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Studies on the Fish Ponds at Pitipana, Negombo 1. Seasonal and Diurnal Variation of Some Hydrobiological Factors

By

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Introduction

At the lowest reckoning water is the medium in which fish live and from which they derive their oxygen. Hence the quantity and quality of water must very much effect the prospects of fish culture (Hickling, 1971). A study of physico-chemical properties of water and its basic productivity, along with the eco-physiology of the fish species concerned is an essential prerequisite for any rational system of culture.

Sri Lanka is blessed with approximately 22,000 ha of brackish marshy land along the coast line, suitable mostly for fish culture (Ling, 1973). In addition Sri Lanka has a multitude of inland waterways, reservoirs, etc. However, fish culture is still in its stages of infancy. There is a lack of basic knowledge on the biology of cultivable species, the quality and productivity of waters available for fish culture and a multitude of socio-economic problems, which are some of the main constraints for development of fish culture in Sri Lanka (Raphael, 1976).

The present paper is a part of a detailed investigation on the biology of grey mullet, *Mugli cephalus* L., and the feasibility of its culture in the brackish waters of Sri Lanka (also *see*, De Silva and Perera, 1976 ; De Silva and Wijeyaratne, 1977 ; Perera and De Silva, 1977 ; Perera and De Silva, 1978). In this paper results of investigations on the water quality of five experimental ponds at the Pitipana Brackishwater Fisheries Station, Negombo, carried out over a period of one year, December 1976 to November 1977, together with studies on the primary productivity are presented.

Materials and Methods

The lay-out of the experimental ponds is shown in Fig. 1. The ponds used in the study are numbered 10 to 14, and they are earthen rearing ponds, with a bottom layer of mud, 30–40 cm thick. The water levels in the ponds were found to fluctuate through the year from 0.5–0.8 m. The sluice gate of P 13 was blocked after stocking with young mullet fry, for purposes of a comparative study, and along with the preparation of the ponds for stocking will be dealt with in a later publication.

The parameters studied were temperature, salinity, pH, and dissolved oxygen ; every determination being carried out twice daily, between 0800–0900 hr. and 1400–1500 hr. on all working days of the week, as far as possible. However, due to unavoidable circumstances in July 1977 readings

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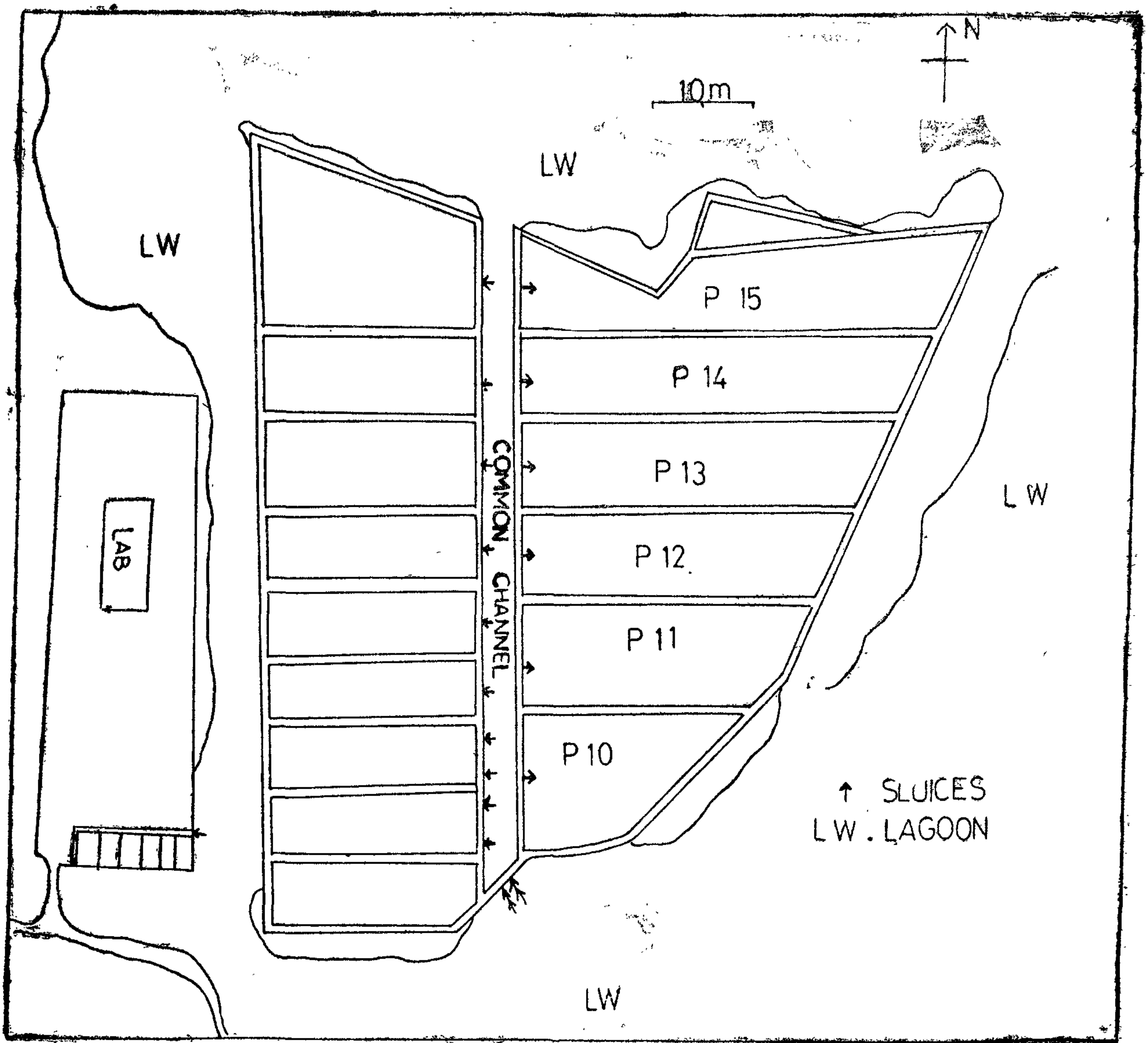

Fig. 1 —The lay out-of the experimental ponds at the Brackishwater Fisheries Station, Pitipana, Negombo.

could be taken only for 11 days. Temperature and salinity were measured using a Beckman RS 5–3 salinometer, pH using a glass-calomel electrode and oxygen by the Winkler method.

Two diurnal surveys were carried out to coincide with the spring equinox and the autumn equinox and during these surveys in addition to the measurement of above parameters at 4 hourly intervals, the mean tidal level at the middle of the main channel (*see* Fig. 1) was determined at hourly intervals.

