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Algal biomass and pigment diversity in typical tropical fish ponds

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Abstract: Chlorophyll distribution, phytoplankton biomass and pigment diversity were investigated at fortnightly intervals, in eight fish ponds located in Ile-Ife, Nigeria. Except for stations 6 and 7, the diatoms were the most prominent phytoplankton group while the chlorophyceae were less prominent. Peak periods of chlorophyll-*a* coincided with peak periods of nutrient availability and generally, the stations recorded high algal biomass. Margalef Index (M.I.) ratios were negatively correlated with both gross and net production while the latter were positively correlated with chlorophyll-*a* but negatively correlated with chlorophylls *b* and *c*. In terms of phytoplankton diversity, station 7 recorded the least number of species while the maximum number was recorded in station 4.

Resumen: Se investigó la distribución de la clorofila, biomasa del fitoplancton y diversidad de pigmentos en intervalos catorcenales, en ocho estanques de peces localizados en Ile-Ife, Nigeria. Excepto para las estaciones 6 y 7, las diatomeas fueron el grupo de fitoplancton más importante mientras que el menos prominente fue el de las clorofilaceae. De los períodos con picos de clorofila, uno coincidió con el de disponibilidad de nutrientes y, en general, las estaciones registraron una alta biomasa algal. Las tasas del Índice de Margalef (M.I.) estuvieron correlacionadas negativamente tanto con la producción bruta como con la neta, mientras que la última estuvo positivamente correlacionada con la clorofila a, pero negativamente correlacionada con las clorofilas *b* y *c*. En terminos de la diversidad del fitoplancton, las estación 7 registró el menor número de especies, mientras que el número máximo fue observado en la estación 4.

Resumo: A distribuição clorofilina, biomassa do fitoplâncton e a diversidade pigmentar foram investigados em intervalos de quinze dias em oito tanques piscícolas localizados em Ile-Ife, Nigéria. Excepto para as estações 6 e 7, os diatomas foram o grupo de fitoplâncton mais proeminente enquanto a chlorophycea foi a menos frequente. Os picos de clorofila a coincidiram com os picos de disponibilidade em nutrientes e, geralmente, as estações que registaram ratios mais elevados do índice de Margalef (M.I.) da biomassa das algas estavam negativamente correlacionadas quer com a produção bruta quer com a produção líquida enquanto que esta última estava positivamente correlacionada com a clorofila *a* e negativamente correlacionada com a clorofila *b* e *c*. Em termos da diversidade do fitoplâncton, a estação 7 registou o menor número de espécies enquanto o número máximo foi registado na estação 4.

Key words: Phytoplankton biomass, pigment, diversity, tropical fish ponds.

Introduction

Phytoplankton are of great ecological significance since they comprise the major portion of primary producers in the aquatic environment. They are, like the plants on land, the basic food in the aquatic environment for all consumers such as zooplankton and fish. The algal biomass of phytoplankton can be expressed as numbers of organisms per unit volume but since plankton population vary greatly in their size distribution, numbers alone do not give adequate picture of population dynamics or of the diversity and structure of the ecosystem (A.P.H.A. 1980).

The use of photosynthetic pigments as predictors of algal biomass is widely known (Fogg 1975) and mainly because the pigments are specific to plants and their determination is relatively simple and straightforward (Moses 1979). Of all the pigments, chlorophyll-*a* is the most widely used measure of phytoplankton biomass because it constitutes approximately 1-2% the dry weight of phytoplanktonic algae and is the preferred indicator for algal biomass estimates (A.P.H.A. 1980).

Perhaps the most important reason for preferring chlorophyll *a* in phytoplankton biomass determination is that it is the main photosynthetic pigment in all oxygen-evolving photosynthetic organisms while other algal pigments (chlorophylls *b* and *c*, carotenoids and phycobillins), have limited distribution and are, therefore, considered as accessory or secondary pigments (Akpan 1994). A pigment diversity could be computed according to the way plant pigments are distributed among different molecular species. It is assumed that the simple pigment ratio D_{430}/D_{665} (or Margalef Index ratio) gives a rough estimate of such diversity. As used by Margalef (1964), the Margalef Index ratio is roughly the ratio of the ‘yellow/green’ pigments of the plant population and it has been found to be well correlated with the biotic diversity as well as other indices of community structure and can be used to determine maturity or succession within a community.

The present study aimed at estimating the photosynthetic pigments (chlorophylls *a, b* and *c*) and relating them to the phytoplankton composition as well as determining the phytoplankton biomass and the pigment diversity of the study fish ponds.

