PHYTOPLANKTON POPULATION DYNAMICS AND DISTRIBUTION IN TWO ADJOINING LAKES IN SRINAGAR

I. Macroflora in Relation to Phytoplankton

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Ecology of phytoplankton with respect to their distribution at different depths of water and associated hydrobiological factors (viz. temperature of water and atmosphere, *p*H and water level) and macrovegetation have been studied in two adjoining lakes during 1968–69. Observations were recorded at three depths: *surface*, 1 m *deep* and *bottom*. The phytoplankton showed three peaks: March–April, July–August and October–November. Of these, the organisms showed three patterns: (a) the diatom-dianoflagellate peak, (b) the copepod peak and (c) the peak of varied phytoplankton and high zooplankton. Dominance of algae was in the order: Diatoms, Chlorophyceae and Myxophyceae. A census of algae revealed *c.* 100 genera and their frequency was determined. Stationwise distribution of algae in relation to dominant macroflora is also given.

Introduction

Ecology of phytoplankton in the freshwater ponds in India has attracted little attention in the past. Some interesting studies on the ecological aspects of algae appeared in the 'Symposium on Algology' (1959). Of the more recent investigations may be cited those of Ramanadham *et al.* (1964), Chakravarty *et al.* (1959), Singh (1964), Sarkar and Rai (1964), Lakshminarayana (1965*a*, *b*), Singh (1965), Misra and Singh (1968), Vyas (1968) and Vashisht (1968). Zafar (1959, 1964*a*, *b*, 1968) made an exhaustive limnological study of a few ponds in Hyderabad.

In contrast to the little attention paid in India, the ecology of phytoplankton has attracted wide and varied interests in other parts of the globe; and of the recent works on the distribution dynamics, stratification, group composition, quantitative analysis, production, micronutrient as limiting factor on phytoplankton, mention may be made of Goldman (1965), Jankaviciute (1966), Javornicky (1966*a*, *b*), Kidd (1964), Klimova (1966) and

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Marshall (1969), and of the investigations carried out at the Limnologiska Institutionen (Uppsala).

It is evident that considerable work needs to be done to unravel the phytoplanktonic depths of temperate waters in this country; and the present work, therefore, aims at an exhaustive study of the phytoplankton populations in Kashmir waters. The lakes considered in the present report are the Dal and the Nagin. Microvegetation at various levels and during different seasons of the year in relation to macrovegetation, together with the drifting of the plankton due to wind and surface currents along with other disturbances in surface water, such as those caused by ducks, fowls, boatmen, fishermen and collectors of submersed water weeds. The effects of water and temperature, both at the surface and the bottom levels, as also of the atmospheric temperature on the presence and growth of plankton, have also

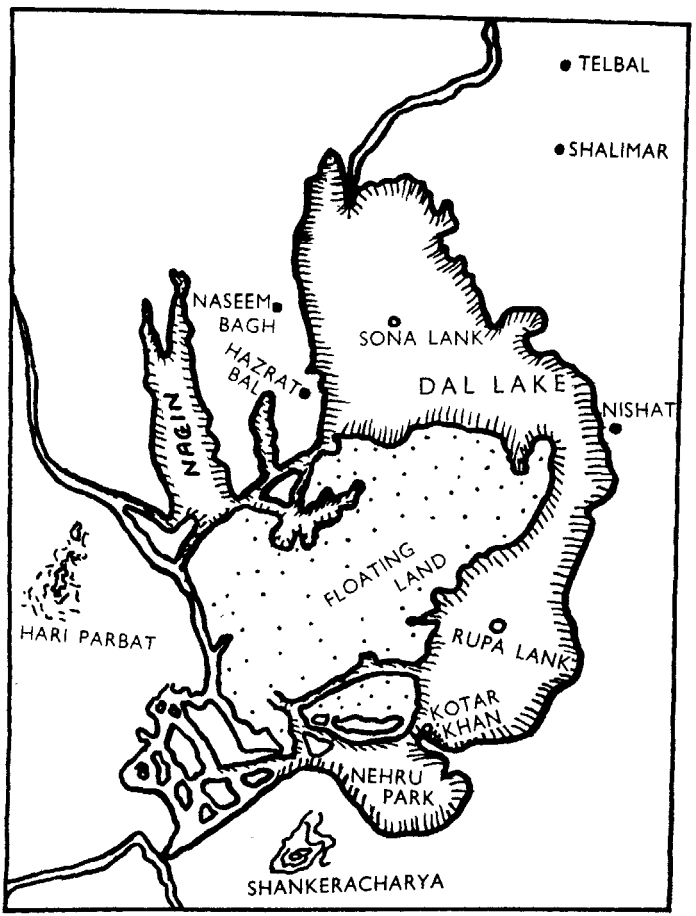

FIG. 1. Location of the Dal and the Nagin lakes.

been studied. Prime importance has been given to the collection of plankton throughout the year and recording them quantitatively and qualitatively. Water quality at various depths and soil analysis of the lake beds are also being determined with respect to their bearing on the plankton populations. For the present study the period covered is one year: October 1968 to October 1969.

Materials and Methods

An extensive survey of the Dal and the Nagin lakes (Fig. 1) was made during October–December 1968; and 66 stations were established for collection and observation which was done every month on a fixed date. These stations are located between the Ashaibagh Bridge and the Telbal Nala mouth into the Dal, from one end to the other breadthwise; and from Hazratbal to the Camel Bridge lengthwise (Figs. 2, 3). During February–March 1969,

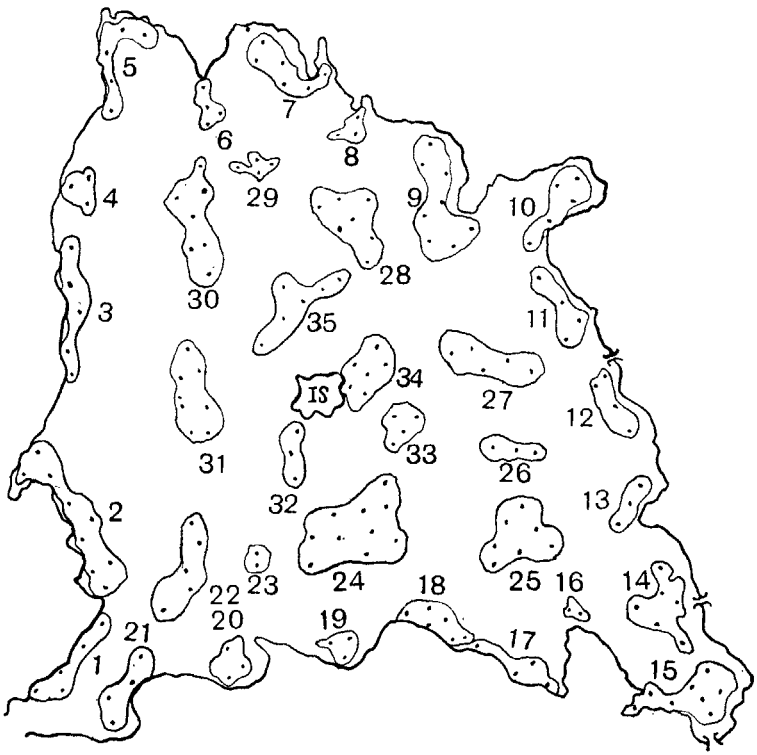

Fig. 2. Collection stations in the Dal (each number represents a group of sites IS—the Sona Lank island).

observations were made with regard to the growth of macrovegetation and increase in the water level. The small channels formed by the invasion of

the floating lands were also surveyed for phytoplanktonic vegetation and its association with macrovegetation within the lakes and along the banks.

