SEASONAL CYCLE OF PELAGIC COPEPODS FROM THE FISHING GROUNDS OFF BOMBAY

V. KUNJUKRISHNA PILLAI[1]
Central Marine Fisheries Research Institute; Sub-station, Bombay

ABSTRACT

The seasonal cycle and relative abundance of the common copepods of Bombay waters are discussed. The influence of surface temperature and salinity on the seasonal abundance of copepods is pointed out. The copepods exhibited considerable fluctuation, with two peak periods during March-April and October-November. It is observed that the breeding season of copepods coincided with phytoplankton maximum during January-February. The probable influence of copepod abundance on the local fishery is discussed.

It is well known that the copepods form a major food item for many fishes and their young ones. The object of the present investigation was to study the seasonal cycles and relative abundance of the common copepods of Bombay waters and to examine whether any relationship exists between the copepod abundance and the local fishery.

MATERIAL AND METHODS

The data discussed here form part of the regular programme of hydrobiological observations from the trawling grounds within the depth range of 25-30 m. Samples were collected from the major fishing area 18-72 (in and around the sub-area 18-72/6D) and around the floating light house, Bombay harbour. The plankton was collected using a half-meter diameter organdy cloth net. The displacement volume of the plankton and the total number of copepods were calculated per unit volume (1000 m^3). Surface temperature and salinity were also recorded from the stations of plankton collection. Observations presented here are based on weekly samples collected from January 1966 to May 1968. As only surface tows were made there are no data on the occurrence of organisms throughout the water column. When the frequency and the time of sampling are taken into consideration the possibility that important species might have been missed entirely by the net must be emphasized.

---

1. Present address: Central Marine Fisheries Research Institute, Cochin-11.

OBSERVATIONS

The data on surface temperature show a bimodal fluctuation with two maxima, one in May and the other in October. The maximum temperature recorded was 30° C (May) and the minimum was 24.2° C (January). The salinity values varied between 36.2‰ (May) and 33.7‰ (November). On the west coast of India, Subrahmanyan (1959) observed a double oscillation of surface temperature with maxima during April-May and October-November. He also observed the maximum salinity values during April-May and a fall in surface salinity values during the south-west monsoon. In the present investigation there are no data for the south-west monsoon period. But earlier observations of Jayaraman *et al.* (1962) showed a fall in the surface salinity values during July-August, the south-west monsoon months, in the Bombay waters.

Taxonomic list of the common copepods of Bombay waters

Family: Calanidae
- *Nannocalanus minor* (Claus)
- *Undinula vulgaris* (Dana)

Family: Eucalanidae
- *Eucalanus crassus* Giesbrecht
- *Eucalanus subcrassus* Giesbrecht

Family: Paracalanidae
- *Acrocalanus gibber* Giesbrecht
- *Acrocalanus gracilis* Giesbrecht

Family: Euchaetidae
- *Euchaeta concinna* Dana
- *Euchaeta marina* Prestandrea
- *Euchaeta wolfendeni* Scott

Family: Centropagidae
- *Centropagus orsinii* Giesbrecht
- *Centropagus tenuiremis* Thompson and Scott
- *Centropagus dorsispinatus* Thompson and Scott

Family: Pseudodiaptomidae
- *Pseudodiaptomus aurivillii* Cleve

Family: Temoridae
- *Temora turbinata* (Dana)
- *Temora discaudata* Giesbrecht

Family: Pontellidae
- *Labidocera pectinata* Thomoson and Scott
- *Labidocera minuta* Giesbrecht

Family: Acartiidae
- *Acartia spinicauda* Giesbrecht

Family: Tortanidae
Tortanus barbatus (Brady)
Tortanus gracilis (Brady)

Family: Macrosetillidae
Macrosetella gracilis (Dana)

Family: Clytemnestridae
Clytemnestra scutellata Dana

Family: Tachididae
Euterpina acutifrons (Dana)

Family: Oithonidae
Oithona plumifera Baird
Oithona brevicornis Giesbrecht

Family: Oncaidae
Oncaea venusta Philippi

Family: Corycaeidae
Corycaeus catus Dahl

Apart from these, the following species were identified in the plankton. Since their appearance is infrequent and quantitatively negligible, they have not been considered for detailed observation.

