

A NOTE ON THE BREEDING OF COPEPODS AND ITS RELATION TO DIATOM CYCLE¹

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INTRODUCTION

DURING the last fifty years a considerable amount of work has been done on the copepods of the Indian waters but these investigations deal mainly with the taxonomy and seasonal variations in their abundance and our knowledge of the biology of these is very meagre. Because the copepods play an important rôle in the economy of the sea, detailed work on the biology of the common copepods was taken up in the Central Marine Fisheries Research Station and the present observations relate to the breeding of copepods in general and its relation to the diatom cycle. The observations are based on regular samples collected from the inshore waters of the Gulf of Mannar and Palk Bay off Mandapam.

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BREEDING OF COPEPODS

The occurrence and abundance of nauplii and copepodites (Figs. 1-3) have been taken as an indication of the breeding time and intensity. This procedure was necessitated in view of the practical difficulties in estimating the number of eggs particularly in those species of copepods which do not carry egg-sacs. In considering the breeding of copepods as a whole, it is found that one species or another is breeding throughout the year in varying intensities. But it is equally obvious that there are distinct peak periods.

In Palk Bay breeding seems to take place almost throughout the year but the intensity extends from the second half of April or early May up to October. During this period a series of peaks are noticed in the distribution of nauplii, the peaks occurring almost at intervals of one month. This is obviously indicative of the production of successive broods during the season. The sampling is, however, not adequate to give any information about the number of broods as the copepods pass through the nauplius stage rapidly. In the temperate waters the usual number of broods is three or four and in cold waters this appears to be reduced to one. It is not unlikely that in the tropical waters there are more number of broods than in the temperate and cold waters. In the Gulf of Mannar also breeding takes place

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throughout the year but the pattern seems to be different from that of Palk Bay. Breeding intensity is often at its lowest between May and August when it is at a peak in Palk Bay, and highest during September to March or April. The data available suggest that the intensity of breeding on the whole is lower in the Gulf than in Palk Bay.

It was pointed out by Prasad (1956) that in the Gulf of Mannar during the years 1951-53 the average annual standing crop of copepods is higher compared to that of Palk Bay. This was found to be the case during the year 1953-54 also by Kartha (1959). But surprisingly enough the nauplii population appeared to be distinctly higher in Palk Bay in all these years, except in 1952 when the level of populations was somewhat similar in the two regions. It will therefore be of interest to examine more closely the relative abundance and distribution of copepodites and adults in the two areas in order to ascertain whether the difference noticed in the nauplii populations is real or artificial. Kartha (*l.c.*) has already reported that the distribution of copepodites and the adults in the two areas showed differences not only in abundance but also in species composition. Considering the average annual population of copepodites it can be said that during the period of observation it was higher in Palk Bay except in 1952 when it was the other way about. However, the magnitude of differences in the population levels, as between nauplii on the one hand and copepodites on the other, is less evident in the case of copepodites. In the Gulf, there is distinctly a greater population of copepodites during September to March, whereas in Palk Bay their maximum is during May to September. Comparing the adult population of copepods in the two areas the margin of disparity is still further reduced and it is only during January to March that there is a remarkably higher population in the Gulf, which mainly accounts for the higher average annual population. During January-February a large-scale migration of copepods from Palk Bay, where the sea is turbulent and the phytoplankton production is at an extremely low level, to the Gulf of Mannar where conditions are highly favourable, seems possible. Such movements may also be facilitated by the fact that during this period the drift of water is from Palk Bay into the Gulf. In both areas the adults increase in their number by November but in Palk Bay there is an abrupt decimation in the adult population by about the end of December or early January and the corresponding sudden increase of adults in the Gulf. This is strongly suggestive of the migration from one place to another owing to unfavourable conditions. Detailed study of the adult populations on the basis of measurements of the cephalothorax is in progress in the hope that it will throw some light on this aspect.