During March–April 1969, 42 and 41 collection sites were established in the adjoining Nagin lake to study the micro- and macrovegetation. Twenty-one stations in the Nagin and 23 in the Dal, each on rotation basis, were covered for collecting the specimens during May–October 1969. Collections were made at three different levels: *surface*, 1 m *deep* and *bottom*.

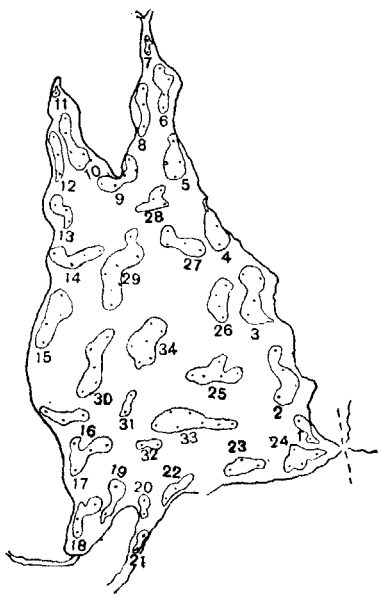

FIG. 3. Collection stations in the Nagin (each number represents a group of sites).

Soil samples were collected along the bank from the Ashaibagh Bridge to Telbal mouth into the Dal, and near the island in the centre of the lake; and further 22 stations were dug out for soil in the Nagin. For macrovegetation the studies were conducted on the spot. Climatological data with regard to temperature (both atmospheric and water), rainfall, humidity, wind direction and speed, and *p*H of water were recorded areawise in both the lakes.

The methods used for collection were very simple; surface water was collected for planktonic studies with the help of a pipette or a dropper, the water from depths and bottom was collected with the help of a self-made apparatus working on the principle of siphons. Temperature was recorded from depths and bottom by a Centigrade thermometer specially covered by thick tubing to avoid effect of air temperature and of surface disturbances. Materials to be studied in the laboratory were preserved in the F.A.A. (as

given in Kamath 1965). The following scale is used to indicate the degree of abundance: *D*, dominance; *R*, rare; *C*, common; *P*, patches; —, not observed.

All observations and collections were made in a rowboat with a few stop-gap arrangements.

Self-made apparatuses used in this study:

(1) *Apparatus for collecting water from depths.*—The apparatus consists of a flat steel rod, with a metric scale painted on it and sufficiently heavy to prevent its deviation from the straight path when it is immersed in water. A rubber tubing longer than the rod and with a wide bore is fixed tightly to the rod with the help of clippers; the upper end is connected to a suction pump while the lower end is fitted into a two-mouthed cork of the sampler. Into the other mouth of the cork is inserted a short tubing which is left open outside. The apparatus is dipped into water at the depths required, and with the help of a suction pump water is sucked into the sampler till it is full. The apparatus is then pulled out of the lake for examination.

(2) *Apparatus for measuring temperature of deep waters.*—A wide bore hard-glass tubing is mounted on a heavy steel rod marked with scale. The glass tubing is covered over by a heavy insulated rubber tubing, cut at one place to leave a slit open for noting down the reading on the thermometer. At the lower end of the tube is fixed a movable lid attached on one side with an insulated brass wire, which can be worked at will to open or close the lid. Inside the glass tubing is inserted a Centigrade thermometer attached with the insulated brass wire at the upper end to release the thermometer into water or to lift it up. The rod is dipped to the required depth and the lid of the glass tube is opened before the thermometer is released in water. It is kept in the same position till the reading is constant (normally for a minute or so). The thermometer is lifted up and the lid closed. In the meantime, the water is also collected in the glass tubing which does not allow the reading of the thermometer to change. The apparatus is then lifted up as a whole and thermometer brought in parallel with the slit to note down the reading without taking the thermometer out of the tube. The upper end of the tube is closed with a cork through which passes the brass wire.

(3) *Electronic device.*—The apparatus at 2 above has been modified by using an electronic device invented by Kanwar K. S. Jamwal and Shashi Kant. 'Electronic thermometer', as it has been called, consists of supersensitive transistors which work as the probe, and a battery connected with an m-meter to complete the circuit. The probe is dipped into water at the required depth and allowed to remain for a few seconds till the reading is stabilized. The deflection is noted on the m-meter and calibrated into 0 °C under the laboratory conditions. The device has confirmed the readings taken with the help of the 'crude' apparatus at 2 above.

The Lakes and Factors Considered

Topography.—The Dal and the Nagin are situated close to Srinagar city at a latitude of 34·07′ E and longitude of 74·52′ N. These lakes are surrounded on all sides by mountain ranges. Citywards from the lakes stand the famous Shankeracharya Hills to the left and the Hariparbat Fort to the right. Between these hills lies Srinagar, and far away to the west are the snow-clad mountains of the Pirpanchal range; towards the east are the extensions of the Kailash Parbat (Fig. 1.)

The Dal is 6,230 m long and 4,153 m wide and covers an area of about 16,067 m. Of this *c.* 3,975 m consist of fixed cultivated zone; leaving only about 12,072 m under the free water surface, including the so-called floating lands. The lakes or tarns, which occur in the mountains surrounding the valley, mostly lie in what are generally considered to be true rock basins; but it is difficult to say whether the lakes themselves have rock basins. They are so covered by alluvium that no conclusion can be drawn as to the nature of their basins. In view of this, it is not possible to classify the basins into various types enumerated and diagrammatically represented by Zafar (1959). The winter here is very severe and is accompanied by snowfall. The water of the lakes touches freezing point or even gets frozen sometimes. The lake is customarily divided into five parts (the fifth being recognized as a separate entity by itself) as enumerated below:

(1) this is demarcated as that lying between the Dal Gate and the Nehru Park island, also sometimes called as the *Boulevard Lake.* It is not important from our point of view;

(2) it is from the Nehru Park to the rest-house called the Kotarkhan and is called the *Gagribal Lake.* It is mainly used for aquatic sports and is, therefore, of no use in this study;

(3) it is the portion lying between the Gagribal Lake and a longitudinal bund separating the lake into nearly two halves; being a tongue-shaped expanse, called the *Bod Dal,* and most susceptible to wind action and continued biotic interference;

(4) this part, known as the *Hazratbal Lake,* is a sort of continued reservoir of aquatic and planktonic vegetation, and least prone to drastic biotic or otherwise interferences. This has been selected for a sustained study during this investigation. The water-level regime and zonation caused in vegetation in this area is more pronounced; and

(5) this part of the lake is separated from the main expanse of the lake by the intervening land, the only connexion being through a channel under the two bridges: the Ashaibagh and the Saidakadal. This part, called the *Nagin Lake,* is also used for water sports but the

southern and northern fringes, which assume marshy conditions after recession of water, provide biological activity in which plankton plays quite a significant role.