Family: Calanidae
Calanus tenuicornis Dana
Canthocalanus pauper (Giesbrecht)

Family: Eucalanidae
Eucalanus monachus Giesbrecht
Eucalanus attenuatus (Dana)

Family: Paracalanidae
Paracalanus parvus (Claus)
Paracalanus aculeatus Giesbrecht
Acrocalanus longicornis Giesbrecht

Family: Candaciidae
Candacia bradyi Scott
Candacia sp.

Family: Pontellidae
Labidocera acuta (Dana)
Pontella securifer Brady
Pontellopsis scotti Sewell
Pontellopsis herdmani Thompson and Scott

Family: Acartiidae
Acartia erythraea Giesbrecht
Acartia clausi Giesbrecht

Family: Oithonidae
Oithona spinirostris Claus
Oithona similis Claus

Family: Oncaeidae
Oncaea conifera Giesbrecht

Family: Corycaeidae
Corycaeus danae Giesbrecht
Corycaeus speciosus Dana
Corycaeus limbatus Brady

Family: Sapphirinidae
Sapphirina stellata G esbrecht
Sapphirina sp.

Of the above 50 species identified, seven species occur almost throughout the year and form the bulk of the copepods present (Fig. 1). Others appear only occasionally. Details about their seasonal cycles and relative abundance are given in Table 1.

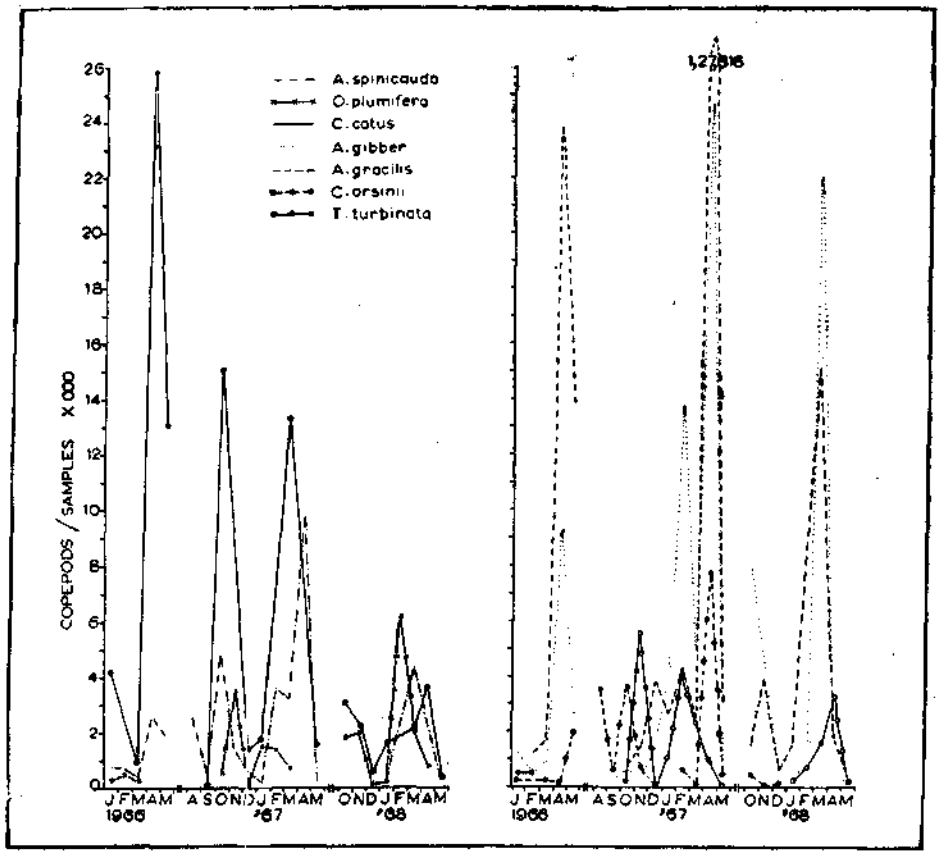

FIG. 1. Seasonal cycle and relative abundance of dominant species of copepods.

