

OBSERVATIONS ON THE DISTRIBUTION AND FLUCTUATIONS OF PLANKTONIC LARVAE OFF MANDAPAM*

by

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A few of the important groups of planktonic invertebrate larvae that occur in our coastal waters have been studied by various investigators who were concerned chiefly with the taxonomic and developmental aspects. Of the several contributions, mention may particularly be made of those by Menon (1914), Panikkar (1936, 1938 and 1947) and Nair (1944 and 1950) on Coelenterates; Aiyar (1933 and 1935) on Polychaetes; Menon (1933, 1937, 1940, 1949 and 1951) and Prasad & Tampi (1953) on Decapods and Alikunhi & Aiyar (1942 and 1943) and Alikunhi (1944a, 1944b and 1950) on Stomatopods. In their general accounts of the plankton Menon (1931), Aiyar, Menon & Menon (1936), Bal & Pradhan (1945 and 1952), Menon (1945), Chacko (1950), George (1953) and Prasad (1954) have made brief remarks about the seasonal distribution of larval forms off Madras, Bombay, Trivandrum, Krusadai, Calicut and Mandapam. But no attempt has so far been made to study in detail the fluctuations in intensity, distribution and composition of the planktonic larval fauna. The present paper is an effort to provide some preliminary information on these aspects of the problem and should be considered essentially as a part of the author's work on the general plankton characteristics of the Mandapam area. It should also be mentioned that this report is not meant as an inventory of the innumerable species of larvae that occur in our plankton and the scope has been very much restricted to a general treatment of the distribution and fluctuations of the planktonic larvae off Mandapam.

MATERIAL AND METHODS

The material on which the present findings are based included larval forms obtained from regular plankton samples collected from the inshore waters off Mandapam. The observations extended from January 1950, to December 1952, in the Gulf of Manaar (except for a break during May-June 1951, when unfortunately the collections were

interrupted and in April 1952, when only one sample could be obtained) and from May 1951, to April 1953, in the Palk Bay.

The method of collection of plankton samples and enumeration of the larvae has been the one followed in this institution (*vide* Prasad *et al.*, 1952). The number of larvae has been expressed in terms of 1 cc of the standardized sample.

ENVIRONMENT

The environment in which these observations were made is a shallow-watered area, depth not exceeding about three fathoms with a rich fauna and extensive coral reefs.

The area is exposed to the two prevailing monsoons but the rainfall during the southwest is negligible. The data relating to the rainfall are given in Table 1. Although the southwest monsoon does not contribute much to the annual rainfall of this region it has considerable influence on the waters of the Gulf of Manaar. Extremely turbulent conditions set in during May which continue sometimes even up to August. During this period the drift of water in this area is from south to north and is particularly strong through the Pamban Pass reaching sometimes a velocity of 5 to 6 knots. On the contrary at this time the waters of the Palk Bay are calm. With the onset of the northeast Trade Winds, generally sometime during September, conditions are almost exactly opposite to those mentioned above. The Gulf of Manaar becomes comparatively calm, the direction of the drift of water is reversed, turbulent conditions prevail in the Palk Bay, and then the northeast monsoon, the rain-bearing monsoon for this area, breaks out.

Fluctuations in the surface temperature of the sea water of the Gulf of Manaar show a double oscillation in the course of the year. Starting from a minimum in January the temperature rises steadily until April when it reaches the maximum.

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From May the temperature registers a fall. This lowering of the surface temperature of the coastal waters may be purely due to the strong wind causing a high rate of evaporation. There is again an increase in the surface temperature, but not reaching the same level as that of April, sometime during August—October, the exact month varying slightly from year to year. The time when this secondary peak is reached usually marks the end of the southwest monsoon and the slight increase in the surface temperature may be due to the dying down of the strong wind and consequent reduction in the rate of evaporation. The temperature again falls for a second time with the onset of the northeast monsoon when the sun is at its maximum southern declination. During 1950-1952 the lowest temperature (24.00°C) was recorded in January 1950, and the highest (31.50°C) in April of the same year. The difference between the lowest and the highest mean monthly temperatures for the three year period is 5.32°C, but the range was 5.20°C in 1950, 3.95°C in 1951 and 4.43°C in 1952 (Table 2). It is very unfortunate that regular records of surface temperature of the Palk Bay waters could not be maintained but the data available suggest that the surface temperature here is slightly of a lower order than that of the Gulf of Manaar.

