Synopsis of thesis

Diversity and Distribution Pattern of Bryophytes in Eastern Central Gujarat

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Introduction

Bryophytes are photosynthetic, non-vascular plants that have heteromorphic alternation of generation. Bryophyte is derived from greek word "Bryon" means moss and "Phyton" means plant. It is the second largest group of plants (Goffinet *et. al.*, 2009). They inhabit different habitats like soil, rocks, crevices, dead logs, bark/branches of trees etc (Bahuguna, 2012). Bryophytes are divided into three major groups *viz*., liverworts, hornworts and mosses. Morphologically they occur in two distinct forms: 1) thalloid and 2) leafy. The liverworts are both thalloid as well as leafy, the hornworts are thalloids while the mosses are leafy in nature. Bryophytes need water water for completing their life cycle and are hence known as "amphibians of the plant kingdom. Bryophytes reproduce vegetatively through fragmentation, innovations, tubers, gemmae etc. Sexual reproduction is of Oogamous type. Bryophytes are distributed worldwide and comprise of about 900 genera and 15000 to 25000 species (Gradstein *et. al.*, 2000; Crum, 2001). They are distributed from coastal Antarctica to the tundra of the Northern Hemisphere, and from the Australian deserts to the Amazon rainforests (Hallingback, 2000). They are also found in the temperate regions of the northern hemisphere (Frahm, 2003). Apart from these they have a good diversity in northern, central, and western Asia, northern Africa and the Pacific Islands (Hallingback, 2000). There are about 5000 species of liverworts (Vanderpoorten & Goffinet, 2009), 300 species of hornworts (Duff *et. al.*, 2007) and 13,000 species of mosses spread around the globe. (Goffinet *et. al.*, 2009).

A total of 887 species of liverworts, 39 species of hornworts and 1636 species mosses have been reported from India (BSI, 2020). They are rich in diversity and well represented in Himalayas, Northeast and peninsular India and in Andaman & Nicobar Islands due to high rainfall and humidity. Two genera and 168 species of liverworts, 19 species of hornworts and 547 species of mosses are endemic to India. In Gujarat, a total of 13 liverworts, 10 Hornworts and 44 Mosses have been reported (Chaudhary *et. al.,* 2006). The Pavagadh Hill (Panchmahal District), Girnar Hill (Junagadh District) and Saputara Hill (Dangs District) have been identified as the main areas of bryological diversity in the state. In addition to these, several sites which have historical monuments, that act as favorable habitats of bryophytes are present in the state. The systematic study of bryophytes of the state had not been taken up by the plant workers of the state and before the work of Chaudhary *et. al.* (2006). Prior to this work the diversity of bryophytes had been limited to scattered papers by different authors. They had reported 17 species of bryophytes from all over the state. During their work, Chaudhary *et. al.* (2006) had focused on sites located at different parts of the state but they had just one sampling site in Eastern Central Gujarat which comprised of five districts. This region of the state had the presence of hilly terrain and had large forested tracts. They also had the presence of three wildlife sanctuaries.

The lacuna on information on the diversity of bryophytes and their distribution in this part of the state prompted the present study with the following objectives.

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 morphoanatomical identification of bryophytes..

Methodology

The methodology component consisted of two main components for which standard protocols were followed. The outline has been detailed in the graphic below.

