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Hydrobiology of Colombo (Beira) Lake, I. Diurnal Variations in Temperature, Hydrochemical Factors and Zooplankton

By

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AN extensive study of the hydrobiology of the Colombo lake was initiated by the authors in May 1969 as a contribution to the International Biological Program (Productivity of freshwater communities) by the Department of Zoology, Vidyalankara University of Ceylon, Kelaniya.

The Colombo lake often referred to as the Beira lake covers an area of approximately 160 acres. The water is usually very turbid with a greenish blue appearence due to the presence of large quantities of blue green algae. The bottom of the lake is almost completely muddy. The most recent morphometric data for the lake has been given by Mendis (1964).

Area of the lake	64.8 hectares (160 acres)
Volume of water in the lake	1872 x 10^3cu.m.
Maximum depth	8.5m.
Mean depth	2.8m.
Shore line	11,315m.
Shore development	2.1.

The area of the lake has tended to change very slightly as small areas are being continuously reclaimed for building purposes. Recently, due to dredging the depth has increased.

As described by Mendis (1964), the lake has two main parts ; East Lake and South West Lake. These two are connected together by the narrower West Lake. The Lake has two main outlets to the sea ; one at the Galle Face Spill and the other at the Colombo harbour (Fig. 1). The connection to the harbour is through a canal provided with lock gates which are opened only to allow the passage of boats and barges.

The depth of the lake is not uniform ; deepest being the area closer to the harbour in the East Lake and the shallowest being the South West Lake. Most of the sides of the East Lake and West Lake are built up in cement.

The lake receives the outlets of several surface drains and also the waste matter of several engineering and commercial concerns bordering the lake which tend to pollute the water at several points. Portions of West Lake and South West Lake also receive the domestic waste from a large number of tenements situated bordering the lake. Large areas of South West Lake and Vaxuhall street area of E. Lake sometimes tend to be covered by a thin layer of oil.

Several workers earlier have studied varying aspects of the biology of Colombo Lake. The earliest work recorded was done by Daday (1898) who described several new animal species. Subsequently work has been done by Gurney (1906), Apstein (1907) Lemmermann (1907), Crow (1923), Bar (1924), Holsinger (1955), Arudpragasam and Costa (1961) and Mendis (1964). Apstein (1907) worked on the succession of Rotifera and Cladocera populations while Holsinger (1955) studied the distribution and periodicity of phytoplankton. Investigations of Mendis (1964) was on the plankton, benthos and the fish fauna mostly in relation to fish potential.

