

Proceedings of the  
FIRST WORKSHOP ON SCIENTIFIC RESULTS OF  
FORV SAGAR SAMPADA

5-7 June, 1989, Cochin

*Sponsored by*

DEPARTMENT OF OCEAN DEVELOPMENT  
&  
INDIAN COUNCIL OF AGRICULTURAL RESEARCH  
NEW DELHI

*Organized by*

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE  
&  
CENTRAL INSTITUTE OF FISHERIES TECHNOLOGY  
COCHIN

OCTOBER, 1990

*Published by*

**Dr. P.S.B.R. JAMES**

**DIRECTOR**

**Central Marine Fisheries Research Institute**

**COCHIN - 682 031**

*Edited by*

**Dr. K.J. MATHEW**

**Central Marine Fisheries Research Institute**

**COCHIN - 682 031**

## DISTRIBUTION OF EUPHAUSIACEA IN SPACE AND TIME IN THE INDIAN EEZ AND CONTIGUOUS SEAS

K. J. MATHEW, T.S. NAOMI, GEETHA ANTONY AND K.S. SCARIAH

Central Marine Fisheries Research Institute, Cochin-682 031

### ABSTRACT

The Euphausiacea collected from 1,086 stations during the cruises 1-44 of FORV *Sagar Sampada* in the eastern Arabian Sea and the Bay of Bengal from 1985-'88 were studied for their spatial, seasonal and day and night abundance. The average density of euphausiids in the entire area investigated was estimated to be 3,214 per 1000 m<sup>3</sup> of water. With regard to spatial distribution, areas of maximum density of over 20,000 per 1000 m<sup>3</sup> were observed in the shelf areas off Cochin and the far oceanic areas off Gujarat, off and south of Marmagoa, off Cochin and off Cape Comorin. In the Bay of Bengal, high population density was observed around Nicobar Islands and east of Andamans. On the whole more euphausiids were present in the eastern Arabian Sea (3,680/1000 m<sup>3</sup>) than in the Bay of Bengal (2,517/1000 m<sup>3</sup>). Separate estimates made for the entire continental shelf and the oceanic areas showed that while the shelf had a density of 4,824 euphausiids, the oceanic area had a concentration of only 2,507 per 1000 m<sup>3</sup> of water. The observed percentage of increase for the eastern Arabian Sea over the Bay of Bengal worked out to 92.42. When an attempt was made to understand the seasonal variation, it was found that off the west coast, more number of euphausiids was present (the rate being 5,272/1000 m<sup>3</sup>) during the south west monsoon season. Least abundance of 2,505 was noticed during the premonsoon season. The postmonsoon abundance was estimated to be 2,776. The number of individuals obtained off the east coast during the three seasons was of low magnitude than off the west coast. Off the east coast while 2,437 euphausiids per 1000 m<sup>3</sup> were present during the premonsoon, the number collected during the monsoon and postmonsoon seasons were 3,384 and 1,434 respectively. The day time abundance of euphausiids in the upper 150 m of water column was at a rate of 2,282 while the same during the night was 4,651, thus indicating 103.81% of increase in the night samples. As far as the latitudinal abundance of euphausiids was concerned, it was found that the region above 20°N was the most productive in both the eastern Arabian Sea and the Bay of Bengal. Further microlevel analysis of distribution in the various latitudes during different seasons were carried out for the shelf and oceanic areas separately for the two sea areas and the results obtained are also presented in the paper.

### INTRODUCTION

The euphausiids form an important constituent of the zooplankton in the epipelagic, mesopelagic and bathypelagic zones of the marine environment. By virtue of their great importance in the marine food chains, considerable attention has been paid to the study of this group of planktonic crustaceans. Being larger in size than many of the zooplankton organisms, sometimes their biomass may surpass any other single groups in the plankton. A good amount of work on taxonomy, distribution, ecology and biology of euphausiids has been carried out the world over. But the euphausiid fauna of the Indian Ocean, especially that of the Indian seas is less investigated. Although several expeditions which visited Indian Ocean have made studies on euphausiids, all except the 'Discovery' (1932, 1937, 1950-'51) and the IIOE (1959-'65) did only faunistic surveys. However, the 'Discovery' reports did not pertain to the Indian seas.