It is well known that the productive potential or rate of fecundity and breeding time varies from species to species. Kartha (*l.c.*) in his detailed study on the adult copepods of these areas reported that in the Gulf of Mannar there is a higher population of *Paracalanus parvus*, *Acrocalanus* spp., *Corycaeus* spp., and *Oithona* spp. An examination of the occurrence of these different species indicates that during January-February there is a very large population of *P. parvus*; *Acrocalanus* spp. are abundant during the second half of the year; *Corycaeus* spp. have peaks in March and September-November and *Oithona* spp. are at their maximum in September. In January several specimens of *Pseudodiaptomus mertoni* also are seen carrying eggs. It was mentioned earlier that in the Gulf of Mannar copepodites are present throughout the year but are more abundant during the months of September to March (Fig. 3) which clearly indicates the greater intensity of breeding during this period. The species commonly occurring during these months have been listed above and

all of them are known to have relatively small nauplii; their size ranging from 68 to 180 μ . The question therefore arises whether in the event of the above-mentioned species breeding, their nauplii are adequately represented in the net plankton collections. The meshes of the net used are ca. 230 μ and it is obvious that a large percentage of these small nauplii would have escaped through the meshes. Thus, the low population of nauplii observed in the Gulf is purely artificial caused by inadequate sampling. This is further substantiated by the data on the nauplii of the same area collected recently during the investigations on the primary production of the area, by filtering through filter paper or centrifuging known quantities of water. These data also indicate that nauplii are more abundant during September to March. Several other factors undoubtedly influence the level of population of nauplii. One such factor may be the rate of mortality. The breeding of copepods in the Gulf, from September to March, coincides well with the spawning of fishes of this area, whereas there appears to be very little spawning of fishes, as judged from the occurrence of fish eggs and larvae in the plankton, in the inshore waters of this area during April or May to August when there is active breeding of copepods in Palk Bay. The main peak of spawning of fishes in both the areas is in February-March and a secondary one during September-November and Bapat (1955) has reported that there is a greater concentration of pelagic fish eggs in the Gulf of Mannar than in Palk Bay. During both these periods there seems to be active breeding of copepods in the Gulf particularly of those species having small nauplii and consequently a large crop of minute nauplii are available for the fish larvae. It is well known that larval copepods form a most important source of food for some of the fish larvae and the feeding by a large number of fish larvae on the nauplii is bound to reduce their number appreciably.

In considering all these it appears that the difference in the intensity of nauplii population noticed between the two areas is more apparent than real and that intensive breeding of copepods does take place during September to March in the Gulf when most of the species spawning have relatively small nauplii, while in Palk Bay intensive breeding is noticed during May-September and the species then breeding mostly have relatively larger nauplii. Further, there is no indication to suggest that the same species is breeding at different times in the two regions. The breeding periodicities show a positive relation to the diatom cycles of these areas as will be discussed below.

BREEDING AND ITS RELATION TO DIATOM CYCLE

The connection between the phytoplankton maxima and breeding of copepods in the temperate and cold waters has been discussed by many workers. Considerable amount of information is available which indicates that there does exist a relation between the breeding of copepods and the presence of an abundant phytoplankton population. It has even been shown that in areas where there is only one diatom increase in the year, as in East Greenland, copepod reproduction was entirely dependent on the diatom increase (Ussing, 1938. See also Marshall and Orr, 1952 for other related references). As against this the investigations of Clarke and Zinn (1937) in the Woods Hole region did not indicate any necessary dependence of copepod production upon diatom abundance. Recent experiments on *Calanus finmarchicus* by Marshall and Orr (1952) to study the effect of food on egg production have revealed that food does not act as an immediate stimulus for the actual egg-

