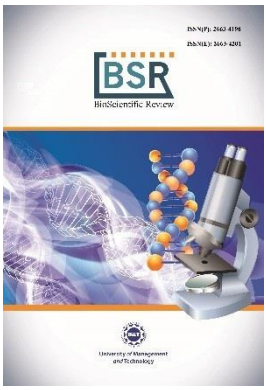

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The Diversity of Non-Vascular Land Plants (Bryophytes) in the Kakkayam Forests of Kerala, India

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Abstract

The current study on the bryophytes of Kakkayam Forests, Kerala, India revealed about 20 species of these plants documented in the study area. These documented species are classified in 13 families and 15 genera. The current observation also found that out of the 20 documented species 9 are common, 6 are uncommon and 5 are rarely distributed in the study area. More bryo-explorations are essential in unexplored areas for its proper documentation and conservation.

1. Introduction

Bryophytes are a distinct and diverse group of primitive plants. They are the second largest group of terrestrial plants with about 25,000 species distributed all over the world. They are called '*Amphibians of plant kingdom'* due to their preference of wet and aquatic habitats. Bryophytes lack vascular tissues and they have a unique life cycle with a dominant gametophyte generation except in a few genera, such as *Buxbaumia* [1]. Sporophyte, which produces spores, is dependent on gametophyte for existence. The group includes three distinct lineages *viz.*, liverworts, hornworts and mosses [2, 3].

Bryophytes inhabit a variety of microhabitats ranging from human habitation to higher altitude areas which include soil (terrestrial), bark (epiphytic), leaves (epiphylls), rock (lithophytes) and water (aquatic). The diversity and frequency of bryophytes is maximum in shady and wet regions as compared to open areas [4]. They are generally considered a key group in our understanding of the phylogenetic interrelationships of modern land plants and pioneers in conquering the land with a hostile environment different from their primitive home in fresh water [5].

Bryophytes include small, non-vascular plants such as mosses, liverworts and hornworts [6]. They play an important role in regulating the ecosystem because they provide a vital buffer system for other plants near them. These plants also benefit from the nutrients and water that

bryophytes collect. They are also a good indicator of the habitat quality and many plant species in this group are sensitive to the level of moisture in the atmosphere [7]. Among bryophytes, mosses and liverworts do not have roots and produce spores for reproduction rather than flowers [8].

The current study mainly strived to document the diversity of bryophytes distributed in the study area.

2. Study Area

Kakkayam (11°33'16.9"N 75°55'22.7"E) is situated in the Kozhikode district of Kerala, India. Teeming with varied floristic and faunistic components, this piece of land can contribute more to enrich the biodiversity of the area as well as the biodiversity of the state. The Kakkayam dam is situated 45-50 kms away from the town and it is also a fantastic site for trekking due to the scenic beauty of its evergreen forests and grasslands.

This reservoir is a part of the Kuttiyadi Hydro Electric Project. It is situated at a height of about 2450 feet above sea level. The pen stock runs down from the dam site. It goes through numerous hills and tunnels to the Kuttiyadi tail race power house situated at Kakkayam. Water coming out of this power house drains into a river. This water is used for Peruvannamoozhi Irrigation Project. Kakkayam is actually a forest area which is fenced by waterfalls, streams hills. Moreover, it is one of the beautiful evergreen forest in Kerala [9].

Kakkayam is also famous for its variety of animals and plants. International Union of Conservation of Nature (IUCN) selected its biodiversity as one of the best bio zones. On the way, one can spot many monkeys, deer, and elephants. Diversity of butterflies and birds can be seen at dam site. Kakkayam is also well-known for its trekking areas and facilities. The local tourist authorities such as the clubs of Kakkayam provide guides and helpers to assist visitors. It is a good place for those who love adventure (Fig. 1&2) [10].

Figure 1. Map of the study area

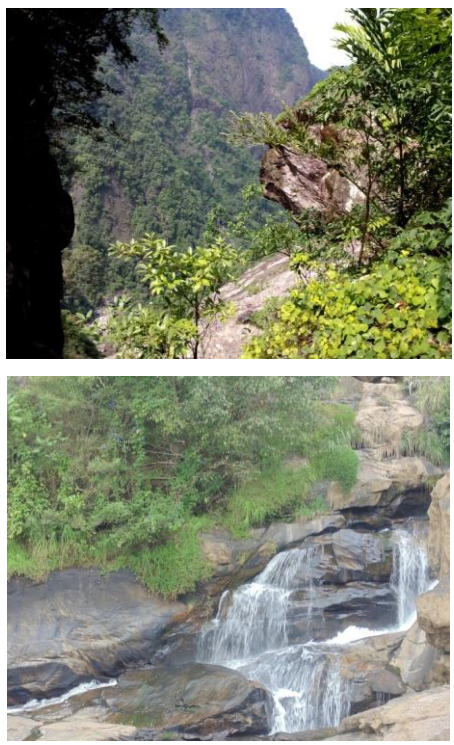

Figure 2. Different views of the study area

3. Methodology

The techniques used to collect, preserve, and store bryophytes are vary slightly from those used for higher plants.