At fortnightly intervals primary production was estimated for P 10 and P 13, randomly selected, using the light-dark bottle method, after an incubation period of 24 hrs. During these determinations the methods described and the precautions recommended by Vollenweider (1973) were followed. Plankton samples were collected from each pond using a 55 μ mesh Apstein quantitative net, each

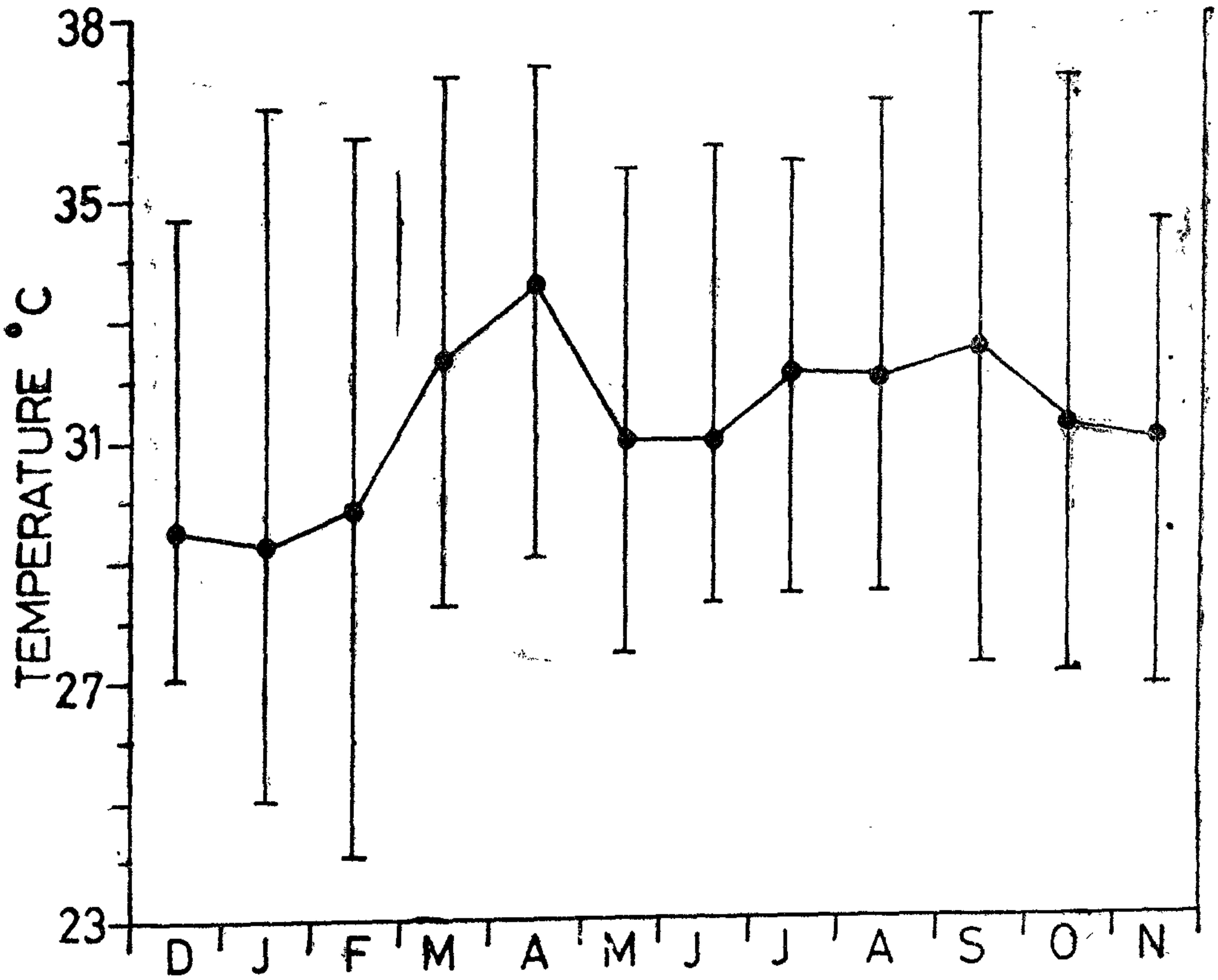

Fig. 2A.—Seasonal variation of the mean monthly temperature of the Ponds (the vertical lines indicate the range fo each month).