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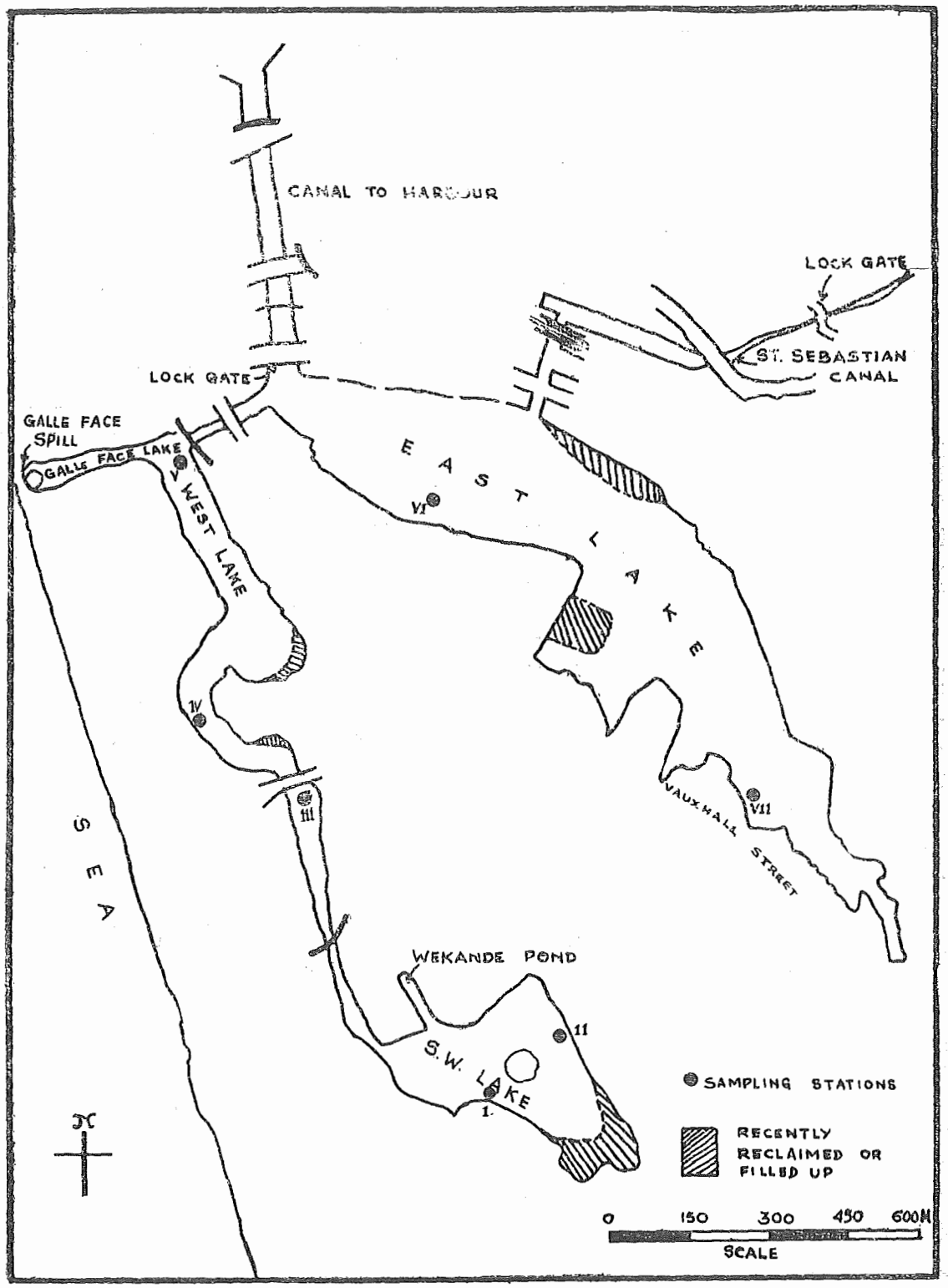

Fig. 1.— Map of Colombo (Beira) lake.

The first paper in this study deals with diurnal variations in temperature, hydrochemical factors and zooplankton of the Colombo lake. This investigation was undertaken because of the complete absence of information on diurnal variations in freshwater bodies in Ceylon; and this study is therefore the first of its kind in Ceylon. Some information is however available on diurnal variations in other tropical freshwaters ; the notable contributions being those of Carter and Beadle (1930), Hutchinson (1957), George (1961) Sreenivasan (1964), and Verma (1967).

MATERIALS AND METHODS

The investigations reported in this paper were carried out on the 15th of September 1969. The day on which the observations were made was bright and sunny, though a few patches of dark clouds were seen in the early hours of the morning and in the evening. Meteorological department temperature recordings for this day were 31°C maximum and 27°C minimum.

Collections were made at three sampling stations I, IV, and VI (See Fig. I) from 6 a.m. to 10 p.m. at two hourly intervals. At station VI, the deepest area of the lake collections and determinations. were made at three different depths ; at the surfce, at a depth of about 6m. and at the bottom (depth 12m). At stations I and IV determinations were done on samples taken just below the surface of the water. At station VI water samples were collected from various depths using a Ruttner sampler. Samples were collected as far as possible when the water was undisturbed by passing boats. Plankton samples were taken only at station IV and at 3 hour intervals. Analysis reported in this paper were done immediately after collections were made. Determinations were done according to methods described by Mackereth (1963). Surface water temperature was measured by a mercury thermometer graduated upto 110°C.

RESULTS

Temperature

The data indicate (Fig. 2 A) that at all the sampling stations the highest temperature of the day occured between 1300 and 1500 hr. The variation within a day appears to be less than 6°C. At station VI where the temperature was measured with depth (Fig. 2 B), slight thermal stratification was noted with a very thin upper warmer layer. This stratification of temperature occurs just before evening.

