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Research Article

Studies on Bryophytes of Thar Desert with Particular Reference to Ganganagar District (Rajasthan), India

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ABSTRACT

Bryophytes are most abundant and conspicuous in moist habitats, but are also found in grasslands and deserts where they endure prolonged dry periods. Number of Bryophyte species like *Funaria hygrometrica, Marcantia palmata,Riccia robusta* are collected from Thar desert of Rajasthan particular from Ganganager district during 2008-2010 for the studies on morphlogical and anatomical adaptation. These studies reveal the anatomical adaptations of bryophytes to xeric conditions (like presence of tufts of tough rhizoids and longer rhizoids etc.). The study was carried out through section cutting using rotary microtome. Different photographs of these sections were taken from microscope with the help of digital camera.

KEY WORDS- Bryophyte ,Thar desert , Ganganager.

INTRODUCTION

Bryophytes rank second (after the flowering plants) among major groups of green land plants, with 24,000 species found world wide. Bryophytes occupy a unique position in the evolutionary trends of cryptogams. Bryophytes are small terrestrial plants that grow closely packed together in mats or cushions on a variety of substrates (Kashyap 1929). Bryophytes have successfully exploited many habitats because they are rarely in direct competition with higher plants (Anderson 1980). For such small organisms, the climate near the ground (microclimate) is often very different from conditions recorded by standard meteorological methods and shifts in temperature and humidity are often extreme (Vitt and Darigo1997).

A remarkable adaptation of bryophytes is their ability to remain alive for long period without water, even under high temperature, and then resume photosynthesis within seconds after rain or onset of favorable conditions (Smith and Merrill 2004).

Mosses are the best known bryophyte groups and have the most species that is 1320 species spread over 312 genera (Anderson *et al.,* 1990). Mosses are the highly developed group of bryophytes occupying unique position between lower bryophytes and vascular cryptogams. Systematic account of some members of this group is available in the moss floras of eastern India (B.LChoudhary and G.S. Deora 1993). North-west Himalayas. Nilgiri hills (Siegal S.M 12969) but such a study for the mosses flora of north western desert of India has remained neglected.Bryophytes seem all the more elaborate because of their small size. One contribution to their small size is the lack of lignin (Winterringer et.al., 1956), limiting their size to that which their unlignified tissues on support, (Zander 1993) suggests that maintaining hydration necessarily imposes a small size on bryophytes.

Even with their vascular limitations, bryophytes in particular can occupy large surface area on rocks, soil, logs and tree trunks, and they can spread negatively to occupy a large area, the minute beginnings of a single branch, a single spore or a single fragment (Majestyk 2001).

Both green algae (Chlorophyta) and the members of the plant kingdom share with the bryophytes and presence of chlorophyll a and b, xanthophyll and carotenes, true starch in plastids, sperms with whiplash flagella and cellulose cell walls. But bryophytes possess flavanoids (a group of pigments that absorb UV light) (Chaudhary 2000).

The unique thing about the mosses and liverworts among members of the plant kingdom is that all the vegetative structures, the leaves (or thallus); stem and rhizoids (filamentous structures that anchor the plant) belong to n (gametophyte) generation having just one set of chromosome to dictate their appearance and function (Gupta 1997).

In fact, in the bryophytes the sporophyte is unbranched and dependent on the gametophyte. The gametophyte lacks secondary growth and meristamatic tissue, growing new tissue instead from a single apical cell (Crum;1991) but they have hydroids with similar function as the tracheids of higher plants, and moss

leptoids are similar enough to sieve cells that some biologists consider them to be suit. Because in abroad also few biologists study these plants, therefore very small amount of data have been collected that could be useful for bryophyte conservation. As of 2008, no bryophytes have been listed as either endangered or threatened. The Ganganager district selected for present investigation because this is the best example of man engineered ecosystem in Thar desert . The agriculture practice in the area is done by well developed canal irrigation system. The two canals viz. the Gang Canal and Indira Gandhi Canal serves this purpose. It is a testimony to land transformation in past. Desert land was converted to a lush green town credited to the efforts of the Maharaja Ganga Singh who bought the Rajasthan canal which carries the excess waters of Punjab and Himachal Pradesh to the region, making Ganganagar known as "The Food Basket of Rajasthan"

The main objectives of the present study were:

1. To asses the diversity of Bryophyte in Thar desert particularly in Ganganager district.
2. To make survey and collection of bryophytes in the field during the favorable environmental (climatic) conditions.
3. To study morphological and anatomical adaptations studies of bryophytes in this area.