A regular seasonal cycle in the salinity of the surface waters of the areas under consideration has been observed. In the Gulf of Manaar as well as in the Palk Bay the salinity is low in January, increases gradually and remains high until the middle of November, then there is a decrease, presumably an effect of the northeast monsoon, and the lowest values are often recorded in December (Table 2). With slight variations in the actual values and the exact period of occurrence of the highest and lowest salinities, the general cycle indicated above repeats itself. Thus May to about the middle of November can be regarded as the high salinity period and from late November to April the low salinity period. The annual range of salinity in the Gulf of Manaar varied from 6.92 ‰ to 9.00 ‰ during 1950-1952, whereas in the Palk Bay it was 6.64 ‰ in 1951 (May to December) and 8.80 ‰ in 1952. The greatest difference between the maximum and minimum in both the areas was in 1952.

DISTRIBUTION AND FLUCTUATIONS OF LARVAE

A wide variety of larvae, in varying intensities is seen almost throughout the year in the coastal waters of this area and, of the innumerable species, many have not been correctly identified. While studying the general characteristics of the plankton

of the coastal waters systematic records were maintained of the larval forms occurring in the plankton. The distribution and fluctuations of the following groups: Polyzoans, Polychaetes, Echinoderms, Decapods, Lamellibranchs and Gastropods, larvae of which form the dominant elements, have been dealt with somewhat in detail. Of those of the other larval forms, only brief references have been made under "Other larvae". These minor groups have been pooled together for purposes of computing their percentage and average number in the larval stock. Fish larvae, which will form the subject matter of a separate paper to be published from this institution, have been excluded from this report.

(a) Polyzoa

Cyphonautes larvae occurred both in the Gulf of Manaar and the Palk Bay, but often in greater numbers in the Gulf of Manaar, during several months of the year. There were two distinct types of larvae of which one was found to be always more abundant than the other. The two common encrusting Polyzoans recorded in this area are *Thalamporella rozieri* and *Membranipora* sp.

Great variations were noticed in the occurrence of these in the same area from year to year and also between the areas during the same year. Thus, in the Gulf of Manaar the *Cyphonautes* larvae showed distinct peaks during May, September-October and December-January. There was an unusual increase in their number in December 1952. During the three years of this investigation *Cyphonautes* larvae were always at a minimum in February-April. Occasionally they were noticed to be scarce in other months, too (Table 3a). Kuriyan (1952) observed that *T. rozieri*, and *Membranipora* sp. were the important polyzoans attaching to the 'monthly collectors'. While mainly restricted to the monsoon months, their appearance in other seasons was not uncommon and he adds: "The breeding season is generally confined to the periods of monsoon". In the Palk Bay the pattern of distribution was strikingly different from that of the Gulf of Manaar. During the period May 1951, to April, 1952, *Cyphonautes* were very poorly represented, whereas in the following twelve months they showed two distinct peaks, one in August and the other in December. Except for the months August and December, 1952, and January, 1953, the larvae were either completely absent or occurred only in insignificant numbers (Table 3a).

In the Gulf of Manaar *Cyphonautes* once constituted as much as 75 per cent of all the larvae included in this study and the percentage varied from 0 to 75 (Table 3). The maximum percentage was

in 1952 and the minimum in 1950 (Table 4). The average number of *Cyphonautes* for a year also showed marked variations and on an average there were 13.2, 10.4 and 41.2 larvae for 1950, 1951 and 1952 respectively (Table 5). As already mentioned these larvae were not so abundant in the Palk Bay as in the Gulf of Manaar and hence constituted only a relatively smaller percentage of the larval population. From May, 1951, to April, 1953, their percentage fluctuated from 0 to 35.5 and the highest was in January, 1953 (Table 6). On a twelve month basis the percentages were 0.4 and 5.2 during May, 1951, to April, 1953 (Table 7). The average number of *Cyphonautes* for these two periods is shown in Table 8.

