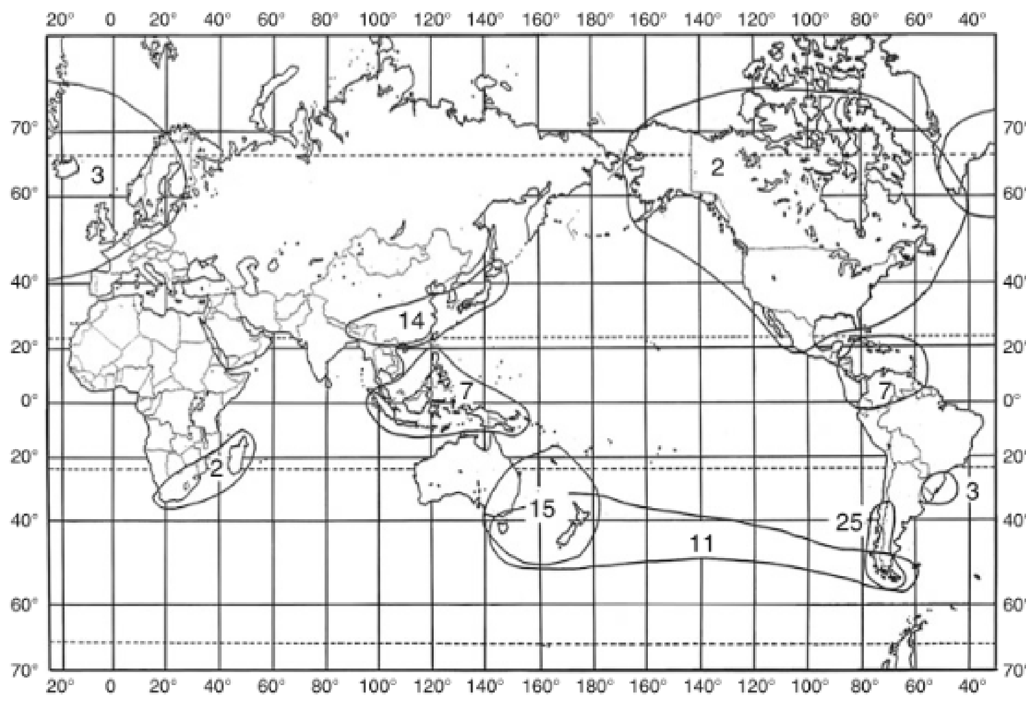
Source: Vanderpoorten and Goffinet, 2009

Figure 6. Nearly pantropical distribution of the moss Erpodium biseriatum



Source: Vanderpoorten and Goffinet, 2009

Figure 7.Number of endemic genera of bryophytes



Source: Inoue, (1978)

India and Sri Lanka, which belongs to the Palaeotropical Kingdom (Figure 8) are also rich in liverwort species where 555 and 110 species have been recorded respectively and in Nepal and Bhutan, in sequence, 36 and 44 taxa of liverworts are identified (Chaturvedi and Chaturvedi, 2008). Sri Lanka consists of 327 species of liverworts, 560 species of mosses and 5 species of hornworts (Ruklani and Rubasinghe, 2016). In Sri Lanka, these plant species have been recorded mainly from central highlands and low land areas in the country due to the limited literature on a past collection of bryophytes. Since the establishment of Botanical garden and herbarium in Peradeniya which make the linkage to the British period, of which George Gardner and George Thwaites made a great contribution, resulted in three publications by William Mitten (1960) on both mosses and liverworts (Rubasinghe and Long, 2014). The first checklists of bryophytes of Sri Lanka were published a collection of limited number of literature by B. A. Abewickrama where 16 species of complex thalloid in 9 genera and 4 families belong to liverworts have mentioned (Abewickrama and Jansen, 1978 a, b; Long and Rubasinghe, 2014; Rubasinghe and Long, 2014 and Pethiyagoda, 2011). However, by the mid-nineteenth century, several collectors from Europe (Table 1) gone through bryophyte world. Among them, Johannes Nietner from Germany and Odoardo Beccari from Italy were the first. Victor Schiffner and Max Fleischer from Austria and Germany respectively, became prominent bryologist throughout South East Asia, by the early twentieth century and both bryologists visited Sri Lanka (Rubasinghe and Long, 2014). Fleischer's study leads to various new genera and species.