The first major work on the euphausiids of the Indian Ocean in general was by Gopalakrishnan and Brinton (1969) based on IIOE data. They dealt with the quantitative geographical distribution and seasonal abundance of total euphausiids. However, the inadequacy of samples was a great constraint of this study. Weighmann (1970) dealt with the euphausiids of the Arabian Sea during the northeast monsoon. Ponomareva (1972) also studied the quantitative distribution of total euphausiids of the Indian Ocean. In 1973 Brinton and Gopalakrishnan made a study on the quantitative distribution of euphausiids of the Indian Ocean based on IIOE material.

Ponomareva (1975) carried out investigations on the vertical and quantitative distribution of Indian Ocean euphausiids based on 2,390 plankton samples. Mathew (1980, 1985) studied the quantitative spatial abundance and ecology of euphausiids in general and of various species of the southwest coast of India. All the above studies point to the fact that

they were either highly generalised spatially with inadequate samples or restricted to certain areas so that realistic information could not be obtained over a fairly wider area. So far there is no single study on euphausiids of the EEZ of India based on intensive sampling. The present study is expected to give a comprehensive idea about various aspects of euphausiid distribution in the EEZ and contiguous seas. A total of 1,087 zooplankton samples have been analysed for this purpose which is the largest number ever used for such a study in the area concerned. The material and methods, the area covered and the frequency of sampling for this study have been dealt with in detail in another paper by Mathew *et al.* (1990) which deals with the zooplankton biomass elsewhere in this volume. For all consideration the number of euphausiids (total) per 1000 m<sup>3</sup> of water has been made use of.

## RESULTS AND DISCUSSION

### Total euphausiid biomass

First of all it was let to understand the average biomass of euphausiids, numerically, in the entire area of investigation and the same has been estimated to be 3,214 individuals per 1000 m<sup>3</sup> of water. This is a remarkable figure and is comparable to what is present in any other sea area in the world except the Antarctic waters where the Krill occurs in huge quantities or in the north Pacific where *E. pacifica* occurs in very large numbers. When a further estimate was made for the eastern Arabian Sea and the Bay of Bengal separately, it was found that 3,680 euphausiids per 1000 m<sup>3</sup> of water were present in the former sea area while the latter claimed only 2,517. This clearly indicates the fertility and richness of the eastern Arabian Sea. Mathew (1980) who studied the density of euphausiids in the shelf waters of the southwest coast of India obtained an average of 1,981 individuals only per 1000 m<sup>3</sup> of water for the area. The reason for the significant difference between the two estimates is the oceanic nature of the euphausiids which could not be collected in good quantities from a number of shallow water stations covered in the study of Mathew (1980). Separate estimates made for the entire continental shelf and the oceanic areas showed that while the shelf had a density of 4,824 euphausiids, the oceanic area had a concentration of only 2,507 per 1000 m<sup>3</sup> of water. The average euphausiid abundance in the shelf and oceanic waters of both the coasts when worked out separately was found that the shelf of the west coast had 5,326

individuals while the corresponding area of the east coast had a density of 4,821 only. While the oceanic area of the west coast accounted for 2,907 individuals, that of the east coast had only 2,449 individuals per 1000 m<sup>3</sup> of water.

### Distribution in space

As seen from Fig. 1, the euphausiids have a large population in the eastern Arabian Sea and the Bay of Bengal. Of the two sea areas, the former is rich in euphausiids with number of euphausiids exceeding 20,000 per 1000 m<sup>3</sup> of water in certain areas. Areas of maximum density were observed in the shelf areas off Cochin, and the far oceanic areas off the coast of Gujarat, off and south of Marmagoa, off Cochin and off Cape Comorin. In the Bay of Bengal, high population density was observed around Nicobar Islands and east of Andamans. In most part of oceanic areas of the Bay of Bengal, the population density ranged between 1 and 5,000. High density patches above 10,000 per 1000 m<sup>3</sup> of water were found to occur here and there in the shelf as well as oceanic areas Fig. 1.

### Monthly variations in abundance

A great deal of variations in the monthly occurrence were observed (Fig. 2). High abundance was noticed during the August-November period, with the maximum density of 6,843 individuals during September. This four month period accounted for 50% of the total euphausiids caught. The period of maximum abundance which could be the active breeding period coincides with the latter half of the southwest monsoon and former half of the postmonsoon period. The January-February period accounted for the least abundance when the density of occurrence was around 1,600 only.

