SUSPECTED PARASITISM IN A MOSS.

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The Mosses, though of very common occurrence and of wide distribution, have received little attention from the botanist as regards their physiology of nutrition. In the eighties, there were two opinions about the function of rhizoids in mosses. In 1886, Vaizy [1] showed experimentally that there was no transpiration current in the stem of a moss because no eosin rose into the stem when the cut end was dipped in a solution. Vaizy held that all water absorption was done by the leaves. Later, Haberlandt [2] wrote that, a study of rhizoids in mosses and a consideration of their abundance and extensive branching in the soil, had led him to believe that their function was not merely fixation but was also absorptive, A different aspect of the function of rhizoids is met with in saprophytic mosses, though only very few thorough saprophytes with colourless aerial portions are known. The others have a green aerial portion but their rhizoids penetrate into dead organic substratum. The rhizoids in these are described as being minutely sub-divided and as having the appearance of fungal hyphae with H shaped connections or netted masses.

Observations made by the author on a species of moss, common in Madras, may be of interest, as they show that the rhizoids are, in the early stages, parasitic on colonies of algae, a habit not hitherto suspected in mosses.

The moss grows on walls coated with lime and exposed to the rains during the monsoon weather. Before the rains, the wall has a debris of old dried up mosses on it. After the rains in two or three days, the dried up stumps put forth a few leaves by the growth of the dormant buds at their tips and small green plants dot the surface of the wall. New rhizoids develop immediately below the cluster of leaves and fresh buds are formed in between the plants from the old rhizoids which contain food material stored in them. At the same time, this portion of the wall and also fresh areas surrounding it get coated with a dirty green colour due to the growth

[1] Vaizy, J. Reynolds: *Ann. of Bot. Vol. 1*; *p. 148.*

[2] Haberlandt; *Physiolcgical Plant Anatomy*: *Enq. Ed. 1914, pp. 226—230, 725.*

of blue-green algae. The algae commonly found in these situations, are colonies of Nostoc embedded in soft mucilage, colonies of another blue-green with tough mucilage and filaments of Scytonema. Under the microscope, these appear as masses of algal cells or filaments. The rhizoids of the young plants enter into the algal masses and come into intimate contact with them. In a few more days, the young plants produce a great number of gemmae from the axils of the leaves near the tip of the stem. These get detached and are distributed beyond the area of the wall originally covered by mosses, and get mixed up with the algae growing in these regions. In the outskirts of the older patches, the rhizoids of the young plants grow into the new substratum and give rise to protonema filaments which are covered by masses of blue green algae. Gradually new moss plants appear in these regions and the spreading of the moss on the wall continues. It is a matter of constant observation that no new plants develop in regions of the wall where the algae have not already appeared.

Protonemal Stage.—A microscopic examination of the outskirts of the moss patches, where to all outward appearance no moss plants but only algae are found, show masses of protenema filaments or germinating gemmae. The protenema filaments arise from rhizoids of young plants further up or from hibernating rhizoids of the previous season which had extended so far. The protonemal filaments branch frequently and are mixed up with algal masses and soil particles.

In the preparation of slides, the lime substratum was dissolved with dilute HCl and the sand particles left behind were removed by careful teasing with fine pointed needles. The material for mounting, both in the case of protonema and also in the case of rhizoids of the moss plants in different stages, was prepared in this way, stained and mounted in glycerine.

