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PHYTOPLANKTON DISTRIBUTION IN COCHIN BACKWATERS — A SEASONAL STUDY

JAYALAKSHMY, K. V., S. KUMARAN AND M. VIJAYAN
National Institute of Oceanography, Regional Centre, Cochin-682 018.

ABSTRACT

Skeletonema costatum was the most abundant species in all the 3 stations. The distribution of *Asterionella japonica* was least consistent than that of *Nitzschia closterium* which was most consistent at Station 1. At station 2,29.3% of the species were found to coexist. Temperature, salinity and oxygen were insignificant in predicting the abundance of the species in the three stations. The species abundance differ significantly station-wise and species-wise but not season-wise.

Mac Arthur's measure of equitability which was used to find species diversity, indicated that sample community has a species diversity "appropriate" to a community of only 40%, 20% & 27% of the species actually observed in the 1st, 2nd and 3rd station respectively.

Key-words : Phytoplankton, standing stock, Cochin backwaters.

INTRODUCTION

Earlier studies on phytoplankton (Qasim, Wellershaus, Bhattathiri and Abidi, 1969; Gopinathan, 1972; Qasim, Sumitra Vijayaraghavan and Balachandran, 1974; Sumitra Vijayaraghavan, Joseph and Balachandran, 1974; Joseph and Kunjukrishna Pillai, 1975; Kumaran and Rao, 1975; Ramachandran Nair, Joseph, Balachandran and Kunjukrishna Pillai, 1975; have contributed to an understanding of the species composition and primary production of Cochin Backwaters The present investigation is the first attempt to study statistically the seasonal changes in standing stock and species composition of phytoplankton.

MATERIAL AND METHODS

Continuous collections of water samples from different depths of 3 fixed stations in Cochin Backwaters (Fig. 1) were made every month for a period of one year. Station 1 was at Harbour mouth, which is the entrance channel from the backwater to the sea with an average depth of 8 — 10 m. The second (depth 4 m.) and third (depth 1.5 m.) stations were 14 km away on either side of the Station 1. At Station 1 and 2 samples were taken from 3 depths but at Station 3 being shallow, only surface samples were taken. Consequently only surface samples were considered for the present study in all the 3 stations. A 10 litre bucket was used for collecting surface samples while sub-surface samples were collected by Nansen bottle.

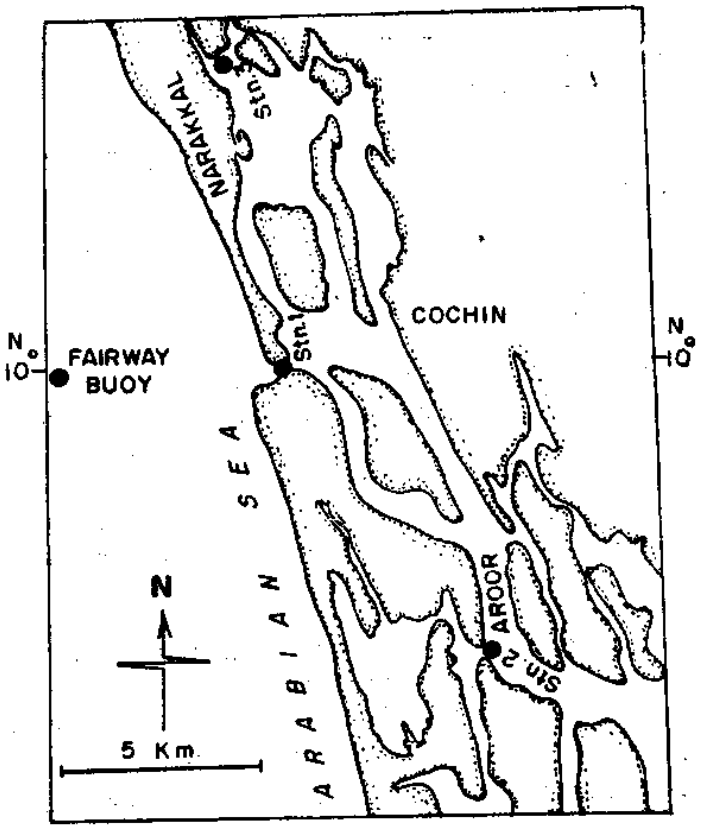


Fig. 1. Map of Cochin backwaters showing areas of study.