Table 1.Details of Bryophyte specimens deposited in National herbarium in Peradeniya

Collector	Name as mentioned on the herbarium packet	Year	Locality
A. H. G. Alston	• *Marchantia palmate* • *Marchantia* sp. • *Lunularia cruciate* • *Dumortiera hirsute* • *Plagiochasma rupestre* • *Riccia* sp.	• 1927 • 1925 • 1925 • 1925 • 1925 • 1925	• Rangala • Near Peradeniya • Hakgala • Kandy • Peradeniya • Peradeniya
M. Fleischer	• *Marchantia* sp. • *M. lecordiana*	• 1898 • 1898	• Hantana • Peradeniya
G. Gardner	• *Riccia crispatula*	• 1844	• Matale

Source: Ruklani *et al*, 2015

In 2002 Sri Lankan checklist of mosses was updated by B. J. O'Shea (O'Shea, 2002). During the year 2014 Long and Rubasinghe updated the checklist of liverworts and hornworts of Sri Lanka (Ruklani *et al*, 2015). According to literature hornworts and liverworts are the least studied two group of plant species in Sri Lanka (Gunawardena *et al*, 2007 and Rubasinghe and Long, 2014). The most recent updated checklist of liverworts and hornworts complex thalloids in the country consists of nine families; Aytoniaceae, Blasiaceae, Cyathodiaceae, Dumortieraceae, Exormothecaceae, Lunulariaceae, Marchantiaceae, Ricciaceae and Targioniaceae, ten genera: *Plagiochasma* and *Reboulia*, *Blasia*, *Cyathodium*, *Exormotheca*, *Lunularia*, *Marchantia*, *Riccia* and *Targionia* and seventeen species (Long and Rubasinghe, 2014). However, Sri Lankan liverworts; leafy, complex and simple thalloid have not been analyzed for a biogeographic relationship (Rubasinghe and Ruklani, 2017). As well as many studied have been carried out on flowering plants in Sri Lanka (Murawski et al, 1994; Rubasinghe et al, 2005). However, the bryophyte species of Sri Lanka remains poorly studied (Ruklani et al, 2015).

1.2 Bryogeographical regions

Takhtajan in 1986 was the first plant bio-geographer who introduced a comprehensive, detailed system of floral units based on their levels of endemism. Further explaining the principle underlying Takhtajan's system Vanderpoorten and Goffinet (2009) stated that distinctiveness of each floral unit, as expressed by its level of endemism, is the result of isolation, which has permitted independent evolution within the area in question. German Theodor Herzog (1880-1961) was the most important after Fleischer who was the first to describe the ecological structure and bryological richness of different forest zones in southern Sri Lanka. Theodor's study also summarized biogeographical links of the bryoflora where he has mentioned six broad bryogeographical zones or kingdoms (Figure 3), possibly with some minor variations are still accepted (Australian national herbarium, 2008). H. N. Dixon an English bryologist continued on Mitten's work, in describing/ed many new moss species (Rubasinghe and Long, 2014). Local bryologist B. A. Abeywickrama's contribution has had a major influence on bryology. Among the visitors who contributed on bryoflora were H. Inoue from Japan, C. C. Townsend from England, and P. P. M. Tixier from France and Maurice Onraedt (1981) from Belgium.

