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## DISTRIBUTION AND ABUNDANCE OF PTEROPOD AND HETEROPOD MOLLUSCS IN THE EEZ AND ADJOINING WATERS OF INDIA

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### ABSTRACT

The pteropod and heteropod molluscs formed an important constituent in the zooplankton of the EEZ of India and the adjacent areas. Between them the pteropods dominated numerically over the heteropods in all situations. The average density of pteropods in the area investigated was 734 (expressed as number per 1000 m<sup>3</sup> of water) and heteropods was 335. Both the groups were more in the eastern Arabian Sea than in the Bay of Bengal. However, the difference in the rate of occurrence in the two sea areas was more pronounced in the case of heteropods, being 46.56% against 21.35% for the other group. Both the groups were relatively more in the shelf waters, the increase over the oceanic area being more than one and a half times for the pteropods which sometimes exhibited some kind of population explosion in the shelf waters. For the heteropods the increase in the shelf area was of the order of 87.88%. The pteropods had a trimonthly abundance, say, during February, May, August and November. November and December were the favourable months for the heteropods. A seasonal variation was not very significant for both the groups. However, pteropods were comparatively more during the premonsoon season off the west coast (826) and the east coast (729). With regard to heteropods, while an increase (449) was noticed in postmonsoon season in the eastern Arabian Sea, in the Bay of Bengal the increase was during the premonsoon period (373). In the eastern Arabian Sea there appeared to be a gradual reduction in population of both the groups from south to the north. However, in the Bay of Bengal the situation prevailed was exactly the opposite. The observed reduction in population was effected through the various seasons starting from premonsoon through monsoon to the postmonsoon. A population outburst was noticed for pteropods in the shelf waters of the southernmost latitudinal region of the eastern Arabian Sea during the premonsoon. In the same region off the east coast a similar phenomenon occurred during the monsoon season. The day-night variations in the two groups was striking in that both had an overall increase by 27% in the night samples. There was considerable difference in regard to diurnal variations during different months for pteropods and heteropods.

### INTRODUCTION

Pteropods and heteropods are two groups of pelagic marine gastropod molluscs found abundantly in the zooplankton. The former is a sub-order belonging to the Sub-class Euthyneura, Order Ophisthobranchiata. The latter comes as a section of Sub-order Taenioglossa which belongs to the Sub-class Streptoneura and Order Aspidobranchiata. These two groups from the Indian Ocean have been studied in the past from the taxonomic point of view (Ref: various expeditions which visited the Indian Ocean). Some studies have been made in the Indian Ocean on the spatial distribution and quantitative abundance of some species of pteropods and heteropods. Sakthivel (1969) made a preliminary study on the distribution and relative abundance of euthecosomatous pteropods in general and the seasonal variation of species of the genus *Limacina*. The seasonal and diurnal variations and also the spatial abundance of *L. inflata* was studied, again, by Sakthivel (1973a). The biogeographical change in the latitudinal boundary of a species of pteropod was also investigated by

him (Sakthivel, 1973b). Aravindakshan (1969) has given a preliminary report on the geographical distribution of some species of heteropods of the Indian Ocean. Later he (Aravindakshan, 1973) made a study on the distribution and ecology of one species of pterotrachea. Another study made by him was on the distribution of the species of the family Pterotracheidae in the Indian Ocean (Aravindakshan, 1977).

The above studies being highly generalised for the Indian Ocean as a whole and supported by relatively less number of samples, they cannot be considered conclusive. For the geographical distribution, the average values for 5° squares only were worked out which again tell upon the inadequacy of samples. The present study pertaining mainly to the EEZ of India based on a relatively large number of samples has permitted a microlevel analysis of the spatial distribution on a half-degree basis and of other aspects of abundance.

The material and methods have been detailed in the paper dealing with the zooplankton biomass

given elsewhere in this volume (Mathew *et al.*, 1990) The unit biomass is always expressed as number per 1000 m<sup>3</sup> of water.

#### RESULTS AND DISCUSSION

While sorting zooplankton collected onboard FORV *sagar sampada* it was found that the planktonic gastropods formed a major constituent. Among them the pteropods and heteropods had a major share quantitatively and hence were taken up for a common consideration to facilitate a rather comparative study. Some species of the pteropods are known for their swarming habit in the shelf waters during some months when the food is plentiful. In view of this, the pteropods were considered separately from the heteropods.