TABLE 1. *Seasonal cycle of copepods from the fishing grounds off Bombay*

Months:	J	F	M	A	M	A	S	O	N	D	J	F	M	A	M	O	N	D	J	F	M	A	M
	1966										1967								1968				
Nannocalanus minor	—	—	—	—	—	—	—	C	C	F	—	—	—	—	—	A	—	—	—	—	C	—	—
Undinula vulgaris	—	—	—	F	A	—	—	—	—	—	—	—	F	—	—	—	—	—	—	—	C	C	F
Eucalanus crassus	—	F	A	A	A	R	R	—	R	—	C	A	F	A	A	—	C	F	—	—	—	—	—
Eucalanus subcrassus	—	—	—	—	—	—	—	A	—	—	—	—	—	—	—	—	C	F	F	—	C	C	F
Acrocalanus gibber	A	C	C	A	A	—	F	C	F	A	A	A	A	A	A	A	A	C	C	C	A	F	F
Acrocalanus gracilis	—	A	A	A	A	—	—	C	A	A	A	A	A	A	A	A	A	C	C	C	A	C	F
Euchaeta concinna	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euchaeta marina	C	F	F	—	F	—	—	—	—	—	F	F	R	R	A	—	—	—	—	—	—	—	—
Euchaeta wolfendeni	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	A	A	—
Centropaous orsinii	F	—	F	F	A	A	C	A	C	R	—	C	F	A	C	F	R	F	—	—	—	—	—
Centropagus tenuiremis	—	—	—	—	—	C	F	A	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—
Centropagus dorsispinatus	—	—	—	—	—	—	F	R	—	—	—	—	—	—	—	—	A	—	—	—	—	—	—
Pseudodiaptomus aurivilli	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C	—	—	—	—	—	R
Temora turbinata	C	C	—	—	—	—	—	F	A	R	A	A	A	A	F	—	F	—	F	C	A	A	R
Temora discaudata	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—
Labidocera pectinata	—	—	—	—	A	—	—	—	—	—	—	—	—	—	—	—	—	—	—	A	—	—	R
Labidocera minuta	—	—	—	A	A	—	—	R	A	—	—	C	F	—	—	—	F	F	—	—	—	—	—
Acartia spinicauda	C	C	C	A	A	A	C	A	A	C	F	A	A	A	F	—	A	—	F	—	A	—	R
Tortanus barbatus	—	—	—	—	—	—	—	—	—	—	—	—	—	A	—	A	C	F	—	—	A	C	R
Tortanus gracilis	—	—	—	—	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—
Macrosetella gracilis	—	—	—	—	C	—	F	—	—	—	—	C	A	A	A	—	—	—	—	—	—	A	—
Clytemnestra scutellata	F	F	—	—	—	—	—	—	—	—	—	—	—	C	C	—	C	—	F	—	—	—	—
Euterpina acutifrons	—	—	—	F	F	—	—	F	—	—	A	A	A	A	A	A	F	F	—	—	—	—	—
Oithona plumifera	F	C	F	—	—	—	—	C	A	R	A	A	C	—	—	A	A	F	F	A	A	C	—
Oithona brevicornis	—	—	—	—	—	—	—	—	—	—	—	—	—	F	—	F	A	—	R	A	C	—	—
Oncaea venusta	C	—	F	—	A	—	—	—	—	—	A	A	A	A	F	F	A	—	C	A	A	A	—
Corycaeus catus	A	A	C	A	A	—	R	A	A	A	A	A	A	A	A	A	A	C	A	—	A	A	F

The symbols used denote as follows: R—rare <100; F—few 100-500; C—common 500-1000; A—abundant> 1000; —not recorded

DISCUSSION

The data show that the copepods exhibit considerable fluctuation in their occurrence and abundance. There are two peak periods, one in March-April and the other in October-November (Fig. 2). The March-April peak was comparatively richer.

About twenty seven species were observed to be common. Of these, the following species, *Eucalanus crassus*, *Acrocalanus gibber*, *A. gracilis*, *Temora turbinata* *Acartia spinicauda*, *Oithona plumifera* and *Corycaeus catus* were numerically more abundant and were present almost throughout the year (Fig. 1). Some species show very interesting periodicity in their appearance in the plankton. For instance, *Euchaeta marina* was observed only during the first half of the year (January-May) and *Centropagus tenuiremis* was present only during the second half of the year (August - December). *Centropagus dorsispinatus* occurred only during the months of September, October and November. Species which occurred only once during the entire period of investigation were *Euchaeta concinna* (August 1966), *Temora discaudata* (February 1967) and *Tortanus gracilis* (December 1966). During March-April the sea water was comparatively warm (27.4° - 27.5°C) and salinity values high (3.55‰ - 35.7‰). Many species appear to show a preference to this period in their occurrence. During October-November also copepods were abundant but to a lesser magnitude when compared with the March - April peak. Sudarsan (1964) observed that the standing crop showed a considerable increase during March. Carruthers *et al.* (1959) observed upwelling off the coast of Bombay in October 1958 during the north-east monsoon period resulting in high production of plankton. Subsequent observations of Sudarsan (1964) and Pillai (1969) also showed that the standing crop of plankton reached a peak during October - November (temperature 28.7° - 27.5° C and salinity 34.3‰ - 34.4‰). Early and late copepodites were abundant in the plankton during January and February. Here it is significant to note that there is a phytoplankton maximum in Bombay waters during the same period (Gonzalves, 1947 and Pillai, 1969). The subsequent abundance of the adult copepods observed during March - April shows that the conditions then existing were favourable for their growth and abundance.