(b) Polychaeta

The various polychaete larvae that occur commonly in our waters are fairly well known due to the fundamental work of Aiyar (1933). During the course of the present investigation several polychaete larvae were encountered in the plankton throughout the year in both areas but in distribution they differed widely. Larvae belonging to the families Polynoidae, Nereidae, Eunicidae, Spionidae, Owenidae, Chaetopteridae, Terebellidae and Sabel-laridae were usually represented in the collections.

Polynoid larvae were noticed in the plankton of the Gulf of Manaar in February, May and November; the larvae of Nereids from October to December in the Gulf of Manaar, May to August and again in greater numbers during October-November in the Palk Bay. In the Gulf of Manaar as well as the Palk Bay, Eunicid larvae were often seen during February to April. Larval spionids were extremely common. From February to September, with a maximum in May, they occurred in the Gulf of Manaar and in the Palk Bay during May to August and November with a maximum in August. The Mitraria larvae of *Owenia fusiformis* Delle Chiaje were present in both areas but in greater numbers in the Palk Bay where they occurred during May to August and November, with a maximum in June. In the Gulf of Manaar, on the other hand, they were noticed from January to March, August and November-December with no indications of definite maximal periods. Among the Chaetopterids the only one seen in this locality was the larvae of *Phyllochaetopterus eleoti* Crossland, but the season of occurrence was observed to be short and somewhat irregular. They were seen in the Gulf of Manaar during January and November with a maximum in January and in the Palk Bay in the months of February, May and September, their largest number being usually in May. Larval and post-larval stages of the Terebellid, *Loimia medusa* Savigny were often seen during several months

(January to April, July, August and October to December) in the Gulf of Manaar, whereas in the Palk Bay they occurred from April to August and again in October-November. In the Gulf of Manaar they showed two maxima, February-April and July-August but in the Palk Bay there was only a single maximum, sometime in June to August. During January, April-May, July and October larvae of *Sabellaria* sp. occurred in the plankton of the Gulf of Manaar with the largest number in May. They were recorded in the Palk Bay during June, August-November, their peak falling sometime during August-September. Occasionally larvae of the Syllid, *Autolytus orientalis* Willey were also encountered in the plankton, particularly in August, in the Gulf of Manaar.

Table 3a shows the monthly average number of polychaete larvae for 1950-1952 in the Gulf of Manaar. In 1950 between January and September their average varied from 5 to 10, then there was a slight increase in October followed by an abrupt fall. The distribution in the subsequent year was slightly different, showing a minimum during January, completely absent in December, at a low level during March, April and July to September and two maxima, one in February and the second in November. Polychaete larvae in 1952 showed the maximum in January, then there was a gradual decline in their number (being completely absent in June and October) and from October their number increased. Thus, considerable variations were observed in the distribution from year to year but they were almost at a low level during June to September throughout.

Vagaries in the distribution were noticed in the Palk Bay also. As Table 3a shows they were at a maximum in October, 1951, and May, 1952. During the period of this study their number was low in September, January and February and there were minor peaks in August, 1951, and 1952, and April 1953.

Aiyar (1933) in his detailed study of polychaete larvae of the Madras plankton recorded the seasonal occurrence of the larvae of Polynoids, Phyllodocids, Alciopids, Nereids, Nephthyds, Eunicids, Capitellids and Mitraria larvae. Most of these were present all through the year except those of Chaetosphaerids (for 8 months), Chaetopterids (for 7 months) and Terebellids (for 11 months). But they all showed distinct intensive period or periods. Considering the stock of polychaete larvae Aiyar observed that November to March were the crowded months.

