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Algae Growing in Association with *Salvinia molesta* Mitchell in Veli Lake

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As a part of the ecological studies on the floating weed *Salvinia molesta* Mitchell in Veli lake, the algae growing in association with the weed were investigated during 1977-78. Seasonal abundance of 40 genera of algae belonging to five classes, viz., Chlorophyceae (12), Bacillariophyceae (18), Cyanophyceae (8), Euglenineae and Dinophyceae (1 each) growing along with the weed, was studied. The variety and number of organisms associated with *Salvinia* were maximum in January and the variety was poorest during the monsoon months. The major epiphytic diatoms attached to the submerged roots of this weed were also recorded as regards their seasonal occurrence. A study of the faunal associates of *Salvinia* revealed that many of them are algal feeders. The significance of these algal organisms associated with *Salvinia* community and the importance of nitrogen-fixing blue-green algae in increasing the fertility of the surrounding water associated, are discussed.

Keywords: **Biocoenosis, phytal associate, epiphytic diatom, biotope, floating stage, folded stage**

Introduction

Salvinia molesta Mitchell (Mitchell 1972)—the exotic aquatic fern accidentally introduced into Kerala State has become a very serious menace paralysing water transport, hampering fishing and shell collection, preventing agricultural operations, and choking turbines of generators in hydroelectric projects. It grows in freshwater ponds, lakes, canals, paddy fields and reservoirs and from there is transported to backwaters and lagoons particularly during the monsoon. During the pre- and post-monsoon months when the rivers run low, tidal water sweeps large quantities of the weed up-stream, and over the back waters they occur as stagnant blankets undergoing decay due to salinity and getting deposited at the bottom, creating anoxial conditions.

Ecological studies on the weed were initiated with a view to finding out the nature of the biocoenosis in the water bodies of Trivandrum. A prerequisite for a proper understanding of the *Salvinia* community is the collection and identification of the different components. Ecological studies on the phytal association of animal communities have been gaining attention in recent years (Ida et al. 1967, Sarma & Ganapathi 1972). Considerable research has been carried out on the ecology of *Salvinia* in Africa where the weed has

caused heavy economic losses (Schelpe 1961, Hattingh 1962, Mitchell 1960, 1963, 1965, 1967, 1969, 1970, 1972, Bowmaker 1969, Mitchell & Thomas 1972) in Indonesia (Nguyen van Vuong 1973) and in Kerala (Gopalan & Nair 1975). However, a study of the phytal associates of *Salvinia* has not been hitherto attempted.

Covering a large surface area of the fresh and brackish waters, the *Salvinia* mat provides a unique and altogether new habitat for algae. The present communication presents a preliminary account of the nature and relative density of various algae growing along with *Salvinia molesta* in the Veli backwaters during the period 1977-78.

Materials and Methods

Random samples from the drifting weed were taken twice every month at the Veli lake. A square-mouthed (No. 21) bolting silk net was lowered to a depth just below the weed mat and lifted suddenly. Approximately 1 kg of weed was then transferred to a trough containing filtered water to which was added 1% formalin. After 24 hr the weed was rinsed carefully to remove all the organisms. The contents of the trough were then sieved through bolting silk cloth (No. 21) and the material retained in the cloth was then preserved. The associated organisms were counted from subsamples under a microscope using a plankton-counting chamber. For the study of epiphytic diatoms on *Salvinia* roots, 10g of the sample from the collected sample was weighed and the roots were removed carefully. Each root from the separated sample was examined under a microscope and the diatoms attached to the surface were counted. Five such samples were examined each month and the results reported represent the average of these calculated for a kilogram of sample. Samples of *Salvinia* in the mature "folded stage" and young "floating stage" were analysed for a month to find out the differences in the density of algae associated with them. Data have been pooled to calculate average cell numbers per unit (1 kg of weed).

Water samples from the weed-covered areas in Veli lake were collected for the determination of silicate content and salinity using standard procedures (Strickland & Parsons 1965).

Results

The seasonal changes in density of algae associated with *Salvinia molesta* Mitchell in Veli lake and the number of genera associated with the weed are given in table 1. Forty genera of algae belonging to five classes, viz; Chlorophyceae (12), Bacillariophyceae (18), Cyanophyceae (8), and Euglenineae and Dinophyceae (1 each) were found associated with the weed. Bacillariophyceae and Chlorophyceae occurred in abundance. Among Chlorophyceae, *Oedogonium* and *Spirogyra* and among Cyanophyceae *Oscillatoria* and *Scytonema* were found to be dominating. Among diatoms, *Navicula*, *Fragilaria* and *Amphora* occurred more frequently. The relative density of the 12 major genera is represented in figure 1 A–L. *Navicula* and *Spirogyra* occurred throughout the year. All the 12 species showed well-marked periodicity and a majority exhibited maxima in pre-monsoon season (figure 1 A–L).