Although the tidal influence is considerable in this region the salinity conditions remain more or less steady except during the south-west monsoon period. Since most of the copepods prefer warmer waters during March-April and October-November, it would appear that variations in the temperature is one of the important factors that influence the seasonal abundance of copepods in this area. It is well known that upwelling of the waters occurs along the west coast of India during the south-west monsoon period. The nutrient-rich water thus prevailing during those months may have contributed to the increased production of plankton organisms in general and copepods in particular. Banse (1968) observed that the cool water rising regularly on to the shelf between Bombay and Karachi and most probably south of Bombay as well, during the south-west monsoon is present at shallow depths at least until

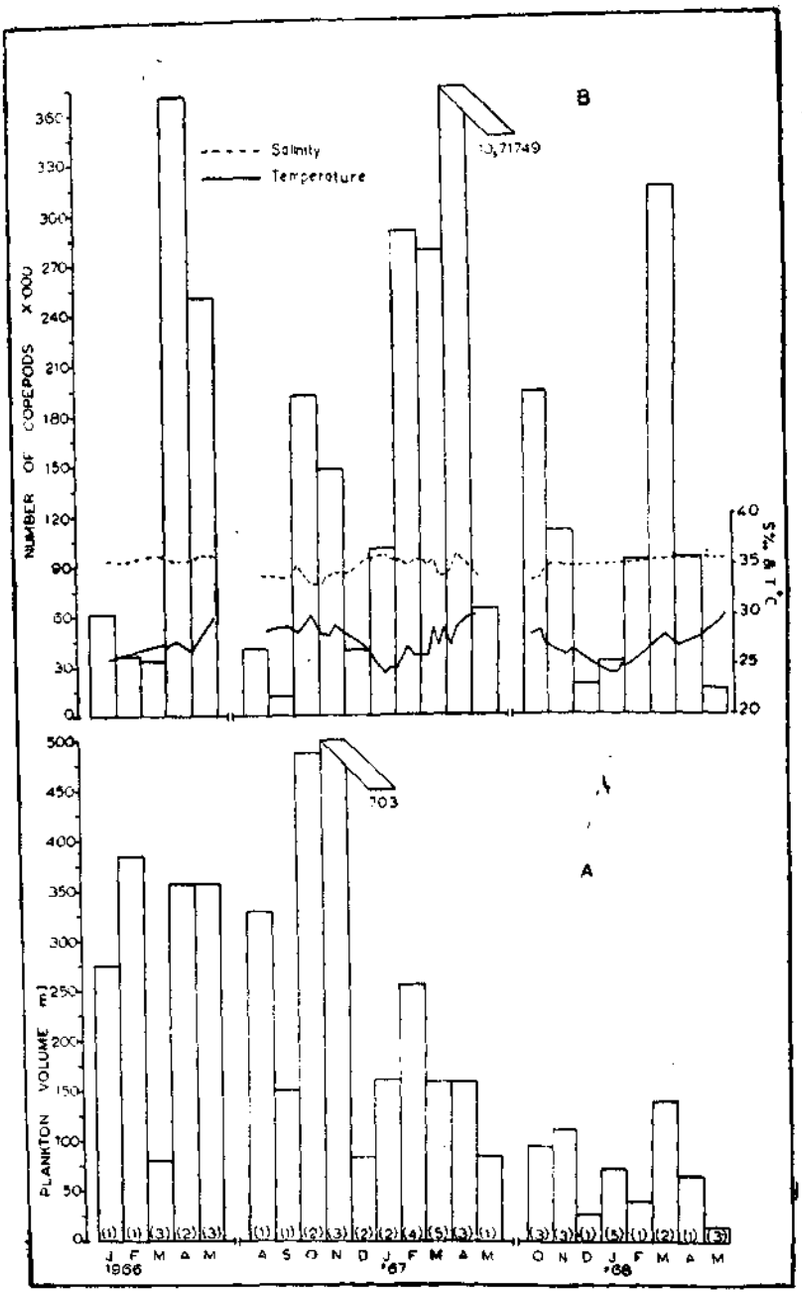

FIG. 2. A. Seasonal variation in the displacement volume of zooplankton. (Figures in parantheses show the number of samples). B. Seasonal variation and relative abundance of copepods with reference to temperature and salinity.

