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Phytogeographical Study of Bryophytes present in Central Region of Rajasthan

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ABSTRACT:

In this study, bryophytes are investigated in connection to the three primary bryoecological zones, which are established according to the conditions of the soil and the climate. These regions are arid and semi-arid, and the southern region and the plateau have very different climate conditions and types of plant than the rest of the region. Both biotic and abiotic factors play a key role in determining the presence of bryophyte vegetation throughout the state as well as its spread. The distribution of bryophyte species is affected by biotic factors such as the availability of water, the moisture content of the air, temperature, light, elevation, the type of soil, and its capacity to retain moisture. There are sixty-four different species of bryophytes, all of which have been collected from various areas across this state. Of these, thirty-three can be found in the Western Himalayas, thirty-four can be found in the Eastern Himalayas, and thirty-two can be found in South India. In addition, it has been demonstrated that in order for plants to survive in severe environments, they generate structures such as gemmae, tubers, meristematic rolling apices, and several other vegetative elements.

Keywords: *Phytogeography, Rajasthan region*

INTRODUCTION

The state of Rajasthan is the second largest in India. It has a total land area of 3,42,274 square kilometers and is located between the latitudes of 2303 and 30012 north, as well as between the longitudes of 69030 and 78017 east. Temperature, precipitation, humidity, and wind patterns all change significantly over Rajasthan's landscape, contributing to the state's very variable climate. The temperature swings that occur during the day in this state are among the most notable characteristics of its climate. In the region of the soil located to the northwest there is neither a considerable amount of vegetation nor plants that have significant ecological adaptations. The temperature plummets to a low of 200 degrees Celsius in the month of January, and then gradually climbs to a high of 50 degrees Celsius in the months of May and June.

The bryophytes, in particular, are very unhappy with the climate that exists here. The vegetation, in general, is not pleased. In Rajasthan's xerothermic index, bryophytes are given less weight than other plant groups. Regarding the xerothermic circumstances that are present in this state, the data that Legris and Viart (2016) acquired are extremely informative. Despite the fact that Bapna (2015, 2018, 2020), Chaudhary and Deora (2016, 2021), and Deora and Chaudhary (2015, 2016) made significant advances to our knowledge of the bryophytes in this region, their work should not be overlooked. Bapna and Vyas (2022) conducted an investigation into the preliminary reports on the hepataceae of Mount Abu as well as the ecological aspects of

the area. In their description of the ecological aspects of the vegetation on Mount Abu, Mahabale and Kharadi (2016) cited a few species of liverwort. Despite this, a comprehensive investigation of this state is absolutely necessary, with special attention paid to the ecology of bryophytes, phytogeography, and perennation in drought conditions.

In light of this, the authors went out to collect bryophytes from a wide range of ecological settings across the state of Rajasthan. Following this, they divided the state into a number of bryoecological zones based on the phytogrographical characteristics of the various regions.

OBJECTIVES

1. To study central region of Rajasthan's phytogeography
2. To study phytogeography of Rajasthan

RESEARCH METHODOLOGY

In order to collect bryophytes, a comprehensive and exhaustive field study was carried out, which involved going to a variety of locations across Rajasthan over a number of distinct seasons. Each specimen was given a number and a label, and it was processed correctly so that it could be used in further research. The voucher specimens were transferred to the bryology laboratory of the botany department at Udaipur, which is located in Rajasthan.

RESULTS AND DISCUSSION

The Indian state of Rajasthan features a layout that is rhomboidal in shape. The entire state can be broken down into these categories due to the presence of three distinct bryoecological divisions, each of which is the cause of a distinct variety of plant life as a direct consequence of the state's particular climate (Table 1).