In the Gulf of Manaar the percentage of polychaete larvae varied from 0 to 18.7. Except for November 1951, and December 1952, these larvae were present in all the months (Table 3). Comparing

the percentages of these for the three years it will be noticed that there were no very great changes, the larvae contributing from 2.7 to 4.3 per cent of all the larvae (Table 4). Table 5 shows the average number of polychaete larvae for 1950-1952. The percentage of these larvae was slightly higher in the Palk Bay. On an average there were 7.5 to 8.4 larvae and constituted between 4.3 and 5.9 per cent (Tables 7 and 8). The percentage from month to month varied from 0 to 29.4 (Table 6). An interesting feature about the polychaete larval stock in these areas was that their percentage did not show violent fluctuations from year to year.

(c) Echinodermata

Our knowledge of the echinoderm larvae of the Indian waters is meagre. Such larval types as Auricularia, Bipinnaria, Echinopluteus, and Ophiopluteus were usually present in the plankton but Ophioplutei always predominated and as much as 94 per cent of all echinoderm larvae known from this area was once observed to be ophiuroid larvae. Thorson (1946) observed that: "The ophiuroid larvae dominate entirely among the Echinoderm larvae in the Sound. The larvae of *Ophiura robusta* and *Amphiura filiformis* alone constitute no less than 82 per cent of all the Echinoderm larvae known from the area in question." The ophiuroid larvae were present during several months of the year, whereas the other types seemed to have a rather much restricted season.

The larvae of ophiuroids were present practically in all months and invariably reached the maximum in May. The next common echinoderm larvae were the Bipinnaria which appeared during March, April and July-September with a maximum in September in the Gulf of Manaar. They were noticed in the plankton of the Palk Bay only in June. Auricularia were present during February to April and July in the Gulf of Manaar plankton and were very few in number. Similarly a few specimens of Auricularia were obtained from the Palk Bay during the months of February, March, May and July. Echinoplutei were comparatively rare in the plankton samples collected so far and a few specimens were seen in April and October.

In the Gulf of Manaar the echinoderm larvae showed two distinct maxima one in May and the other in September (except in 1952 when the peak was in November). In all the three years they showed the same minimal period, June to August. Their number was relatively low in December to January, too (Table 3a). The occurrence of echinoderm larvae seemed to be somewhat similar in the Palk Bay also, with two maxima one in June or July, then a decline followed by a second peak in November. The number decreased again and

reached a minimum in December or January (Table 3a). Despite minor variations in the exact time of maxima and minima the echinoderm larvae showed two distinct maxima, one during the summer months and the other during the autumn.

From the foregoing observations it appears that among the echinoderms, intensity of spawning reaches a maximum during the summer months and in some groups there may be a second but less intense spawning activity during the autumn. The ophiuroids seem to have a prolonged spawning season extending over several months but there again the peak spawning was in May.

Echinoderm larvae constituted annually only about a maximum of 2.8 per cent of all the larvae, the percentage fluctuating from 1.9 to 2.8 in the Gulf of Manaar and 1.9 to 2.0 in the Palk Bay (Tables 4 and 7). On an average there were 6.6, 2.1 and 3.3 in the Gulf of Manaar and 2.8 and 3.3 in the Palk Bay during the years covering this investigation (*vide* Tables 5 and 8). As is only to be expected, the percentage of larvae present from month to month showed considerable fluctuations in both the areas, ranging from 0 to 26.4 in the Gulf of Manaar (Table 3) and 0 to 25.1 in the Palk Bay (Table 6). The highest percentage in the Gulf was in September, 1950, whereas in the Palk Bay it was in June, 1952.

(d) Decapoda

The most important single group of planktonic invertebrate larvae was decapod. There is a variety of forms and different developmental stages that occur in the plankton and our present knowledge of the various species is mainly due to the series of contributions by Menon (1933, 1937, 1940, 1949 and 1951). In varying numbers they were found throughout the year in the environs of Mandapam and on certain days in enormous numbers.

Larvae of Portunids, Xanthids, Grapsids, Porcellanids, Alpheids, Penaeids and Palinurids were generally found in the plankton of the Gulf of Manaar and the Palk Bay. Zoeae of certain species of crabs such as *Neptunus pelagicus* (Linnaeus) were seen in this area during many months of the year, whereas Phyllosoma larvae of *Panulirus ornatus* (?) Fabricius and *Thenus orientalis* Milne-Edwards were generally found during February-March and occasionally in June.