In all the situations the pteropods surpassed the heteropods in number. Thus while the pteropods had an average density of 734 in the entire area of study, the heteropods had an average concentration of 335 only. The former group occurred at a rate of 790 in the eastern Arabian Sea and at a rate of 651 in the Bay of Bengal. The heteropods also had a dominance off the west coast with 384 individuals against 262 in the Bay of Bengal.

The abundance of pteropods in the continental shelf waters was the most striking. While they were present at a rate of 1,292 in the shelf waters, the oceanic area had them at a rate of 489 only. Such abundance in the shelf waters could be due to the swarming of pteropods in certain months. Such a difference in abundance was not noticed with the heteropods whose density in the two sea areas was 496 and 264 respectively. Both the groups exhibited difference in the diurnal occurrence also, being more in night samples. An interesting point noted was that the percentage of increase in night samples was exactly the same for both the groups (27%) which may suggest their equal ability to perform diurnal vertical migration.

#### *Distribution in space*

The pteropods had a cosmopolitan distribution in the area investigated, of course, in varying densities and this is shown in Fig. 1. Very high-density areas where the number of pteropods exceeded 5,000 per 1000 m<sup>3</sup> of water were found off Ratnagiri, Kanyakumari, Madras and south of Calcutta. High-density areas where the range was between 2,000 and 5,001 occurred off Paradeep, around Andamans, north of Cochin, in the Lakshadweep

seas and southwest of Veraval.

The spatial distribution of heteropods is presented in Fig. 2. They also enjoyed a universal distribution but in smaller quantities. Area of maximum density exceeding 5,000 was observed north of Cochin in the shelf waters, besides other pockets in the shelf and oceanic areas as seen from Fig. 2.

#### *Monthly variations*

In the case of pteropods, November accounted for the maximum abundance with 1,541 which can be considered a swarm (Fig. 3). The least abundance was in October with 328 specimens. On the whole the April-October period was comparatively less productive with the exception of May and August. It was interesting to note that from February onwards, once in every three months there was an unusual increase in population.

With regard to heteropods also, November accounted for the maximum abundance with 752 specimens. December also had a proportionately high density. Any significant variation in other months was not noticed (Fig. 4). September with 186 individuals represented the month of least abundance.

On a consideration of the coastwise monthly abundance of the two groups, it was found that in most of the months the pteropods occurred in greater numbers in the eastern Arabian Sea (Fig. 5). In the Bay of Bengal they were relatively more abundant in April, August and January. Off the west coast, while November with 1,541 pteropods stood first, off the east coast it was August which yielded the maximum number, of course, of a low magnitude (992). In regard to heteropods also, abundance in the Bay of Bengal was noticed in February, April and October (Fig. 6). In the eastern Arabian Sea they had the greatest abundance in June.

#### *Seasonal variations*

A further consideration of the abundance on the basis of three seasons, viz., premonsoon (February - May), monsoon (June - September) and postmonsoon (October - January) in the two sea areas separately, revealed that no significant difference was observed in the case of pteropods during the three seasons either in the eastern Arabian Sea or in the Bay of Bengal. The differences between the seasons of maximum and minimum abundance were 46 in the former sea area and 209 in the latter. As far as the heteropods also are concerned, there was no