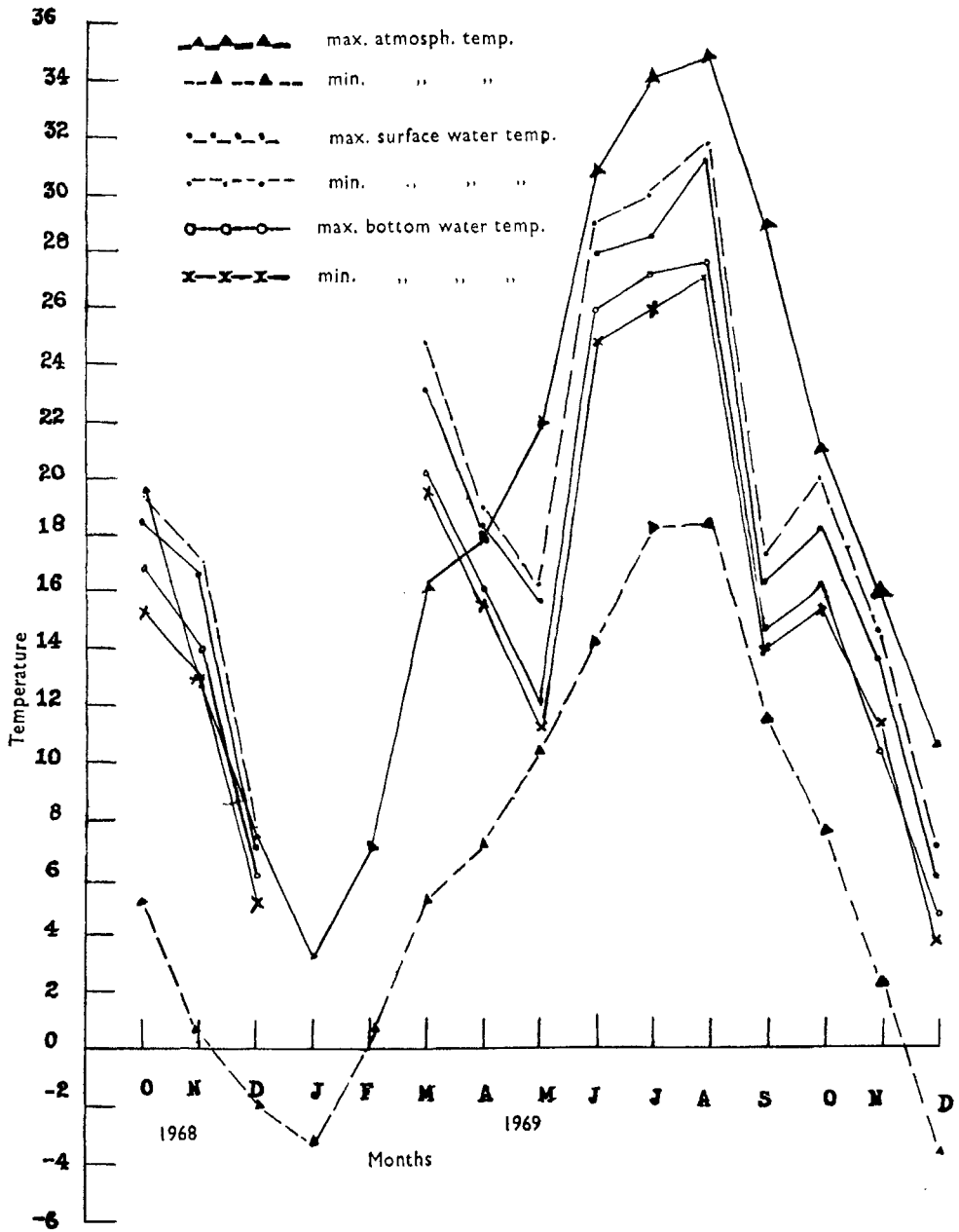

FIG. 4. Temperature regime in and over the Dal from October 1968 to December 1969.

Temperature.—Water temperature was recorded in both the lakes at surface and bottom level throughout the year and corresponding temperature of the air was also taken into consideration. In both the lakes, temperature exhibited a fluctuation in response to the other climatological changes. Due to heavy rains in the last spell of April there was a considerable fall in temperature which still fell down to 16·2 °C and 12·1 °C due to snowfall in the last part of this month; increasing through August when it was 31·6 °C and 27·6 °C as the maximum temperature of the year.

On an average, surface temperature showed a variation of 1·5 °C, and the same variation was observed in the bottom temperature as well. It was interesting to note that the surface temperature as well as the corresponding bottom temperature at various stations showed a horizontal variation, which was not associated with variations in temperature recorded in vertical horizons (Figs. 4, 5).

*p*H: The *p*H of water changed with the change in the other climatological and vegetational factors. In spring when there was very little of vegetation and the temperature was low, the *p*H almost reached 6·9; whereas in summer the *p*H reached the ultimate maximum of the season *vis-à-vis* vegetation, being 8·7. The autumn showed a slight decrease in *p*H and in winter again the *p*H was almost neutral or slightly acidic, for there was practically no emergent and floating flora in the lakes, except for the submersed vegetation.

It was also interesting to note that the fluctuation was between the surface and bottom *p*H and, at an average, was only 0·5, but it showed that there was only horizontal variation (i.e. at same depths) between the two and not vertical, i.e. at different depths (Figs. 6, 7).

Water level (*Depth*).—There was considerable rise in water level in both the lakes due to heavy rains in the last phase of April 1969 and because of considerable amount of snowfall, i.e. 97 mm. Then in summer the water level went down and in autumn it was still down but was maintained till winter set in and it came to the minimum of 0·53 m. A diagrammatic representation of water level in different seasons is shown in Fig. 8.

In spring the water level started to rise. The heavy rain accompanied by snowfall had a great impact on the flora and the plankton alike; the floating vegetation was washed off towards shoreline leaving the surface clear; this also delayed flowering season of the weeds: affecting both the zoo- and the phytoplankton.

Macrovegetation.—The Dal is a natural sheet of water and is fed by a number of streams, which, as expected, result in gradual silting up of the lake and also bring with them accumulated organic matters. This causes change in organic matter of the bottom and also of water in general, thus effecting phytoplanktonic population and distribution. To control this excess of water, stray streams have been provided. This fluctuation in water level creates the

same hedgemony in vegetational set-up as would be expected from any pond (pond used in the sense of Welch 1952). Consequently, the aquatic and semiaquatic plants growing within and around the lakes would fall within the aquatic category and this category only has been considered.