Seasonal changes in the density of flora shown in table 1 indicate that the variety and number of organisms associated with the weed were at their maximum (14,52,990/kg) in January when the surface salinity recorded for the month was 1.8‰ in Veli lake (table 2). The variety of algae was poorest during the monsoon months when the fresh weed was being transported to backwaters and the surface salinity varied between 0.2 and 1.0‰ during these months

Table 1 *Seasonal changes in density of algae associated with* Salvinia molesta *Mitchell of Veli lake (in Cell Numbers/1 Kg. of Weed)*

Name of organisms	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.
Chlorophyceae												
Oocystis	—	—	150	—	—	—	—	—	—	—	—	—
Dictyosphaerium	100	—	42000	—	—	—	—	—	—	—	—	100
Scenedesmus	—	1300	—	—	—	—	—	—	—	3200	—	1000
Bulbochaete	—	3900	—	—	—	—	—	—	—	19200	—	4000
Oedogonium	18000	13000	54600	75000	46125	53000	22500	18000	54000	9600	—	35000
Spirogyra	25000	16350	6000	2000	2824	61200	7200	19200	66000	11200	33300	26000
Mougeotia	—	—	—	—	—	—	27000	20900	18000	8000	—	7200
Desmidium	—	7200	—	—	—	18360	—	—	—	20800	—	16200
Ulothrix	16000	—	—	—	—	—	—	—	—	—	—	12000
Gloeocystis	—	1000	—	—	—	—	—	—	—	—	—	—
Cosmarium	—	1300	—	400	—	—	—	—	—	1600	1850	—
Closterium	—	1300	—	—	—	—	—	—	—	—	—	2500
Bacillariophyceae												
Cyclotella	8000	2000	—	80	—	—	—	—	3270	—	—	2000
Cerataulina	15750	10400	12600	15000	—	—	—	—	—	—	11100	77500
Achnanthes	12000	1170	585	—	—	3500	20000	—	—	—	—	—
Plagiogramma	5000	—	—	—	2500	—	—	—	—	—	—	—
Gomphonema	5000	12000	—	—	—	35000	40000	—	—	6400	—	24000
Fragilaria	13500	7000	4237	3000	5000	10200	—	7200	15000	1600	3700	270000
Rhizosolenia	—	—	—	—	—	—	—	—	—	—	—	3000
Tabellaria	—	—	—	—	—	—	—	—	—	—	—	6000
Amphora	50000	4000	3250	8000	3250	11200	6000	—	—	100	3700	12000
Cymbella	3500	3250	—	—	—	1000	—	—	—	—	—	—
Pinnularia	2000	100	—	—	—	—	—	—	7800	5000	4900	5000
Pleurosigma	—	—	—	—	—	—	—	—	—	4000	7400	—
Eunotia	3500	3250	—	—	—	—	—	7000	—	3200	—	4000
Cocconeis	18000	8000	—	1000	3250	—	—	4000	—	—	3700	4500
Navicula	32000	3900	2250	1000	14250	6120	4600	800	2500	8000	14800	4800
Synedra	8000	—	—	—	—	20400	202500	—	21700	9600	3700	2000
Bacillaria	16000	1000	—	—	15000	—	—	—	—	3200	—	860000
Nitzschia	5000	2300	—	—	—	—	4500	400	—	—	2000	10000

Euglena	—	100	4500	—	—	—	—	—	—	—	—	4000
Dinophyceae												
Peridinium	9500	1600	—	—	—	—	—	—	—	440	—	5000
Cyanophyceae												
Oscillatoria	27500	4550	12600	96000	8500	—	—	—	8000	1600	3700	40
Phormidium	5000	10000	—	—	—	—	—	—	—	—	—	—
Spirulina	—	3250	—	—	—	—	—	—	—	—	—	—
Lyngbya	—	5850	—	—	—	—	—	—	—	—	—	25000
Anabaena	40000	6500	1500	4000	1000	—	—	—	—	—	—	30000
Aphanizomenon	—	—	12800	8400	—	—	—	2800	1600	586	—	—
Scytonema	—	30000	84000	90000	8500	7600	11250	6000	24000	—	—	150
Microchaete	—	100	6500	—	1000	—	13500	6750	3270	—	—	—