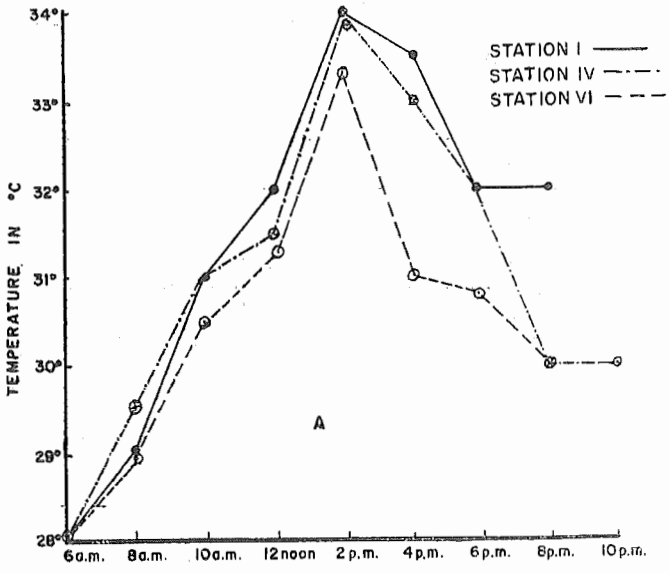

Fig. 2 A.—Diurnal variation of surface temperature

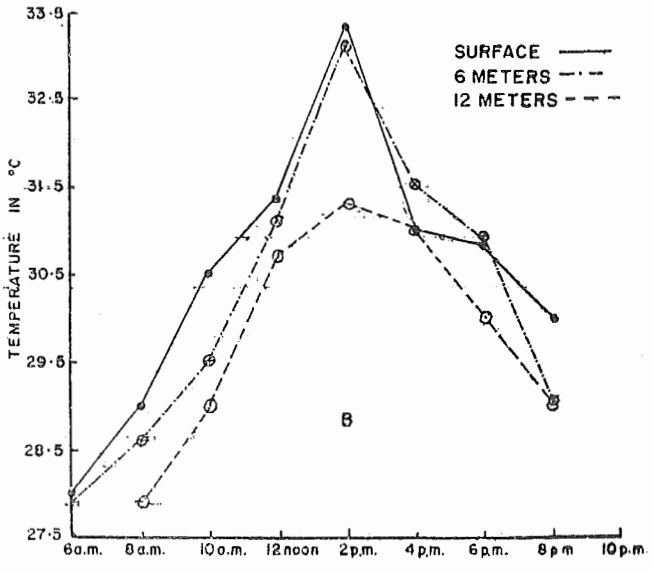

Fig. 2 B.—Diurnal variation of temperature at station VII with depth

Oxygen

The highest surface oxygen content of the day occured between 1300 and 1700 hr. From the dissolved oxygen figures for the three sampling stations (Fig. 3 A) it was very apparent that at the stations I and IV the water was less than saturated during the early part of the day and more than saturated in the later part. It is also to be concluded that the maximum photosynthetic rate occurred between 1100 and 1400 hrs. and subsequently declined. At station VI the oxygen production in the surface water was higher in the early hours of the day (Fig. 3 B). The oxygen curves at station VI show that even in mid-day the dissolved oxygen content was low, although still super saturated, when compared with the other two stations showing that the photosynthetic rate here is lower. Conspicuous stratification of oxygen with depth was not apparent ; the super saturation was also noticed below 1m. However, a very slight stratification was observed in the very early hours of the day.

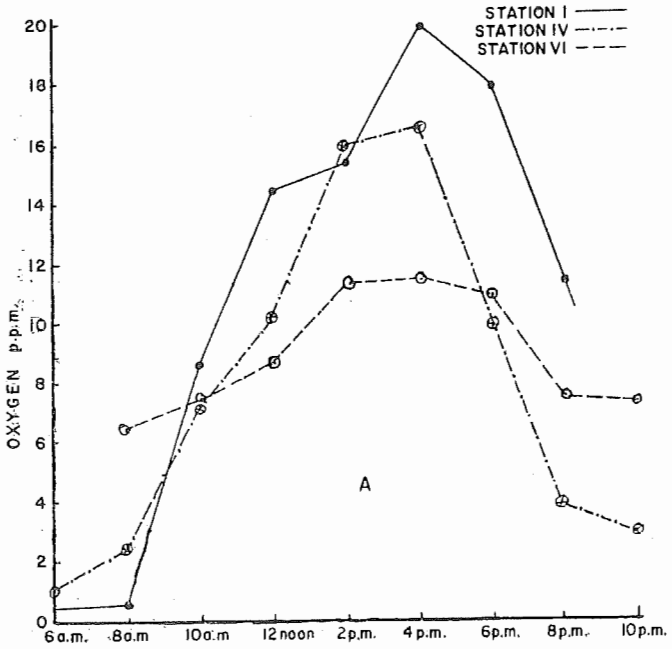

Fig. 3 A.—Diurnal variation of surface plankton.