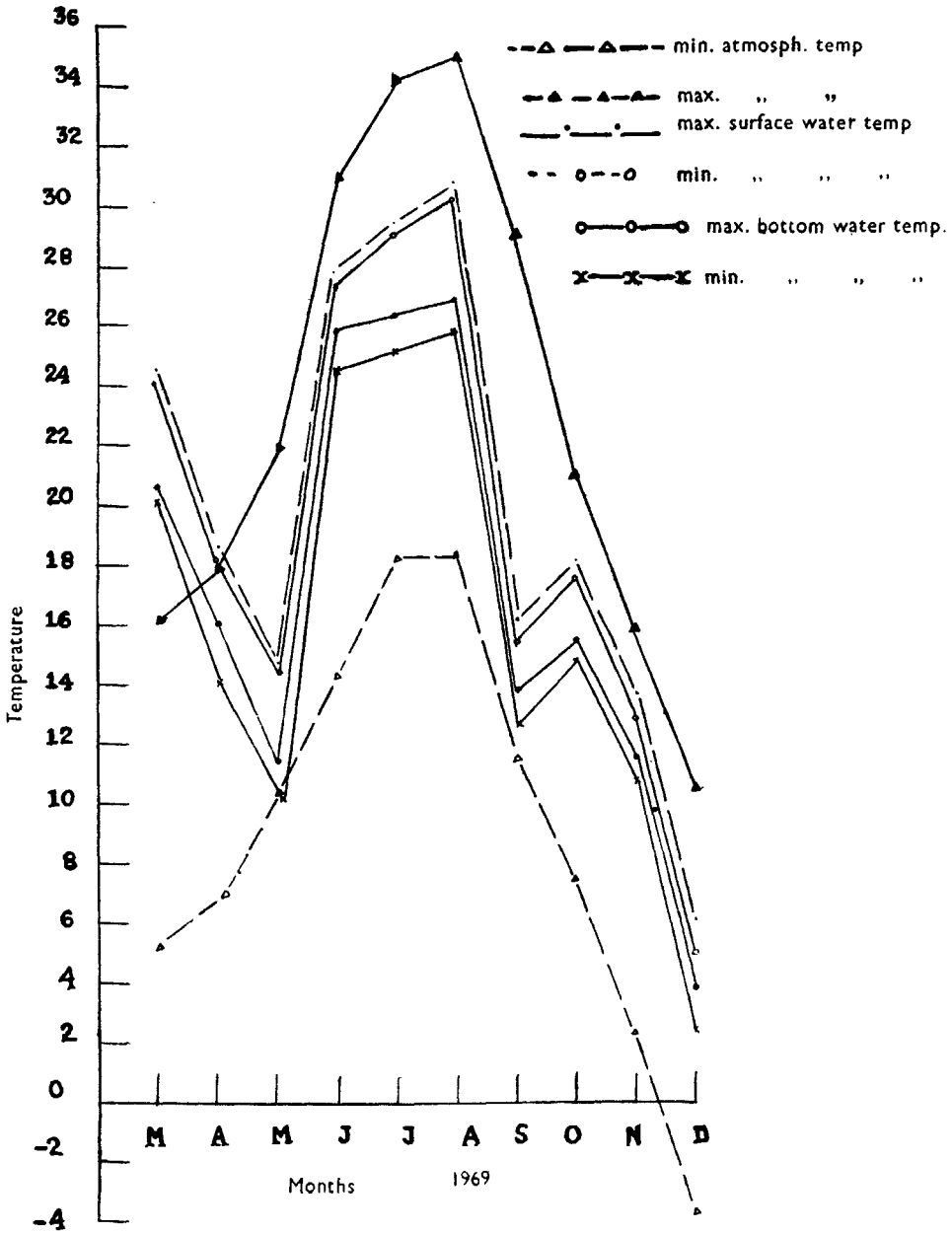

FIG. 5. Temperature regime in and over the Nagin from March to December 1969.

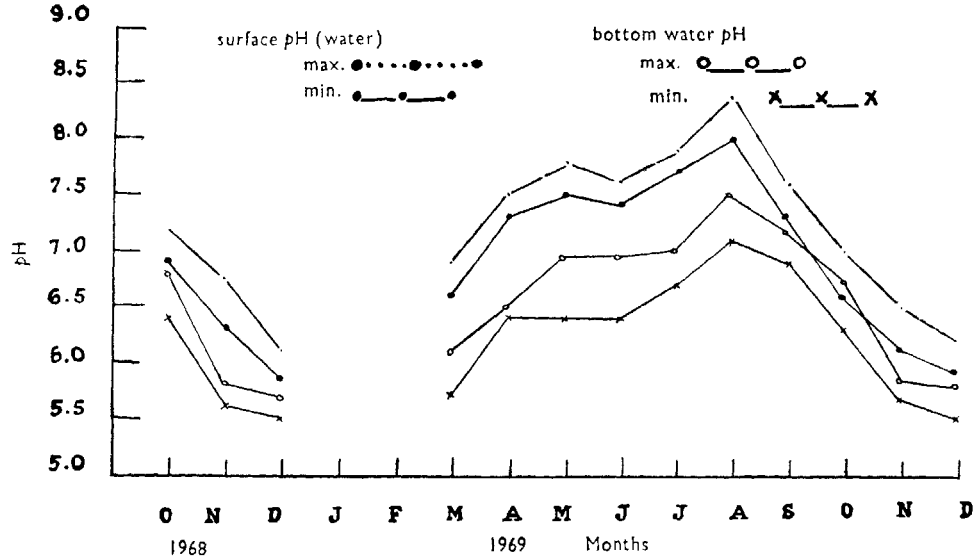

FIG. 6. *p*H of water in the Dal (October 1968–December 1969).

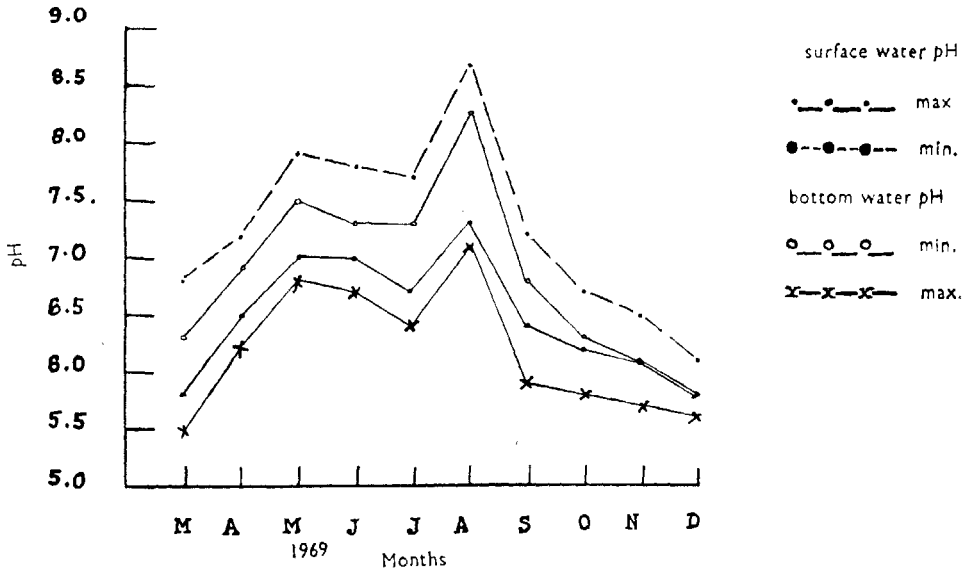

FIG. 7. *p*H of water in the Nagin (March–December 1969).

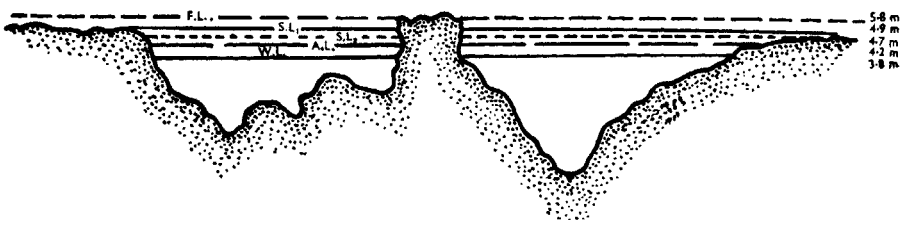

FIG. 8. Diagrammatic representation of water level in the Dal during 1968–1969. (*A.L.*, autumn level; *F.L.*, flood level; SL_1, spring level; SL_2, summer level; *W.L.*, winter level).

Under this category, the classification methods of Hess and Hall (1945) and Penfound (1953) as modified by Kachroo (1959*a*, *b*) have been used and the following divisions have been recognized for the study and for selecting