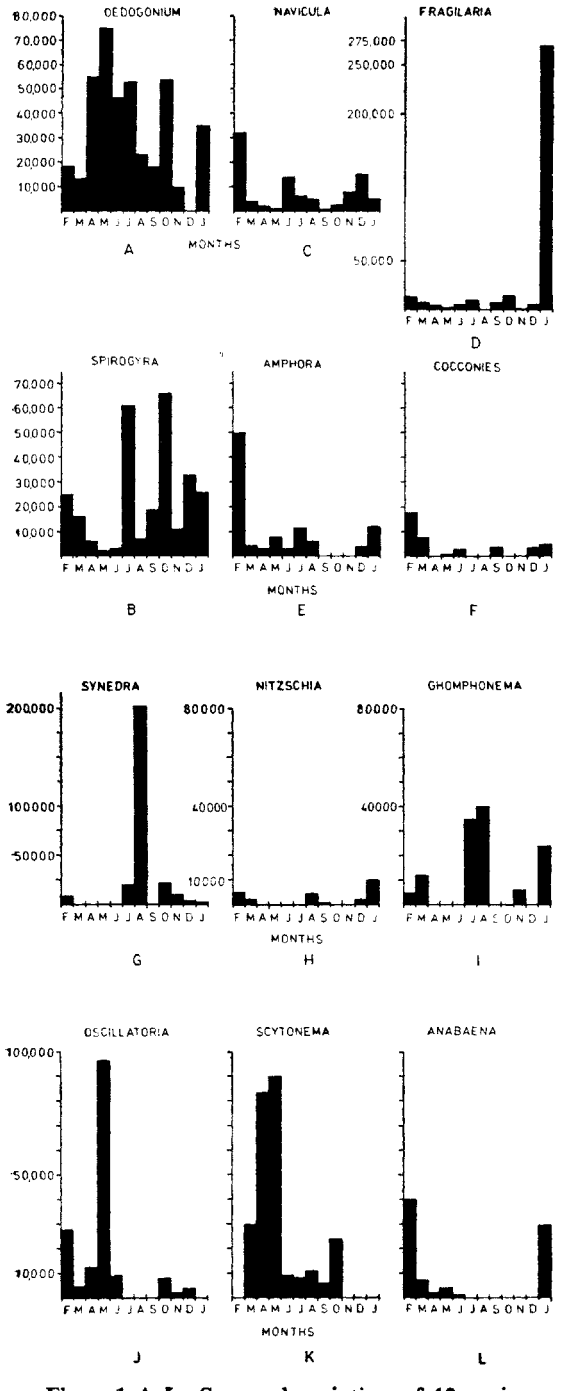

Figure 1 A–L Seasonal variation of 12 major algae associated with *Salvinia molesta* Mitchell

(tables 1 & 2). However, filamentous green algae like *Spirogyra*, *Oedogonium*, *Desmidium*, *Mougeotia*, *Zygnema*; an epiphytic diatom *(Gomphonema)* and a heterocystous filamentous blue-green alga *(Microchaete)* were abundantly found during the monsoon period. Certain organisms occurred very rarely in certain months only. For example *Rhizosolenia* and *Tabellaria* appeared only in January, *Plagiogramma* in February and June, and *Gloeocystis* and *Spirulina* in March (table 1). The variety and abundance of the diatoms were specially noteworthy, when the salinity of the lake water was 1.8‰. Members of Cyanophyceae appeared in fair numbers in March and April when the surface salinity varied between 2.2 and 2.8‰. Similarly, the diatom, *Pleurosigma* flourished well in comparatively high salinities i.e., 3.5 — 4.0‰. Thus the salinity of the lake water plays an important role in the indication of algal species associated with *Salvinia*.

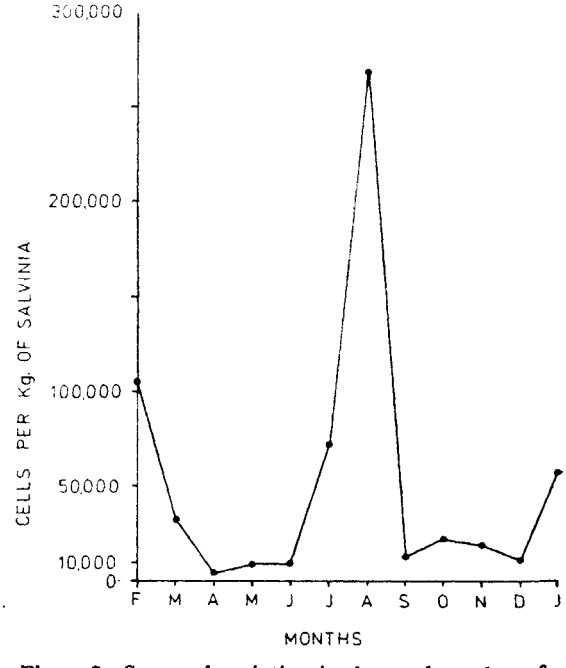

Figure 2 Seasonal variation in the total number of epiphytic diatoms on *Salvinia* roots in Veli lake.