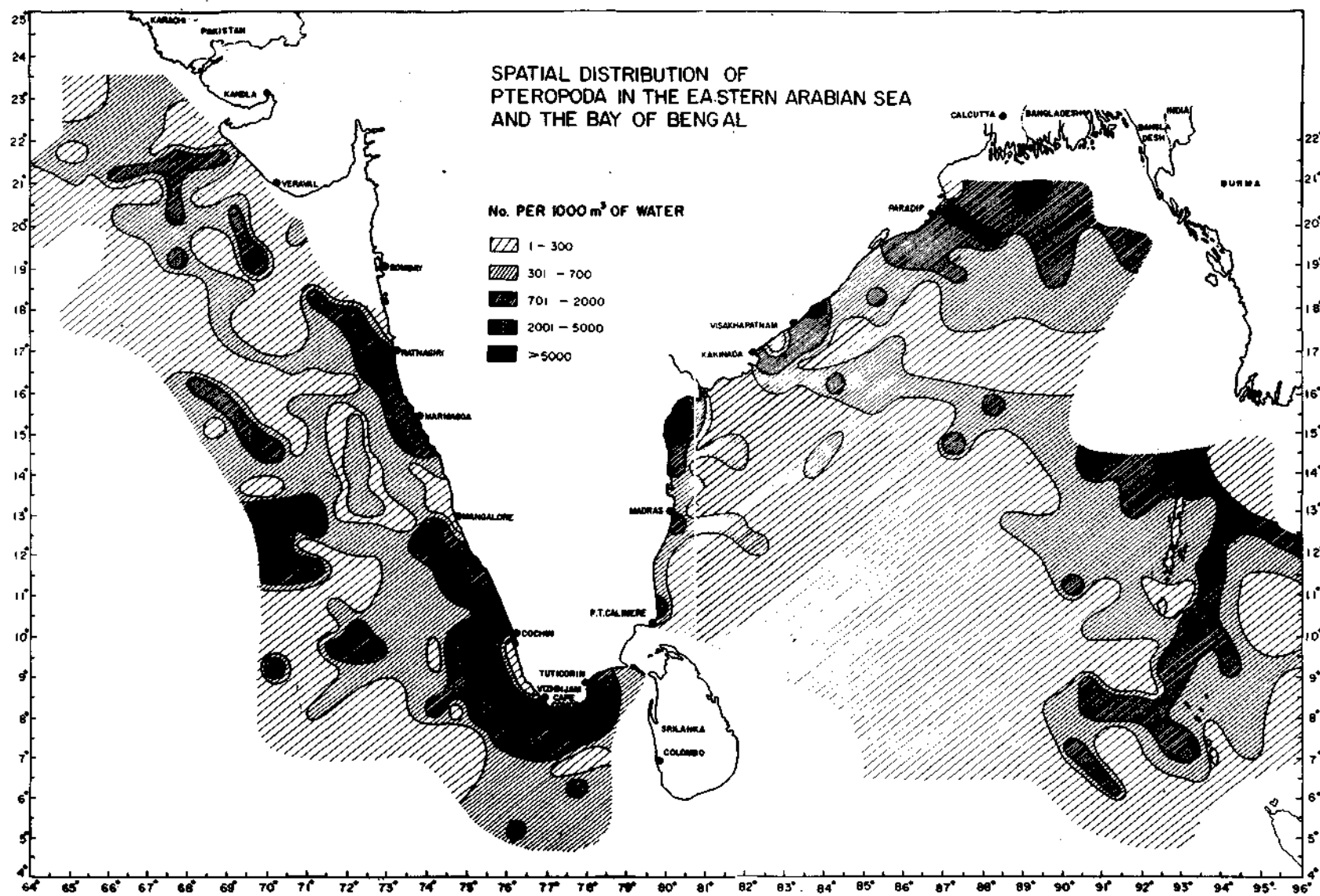


Fig. 1. Spatial distribution Pteropoda in the EEZ of India and adjacent seas.