Table 1: Average Bryoecological Zone Temperature, Rainfall, and Humidity

Bryoecological zones	Altitudes	Temperature ^{0}C Jan June	Rainfall	Relative Humidity %
1. Arid and Semiarid	200-400m	Max 27.85 45.91 Min 3.01 20.64	5.1 to 11.6	54.76
2. The Plateau region	400-700m	Max 25.64 44.67 Min 3.58 20.10	18.3 to 23.5	55.45
3. Southern region	700-1558m	Max 27.68 41.11 Min 4.38 18.05	25.1 to 61.27	66.02

The Region of Arid and Semi-Arid

Sand dunes can be found 200–400 meters above mean sea level in the western part of Rajasthan, which accounts for over 60% of the state's total land area. In modern times, the region has expanded to incorporate the administrative districts of Bikaner, Barmer, Ganganagar, Jaisalmer, Jhunjhunu, Jaipur, Jodhpur, Churu, Pali, and Sikar. There is a relatively low amount of vegetation, and the majority of the species that do exist are xeric because of the high temperatures and low rainfall. The bryophyte vegetation that typically grows on most sand dunes during the rainy season near water sources is almost completely missing from this clearly defined area. Only a handful of plant species may be found growing close to water reservoirs in this historically arid region. These include *Marchantia polymorpha, Plagiochasma appendiculata, Riccia disolor, R. tuberculata, Funaria hygrometrica, Hyophila involuta,* and *Brachymenium exile.*

The Plateau Region

The Aravalli hills can be seen in the distance from this region, which features an elevation ranging from 257 to 486 meters above mean sea level. The soil in the valleys of this region is often loam, alluvium, and substantially more fertile than the soil in the neighboring semi-arid and dry regions. This is one of the distinguishing characteristics of this region. The districts of Beawar, Ajmer, Jaipur, Alwar, Sawai Madhopur, Bhilwara, Chittorgarh, and Kota are all included in this region. Hilly areas that are widely separated from one another make up the region. Along with the broad valleys, there are a number of distant hills and peaks that range in height from 400 to 800 meters. In this area, several species of mosses and liverworts can be discovered growing in wet and humid areas, on damp soil, or in crevices in the rocks. A few of the common species include *Plagiochasma appendiculata, Fissidens sylvaticus, Semibarbula orientalis, Hyophila involuia, Gymnistomiella vernicosa,* and *Riccia discolor*.

Southern Region

This region, which is dominated by the Aravalli mountains, can be described as a zone that is pretty well defined. This is because the Aravalli ranges dominate the area. There is a string of hills that range from 600 to 1200 meters in elevation, and they are separated by a multitude of teeny-tiny streams that make deep valleys. The most important places in this area are Mount Abu, Sirohi, Kumbhalgarh, Dungarpur, Parasramji, Udaipur, and Banswara. The region's higher humid weather and perfect growing circumstances for native species make it the most major botanical area in Rajasthan. As a result, the region is the most significant botanical area in Rajasthan. The soil was collected from a variety of settings across the country where bryophytes are prevalent. It was found to have a calcareous texture, and it included a high concentration of calcium carbonate, potassium, phosphates, and nitrates; all of these components were required for the proper development of bryophytes. The water content of the soil varied from 22% all the way up to 30% when it was at normal temperature. The vast majority of this region is composed of wooded areas. Many flora that are only found in isolated pockets can be found here. Bryophytes thrive in environments with both cool temperatures and high levels of humidity. In addition to the abundant angiosperm flora, this zone is home to several significant liverworts and mosses, including *Fossombronia himalayensis, Pellia epiphylla, Asteralla, blumeana; A angusta; Plagiochasma appendiculata, P. articulata, Targionea hypophijlla, Cyathodium barodae,* and *C.tuberosum; Riccia melanospora, R. discolor, R.aravalliensis, R.gangetica, R.plana, R.fluitans, R.crystallina, R.frosti, Anthoceros erectus, A.subtilis, Phaeoceros himalayensis, Notothylus levieri,* etc. Common mosses include *Fabronia minuta, Entodon prorepens, E. myrus, Fissidens diversifolius, F. sylvaticus, Funaria hygrometrica, F. nutans,*

Timmiella anomala, Bryum dichotomum, B. recurrulum, Philonotis mollis, Dlaphnodon procumbence, and *Wijkia tanytricha*, among others.

Habitat and Factors:

The presence of moss vegetation and the range it covers are both greatly influenced by the climate in different areas. In the following paragraphs, we will talk about the primary factors that influence the dispersion of bryophytes.

