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PHYTOPLANKTON OF THE INDIAN OCEAN : SOME ECOLOGICAL PROBLEMS*

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ABSTRACT

Investigations on the ecology of the phytoplankton of the Indian Ocean are scanty and confined to the inshore waters. The results of the International Indian Ocean Expedition so far published give a cursory picture of the phytoplankton of the oceanic waters. In the present account some preliminary results of continuous ecological investigations of the shelf and oceanic areas on the west coast of India between 6°–16°N and 72°–77°E, based on the collections of R. V. VARUNA are dealt with and compared with the earlier observations.

The shelf and oceanic waters on the west coast of India presents the same trend in the fluctuation of the standing crop of phytoplankton. During the southwest monsoon months (April to October), the displacement volume of the standing crop is high, the peak occurring in July; from November onwards, the values diminish reaching the minimum in February. The bulk of the crop is constituted by the Diatomaceae. Available data indicate that the waters of the west coast of the Indian Peninsula are more fertile than those of the east coast mainly due to the extensive upwelling and other favourable factors conducive to plankton growth; a few species always contribute to the bulk of the crop though many occur, while this cannot be stated for the east coast where at a given time no single species is in domination could be noted. A similar pattern is reflected in the constituents of fish landings—while a few contribute to the bulk of the catches on the west coast, the bulk on the east coast is always made up by many species. Some of the probable ecological factors contributing to the pattern of production of the phytoplankton are also discussed.

INTRODUCTION

ECOLOGICAL investigations on plankton of Indian waters have been few and most of them until very recently have been of a preliminary nature and few taxonomical. These were for short periods only, hence make it difficult to draw any conclusions. It may not be irrelevant to state that until the senior author's work, there were no sustained investigations on phytoplankton whose role in the waters as prime synthesizers needs no emphasis.

The investigations conducted, owing to lack of facilities in the early stages had to be confined to the nearshore region, within the 10 mile belt. The results are published in a series of papers by the senior author and colleagues (Subrahmanyan, 1958 a, b, c; 1959 a ,b, 1960; Subrahmanyan and Sarma, 1960, 1965; Subrahmanyan and Gupta, 1963, 1965).

RESULTS AND DISCUSSION

The salient points of an overall picture which emerged are briefly discussed below:

From April to October, the southwest monsoon months, the quantity of net plankton (No. 21 bolting silk, vertical haulsmostly from 50 to surface) in

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terms of displacement volume is by far higher than the succeeding or preceding months. From November onwards, values record a fall reaching a minimum in February. The bulk of the standing crop is constituted by the Diatomaceae. Data available on nutrients and the magnitude of the standing crop indicate that the waters of the west coast of India are among one of the most fertile waters known so far, extensive upwelling during the southwest monsoon being one of the cheif causes.

The physico-chemical conditions, during this time appear to be ideal for the reproduction and multiplication of the phytoplankton elements, *viz.* high nutrient content of water, fall in temperature to optimum levels, (from 32–33°C to 24–25°C) and of salinity (from 35‰ to 31‰) (Subrahmanyan, 1959 b). Studies on laboratory cultures have borne these factors out (Iyengar and Subrahmanyan, 1944).

It would be interesting to draw attention here to a striking phenomenon. Usually, one would expect a very high oxygen content, even super-saturation during heavy phytoplankton blooms. On the west coast, though oxygen values rise, they never reach super-saturation until the bloom has waned in November. This would indicate that the oxygen level is being kept up by the phytoplankton photosynthesis in the water which being upwelled water is poorer in oxygen content. It is known that in the Arabian Sea, there is an oxygen minimum layer as a result of consumption of oxygen by distintegrating organic matter in the lower layers. This layer rises during upwelling and sometimes breaks surface and one comes across mass mortality of marine organisms. There is another reason also for oxygen content not reaching saturation values; the floral elements of the bloom being diatoms, consumers of silica for building their cell walls, considerable oxygen is used up during growth of these diatoms.

During the same season, on the east coast also, as witnessed in places where investigations have been conducted, a phytoplankton bloom occurs with slight variation in the actual time of the bloom. The standing crop records a fall after September, but, however, shows a slight increase sometime during the northeast monsoon. The most significant difference between east coast and west coast waters are: while the bloom on the west coast is very extensive throughout the region during the south west monsoon, this is not so on the east coast where the blooms are localised, apparently due to local favourable factors. The intensity of the bloom and the standing crop on the west coast are almost four times those of on the east coast; very many species occur, over a hundred at any given time, but only a few always by their quantity contribute to the bulk on the west coast whereas this cannot be stated for the east coast where no one species could be stated to dominate the crop or over another species. There is a cyclical change in the species constituting the bulk from year to year though genera-wise not much change is noticeable.