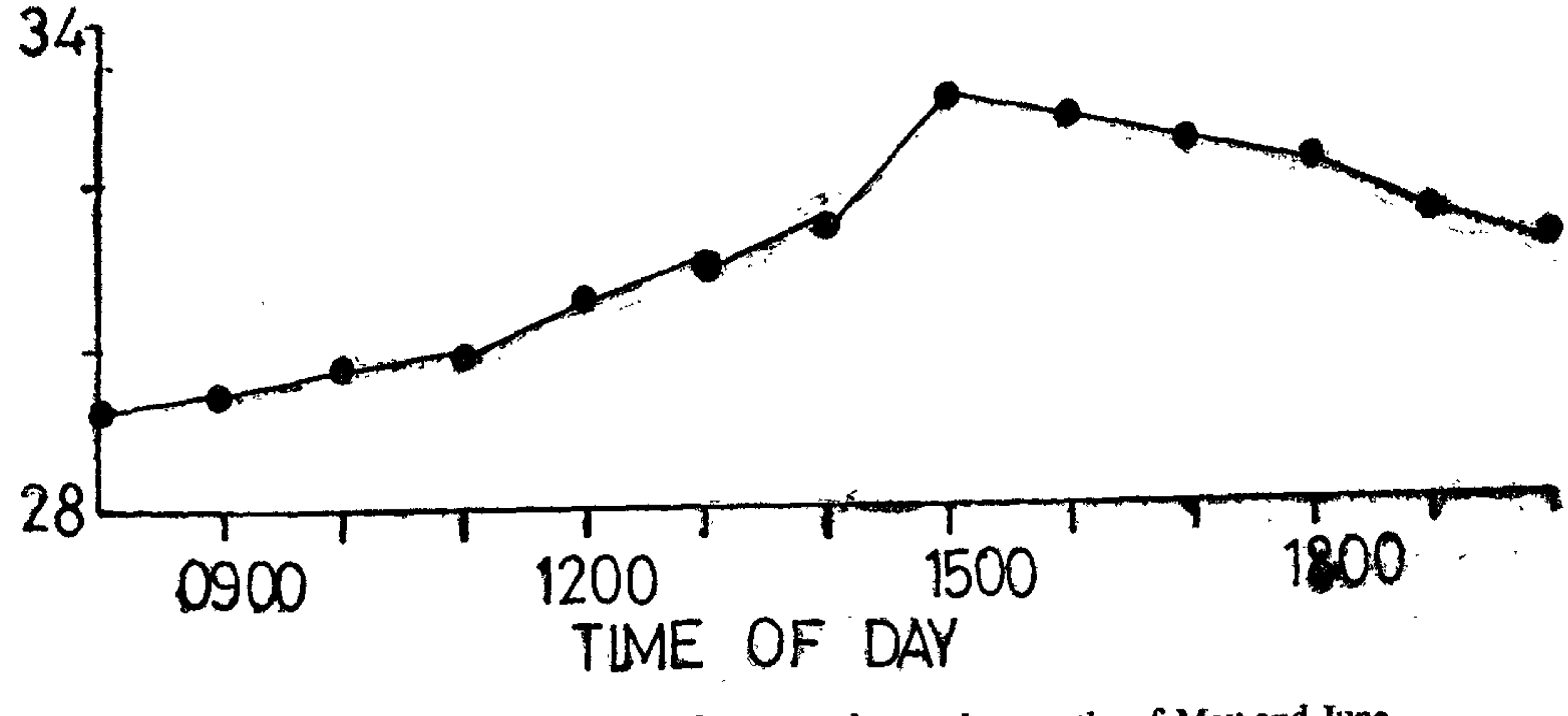

Fig. 2B.—The mean hourly temperature for the Ponds averaged over the months of May and June.

being collected by sweeping the net 10 times around a central point in the pond. Plankton samples collected were preserved in 4 per cent formalin for detailed analyses in the laboratory, and the results will be dealt with later.

Results

Tables I to III give the mean monthly temperature, salinity and the pH for each of the experimental ponds, together with the ranges for each month, respectively. Figures 2, 3 and 4 show the mean monthly temperature, salinity and pH with their ranges, respectively averaged for all the ponds. It is evident from Tables I to III that for any one parameter the differences between ponds are very small during any one calendar month. It is seen from Fig. 2 that the mean day-time temperatures reached the lowest value of 29.2°C in January and gradually increased to a maximum of 33.6°C in April. The mean hourly temperatures, through the day, averaged for the months of May and June, when measurements were taken, along with the degree of variation is shown in Fig. 2*b*. It is evident that the daily maxima occurred generally, as expected, between 1400–1500 hrs. and the difference between ponds were also found to be greatest at about that time.

It is clear from Fig. 3 that there are two peaks of increase in salinity, first around February and the second from June to September. It is also evident from both Fig. 2 and Table II that during certain months of the year, particularly in May and October, the salt content of the ponds could change drastically, from almost a completely saline condition to nearly fresh water. Also incorporated into Fig. 3*b* is the rainfall at the site during the study period and the monthly rainfall for Negombo, averaged for the last 10 years. A close study of the Figure reveals that the rainfall for the study period has followed the general pattern of rainfall and that there is a marked correlation between rainfall and salinity of the ponds ; the salinity being lower during the rainy months and vice versa. The changes in pH (Fig. 4) appears to follow that of salinity, with increases of pH almost coinciding with those of high salinity. It is also evident from Table III and Fig. 4 that the pH of the ponds remain alkaline throughout the year.

Tables IV and V and Fig. 5 give the dissolved oxygen content—its monthly mean and the range for individual Ponds and averaged for all the Ponds for each month, during the morning hours and in the afternoon respectively. It is evident from Fig. 5 that the dissolved oxygen content, either in the morning or in the afternoon, does not appear to show any predictable seasonal variation, and the monthly means are well above the stress levels for fish as well as for most aquatic organisms. However, it is seen from the ranges that the ambient oxygen levels could fall, on some days, to a low value such as 2.0 ppm, which could bring about stress or even death of fish, especially if the stocking densities are high.

The results of the two diurnal surveys are presented in Fig. 6. The dissolved oxygen content shows a marked pattern of variation, with a maximum of 12.5 mg 0/1 between 1400–1600 hr and reaching a minimum of 2.8 mg 0/1 during the early hours of dawn. It is also evident from the Fig. 6 that the salinity tends to remain constant (the slight drop in salinity during the survey in March was probably brought about by rain which fell down around 2000 hr and continued until 2200 hrs) and that there is little, if any change brought about by the tide.

The monthly mean production, both gross and net, for ponds 10 and 13 are given in Table VI. It is evident that production tends to increase from November and reaches a maximum in February. From the data given in Table VI a mean gross production of 1.639 gC/m^2/day or 5982.4 kgC/ha/yr and a net production of 0.559 gC/m^2/day or 2040.4 kgC/ha/yr is obtained.