Moisture

The amount of moisture present in both the soil and the air is an important factor that plays a role in determining the prevalence and distribution of bryophytes. The relative humidity is an important component that plays a role in the dissemination of bryophytes. There is a direct correlation between Mount Abu's highest relative humidity (63.51%) and the region's most abundant moss flora. When we proceed toward the west, the north west, or the extreme north of the region, the relative humidity drops across the majority of the territory. It is quite rare for this to be sufficient to maintain both moss vegetation and forest vegetation. We make the connection between the absence of wooded areas and the dearth of moss flora in the region, which we find to be virtually nonexistent.

In the regions that were researched, the majority of mosses were found to grow on moist soil close to water, in shady areas, on the walls of old houses, or on the trunks of trees that finally became dry. Their population suffers as a direct result of the prolonged droughts that are typical in this region, which also contribute to the eventual extinction of several species.

A study that was carried out on the mosses of Rajasthan in their natural habitats revealed that the majority of the species are forced to tolerate difficult conditions in order to be viable. The biotic effect of humans may have caused some to become extinct entirely, while a large number of others are only just holding on for dear life. The majority of mosses require continually damp places, however there are a few species that are able to endure extreme conditions. For example, the *Entodon prorepens* plant grows on bare rocks, the *Fabronia minuta* plant grows on the trunks of trees, and the *Hyophila rosea* plant grows in close proximity to moving water.

Temperature and Light

It is difficult to assess how temperature influences the distribution of mosses because temperature has an effect on both the soil moisture and the relative humidity of the environment. On the other hand, mosses are typically more abundant in settings that see little change in temperature, but the amount of flora present in eurythermal zones is typically limited. This point will be made abundantly evident by the information that follows:

Table 2: Rajasthan's Bryophyte Distribution

S. No.	Ecological region	Temperature Fluctuation (^{0}C)	No. of species
1	Southern	15-20	42

2	The plateau	25-30	15
3	Arid and semi-arid	30-35	07

In terms of ecology, light has an effect on the amount of moisture present and the temperature of a habitat. An investigation of the northern and western sections of Mount Abu provides evidence for this assertion. They get more shadow than the eastern sections, which get more light; the former have more diverse bryophyte vegetation than the latter, which are quite poor and only display a few xeric forms of plants. This is most likely due to the fact that the majority of species are barred from residing in regions that have higher light intensities, such as the northern part of Mount Abu (Achalgarh, Gurushikar), which is subjected to direct sunshine. It has been observed that plants that are grown in regions with extended photoperiods develop their sexual organs faster than plants that are grown in areas with shade. In addition to this, it was discovered that the vast majority of light-loving species are annuals and, in general, do not utilize any asexual ways of reproduction.

Soil

The features of the soil and the capacity of the soil to keep moisture are key factors that have a considerable impact on the distribution of various species. It has been observed that bryophyte vegetation is not present in arid and semi-arid regions that have sandy soil, whereas mosses are plentiful in places that have compacted water-retaining substrata such as sandy loam, loam, and clay found in the southern region of the country. There are certain species that are able to thrive on soils with a pH of 6.7, but the vast majority of the species found in this state require alkaline soils with a pH ranging from 7.5 to 8 in order to thrive. It would indicate that pH has very little of a role in determining the locations of bryophytes, at least in Rajasthan. It has been observed that plants that are grown on walls develop in a more lush manner than those that are grown on damp rocks or in soil. Because of this, it appears that the species may have a predilection for calcium.

Elevation

It was seen that there was less and less vegetation the closer we got to Mount Abu's highest peak, Gurusikhar, which is located at an elevation of 1,201 meters above sea level. However, there is quite a luxuriant flora blossoming between 750 and 1120 meters above sea level at Gurusikhar, despite the fact that there are no moss plants growing there. This exemplifies how elevation changes unquestionably have an effect on the distribution of bryophytes. It was discovered that the southern region, at elevations ranging from 700 to 1500 meters above mean sea level, is home to the vast majority of the species. The arid and semi-arid zone, which ranges in altitude from 200 to 300 meters, is the most impoverished part of the region. On the plateau, which ranges in height from 400 to 600 meters, only a very small number may be found. When it comes to the patterns of distribution, the majority of northern species can be found at the peak of the highest elevation points, but the majority of southern species can only be found in low-elevation locations. This is because the northern species evolved at higher elevations. The spread of mosses normally follows the same pattern as described previously. However, it is not the case in this specific circumstance. This is due to the fact that a significant portion of the state is currently experiencing dry conditions.