Phytoplankton samples were preserved in 5% neutralised formalin and cells were counted in a Sedgwick-Rafter Chamber, under inverted microscope. In the case of chain forming species the number of chains were counted. The seasonal phytoplankton periodicity at all stations is illustrated in Fig. 2.

Statistical analysis was carried out on the logarithmically transformed data (Fig. 2) using $\log_{10}(x+1)$ transformations (Colebrook, 1965). The mean and coefficient of variations of the species abundance were calculated for the 3 stations (Kumaran and Rao, 1975) (Table I). Intergroup correlation coefficient matrix showing the coefficient of correlation between species were formed. Cluster analysis was carried out using the correlation matrix by combining the species at various similarity levels and the dendrogram showing the grouping at different similarity levels was drawn (Howard, 1978). The affinity of species for the parameters, temperature, salinity and oxygen was traced through the correlation coefficient (Fisher and Yates, 1963) of the species with these parameters. The prediction for species occurrence was studied using a multiple regression model

$$Y_i = a_0 + a_1 x_{1i} + a_2 x_{2i} + a_3 x_{3i} \quad \ldots \quad \ldots \quad (1)$$

where Y_i = abundance of all species; x_{1i} = temperature; x_{2i} = salinity and x_{3i} = dissolved oxygen for the ith month. a_1, a_2, a_3 are the multiple regression