MATERIALS AND METHODS

Survey and Collection-

The survey and collections of bryophytes in the field was done by us twice in a year during August-September and February-March during 2008-10 . The material was collected thrice in a year from the different location of Ganganagar district particularly Ganganagar, Sadulshahar and Padampur thesil. Visit was made during the rainy season. In rainy season the gametophyte plant body grow flourishely due to favorable condition. Generally plant collected near the canal where the habitat like moist places exist such as damp soil, moist rocks, shady bank and tree bank etc.

Identification of species

The species collected were carefully determined. Their identification was confirmed by matching the herbarium specimen at Maharshi Dayanand P.G. College, Sri Ganganagar. Only the species fully identified and confirmed are included here.

Preservation of Materials

The collected material were washed carefully in fresh water and then preserved in 10% formalin solution for further investigations for the preparation of permanent slides to observe the anatomical features of bryophytes.

Method for anatomical studies

Collected plant materials were washed 5-6 time from water and then were preserved in formalin solution up to 10 days. After 10 days microtomy was performed. To observe the tissue under a microscope, the sections were stained (colored) with one or more stains. That was done to give contrast to the tissue being examined, as without staining, it is very difficult to see differences in cell morphology. Safranin and fast green were the stains that were used to study histology.

RESULT

The distribution and environmental parameters related to the bryophytes of the Ganganagar district were studied over a period 2008 to 2010.For anatomical studies permanent slide prepared by microtome and compared with existing slides in laboratory for identification . Three species of bryophytes i.e. *Funaria hygrometrica, Marcantia palmata*, *Riccia robusta* were found in the present study area. Their description as fellow:

Riccia robusta

The gametophyte is the dominant phase of bryophytes;

Therefore, the main plant body (the thallus) of *Riccia robusta* represents a well developed gametophytic phase.

Figure 1: ***Riccia robusta***

External FeaturesThe plant body is prostrate, flat, and somewhat fleshy and a green dichotomously branched thallus. The branching determines several shapes of thallus e.g. Riccia robusta.Each branch of a thallus has a midrib represented by dorsal median groove and the ventral median ridge. Sometimes it is quite prominent where it forms a broad deep channel terminating into the apical notch.The ventral surface bears numerous rhizoids and scales.

The rhizoids are unicellular, elongated, tubular and hair-like structures which attach the thallus to the substratum and absorb water and nutrient solution.

They are analogous to the roots of higher plants.*Riccia* has two types of rhizoids, the simple rhizoids with smooth inner walls and the tuberculate rhizoids with prominent peg-like progestion in the inner layer of the wall projecting inwards into the lumen. The projections are also known as tubercles.The scales are arranged in a transverse row. These are conspicuous multicellular, membranous, pink, red, violet or black and one celled thick structures. Scales contain anthocyanin pigment which in a very moist habitat may develop a faint green color due to chlorophyll. They form continuous transverse strips toward the apex and project forward to protect growing points. In the older portion, on account of the widening of the thallus, the basal part of each scale is torn apart form the mid region into two separate portions, one near each lateral edge of thallus appearing as if arranged into rows. The prominence and persistence of these scales depend upon the climatic condition of plant. In moist places, they are small and soon perish but in dry habitats they are large and persistent.

Internal Features

A vertical cross section of thallus of terrestrial species of Riccia robusta shows a more elaborate internal differentiation of tissue arranged in two distinct regions (fig. 2)

(i) An upper assimilator

(ii) A lower storage region

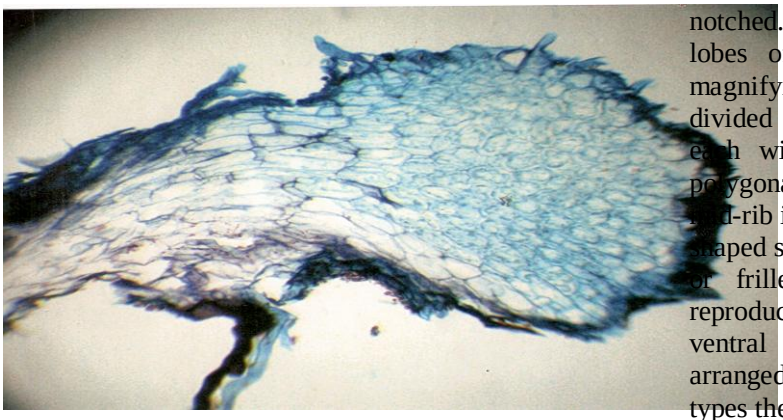

Figure 2: V.S of *Riccia robusta* thallus

(i)Assimilatory region :