Biotic Factors

The human population and their voracious herds of grazing animals are largely responsible for the arid conditions that prevail across Rajasthan. The negative effect that human activity has had on the plant life has been significant. Large swaths of forest were clear-cut to meet the need for firewood and other materials used in domestic settings, virtually resulting in the extinction of the plant life. Nomadic nomads keep herds of grazing animals wherever there is vegetation so that the vegetation can be grazed by the animals. Because of such intense and continual biotic intervention, large swaths of tree vegetation in Rajasthan, which were formerly covered in grasses only during the autumn months, have been eradicated. The damaged patches of vegetation continue to be subjected to grazing pressure that is either constant or even increasing, which contributes to their further depletion and final destruction. Therefore, bryophytes are impacted both by the harsh climate and the lack of vegetation. On top of that, the abundant lantana vegetation that can be found on Mount Abu is having a detrimental effect on the development of bryophytes. The extensive coverage of Lantana camara vegetation is likely to blame for the extinction of the vast majority of the species in the region where specimens were gathered during the past few years. In addition, Eva Clausen (1952) proved that relative humidity has a crucial role in determining the spread of bryophytes. Their resistance to drying out is a crucial factor that contributes to their widespread distribution. Mahabale and Chavan (1954) arrived at a conclusion regarding the geographic distribution of liverwort in Gujarat that was very similar to this one.

Phytogeography

The vast bulk of Rajasthan does not see significant rainfall for extended periods of time. With very few notable exceptions, the circumstances of the climate are not particularly conducive to the development and continued existence of bryophytes. Only those species with a wide range of tolerances will be able to make it through. So far, 64 species have been identified as having originated from this state. Of these, 24 can be found growing in South India, 36 in the West Himalayas, and 27 in the East Himalayas. (See Table 1)...

The majority of the bryophyte species that are found in Rajasthan, particularly in the southern part of the state, are widespread and may be discovered in the east, the north, the west, and the south of the region. It's possible that this is due of the way the Aravalli mountains are laid out; many of the species that do well in this area are also found in the North and the South, making this area something of a connector between the two parts of the country. Table-II provides an overview of the flora and fauna found in the several districts of Ajmer, Alwar, Banswaran, Chittorgarh, Ganganagar, Jaipur, and Jodhpur in the Indian state of Rajasthan.

Mosses: Elements, Affinities and Analysis

An examination of the affinities with the local flora reveals the following pattern: there are only about 24 species that are common with South India, in contrast to the 36 species that are common with the Western Himalayas and the 27 species that are common with the Eastern Himalayas.

1. **The following genera are prevalent in Rajasthan and the West Himalayas: -**

Fissidens Anoectangium Barbula

Bryocerythrophyllum Hydrogonium Hyophila

Timiella Weissia Funaria

Physcomitrium Gymnostomiella Anomobryum

Brachymenium Bryum Semibarbula

Febronia Levierella Philonotis

Pseudobarbella Entodon

2. **The following genera can be found in South India and can also be found in Rajasthan:**

Fissidens Anoectangium Hydrogonium

Hyophila Timmiella Weissia

Funaria Gymnostomiella Anomobryum

Brachymenium Bryum Philonotis Levierella

3. **The Western Himalayas, South India, and Rajasthan are home to a number of the same genera:**

Fissidens Anoectangium Hydrogonium

Hyophila Timmiella Weissia

Funaria Gymnostomiella Anomobryum

Brachymenium Bryum Philonotis Levierella

4. **The following species, which have been found in other parts of Rajasthan, are not present: Mount Abu:**

Fissidens bryoides F.sylvaticus Hyophila comosa

H. rosea Mnium species

5. **Species of moss that are native to Rajasthan and are also found in the Western Himalayas, the Eastern Himalayas, and South India are-**

Fissidens curvato- involutus H. consanguineum Anoectangium stracheyanum

Semibarbula orientalis Hyophila involuta Funaria hygrometrica

Gymnostomiella vernicosa B. exile Brachymenium acuminatum

Bryum cellulare B. plumosum

6. **The following is a list of extremely uncommon species that have only been found on Mt. Abu in Rajasthan:**