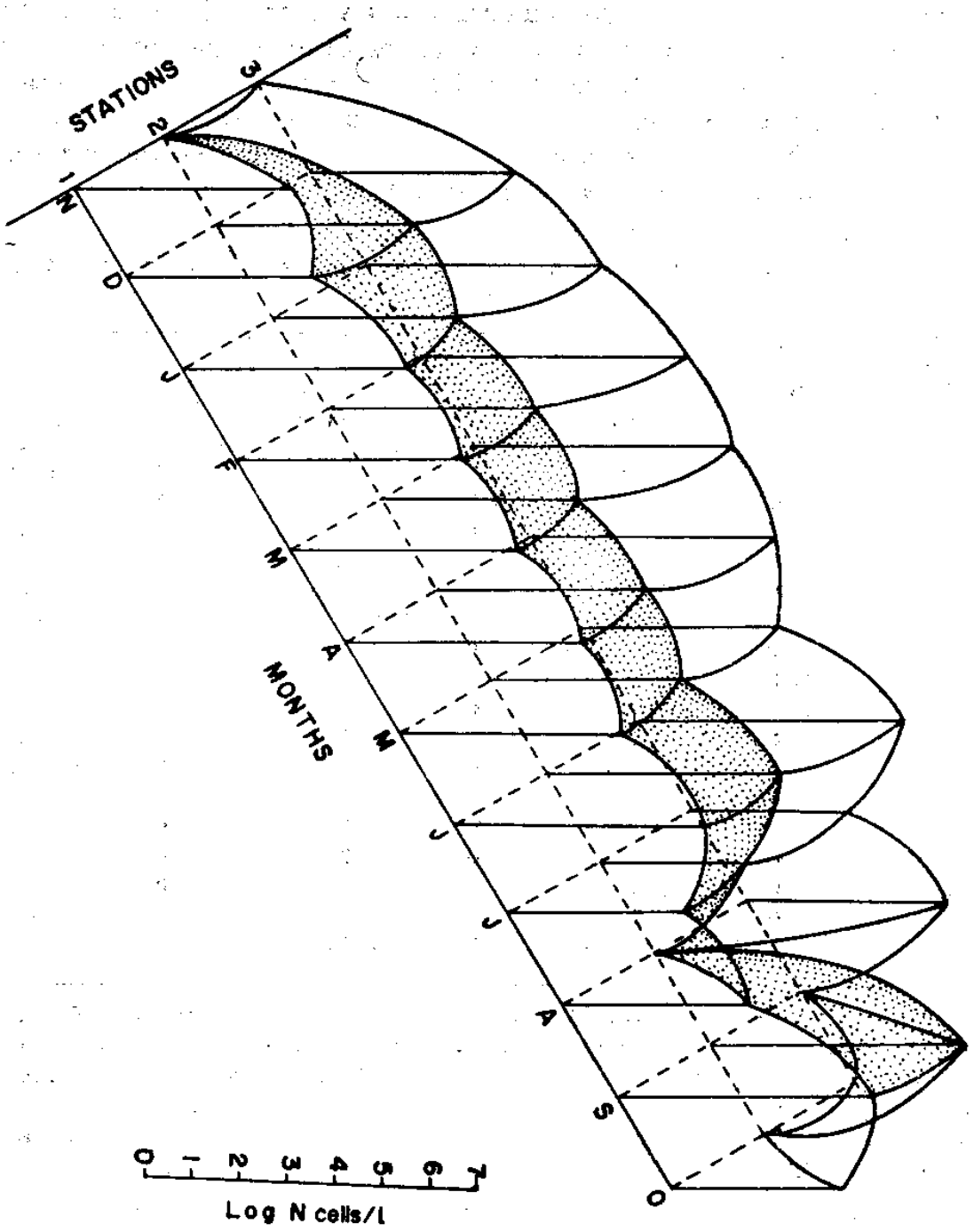


Fig. 2. Mean monthly variations of phytoplankton counts in the surface samples at all the three stations.

coefficients. Fisher's species diversity index α (Fisher, Orbert and Williams, 1943) was calculated for each station, to see the type of environment α was obtained from the equation :

$S = \alpha \text{ Log}_e (1+\frac{N}{\alpha})$ Variance of α is calculated using the formula,

$$V(\alpha) = \frac{\alpha^3 \left[(N+\alpha)^2 \text{ Log}_e \left(\frac{2N+\alpha}{N+\alpha}\right) - \alpha N \right]}{(S N + S \alpha - \alpha N)^2} \quad .. \quad .. \quad (2)$$

Mac Arthur's model to measure the equitability was applied (Monte Lloyd and Ghelard, 1964). The measure of equitability was expressed as $\varepsilon = S^1/S$ where S^1 = the solution for S from the equation H(s) = M(s) obtained from tables (Monte Lloyd and Ghelard, 1964). ANOVA technique (Snedecor and Cochran, 1963) was employed to test the significance of the difference between stations, species and seasons for the abundance of the species.

Table I. Mean standard deviation (% coefficient of variation) of the species at Stations 1, 2 and 3.

Parameters / Species	Station 1 $\bar{X}$	Station 1 (%) Coeff. of variation	Station 2 $\bar{X}$	Station 2 (%) Coeff. of variation	Station 3 $\bar{X}$	Station 3 (%) Coeff. of variation
S.c.	2.4876	48.86	1.1731	127.46	2.3217	66.26
N.c.	2.1261	39.77	0.4636	176.36	1.2980	97.93
C.	1.6527	62.54	0.8948	121.76	0.7339	142.10
T. f.	0.8898	68.41	0.1670	331.72	0.1919	331.74
L.d.	0.8170	142.19	0.5411	175.69	0.3828	229.21
T.n.	0.7045	146.35	0.2764	225.03	0	—
R.	0.8706	119.20	0.1522	331.60	0.4962	173.64
N.s.	0.1488	331.59	0.1488	331.60	0	—
N.l.	0.1985	331.66	0.1243	331.61	0	—
C.b.	0.3955	226.79	0.2166	331.61	0.1522	331.60
C.a.	0	—	0.5082	178.89	0.1522	331.60
S.f.	0.8418	118.99	0.2913	226.47	0	—
P.	0.8818	121.82	0.2765	224.92	0.6285	173.72
P.e.	0.5163	179.72	0.1423	331.67	0.5721	173.76
A.j.	0.1488	331.67	0	0	0.1488	331.59
P.m.	0.2486	223.57	0	0	0	—
S.	0	—	0.1670	331.72	0	—