the onset of the north-east monsoon . He also adds that high photosynthetic rates can be expected during the south-west monsoon and later until the cool, deoxygenated sub-surface water withdraws from the shelf. Unfortunately owing to various limitations no data could be collected during the south-west monsoon period and hence the seasonal cycle and relative abundance of the copepods could not be estimated for that period.

The fishery of Bombay is mostly of fishes of a semidemersal nature predating on plankton-feeding fishes. The larvae and juveniles of these fishes depend on the plankton organisms for their nourishment. Also adult fishes such as *Bregmaceros mcclellandi* feed mainly on copepods and prawn larvae and they, in turn form the food of *Harpodon nehereus* and other fishes. It is interesting to note that *Bregmaceros mcclellandi* and *Harpodon nehereus* are landed in large quantities after the south-west monsoon period.[2] Sudarsan (1964) observed two peaks in the fish catches of Bombay, one following the period of plankton maximum in March and the other coinciding with the period of high plankton standing crop in the post-monsoon months. The observations of Bapat and Bal (1950 and 1952) on the food and feeding habits of twenty three species of fishes from Bombay waters revealed that most of them are surface plankton feeders. They further state that the occurrence of larvae and post-larvae of clupeoids in the summer and early rainy seasons only seems to indicate that many of them breed during that period. Here, the importance of plankton maximum, particularly of copepods, during those months may be emphasized since the greatest influence of plankton on fish is undoubtedly in providing proper food at the proper time and in proper quantities for the developing young ones.

ACKNOWLEDGEMENTS

I wish to express my sincere thanks to Shri K. Virabadhra Rao for suggesting the problem and encouragement during the course of this study. I am deeply indebted to Dr. R. Subrahmanyan and Dr. E.G. Silas for their guidance, critical perusal of the manuscript and valuable comments. I am also grateful to my colleague Shri P. Parameswaran Pillai for his help in the preparation of this paper. I am specially thankful to the Director, Department of Fisheries, Maharashtra State, Bombay, for kindly permitting me to collect part of the data presented here on board their research vessel *Mysis*.

2. Rao (1969, *Bull. cent. mar. Fish. Res. Inst.*, No. 6) observed that in this region the overall catch rates for all fishes are generally very high from January to March and October to December.

REFERENCES

BANSE, KARL. 1968. Hydrography of the Arabian Sea shelf of India and Pakistan and its effects on demersal fishes. *Deep Sea Res.*, **15**: 45-79.

BAPAT, S.V. AND D.V. BAL. 1950. The food of some young clupeids. *Proc. Indian Acad. Sci.*, **32B**: 39-58.

BAPAT, S.V. AND D.V. BAL. 1952. Food of some young fishes. *Proc. Indian Acad. Sci.*, **35B**: 78-92.

CARRUTHERS J.N., S.S. GOGATE, J.R. NAIDU AND T. LAEVASTU. 1959. Shoreward upslope of the layer of minimum oxygen off Bombay: its influence on marine biology especially fisheries. *Nature*, **183**: 1084-1087.

GONZALVES, E.A. 1947. Variations in the seasonal composition of the phytoplankton of Bombay harbour. *J. Bombay Univ.*, **4**: 105-143.

JAYARAMAN, R., R. VISWANATHAN AND S.S. GOGATE. 1962. Characteristics of sea water near the light house, Bombay. *J. mar. biol. Ass. India*, **3**: 1-5.

PILLAI, V. KUNJUKRISHNA. 1969. Observations on the plankton off Bombay coast with remarks on the hydrographic conditions and fishery. *J. mar. biol. Ass. India*, **10**: 237-244.

SUBRAHMANYAN, R. 1959. Studies on the phytoplankton of the west coast of India. Part II. *Proc. Indian Acad. Sci.*, **50 B**: 189-252.

SUDARSAN, D. 1964. Observations on the plankton and trawler catches off Bombay. *J. mar. biol. Ass. India*, **6**: 222-225.