Entodon prorepens E. myurus Funaria nutans

Fissidens diversifolius Wijkia tanytricha

7. The specimens of these species were gathered from Mount Abu and one other location-

Barbula constricta Brachymenium exile Fissidens curvato-involutus

Semibarbula orientails Hyophila involuta Hydrogoniumconsenguineum

Fabronia minuta

According to the aforementioned analytical description, the general tendency in floral dispersal for moss elements is the same as that of higher plant elements. As previously indicated, the current study indicates that Rajasthan's moss flora is not all that dissimilar from that of South India or the Western Himalayas. Additionally, the current research indicates that the Aravalli range may have offered these species a viable migration route.

6. Perennation

The climate in Rajasthan is characterized by extended stretches of dryness throughout the year. The vast majority of the species begin to emerge not long after the very first rainstorms, and they complete their life cycles anywhere from one to three months later. The vast majority of species perish before reaching the end of their life cycle as a direct result of the high temperatures and low levels of precipitation. Because the summer temperatures there are rather high, plants are entirely dried out, therefore certain species that grow in arid and semi-arid environments are annuals that rely solely on spores for survival and propagation. This is because the plains of Rajasthan are located in an area of Rajasthan that is particularly arid. It has been observed that when favorable conditions are getting closer, plant parts like stems, rhizomes, and leaves begin to sprout again and multiply through the process of regeneration as soon as the first showers arrive. Each part of the plant will produce one or more apical shoots when the older component of the plant passes away.

After being dehydrated for a few days, the leaves of plants that are adapted to thrive in xeric circumstances will become enrolled, and the portions of their stems will distribute themselves across the ground or rocks. These plants are able to quickly recover from a downpour and continue to develop (regardless of the season). It was observed that there were a much higher number of sterile plants compared to fertile ones.

In species such as *Physomitrium japonicum*, unfavorable conditions trigger the production of underground gemmae, which are then used for perennation. These can be identified by their red hue and their formation on the rhizoids. In unfavorable conditions, the parent plant dies, but the gemmae live on in the dormant stage and are able to outlive the many seasons. These latent gemmae are capable of producing new gametophytes in the event that the conditions are favorable. On the other hand, there have been no discoveries of subterranean gemmae in any other species of moss.

In addition to Hyophila rosea and *Semibarbula orientalis*, we now know that gemmae can be produced by these two species. Whereas these multicellular vegetative structures only emerge in the axil of leaves in *Hyophila rosea*, in *Semibarbula orientalis* gemmae form on the apex of shoots as well as in the axil of leaves in the central region of the stem. In Hyophila rosea, these multicellular vegetative bodies only appear in the axil of leaves. In severe conditions, plants die from complete dehydration, and their dried-out gemmae become dispersed across the substrate. These gemmae are capable of reviving themselves and producing new moss

plants if the conditions are just right.

CONCLUSION

Extensive research has shed light on the unique and varied phytogeography that can be found in the central part of the state of Rajasthan in India. This information has been provided by the research. It is difficult for plant life to flourish in this area since it is characterized by arid and semi-arid climatic conditions. since of this, the habitat is tough to access. Researchers have found a diverse range of plant species that have adapted to the difficult environmental factors, so exhibiting an incredible capacity for adaptability and perseverance. The xerophytic type of plant life makes up the vast bulk of the vegetation found in the central region of Rajasthan. This category of vegetation is comprised of plants like the Prosopis cineraria, Acacia senegal, and Commiphora wightii trees, all of which play an important role in the preservation of the fragile ecological balance. In addition, recent studies have shed light on the significance of these plants to the environment as a means of preventing the process of soil erosion and maintaining accessible water supplies. This has been brought to light as a result of the research that has been conducted. The investigation of phytogeography that has been carried out in this region not only contributes to our comprehension of the methods by which plants adapt to dry environments, but it also has consequences for the sustainable management of resources and the conservation activities that are currently being carried out. It brings to light the critical importance of taking particular conservation measures in order to preserve the rich biodiversity and delicate ecological balance of this one-of-a-kind phytogeographic zone in Rajasthan.

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