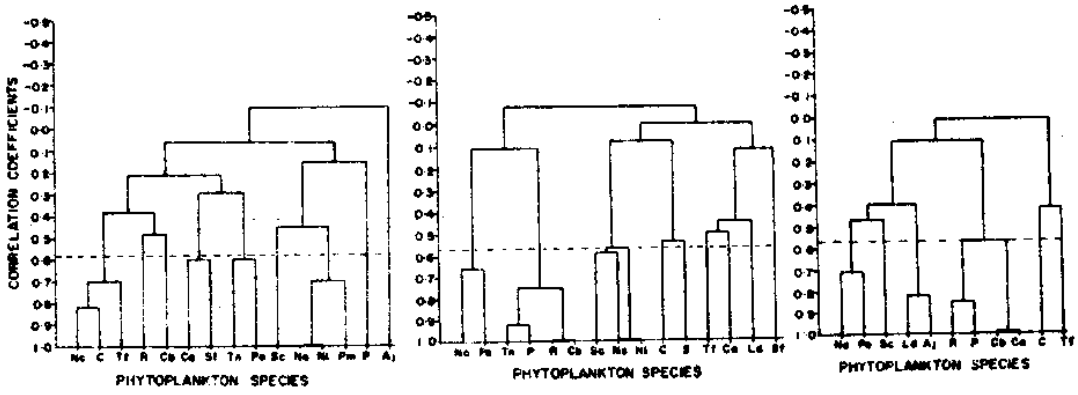
S.c. Skeletonema costatum; N.C. Nitzschia closterium; C. Coscinodiscus sp.; T.f. Thalassiothrix frauenfeldii; L.d. Leptocylindrus danicus; T.n. Thalassionema nitzchioides; R. Rhizosolenia sp.; N.s. Nitzschia seriata; N.l. Nitzschia longissima; C.b. Ceratulina bergonii; C.a. Chaetoceros affinis; S.f. Surirella fluminensis; P. Pleurosigma sp, P.e. Pleurosigma elongatum; A.j. Asterionella japonica; P.m. Prorocentrum micans; S. Streptotheca sp.

RESULTS AND DISCUSSION

Skeletonema costatum was the most abundant species in all the 3 stations. The distribution of *Asterionella japonica* (*Asterionella glacialis*) was the least consistent and that of *Nitzschia closterium* (*Ceratoneis closterium*) the most consistent at Station 1. At stations 2 and 3 almost all the species were found distributed in an uneven manner except for *S. costatum* at Station 3 (Table I). Of the correlation coefficients 35.2%, 61.0% and 30.9% are -ve, and among -ve correlations only 0.5%, 0.1% and none are significant and of the+ ve correlations 19.1%, 29.3% and 10.5% are significant in Stations 1, 2

and 3 respectively. Since the significance of the +ve correlations is greater, these species show (Colebrook, 1965) a tendency to exist together.

From dendrogram (Fig. 3a) for Station 1, it is inferred that *N. longissima* and *N. seriata* have the maximum affinity followed by the group *N. closterium* and *Coscinodiscus* sp.



(a) (b) (c)

Fig. 3. Dendrograms for station 1 (a), station 2 (b) and station 3 (c) respectively.

At 5% level of significance, the 4 clusters formed are :

1. *N. closterium*
   Coscinodiscus sp.
   Thalassiothrix frauenfeldii
2. *Chaetoceros affinis*
   Surirella fluminensis
3. *Thalassionema nitzschioides*
   Pleurosigma elongatum
4. *N. seriata*
   N. longissima
   Prorocentrum micans

From the dendrogram (Fig. 3b) for the station 2, it is seen that 1) *Rhizosolenia sp* and *Ceratulina bergonii* (*Ceratulina pelagica*) and 2) *N. seriata* and *N. longissima* have maximum affinity.