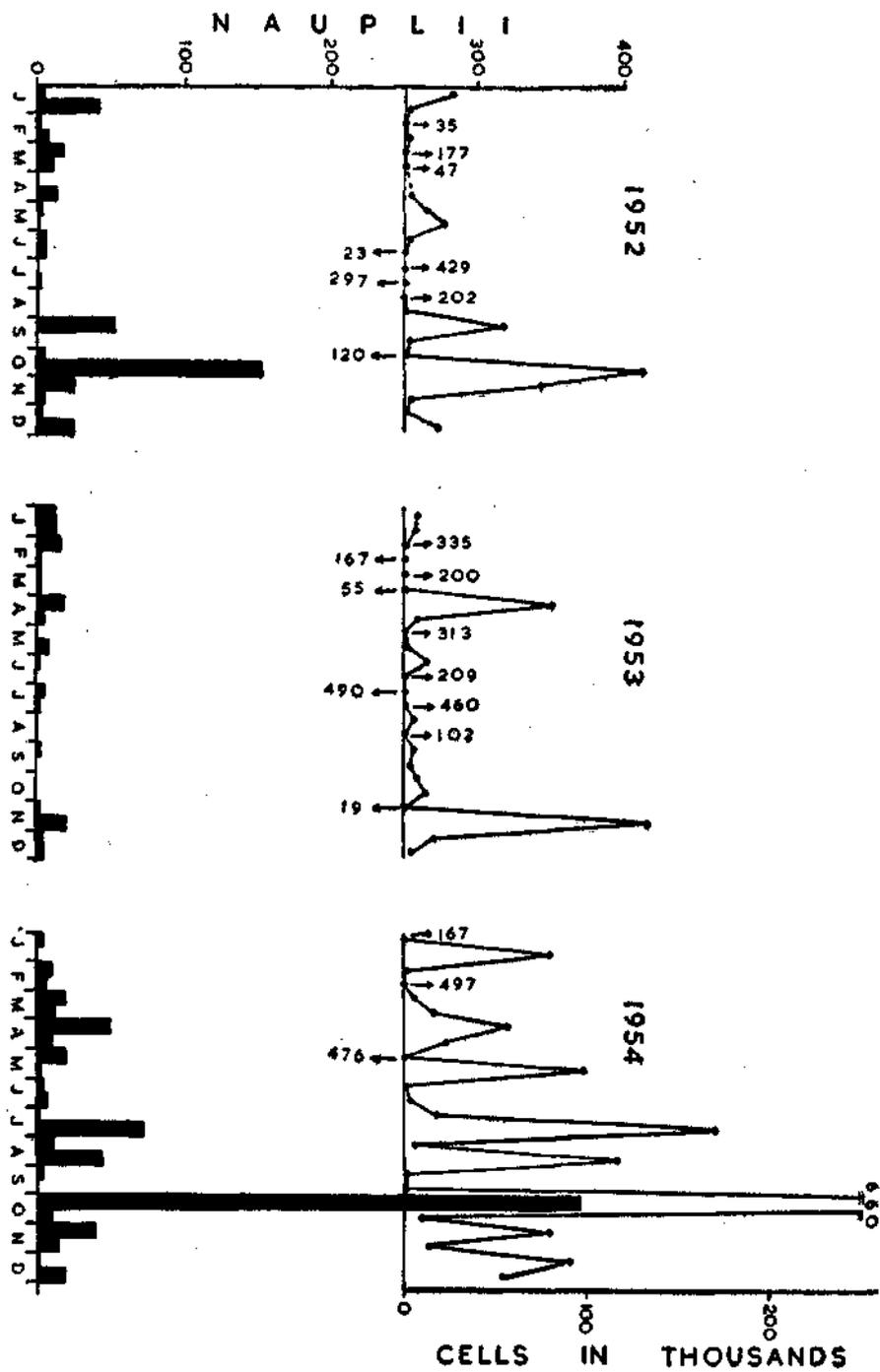


FIG. 1. The distribution of nauplii and the diatom cycle in the Gulf of Mannar.

