Abstract of Thesis

Diversity and Distribution of Bryophytes in Eastern Central Gujarat

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Introduction

Bryophytes are non-vascular, photosynthetic plant group. It includes liverworts, hornworts and mosses. Liverworts are of three types simple thalloid, complex thalloid and leafy liverworts. Hornworts are thalloid in nature. Mosses are leafy in nature and are either acrocarpic (erect) or pleurocarpic (prostrate). It is distributed across the world from coastal Antarctica to the tundra of the Northern Hemisphere and from the Australian deserts to the Amazon rain forests. They occupy various habitats like soil, wall, rock, brick, tree trunk etc. They are ecologically as well as medicinally important. They also have an economic value, whether it is as peat for fuel, horticulture, oil absorption or as sources for a wide variety of chemical compounds.

Worldwide about 15000 to 16000 species of bryophytes occurs while in India and Gujarat it accounts for about 2562 and 67 species respectively. Major work on bryophytes is mostly restricted to the hot spots of the country viz. Eastern & Western Ghats, Gangetic plains, Himalayan regions etc. There is a lacuna in its database in comparison to higher plants especially at regional and state level. They are the second largest group of land plants. Yet, they are one of the most neglected groups of plants in India. It is not just neglected in terms of research but also neglected academic at academic level. In Gujarat also database of bryophyte diversity is poor. The important reasons for this is less amount of bryophyte research, lack of expertise, absence of reproductive bodies, paucity of authentic literatures atleast for some states like Gujarat. The present study was carried out in 5 districts namely Chhota Udaipur, Dahod, Narmada, Panchmahal and Vadodara that lies in the Central Gujarat.

The main objectives of the study were:

1. Assessment of diversity of bryophytes in the study area
2. Delineating the distribution of different species of bryophytes in the study area.
3. Standardization of protocol for tissue culture of bryophytes of importance.
4. To evaluate barcoding of bryophytes and their role in molecular identification.
5. Preparation of a Computer Aided identification (CAI) Module in Delta INTKEY for morpho-anatomical identification of bryophytes of the study area.

To achieve the above objectives various habitat ranging from the agricultural plains to moist deciduous forest were visited. The specimens were collected from various locations, identified using authentic references and submitted to the BARO herbarium. The culturing of bryophytes was carried out in presence and in absence of sugar using Knops medium at different concentration. DNA barcoding of bryophytes were carried out using the Universal primer rbcl. For the generation of computer aided identification (CAI) module DELTA INTKEY, an open source module was used.

Results and Discussion

In this study, a total of 45 species of bryophytes were recorded comprising of 13 liverworts, 6 hornworts and 26 mosses. The recorded species constituted more than half of the bryophytes reported from the state. Two bryophytes namely *Cyathodium cavernarum* and *Gymnostomiella vernicosa* were mostly commonly occurring species. It comprised of a total of 14 families of which Pottiaceae was the dominant families represented by 7 species viz. *Hydrogonium arcautum* (Griff.) Wijk & Margad, *Hydrogonium consanguineum* (Thwaites & Mitt.) Hilp., *Hyophila involuta* (Hook.) A. Jaeger, *Hyophila nymmaniana* (M. Fleisch.) M. Menzel, *Hyophila spatulata* (Harv.) A. Jaeger, *Hyophila walkeri* Broth and *Semibarbula orientalis* (F. Weber) Wijk & Margad. Whereas, the Lejeuneaceae was the least dominant family represented single species viz. *Rectolejeunea aloba.*

The habitat analysis of the recorded bryophytes was also carried. It revealed that the bryophytes were recorded from 5 different habitat types namely soil, bark, wall, rock and brick of which rock was the most preferred habitat of the recorded species of bryophytes. Maximum number (24 species) of species were recorded from the rock substratum, while least least number were recorded from brick (7 species).Most of the area surveyed were hilly outcrops with an undulating terrain and Panchmahal was also one of such kind. The district-wise analysis indicated that maximum (38 species) hydrophytes were recorded from the Panchmahal district followed by Dahod district (31 species), Narmada district (23 species), Chhota Udaipur (20 species) and Vadodara district (13 species). The reason for less diversity of bryophytes in Vadodara district might be the absence of the forested area.