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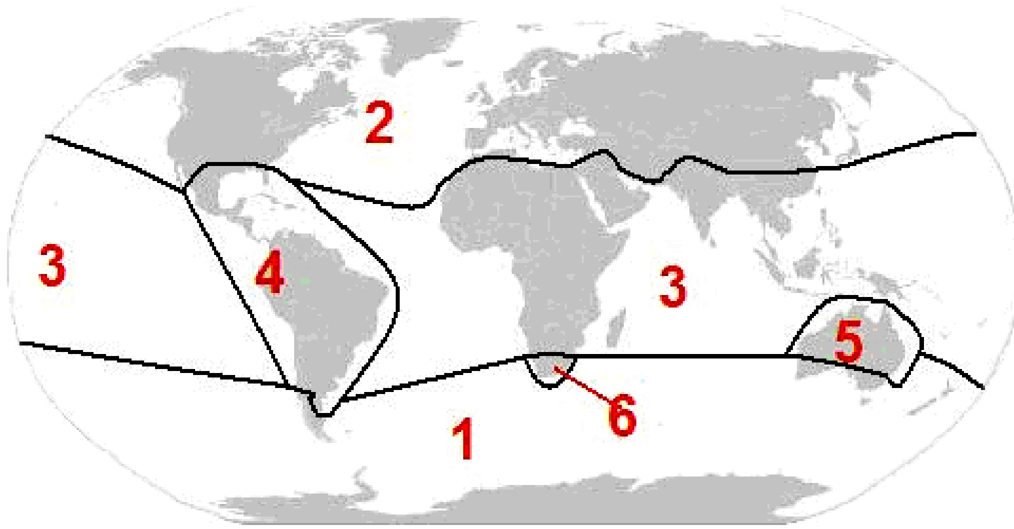
Figure 8. Bryogeographical zones described by Theodor Herzog

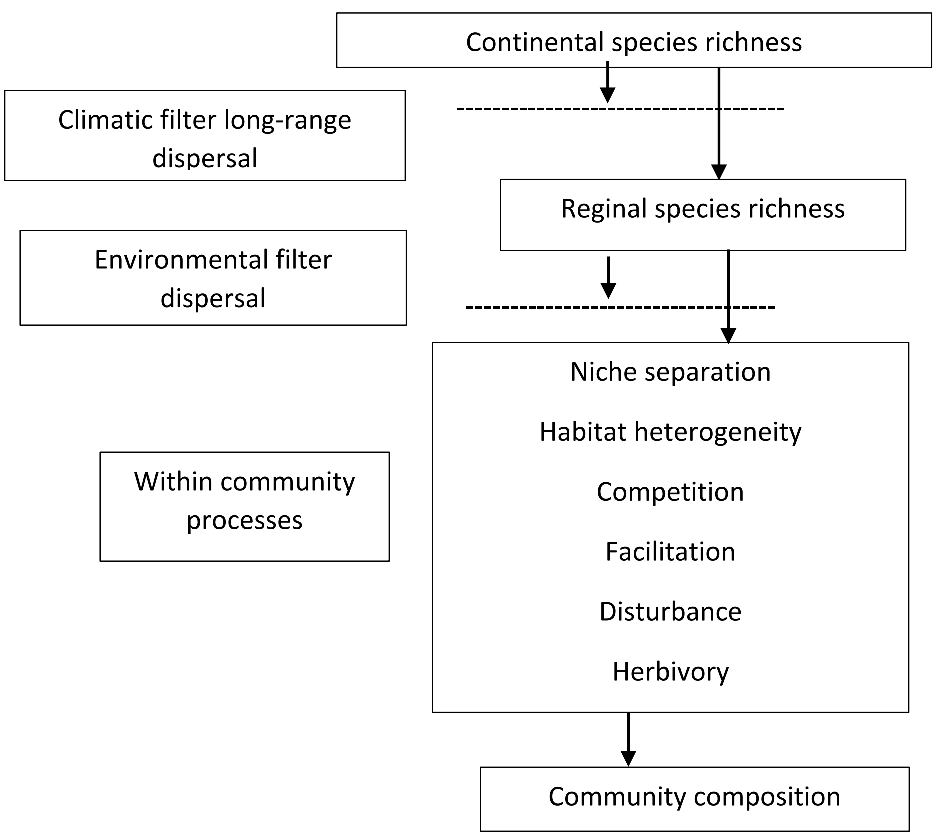


1. Holantarctic Kingdom 2. Holarctic Kingdom
3. Paleotrophical Kingdom 4. Neotropical Kingdom
5. Australian Kingdom 6. South African Kingdom