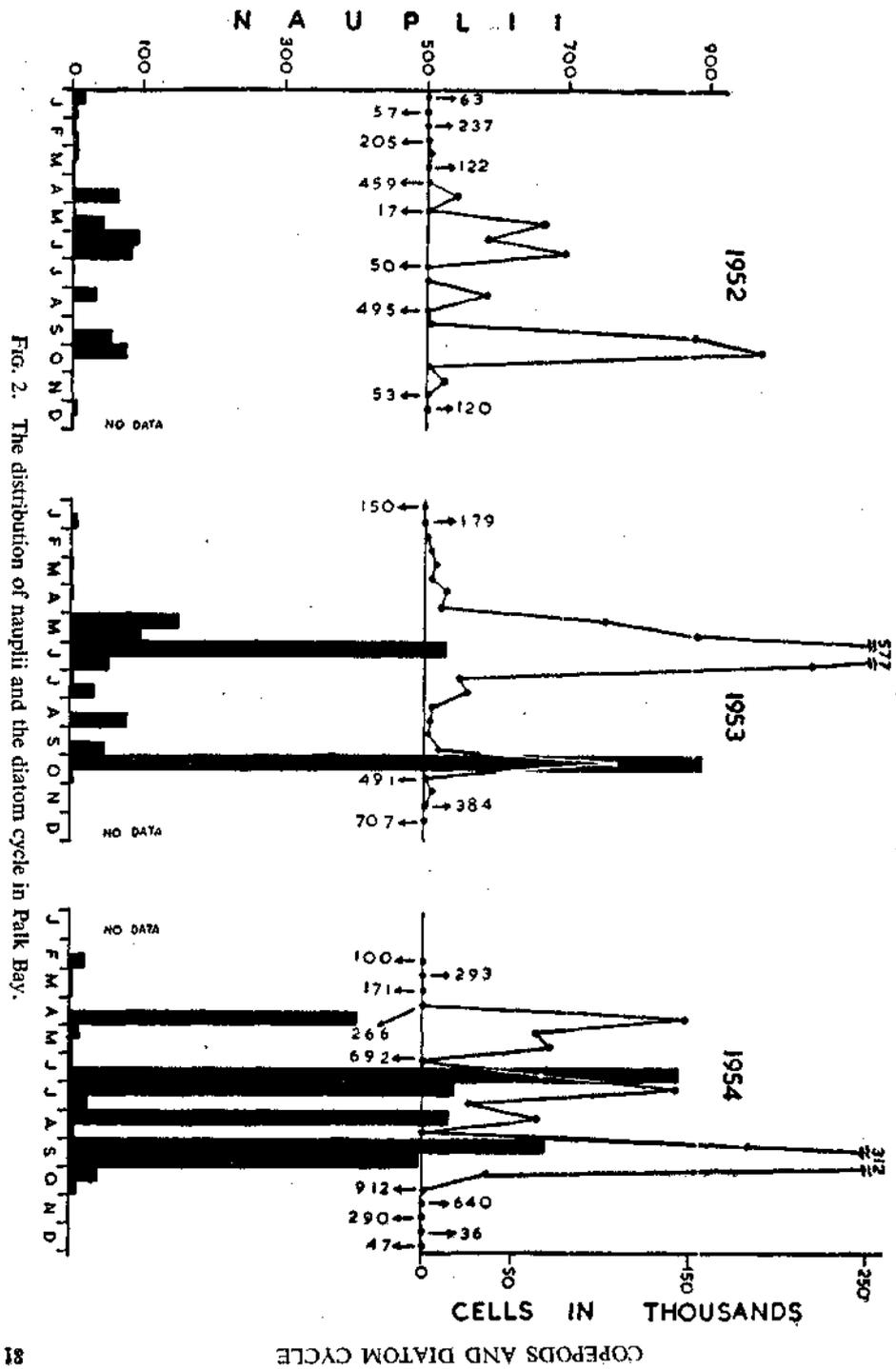


Fig. 2. The distribution of nauplii and the diatom cycle in Palk Bay.

