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Contribution of Microplankton & Nannoplankton in the Waters of a Tropical Estuary

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Four different size groups of algae were sampled from Cochin Backwater by passing sea water through different grades of bolting nylon. ^{14}C assimilation, chlorophyll (chl.) *a* concentration and cell numbers of each size group were determined throughout the year along with those of non-fractionated material. The contribution of nannoplankton, largely composed of diatoms, was found to be much greater than that of microplankton throughout the year. Pooled values of fractionated material agreed closely with those of non-fractionated material, but no regular seasonal trend was found in photosynthesis, chl. *a* and cell numbers of any size group. A greater dominance of nannoplankton as primary producers over microplankton seems relevant to food chain considerations, as filter-feeding larval stages are probably able to utilize nannoplankton more efficiently than microplankton.

FROM earlier studies it is clear that a greater proportion of organic production in the sea (80-100%)[1], is contributed by small forms or 'nannoplankton' which pass through the net made of finest mesh, as compared to 'microplankton' or net plankton, which are larger and normally retained by the apertures of the net[2-4]. This is true not only of neritic and oceanic waters[5] of both temperate and tropical regions[6,7], but also of fresh water lakes[8-10]. In polluted waters, the contribution of nannoplankton very often becomes many times greater than that of any other form of life[11], except perhaps fungi and bacteria.

In an earlier communication dealing with the organic production of Cochin Backwater, a quantitative assessment of phytoplankton was made by ^{14}C uptake, chlorophyll measurement and counting microplankton retained by the net[12]. Even in other studies where an estimation of phytoplankton crop was made by counting the organisms in groups (diatoms, flagellates and other algae) as part of demonstrating the influence of salinity[13], nutrients[14], or flushing rate[15] in the backwater, the phytoplankton organisms smaller than 50 μm were largely omitted. The earlier inference deduced from the production coefficient (ratio of gross production to carbon content of phytoplankton) that the phytoplankton crop sampled by the phytoplankton net comprised only 1-28% of the total carbon assimilated[12], makes it necessary to investigate in greater detail the contribution of different size groups of algae in the total biomass. In this study, the phytoplankton communities were fractionated as a part of continued investigation on the hydrography of Cochin Backwater.

Materials and Methods

Water samples from the surface were collected at fortnightly intervals for a period of 1 yr (Sept. 1972 to Aug. 1973) from a fixed station in the Cochin Backwater. About 5 l of water was shaken up thoroughly and passed through bolting nylon materials of 99 (No. 14), 76 (No. 20) and 64 (No. 25) μm grades fixed to filtration discs mounted on a stand. The organisms retained by each grade of bolting nylon were carefully rinsed with millipore-filtered sea water and collected in petri dishes. Each sample was made up to 500 ml for the estimation of ^{14}C uptake, chlorophyll (chl.) *a* and cell numbers of the organisms retained. Similarly, the water which had passed through all the three grades of bolting nylon was also used for the above three measurements. In addition, the unfiltered water was also taken for these three estimations. Thus, in all, there were 5 different types of materials, viz. (i) algae of all sizes (unfiltered samples), (ii) algae larger than 99 μm, (iii) algae larger than 76 μm, (iv) algae larger than 64 μm, and (v) algae smaller than 64 μm.

For ^{14}C assimilation, samples were taken in light and dark bottles of 70 ml capacity and incubated with 5 μCi of $NaHCO_3$ for 2 hr under constant illumination of 10k. lux. Rate of production was estimated by the usual procedure. Chl. *a* determinations were made using Whatman GF/C pads and according to the method suggested by Unesco[16]. For cell numbers, about 50 ml of the sample was fixed with 5% formaldehyde solution and allowed to settle in a chamber for 24 hr. The settled material was diluted to 10 ml, and after mixing well, a sample of 1 ml was drawn and placed in Sedgewick Rafter counting cell and practically all the cells contained in it were counted.