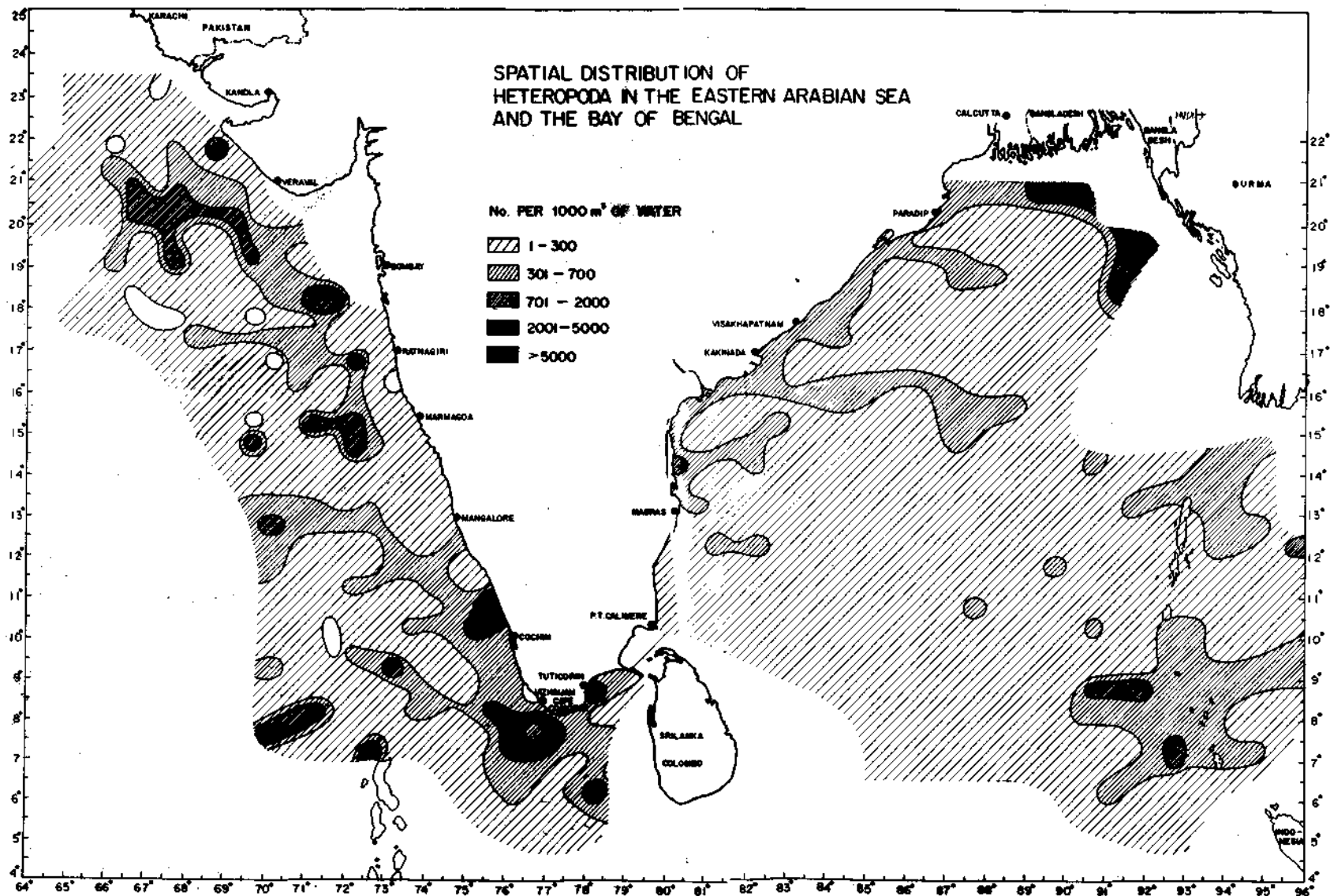


Fig. 2. Spatial distribution of Heteropoda in the EEZ of India and adjacent seas.

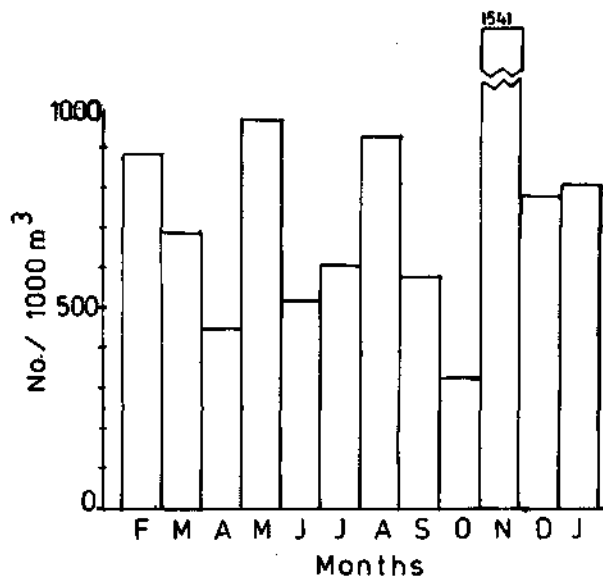


Fig. 3. Monthly abundance of Pteropoda in the area investigated.

substantial seasonal difference off the west and east coasts.

**Monthly distribution in the shelf and oceanic areas**

As seen from Figs. 7 and 8, the pteropods and heteropods were more abundantly present in the shelf area than the oceanic. When the shelf area contributed pteropods at the rate of 1,292, the share of the oceanic area was only 489. Its maximum density in the shelf was observed during March, June and December. An interesting point noted was that some kind of population outbursts occurred in the shelf waters in these months during which the density went up sharply from 1,091 in may to 4, 454 in June and from 380 in November to 4,824 in December. However, similar outbursts in population never

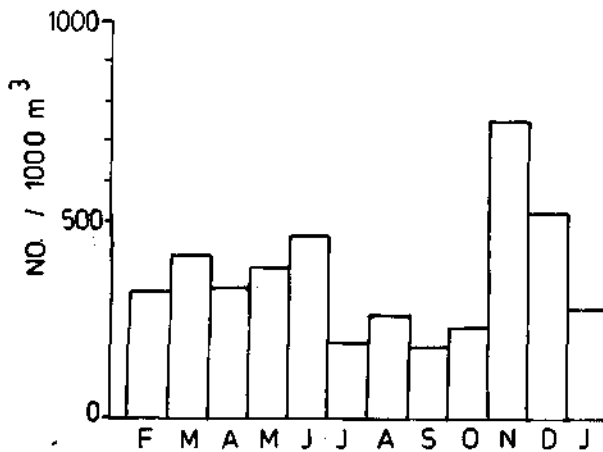


Fig. 4. Monthly abundance of Heteropoda in the area investigated.