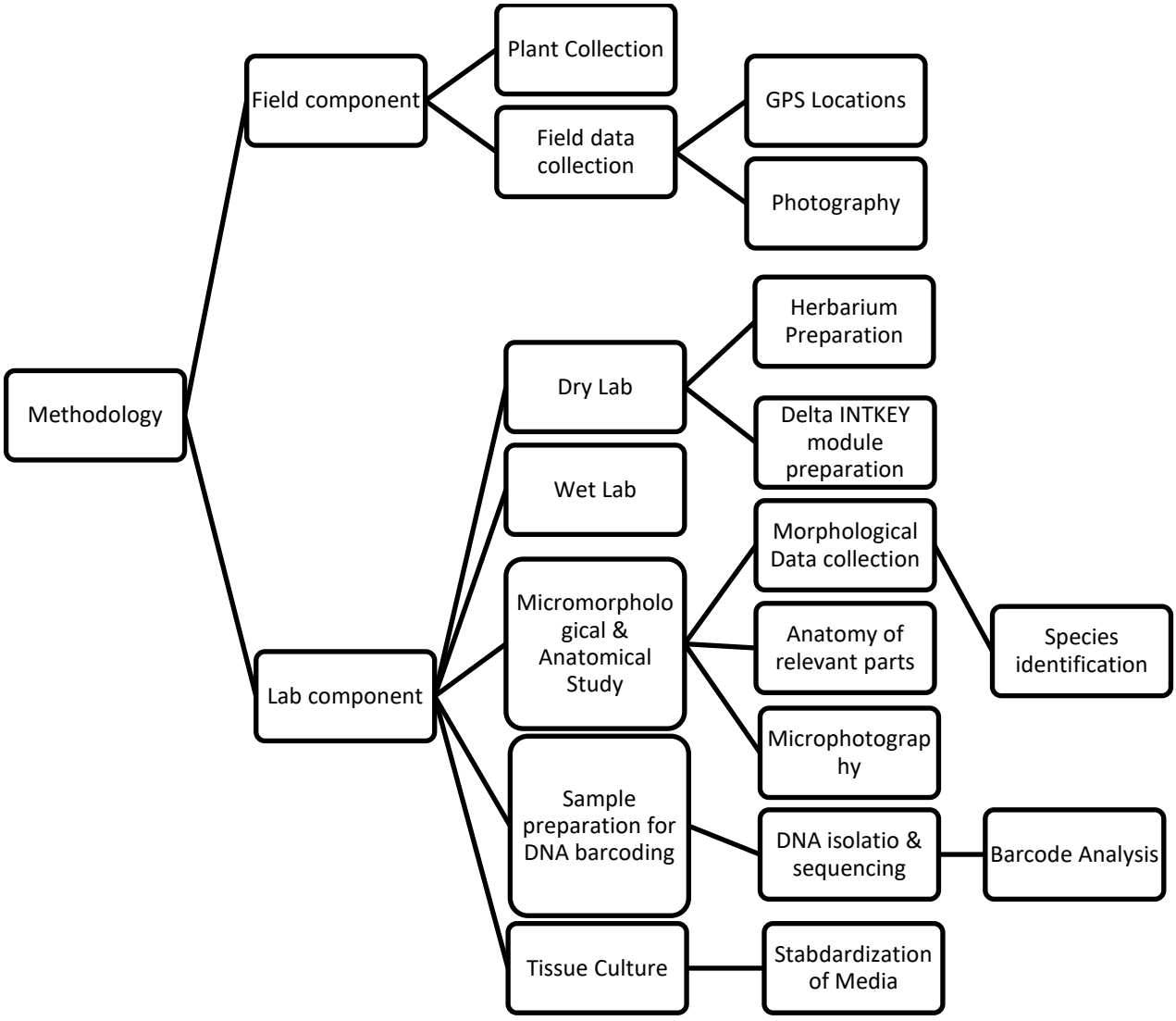

Fig. 1: Outline of methodology followed during the study.

The Study area

The state of Gujarat is situated between 20°01'& 24°07' North Latitude and 68°04' & 74°04' East Longitude covering a geographical area of 196022 sq. km. This accounts for about 6% of the country's land area (Anon, 2019). Administratively, the state is divided into 33 Districts which broadly fall into five zones namely North Gujarat, South Gujarat, Central Gujarat, Saurashtra and Kutch. 18,569 villages and 246 talukas are distributed within these different districts. The present study was carried out in five district of central Gujarat namely i.e. Dahod, Panchmahal, Vadodara, Chhota Udaipur and Narmada. These districts are located in the Eastern part of Central Gujarat. Figure 2 below shows the location of the study area.