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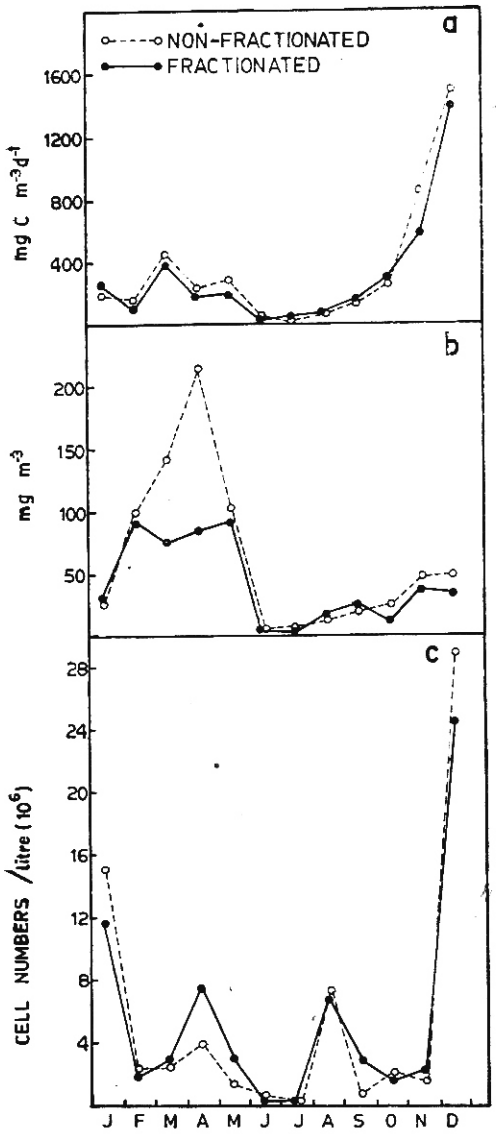

Fig. 1 — Seasonal cycles of (a) photosynthesis (b) chlorophyll *a* and (c) cell numbers, shown by non-fractionated samples and pooled values of fractionated samples taken from the Cochin Backwater

Results

Seasonal cycle of production — Fig. 1 gives photosynthesis, chl. *a* concentrations and total cell numbers for 1 year. The values for each fortnight were averaged. The figure includes two sets of data — one from non-fractionated samples and the other from integrated values of four fractionated samples. For photosynthesis the two sets of values agreed very closely (Fig. 1a). The daily production ranged from a minimum of 4 mgC m^{-3} d^{-1} in July to a maximum of 1500 mgC m^{-3} d^{-1} in December. The seasonal cycle obtained in the present study was quite different from that reported earlier for the period August 1965 to July 1966[12], indicating that there is no regular seasonal trend. Here also, brief pulses of high production were observed in March, November and December. Apart from the lowest values recorded in July and August, and the highest values in November and December, the rate of photosynthesis ranged between 100 and 200 mgC m^{-3} d^{-1}.

Seasonal cycle of chl. *a* was somewhat different from that of photosynthesis (Fig. 1b). Peak values obtained from February to May were independent of a similar rise in the rate of ^{14}C uptake indicating that much of the chl. *a* recorded during this period was not photosynthetically active. Probably it came from detritus or physiologically inactive algae. In March and April, the pooled values obtained from fractionated samples were lower than those from the non-fractionated samples. This indicates that the inactive chlorophyll was largely contained in the unfiltered sample. Similarly, the high values of carbon assimilation recorded in November and December were associated with only a slight increase in chl. *a* content, although the former agree well with the cell numbers (Fig. 1c). This is probably because of the variations in the chlorophyll content of the cells constituting the total algal biomass. A similar variation in the chlorophyll per cell has been reported from the waters of Vineyard Sound[3].

Seasonal variations in the total cell number generally corresponded with the seasonal trend in photosynthesis (Fig. 1c), except for some months (January, April and August), when the counts showed minor peaks. This was largely because of relative predominance of one or two organisms which formed dense concentrations (blooms) in those months.