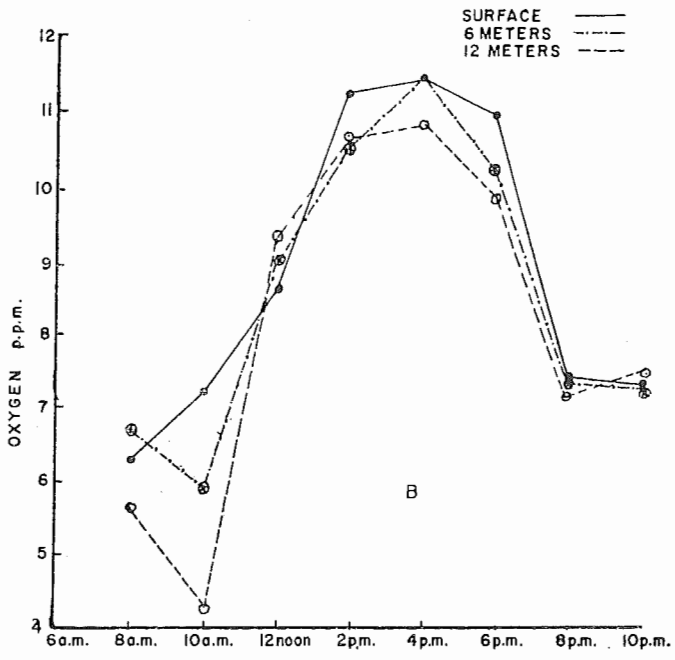

Fig. 3 B.—Diurnal variation of dissolved oxygen at station VI with depth.

Table 1 **Showing % oxygen saturation values at the three sampling stations**

Time	Station I	Station IV	Station VI
6 a.m.	6	12	—
8 a.m.	7	30	82
10 a.m.	116	95	96
12 noon	198	138	116
2 p.m.	215	225	154
4 p.m.	276	229	156
6 p.m.	245	136	149
8 p.m.	157	50	98

Carbon Dioxide

Free carbon dioxide was completely absent at all three stations sampled, probably because of its utilization in photosynthesis.

Salinity

The three stations sampled show distinct differences (Fig. 4 A) in salinity, the least amount of dissolved solids was at station I which also showed the least amount of diurnal fluctuations. At station IV the salinity was low but some slight diurnal fluctuation was seen in the salinity content. At station VI the salinity was rather high and a noticeable vertical distribution of salinity (Fig. 4 B) was seen, the deeper waters were slightly more saline than the surface waters.

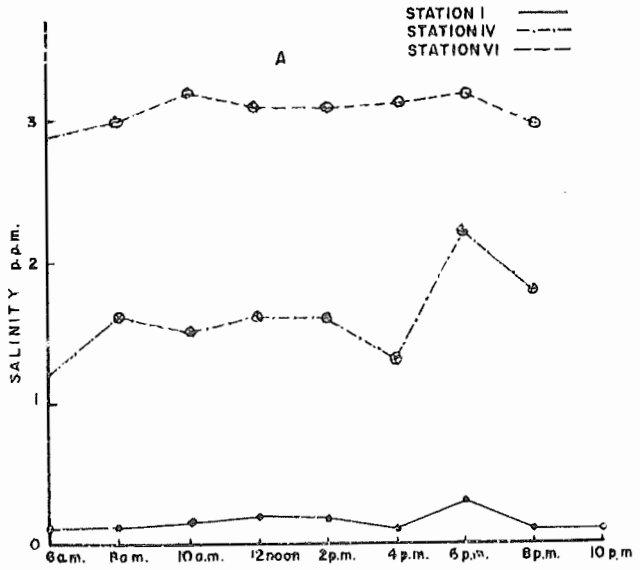

Fig 4 A.—Diurnal variation in surface salinity.