The assimilatory or photosynthetic region of the thallus consists of unbranched green photosynthetic filaments. These filaments are arranged in vertical rows each consisting of a single row of cells. Upper epidermis is discontinuous having larger usually non-green cells. All other cells of the filaments are alike and contain numerous discoid chloroplasts capable of manufacturing food.

Vertical rows of assimilatory filaments enclose vertical spaces which may be called air chambers, air canals or air channels. The air chambers may be narrow or wide due to compactly or loosely organized assimilatory filaments.The air chambers of Riccia robusta lack assimilatory filaments. The partition walls take the function of assimilation and sometimes these are referred as assimilatory filaments. The air chambers communicate outside through the simple and unspecialized air pores which occur in upper epidermis.
(ii)Storage Zone:

The assimilatory region merges gradually into a compact colorless, undifferentiated parenchymatous storage region. The cells of this region are comparatively larger, thin walled and devoid of chloroplast and inter-cellular spaces. Prominent reserve food granules occupy the major part of the cells. The lowermost layer of the thallus bounding storage region is the lower epidermis. It consists of apparently small cells, some of which give off unicellular (rhizoids) and multicellular outgrowths (scales) for the purpose of anchorage, retention and absorption of water.

Marchantia palmata

The plant body consists of a dorsiventrally flattened, prostrate and richly dichotomously branched thallus. The thalli are conspicuous. These when mature often reach a length of 7 cm. The apex for each thallus is notched. The growing point lies in between the two lobes of the notch. If viewed with the help of magnifying lens the dorsal surface of thallus appears divided into large number of distinct polygonal areas each with a distinct pore as a black dot. These polygonal areas are air chambers or areolii.. Along the mid-rib is present characteristic, prominent goblet or cup shaped structures, the gemma cups, with smooth, dentate or frilled margins. These cups enclose asexual reproductive bodies called gemmae.The brownish ventral surface of the thallus has almost regularly arranged scale and rhizoids. The rhizoids are of two types the simple and the tuberculate.

The tuberculate rhizoids are narrow and sometimes for a dense tuft in mid-ventral region and retain sufficient moisture whereas simple rhizoids are found beneath the scales and serve the purpose of anchorage.The membranous one cell layer thick scales are prominent and characteristic. They show almost a regular arrangement. They are arranged in two rows on each

side on mid-ridge region. The two rows are median and marginal where the third row, present in between the two, is known as laminar. The median scales are large, wedge-shaped, appendages and provided with prominent body arising from constriction. They run along the mid-rib form apex towards base, i.e. decurrent type. The marginal (outer) and laminar (middle) scales are small simple and unappendaged. The papillate mucilage cells along the margin and scattered oil cells are present in each scale.

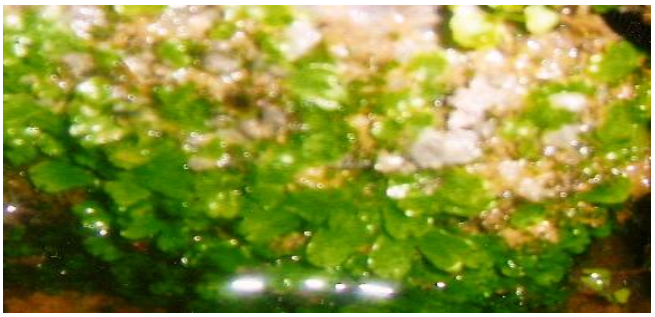

Figure 3: *Marcantia palmata*

Internal Features

A vertical section reveals that the thallus has two distinct zones, the upper assimilatory region and the lower storage region. The assimilatory region consists of large number of air chambers surrounded by one cell thick and 4-8 cells high partitions or septa. Air chambers are covered over by single layered thin-walled upper epidermis. The height of septa is less on lateral margins.