Components of micro- and nannoplankton — The organisms listed below were largely common to both micro- and nannoplankton. If they were small in size, they contributed profusely to the nannoplankton and when large they were retained by the net as microplankton.

Skeletonema costatum, *Thalassiosira* sp., *Navicula* sp., *Nitzschia closterium*, *Ceratulina* sp., *Fragilaria oceanica*, *Synedra* sp., *Ditylum* sp., *Rhizosolenia* sp., *Corethron* sp., *Gyrosigma* sp., *Pleurosigma* sp., *Chaetoceros* sp., *Asterionella japonica*, *Thalassionema nitzschoides*, *Coscinodiscus* sp., *Surirella* sp., *Biddulphia* sp., *Chlorella* sp., *Ankistrodesmus* sp., *Scenedesmus* sp., *Pandorina* sp., *Eudorina* sp., *Oedogonium* sp. (last 3 occurred as microplankton only), *Synechococcus* sp., *Merismopedia* sp., *Oscillatoria* sp., *Peridinium* sp., *Gymonodinium* sp., and *Ceratium* sp.

From the above list it is clear that under both groups, the main constituents of the algae were diatoms. The organisms which formed blooms (constituting 50% or more of the total algal counts) were: *Skeletonema costatum* from January to July and October to December; *Ceratulina* sp., in June; and *Merismopedia* sp. in August, September and November.

Seasonal variations in the rate of photosynthesis, chl. *a* concentration and cell numbers of different size groups are shown in Fig. 2. All the three properties indicate that the contribution of smallest organisms (less than 64 μm) remains large practically throughout the year. However, there was neither any uniformity in the seasonal abundance of any one particular size group of organisms nor was any clearly marked rhythm in the properties. It seems that the larger organisms need not have correspondingly higher photosynthetic rate or chlorophyll content as compared to smaller forms. Similarly, the high counts of smaller forms may not necessarily be associated with high values of photosynthesis or chlorophyll.