Incidentally, it may be remarked, that the fishery resources reflect a similar pattern as the plankton standing crop/production, *viz.* almost 80% of marine fish landing is on the west coast and the bulk is constituted by only 3 or 4 species. On the east coast marine fish landing is as may be obvious, far less and no one species could be said to contribute to the bulk and many species are involved.

Further the fat content of marine plankters of the west coast is more than those of east coast plankters, probably due to the nature of the composition of species (Subrahmanyan and Gupta, 1963).

One probable cause for the relatively poorer fertility of the waters of Bay of Bengal could be that almost all the large rivers of India empty into the Bay carrying a

lot of silt and over a major portion of the Bay, salinity values are extremely low. One could consider the Bay a large estuary.

The detailed studies on the magnitude of the standing crop of phytoplankton on the west coast in relation to the environment has enabled, by comparative evaluations, an assessment of the potential fishery resources. The studies point out that the present level of exploitation is of a very low order, and the harvest from the sea could be increased at least ten times the present level (Subrahmanyan, 1959 b; Shomura *et al.*, 1967).

Published results of the IIOE (Sukhanova, 1962 a, b, 1964; Zernova, 1962; Zernova and Ivanov, 1964; Wooster *et al.*, 1967) also indicate that standing crop is of a high order in areas of upwelling; that it is more, 2–2.5, times during southwest monsoon than during northeast monsoon and generally Arabian Sea is the richest of all the areas. In the Bay of Bengal rich areas are confined to two or three spots only.

In recent years investigations have been carried out by the Central Marine Fisheries Research Institute from on board *R. V. Varuna* over the shelf and waters beyond, in the region 6–16°N and 71–78°E. Voluminous data have been collected and these require processing. Nevertheless, some tentative conclusions may be drawn which throw light on the ecology of phytoplankton of the shelf and oceanic waters.

The trend in the fluctuation of the standing crop reflects the same pattern seen in the near shore areas; however there are great differences in the quantity and quality of crop involved. The standing crop shows an increase from April onwards reaching the maximum in July, remains fairly high upto October and thereafter records a fall reaching the minimum in February (Table 1). It is not possible to establish a second peak which is somewhat evident in the near shore areas.

TABLE 1. *Overall monthly average values for displacement volume of plankton in vertical hauls from 75 m to surface*

	Month	Displacement (volume in cc)		Month	Displacement (volume in cc)
1963	April	1.4	1964	February	1.6
	May	2.0		March	2.3
	September	5.5		April	4.6
	October	4.9		May	5.3
	November	2.4		July	7.2
	December	1.8		August	4.3
				September	3.5
				October	1.7

The quantity of plankton per haul in these waters is very much less compared with near shore samples; this is the usual feature everywhere. Further, the composition of the floral elements indicate that though diatoms constitute the bulk, no one or two species could be said to be dominant as in the near shore areas; the number of species on the whole is lesser unlike near shore samples. Again, while at no time dinoflagellates dominate the samples in the near shore region, in the shelf and oceanic samples they at times occur almost to the total exclusion of diatoms. Some species of Dinophyceae met with here are rare or practically non existent

in the near shore samples. This applies to some silicoflagellates also. Among the diatoms quite a few species are present only in the offshore samples. It appears that the dominance of some species over others in the near shore region is very probably due to blooming of locally occurring species stimulated by favourable conditions; for, at times when generally plankton crop is poor as during north east monsoon months, if there should be any mixing up of the water by increased wind force, a bloom of phytoplankters occurs, presumably due to favourable effect of substances locked up in the bottom getting liberated to the upper zones as pointed out by Subrahmanyan (1959 b).

It had been the belief that tropical waters in general and Indian Ocean in particular are not productive compared with temperate and boreal waters. It appears that this view was due to lack of sufficient knowledge about the organic life in these waters. subrahmanyan (1959 b, c) has shown that the west coast waters are one of the most fertile regions comparable with the highly productive waters in the temperate and the arctics. The IIOE results, as also the results of continuous investigations from on board *R. V. Varuna*, have further confirmed the earlier results. Of course, as everywherelse there are barren tracts in this region also.

In conclusion, one could say a good beginning has been made at last for a study of the waters around India and Indian Ocean. Very much remains to be done—not much is known of the taxonomy of hundreds of species occurring except for few recent accounts (Subrahmanyan, 1946, 1958, 1968, 1971). The presence of certain species only in certain seasons and under certain conditions and so on should throw light on water movements and they may prove to be indicator organisms, may be of fisheries too. The cyclical occurrence of species, their dominance during certain times, outburst of a bloom of a single species on rare occasions discolouring water are some of the other problems which require investigations along physiological and life history aspects also. Being almost a virgin field, Indian Ocean waters promise a fund of knowledge to the seeker.

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