Table 8a shows the distributions of decapod larvae in the Gulf of Manaar and the Palk Bay. During the years 1950-1952 the general trend of the distribution of decapod larvae showed good similarity in the Gulf of Manaar. January to June may be considered as the season when their number is usually at a high level (maximum in

March) and from June these larvae become relatively scarce, July to October being somewhat the minimal period. Again in November there was an increase which led to the maximal period of January to June. The fluctuations in the decapod larval population of the Palk Bay were different from those of the Gulf of Manaar. In 1951 the decapod larval population gradually increased from a low level in May to high level by September and remained high up to November when it registered a decline reaching a minimum in June 1952. Again from June, 1952, there was a steady rise which resulted in September in a population about three times that of September, 1951, and succeeded by a sudden, marked decrease ultimately reaching a minimum by February, 1953. Thus, while in the Palk Bay the greatest concentrations of these larvae were during July to November with the maximum in September, in the Gulf of Manaar the population was low from July to October and high during the period January or February to May or June with the maximum in March (Table 3a).

The percentage of decapod larvae present in the plankton samples from month to month varied considerably, the lowest in the Gulf of Manaar being 1.0 per cent in October, 1950, and the highest, 79.1 per cent in December, 1951, (Table 3). Annually they showed variations and for the three years the percentages were 10.5 in 1950, 56.6 in 1951 and 24.1 in 1952 and on an average there were 24.8, 64.4 and 36.3 larvae for these years (Tables 4 and 5). In the Palk Bay similar fluctuations were noticed, the lowest monthly percentage of 7.3 was in March, 1951, and the highest (87.5) in October, 1952 (Table 6). Their percentage on a twelve-month period commencing from May, 1951, was 26.1 and during the next twelve-month period ending with April, 1953, it was 35.4 and on an average there were 36.9 and 62.0 decapod larvae during these two periods (Tables 7 and 8).

(e) Lamellibranchiata

Another important group of larvae that occurred in the plankton throughout the year was the Lamellibranch. The larvae of the following Lamellibranchs were identified.

Ostrea cuculata Born, the Rock oyster of which the larvae were common in both the areas from November to March. While these larvae of the Rock oysters were found abundantly in the Gulf of Manaar and the Palk Bay, the larvae of the Back-water oyster, *Ostrea madrasensis* Preston were relatively scarce and have so far been observed only in the Palk Bay during December-January. The larvae of *Pteria* sp. were abundant from December to March and appearing a little later in the year

by about April were the larvae of *Donax* sp., which were particularly abundant in the Palk Bay. The larvae of *Pinna* sp. were not as common as the others mentioned above and occurred in small numbers from November to March. Larvae of *Modiola* sp., *Solen* sp., *Teredo* sp., *Spisula* sp., and *Tellina* sp., all occurred in varying numbers both in the Gulf of Manaar and in the Palk Bay.

The Lamellibranch larval stock invariably showed two maxima in the Gulf of Manaar, one during the early part of the year and the second towards the end. Thus, in 1950 the two important peaks fell in April and October with a third minor peak during January. The number of larvae decreased steadily from April and reached a minimum during July. In the following year also there was a peak in October but no data are available for May-June. The distribution in 1952 was entirely different from that of the preceding years. In January the number of Lamellibranch larvae was low as in 1951, but in February there was a sudden increase followed by a steady fall, and from then on these larvae were comparatively few and there was no subsequent maximum observed. Certain features were common in all the three years, i.e., during the months of June to September and in December the Lamellibranch larval population was at a relatively low level (Table 3a). Striking similarity in the distribution pattern of Lamellibranch larvae from year to year in the Palk Bay was noticed during the course of this investigation. There was a distinct peak in March, 1952 as in 1953, although in March, 1952, there were about four times the number of larvae as in March, 1953 (Table 3a). During the other months of the year, Lamellibranch larvae occurred in relatively small numbers. This distribution seems to be very much similar to that observed in the Gulf of Manaar during 1952 except in the exact time of occurrence of the single peak, being February in the Gulf of Manaar and March in the Palk Bay.