At 5% level of significance the following 3 clusters are formed :

1. *N. closterium*
   Pleurosigma elongatum
2. *Thalassionema nitzschioides*
   Pleurosigma sp.
   Rhizosolenia sp.
   Ceratulina bergonii
3. *Skeletonema costatum*
   N. seriata
   N. longissima

It is evident from the dendrogram (Fig. 3C) for the station 3, that the clusters having maximum affinity are *Ceratulina bergonii* and *Chaetoceros affinis*. At 5% level the 3 clusters formed are :

1. *N. closterium*
   Pleurosigma elongatum

2. *Leptocylindrus danicus*
   Asterionella japanica
3. *Rhzosolenia sp.*
   Pleurosigma sp.
   Ceratulina bergonii
   Chaetoceros affinis.

None of the species was significantly correlated with temperature except *Nitzschia closterium* (+have correlation) at Station 3. Only *Skeletonema costatum* and *Thalassiothrix frauenfeldii* at station 1 (+ve correlation), *Coscinodiscus* (+ve correlation) and *Leptocylindrus danicus,* (—ve correlation) at station 3 with salinity. Only *Skeletonema costatum, Nitzschia closterium and Cerataulina bergonii* at Station 1, *Surirella fluminensis* at Station 2 and *Cerataulina bergonii* and *Chaetoceros affinis* at Station 3 were +vely significantly correlated with oxygen (Table IV). Coefficient of correlation being an index of affinity which in turn can be taken as the degree of prediction, ability of these parameters to predict the abundance of the species it can be said that the prediction efficiency is very small as justified by Table II.

Table II. ANOVA Table for testing the significance of the Multiple Regression Model.

Source	Sum of Squares			Deg. of freedom			F. Ratio
Station	Total	Regression	Deviation	T	R	D	
Station 1 Surface	280.8106	20.5975	260.2131	11	3	8	0.2111
Station 2 Surface	206.1562	0.0938	206.0589	11	3	8	0.0013
Station 3 Surface	347.5399	137.3576	210.1823	11	3	8	1.7429

The multiple regression equation fitted for the three stations are as follows :

$$Y_i = 6.9446 + 0.4547\,X_{1i} + 4.0338\,X_{2i} + 0.6469\,X_{3i} \text{ for St. 1.}$$
$$Y_i = 1.8098 + 2.5059\,X_{1i} - 0.0004\,X_{2i} + 0.0053\,X_{3i} \text{ for St. 2.}$$
$$Y_i = -0.0535 + 4.1869\,X_{1i} + 3.0707\,X_{2i} - 3.5420\,X_{3i} \text{ for St. 3.}$$

None of the derived regression equation is significant. That is the regression model for the abundance of the diatoms on temperature, salinity, and oxygen cannot predict efficiently the abundance of the diatoms. Therefore it shows that these parameters taken alone cannot explain a significant part of the variability in the prediction of the abundance. The usefulness of the model can be enhanced by including the additional parameters, like nutrients, light intensity and depth stratification and their interactions. Then the model can extract maximum variability in the predicted abundance.

Species diversity index α and variance of α are small (Table III) at all the 3 stations, which indicates that the ecosystem is mature and old, and it will not alter frequently. Stations 1 and 2 differ significantly from that of Station

Table III. Species Diversity index α and V (α) and equitability coefficient.

Station	S	N	α	V (α)	S^1	$\varepsilon = S^1/S$	TS*
1	15	35600	1.4910	0.01258	6	0.4001	(1) & (2) N.S.
2	15	19818	1.5906	0.01551	3	0.2000	(2) & (3) 3.7204**
3	11	49557	1.0288	0.0076	3	0.2727	(1) & (3) 3.2340**

* Test of significance for the difference of ; **Significant at 1% level ($P < 0.01$)

Table IV. Correlation coefficient of species with parameters.