The upper epidermis is interrupted by barrel-shaped pores. The pores are simple but consist of 4 to 8 rings, each consisting of 4-5 cells, of superimposed cells and form a unistratose wall. Thus, a single pore of Marchantia is surrounded in all by 16-40 cells, arranged in one cell thick 4-8 rings. Half of the rings project above the level of epidermis and the other half below in the cavity of air chamber. The pores are broad in the middle but narrow at both the ends. Some times the lower end in more or less closed. In few cases the cells of ring towards inner surface develop papilla and give circulate appearance or quadrate appearance as in M. palmata.

From the base of the air chamber arise several frequently branched filaments. These are commonly called assimilatory filaments and contain large number discoid chloroplasts. The chloroplasts are also present in many cases in the epidermis and partitions. Since this upper portion of the thallus manufacture the food, the region is called assimilatory region.

Below the assimilatory region is present a well-developed and considerably differentiated storage region. It is consists of compactly arranged thin walled cells interspersed with few mucilage cells, irregularly intermingled oil cells ad a few scattered scleroid cells. Some of the cells of the upper layers may also contain chloroplasts but the remaining parenchymatous cells are packed with large number of starch grains. Reticulate type of thickenings is present in the cells mid region. The lower most layer of storage region makes up the lower epidermis of which many cells get elongated to form simple or tuberculate rhizoids and rows of scales that appear as more or less beaded structures.

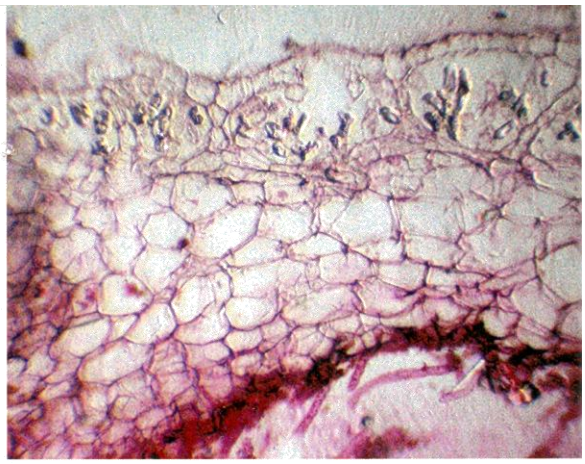

Figure 4: T.S of *Marcantia palmata*

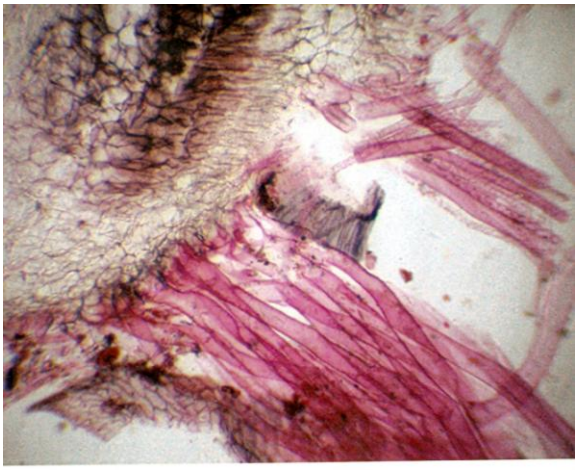

Figure 5: Two types of rhizoids in *M. palmata*

Funeria hygrometrica

The adult gemetophytic plats are short about 1-3 cm, high, and green and branched. The plant body consists of a small erect axis (stem) surrounded by spirally arranged leaves and numerous rhizoids at its base.

Rhizoids The rhizoids are branched, slender and multi cellular structures. They rise from the base of the main axis of the plant. Each of them emerges out from the basal cell of the axis and looks like a branched row of cells with oblique partitioned walls. The rhizoids grow vertically downwards deep in substratum (2-3 cm) and form a tangled mass. These fix the plant as well as absorb the water and minerals. The conduction of water is perhaps made easier and rapid by the oblique septa found in between the cells. When young, they are colorless but in later stage become brown or red.

Axis (stem) The main axis is slender, upright and branched. The branching usually monopodial and extra axillary and branches arise from the lower portion of plant. They become erect and vertical similar to main axis.