The percentage of Lamellibranch larvae occurring in the different months in the Gulf of Manaar varied from 2.6 in January, 1951, to 61.1 in October 1950, (Table 3), whereas they contributed 43.3 per cent, 9.8 per cent and 23.1 per cent of all larvae for 1950, 1951 and 1952 respectively (Table 4). The average number of larvae fluctuated very strikingly from year to year being the minimum in 1951 and maximum in 1950 (Table 5) but the larvae were present in all the months. Except in December, 1951, and October, 1952, Lamellibranch larvae were present in the Palk Bay and their percentage varied from 1.8 in January, 1952, to 64.3 in March, 1952, (Table 6). For the two twelve-month periods commencing from May, 1951, their percentages were 34.4 and 13.4 (Table 7)

and for the same period on an average there were 48.7 and 24.4 larvae of Lamellibranchs (Table 8).

(f) Gastropods

Just as in the case of Lamellibranch larvae, several species of Gastropod larvae too occurred in the plankton almost throughout the year in the areas under consideration (Table 3a). In the Gulf of Manaar the number of larvae was generally at a low level in January, but it showed a gradual increase with a peak sometime in April (the value for April 1952, is based on a single observation). Following this peak there was a decline and generally during May to June they were few. In August, 1950 and 1951, there was an abrupt increase in their number and a subsequent fall. Throughout 1952, Gastropod larvae were comparatively few and particularly in August there was no marked increase in their number. In the Palk Bay also these larvae were relatively scarce in January. From then on they showed a steady rise resulting in a peak sometime during March-April. This was followed by a decline and from June to October larval Gastropods were at a low ebb. Two peaks, one in November, 1951, and another in December, 1952, were also recorded (Table 3a).

Sometimes as much as 73.00 per cent of all the larvae were those of Gastropods and their percentage went down as low as 3.2 (excluding the single observation made in April 1952) at other times. Of all the larvae, 33.8, 18.1 and 19.3 per cent were Gastropods during 1950, 1951 and 1952 respectively (Table 4). The average number fluctuated from 20.6 in 1951 to 80.2 in 1950 (Table 5). Similarly in the Palk Bay their percentage varied from 6.5 in December, 1951, to 72.2 in April, 1952, (Table 6). From May, 1951, to April, 1952 they contributed to 30.1 per cent and during the ensuing twelve months (May, 1952 to April, 1953) their percentage was 38.3 (Table 7). The mean numbers of these larvae for periods of twelve months from May, 1951 to April, 1953, were 42.6 and 67.2 (Table 8). Thus, along with the larvae of Decapods and Lamellibranchs the Gastropod larvae also form an important constituent of the larval population of the local plankton. Since detailed investigations are being carried out in this institution on the various planktonic Gastropod larvae of this locality their seasonal fluctuations are not given here.

(g) Other larvae

In the foregoing pages a general account of the important groups of larvae which form the major constituents of the planktonic larval population of this area has been given. Besides those already described there are several groups of larval forms

which, though sometimes found in appreciable numbers, cannot be considered as regular features or as important members of the plankton off Mandapam.

Coelenterata.—Both in the Gulf of Manaar and in the Palk Bay innumerable planula larvae occurred on a few days. Usually they were present in March in the Gulf of Manaar and in the Palk Bay. From the Gulf of Manaar stray specimens of Ceriantharian larvae were also recorded in March, 1951. From April to June, 1952, and April of 1953 Semper's larvae were found in large numbers in the Palk Bay, particularly in 1952. The same type of larvae were relatively few in the Gulf of Manaar and were collected only on one or two occasions during June, 1952. These brownish cigar-shaped larvae probably are of a species of *Zoanthella*.

Platyhelminthes.—Müller's larvae although occurring on several occasions in the plankton were never observed in large numbers. In the Gulf of Manaar they were noticed in April, May and again in August-September, whereas from the Palk Bay they were collected during February, March, May, July and August.