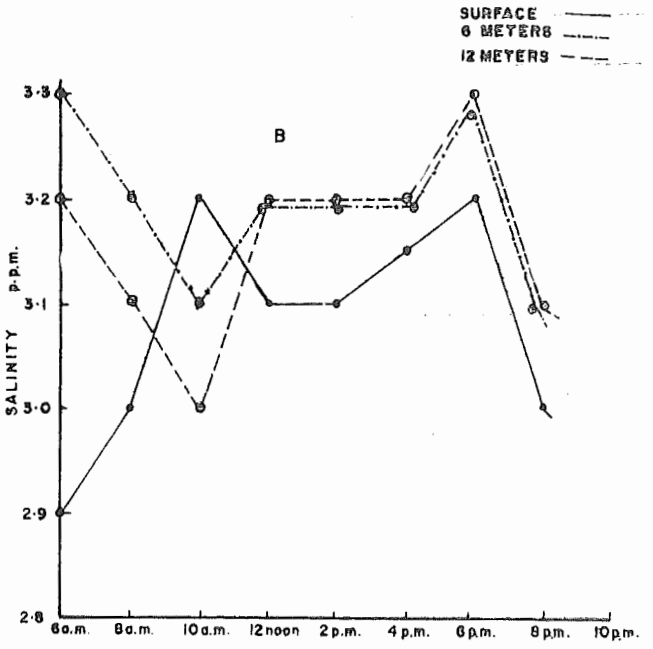

Fig. 4 B.—Diurnal variation of salinity with depth.

Alkalinity

The range of variation in total alkalinity in the appreciably waters was not surface conspicuous (Table II). Maximum 99 ppm. at station I was at 1800 hr.; at station IV the maximum 108 ppm. was at 1400 hr. and at station VI the maximum 114 ppm. was also at 1400 hr. At station VI the alkalinity values of the bottom water was not very different to those of the surface water.

Table II showing diurnal variation of alkalinity in p.p.m

Time	Station I	Station IV	Station VI
6.00 a.m.	87.0	87.0	112.0
8.00 a.m.	90.0	104.0	113.0
10.00 a.m.	88.0	104.0	109.0
12.00 noon	83.0	105.0	109.0
2.00 p.m.	84.0	108.00	114.0
4.00 p.m.	81.0	110.00	109.00
6.00 p.m.	99.0	100.00	113.00
8.00 p.m.	92.0	100.00	113.00

Hydrogen Ion Concentration

The pH of the surface water fluctuated from 7.4 to 9.0 at station I ; 7.2 to 8.4 at station IV ; and from 7.5 to 8.6 at station VI (Table III). The data for station VI, where the pH of the water was measured at different depths, indicates that like alkalinity there was no discernible pH stratification from surface to bottom.

Table III showing diurnal variation of pH

Time	Station I	Station IV	Station VI Surface	Station VI 6m.	Station VI 12 m.
6.00 a.m.	7.4	7.2	7.5	7.5	7.5
8.00 a.m.	8.1	7.0	8.1	8.0	8.0
10.00 a.m.	8.1	8.2	8.3	8.2	8.2
12.00 noon	8.2	8.1	8.6	8.6	8.7
2.00 a.m.	8.6	8.4	8.9	8.6	8.9
4.00 p.m.	9.0	8.1	8.5	8.3	8.5
6.00 p.m.	8.0	8.1	8.1	8.1	8.1
8.00 p.m.	8.5	8.0	8.1	8.1	8.1

Zooplankton

Samples were collected with a cone shaped net made up of no. 21 bolting silk and attached to a ring which was 12 inches in diameter. The method of sampling was to tow the net at an average speed of that of a hand oared boat. The net was usually fishing just below the surface. All tows of the series were of the same duration ($1\frac{1}{2}$ minutes).

The samples were immediately preserved in 4 % formalin. The sample was later concentrated to 100ml volume. Three subsamples each of 1 ml volume was taken to a rafter cell and all the specimens were counted fully in each subsample. The relative numbers are expressed in Fig 5.