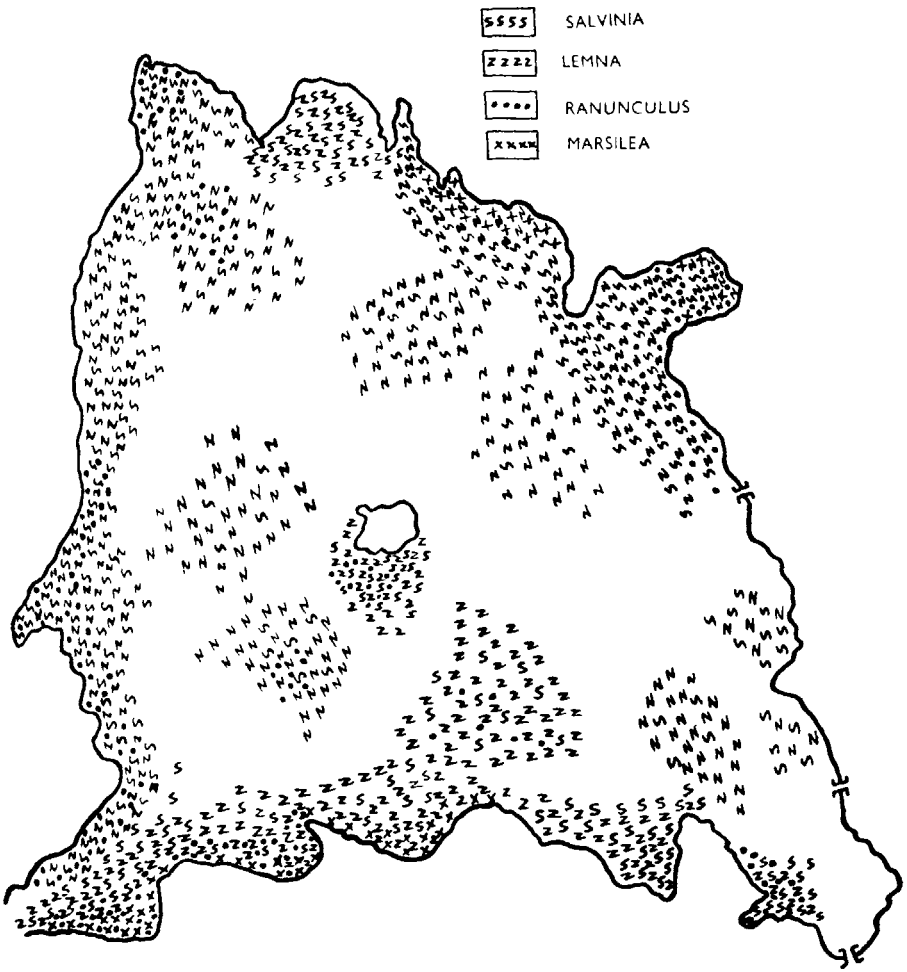

FIG. 9. Floating vegetation in the Dal (distribution of dominant species, diagrammatic; March 1969).

various collection and observation sites. As far as possible these relate, rather strictly, to the continuous water zone:

1. *Floating* (free or attached or both, Figs. 9, 10). Here the association was mainly between *Salvinia natans*, *Nelumbium speciosum*, *Nymphaea alba*, *Potamogeton natans* and the submersed species.

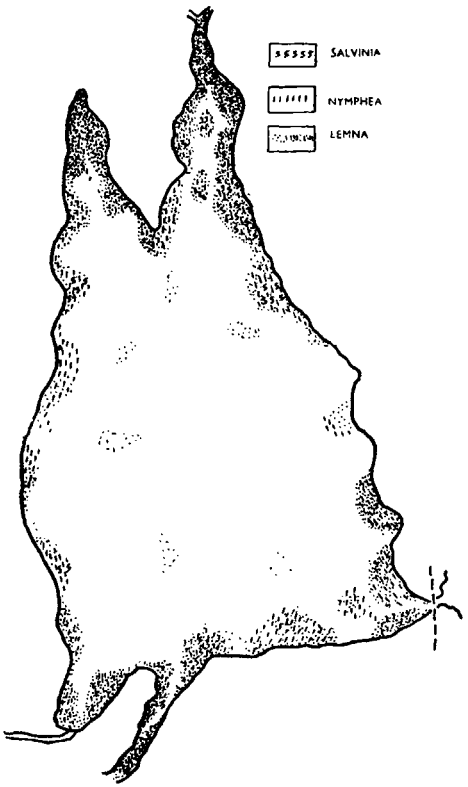

FIG. 10. Floating vegetation in the Nagin (index as in Fig. 9).

2. *Flexuous* (Figs. 11, 12). It represented the emergent and floating association with preponderance of the emergent leafy plants, whose leaves rise and fall with water level. Here the association was represented by *Typha angustata* (most common), *Phragmites communis*, *Marsilea quadrifolia*, *Alisma plantago*, *Sparganium ramosum*, stray *Salvinia natans*, *Potamogeton natans*, etc.
3. *Floating mat.* Few stations showed this association.
4. *Carpet.* It was represented by a close association of *Lemna minor* and *Salvinia natans* (in spring) and later mostly by *Salvinia natans* alone (till autumn) with or without marginal vegetation. Obviously, it was mostly affected by wind action which caused disturbances and dispersed the species, thus compelling their entry into zones where they were absent heretofore. This natural interference coupled with biotic disturbance caused by boatmen and fishermen did create an imbalance at times, permanent in phytoplanktonic elements in various stations.

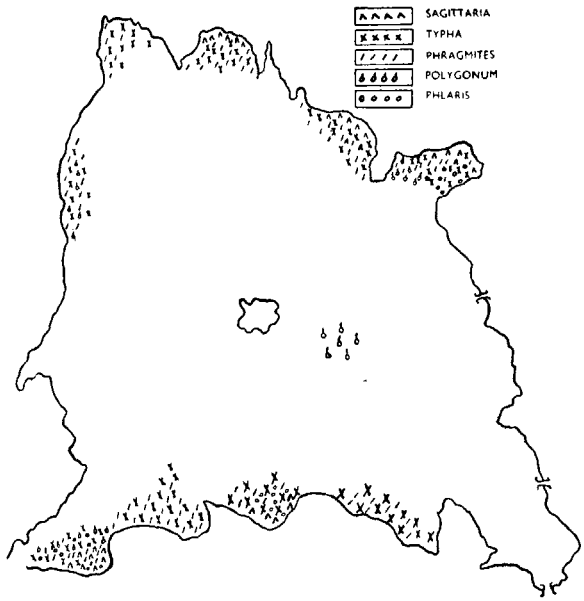

FIG. 11. Flexuous vegetation in the Dal (distribution of dominant species, diagrammatic; March 1969.).

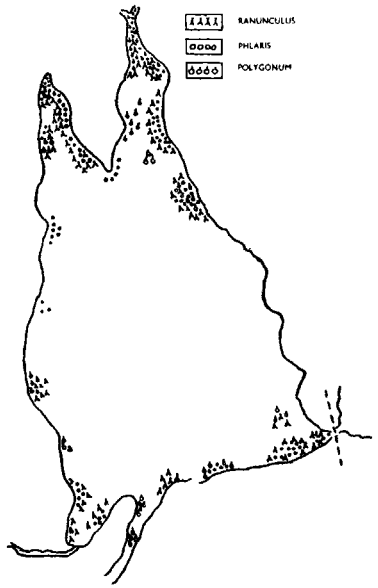

FIG. 12. Flexuous vegetation in the Nagin (index as in Fig. 11).

5. *Submersed* (Figs. 13, 14). It is hardly to visualize a zone of vegetation which did not have one or two or more submersed components. Species of *Myriophyllum* and *Hydrilla* were found in absolutely pure associations at many a station widely separated from one another.

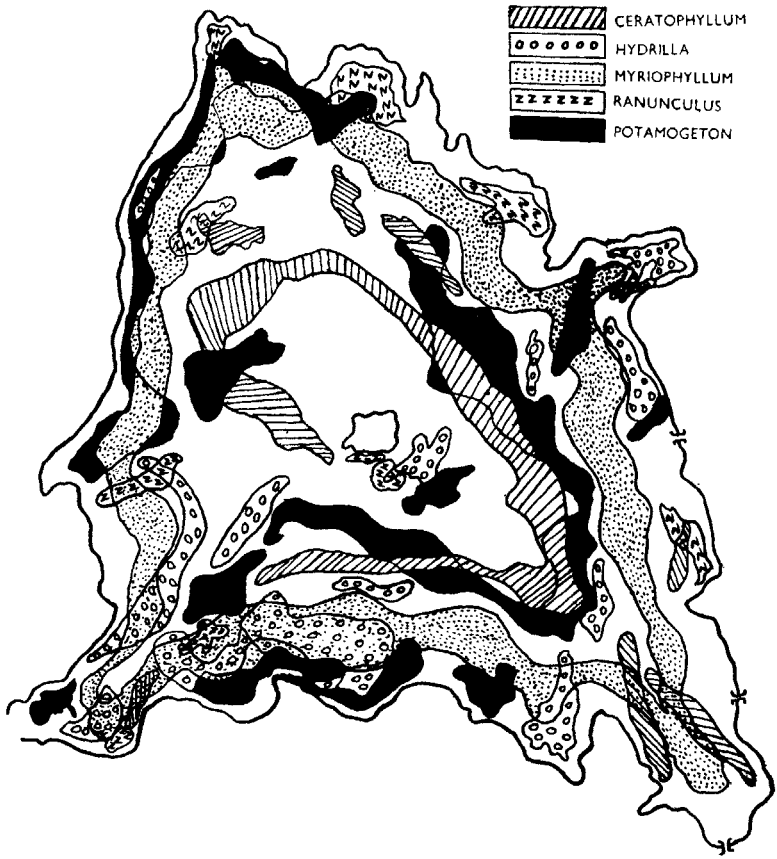

FIG. 13. Submersed vegetation in the Dal (distribution of dominant species, diagrammatic; March 1969).

