Chapter

Introductory Chapter: Bryophytes 2020

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1. Bryophytes

Bryophytes, amphibians within the plant kingdom, were among the first plants that lived in the water and settled in terrestrial environment. They faced such a harsh and bare environment they needed to cope with; but on the other hand, these facts gave opportunities to diversify so much. Nowadays, they count between 18,000 and 23,000 extant species [1]. However, one can estimate many undescribed species that appear with classical and molecular approaches, and every year many new species for science are reported, even from Europe [2] that is bryologically among the best investigated world areas. Classification of such a huge diversity as bryophytes is the matter of discussions leading to treating them as one division or alternatively three or more within the common subkingdom of plants named Bryobiotina. Irrelevant of classification level, the three widely accepted group can be considered within bryophytes: mosses (11,000–13,000 species), liverworts (7000–9000 species), and hornworts (200–250 species).

During the decades of accumulation on the knowledge on bryophytes, bryophyte science developed and changes our views on the three group relationships among themselves and with other plants and algae. One of the latest views is that mosses and liverworts can be considered as Setaphyta while hornworts (Anthocerotophyta) seems to be near vascular plants [3].

Nevertheless, these groups share common ancestor, as well as a number of biological and ecological traits. Even though some lignin-like compounds are discovered to be present in some species, they do not produce lignin which preclude them to develop into huge forms due to the absence of mechanical body support. They are all rather small plants, even some species can reach few decimeters in height. The life cycle of bryophytes is dominated by haploid gametophytes, while diploid sporophyte has even shorter appearance during the sexual reproduction.

The strong cuticles are absent unabling them to keep body water balance. This means they are water dependent from the water balance in the immediate environment, i.e., poikilohydric. Thus, many of bryophytes can go to anabiosis which means drying out during dry period and once the wet period is back they can quickly resume their metabolism with no damage. This is why many species belong also to the group of unrelated vegetation representatives called resurrection plants.

The lack of cuticles, whole body collecting water from the atmosphere, and the absence of rootlike structure for soaking (rhizoids have mainly anchoring function) are some of the characteristics which makes them good bioindicator species quickly reacting to small changes in proximate environment. So, bryophytes possess a huge potential in specific sensitivity also due to their relations to specific microhabitats and proximate ecological conditions, and they greatly exceed the sensitivity of vascular plants to pollutants or in general environmental changes.

Bryophytes inhabit almost all ecosystems on the Earth. There are no representatives in the seas, but there are representatives in the brackish waters or moderate salt environment [4]. Though, over the times we learn that they have significant roles within the communities they live in. A range of significant ecological functions of bryophytes are huge and vary from biomes to biomes, but the general ones include water retention (acting like a huge sponge; they play a significant role in water balancing in the ecosystems), carbon sequestration (i.e., carbon locking by peatland dominated by peat mosses), or biotic interaction with other organisms (e.g., providing shelters, acting as a seed bed, or representing habitat *per se* for many other organisms).

The geographical ranges of bryophytes are wider than those of vascular plants [5]. This is due to the long-distance dispersal of small spores, huge survival rate or diaspores during transportation, and settling specific microhabitats over the huge areas. In general, we can say they are ubiquitous, since species can be found in dry desert to the underwater deep in freshwater lakes and from the sea level till the top of the highest mountains surviving even under the long laying ice. Their nutrient supply is over the whole body surface coming from precipitates. Drying out, i.e., suspending physiological activities, versus rewetting, i.e., establishing back normal life function, can occur on a daily basis (e.g., *Grimmia* and *Schistidium* that live on exposed rocks), or they can survive longer periods of inactivity upon dehydration (many members of Pottiaceae).

Most of the bryophyte species are rather less competitive to resources in the environment than vascular plants. Thus, they have a wide range of distinctive feature to survive including, beside the abovementioned, life forms and life strategies. Also dispersal and propagation can be through various vectors both biotic (e.g., birds, snails, mammals) and abiotic (e.g., wind, watercourses), and apart from spores that are produced sexually, diaspores can be produced on rhizoids (e.g., *Bryum*), stem tips (*Aulacomnium*), or on the leaves (*Pohlia*, *Orthotrichum*, etc.) for vegetative spread. Even parts of the whole bodies can serve for this purpose. Such an efficient possibility for wide dispersion and long viability of spores and diaspores enables them to rich long distances, and this is why the endemism is rather low compared to vascular plants. Some authors stated that 10% among European bryophytes express the endemic characters compared to 28% of tracheophytes. On the other hand, the discontinuous ranges and disjunctions are very high among bryophytes [5] as a consequence of very efficient spread and the microhabitat importance for new population establishment.