The whole data when consolidated into three seasons i.e., premonsoon, monsoon and postmonsoon, it was found that in general the monsoon season with 46% of euphausiids was the most productive, the premonsoon and postmonsoon sharing almost the same quantity equal to around 27%. (The classification is based on the southwest monsoon which is the major monsoon affecting both the Arabian Sea and the Bay of Bengal).

When the seasonal abundance was considered for the two sea areas separately, it was found that off the west coast more numbers of euphausiids were present (the rate being 5,272/1000 m<sup>3</sup>) during the southwest monsoon. The postmonsoon abun-

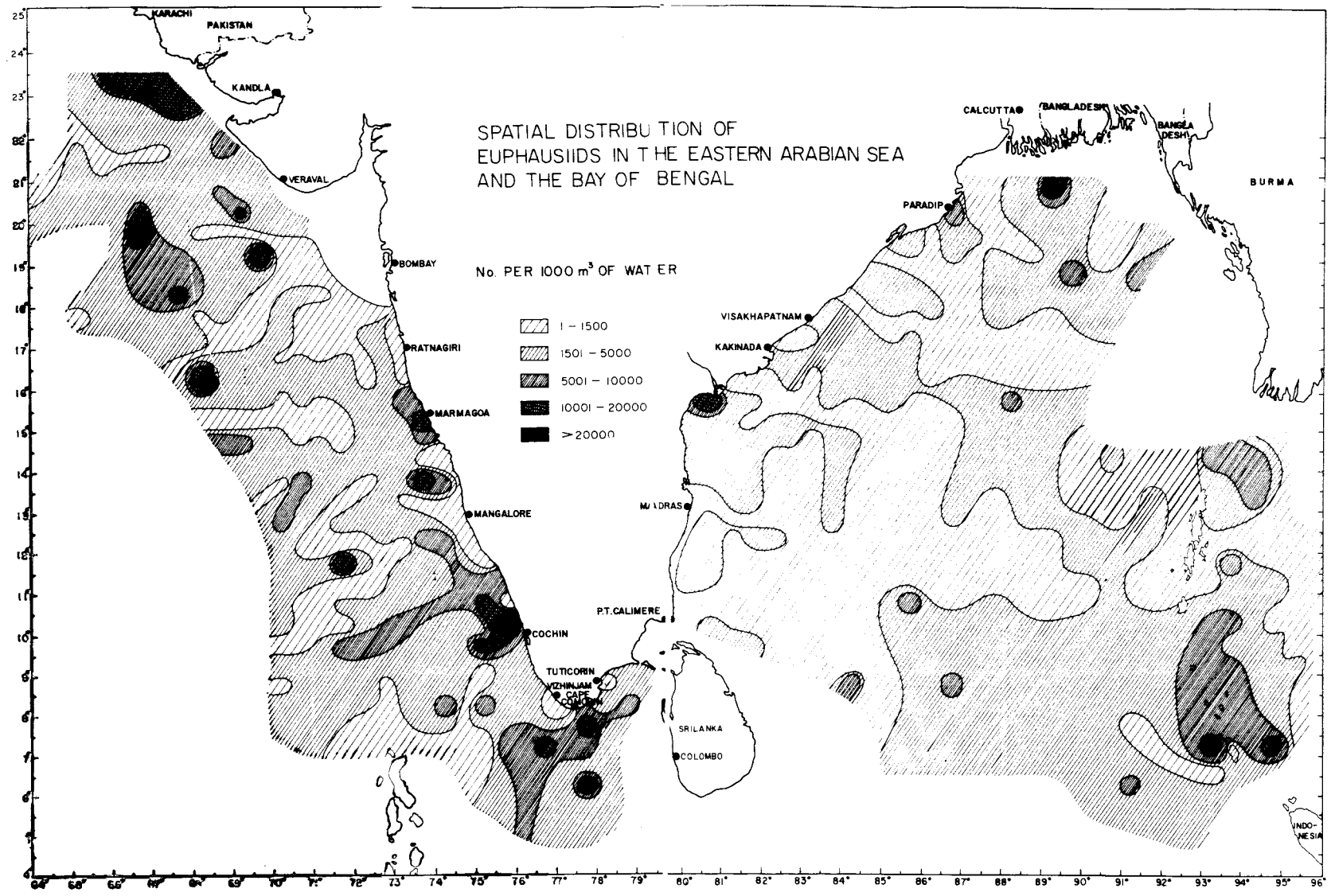


Fig. 1. Spatial distribution of Euphausiacea in the EEZ of India and adjacent seas.