That the *Salvinia* mat is associated with a rich epiphytic flora is evident from the data presented in table 1 and figure 2. The *Salvinia* roots become coated with a mass of diatoms, blue-green algal spores and sporelings. The most frequent epiphytic diatoms on *Salvinia* roots and their seasonal occurrence are recorded in figure 2. The major epiphytic diatoms observed on the submerged roots of the weed were *Amphora*, *Achnanthes*, *Plagiogramma*, *Gomphonema*, *Tabellaria*, *Cymbella*, *Eunotia*, *Cocconeis* and *Synedra*. *Amphora*, *Cocconeis* and *Eunotia* were found growing appressed to the cuticle of *Salvinia* roots. Diatoms such as *Amphora* and *Cocconeis* sometimes encrust the entire surface. Between these and on them the second growth form appears, producing small attachment discs which support species of *Synedra* and *Tabellaria*. The disc may extend into short- or long-branched mucilage stalks—e. g., *Achnanthes* sp., *Cymbella* sp. and *Gomphonema* sp. Another growth form observed in the epiphytic community is the larger filamentous green algae, attached by a basal disc or by a basal system of creeping filaments as in *Oedogonium* and *Bulbochaete*. Amongst the growth of epiphytic algae motile species were also found e.g., flagellates (*Euglena*, *Peridinium*) and *Navicula* and also nonmotile coccoid species, e.g., *Scenedesmus*, *Dictyosphaerium*, *Cosmarium*, *Closterium*, and filaments of *Spirogyra*, *Mougeotia*, *Ulothrix*, *Desmidium*. A variety of algae were found attached to the underside of *Salvinia* leaves which included genera of Cyanophyceae (species of *Oscillatoria*, *Lyngbya*, *Scytonema*) and of Chlorophyceae (*Spirogyra*). Figure 2 shows that the maximum number of epiphytic diatoms was recorded in August (268500/kg) and a second maximum in February (105000/kg) whilst low numbers in April (3835/kg), May (9000/kg) and June (9000/kg). The silica content of the lake water was highest (114.5 μg at. s./l.) during August and lowest (54.1 μg-at. s./l.) during April (table 2).

Table 2 *Monthly variation in salinity and silicate in the Veli lake water*

Month	Salinity ‰	Silicate (SiO_3 μg-at.s/l.)
February	1.75	74.5
March	2.2	57.3
April	2.8	54.1
May	1.7	73.6
June	1.0	74.0
July	0.2	107.5
August	0.2	114.5
September	0.25	112.5
October	2.8	93.5
November	3.5	78.2
December	4.0	65.8
January	1.8	69.3

It was also observed that the thick carpet of the matured weed termed the "folded stage" discouraged the growth of filamentous algae whereas the "floating stage" promoted it (table 3). Further, the luxuriant growth of the associated algae retards the growth of young sporophytes in the "floating stage". As already stated, *Amphora* sometimes encrusts the whole of *Salvinia* roots and this was found to retard the growth of the young sporophytes of *Salvinia*.

Table 3 *Algae associated with* Salvinia *in the young "floating stage" and the mature "folded stage" collected in May 1978 from Veli lake*

Name of filamentous algae and diatoms	Floating stage (Algae in cell nos./kg of *Salvinia*)	Folded stage (Algae in cell nos./kg of *Salvinia*)
Oedogonium	50000	nil
Bulbochaete	12000	nil
Spirogyra	37500	nil
Cerataulina	7000	nil
Achnanthes	25000	nil
Gomphonema	12500	nil
Fragilaria	3000	nil
Amphora	15000	nil
Navicula	2000	2000
Synedra	20000	nil
Oscillatoria	4000	nil
Scytonema	8000	2500
Peridinium	—	1000