Study area

The eight fish ponds used for this study are located in Ile-Ife, Osun State of Nigeria. The climate of Ile-Ife which is governed by the southwest and the northeast winds, is characterised by distinct wet (or rainy) and dry seasons. The wet season starts from April and lasts till about the middle of October, while the dry season lasts for the remaining part of the year.

The rainfall regime is characterized by two peaks. A minor peak occurs either in September or October while the major peak occurs between June and July each year. There is abundant sunshine throughout the year, and temperatures are more or less equable, with very low ranges of variation (Fig. 1).

Materials and methods

Surface water samples were collected at fortnightly intervals, from the study ponds in clean, 1 litre plastic containers and taken to the laboratory for analyses which were carried out within five hours of sample collection.

Chlorophyll pigments were determined according to Golterman (1969). Water sample (100 ml) was filtered through a millipore filter paper (size, 0.15) and one or two drops of magnesium carbonate suspension was added as an aid to retention, besides guarding against the development of acidity in the filtrate. Pigments were extracted from the filtrate using 90% acetone and the optical density of the solution was determined spectrophotometrically at wavelengths 750 Å, 663 Å, 645 Å, 630 Å and 430 Å (Strickland & Parsons 1960). To obtain extinction due to chlorophyll alone, the background extinction value at 750 Å was subtracted from values at other wavelengths, and the various chlorophylls were calculated from the equations of Strickland & Parsons (1960) listed below.

$$\text{Chl } a \ (\text{mg l}^{-1}) = 15.6\ D^1_{663} - 2.0\ D^1_{645} - 0.8\ D^1_{630}$$

$$\text{Chl } b \ (\text{mg l}^{-1}) = 25.4\ D^1_{645} - 4.4\ D^1_{663} - 10.3\ D^1_{630}$$

$$\text{Chl } c \ (\text{mg l}^{-1}) = 109\ D^1_{630} - 12.5\ D^1_{663} - 28.7\ D^1_{645}$$

where,

$D^1_{663} = D^1_{665} - D^1_{750}$

$D^1_{645} = D^1_{645} - D^1_{750}$ and

$D^1_{630} = D^1_{630} - D^1_{750}$

From the above, the Margalef Index (M.I.) ratio was calculated, from the equation given below :

$$M.I. = D^{1}_{430} / D^{1}_{663} \quad \text{(Margalef 1964)}$$

Results

Variation in the concentrations of chlorophylls *a*, *b* and *c* followed similar pattern in stations 1,2,3,4 and 8 (Fig. 2) with maximum concentrations occurring in the second half of May. Thereafter, no particular pattern was observed till the end of the sampling. Two chlorophyll maxima were recorded in station 5 in the course of the study, a minor one occurring in the second half of April while the major one was observed in the first half of July. Stations 6 and 7, however, did not follow any particular trend throughout the study period.

Except in stations 6 and 7, where chlorophyll *a* was the dominant pigment, chlorophyll c was always the dominant pigment in the study ponds while chlorophyll *b* was the least (Fig. 3). Margalef Index (M.I.) values ranged from 1.5 in station 7 to a maximum of 9.6 in station 4 (Fig. 4). The relationships amongst various chlorophylls, gross and net productivity values and Margalef Index ratios (M.I.), reflected in the correlation matrix (Table 1), show both positive and negative correlations between the parameters. None of the parameters was positively correlated with Margalef Index (M.I.) while highly positive and significant relationships were observed between gross and net production (r = 0.897) and between chlorophyll *b* and chlorophyll *c* (r = 0.897). Chlorophyll a was highly correlated with both the gross and net productivity with correlation coefficient values of 0.528 and 0.546, respectively.

Discussion

Except for the first six weeks of study during which regular patterns of variation were observed for all the stations (except stations 6 & 7), there were widespread fluctuations in the values of the various chlorophyll pigments. Similarly, Akpan (1993) observed wide variations in chlorophyll a concentrations in the Cross River System of Nigeria. According to him, this could be due to change in the species composition of the phytoplankton as could also be the case in the preset study. Ac-