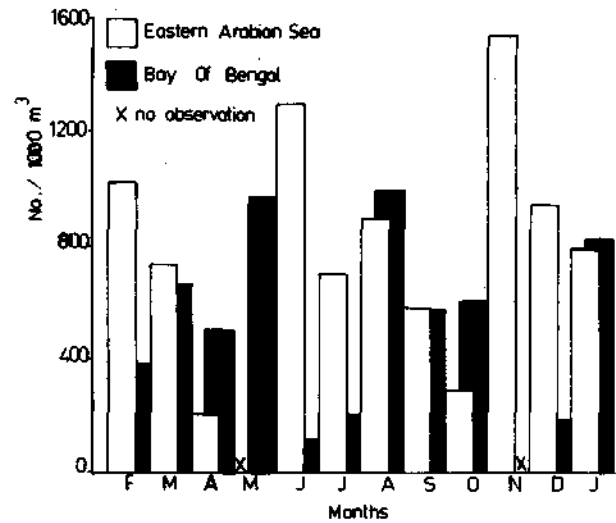


Fig. 5. Monthly abundance of Pteropoda in the eastern Arabian Sea and the Bay of Bengal.

occurred in the oceanic waters even though ups and downs in population size took place in different months.

In the case of heteropods, a sudden increase in population took place in December only, of course, in a moderate way (Fig. 8). In the oceanic areas vast variations were not noticed in different months.

**Coast-wise latitudinal abundance**

With regard to both the groups there was a gradual reduction in population from the southern to the northern latitudes in the eastern Arabian Sea (Figs. 9 & 10). While in the southernmost region 1,126 specimens of pteropods were taken, the contribution of the northernmost region was at a rate of 390 specimens only. Similarly the heteropods from a maximum of 496 in the southern latitudinal region

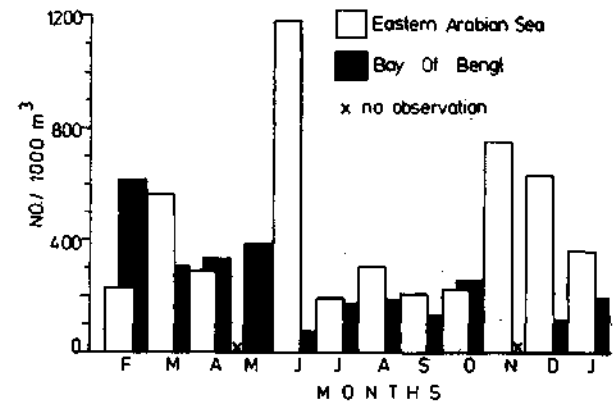


Fig. 6. Monthly abundance of Heteropoda in the eastern Arabian Sea and the Bay of Bengal.

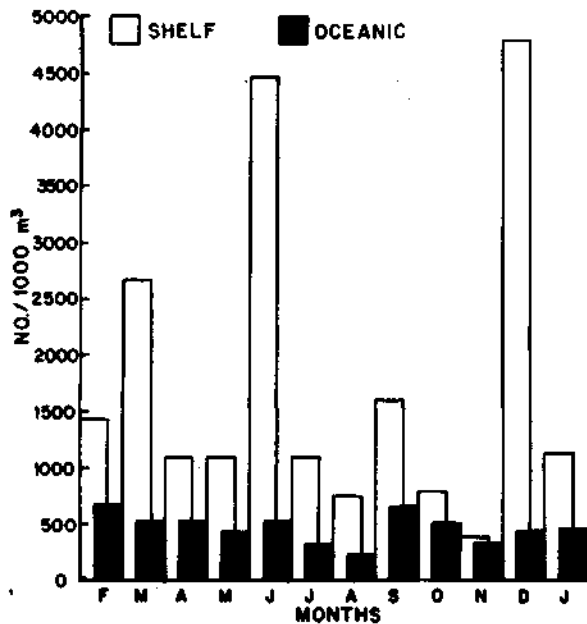


Fig. 7. Monthly abundance of Pteropoda in the shelf and oceanic waters.

thinned down to 355 in the northernmost region.

In the Bay of Bengal the situation was almost the opposite: the two groups were more in the northern latitudes (Figs. 9 & 10).

