Precursory Studies on the Epiterranean Soil Algae of Singapore and Malaya

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Introduction

Algae are present in Malayan soils to a depth of several centimeters or sometimes to one meter. Deeply buried subterranean forms probably have their origin from the soil surface having been washed down by the rain, aided by the movement of soil animals and by cultivation. These algae are undoubtedly in complete darkness and must survive as saprophytes (Tiffany, 1951). In general they are of little importance in soil economy. On the other hand, the truly epiterranean forms which remain at or near the soil surface are exceedingly important since they can increase the organic content of the surface layers of the soil by photosynthesis, while certain Nostocaceae can contribute to the fertility of the soil by nitrogen fixation (De, 1939). Soil algae are exceedingly important ecologically particularly in tropical regions as first colonisers of bare ground. Many algae assist in the actual disintegration of a rock surface to form soil, in addition to forming an organic matrix suitable for higher plant growth. (Fritsch, 1907; Treub, 1888).

Investigation of surface algae in Europe include those of Petersen (1935); Bristol (1920); James (1935) and John (1942). In America Coyle (1935); Booth (1941); Lowe & Moyse (1934); Moore & Carter (1926) and many others have made studies of the soil flora of different districts. Valuable contributions to our knowledge of the soil algae of Ceylon were made by Fritsch (1907, 1907 a, 1907 b). Ghose gives an account of the Cyanophyceae of Lahore and Simla (1923). As far as I am aware the only paper on Malayan soil algae is that of Bristol (1919).

II. The Soil Samples and their mode of collection and culture

The technique of collection and culture was very similar to that used by John (1942), but various details were modified to suit local conditions.

Soil samples were taken from the top, second, third and fourth centimeter below the surface of the soil with the usual precautions to prevent contamination or mixing of the layers. Each sample was examined microscopically and any algae were recorded. For each soil sample two series of cultures were set up. *Moist cultures* consisted of soil placed to a depth of 1 cm. in sterile petri dishes, moistened with sterile distilled water, and exposed to continuous light. *Liquid cultures* consisted of small quantities of soil introduced into a nutritive solution in conical flasks under sterile conditions. The nutritive solution used was Knop's solution (Pringheim, 1951, p. 349) at either full- or half-strength. Liquid cultures were also exposed to continuous light supplied by flourescent strips of the warm daylight type.

Sub-cultures were made (i) by re-inoculating fresh Knop's solution in flasks, (ii) by plating on to Knop's agar or peptone agar, (iii) by inoculation with a sterile needle on to agar slopes in tubes.

III. General description of soils examined

Soil samples were taken from the following six localities:—

Locality 1. Hard exposed ground, University of Singapore.

This soil consisted of dark brown excrusting surface layer about 2 mm. thick, beneath which was a red clay soil about 3 cm. deep. At 3–4 cm. depth the soil was lighter in colour. The pH of all soil samples was approximately 6.4.

Locality 2. Exposed silt, 300 yards from the sea, Dungun, Trengganu.

This soil is a medium brown silt with a fair amount of organic content. The first 4 cm. are more or less homogeneous, apart from a very narrow surface layer. The pH of all soil samples was approximately 6.1.

Locality 3. Exposed cleared building site, Cluny Road, Singapore.

The first three centimeters were of a medium brown colour and consisted of about 34 per cent silt and 62 per cent clay. Beneath this was a heavier red soil with a slight increase in the silt content. The pH of all soil samples was approximately 6.3.

Locality 4. Botanic Gardens Jungle, in forest with heavy leaf litter.

The first centimeter consisted of a dark brown layer with abundant humus, tree roots and dead leaves. The second centimeter consisted of a lighter zone but still with many tree roots. Beneath this was a pale beige crumbly clay soil with fewer roots. The pH of all soil samples was approximately 6.3.

Locality 5. Sunlit Path, MacRitchie Reservoir.

The soil was a homogeneous sticky clay of a pale gamboge colour. The pH of all soil samples was approximately 5.3.

Locality 6. MacRitchie Reservoir Forest, under heavy leaf litter.

The soil was a dark clay rich in tree roots and organic matter. The pH of all soil samples was approximately 5.7.

IV. Examination of initial samples

In soil taken from the natural habitat, soil algae are often sparse, frequently only spores or more or less dormant cells are available; and they are easily overlooked when present in small numbers in a large mass of soil. (Tiffany, 1951). In soil from five of the above localities no algae were observed in any of the top four centimeters. However locality 1 showed an abundant growth of surface algae in the field consisting of *Scytonema javanicum (Kurtz) Born.*, together with *Gloeotheca sp., Oscillatoria sp.* and a little *Microcoleus vaginatus (Vauch.) Gomont.* The second centimeter showed a few coccoids and minute flagellates while no algae could be found in the lower soil layers.

V. Examination of moist cultures

Moist cultures are the best imitation of natural conditions (John, 1942). The growth of soil algae is encouraged by exposure to light over a twenty-four hour instead of a twelve hour period. After a month or two the growth of soil algae on the surface becomes apparent. Later in some cases fern prothalli or seedlings of higher plants make their appearance. The development of a surface layer of algae is slower in soil from deeper layers.

The following is a list of algae which grew in the moist cultures over a five month period. The number in brackets indicates the mean depth from which the soil sample was taken.

Chlorophyceae

Pleurococcus naegelii Chodat
Sunlit path, MacRitchie Reservoir (2.5 cm.).

Trentepohlia torulosa De Wildemann
Sunlit Path, MacRitchie Reservoir (3.5).