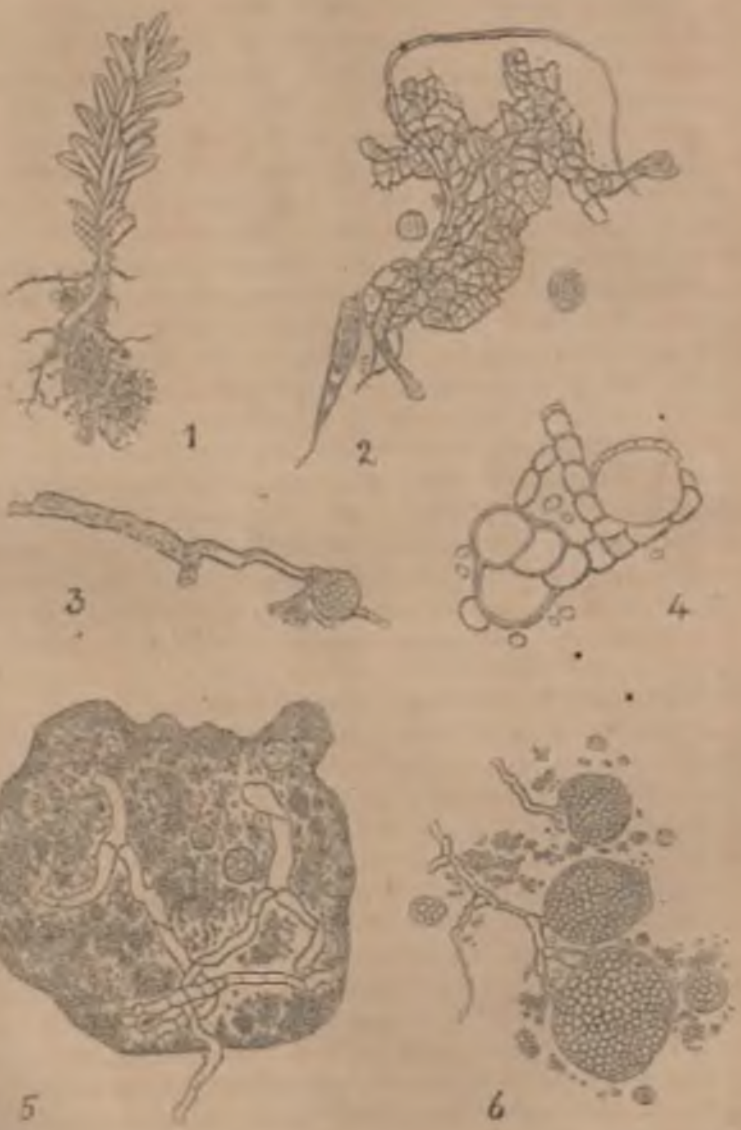
The greater part of the protonema branches were bright green in colour with prominent chloroplasts. But the tips of the filaments in many cases and some of the branches gradually became colourless and finely branched. (Fig. 2.) This colourless portion was always in intimate contact with the algal masses. During teasing, it was often noticed that the green portion was easily detached from the algal masses but they always had their ends broken. Light crushing of the algal mass and differential staining showed that the colourless tips of the protonemal filaments extended into the gelatinous masses of algae and there spread in between the algal cells. In some, where the algae form soft gelatinous masses, the branches had short beaded cells which occupied the centre of the mass. In others, where the algae had tough

mucilage and formed smaller colonies or where they were filamentous, the protonema branches became long and filamentous with long or short cells, and surrounded or intertwined with the algae. During examination of the slides, one is often reminded of the condition in Lichens, with the fungus filaments coiling round big algal cells. This condition is much more striking in the case of the rhizoidal branches of the young moss plants. In the protonemal masses, the similarity is brought out especially, where the cells in contact with the algae are beaded and short as in some lichens. In the mass of algae in the vicinity of the branches, it is common to meet with both decaying and healthy algal cells and those which have partly or fully lost their cell-contents.

Germinating Gemmae.—The Gemmae, when detached from the plant, are club-shaped and 3 or 4 cells long. The first sign of germination is the putting forth of a rhizoidal cell from the basal end. This is followed or in some cases preceded by an oblique division of the apical cell. The rhizoidal cell grows quickly into a filament and extends into the algal masses, in the same manner as that described for the protonema branches though not to the same extent in the early stages. (Fig. 2.)

The Young Moss Plant.—In the young moss plants, when the mud attached to the rhizoids is carefully washed out, it is found that the main rhizoids have dark clots hanging from their ends. These clots, when repeatedly crushed lightly under the cover slip and washed or when treated with dilute HCl, show masses of algae attached to the tips of the main rhizoidal branches. (Fig. 1.) The algae are again of all the three kinds mentioned above, namely, big soft jellies, tough small colonies, and long filaments. These three are the predominant forms, though other forms occur more rarely. The rhizoids on entering the algal masses behave very much in the same way as the tips of protonema branches. In many cases, a much more extensive and minute branching takes place and the resemblance to fungal hyphae coiling round algal cells in Lichens, is very striking. H like connections and net-work formations are more common. In favourable preparations, the encircling of the algal colonies by rhizoidal branches is clearly seen.