*Latitudinal seasonal abundance off the two coasts*

Figs. 11 and 12 show the seasonal variations of pteropods and heteropods in the four latitudinal regions in the eastern Arabian Sea and the Bay of Bengal. In all the latitudinal regions, the density of pteropods during different seasons was almost diametrically opposite in the two sea areas (Fig. 11). While in the southernmost region in the eastern Arabian Sea there was a gradual reduction in population from the premonsoon through monsoon to

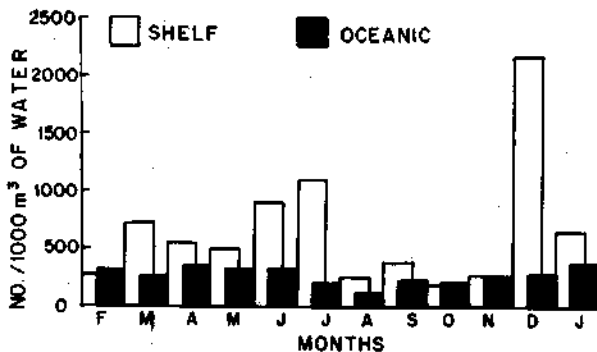


Fig. 8. Monthly abundance of Heteropoda in the shelf and oceanic waters.

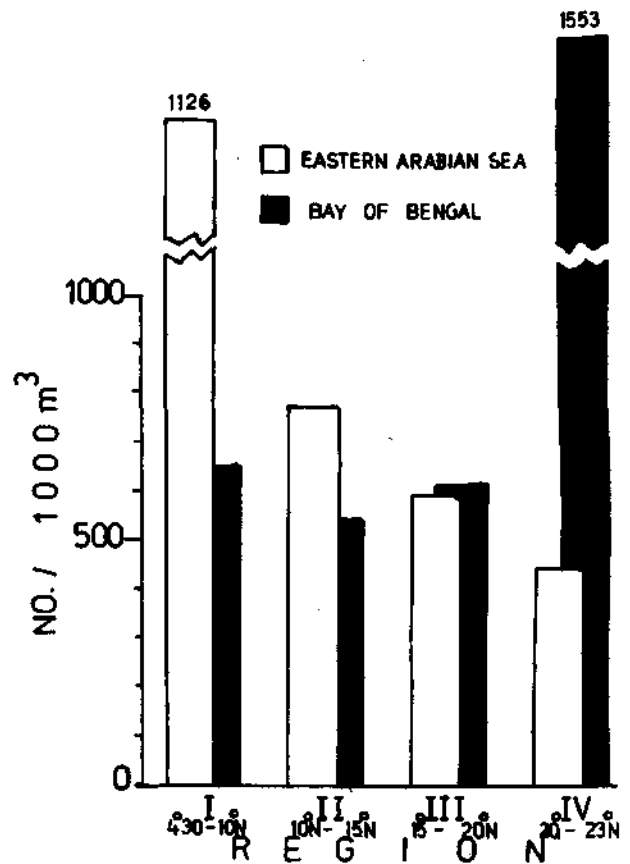


Fig. 9. Latitudinal abundance of Pteropoda in the eastern Arabian Sea and the Bay of Bengal.

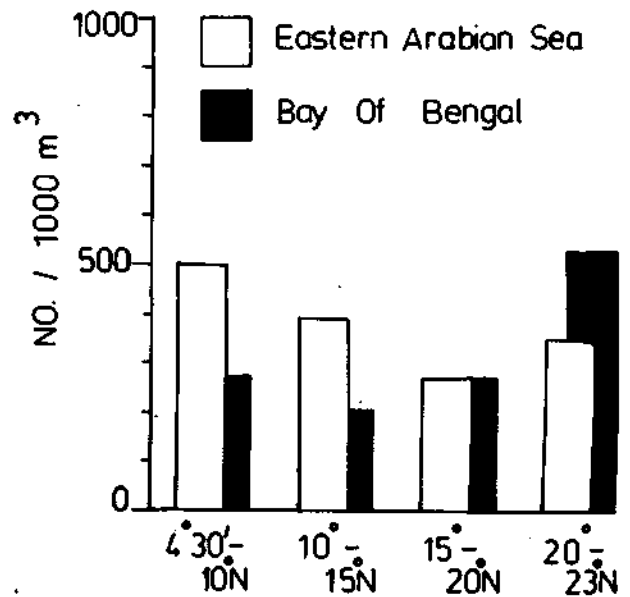


Fig. 10. Latitudinal abundance of Heteropoda in the eastern Arabian Sea and the Bay of Bengal.