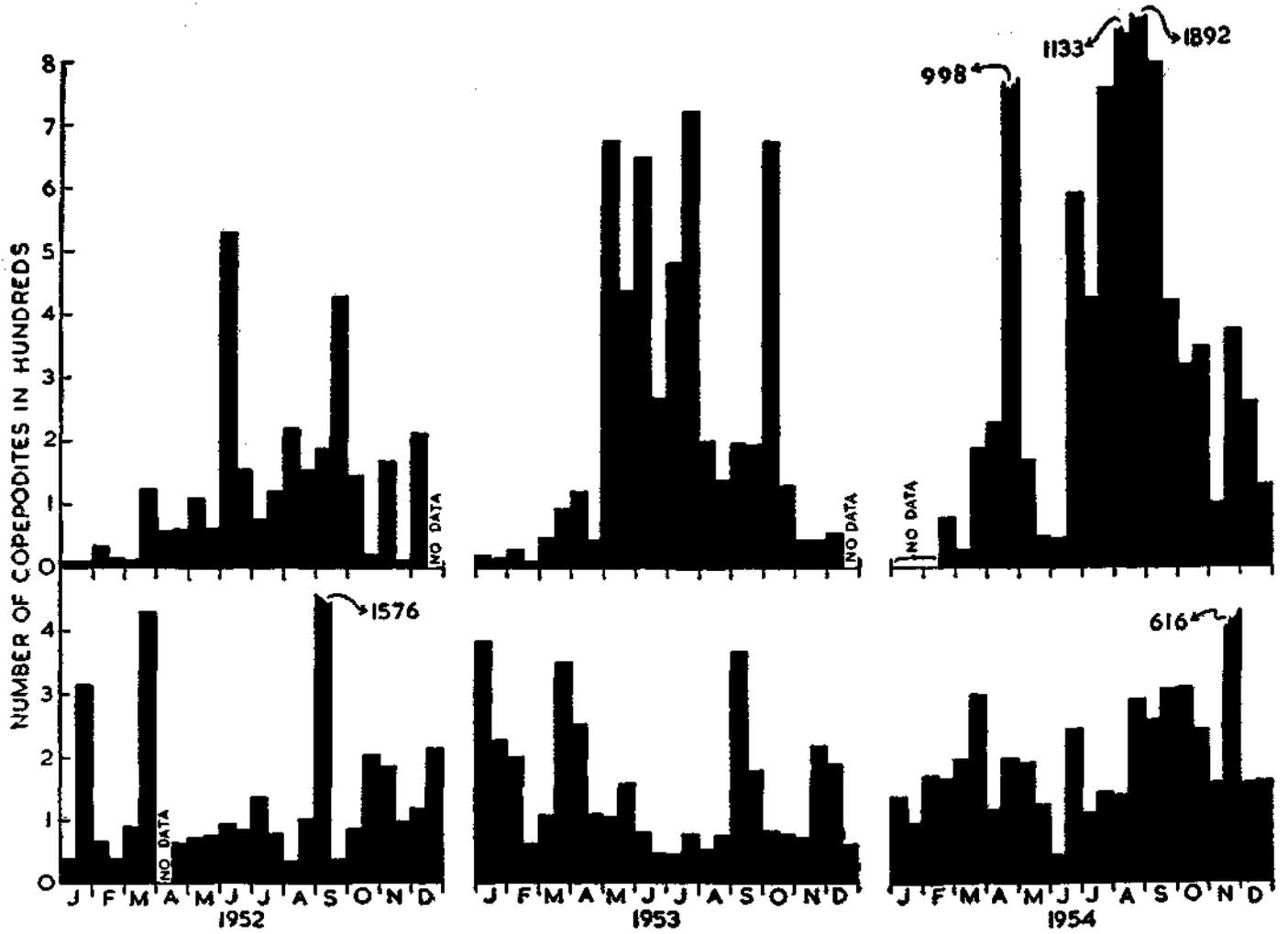


FIG. 3. The distribution of copepodites in the Gulf of Mannar (Lower half) and Palk Bay (Upper half).