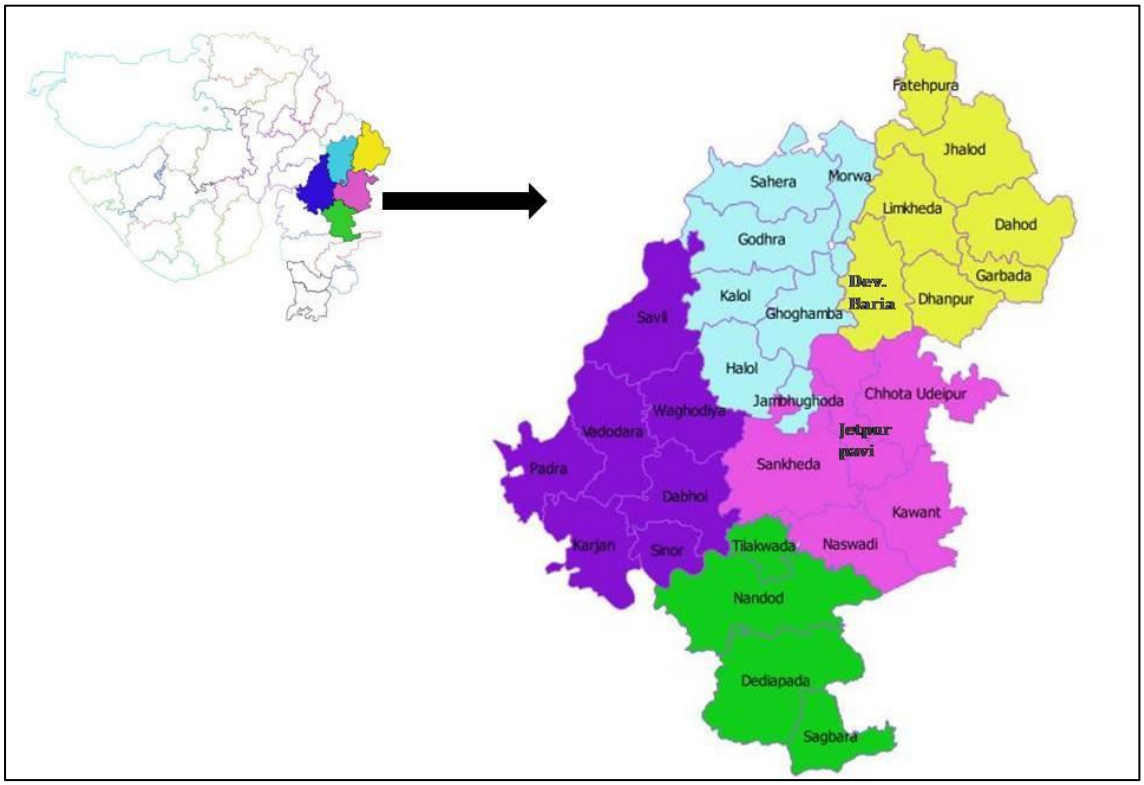

Fig. 2: Location map of the study area

Results and Discussion

The results of the different objectives of the current study are summarised below. They have been discussed in detail citing relevant literature under different chapters in the thesis.

1) Diversity and Distribution

In the present study a total of 45 species of bryophytes were recorded from the study area. This included 13 species of liverworts, 6 of hornworts and 27 species of mosses. This represents

more than half of the reported bryophyte diversity of the state. This also highlights the importance of the eastern part of central Gujarat to the bryophyte diversity of the state. The dominant family in liverworts was Ayotoniaceae which was represented by 5 species. In Hornworts Notothylaceae was the dominant family represented by 4 species while with 8 species, Pottiaceae was the dominant family among mosses. They were recorded from different substrates like soil, rock, bark of trees, walls etc. A majority of the bryophytes were collected from walls (i.e. 27 species). The study contributed two new records to the bryophyte flora of the state in the form of *Notothylas levieri* Schiffner and *Physcomitrium eurystomum* Sendtn.. Among the 5 district studied, Panchmahal had the highest bryo-diversity with 26 species which consisted of 10 species of liverworts, 3 species of hornworts and 13 moss species. The current study extends the distribution of bryophyte species to three districts for which no information was available earlier. Except for two locations, Vadodara and Pavagadh Hills, all the others represent new locations of bryophyte diversity. They were recorded from different altitude that ranged from as low as 40 feet to as high as 2000 feet. Distribution and elevation maps for different species have been prepared. The vouchers of the collected samples were deposited at BARO Herbarium, Department of Botany, The Maharaja Sayajirao University of Baroda, Vadodara.

2. Standardization of protocol for tissue culture of bryophytes

Funaria hygrometrica Hedw. is a cosmopolitan moss which is extensively used in the teaching of bryophytes at the undergraduate level in India. It belongs to the family Funariaceae. It is mostly found on the rocks and wall in shady places. The supply of this moss species is irregular in this part of the state due to which the culturing of *Funaria hygrometrica* Hedw. from its spores was carried out. For establishing the cultures, Knop's medium was used in different concentration as it was most commonly used medium for the culturing of mosses (Cano et. al. ,1996; Chen *et. al.*, 2009; Liang *et. al.*, 2010; Awasthi *et. al.*, 2012, Sahu & Asthana, 2013; Silva-e-Costa *et. al.*, 2016; Sahu & Asthana, 2018; Srivastava *et. al.*, 2018). The culturing was attempted with and without the addition of sucrose. Despite repeated attempts and the use of different surface sterilization procedures, moss grown with sugar in the medium was reputedly getting contaminated within few days (3-4 day) and hence could not reached the protonemal stage. Contrarily, the growth of the moss on the sucrose free medium was very slow and it took about 90 days to reach the protonemal stage. All the process associated with the protonemal growth i.e. germination of spores, increase in volume of spores etc also occurred late than the normal time required. The final culture protocol for the mass production of *Funaria* plants could not be finalized.

3. **DNA Barcoding**

The paucity of experts in bryophyte taxonomy and in the increasing availability and diversity of molecular tools led us to use DNA barcoding as tool for bryophyte identification. DNA barcoding was carried out for selected species of bryophytes that included three species of liverworts and two species of mosses. The DNA barcoding was attempted using rbcL (ribulose 1,5-bisphosphate carboxylase/oxygenase gene) gene from the plastid genome. The sequence obtained from the DNA analysis was submitted to the Bold (Barcode of Life database) for generating barcodes. Barcode of life data system is an online platform with DNA bardcode database freely available for the scientific community (Rantnasingham & Hebert, 2007). The DNA Barcodes of a total 5 species were then analyzed for use in identification as well as generation of phylogenetic trees.

4. **Development of Delta INTKEY module for Computer Aided Identification of bryophytes.**

The DELTA system is an integrated set of computer programmes which are based on the DELTA format (DEscriptive Language for TAxonomy). This has been recognised as a flexible and powerful method of recording taxonomic descriptions to be used in computer aided identification (Singh, 2019) of plants. Three separate keys have been developed for the three different groups of bryophytes using different gametophytic and sporophytic characters of the different species found in the study area. The keys would be useful in identification plants even when all the characters are not available.

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