Nemertea.—Nemertean larvae, *Pilidium*, were seen only seldom in this area and stray specimens were seen in March, May and November from the Palk Bay. From this area two or three Nemerteans have been recorded by Gravelly (1927a) who identified only one species, *Eupolea hemprichi* (Ehrenberg). He, however, remarked: "Pilidium larvae have been seen in the plankton".

Phoronida.—Another larva that did not appear often in the plankton was *Actinotrocha*. It was seen only once in the Gulf of Manaar during October 1951, and presumably belongs to *Phoronis* sp., which has been recorded from this area (Gravelly, 1927b).

Brachiopoda.—The larvae of Brachiopods were extremely rare in this locality and so far collected only once in June 1952, from the Gulf of Manaar. They probably belong to a species of *Lingula*.

Stomatopoda.—Several species of Stomatopod larvae particularly *Alima* of *Squilla* occurred in this area during March, April, June and September in the Gulf of Manaar and January to March and again in November-December in the Palk Bay. In the Palk Bay, where they were often found in greater numbers, they reached a maximum in January-February.

Enteroprocta.—Tornaria larvae were observed in considerable numbers in January 1950, in the Gulf of Manaar and in October 1952, in the Palk Bay. More than one type has been observed in

this area and full details regarding these have been given by Devanesan and Varadarajan (1940).

Ascidacea.—In small numbers Ascidian 'tadpoles' were found on several occasions in the plankton of both the localities in question. From January to April and November-December they were invariably seen in the Gulf of Manaar but in the Palk Bay they appeared during February to April, June to August and again in October.

The monthly percentage composition of these "Other larvae" varied from 0 to 3.9 in the Gulf of Manaar (Table 3) and from 0 to 4.1 in the Palk Bay (Table 6). During the years 1950, 1951 and 1952 they formed 1.2, 0.3 and 0.5 percent respectively, of all the larvae in the Gulf, while from May, 1951, to April, 1952, the percentage was 1.6 and from May, 1952, to April, 1953, it was 1.5 in the Palk Bay (Tables 4 and 7). On an average they formed about 0.5 to 1.3 in the Gulf of Manaar and 1.6 in the Palk Bay (Tables 5 and 8).

(h) Total larvae

Fluctuations in mean monthly number of the entire larval stock are shown in Table 3a. Broadly speaking there are two maximal periods separated by a short interval when the entire larval population is at a low level. The fluctuations further suggest variations from year to year and changes in the intensity of population. Disregarding the finer details, it may be said that the greatest number of larval forms were encountered during the first few months of the year particularly February to May, the maximum occurring in March or April. The decline in the number of larvae following the maximal period continued up to July and generally during the months June-July there are relatively few larvae in the plankton. The fluctuations in the larval population were rather erratic during the second half of the year. Thus, in the Gulf of Manaar in 1950 from August to October there was a fairly large number of larvae, but in 1951 during August-September and in 1952 from August to November their number was low and the peaks were in October, 1951, and December, 1952. In the Palk Bay the mean number of total larvae increased gradually from May, 1951, reaching a peak in November and then there was a fall to a minimum in January, 1952. The distribution was somewhat different during 1952-53. Commencing with January, 1952, the number of larvae increased reaching a high level in March but in April there was a steep fall and in June it was at its lowest. During the subsequent months there was again a rise culminating in a peak in September. This was succeeded by a decline and again an increase until December. In 1953 the total number of larvae was low once again but the lowest level was in February as against

January in the previous year. There was a peak in March, 1953, as in the previous year followed by a fall in number. Thus, while in certain respects there were similarities there are distinct differences, too, between the two areas in the fluctuations of the total larval population. It is also interesting to note that in December, 1952, there was an unusually large number of larvae in the Gulf of Manaar and the Palk Bay which was caused by an increase mostly of *Cyphonautes* larvae. The general trends may, therefore, be summarised as follows. During January the total number of larvae was usually low but then it increased, reaching a peak sometime in February, March or April. Following this there was a marked decline and in June-July planktonic larvae were comparatively few. There was a second increase in larval population which might reach various levels of intensities during August to October. In all the three years the number of larvae in the Gulf of Manaar was low in July and November. Both the areas showed a large number of larvae in December, 1952, caused by the increase in the number of *Cyphonautes* but for which the level was usually low in this month.