3.1. Tools used for the Collection of Bryophytes

- A knife for prying the specimen from the substrate.
- Paper bags for transportation
- Zipper bags of plastic are suitable, particularly if the specimen number is large and requires to be collected during wet spring.
- Plastic bags to observe the specimens closely and also to dry them at room temperature.

3.2. Techniques Applied for the Collection of Specimens

- A small wooden frame inserted inside the packet helps to protect delicate specimens from damage.
- Do not collect any samples, if you think that it is a rare species.
- Keep a good photographic record of collected specimens.
- Collect samples in the sporophytic phase when possible. The sporophytes are often required for precise identification of specimen.

3.3. Precautions during the Collection of Specimens

- The specimens should be kept in moist and cool conditions.
- To transport bryophytes for long distances using plastic bags, the bags should be blown before sealing them to avoid crushing the specimens.
- Make sure that the specimens are kept away from sunlight and are placed in cool conditions to avoid moulding.
- Cellular oil bodies of leafy liverworts are used for identification of specimen. These oil bodies are destroyed when the specimen dries.
- It is difficult to identify many thallose liverworts after they have dried.
- Identify the specimens as quickly after collection, or refrigerate them until identification.

3.4. Identification of Collected Specimens

- Observe the collected specimens critically, notice their peculiar characters and identify them with the help of available literature [2].

3.5. Preparation of Voucher Specimens

- Dry the specimens properly under blotting paper.
- Frequently change the blotting paper until it becomes aptly dry.
- Paste the dried specimens on standard herbarium sheets using gums.
- Deposit the prepared voucher specimens in the herbaria (Herbaria of Post graduate Department of Botany, Deva Matha College, Kuravilangad, Kottayam) for future reference.

4. Results and Discussion

The current study on bryophytes of Kakkayam Forests, Kerala, India revealed about 20 species of bryophytes documented in the study area (Table-1). These species included *Philonotis hastate* (Duby) Wijik (Bartramiaceae), *Bryum argenteum* Hedw. (Bryaceae), *Bryum coronatum* Schwaegr. (Bryaceae), *Bryum plumosum* Dozy. (Bryaceae), *Bryum wightii* (Mitt.) Linn. (Bryaceae), *Campylopus ericoides* (Griff.) A. Jaeger

(Dicranaceae), *Campylopus flexuosus* (Hedw) Brid (Dicranaceae), *Fissidens ceylonensis* Donzy and Molk. (Fissidentaceae) *Fissidens crispulus* Brid. (Fissidentaceae), *Vesicularia vesicularis* (Schwaegr) Broth. (Hypnaceae), *Octoblepharum albidum* Hedw, (Leucobryaceae), *Dumortiera hirsuta* (SW) Nees (Marchantiaceae), *Marchantia linearis* Lehm and Lindenb (Marchantiaceae), *Aerobryum speciosum* Dozy and Molk (Meteoriaceae), *Meteoriopsis squarrosa* (Hook) M. Fleisch (Meteoriaceae), *Pallavicinia iyellii* (Hook) S. Gray (Pallaviciniaceae), *Porella campylophylla* (Lehm and Lindenb) Trev (Porellaceae), *Racopilum orthocarpum* Wils and Mitt (Racopilaceae), *Sematophyllum subpinnatum* (Brid) Britton (Sematophyllaceae), *Cyathodium cavernarum* Kunz (Targioniaceae).

These documented species are classified into 13 families and 15 genera. Out of the 13 families represented, Bryaceae was the dominant family with 4 species followed by Dicranaceae (2 species), Fissidentaceae (2 species), Marchantiaceae (2 species), and Meteoriaceae (2 species) (see Table 2). Similarly, among 15 genera represented the dominant genus was *Bryum* (4 species), followed by *Campylopus* (2 species) and all other families were represented by a single specie each.

Similar studies were conducted by Venugopal and Manju [11]. They reported many interesting findings from their study area, such as there were no previous records for *Taxiphyllum giraldi* and *T. laevisculum* from Peninsular India. Similarly, the diversity and distribution of stream side bryophytes of China were studied by Tessler and his colleagues [12]; and bryophyte diversity and distribution patterns along three altitudinal gradients in Yunnan, China were studied by Song and his friends [13].