Source: https://www.anbg.gov.au/bryophyte/bryogeography, 2008

Bryophyte distributions are influenced by a variety of factors (Figure9) operating over a range of temporal and spatial scales (Rydin, 2009).

Figure9. Nested spatial structure of the processes shaping bryophyte species diversity and composition



Source: Vanderpoorten and Goffinet, 2009

Figure 10.Dumortiera hirsute (Sw.) Nees

Source: http://bryologia-zeylanica.blogspot.com/, 2012

Figure 11. Phyrrhobryum spiniforme (Hedw.) Mitt.

Source: http://bryologia-zeylanica.blogspot.com/, 2012

Figure 12. Orthorrhynchium elegans

Source: http://bryologia-zeylanica.blogspot.com/, 2012

Figure 9.Frullaniaceae family

Source: http://bryologia-zeylanica.blogspot.com/ , 2012

The distribution of this group of plant species emphasizes the vast majority of bryophytes species are sparsely distributed within a given area or globally (Cleavitt, 2005). Adding further explanation Longton and Hedderson (2000) stated that species frequency distributions are typically extremely skewed, with rare and potentially threatened species representing the bulk of the flora. Most countries in the world do not a concern for bryophytes, due to this limited availability of precise data on species distribution the threat levels on species are difficult to evaluate. In 1995 Ines-Sastre and Tan mentioned that the loss of species no less than 12 per cent in Puerto Rico in the course of twentieth-century and 50 per cent of the moss species in Mount Santo Thomas in the Philippines within a 50 year period. Although this indicates that even 10 per cent of bryophyte species loss per year from one country, it is quite difficult to measure the impact of this loss as there are no data related to the extent of bryophytes and also without a clear understanding of root causes stand behind this loss.

2. ECONOMIC AND ECOLOGICAL VALUE OF BRYOPHYTES

The economic and ecological value of bryophytes is not emphasized in the community. Liverworts and mosses have been tried and used as a source of fuel for a long time in developed countries including Sweden, Ireland, Poland, Soviet Union, West Germany and Finland. Peat mosses are identified for the production of methane and heat which will be going to apply in producing electricity in the future. Bryophytes have excellent power to absorb moisture and act as a preservative agent. They have the ability to preserve dead bodies too. In addition, these plant species are used as a material for the construction of temporary dwellings. E.g. at Kapkot in the Himalayas, villagers use moss mats with grasses, bamboo and shrubs to make *parking* (a kind of door placing at the openings of their temporary huts). Due to lower cost and easy transport, these dwellers use *Sphagnum* peat as housing construction materials. Himalayans used to keep mosses as insect repellents when storing their food; dried mosses along with liverworts made into a coarse powder and sprinkled over grains and stored in containers. Fibre industry also applies bryophytes for different purposes; as a lining of diapers to improve absorbing power, as decorations for net bags and make cheap clothes mixed with wool. In Sri Lanka, the use of bryophytes can be clearly identified in several ways such as eco-friendly products; coir pots, coir fibre pitch (coco-peat), moss sticks and hanging wire baskets. Medicinal value of bryophytes particularly identified for skin cases; help to cure ringworms, mixer of ash of moss and honey to treat burns, cuts and wounds, for Sphagnol' chilblains, scabies, acne and to cure allaying arising skin problems from insect bites. China is important in commercial medicines made up of bryophytes for bronchitis, tympanitis, cystitis, cardio-vascular system and tonsillitis. Bryophytes are used in the biotechnological field, transgenic *Physcomitrella* sp. are now being used to produce 'blood-clotting factor IX' for treatment of haemophilia B and other proteins. Roig and Mesa (1945) mentioned the use of *Marchantia polymorpha* to cure pulmonary tuberculosis and affections of the liver. Hartwell (1971) further explained that *Marchantia polymorpha*, *Marchantia stellate* and *Polytrichum commune* possess antitumor too. Aqueous extract of *Conocephalum conicum* is antibiotically active against *Candida albicans* (Hayes, 1974), an opportunistic pathogenic yeast. Krishna cited (2011) on Landley's (1856) mentioning of *Sphagnum* species as a wretched food among barbarous countries as bryophytes are not directly used as human food.