Leaves The arrangement of the leaves on the axis is spiral with the young leaves at the apex in three vertical rows and the older ones away from the apex with a phyllotaxy 3/8. The leaves are flat, simple, bright green, membranous, more or less ovate and sessile. Each leaf bears a well defined and distinct mid-rib. The lower leaves, which are not so frequent and regular in shape, are smaller and scattered while the upper leaves are large and crowded at the apex of the axis.

The stem leaves and rhizoids differ in nature with those of higher vascular plants. No doubt they perform similar functions and are analogous, yet they possess haploid (n) number of chromosomes in their cells unlike higher vascular plants where a cell has diploid (2n) number of chromosomes.

Internal Features

Axis (stem)

The axis has a simple organization, through a well marked differentiation of the tissue into the epidermis, cortex and central cylinder occur.

Figure 6: *Funaria hygrometrica*

Epidermis

It is a single cell thick outermost layer and consists of thick walled cells. The cells usually contain chloroplasts stomata are absent.

Cortex

It is multilayered zone situated just beneath the epidermis and consists of parenchymatous cell. The chloroplast which occurs in the cells of the younger part of the axis may be lacking when the stem becomes mature. The cells of the outer cortex of mature axis are thick and those of inner are walled.

Central cylinder

It forms the central core of the axis and consists of vertically elongated, thin walled, compactly arranged narrow cells which are often colorless and lack protoplasm. The central cylinder provides mechanical strength to the erect axis and helps in conduction of water and solutes.

Leaf

The leaf is single layered thick except for the mid-rib which is several layered thick. The mid-rib on its outer and inner side is bounded by the outer and inner epidermis, the cells of which are rich in chloroplasts. The central part of the mid-rib is similar to that of the central cylinder of the axis and consists of narrow and thin walled cells. Outside this occurs a sheath of thick walled narrower cells. The parenchymatous cells forming the lateral wings are undifferentiated, but large rectangular or hexagonal cells.

DISCUSSION

The study embodies the results of morphological, anatomical studies done on the bryophytes from Thar Desert of Rajasthan with special reference to Ganganagar District. The present study has been taken up to evaluate the adaptation of bryophytes in the arid condition. The soil in the plains of Thar desert of Rajasthan is mainly a sandy loam placed above the slightly compact soil of light grey colour. The fine sand forms a large tract of Ganganagar District.

The region has a hot dry summer and cold bracing winter. The winter extends from December to February while the summer season extends from March to the end of June. The rainy season is comparatively short in this region and lasts only till mid-September. The maximum temperature at Sri Ganganagar reaches 49°C (June) and the minimum -0.3°C is recorded in January 08. The mean maximum temperature was recorded to be 44.1°C in May 08 and minimum 4.3°C in December 09. The actual rainfall recorded was 124.5 mm from the field by

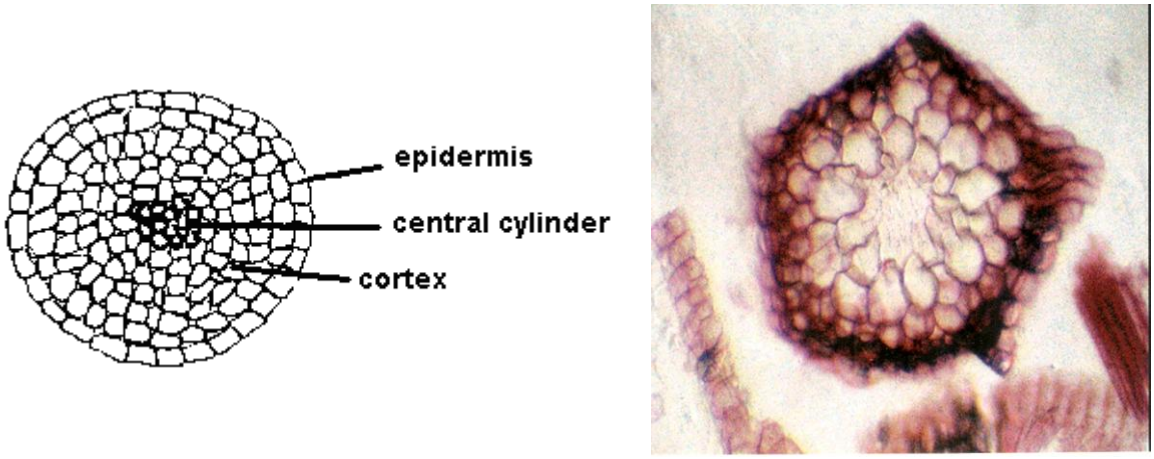

Figure 7: .Sketch and Slide showing T.S. of axis of *Funeria hygrometrica*

the first week of June.By the mid April selected plants starts disappearing.Therefore plant collected during the month of August – September and February – March in which both gametophytic and sporophytic plant body develop respectively.