Vaucheria sessilis (Vauch.) D.C.
Botanic Gardens Jungle (0.5).

Xanthophyceae
Tribonema bombycinum (Ag.) Derb. et Sol.
Sunlit Path, MacRitchie Reservoir (0.5).

Cyanophyceae
Chroococcus varius A.Br.
Sunlit Path, MacRitchie Reservoir (3.5).

Chroococcus sp.
University of Singapore (0.5).

Lyngbya sp.
Sunlit Path, MacRitchie Reservoir (0.5) and (3.5).

Lyngbya mesotrichia Skuja
Expose silt, Dungun (2.5).

Symploca elegans Kütz.
Exposed cleared building site, Singapore (1.5).

Microcoleus vaginatus (Vauch.) Gomont
Exposed silt, Dungun (1.5); University of Singapore (0.5).

Aulosira pseudoramosa Bharadw.
University of Singapore (0.5).

Scytonema javanicum (Kütz.) Born.
University of Singapore (0.5), (1.5), (2.5); Exposed cleared building site (3.5).

Tolypothrix fragilis (Gardn.) Geitler
University of Singapore (3.5).

Tolypothrix arenophila West, W. & G.S.

Exposed silt, Dungun (0.5).

In these cultures ten different species of Cyanophyceae, three species of Chlorophyceae and one of Xanthophyceae were observed. There were no diatoms. These results are similar to those of Esmarch (1914) who obtained mostly blue-green algae from moist cultures and no diatoms.

It is to be noted that soil from MacRitchie Reservoir Forest (Locality 6) did not develop any identifiable algae in moist culture, although some minute colourless flagellates were observed. The soil in this locality is in heavy shade and is covered with a dense layer of large leaves throughout the year. It is not surprising that the pigmented algae are relatively sparse. Similarly no algae were obtained from the lower levels of the soil from the Botanic Gardens jungle where similar conditions are found.

VI. Examination of Liquid Cultures

The conditions in liquid cultures differ markedly from those of the natural environment. An additional supply of mineral substances is supplied to the soil, in addition to an abundant supply of water. Determination of the abundance of soil algae on growth in cultures is subject to error in that they favour the more hydrophytic plants (Petersen, 1935) in addition to selecting out those algae which are particularly adapted to the culture environment. Nevertheless, since all operations are carried out under sterile conditions, the medium is autoclaved, etc., all algae which appear in such cultures must have been present in the original soil habitat. Therefore this method indicates at least some of the algae spores, cells and other bodies must occur in the natural environment but does not indicate the relative abundance of these organisms.

The following is a list of the algae which grew in the liquid cultures. In most of the cultures a green or blue-green colour was observable from seven to fourteen days after inoculation, but this colour appeared earliest in those cultures of soil from nearest the surface. The composition of the cultures was recorded at intervals of one month. After two to three months staling phenomena commenced and sub-culturing was necessary.

Chlorophyceae

Palmella miniata Naeg.
Exposed cleared building site, Singapore (1.5), (2.5), (3.5).

Ourococcus bicaudatus Grobety
MacRitchie Reservoir Forest (3.5).

Pleurococcus naegelii Chodat
University of Singapore (0.5), (1.5), (2.5), (3.5); Exposed silt, Dungun (0.5); Exposed cleared building site (0.5); Botanic Gardens Jungle (1.5); Sunlit Path, MacRitchie Reservoir (0.5), (1.5), (2.5), (3.5).

Trochisia aspersa (Reinsch.) Hansg.
MacRitchie Reservoir Forest (0.5), (1.5).

Vaucheria sessilis (Vauch.) D.C.
Botanic Gardens Jungle (0.5).

Cyanophyceae

Chroococcus multicoloratus Wood
Botanic Gardens Jungle (1.5), (2.5), (3.5).

Chroococcus varius A.Br.
Sunlit Path, McRitchie Reservoir (1.5), (2.5), (3.5).

Gloeotheca sp.
Exposed silt, Dungun (1.5).

Synechococcus cedrorum Sauvageau
MacRitchie Reservoir Forest (2.5), (3.5).

Oscillatoria sp. 1. (1.3 wide, slightly capitate and twisted)
University of Singapore (0.5), (1.5), (3.5).

Oscillaoria sp. 2. (very coiled, strongly capitate)
Exposed silt, Dungun (0.5), (1.5), (2.5), (3.5).

Phormidium angustissimum West, W. et G.S.
Botanic Gardens Jungle (0.5).

Lyngbya mucicola Lemm.
Exposed cleared building site, Singapore (0.5), (1.5), (2.5), (3.5).

Microcoleus vaginatus (Vauch.) Gomont
University of Singapore (0.5), (1.5).

Microchaete tenera Thuret
University of Singapore (1.5).

Scytonema javanicum (Kiitz.) Born.
University of Singapore (1.5).

Summary and Conclusion

Samples of soil from five localities on Singapore Island and one in the Federation of Malaya were cultured under sterile conditions. "Moist cultures" were the best imitation of natural conditions but continuous light was supplied. In these cultures three species of the Chlorophyceae, one of the Xanthophyceae and ten of the

Cyanophyceae were observed. There were no diatoms. No algae appeared in the cultures from a forest locality.

"Liquid cultures" differed widely from the conditions of the natural environment since they favoured the growth of hydrophytic organisms particularly adapted to the nutrient medium supplied. In these cultures five members of the Chlorophyceae and eleven members of the Cyanophyceae were recorded.

All the algae recorded must have been present at least as spores in the natural environment but no conclusions of their relative abundance can be made.

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