Table 2. List of Bryophyte Species with Respect to their Dominant Families

S No.	Botanical Name	Dominant Families
1.	*Bryum argenteum* Hedw.	Bryaceae
2.	*Bryum coronatum* Schwaegr.	Bryaceae
3.	*Bryum plumosum* Dozy.	Bryaceae
4.	*Bryum wightii* (Mitt) Linn.	Bryaceae
5.	*Campylopus ericoides* (Griff) A. Jaeger	Dicranaceae
6.	*Campylopus flexuosus* (Hedw) Brid.	Dicranaceae
7.	*Fissidens ceylonensis* Donzy and Molk.	Fissidentaceae
8.	*Fissidens crispulus* Brid.	Fissidentaceae
9.	*Dumortiera hirsuta* (SW) Nees.	Marchantiaceae
10.	*Marchantla linearis* Lehm and Lindenb.	Marchantiaceae
11.	*Aerobryum speciosum* Dozy and Molk.	Meteoriaceae
12.	*Meteoriopsis squarrosa* (Hook) M. Fleisch.	Meteoriaceae

The current observation also noticed that out of the 20 documented species, 9 are common, 6 are uncommon and 5 are rarely distributed in the study area. The commonly distributed species are found in varied habitats, while the species which are sporadically/uncommonly or rarely distributed are only found in specific habitats in the study area (Table 3).

Table 3. Pattern of Distribution of Bryophyte Species in the Study Area (√)

S No.	Botanical Name	Family	Common	Uncommon	Rare
1.	*Philonotis hastata* (Duby) Wijik	Bartramiaceae			√
2.	*Bryum argenteum* Hedw	Bryaceae	√		
3.	*Bryum coronatum* Schwaegr	Bryaceae	√		
4.	*Bryum plumosum* Dozy	Bryaceae	√		
5.	*Bryum wightii* (Mitt) Linn	Bryaceae	√		
6.	*Campylopus ericoides* (Griff) A. Jaeger	Dicranaceae		√	
7.	*Campylopus flexuosus* (Hedw) Brid	Dicranaceae		√	
8.	*Fissidens ceylonensis* Donzy and Molk	Fissidentaceae		√	
9.	*Fissidens crispulus* Brid	Fissidentaceae		√	
10.	*Vesicularia vesicularis* (Schw) Broth	Hypnaceae			√
11.	*Octoblepharum albidum* Hedw	Leucobryaceae			√
12.	*Dumortiera hirsuta* (SW) Nees	Marchantiaceae	√		
13.	*Marchantla linearis* Lehm and Lindenb	Marchantiaceae	√		
14.	*Aerobryum speciosum* Dozy and Molk	Meteoriaceae		√	
15.	*Meteoriopsis squarrosa* (Hook) M. Fleisch	Meteoriaceae		√	
16.	*Pallavicinia iyellii* (Hook) S. Gray	Pallaviciniaceae	√		
17.	*Porella campylophylla* (Leh and Lind) Trev	Porellaceae	√		
18.	*Racopilum orthocarpum* Wils and Mitt	Racopilaceae			√
19.	*Sematophyllum subpinnatum* (Brid) Britt	Sematophyllaceae			√
20.	*Cyathodium cavernarum* Kunz	Targioniaceae	√		

Even though there are no direct applications of bryophytes, they are ecologically significant since they play a key role in ecosystems dynamics. In recent years, studies on the various applied aspects of bryophytes have been conducted, particularly on their horticultural and medico-potential values. They are also used as seed bed for higher plants. Moreover, they are bioindicators, that is, the diversity of bryophytes in any particular area can indicate the richness of

the phytodiversity of that area. The dense packing of bryophyte members over stones/rocks and soil can preserve such microhabitats from erosion. Moreover, bryophytes play an important role as pioneer plants in any primary and secondary habitats after disturbance. They also serve as home to many invertebrates and often provide food for many insects and other micro fauna. The prominent growth of bryophytes in any area can form a cushion like substratum for seed bed and also a habitat for other faunastic elements.

The current observation on bryophyte diversity of Kakkayam Forests, Kerala, India also revealed that the potential plant groups documented in the study area were highly specific to the moist shady patches of that particular area. Moreover, the occurrence of such lower group in any ecosystem can indicate the value of that particular area, where it may contribute to enrich the existing biodiversity. Bryophytes specifically prefer evergreen or semi-evergreen habitats for their growth and survival. Such climatic zones are highly suitable for the growth and distribution of other floristic elements. According to this point of view, the current study area is very suitable for the contribution of various floristic and faunastic elements and, thereby, it also enriches the biodiversity of that area. More bryo-explorations are essential in unexplored areas; otherwise, many bryophytes may disappear in future or else chances are there for the disappearance of many species before their documentation in these potential areas. This is because of the fact that day by day, the growth and distribution of bryophytes is decreasing due to many anthropogenic pressures. Hence, proper conservation is essential to conserve this ecosystem from any type of natural imbalance for future generations.

4.1. Images of Selected Plants from the Study Area

Figure 3. *Marchantlalinearis* Lehm & Lindenb

Figure 4. *Aerobryum speciosum* Dozy & Molk

Figure 5. *Meteoriopsis squarrosa* (Hook) M. Fleisch

Figure 6. *Pallavicinia iyellii* (Hook) S. Gray

Figure 7. *Porella campylophylla* (Lind) Trev

Figure 8. *Racopilum orthocarpum* Wils & Mitt

Figure 9. *Sematophyllum subpinnatum* (Brid) Britt

Figure 10. *Cyathodium cavernarum* Kunz

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