Role of the ecological value of bryophytes is too important like economic value. Peat formation, as seed beds for germination of vascular plant seeds, supply a micro habitat, numerous invertebrate species e.g. aphids, nematodes, rotifers and tardigrades (Merrifield and Ingham, 1998 and Peck, 2006) and some bird species eat bryophytes; Red grouse chicks prefer *Bryum* species and birds like Field fare, Song thrush and Black birds include some small amount of mosses to their regular diet, most invertebrates lay their eggs or shelter them, as construction material of nests of some birds, high tolerable for pollutants e.g. *Funaria hygrometrica* and *Bryum argenteum* tolerant for sulfur dioxide, pollution preventer of soil erosion; intertwined moss stems and rhizoids bind soil particles firmly and hold a large amount of water and helps to reduce runoff, supply and maintain micro climates, nutrient cycling; absorb nutrients dissolved in rain water or mist and then die where decaying bryophytes release nutrients to surrounding plants, indicator of soil pH; liverworts and mosses e.g. *Campylopus paradoxus* indicate acidic soil and indicator of acid rain as they lack epidermis and cuticle hence are most vulnerable than vascular plants e.g. *Neckera crispa* indicate high pH as like acid rain. *Neckera crispa* species were used by prehistoric men in a lakeshore settlement in West Germany indicated Stone Age uses of mosses (Grosse-Brauckmann, 1979).

3. THREATS OF BRYOPHYTES

3.4. Direct threats

Direct threats derived from horticulture as a long term traditional use of bryophytes, especially among commercial epiphyte growers. Due to the high water holding capacity of bryophytes, those with highly specialized hyalocytes e.g. *Leucobryum* and *Sphagnum*, make them very useful potting medium mostly in greenhouse crops and potted ornamental plants and seedlings, particularly favoured by orchid growers and for wrapping flowers or fruit tree rootstocks for transportation. Today outdoor *Sphagnum* nurseries are an interesting option that can be seen for horticulture (Rochefort and Lode, 2006), though this is an option for a new type of professional horticulture, bryophytes are directly harvested from natural populations throughout the world. However the local regulations are existed e.g. the EU Directive in Europe and the Flora and Fauna guarantee in Victoria- Australia, the destruction of bryophytes are not monitored worldwide and can result in ecological damage and decline in bryophyte diversity. Whinam and Buxton (1997) mostly focused on *Sphagnum*, commercial moss harvest has been increased and expanded to other taxa including epiphytes. Epiphyte moss harvest is developed in temperate rainforests mostly including Pacific coast of western North America. Commercial harvesting has become a serious sensitive threat in this area which appears to be one of the impotent regions for conservations of bryophytes as 15 per cent of moss species are endemic in this area (Schofield, 1984). Considering the frequent loss of bryophytes especially due to commercial harvest, it will take at least 20 years to regrowth and biomass recovery even longer (Peck, 2006).