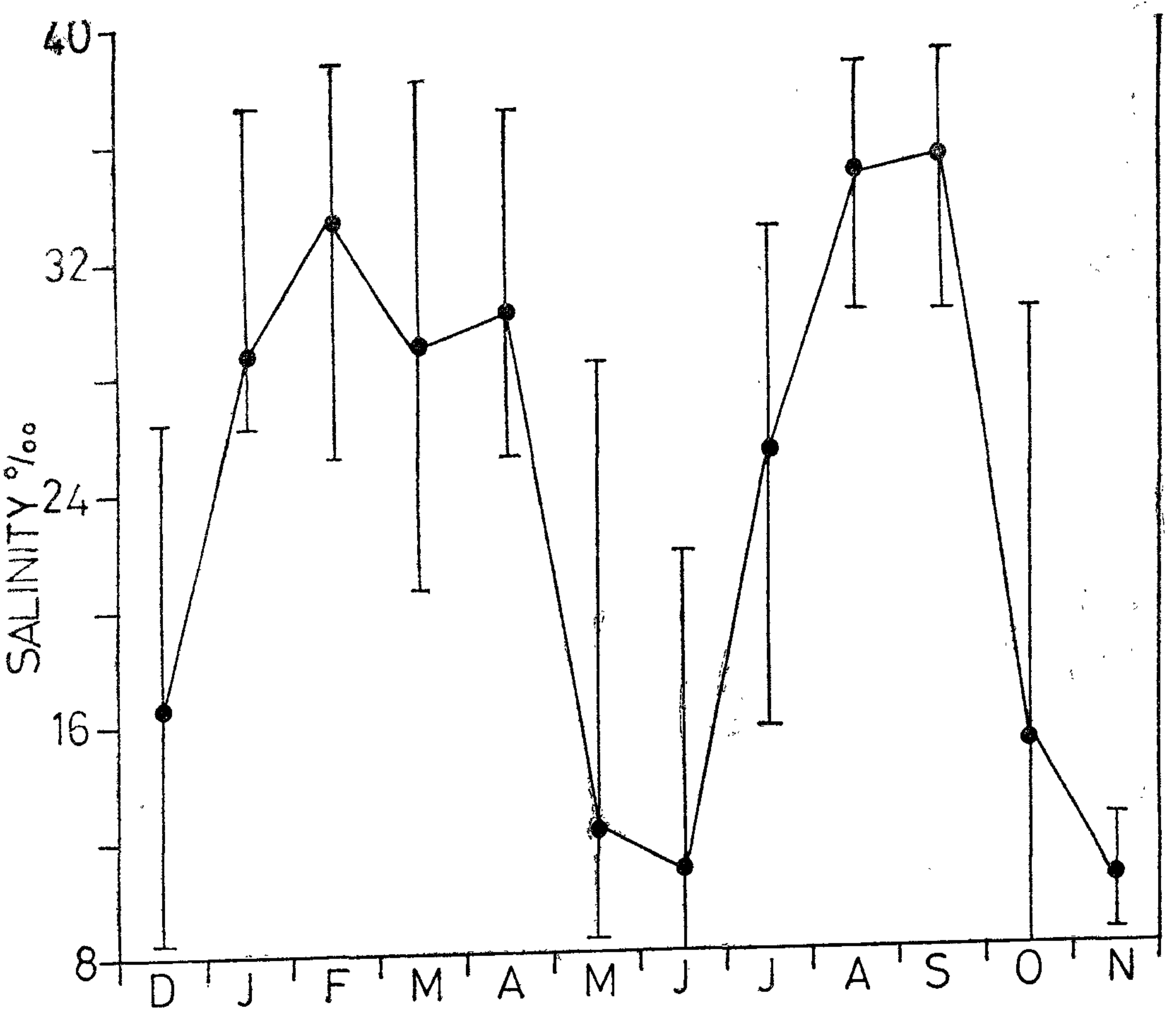

Fig. 3A.—Seasonal variation of the mean monthly salinity of the Ponds (the vertical lines indicate the range in salinity)

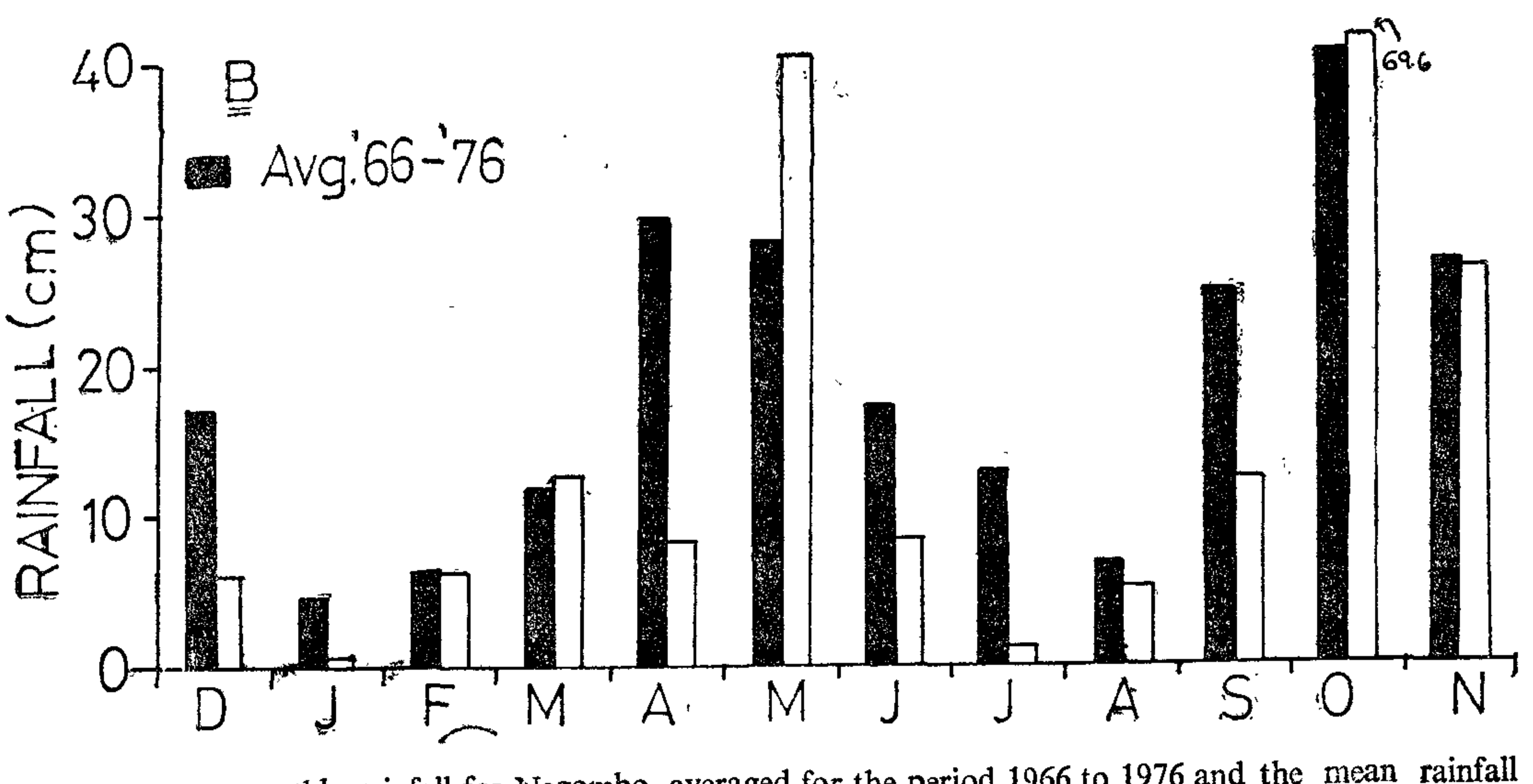

Fig. 3B.—The mean monthly rainfall for Negombo, averaged for the period 1966 to 1976 and the mean rainfall for the experimental period.