Temperature and precipitation are important factors for growth of bryophytes and many species of these groups of plants are generally found at higher elevation. Therefore, altitudinal distribution of the recorded species were also studied and represented in the form of elevation maps. They were recorded at several altitudinal gradient ranging from 100 to 1100 m. Liverworts were mostly recorded at low altitude (below 200 m) except the epiphytic leafy liverwort i.e. *Rectoleujena aloba* (about 800 m). Most of the epiphytes namely *Stereophyllum* spp, and *Fissidens zollingeri* were recorded at higher altitude (800 & above m). Hornworts were largely recorded at lower altitude with rare occurrence at moderate altitude (400 m). Some of the species were recorded at wide range of altitude i.e. low like memebers of pottiaceae like *Hyophila involuta*, *Hydrogonium* spp. as they were recorded at lower as well as the higher altitude

The culturing of *Funaria hydrometrica* Hedw moss was experimented to determine the effect of sugar on the protonemal growth of the moss. The reason for selecting this moss is being one of the model moss in academic curriculum as well as in experimental design. The culturing of moss was carried out on solid agar medium as the liquid medium limits the growth of gametophytes. The experiment was carried out in two different sets of condition one with sugar (sucrose) and the other without sugar (sucrose). The results of the experiment showed that the moss grown in the presence of sugar was contaminated frequently. The germination in absence of sugar took double time (10-15 days) in contrast to the germination in presence of sugar (5-10 days).

On the other hand, moss in absence of sugar took about 3 months for the complete growth of protonema, but was not contaminated till the end of the experiment. Protonema is a thread-like structure formed during the intial stage of germination of spores. However, the growth of protonema in presence of sugar was fast, but needed regular monitoring for contamination. Unipolar germination of spores were common, however bipolar was also recorded. The contamination of the culture grown with sugar was high in comparison to culture grown in its absence. Several antibiotics was also used but it still persisted in sugar containing medium. In case of sugar containing medium, Knop full strength medium gave the best results in comparison to half strength knop medium and one fourth strength knop medium.

Barcoding of bryophyte was attempted as a molecular method of identification. DNA barcoding of 14 species were strived, that included 5 species liverworts, 1 species hornwort and 8 species of liverworts. Of the attempted species, 5 species of bryophytes were successfully barcoded comprising of 3 (*Plagiochasma rupestre*, *Plagiochasma japonicum* and *Asterella angusta*) liverworts and 2 (*Fissidens zollingeri* and *Bryum coronatum*) mosses. The sequence quality of all the species was high. For the barcoding of the bryophytes, the thallus/sporophyte/leaves were used. The barcode was uploaded in the Barcode of life database for obtaining the database.

The phylogenetic analysis tree of the barcoded species with the Indian species available in the NCBI database was also constructed using Maximum likelihood classification. In studying the phylogenetic relationship of the barcoded species with available database in NCBI, the morphological characters of the species were taken into consideration. The phylogenetic analysis of the *Fissidens zollingeri* showed that it is phylogenetically close to *Fissidens nobilis* as well as *F. obscurus* and *F. involutus*. The phylogenetic analysis of *Bryum coronatum* did not show much similarity with the available database. The phylogenetic analysis of *Plagiochasma rupestre*, *Plagiochasma japonicum* and *Asterella angusta* showed that *Plagiochasma rupestre* and *Asterella angusta* was having close resemblance with *Plagiochasma japonicum and P. pterospermum*.

The identification of bryophytes is a difficult task and requires an expertise. They are seasonal plant and dependent on the environmental factors like precipitation, temperature, soil characteristics etc. Many times due to erratic monsoon, the sporophytes are absent. Moreover, the conventional method of identification of bryophytes uses the dichotomous key wherein the user has to select regular order of characters. This absence of sporophytes makes the process of identification more challenging. To overcome this problem of identification, a DELTA (Description Language for taxonomy) INTKEY, an open-source software module was developed. DELTA INTKEY is a software module used for preparing interactive keys for taxonomic groups. Using this module with limited number of characters, species can be identified at genera/ species level. Also, unlike conventional method, choice of selection of characters for identification lies in the hands of user. It is easy and user friendly module. The module was generated using the morphological features of the bryophytes like leaf shape, leaf size, leaf texture, sporophyte length, capsule shape, spores colour, spore size etc for the identification. However, this method has not being largely explored in comparison to the conventional method of identification. This module is not just restricted to studying and analysis the species, but also several features of it are helpful in the preparation of research articles. The features include the dichotomous key, description of species, similarity between the taxa, error tolerance difference between the taxa etc.

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