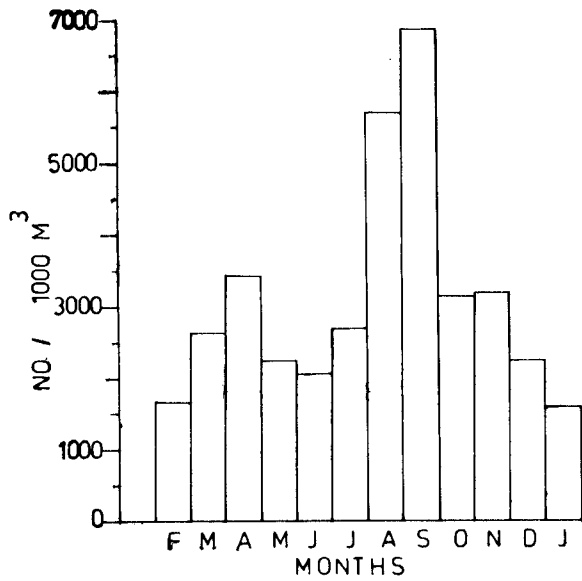


Fig. 2. Monthly abundance of Euphausiacea in the area investigated.

dance was estimated to be 2,776. The least abundance of 2,505 was noticed during the premonsoon season. The seasonal trend was almost the same in Bay of Bengal. However, the number of individuals obtained off the east coast during the three seasons was of low magnitude than off the west coast. Off the east coast while 2,437 euphausiids per 1000 m<sup>3</sup> were present during the premonsoon, the numbers collected during the monsoon and postmonsoon seasons were 3,384 and 1,434 respectively.

**Monthly distribution off the west and east coasts**

Fig. 3 shows the monthly abundance of euphausiids in the eastern Arabian Sea and the Bay of Bengal separately. Generally speaking the density was maximum during the August-September months in the eastern Arabian Sea. October also contributed some sizable quantity from whence it was a gradual reduction upto February. March-June period exhibited large fluctuations in population size.

In the Bay of Bengal, July accounted for the maximum abundance while August and September had moderate quantities. The months from October-November contributed the least. As in the case of the eastern Arabian Sea, the period from February to June experienced great fluctuations in population.

**Monthly distribution in shelf and oceanic areas**

The shelf area accounted for the maximum

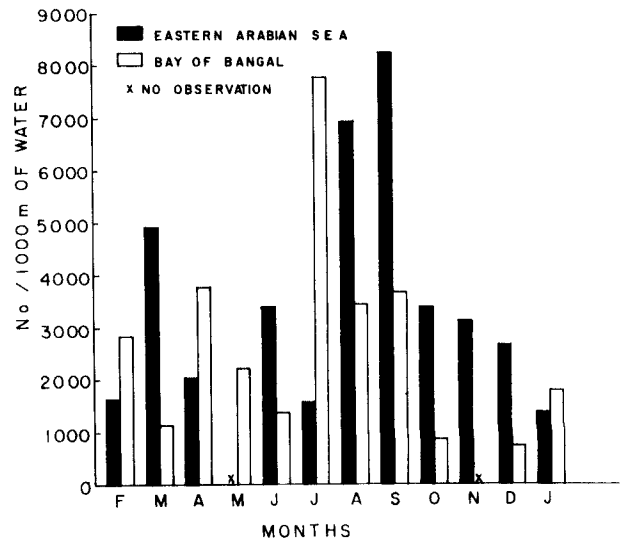


Fig. 3. Monthly abundance of Euphausiacea in the eastern Arabian Sea and the Bay of Bengal.

number of euphausiids. The average density in the shelf area was found to be 4,824 per 1000 m<sup>3</sup> of water whereas it was only 2,507 in the oceanic water, the rate of decrease being 92%. The trend in abundance in the shelf and oceanic areas during different months was almost the same as is seen in Fig. 4. The increase or decrease in each month reflected almost the same way in the shelf and oceanic waters.