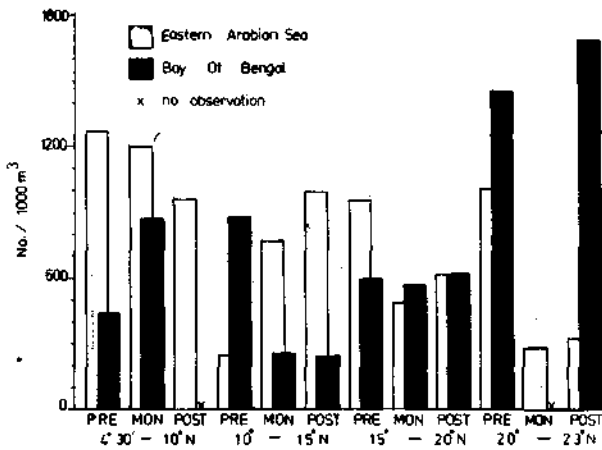


Fig. 11. Seasonal abundance of Pteropoda in the various latitudinal regions of the eastern Arabian Sea and the Bay of Bengal.

postmonsoon, in the Bay of Bengal in the same region an increasing trend was noticed from premonsoon onwards. In the second region the density was the least during premonsoon in the eastern Arabian Sea, which gradually increased to the postmonsoon season. At the same time in the Bay of Bengal the pteropod population decreased from a premonsoon maximum to a postmonsoon minimum. Almost the same was the trend in the third and fourth regions also.

In the case of heteropods, the trend of variation of populations in the various latitudinal regions of the two sea areas during different seasons was noticed in an opposite way in the two southern latitudinal regions (Fig. 12). In the third and the fourth regions of the eastern Arabian Sea and the Bay of Bengal, the seasonal fluctuations followed the same trend, either increasing or decreasing.

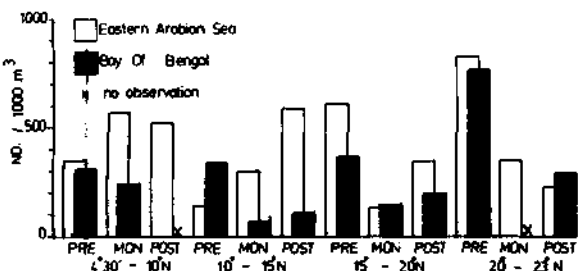


Fig. 12. Seasonal abundance of Heteropoda in the various latitudinal regions of the eastern Arabian Sea and the Bay of Bengal.

*Abundance in the shelf and oceanic waters of the four latitudinal regions of the west and east coasts during different seasons*

A still finer analysis of the data was made to understand the variations in the abundance in the shelf and oceanic areas of the various latitudinal regions in the two sea areas and the results obtained are given in Fig. 13 for pteropods and in Fig. 14 for heteropods. One significant observation made was that the pteropods experienced an explosion of the population in the shelf waters of the southernmost latitudinal region of the eastern Arabian Sea during the premonsoon. Off the east coast three such population explosions occurred in the shelf waters but of comparatively less intensity during the monsoon in the first latitudinal region and during the premonsoon in the second and the fourth regions. In general the populations of pteropods were significantly more in all the regions in the shelf water.

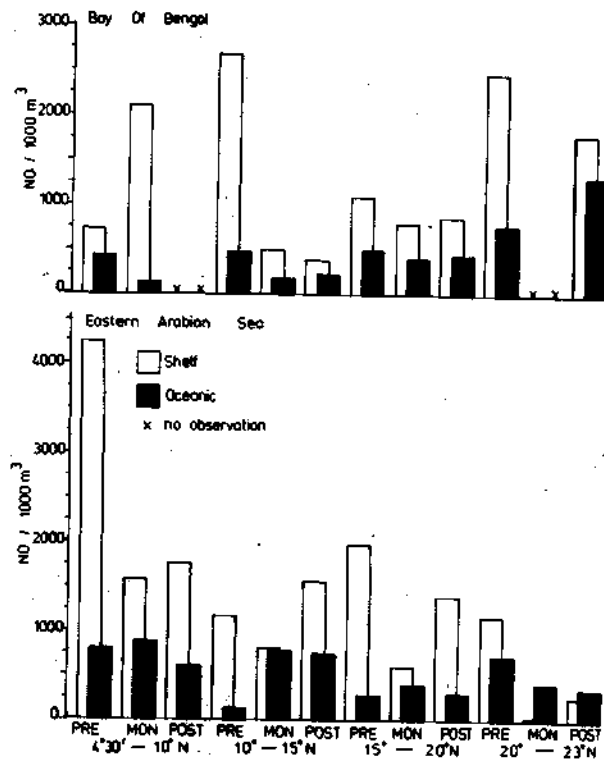


Fig. 13. Seasonal abundance of Pteropoda in the shelf and oceanic waters in the different latitudinal regions of the eastern Arabian Sea and the Bay of Bengal.