The interrelated associations were those of:

(i) *Myriophyllum* and *Ceratophyllum demersum*
Potamogeton crispus
Hydrilla verticillata.

(ii) *Ceratophyllum* and *Hydrilla verticillata*
Potamogeton crispus
Ranunculus aquatilis.

(iii) *Potamogeton* and *Ranunculus.*

However, in parts of the lake demarcated for sports there was absence of submersed flora.

Pleuston.—Mats formed by *Lemna* did occur but these were mainly confined to lagoons and canals (locally called *mar*) leading towards the habitation. Water in such regions is found usually impregnated with organic impurities.

Microscopic.—This stage of vegetation was observed in early parts of winter when the marginal flora and the floating vegetation had already disintegrated, giving place to degenerating diatoms, bluegreen algae, and species of *Chlorella*, *Microcystis*, etc.

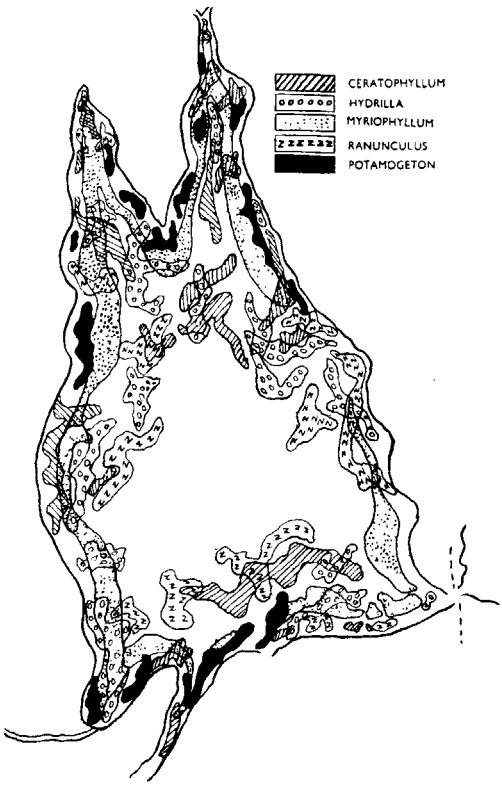

FIG. 14. Submersed vegetation in the Nagin (index as in Fig. 13).

PLANKTON SITUATION

This study was primarily aimed at an assessment of the phytoplankton but it is natural that zooplankton had also to be taken into consideration because the hydrobiological factors affect both the groups in practically the same fashion. Further, it is well known that the plankton form the main food of the aquatic life, particularly entering the food of fish, duck, fowl, and of other aquatic fauna (*see*, e.g. Kachroo's (1956, 59*a*, *b*) work on anopheline

fauna and the role of algae in nutrition of mosquitoes); and this chain is illustrated in Fig. 15.

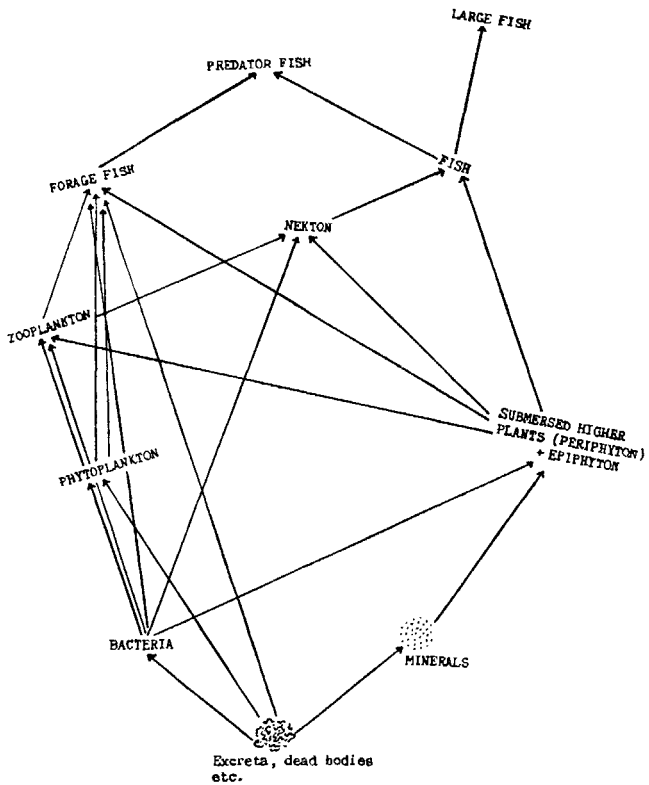

FIG. 15. Food web in the Dal (diagrammatic).

This generalization fits in with the fish food cycle divided into three stages by Russell and Yonge (1948). Of the hydrobiological factors, such as temperature, *p*H, O_2, CO_2, phosphate, SiO_3, our preliminary studies showed that the dissolved salts play an important role in these lakes and they help to maintain an interesting ecological balance between these salts, detritus, plankton, and the littoral and benthic flora and fauna. With respect to zooplankton it is correct to assume that temperature has an effective bearing on their climax and growth. Riley (1941) with respect to Long Island Sound (U.S.A) also stated, 'zooplankton show a significant correlation only with temperature, which appears to be the most important, if not the only, controlling factor'. However, Woodmansee (1958) found 'not very significant correlation between zooplankton and temperature' in Biscayne Bay (U.S.A.).

Obviously, because the zooplankton are dependant for their food on the phytoplankton; therefore, their peak is recorded in April–May and November–December, in between the climax and growth recorded for the phytoplankton.

Woodmansee (1958) also stated that there are apparently only two established causes of zooplankton maxima: an increase in the temperature when it is the limiting factor, and an increase in the quantity of phytoplankton when it is the limiting factor.

These two established causes of zooplankton with respect to the lakes in consideration have been noted only in the Dal. The fact that *p*H shows an associated increase and decrease is obvious, because it is only during high *p*H that the phytoplankton express their maximum development. The zooplankton, on the other hand, thrive best with decrease in the O_2 content. It is our contention that phytoplankton is the limiting factor, thus increase in phytoplankton preceded the zooplankton maximum. This fact has been observed elsewhere as late in 1950 by Smith *et al.* Of the zooplankton, protozoa are in abundance during May–September in the lakes.

The Dal is an eutrophic lake, i.e. shallow with large quantity of organic material present at the bottom and even in suspended state; 'trophy' is used here in the sense of Fageri (1954) meaning the physico-chemical nature of the lake water and this may be read with Pearsall's (1923) contention. Due to abundance in aquatic vegetation the basic fertility of the lake is high. In contrast to the usual conception that in summer there is lack of O_2 in deep waters, it has been noted that it is only in autumn that the deep waters are depleted of O_2 due to the surface of the lake being thickly covered with decaying macrovegetation and a lot of chlorophyllous algae which utilize the maximum O_2.