Diurnal variations in the zooplankton was studied from 6 a.m. to 9 p.m. at 3 hr. intervals from a predetermined spot at sampling station No. IV. *Brachionus* sp., *Keratella* sp., *Diaphanosoma* sp., *Diaptomus* sp. *Cyclops* sp., and crustacean nauplii were the most notable of the zooplankton, with copepoda cyclopoidea constituting the bulk of the zooplankton. The trend in the variation of the different groups at different times of the day is given in Fig. 5.

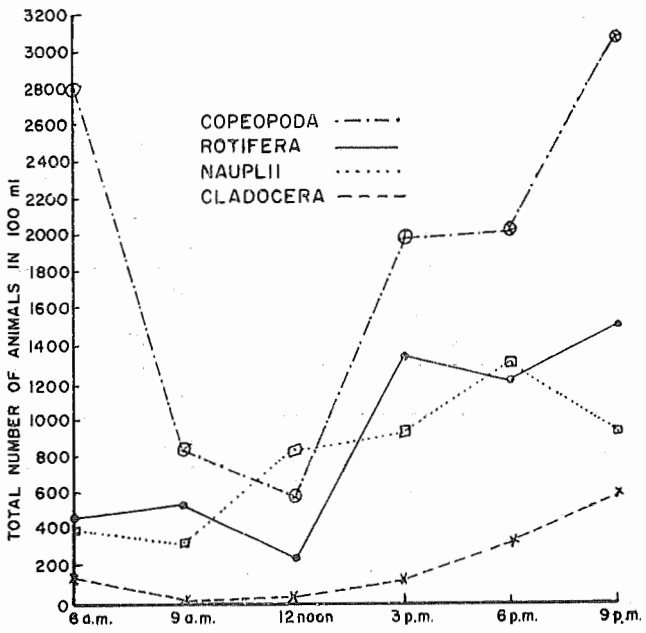

Fig. 5.—Diurnal variation of relative numbers of dominant plankton.

Cyclops which was the dominant zooplankton was maximum at 2100 hr. and least at 1200 hr. *Brachionus* was also maximum at 2100 hr. and minimum at 1200 hr. *Diaphanosoma* was maximum at 2100 hr. and minimum at 9.00 hr. Nauplii showed the highest peak at 1800 hr.

DISCUSSION

In tropical freshwater bodies temperature is of great importance in determining the production of oxygen. A relationship in the increase of temperature and the increase of dissolved oxygen content was seen in the waters of Colombo lake ; the highest temperature recorded for the day was at about 2 p.m. while the highest concentration of dissolved oxygen was noted at about 4 p.m. Increase in temperature brings about an increase in the rate of photosynthetic activity of the phytoplankton (Hutchinson 1957) and this account for the increase in the oxygen content in the illuminated hours.

The absence of free Carbon dioxide in the samples examined is probably due to the presence of large amounts of phytoplankton and because of its utilization in photosynthesis.

On the basis of pH ranges, Colombo lake could be considered highly alkaline inspite of the very slight diurnal variations.