Fig. 6 shows a few Nostoc colonies attached to the rhizoidal branches. Fig. 5 shows one of the colonies lightly crushed under the cover glass. The penetration of the branches into the alagal colony is seen. Further examination shows an extremely minute sub-division of the rhizoidal branches and their extension in between the cells of the colonies. In case of colonies with small algal cells, it was not possible to follow the finer ramifications and see exactly in what



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way the algal cells were attacked by the rhizoidal branches. But usually, either mixed up with the small cells of the colonies or independently, bigger cells of a different species of alga are met with. A few such are shown in Figs. 3 and 4 with the rhizoidal branches, which here consist of short cells, surrounding the algal cells and closely adpressed to them.

But even in these cases no special structures of absorption such as haustoria have been noticed. That haustoria are not a necessary condition for parasitic or symbiotic relationship is shown in the cases of many fungi and also lichens.

The effect of the intimate contact with the algal colonies is seen very clearly. At the beginning, the algal cells are full of protoplasm with bright blue-green colour and have a healthy vigorous appearance. But gradually the colour fades and the contents disappear. Some of the cells of a colony remain vigorous and healthy whereas others are completely or partly decayed. Scytonema filaments, with the portions in contact with the rhizoidal branches in a decaying condition, are quite common. At still later stages, the individual cells of the colonies are not recognisable and only a debris of cell-walls is left. In the case of Scytonema, the thick sheaths devoid of their contents are often met with surrounding the rhizoidal branches.

In plants, which had not been growing for more than a fortnight, large quantities of food material are often found stored up in the rhizoids whose minor branches penetrate into the algal masses. And it is not uncommon to find some of the branches inside the algal masses swollen and full of food material. It is evident that the plants themselves could not have manufactured all this food material by the activity of its green parts, within such a short time and it gives room to a very strong presumption for an external source of the food material. The extraordinary minute branching of the rhizoids, and the intimate contact of the branches with the algal colonies which resembles the behaviour of the fungal hyphae occurring between the algal cells in the Lichens, further strengthens the presumption, that the relation between the moss rhizoids and the algæ, is very likely to be one of parasitism of the rhizoids on the algal colonies. My friend Mr. M. O. Parthasarathy Iyengar corraborates my observation and says that in his wanderings in search of algae he had repeatedly noticed that the young moss plants invariably appear only on substrata which are first covered over with blue green algae. He is inclined to believe that the same thing holds good for the common Liverworts which appear immediately after the monsoon in Madras.

As the mosses grow taller, the algae on the substratum disappear

and in the older mosses no algae are found in contact with rhizoids. But it is at the same time interesting to note that the rhizoidal system is also very much reduced in extent by the death of the finer branches. In these, there is a lot of food material found stored in the bigger rhizoidal branches and most of the finer branches are shrivelled up and non-functional. Here and there, a few algal masses are met with on the plants at the axils of the leaves where some dirt has accumilated and into those also rhizoids from the cortical cells of the stem penetrate. But on the whole, in the older plants the amount of algae in their vicinity is very little when compared with the younger plants.

The absence of the algae in the later stages of the life of the moss plant may be accounted for by the fact that the conditions near the substratum are no longer favourable to the growth of algae. The moss plants grow very close to each other and to nearly the height of an inch, so that there is very little light available near the substratum. Higher up on the plants themselves the moisture conditions are not favourable except in special situations. But where they occur, rhizoids penetrate them.

The above observations lead the author to believe that the common moss in Madras is parasitic on the blue green algae of the substratum, when the moss plant is young and also in the protonema stage.

Explanation of Figures on page 209

Fig. 1. Moss plant with algal masses attached to the rhizoids.

Fig. 2. Mass of protonema filaments, some with and some without chloroplasts; ends of filaments broken. One germinating gemma also shown.

Fig. 3. Rhizoidal branch encircling an algal colony.

Fig. 4. Rhizoidal branch with short cells encircling algal cells.

Fig. 5. Nostoc colony crushed showing main rhizoidal branches inside.

Fig. 6. Rhizoidal branches entering Nostoc colonies.