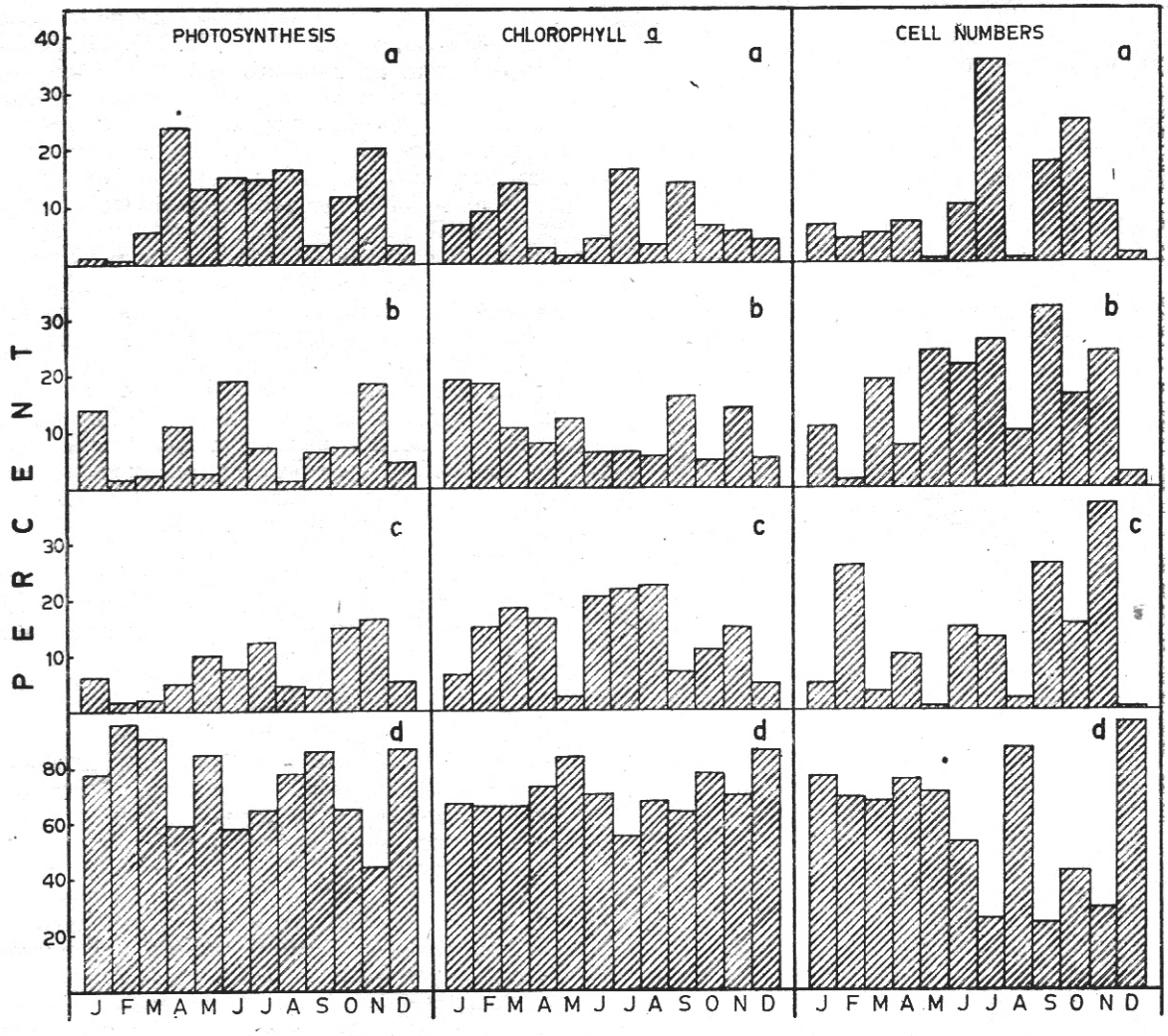

Fig. 2 — Relative proportion of photosynthesis, chlorophyll *a* and cell numbers contributed by the algae of different size groups from the Cochin Backwater (a) larger than 99 μm, (b) larger than 76 μm, (c) larger than 64 μm, and (d) smaller than 64 μm

TABLE 1 — PHOTOSYNTHESIS, CHLOROPHYLL AND CELL NUMBERS OF MICROPLANKTON AND NANNOPLANKTON, EXPRESSED AS PERCENTAGES OF THE TWO COMBINED IN EACH MONTH TOGETHER WITH RATIOS BETWEEN MICRO- AND NANNOPLANKTON

Months	Photosynthesis			Chlorophyll *a*			Cell numbers		
	Micro %	Nanno %	Micro: nanno	Micro %	Nanno %	Micro: nanno	Micro %	Nanno %	Micro: nanno
Jan.	21·18	78·82	0·27	32·91	67·09	0·49	22·66	77·34	0·29
Feb.	3·69	96·31	0·04	43·55	56·45	0·77	30·73	69·27	0·44
March	9·42	90·58	0·11	43·97	56·03	0·78	32·04	67·96	0·48
April	40·50	59·50	0·68	26·73	73·27	0·36	24·19	75·81	0·32
May	16·47	83·53	0·19	15·41	84·59	0·18	29·36	70·64	0·41
June	41·92	58·08	0·72	30·36	69·64	0·55	46·45	53·55	0·99
July	34·41	65·59	0·52	44·66	55·34	0·80	75·23	24·77	3·03
Aug.	22·21	77·79	0·38	31·18	68·82	0·45	12·55	87·45	0·14
Sep.	13·65	86·35	0·15	37·24	62·76	0·59	75·92	24·08	3·15
Oct.	34·71	65·29	0·53	22·20	77·80	0·28	57·10	42·90	1·33
Nov.	55·44	44·56	1·24	39·50	60·50	0·65	71·41	28·58	2·45
Dec.	12·77	87·23	0·14	14·27	85·73	0·16	4·20	95·80	0·04
Average	25·53	74·47	—	31·83	68·17	—	40·15	59·85	—