With regard to heteropods also population density was more in almost all latitudinal regions and seasons in the shelf waters but population outbreaks were not as intense as in pteropods. How-

ever, very high numbers were noticed in the shelf waters of the northernmost region in the two sea areas (Fig. 14).

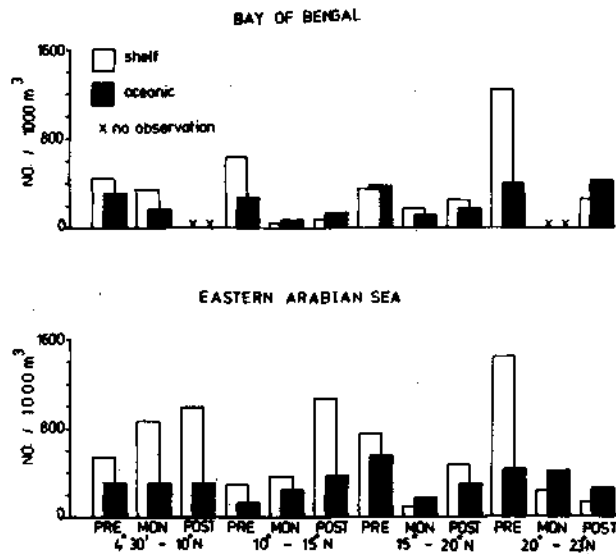


Fig. 14. Seasonal abundance of Heteropoda in the shelf and oceanic waters in the different latitudinal regions of the eastern Arabian Sea and the Bay of Bengal.

#### Day-night abundance

There was a clear difference in the day-night occurrence of both pteropods and heteropods (Figs. 15 & 16) with more numbers in the night samples. The overall increase in the night samples amounted to about 27%. When considered on a monthly basis it was found that in February, March and August, the

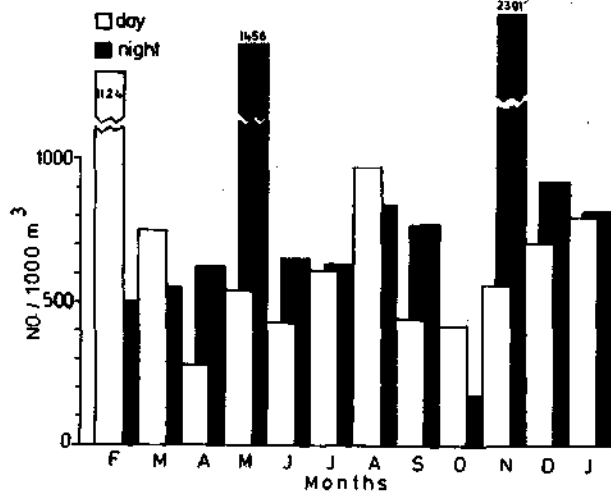


Fig. 15. Monthly day - night variations in the abundance of Pteropoda.

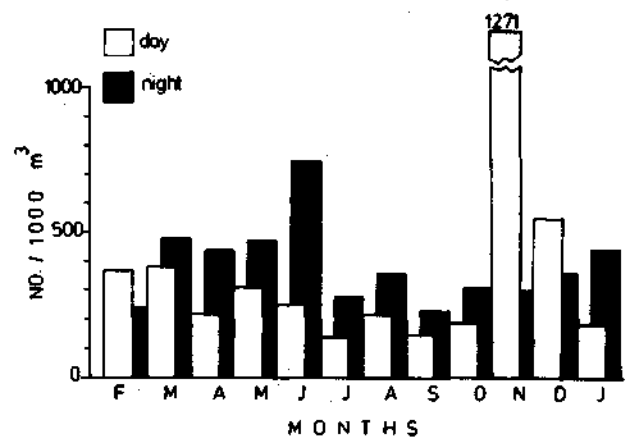


Fig. 16. Monthly day - night variations in the abundance of Heteropoda.

day samples had relatively more pteropods. The diurnal variation was least noticed in June for this group. The night time abundance was phenomenal in May and November when 3-5 times increase was observed.

When compared to pteropods, the monthly diurnal variations among heteropods were not very striking except in June and November. In the former month, more than 100% increase was noticed in the day samples. The other months which exhibited a day time abundance though of low magnitudes were February and December. In general the monsoon months had more number of heteropods in the night samples.

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