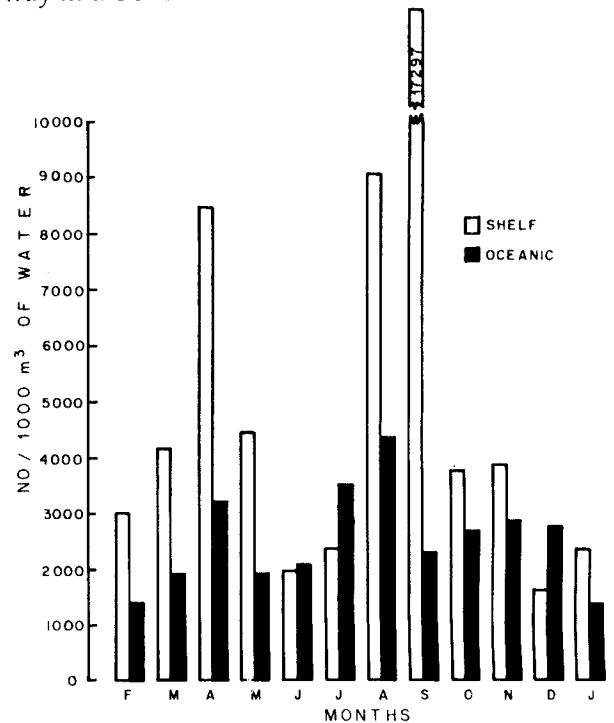


Fig. 4. Monthly abundance of Euphausiacea in the shelf and oceanic waters.

*Coast-wise, latitudinal distribution*

Another study made was the latitudinal abundance in the two sea areas separately (The way in which four latitudinal regions are identified is given in another paper by Mathew *et al.* (1990) which deals with zooplankton biomass in this volume). In the eastern Arabian Sea (Fig. 5) the 2nd and 4th regions yielded the maximum quantity of euphausiids whereas in the Bay of Bengal the 1st and 4th regions contributed the maximum. Thus the 4th region (the northern most region) in the two sea areas proved to be the best sea area for the euphausiids.

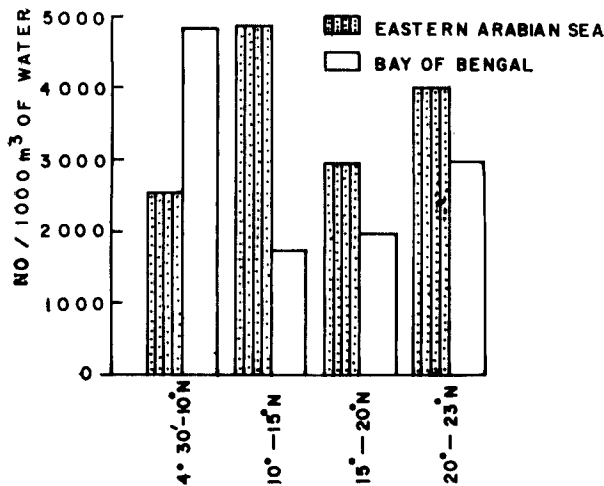


Fig. 5. Latitudinal abundance of Euphausiacea in the various latitudinal regions of the eastern Arabian Sea and the Bay of Bengal.

*Coast-wise, region-wise seasonal distribution*

Further it was sought to understand the region wise seasonal variations in distribution in the eastern Arabian Sea and Bay of Bengal separately (Fig. 6). Off the west coast in regions I and II, the southwest monsoon accounted for the maximum abundance, being 51 and 68% respectively of the total (values standardised to 1000 m<sup>3</sup> of water) of 3 seasons. This was followed by the postmonsoon and premonsoon. In the 3rd and 4th regions of this sea area, premonsoon sharing 58 and 49% respectively happened to be the most favourable period. The monsoon and postmonsoon seasons each contributed only 21-33% of euphausiids only.

In the Bay of Bengal there was no comparable data for all the seasons in the first and fourth regions. In the second region, unlike off the west coast, the premonsoon was rich in euphausiids ( 50% of the 3

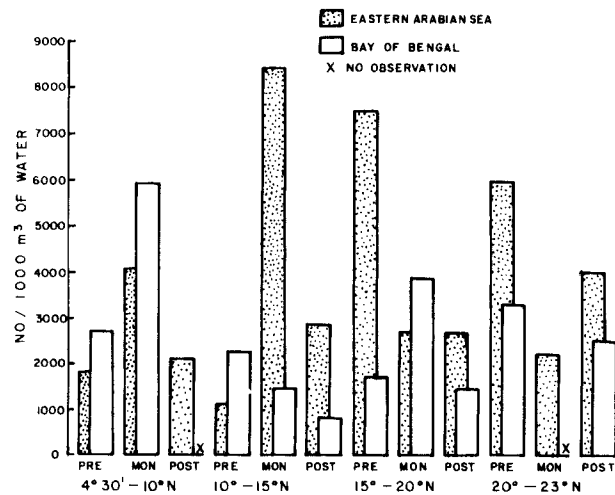


Fig. 6. Seasonal abundance of Euphausiacea in the various latitudinal regions of the eastern Arabian Sea and the Bay of Bengal.