Table 1 gives the relative proportions of photosynthesis, chlorophyll and cell numbers contributed by micro and nannoplankton during the year. Photosynthesis of microplankton ranged from 4 to 55% and that of nannoplankton from 45 to 96%. The ratio, micro: nanno, was less than 1 throughout the year, except in November (Table 1). Similarly, the quantity of chl. *a* in microplankton ranged from 14 to 45%. In contrast to this, the range in chl. *a* content of nannoplankton was from 56 to 86% and the ratio between chlorophyll of micro to nannoplankton was less than 1 in all the months. The range in the percentage of cell numbers of microplankton was somewhat greater, from 4 to 76%, and that of nannoplankton from 24 to 96%. The ratio between the cell number of micro to nannoplankton was greater than 1 in July, September, October and November (monsoon and post-monsoon months), when larger organisms seem to be more abundant. This, however, is not reflected either from their photosynthesis or from their chlorophyll, which once again indicates that the size of the organisms has little relation with their photosynthesis or chlorophyll.

The average annual contribution of the three properties of micro and nannoplankton is given in Table 1. Although in all these properties the contribution of nannoplankton was significantly high, the difference was most marked in the photosynthesis of the two categories and least in their cell numbers (Table 1). Probably, photosynthesis is the best single property for evaluating the characteristic of the algae.

Discussion

In the present communication, the importance of nannoplankton in tropical estuarine waters has been shown, taking into account the algae measuring 20 μm and larger in size. These were predominantly diatoms and this feature supports the view expressed by Yentsch and Ryther[3] that diatoms constitute a crop many times greater than that of the flagellates. However, no estimate of organisms smaller than 20 μm has been made except only in exceptional cases, because of considerable difficulties encountered in identifying them in preserved samples. From a preliminary examination, however, of some of the smaller algae which are probably autotrophic flagellates, it is evident that their contribution may be far greater than diatoms. Knight-Jones[17] has collectively called these 'ultraplankton' and has emphasized their importance in phytoplankton ecology. Thus, the bulk of organic production in the sea seems to be largely due to the activities of autotrophic flagellates and this supports the view expressed by earlier workers[2,18].

The broad distinction of planktonic algae into micro and nanno, which the phytoplankton ecologists have made on the basis of their size must include ultraplankton so as to make the division more realistic. In the English Channel, Harvey[19] found that the contribution of ultraplankton (flagellates) was many times greater than other algae. Similarly, other reports[20,23] have shown a far greater predominance of microflagellates as compared to diatoms.

There is an overwhelming evidence to suggest that practically in all types of environments, organisms of the nannoplankton and ultraplankton categories (smaller than 50 μm), dominate the primary producers[24]. This is because the small cells have a faster rate of growth than that of the larger forms[25]. The nannoplankton organisms, because of their small surface area, have a distinct advantage over the microplankton in the utilization of light and nutrients[26], particularly in turbid waters where the euphotic zone is shallow and nutrients are abundant. The small forms tend to sink far more slowly than the larger forms and hence they continue to remain in the favourable zone of illumination for a longer time.

Production of a large quantity of nannoplankton in the sea is ecologically important as planktotrophic larvae will have to filter a smaller quantity of water to obtain the required amount of food. Probably for this reason, in tropical waters, a high proportion of benthic invertebrates produce planktotrophic larvae (80-85%). This is in contrast to arctic and temperate regions, where, the production of filter-feeding stages by benthic animals is 5 and 55-65% respectively[27]. Evidently, a filter-feeder would find it easier to remove from the environment a smaller cell than a larger one.

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