3.2. Indirect threats

Though the bryophytes directly affected via commercial harvest, most serious threats or stresses derive indirectly especially from the destruction or degradation of their natural habitats. The causes can be at both the local and global level. At the global scale, threats are global warming, pollution and biological invasions. At the local scale, threats include deforestation, logging and agriculture and habitat fragmentation. Biermann and Daniels (1997) and Ketner-Oostra and Sykora (2004) stated a particular example of biological invasion happened in permanent vegetation plots located in Dutch sand dunes; *Campylopus introflexus* has continuously increased in abundance since the 1960s', outgrowing the native vegetation and finally forming a monotonous, dense moss carpet with an open canopy of *Corynephorus canescens*. Due to the habitat fragmentation especially in rainforests which are identified as biodiversity hotspots, bryophytes have threatened highly. The conservation has become a challenge due to habitat fragmentation. Island biogeography which reveals precious knowledge related to fauna and flora, deals with the concept of equilibrium theory since McArthur and Wilson (1967) that the number of species reflects a balance between immigration and extinction rates, which are both influenced by two main intrinsic island characteristics; impact of island size and immigration is controlled by species dispersibility. This model widely applied to predict species richness in both oceanic islands and terrestrial habitats (Whittaker, 1998) which are rich in bryophytes. When the extinction risk increased rapidly in isolates especially at the local levels small fragments exhibit proportionally more degraded edge surfaces. These factors primarily impact epiphytes. Shade epiphytes are less desiccation –tolerant than sun epiphytes and developed putative adaptations such as papillose cell walls, which enhance the capillary absorption and speed up the process of rehydration. This shows their high sensitivity towards disturbance (Gradstein, 1992 a, b, Gradstein *et al*.2001, Acebey *et al*, 2003). The cause of epiphyll species loss in small fragments (<10 ha) is reduced colonization which was confirmed by Zartman and Shaw (2006). Fragmentation also has the potential for disastrous effects on levels of genetic diversity in impacted populations. Wilson and Provan (2003) mentioned that in the study of peatland fragmentation on the genetic diversity and structure of peat moss *Polytrichum commune*, genetic diversity values from completely cut bogs were indeed found to be lower than those from uncut peatlands.

In Sri Lanka, most of the bryophyte species have become threatened due to agricultural practices and clearing of forest areas. Utilization of bryophytes is commonly less among the community and do not have any consideration for these tiny plants. At the same, an evaluation of the impact of threats could be identified which is rather a difficult task due to the lack of statistical data and wide-ranging literature on bryophytes.

CONCLUSION

The literature survey indicates the less awareness of bryophytes among a community which was also mentioned in a recent study done by Ruklani *et al* in 2015. The scarcity of literature sources with a detailed account on bryophytes in Sri Lanka increases the vulnerability of bryophytes as it is difficult to implement necessary conservation measures without understanding the status of species and accurate identification of species. Generally, people are not aware of these plant species and the studies carried out on bryophytes have focused mostly on the species distributed in central highlands and lowland areas in Sri Lanka. In addition, currently, there are no conservation measures implemented to protect this ecologically important plant species. Though deforestation, industrialization and environmental pollution affect the survival of these plant species people are not aware of this issue. When comparing to other countries, the local community have no clear understanding of the economic or ecological value of these bryophytes. Therefore conservation of bryophytes in Sri Lanka has become a challenge which intensifies reduction or extinction rate of some species without revealing their identity. In Sri Lankan context it is again difficult to identify or measure the impact of stresses or the causes of degradation or destruction of bryophytes due to least attention on bryophytes. In order to implement conservation measures, preliminary community awareness program, workshops and training programs have to be carried out especially among farmers or those who regularly work with soil and plants. And also a comprehensive bryophyte flora survey needs to be carried out to create accurate bryoflora species checklist. As it is a time-consuming task it is important to have the cooperation of both government and non-government environmental organizations in Sri Lanka to conduct a thoroughly comprehensive survey on bryophytes in the country to implement conservation measures early as possible to conserve this miracle species as discussed in the beginning.

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