seasons) followed by monsoon and postmonsoon with 32 and 18% respectively. In the third region, the monsoon season with about 55% of euphausiids stood first. The premonsoon and postmonsoon with little more than 20% was almost equally rich.

*Coast-wise, shelf and oceanic, region-wise seasonal distribution*

Fig. 7 presents the region-wise seasonal abundance in the two sea areas in the shelf and oceanic waters. In the eastern Arabian Sea, the 1st region generally contributed less euphausiids. There was not much of a difference between the shelf and oceanic areas in this region with euphausiid numbers falling around 4,000 per 1000 m<sup>3</sup> of water. In both shelf and oceanic areas in this region, the abundance was during monsoon when 64% was the rule in the oceanic area and 49% in the shelf.

In the Bay of Bengal the shelf water with 61% of euphausiids during premonsoon proved to be the best. In the oceanic water also the euphausiids were comparatively more during the premonsoon but the overall quantity was less than in the shelf area.

Unlike in the first two regions, off the west coast, the euphausiids abundance in the shelf and oceanic area of the 3rd region was during the premonsoon. While 76% of the total euphausiids (based on standardised values) of the 3 seasons occurred during the premonsoon in the shelf waters, only 43% occurred in the oceanic waters during the same season.

In the Bay of Bengal also the southwest monsoon period accounted for the maximum euphausiids in both shelf and oceanic areas. However, there was great difference in the abundance, being of the order of 68% in the shelf and 47% in the oceanic area.

In the 4th region the magnitude of difference in euphausiid population between seasons in the shelf as well as oceanic areas was less. While pre-monsoon had a density of the order of 53% in the shelf area, the oceanic waters had it at 38.76% only.

With monsoon data absent, the shelf waters in the 4th region of Bay of Bengal accounted for more euphausiids during the premonsoon (80%) while in the oceanic waters the postmonsoon claimed the maximum (75%).

An analysis of the above results clearly indicates that irrespective of the seasons, maximum fluctuations in the population density is found in the shelf area where the environmental conditions vary drastically according to seasons than in the oceanic area where the same conditions do not fluctuate considerably. Another interesting fact revealed was that in the eastern Arabian Sea the euphausiids migrated southwards as season advanced from pre-

monsoon to southwest monsoon. There was no such migration indicated in the Bay of Bengal.

*Day - night abundance*

As in the case of other diurnally vertically migrating zooplankton, there was a pronounced day-night difference in the abundance of euphausiids also and the results of the study emerged are presented in Fig. 8. A more than cent per cent increase in abundance was noticed in the night samples. While the rate of occurrence was 2,284 per 1000 m<sup>3</sup> of water in the day samples, the same in the night samples was 4,651. A monthwise consideration for the day-night abundance showed that in almost all the months, more than 60% of euphausiids were found in the night samples. The maximum night abundance was noticed in September when the thermocline remains far down. In July when the thermocline used to be in the upper layers of the water column, more euphausiids were taken during the day time, suggesting that the euphausiids were reluctant enough to swim up or down in the water column penetrating the strong thermocline. In June also the night time abundance was not that much pronounced.

In summing up it may be stated that the euphausiids form a major portion of the plankton in the eastern Arabian Sea and the Bay of Bengal. They are more abundant in the former sea area. Seasonally, the monsoon proved to be the best season followed by postmonsoon and then premonsoon and this throws some light on their breeding season. This finding is in agreement with the results made earlier on this planktonic group in the shelf water along the