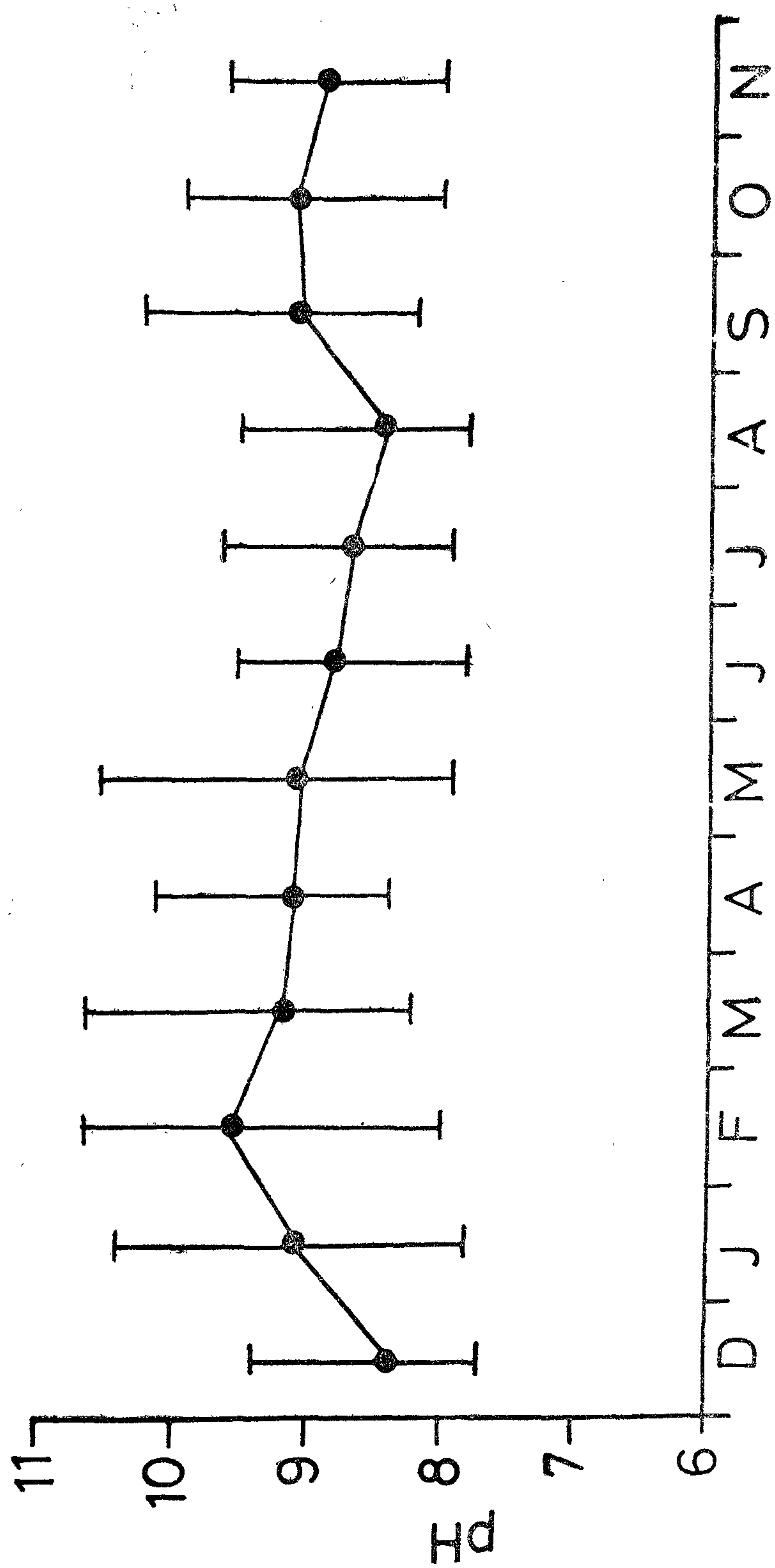

Fig. 4.—Seasonal variation of the mean monthly pH of the Ponds (the vertical lines indicate the range in pH).

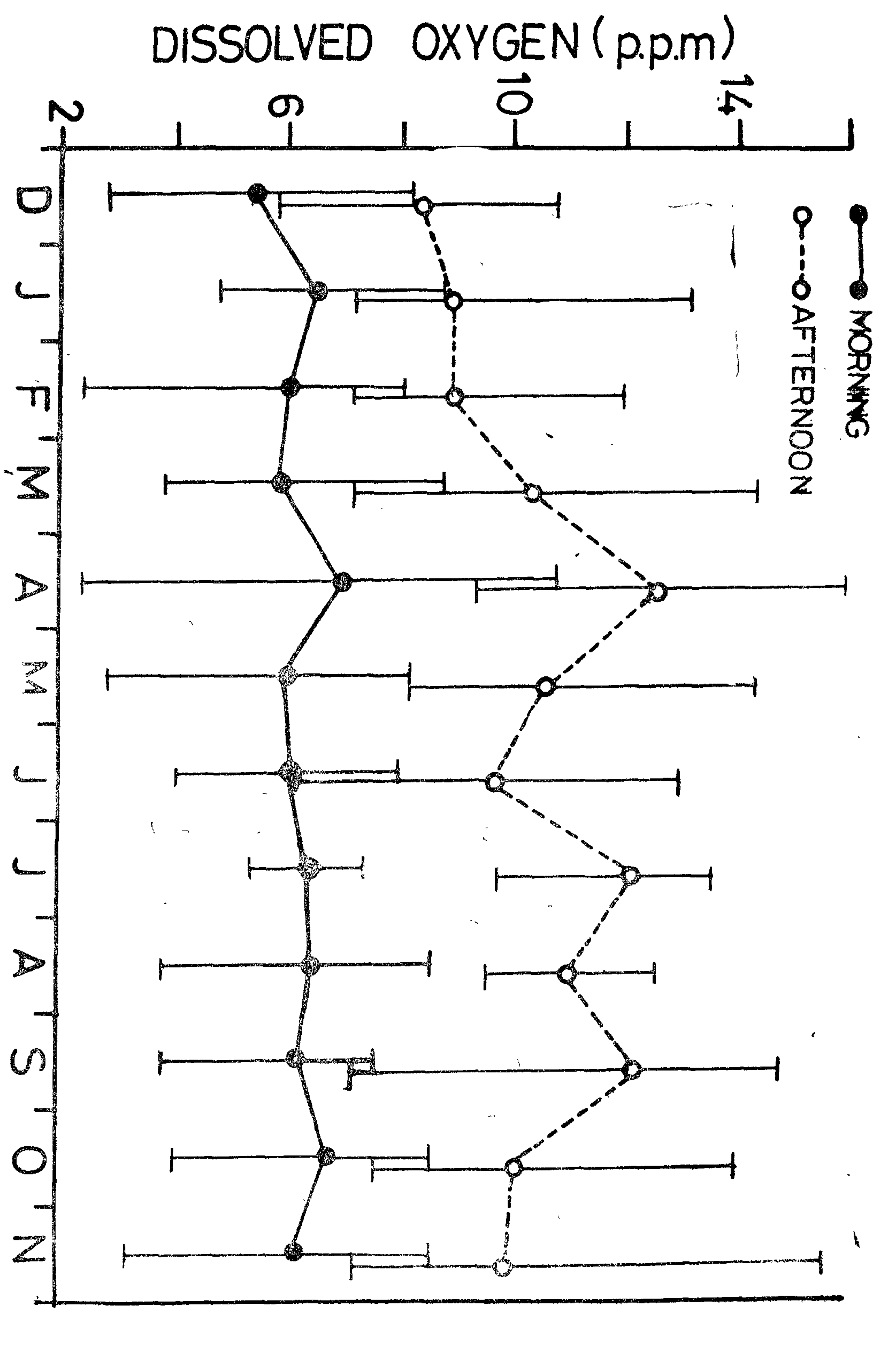

Fig. 5.—The mean monthly dissolved oxygen content of the water in the morning and in the afternoon (the vertical lines indicate the range in d.o. content.)