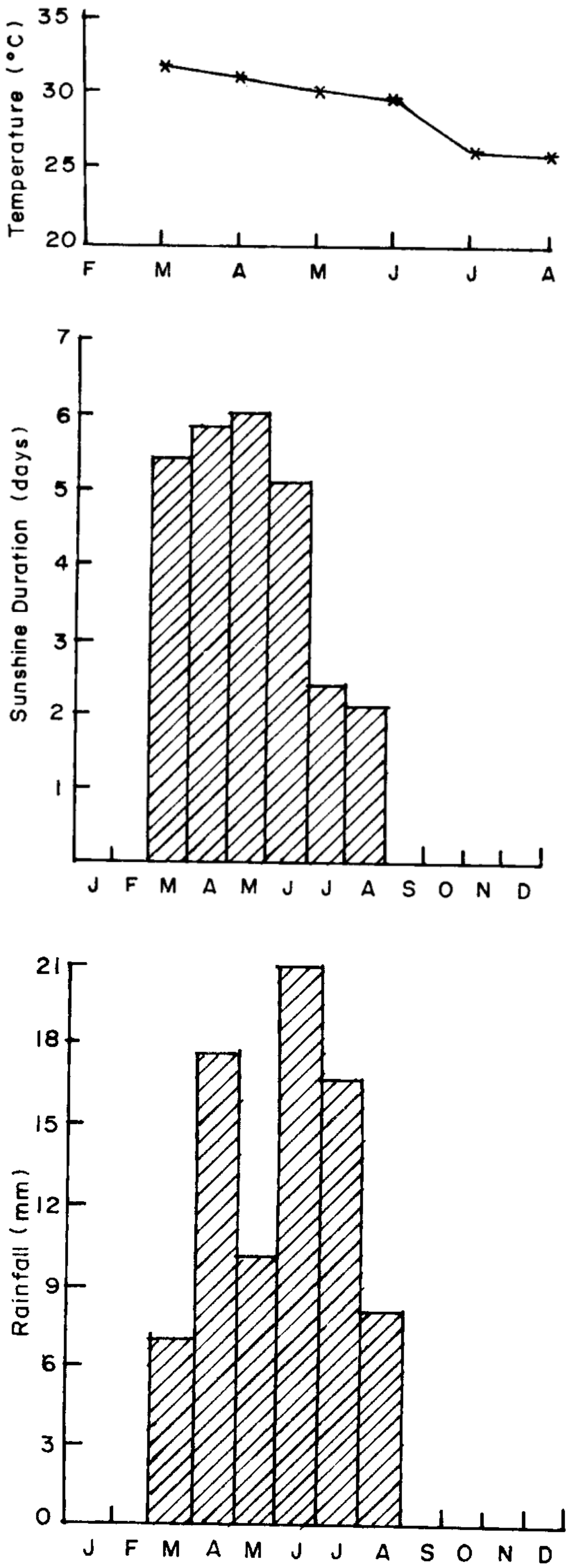

Fig. 1. Rainfall, temperature and sunshine patterns of the study area; data obtained from Obfemi Awolowo University Weather Station.