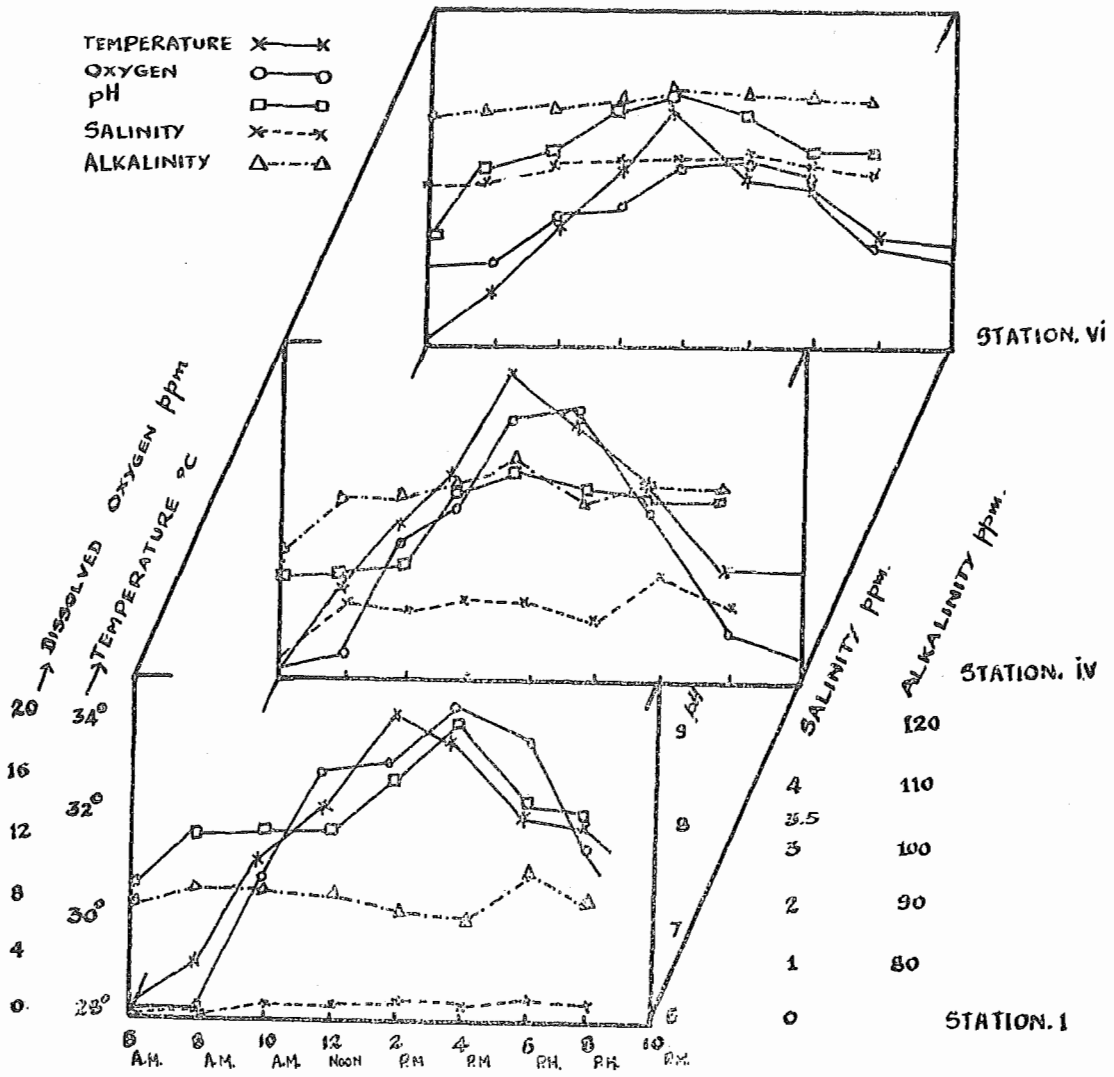

Fig. 6.—Diurnal variation of temperature, oxygen, pH, salinity and alkalinity.

On examination of diurnal records of surface temperature and oxygen for the different stations (Fig. 6) it is apparent that there are slight variations. The maximum surface temperature and maximum dissolved oxygen content was noted at station I while the minimum surface temperature and minimum dissolved oxygen content was recorded as station VI. Station I is rather shallow (1–2m.) while station. VI is comparatively deep (12m.). This could account for the slight differences noted in the temperature. Light and heat stimuli affect the movement of plankton (Worthington–– 1931) and this probably accounts for the increase in oxygen content. Station VI is the closest to the lockgate and station I is the farthest and this accounts for the differences in the salinity recorded in our study.

The present study indicate that the rotiferan *Brachionus* was more abundunt in the collections of the night hours than in those of the day hours. This is in agreement with the observation of Vaas & Sachlan (1953) and contrary to those of Verma (1967). *Cyclops* was found in large numbers both by day and night. The nauplii however showed a tendency for migration to the surface in the evening. Since the diurnal variation in plankton was studied in a very shallow area of the lake more work will have to be done to confirm these results.

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SUMMARY

The diurnal variation of temperature, water chemistry and zooplankton was studied at two hourly intervals for a period of 16 hours. The highest temperatures were attained at about 2 p.m. Oxygen content reached a maximum between 2 and 4 p.m. No free carbon dioxide was found. The diurnal variations in pH, salinity and alkalinity were not very marked. The variations in plankton were similar to those found in other tropical fresh waters. The results are discussed and compared with results of other workers.

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