Topographically this region is characterized by sand dunes of varying heights, interdentally areas, valleys, rivers and canals on hand and sandy plains and stabilized dunes of varying nature on the other. This varied topography associated with peculiar photography has resulted in a highly diverse nature of vegetation of this region. Leaving apart a large number of ephemerals which disappear before the onset of drought period, quite a large number of perennial xerophytic taxa occur in this region. It has been find out that in Northern Rajasthan, forests cover a very small area, while remaining area is shared cultivable, uncultivable and denuded landscapes.

The present study is a report based on survey of bryophytes of Thar desert mainly in the district of Ganganagar over a period of three years (i.e. 2008-2010). Regular and periodical visits to different habitat were made during these years of intensive survey. Numbers of species of bryophytes like *Funeria hygrometrica, Marchantia palmata, Riccia robusta* were found to complete their life cycle here. Both gametophytic and sporophytic phases of life cycle of these species were collected successfully from the bank of canals, rivers etc. during the months of February-March, August-September-October etc. for Morphological and anatomical Studies. It is observed that due to embankment of canals and distributaries, mosses were unable to grow and anchor themselves to the substratum. Hence in these canals and distributaries, no or little growth of bryophytes was observed. Few bryophytes that grow in this region is a result of growth and germination of spores, Gemmae coming with water from Himalyan region and it was possible due to onset of IGNP and Gang canal. The Bryophytes especially mosses travelled a long journey through these canals and river system and got introduced into a new environment of Thar desert of District Ganganagar. The canal banks and its adjoining moist areas along with reservoirs and river basin in monsoonal season serve as a major site for the flourished growth of bryophytes.

The vegetative structure of bryophytes is completely adapted to land habit. However, they still rely upon water for sexual reproduction because the swimming habit is retained by their sperms. The plant body is thalloid; it lacks the true roots, stems or leaves. It is relatively simple in the lower forms and still reminds of the thallus of an alga. It grows prostrate on the ground (*Riccia robusta*) or on the banks of river or canals and is attached to the substratum by delicate, unbranched, unicellular hair like organs called rhizoids. In the higher bryophytes (mosses) the plant body is erect (Funeria hygrometrica). It consists of central axis which bears leaf like extensions. It is attached to substratum by branched, multicellular rhizoids. Like the thallophytes, most conspicuous phase in the life cycle is gametophyte. It is independent and concerned with sexual reproduction.

Anatomically bryophytes lack vascular tissue (xylem and phloem) but they have hydroids with similar functions as the tracheids of higher plants and moss leptoids are similar enough to sieve cells (some

biologists consider them to be such). The gametophyte lacks secondary growth and meristamatic tissue, growing new tissue instead from a single apical cell (Crum 1991). One of the reasons of small size of bryophytes is lack of lignin (Winterringer *et.al.,* 1956) which limits their size to that extent which their unlignified tissue can support. Zander, (1993) suggested that maintaining hydration necessarily imposes a small size on bryophytes. The sporophyte is simpler than the gametophyte and is organically attached to the parent gametophyte throughout its life. It is dependent upon it partially or wholly for its nutrition. Among the very few mosses observed in this region one thing observed common in all is the presence of tufts of well developed, tough rhizoids that could be considered as one of the adaptations for xeric conditions present in this region as a part of Thar desert . These tufts of rhizoids unable to survive these mosses on bank lines and withdrawing abundance of water required for the growth of these cryptogams. Few plants that were found associated and growing with bryophytes included pteridophytes like *Marselia minuta*, *Marselia rajasthnesis* and ferns while the angiospermic plants included few types of grasses, members of liliaceae, Ficus religiosa etc. Few algae like Spirogyra species were also found associated with the bryophytes The Presence of bryophyte in this desert region is very important for soil fertility and to maintain ecosystem stability .

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