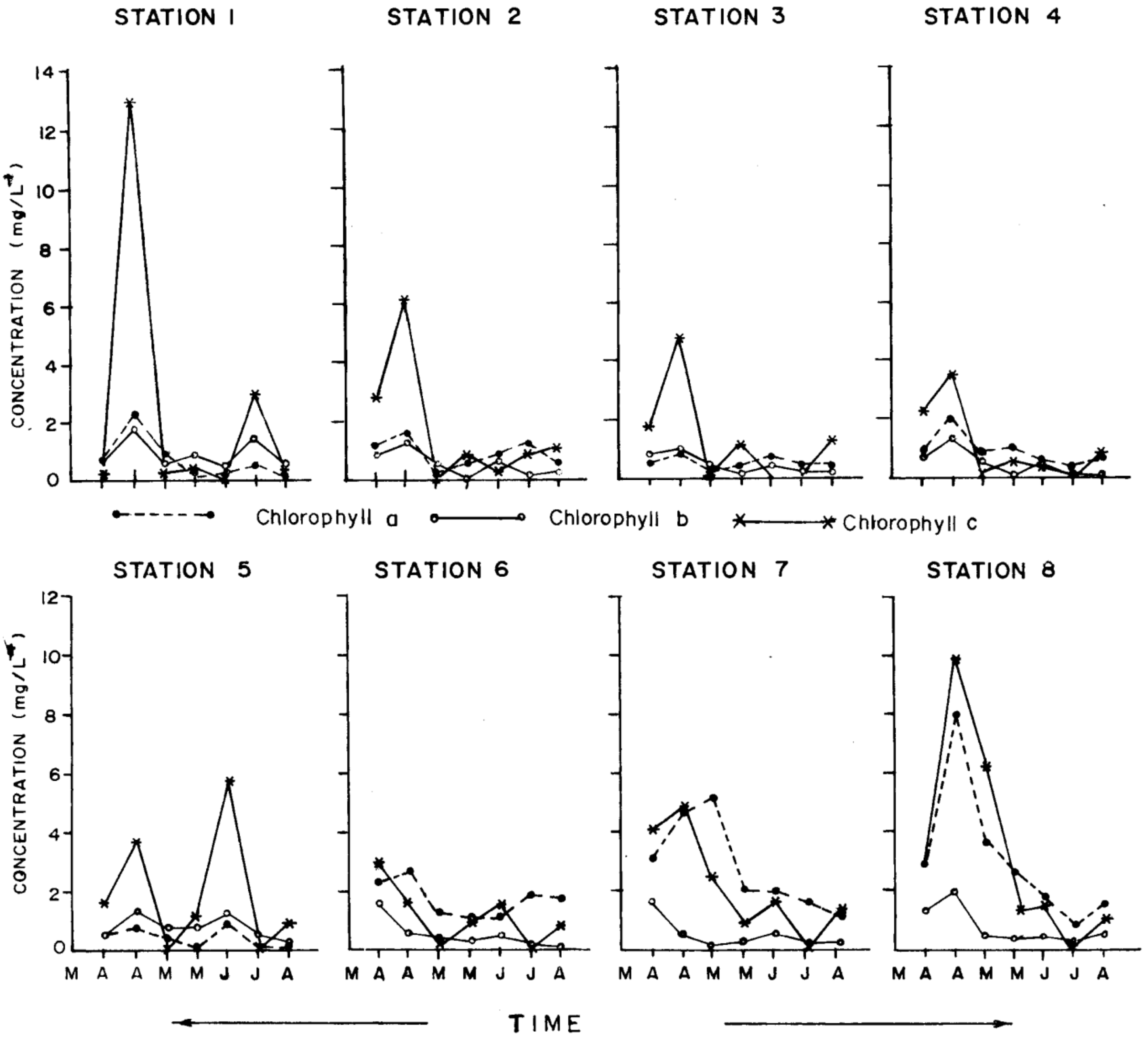

Fig. 2. Variation of the chlorophyll pigments in the study area.

cording to Swingle (1947), even in heavily fertilized ponds, two communities did not have the same appearance either to the naked eye or to the microscope as careful observation shows their appearance to change daily and even at various times during the same day. The implication of this is that phytoplankton communities show unpredictable changes at any time of the same day, week or month, and this is also true of the present study.

In terms of pigment distribution (Fig. 3), chlorophyll *c* has been observed to be the dominant pigment. Since the pigment is usually associated with diatoms, especially with the photosynthetic dinoflagellates (Richards 1952; Strain & Manning 1942a; Strain *et al.* 1943) the most abundant group of phytoplankton in the study ponds (except ponds 6 and 7), are without doubt, the diatoms.

Early suggestions that chlorophyll *b* was also present in diatoms (Pace 1941) have since been disproved and the presence of this pigment has been substantiated only with the chlorophyceae (Dutton & Manning 1941; Gardiner 1943; Richards 1952; Seybold & Egle 1938). There is little won-

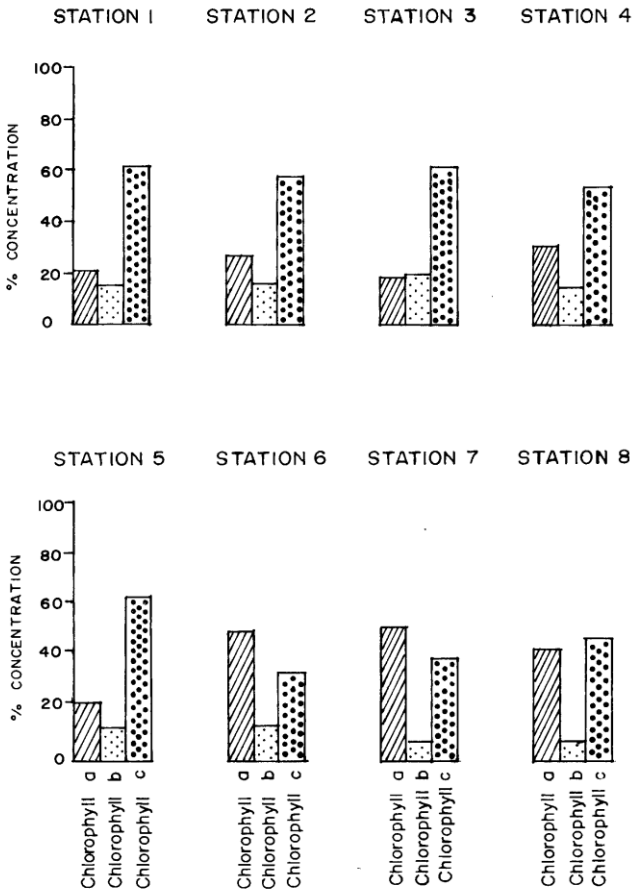

Fig. 3. Distribution of the various chlorophyll pigments in the study ponds.