Phytoplankton generally showed three peaks; the primary peak of diatoms was during June–August; among other algae there were three peaks in the year: March–April, July–August and October–November.

There was a heavy and unusual rainfall in April 1969. Whether this very heavy rainfall and subsequent land-drainage added nutrient salts to the lakes permitting a phytoplanktonic bloom in July–August and subsequent November zooplankton maximum cannot be positively stated. It is only the most likely explanation afforded by the data at hand. Other explanations could be possible, for example the wind velocity might have effected a renewal of the surface waters by the addition of the nutrients where they could have been utilized by the phytoplankton. This is still under study.

Of the three peaks, the biologic succession of the plankton organisms was observed in the following pattern:

(*a*) the diatoms-dinoflagellate peak;
(*b*) the copepod peak; and
(*c*) the peak of varied and high zooplankton.

It can be broadly stated that (1) bright sunlight period, (2) open medium shaded period, (3) water regularly filled in, and (4) associations of aquatic

angiosperms, and probably some other factors stimulated the growth of a number of diatoms and other algae found here and there and the regular fill-up added more elements from time to time to those already existing. Higher atmospheric or water temperature is considered to be one of the important factors in the periodicity of Chlorococcales. They show the maximum growth during the warmer months of the year. They tend to increase at the end of the rainy season (September–October) and persist in good numbers even during the winter months (November–December). Thus, they show gradual growth from January through monsoon in August and September, reaching their peak in August–September. This would correspond to the 'monsoon peak' in the plains. This is followed by a gradual decline through autumn. It is yet to be determined whether following the usual assumption there is another peak in February in the local elements.

The composition of plankton is taxonomically variable in different seasons, but it is too early to designate in *sensu stricto* these periods by dominant algal species. Roughly speaking, the dominant algae in these periods may be classified as follows:

(*a*) Diatoms
(*b*) Chlorophyceae
(*c*) Myxophyceae.

Taxonomic Grouping of Phytoplankton

The genera of algae identified so far are grouped according to the classification of Fritsch and the quantitative data will be given after further collections are assessed. The following analysis is, therefore, limited to the areas already thoroughly surveyed and the estimation of the number of species is an approximation.

Census of algae

Chlorophyceae:

Volvocales.—*Carteria*; *Chlorogonium, Sphaerella, Chlamydomonas, Gonium, Dangeardinella, Eudorina, Pandorina, Volvox, Tetraspora, Apiocystis, Gloeocystis, Sphaerocystis, Chlorangium, Prasinocladus.*

Chlorococcales.—*Chlorococcum, Tetraedon, Characium, Radiococcus, Quadrigula, Dimorphococcus, Pediastrum, Hydrodictyon, Selenastrum, Ankistrodesmus, Oospora, Kirchneriella, Coelestrum, Lagerhaemia, Scenedesmus, Tetradesmus.*

Ulotrichales.—*Ulothrix, Hormidium, Microspora, Cylindrocapsa.*

Sphaerales.—*Cladophora, Pithophora.*

Chaetophorales.—*Stigeoclonium, Drepernaldia, Trentophlia.*

Oedogoniales.—*Oedogonium, Oedocladium, Bulbochaete.*

Conjugales.—*Spirotaenia, Cylindrocystis, Mougeotia, Spirogyra, Zygnema, Micrasterias, Cosmarium, Staurastrum, Closterium, Euastrum.*
Siphonales.—*Vaucheria.*
Charales.—nil, at present.
Xanthophyceae.—nil.
Chrysophyceae.—nil.
Baccillariophyceae.—*Pinnularia, Cymbella, Amphora, Grammatophora, Triceratium, Melosira, Tabellaria, Synedra,* etc.
Cryptomonadaceae.—*Cryptomonas, Rodomonas, Cryptochrysis, Cyanomonas.*
Dinophyceae.—*Glanodinium, Peridinium, Gymnodenium, Blastodinium, Entomosigma, Gloeodenium, Ceratium, Dinoclonium.*
Euglinineae.—*Euglena, Phacus, Scytomonas.*

The percentage of the various groups of algae in the lakes may be summarized as below:

Group/family	Number of genera	Percentage (%)
CHLOROPHYCEAE		
Volvocales ..	57	65
Chlorococcales ..	17	45
Ulotrichales ..	17	100
Cladophorales ..	5	15
Chaetophorales ..	1	65
Oedogoniales ..	3	35
Conjugales ..	3	80
Siphonales ..	1	0·2
Charales ..	0	0
Xanthophyceae ..	0	0
Baccillariophyceae ..	18	100
Cryptomonadaceae ..	4	1·5
Dinophyceae ..	8	1·5
Myxophyceae ..	15	75
Chloromonadineae ..	0	0
Euglinineae ..	8	25

The above analysis reveals the presence of about 110 genera of freshwater algae and on a conservative basis we are inclined to place the number of species at a level of 350, if not more.

TABLE I

Station Nos:	4	6	7	9	10	11	13	15	26
Dominant macroflora	*Hydrilla*	*Limnanthemum*	*Potamogeton*	*Salvinia* and *Phragmites*	*Myriophyllum*	*Nelumbium*	*Polygonum*	*Ceratophyllum* and *Sparganium*	*Marsilia*
Common phytoplankton									
Amphithrix	−	−	−	+	−	−	−	−	−
Anabaena	−	−	−	−	+	−	+	+	+
Anabaenopsis	+	−	−	−	+	−	−	−	+
Anacystis	−	−	−	−	+	−	−	−	−
Ankistrodesmus	+	+	−	+	+	−	+	+	+
Aphanizomenon	−	−	−	+	−	−	−	−	−
Arthrodesmus	−	−	−	−	+	−	+	−	−
Binullaria	−	−	−	+	−	−	−	−	−
Botryococcus	−	−	−	−	+	−	−	−	−
Bulbochaete	−	−	+	−	−	−	+	+	−
Bumullaria	−	−	−	−	+	−	+	−	−
Bumullariopsis	−	−	−	−	+	−	−	−	−
Calothrix	+	−	−	+	+	−	+	+	−
Characium	−	−	−	−	−	−	−	+	−
Characiopsis	−	−	−	−	+	−	−	−	−
Characiosiphon	−	−	−	+	−	−	−	−	−
Chlorobotrys	−	−	−	−	+	−	+	−	−
Chlorococcum	+	−	+	+	−	−	−	+	−
Chlorococcus	−	−	−	−	−	+	−	−	−
Chlorella	−	+	+	+	−	−	−	+	+
Chlorotylium	−	−	−	+	−	−	−	−	−
Chroococcus	−	−	−	−	−	−	−	−	+
Chrysocapsa	−	+	−	−	+	−	+	−	−
Cladophora	−	−	+	+	−	−	−	+	−

TABLE I (*contd.*)

Station Nos:	4	6	7	9	10	11	13	15	26
Dominant macroflora	*Hydrilla*	*Limnanthemum*	*Potamogeton*	*Salvinia* and *Phragmites*	*Myriophyllum*	*Nelumbium*	*Polygonum*	*Ceratophyllum* and *Sparganium*	*Marsilia*
Closterium	−	−	+	+	−	−	−	+	−
Closteridium	−	−	+	−	−	−	−	−	−
Coccochloris	−	−	−	−	+	−	−	−	−
Cocomyxa	−	−	+	−	−	−	−	−	−
Cosmarium	+	+	−	+	−	−	+	+	+
Crenothrix	−	−	−	−	−	−	−	−	+
Cruciginia	−	−	+	+	−	−	−	−	−
Cylandrocystis	−	−	−	−	+	−	−	−	−
Dactylococcus	−	−	−	−	+	−	−	−	−
Dactylococcopsis	−	−	−	−	−	−	−	−	+
Dactylotheca	−	−	−	−	+	−	+	−	−
Debarya	−	−	+	−	+	−	−	−	−
Dengierdiella	−	−	−	−	−	−	−	+	−
Dermocarpa	−	−	−	+	−	−	−	+	−
Desmidium	−	−	−	−	+	−	−	+	−
Entocladia	−	−	−	+	−	−	−	−	−
Epithemia	−	−	−	+	−	−	−	+	−
Euastrum	−	+	−	+	−	−	−	−	+
Eudorina	+	+	+	−	+	+	+	+	+
Genicularia	−	−	−	−	+	−	−	−	−
Gloeobotrys	−	−	−	+	−	−	+	−	−
Gloeocystis	−	−	−	−	+	−	−	−	−
Gloeotheca	−	−	−	−	−	+	−	−	−
Gloeotrichia	+	+	+	+	+	+	+	+	+
Gomphosphaeria	−	−	−	−	+	−	−	−	−