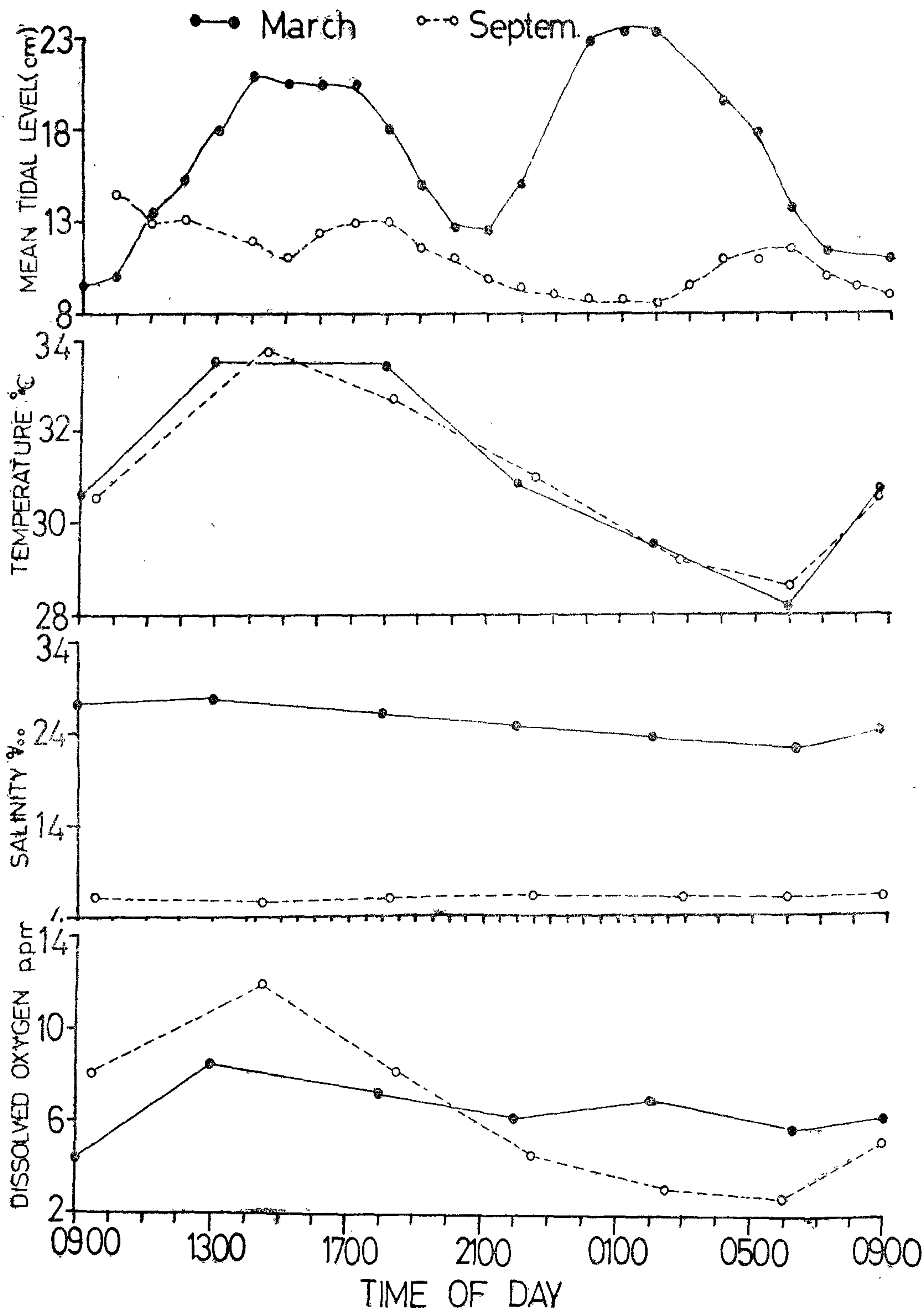

Fig. 6.—Diurnal variation of the mean tidal level, temperature, dissolved oxygen content, and the pH of the ponds.

DISCUSSION

At the outset itself it must be pointed out that the trends observed and described in this study follow the general pattern known hitherto for most tropical bodies of water. However, it is of importance to aquaculturists to be aware of the extremes and the nature of changes, both in time and space, of physico-chemical parameters in order to facilitate the selection of species to be cultured and also to avoid and minimise catastrophes that could possibly occur, for example, due to deoxygenation of the water.

It is seen that the seasonal and daily fluctuations of the physico-chemical parameters dealt with presently, except perhaps the dissolved oxygen content, are well within the tolerance limits of some of the popularly cultured estuarine fish species in the tropics like, *Tilapia mossambica, Mugil cephalus, Chanos, Chanos Siganus* sp. etc. In Sri Lanka the tidal fluctuation around the year is extremely small, and in the fish ponds even smaller. Further the diurnal surveys have indicated that the daily tides have little effect on the salinity in the ponds. It is also evident that the general seasonal pattern of salinity is determined primarily by the extent of the rainfall and during the dry period probably by amount of evaporation, seepage and tidal influx.

It is noteworthy to point out that on certain days the mean dissolved oxygen content could reach a very low value, which could even bring about death of fish. Similarly during the afternoons it could rise to very high levels, the highest observed being 16.0 mg 0/1, resulting in supersaturation of the water. Such a condition is equally harmful to fish because when supersaturation occurs the oxygen is trapped in minute bubbles from which the gills of fish are incapable of extracting oxygen for metabolism.

From the present data an average net production of 0.559 gC/m^2/day of 2040 kgC/ha/yr is obtained for the ponds. There are very little data available for estimates of production in estuarine waters in tropical areas, particularly from the Indian region. Qasim *et al.* (1969) found the average gross and net production of Cochin backwaters to be 2810 kgC/ha/yr and 1950 kgC/ha/yr respectively. On the basis of the present data and on the reasoning of Steele (1974), in that phytoplankton is almost completely utilized and average herbivore efficiency is about 20 per cent, the yield of fish from the ponds should be 408 kgC/ha/yr or using the conversion factor of 1gC=10 gm of fresh fish flesh (Winberg, 1956) a total herbivore fish production of 4080 kg/ha/yr is obtained. This is about 8 times the observed fish production of 524.7 kg/ha/yr. for 1975 in Parakrama Samudra which has the highest inland fish production of the inland reservoirs (Mendis, 1976).