Discussion

The present investigation indicates that the floating mats of *Salvinia* provide a new habitat for a number of algae. The feeding habits of certain fishes and some of the planktonic animals associated with *Salvinia* in Veli lake have been studied (data unpublished) and it was found that the filamentous algae and diatoms such as *Nitzschia*, *Navicula* and *Amphora* attached to the roots of *Salvinia* form a source of food for a variety of planktonic animals which in turn form the food of fish in these habitats. This animal community depends on this biotope both for protection and food and are able to thrive thereby maintaining a steady food supply for larger forms in the food chain of these backwaters. It was also observed that the attached algal mass was found teeming with the larvae of midges and fingerlings of certain fishes. These either scrape out minute unicellular algae from the surface of *Salvinia* roots or suck in the protoplasmic contents of these algae. This has been discussed in a seperate paper. Tilden (1968) has repeatedly observed that the midgefly larva subsists upon the cell contents of *Spirogyra*. Moreover, algae form the major item of diet of the fingerlings of certain species of fishes and hence termed "babyfood" of the young fish. Thus *Lyngbya aestuari* (Mertens) Liebman, forms the "babyfood" of the milk fish (Tilden 1968).

The profusely branched rhizoid system of *Salvinia* traps suspended detritus which also may serve as a source of organic nutrients (Skinner & Gardener 1930). According to Gopalan and Nair (1975) the major components of the fauna inhabiting the *Salvinia* mat utilize the *Salvinia* detritus as food. It becomes clear that the majority of the fauna associated with *Salvinia* are either algal feeders or detritus feeders (Gopalan & Nair 1975 and Sarma & Ganapathi 1972). The works of Sarma and Ganapathi (1972) on the faunal associates of algae and Gopalan and Nair (1975) on the faunal associates of *Salvinia* reveal that the major groups of meio-and macrofauna of these associations are similar. It could be deduced from the faunal study of *Salvinia* in Veli lake (*vide* table 4) that the organisms associated with the weed are, in fact algal associates than *Salvinia* associates.

Table 4 *Fauna associated with* Salvinia *in Veli lake (The figures represent the average of* 12 *observations taken from monthly values)*

Groups of organisms	Number/kg *Salvinia*
Nematodes	226
Annelids	847
Cladocerans	646
Ostracods	201
Copepods	2090
Amphipods	54
Isopods	8
Decapods	10
Insects and larvae	308
Molluscs	105
Fish fry	28

Results of the present study also indicate that the physico-chemical conditions of the water such as salinity and silicate, seasonal variations, the length of life of the weed, its profusely branched rhizoid system and the leaf arrangement and its surface, all influence the nature and growth of the epiphytic and other algal flora of this complex and curious biocoenosis.

The maximum number of epiphytic diatoms were found on *Salvinia* roots during the peak monsoon month (August) in Veli lake. This is because, during the monsoon, the weeds reaching the backwater remain fresh. Jorgensen (1957) also observed that the fresh weeds are rapidly colonised by epiphytic diatoms. In a study of both phytoplankton and epiphytes, in Danish

lakes, Jorgensen (1957) assumed that the growth of plankton had depressing effect on epiphytes. In support of this view, it was observed in the present study that high cell densities of total phytoplankton in Veli lake were noticed in April, July and January (data unpublished) whereas low numbers of epiphytic diatoms were found in these months (figure 2). The maximum number of epiphytic diatoms on *Phragmites* stem in Danish lakes are reported to occur when the silica content of lake water was very low and the assumption was made by Jorgensen (1957) that diatoms could utilise silica from the stems. Conversely, in Veli lake it was seen that the silica content of the lake water and the number of epiphytic diatoms on *Salvinia* roots were found to be maximum during the same month.

Very few ecological studies of the epiphytic communities have been made, but there is no doubt of the fact that identifiable associations do occur and are distinguishable such as for example *Achnanthes/Gomphonema* on *Salvinia* roots. Such an association has already been reported in the case of *Chara aspera* and *C. delicatula* (Round 1965).

The significance of the associated algal organisms in the *Salvinia* community in Veli lake is interesting. Algae in thriving condition provide the water with a supply of oxygen (Tilden 1968), especially in the upper layers. The enormous potential of nitrogen fixing blue green algae cannot be over emphasized (Singh 1961). Allen and Arnon (1955) and Cox and Fay (1967) demonstrated the nitrogen fixing capacity of *Anabaena cylindrica*, which is a blue-green algal associate of this weed. Thus the heterocystous blue-green algae inhabiting the weed would increase the fertility of water and hence contribute to the growth of *Salvinia*. On the other hand, the lush growth of algae and epiphytic diatoms retard to a certain extent the growth of young sporophytes. It would be worthwhile to study in detail the nature and role of these encrusting diatoms in the ecology of this floating fern.

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