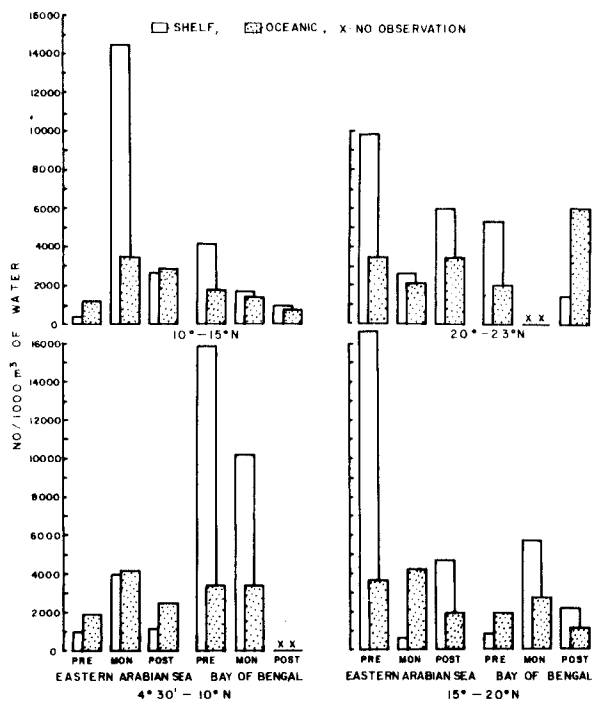


Fig. 7. Seasonal abundance of Euphausiacea in the shelf and oceanic waters in the different latitudinal regions of the eastern Arabian Sea and the Bay of Bengal.

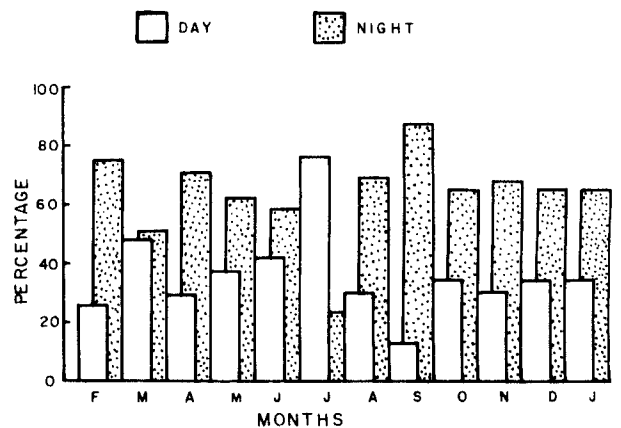


Fig. 8. Monthly day-night variations in the abundance of Euphausiacea.



southwest coast (Mathew, 1980). Considerable differences in abundance were noticed between shelf and oceanic areas with dramatic fluctuations in the shelf waters. And finally, large scale abundance was found in the night samples especially after the southwest monsoon period.

## ACKNOWLEDGEMENTS

The authors are thankful to Dr. P.S.B.R. James, Director, Central Marine Fisheries Research Institute, Cochin for his immense interest in this work and for constant encouragements. Their sincere thanks are also due to Shri P.P. Pavithran for the help rendered in computer processing of the data.

## REFERENCES

- GOPALAKRISHNAN, K. AND E. BRINTON 1969. Preliminary observations on the distribution of Euphausiacea from the International Indian Ocean Expedition. *Bull. Natl. Inst. Sci. India*, No. 38: 594-611.
- BRINTON, E. AND K. GOPALAKRISHNAN 1973. The distribution of Indian Ocean euphausiids. In: *The biology of the Indian Ocean*. Bernt Zeitschel (Ed.), Springer-Verlag, Berlin, 357-382.
- MATHEW, K. J., T. S. NAOMI, GEETHA ANTONY, D. VINCENT, R. ANILKUMAR AND K. SOLOMON, 1990. Studies on zooplankton biomass and secondary production of the EEZ of India. *Proc. First Workshop Scient. Resul. FORV Sagar Sampada*, 59-69.
- PONOMAREVA, L.A. 1964. On the studies of Euphausiacea of the Arabian Sea and the Bay of Bengal. *Tr. Inst. Okeanol. Akad. Nauk SSSR*. 64: 265-270.
- PONOMAREVA, L.A. 1972. Quantitative distribution of euphausiids in the Indian Ocean. *Oceanology, Moscow*, 12: 576-581.
- PONOMAREVA, L.A. 1975. The euphausiids of the Indian Ocean and Red Sea. *Akademy Nauk, SSSR, Moscow*, 83 pp.
- WEICHMANN, R. 1970. Zur ökologie und ernährungs - biologie der Euphausiacea (Crustacea) im Arabischen Meer. *"Meteor" - Forschungsergeb.*; D (5): 11-52.