Therefore it is evident from this study that even though there is a very low tidal effect along the west coast of Sri Lanka, the other important physical characteristics appear to be conducible for fish culture and moreover the very high primary production is indicative of the potential of the harvest, even without manuring and other inputs.

ACKNOWLEDGEMENTS

This work was carried out as part of a feasibility study on fish culture in estuarine waters of Sri Lanka and was supported by grants from the National Science Council of Sri Lanka and the International Foundation for Science, Stockholm, Sweden, to the first author. We are most grateful to the Director of Fisheries for granting us the use of facilities at the Brackishwater Stations and to all its staff for their co-operation.

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TABLE I

Range and the Mean Monthly Temperature (°C) of the Experimental Ponds

(The range is given within brackets)

Month	*Pond* 10	11	12	13	14
December ..	—	—	29.2 (27.0–32.0)	29.6 (27.1–34.6)	29.8 (27.1–34.7)
January ..	29.3 (25.0–32.9)	28.7 (25.2–31.6)	29.2 (25.6–32.5)	29.2 (25.1–33.2)	29.5 (25.7–36.5)
February ..	30.4 (25.0–36.0)	29.5 (25.7–34.2)	29.1 (24.1–35.4)	30.0 (24.3–35.5)	30.0 (24.4–34.8)
March ..	32.8 (29.2–37.9)	32.2 (28.2–36.9)	33.4 (29.2–36.5)	32.5 (29.7–36.3)	32.8 (28.5–37.0)
April ..	34.0 (31.0–37.2)	33.7 (29.0–37.2)	33.8 (30.0–37.0)	33.6 (30.1–36.8)	32.8 (30.0–36.8)
May ..	31.09 (27.7–35.5)	30.9 (28.2–35.2)	30.9 (27.4–34.7)	30.9 (28.5–34.6)	30.8 (27.5–34.0)
June ..	31.07 (28.4–35.0)	31.3 (28.2–35.9)	31.04 (28.4–34.8)	30.9 (28.4–34.6)	31.0 (28.3–34.6)
July ..	32.16 (28.6–35.6)	32.0 (28.7–35.5)	31.97 (28.4–35.0)	32.2 (29.4–34.6)	32.4 (30.0–34.8)
August ..	32.16 (28.6–35.9)	32.2 (28.4–36.6)	31.6 (28.6–35.0)	32.5 (29.0–35.8)	32.0 (29.1–35.5)
September ..	32.20 (27.2–38.2)	31.73 (27.7–38.2)	32.83 (27.7–38.0)	32.88 (29.1–38.7)	32.97 (29.4–38.2)
October ..	31.43 (27.1–35.2)	31.22 (27.1–35.4)	31.41 (27.2–35.5)	31.28 (27.0–36.2)	31.4 (27.2–38.2)
November ..	30.7 (27.3–35.0)	30.71 (27.2–34.6)	31.42 (27.2–34.8)	31.45 (27.4–34.6)	31.34 (27.5–34.8)

TABLE II

Range and the Mean Monthly Salinity Percentage of the Experimental Ponds

(The range is given within brackets)

Month	*Pond* 10	11	12	13	14
December..	—	—	21.9 (9.5–26.2)	9.2 (7.5–10.9)	19.10 (11.1–26.5)
January ..	33.6 (29.0–36.5)	32.5 (28.0–37.3)	32.1 (27.4–35.2)	14.5 (16.0–19.0)	31.5 (26.3–36.0)
February	36.2 (28.2–39.7)	36.9 (33.8–40.4)	35.3 (30.6–38.8)	22.4 (10.1–25.2)	36.7 (25.6–38.9)
March ..	30.4 (20.6–37.0)	33.7 (24.6–38.2)	31.0 (24.9–36.9)	20.0 (12.4–23.4)	30.3 (23.4–36.8)
April ..	33.0 (27.8–31.4)	33.5 (29.2–37.2)	31.8 (26.6–34.9)	22.2 (17.5–25.8)	30.5 (25.2–33.7)
May ..	10.8 (5.6–28.4)	14.6 (10.9–27.2)	13.3 (16.0–26.2)	11.6 (7.0–23.2)	11.1 (6.06–24.8)
June ..	11.4 (4.5–21.8)	11.8 (5.4–18.0)	12.29 (5.4–19.2)	8.2 (5.9–15.5)	10.5 (6.9–14.6)
July ..	28.6 (22.7–32.8)	26.2 (18.8–31.4)	26.6 (19.03–32.4)	21.0 (15.7–26.4)	24.9 (15.8–33.0)
August ..	37.8 (36.3–38.7)	33.4 (30.0–36.6)	34.5 (30.0-36.6)	34.7 (30.1–36.4)	34.7 (32.8–36.1)
September	36.15 (27.26–38.96)	36.01 (26.33–36.62)	36.4 (28.78–37.28)	32.50 (27.62–39.82)	35.70 (31.51–37.57)
October ..	16.29 (7.27–30.3)	15.59 (8.48–25.75)	16.219 (9.09–29.65)	13.87 (6.96–29.81)	13.38 (7.87–30.30)
November	10.52 (10.30–12.15)	11.27 (10.30–12.40)	11.388 (10.12–12.728)	9.893 (9.212–10.92)	11.23 (10.605–12.46)

TABLE III

The Range and the Mean Monthly Dissolved Oxygen Content (mg /1) at 0900 Hours in the Experimental Ponds

(The range is given within brakets)