laying, but when available it seems to be rapidly digested and used for egg production. A number of different cultures of diatoms and flagellates were tested as food and it was found that all the diatoms resulted in the production of eggs while all the flagellates were not successful. It was also observed that females though ready to lay eggs do not necessarily do so but may hold them up until conditions become favourable. They further remarked that the production of broods by some of the smaller copepods also seems to depend upon diatom outburst and it may therefore be expected that these will show a similar effect of feeding on egg-laying. It thus becomes evident that some factor or factors act as a trigger to set off egg laying and it has been suggested that this may explain why in the sea egg-laying often seems to coincide with diatom increase although food does not necessarily act as the immediate stimulus to egg-laying.

In the temperate waters because of the short duration of the phytoplankton abundance the spawning in many marine invertebrates coincides with the diatom increase. This synchrony has been noticed by several workers. Recently Barnes (1957) has remarked: '..... that in many boreo-arctic forms mechanisms exist which tend to synchronize larval development with the spring phytoplankton outburst; and that this takes place not only at the northern limits of distribution but also over a wider range.' Recent investigations on the breeding of tropical marine invertebrates have strongly suggested that there are regular periodicities (Prasad, 1954) and although in the coastal areas phytoplankton may be available almost throughout the year in varying quantities, still there is reason to believe that the phytoplankton cycle has considerable influence on the breeding of many invertebrates. Barnes (1957) discussed the synchronization of the spring diatom outburst and naupliar development with particular reference to *Balanus balanoides* and demonstrated by experimental work the presence of a substance, presumed to be the resultant of the metabolic activity of the diatoms, that stimulates the release of nauplii.

Krishnaswamy (1950) in his study of the larval stages of some copepods of the Madras plankton states that 'the abundance of food due to diatom outbursts may be responsible for the abundance of larvae in July-September, December and March.' He noticed that the larvae were not common when diatoms reached their maximum concentration in April, May and June and remarked that the observations are in agreement with those of Clarke and Zinn (1937) according to whom the spawning periods of *Calanus* did not occur at times of diatom maxima. Ramamurthy (1953), on the other hand, observed in the same area that the peaks in the copepod nauplii were in April-May and November-December and these coincided with the diatom peaks. Further work seems to be necessary to explain this difference.

The present data indicate clearly the relation between the diatom maxima and the breeding of copepods (Figs. 1, 2 and 3). As mentioned earlier the maximum breeding of copepods in the Gulf of Mannar and Palk Bay shows differences in time. In the Gulf there is a comparatively higher diatom population during October to March and blooms of certain species of diatoms causing minor peaks are recorded during January-March and July-August. The two major peaks are, however, during September-October and May, the former being more prominent of the two. In Palk Bay there are only two peaks one in June and another in September and minor peaks are seldom noticed. In July-August the diatom population in Palk Bay is on an average higher than that of the Gulf of Mannar (Prasad, 1956 and 1958). From Figs. 1 to 3 it is evident that the

maximum breeding in the Gulf of Mannar is during September to March and in Palk Bay during May-September which coincides with the diatom abundance of these two areas. Further, in Figs. 1 and 2 the successive peaks of nauplii coincide with diatom peaks, but however, the converse is not always true. Detailed work on the breeding of particular species of copepods and its relation to specific phytoplankters will be interesting and such investigations are necessary to establish more precisely the nature of relationship.

SUMMARY

The breeding of copepods in the Gulf of Mannar and Palk Bay has been discussed. The maximum breeding in the Gulf takes place during September-March, whereas in Palk Bay it is from May-September. The difference in the intensity of breeding at the two regions is more apparent than real and the possible reasons for the observed differences are discussed.

The species of copepods breeding during these periods at the two regions are different.

The close relation between breeding of copepods and the diatom cycles of the two regions is discussed and it is observed that in both the areas breeding, to a very large extent, is dependent on the diatom cycle.

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