TABLE I (*contd.*)

Station Nos:	4	6	7	9	10	11	13	15	26
Dominant macroflora	*Hydrilla*	*Limnanthemum*	*Potamogeton*	*Salvinia* and *Phragmites*	*Myriophyllum*	*Nelumbium*	*Polygonum*	*Ceratophyllum* and *Sparganium*	*Marsilia*
Gomontia	−	−	−	−	−	−	+	+	−
Gongrosira	−	−	−	−	−	−	−	+	−
Goniochloris	−	−	−	+	+	−	−	−	−
Gonium	−	−	−	−	−	−	−	+	+
Grammatophora	−	−	−	−	−	−	−	+	−
Heterothrix	−	−	−	−	+	−	−	−	−
Hormidium	−	−	−	+	−	−	−	−	−
Kircherianella	−	−	−	+	+	−	−	+	+
Melosira	+	−	+	−	+	−	−	−	−
Merismopedia	−	−	−	−	−	−	−	+	+
Mesotaenium	−	−	−	−	−	−	−	+	−
Microcystis	+	+	+	+	+	+	+	+	+
Microspora	−	−	−	+	−	−	−	−	−
Monocilia	−	+	−	+	−	−	+	−	−
Mougotia	−	−	−	−	−	−	−	−	+
Mougotiopsis	−	−	−	+	−	−	−	−	−
Myrmicia	−	+	−	+	−	−	−	−	−
Myxocercina	−	−	−	−	−	−	−	−	+
Nannochloris	−	−	−	−	+	−	−	−	−
Nephrocytium	−	−	−	+	+	−	−	−	−
Nostoc	−	−	+	+	+	−	−	+	−
Oedogonium	−	+	−	+	−	−	−	+	−
Onychonema	−	−	−	−	−	−	−	−	−
Oocystis	−	−	−	−	+	−	−	+	+
Oscillatoria	+	+	+	+	+	−	+	+	+

TABLE I (*contd.*)

Station Nos:	4	6	7	9	10	11	13	15	26
Dominant macroflora	*Hydrilla*	*Limnanthemum*	*Potamogeton*	*Salvinia* and *Phragmites*	*Myriophyllum*	*Nelumbium*	*Polygonum*	*Ceratophyllum* and *Sparganium*	*Marsilia*
Pachycladon	−	−	−	−	+	−	−	−	+
Palmellococcus	−	−	−	+	−	−	−	−	−
Pandorina	−	−	−	−	+	−	+	+	−
Pediastrum	+	−	−	+	+	−	+	+	+
Penium	−	−	−	−	−	−	−	−	+
Phormidium	+	+	+	+	−	−	−	+	−
Pithophora	−	−	−	+	−	−	−	−	−
Planktosphaeria	−	−	−	−	+	−	−	+	−
Polyedriopsis	−	−	−	−	+	−	−	−	−
Protococcus	−	−	−	+	−	−	−	−	−
Protoderma	−	−	−	+	−	−	−	−	−
Pseudotetraspora	−	−	−	−	−	−	−	−	+
Radiococcus	+	−	−	−	−	−	−	−	+
Raphidionema	−	−	−	−	+	−	−	−	−
Rhizoclonium	−	−	−	−	−	−	+	−	−
Rivularia	−	−	−	+	+	−	+	+	+
Scenedesmus	+	+	+	+	−	−	+	+	+
Schizodictyon	−	−	−	−	+	−	−	−	−
Schizogonium	−	−	−	+	−	−	−	−	−
Schroderia	−	−	−	−	−	−	−	+	−
Selenastrum	−	−	−	−	+	−	−	−	−
Sirogonium	−	−	−	−	+	−	+	+	−
Sphaerocystis	−	−	+	−	−	−	−	−	−
Sphaeroplea	−	−	−	+	+	−	−	−	−
Sphaerella	+	−	−	−	−	−	−	−	−

TABLE I (*concld.*)

Station Nos:	4	6	7	9	10	11	13	15	26
Dominant macroflora	*Hydrilla*	*Limnanthemum*	*Potamogeton*	*Salvinia* and *Phragmites*	*Myriophyllum*	*Nelumbium*	*Polygonum*	*Ceratophyllum* and *Sparganium*	*Marsilia*
Sphaerozosma	−	−	−	−	+	−	−	+	−
Spiroclosterium	−	−	−	−	−	−	−	−	+
Spirogyra	−	+	−	+	−	−	+	+	+
Spirotaenia	−	+	−	−	+	−	+	+	−
Spirulina	−	−	−	−	−	−	−	+	+
Spondilosium	−	+	−	+	−	−	−	−	−
Staurastrum	+	−	−	+	+	−	−	+	−
Stigeoclonium	−	−	−	+	−	−	−	−	−
Stigeonema	−	−	+	−	+	−	−	−	−
Tetrachlorella	−	−	−	+	−	−	−	−	−
Tetraedon	−	−	−	+	+	−	−	−	−
Tetraspora	−	−	−	−	−	−	−	+	+
Tetrastrum	−	−	−	−	+	−	−	+	−
Tremosphaera	−	−	−	−	−	−	+	−	−
Trentipohlia	−	−	−	−	−	−	−	+	−
Thamniochaete	−	−	−	−	+	−	+	−	−
Tribonema	−	−	−	+	+	−	+	+	+
Triceratium	−	−	−	−	+	−	−	−	−
Tolypothrix	−	+	−	+	+	−	+	−	+
Trochiscia	−	−	−	−	+	−	−	−	−
Ulothrix	−	−	+	−	−	−	−	−	−
Volvox	−	−	+	+	+	−	+	+	−
Xanthedium	−	+	−	−	−	−	−	−	−
Zygnema	−	−	+	+	−	−	−	+	−
Zygnemopsis	−	−	−	+	−	−	+	−	−

Distribution (frequency)

On the basis of data available so far, the following approximation is presented:

(*a*) dominant.—diatoms.

(*b*) most common genera.—*Tetraspora, Chlorococcum, Oocystis, Ankistrodesmus, Krichneriella, Scenedesmus, Cladophora, Oedogonium, Spirogyra, Gloeotricha.*

(*c*) less common genera.—*Cosmarium, Sphaeroplea, Oedocladium, Bulbochaete, Mougeotia, Gloeocapsa, Eudorina, Tetrastrum, Rivularia, Calothrix, Volvox, Pandorina.*

(*d*) rare genera.—*Staurastrum, Euastrum, Gonium, Gongrospira, Trentopohlia, Pediastrum, Closterium, Penium, Genicularia, Sirogonium, Spirotaenia, Sphaeroederia.*

(*e*) genera found throughout the year.—*Spirogyra, Cladophora, Oedogonium*, diatoms.

Association with macroflora

The association of phytoplankton with dominant macroflora at a few stations is given in Table I (+ indicates presence and — absence of species).

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