Month	Pond 10	Pond 11	Pond 12	Pond 13	Pond 14
December	—	—	5.12 (2.8–7.2)	5.67 (3.2–8.2)	5.52 (3.2–7.7)
January	5.94 (4.8–7.8)	6.55 (5.2–8.0)	6.99 (6.4–8.0)	6.98 (6.0–8.8)	6.27 (5.7–7.6)
February	5.78 (4.4–6.8)	6.23 (2.4–7.2)	6.29 (3.2–8.0)	6.24 (3.8–8.0)	5.94 (3.2–8.1)
March	6.11 (4.0–6.8)	5.95 (4.0–8.8)	5.75 (3.8–7.8)	6.23 (4.2–8.0)	6.03 (4.2–8.6)
April	6.72 (2.4–10.6)	7.57 (4.4–10.4)	5.94 (4.0–9.6)	7.81 (5.8–10.8)	8.51 (4.0–10.8)
May	5.53 (3.4–7.2)	6.4 (4.8–8.0)	5.41 (2.8–7.4)	6.64 (2.8–8.4)	6.19 (4.2–8.0)
June	5.6 (4.0–8.0)	6.47 (5.4–7.8)	6.08 (5.4–7.6)	6.24 (5.4–8.0)	6.28 (5.6–7.4)
July	6.4 (5.8–7.2)	6.6 (6.4–7.2)	6.13 (5.4–6.4)	6.6 (6.2–7.4)	6.53 (6.0–6.8)
August	6.6 (6.2–7.4)	6.2 (5.8–6.8)	6.45 (6.2–7.2)	7.1 (6.8–7.6)	6.25 (5.8–6.8)
September	6.0 (4.2–7.2)	6.81 (6.2–7.6)	6.42 (5.8–6.8)	5.37 (3.8–6.6)	6.36 (5.2–7.6)
October	6.60 (5.6–8.6)	7.16 (6.0–8.0)	6.95 (6.4–8.2)	6.91 (4.2–8.2)	6.67 (4.0–8.2)
November	6.52 (5.6–7.2)	7.08 (6.2–8.6)	6.68 (6.0–7.2)	4.77 (3.4–7.2)	5.52 (3.2–6.8)

TABLE IV

The Range and the Mean Monthly Dissolved Oxygen Content (mg/l) at 1500 Hours in the Experimental Ponds

(The range is given within brackets)

Month	*Pond*				
	10	*11*	*12*	*13*	*14*
December	—	—	6.87 (4.0–8.0)	8.51 (5.6–10.8)	6.91 (5.7–8.6)
January	8.24 (7.6–10.1)	8.7 (7.8–10.4)	9.51 (8.0–12.2)	9.83 (8.0–13.2)	8.30 (7.2–9.6)
February	8.65 (7.2–10.2)	8.69 (7.8–10.2)	9.31 (7.8–11.5)	9.49 (7.8–12.0)	8.80 (7.2–10.4)
March	10.57 (7.2–14.0)	10.17 (8.2–13.2)	10.56 (8.2–13.8)	10.60 (7.8–14.4)	10.30 (8.0–13.8)
April	12.65 (10.2–14.0)	12.98 (9.4–14.4)	11.60 (10.4–13.6)	13.15 (11.0–16.0)	12.93 (10.0–15.2)
May	10.04 (8.4–12.8)	10.79 (7.8–12.8)	10.14 (8.2–12.6)	12.5 (8.6–14.4)	10.2 (8.2–12.6)
June	9.02 (6.2–10.8)	9.9 (7.8–12.6)	9.7 (7.2–12.8)	10.57 (8.6–13.0)	9.4 (7.2–12.0)
July	11.5 (9.8–12.2)	12.1 (9.8–13.6)	12.0 (9.8–13.4)	12.27 (10.4–12.4)	12.67 (10.4–13.2)
August	10.8 (10.8–12.4)	10.05 (9.6–10.4)	11.15 (10.4–12.2)	12.55 (10.6–12.6)	11.1 (10.4–12.4)
September	11.94 (7.2–15.2)	12.91 (8.6–14.8)	12.2 (7.2–15.4)	13.04 (8.4–14.8)	11.2 (9.2–14.8)
October	10.33 (7.6–13.2)	10.11 (9.4–14.00)	10.27 (9.0–13.6)	10.12 (8.2–12.4)	9.52 (8.0–11.8)
November	8.66 (8.2–10.08)	13.37 (11.8–15.6)	12.05 (9.6–13.2)	10.76 (8.8–12.8)	9.75 (7.2–12.2)

TABLE V

The Range and the Mean Monthly pH Value of the Experimental Ponds

(The range is given within brackets)

Month	*Pond* 10	11	12	13	14
December	—	—	8.25 (7.7–8.7)	8.52 (7.8–9.4)	8.47 (7.7–8.9)
January	8.85 (8.6–9.6)	8.80 (8.3–10.3)	9.54 (8.3–10.4)	9.4 (8.9–10.2)	8.92 (7.8–9.4)
February	8.96 (8.0–9.8)	9.8 (8.1–10.6)	9.12 (8.2–9.8)	9.52 (8.5–10.6)	10.3 (8.2–10.3)
March	9.01 (8.5–9.6)	9.21 (8.7–9.8)	8.83 (8.7–9.5)	9.42 (8.7–10.6)	9.41 (8.2–10.4)
April	9.02 (8.6–9.5)	8.97 (8.8–9.7)	8.96 (8.4–9.5)	9.29 (8.7–9.7)	9.38 (8.9–10.1)
May	8.69 (7.9–9.2)	9.14 (8.3–10.1)	8.81 (2.9–9.4)	9.4 (8.6–10.5)	9.27 (8.9–10.4)
June	8.29 (7.8–8.8)	9.14 (8.7–9.4)	8.35 (7.8–9.0)	9.19 (8.9–9.5)	9.09 (8.7–9.4)
July	8.39 (8.0–8.7)	8.6 (8.1–9.0)	8.77 (7.9–9.4)	9.03 (8.1–9.4)	8.83 (8.6–9.6)
August	8.35 (8.0–8.5)	8.3 (7.9–8.7)	8.31 (7.8–8.6)	8.6 (7.8–9.4)	8.71 (8.1–9.2)
September	8.76 (8.05–9.5)	9.05 (8.2–10.2)	9.19 (8.2–10.3)	9.10 (8.3–10.3)	9.12 (8.25–10.2)
October	9.13 (8.55–9.80)	9.04 (8.25–9.65)	9.00 (8.05–9.8)	9.06 (8.10–10.0)	9.04 (8.20–9.90)
November	8.91 (8.3–9.25)	9.17 (8.5–9.6)	8.97 (8.05–9.6)	8.84 (8.00–9.5)	8.78 (8.25–9.35)

TABLE VI

Mean Monthly Gross and Net Primary Production (gC/m²/day) for Ponds 10 and 13

Month	*Pond 10*		*Pond 13*	
	Gross	*Net*	*Gross*	*Net*
January	1.897	0.292	1.791	0.294
February	6.273	4.194	5.640	3.700
March	1.593	0.396	1.863	0.297
April	0.630	0.108	0.432	0.108
May	0.430	0.144	0.522	0.136
June	0.594	0.072	0.594	0.089
July	—	—	—	—
August	0.528	0.038	0.675	0.120
September	0.742	0.072	0.450	0.018
October	0.675	0.096	0.540	0.094
November	0.575	0.090	0.684	0.105
Mean	1.396	0.622	1.318	0.496