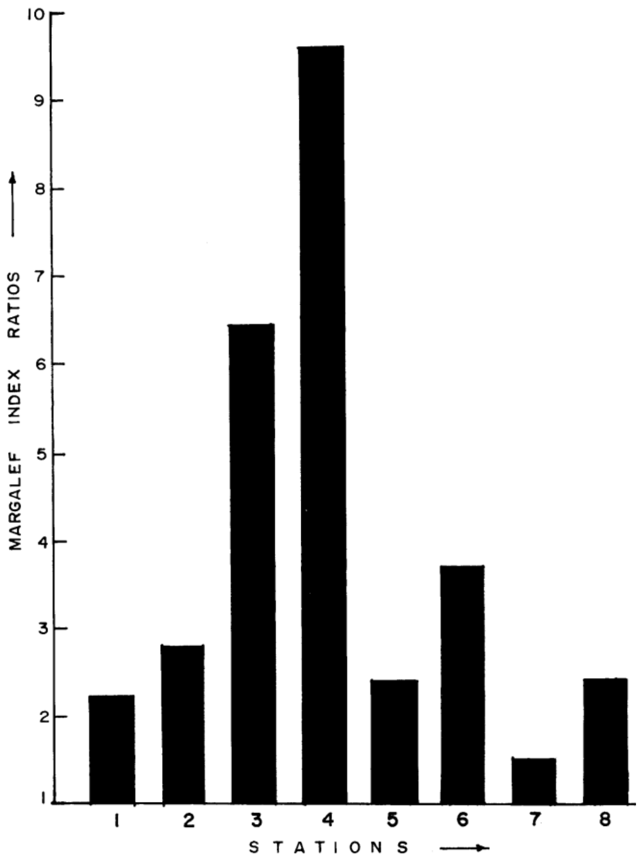

Fig. 4. Margalef Index ratios of the study ponds.

der, therefore, that values of this pigment (chlorophyll b) was the least in all the stations.

The use of chlorophyll *a* in the prediction of algal biomass is widely known. Like other chlorophyll pigments, peak values of chlorophyll *a* were obtained between April and May and thereafter, values maintained irregular patterns of variation till the end of the study (August). The observed periods of peak algal production coincides with the onset of the rainy season during which nutrients are washed via run-offs, into the ponds to cause algal blooms. The fall in the values of the pigment after the bloom could be attributed to a number of factors such as nutrient depletion from the environment as well as sinking of the phytoplankton cells to the bottom of the ponds. Besides, the increased nutrient input could also give rise to increased zooplankton production which would in turn, reduce the phytoplankton biomass through grazing as earlier observed by Akpan (1994), for

Table 1. Relationship between chlorophyll values, productivity and Magalef Index (M.I.) ratios.

	Chl. *a*	Chl. *b*	Chl. *c*	Gross Productivity	Net Productivity	M.I.
Chlorophyll *a*	1.000					
Chlorophyll *b*	0.347	1.000				
Chlorophyll *c*	0.019	0.749	1.000			
Gross Productivity	0.528	-0.108	0.058	1.000		
Net Productivity	0.546	-0.056	0.005	0.897	1.000	
Margalef Index	-0.081	-0.081	-0.118	-0.178	-0.140	1.000

$P \leq 0.05$ ($r = 0.251$); $P \leq 0.01$ ($r = 0.354$); $P \leq 0.001$ ($r = 0.443$)

the Cross River Estuary. The interrelationships between the various chlorophylls, gross and net productivity and Margalef Index ratios (M.I.) are summarized in the matrix of correlation coefficient values shown in Table 1. Margalef Index ratios were negatively correlated with both net and gross productivity, values being r = -0.140 and r = -0.178 respectively. Similar results were obtained by Margalef (1964) for some freshwater phytoplankton populations. Also, as would be expected, both gross and net productivity were positively correlated with chlorophyll *a* concentration and negatively correlated with chlorophylls *b* and *c*. In terms of phytoplankton diversity, station 7 recorded the minimum number of phytoplankton species (M.I. = 1.52) while the maximum was recorded for station 4 M.I. = 4.3) because according to Margalef (1971), biotic diversity has a minimum when all cells belong to the same species and a maximum when every individual belongs to a different species.

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