Among the interesting features of bryophytes, being an ecological indicator should not be passed by (e.g., [6–8]). Many species occur on specific pH of the substrate, or indicate by appearance air quality. Additionally, some species are so well adapted to substrate and nutrients coming from dissolved substrate by precipitation that they can indicate the presence of salt (e.g., *Entosthodon hungaricus*) [9] or minerals (Pb, *Ditrichum plumbicola*; Cu, *Scopelophila cataractae*) [10] and are strict to such a region.

Fast-spreading protonemal growth in a short suitable period can stabilize the soil surface, preventing erosion. Also, they are pioneer colonizers and stabilizers of bare surface, enriching the ecosystems and producing a suitable habitats for further settlers in successional phases of ecosystem changes/development. Spreading colonies on rocks, they initiate soil establishment and participate in protosoil production cohabiting with cyanobacteria, playing an important role in nitrogen fixation, i.e., enabling colonization for other plants and organisms.

Bryophytes have no huge commercial values, at present. These values come from a huge number of both biotic and abiotic interactions as well as their peculiarities (e.g., [6, 11, 12]). However, they have huge applicative potential, which is lately noticed but still neglected compared to vascular plants.

Chemical constituents of bryophytes attract lately very much attention since many new to science and rare or modified known compounds are discovered in different species [13–16]. Also, bioactivities of extracts or target compounds are promising for bio-industrial products such as biopharmaceutical, biopesticides, biorapelents, or cures. Since all these products are environmentally friendly, new biotechnological processes with bryophytes are needed to be established to get to the point when wide use can be done. The treat to some modern diseases like AIDS and different cancer types and even new antibiotics are possible to develop from bryophytes [17–19]. Huge potential of bryophytes are seen by cosmetic industry as well. The problems remain the small biomass in nature for such a project, hard identification, monoculturing, cohabitation, and interfusion with many other organisms. There are steps forward to establish bryo-reactors with selected species to overcome these problems, but still clean start material is needed to do so. Therefore, the axenic and in vitro establishment of target taxa is necessary. This is not an easy task, having in mind that many species are hardly available and not in a proper developmental stage, and also due to lack of cuticles, one-cell thalli layers that unable or hardening surface sterilization without killing target material as well. Additional problem can be endophytic cohabitants.

Though, there are many advantages in bryophytes. For example, easy gene targeting and high rate of homologous recombination are the main pathways for transforming DNA to incorporate in moss genome [5, 20]. This is surely true for the model moss whose genome is completely sequenced, namely, *Physcomitrella patens.* It is widely studied and exhibits high frequencies of gene targeting. DNA constructs with sequences homologous to genomic loci can transform moss rather easy. The outcome then is the organism with targeted gene replacement resulting from homologous recombination although untargeted integration at nonhomologous sites can also occur, but at a significantly lower frequency which can be easily eliminated.

Since, these organisms are rather microhabitat dependent and sensitive to environmental changes, large-scale harvesting and impulsive climate change can cause both diversity and biomass loss not only damaging bryophytes *per se* but the global ecosystem as well. Thus, protection and conservation for the bryophytes are urgently needed in a quick-changing world [21]. Many governments and conservationist have already done a lot in legislative, giving priority to highly threatened species, i.e., applying passive measures for the well-being of mosses, liverworts, and hornworts or habitats they live in. However, it seems these are not enough, and the decrease in populations, even species loss, is taking part. Therefore active conservation measures are needed: species propagation, species reintroduction, habitat management, and constant monitoring [22–27]. The emerging field of conservation biology, namely, conservation physiology, is therefore needed to learn in experimental both laboratory and field conditions, those what is essential on species biology prior to decision which measures will be applied for good species conservation and loss prevention apart from legal measure.

And again, in vitro establishment, studies, and propagation arise as problem solutions in maintaining ex situ collections and preparing material for release to the wild [25, 27]. The reviving of material stored in herbarium is sometimes possible [26], but in most cases good green material is needed which mostly is not the case.

Many problems in different fields of bryophyte sciences remain to be solved, and many phenomena remain to be uncovered, although over the past century many knowledge on bryophyte biology were accumulated. However, in 2020 we still need both to spread among known fact searching for overlooked and to go deeper beyond the point that has been reached up to date.

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