Stations	Temperature			Salinity			Oxygen		
Species	Stn. 1	Stn. 2	Stn. 3	Stn. 1	Stn. 2	Stn. 3	Stn. 1	Stn. 2	Stn. 3
S.c.	0.3710	0.1940	–0.0008	0.7895**	0.4866	0.5352	0.6932*	0.1668	0.4885
N.c.	–0.0027	0.0941	0.9797	0.2195	–0.1289	0.2487	0.7137**	0.3290	0.3149
C.	–0.0116	0.5195	–0.0190	0.1546	0.5611	0.6559*	0.2490	0.3050	–0.1457
T.f.	0.0126	0.0533	–0.0402	0.6071*	0.2011	–0.4164	–0.0592	–0.2836	0.0944
L.d.	–0.0076	0.1075	0.0392	0.4850	0.2086	–0.9042**	0.0432	0.2378	0.2347
T.n.	–0.0133	0.0938	0	0.3067	0.1304	0	0.1561	0.2846	0
R.	–0.1363	0.0572	–0.01857	0.0725	0.2748	0.5428	0.2527	0.0023	–0.1575
N.s.	0.2227	0.0655	0	0.1083	0.0320	0	0.2794	0.0813	0
N.l.	0.0042	0.0655	0	0.1447	0.0320	0	0.0525*	–0.4077	0
C.b.	–0.0069	0.0572	0.0191	–0.1247	0.2747	0.2588	0.5902*	0.0104	0.8505**
S.f.	–0.0122	0.1476	0	0.4009	0.4829	0	0.1506	0.7113**	0
C.a.	0	0.1119	0.0191	0	0.4818	0.2588	0	–0.0170	0.8505**
P.	–0.0107	0.0393	–0.0558	0.0501	0.2442	0.3312	–0.0665	0.0623	–0.0718
P.e.	–0.0214	0.0410	0.0076	0.0001	–0.5555	0.0910	–0.0360	0.1603	0.2404
A.j.	0.0098	0	0.0406	–0.1643	0	0.2314	–0.3293	0	0.2515
P.m.	0.0118	0	0	0.2205	0	0	0.2629	0	0
S.	0	0.1129	0	0	0.2018	0	0	0.3667	0
x	1.4716	1.3644	1.4808	1.1737	0.9899	1.0178	0.5667	0.5686	0.5190
Coeff. of Varn. (%)	46.92	43.76	10.71	32.11	48.88	47.41	32.30	21.81	32.97

* Significant at 5% level ($P < 0.05$); ** Significant at 1% level ($P < 0.01$)

S.c. Skeletonema costatum; N.C. Nitzschia closterium; C. Coscinodiscus sp.; T.f. Thalassiothrix frauenfeldii; L.d. Leptocylindrus danicus; T.n. Thalassionema nitzchioides; R. Rhizosolenia sp.; N.s. Nitzschia seriata; N.l. Nitzschia longissima; C.b. Ceratulina bergonii; C.a. Chaetoceros affinis; S.f. Surirella fluminensis; P. Pleurosigma sp., P.e. Pleurosigma elongatum; A.j. Asterionella japonica; P.m. Prorocentrum micans; S. Streptotheca sp.

3. Therefore, at Station 3 the environment is the oldest. There is significant difference only between stations and among species (Table IV). The degree of abundance of species varies between stations and from species to species but not from season to season (Table V). Mac Arthur's measure of (Table III) equitability for the 3 stations suggests that nearly 40%, 20% and 27% of the species of what is actually present can give a species diversity equal to that given by the whole sample community in the 1st, 2nd and 3rd stations respectively.

Table V. ANOVA table for testing the significance of the difference between stations, seasons and species.

Source	Sum of squares	Degree of freedom	Mean sum of squares	F. ratio
Between Stations	13.9180	2	6.9590	3.1202 +
Between Seasons	9.1885	2	4.5943	2.0599
Between Species	104.6556	16	6.5410	2.9328 +
Stations x Seasons	25.1600	8	3.1450	1.4101
Seasons x Species	155.4635	50	3.1093	1.3941
Species x Stations	148.9807	50	2.9796	1.3360
Intraction between Stations & Seasons	2.0535	4	0.5134	0.2302
Intraction between Seasons & Species	41.6194	32	1.3006	0.5832
Intraction between Species & Stations	30.4071	32	0.9502	0.4261
Error residual	142.7374	64	2.2303	
Total	249.2468	152		

+ Calculated F ratio is significant at 10% level of significance. ($P < 0.10$)

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