BREEDING SEASON

A question that is often much debated is whether the tropical marine animals, particularly the invertebrates, breed continuously during the whole year and it is generally believed that many invertebrates do so. An almost uniform temperature condition and the possibility of a long period of phytoplankton production are the reasons generally advanced for this assumption. The available information on this question has been summarised by Panikkar and Aiyar (1939), Paul (1942) and Thorson (1946 and 1950). In the brackish waters of Adyar, Panikkar and Aiyar (1939) observed some species reproducing equally in all months, others spawning in all months but with definite intensive periods at certain seasons of the year, still others reproducing during a particular season of the year only and finally those whose breeding season may be restricted to two or more seasons of the year in relation to the rainfall. Paul (1942) classified breeding among the animals along the Madras coast into the four categories: (1) single breeding period not lasting the whole year round; (2) continuous breeding all the year round but more active during a certain part of it; (3) continuous breeding throughout the year without any special intensity in breeding during any part of it; and (4) discontinuous breeding related to phases of the moon. Summing up the results of investigations on the breeding in tropical marine animals, Thorson (1950) remarked: "These observations from the tropics show that, although several of the species have a restricted

breeding season, this season is on an average much longer than the breeding seasons of species living in temperate seas, and while in temperate seas most species will breed within the same few months which will result in a crowding and a keen competition of the larvae in the plankton, the tropical species breed within such different seasons that their larval stock taken as a whole is more or less equally distributed in the plankton all the year round. Thus, although maxima and minima occur even in the tropical coastal areas, it is easily understood that the conditions for a pelagic planktonic larval development are specially favourable there. A long season of phytoplankton production is associated with a long season of larval occurrence in the plankton. The competition among the larvae is much less keen than in temperate—not to speak of arctic—seas, where all pelagic larvae have to crowd and feed from the plankton during a few restricted maxima of phytoplankton production."

Judging from the occurrence of larvae in the plankton it may be said that breeding of invertebrates in this area is not always continuous and at the same uniform rate. The types of breeding observed may be broadly classified as follows:

- (1) Protracted spawning season extending over several months of the year or the entire year when larval forms are encountered in the plankton but with distinct intensive period or periods.
- (2) Single, restricted spawning season.
- (3) Discontinuous breeding, the larvae appearing at irregular intervals with intervening periods of quiescence.

No instance of a species reproducing continuously at a uniform rate without distinct, intensive period or periods during any part of the year has been observed so far in this locality. The assumption that the tropical species breed within such different seasons that their larval stock taken as a whole is more or less equally distributed in the plankton all the year round, does not seem to be true for the area under investigation. There is apparently no uniformity in the distribution of the total planktonic larval population throughout the year. Well-defined maxima and minima are observed. Similarly, the various figures of the different groups of larvae presented in Table 3a again demonstrate that there is hardly any group which does not show greater concentration in the distribution of larvae in the plankton at some time or other of the year.

It is not the intention of the author to bring in the highly controversial and complex subject—the factors controlling spawning—but one or two points

need mention, particularly with a view to stimulating interest for further research among the investigators working in tropical regions. For a long time it was believed that temperature is the all-important factor controlling the ripening of sex products and subsequent spawning, but of late, evidence has accumulated to show that temperature need not always be the only or the major decisive factor in controlling reproduction, particularly so in tropical areas where the range in fluctuations is comparatively narrow. Here it may be pointed that in attempting to study the effect of temperature on breeding, as Thorson (1946) remarked, it is necessary to distinguish between "temperatures which allow the animals to ripen their sexual products and temperatures which actually induce the animals to spawn". Other factors such as salinity, availability of food, tide, lunar periodicity etc. have been shown to exert influence on the breeding activity of marine animals. One thing seems quite obvious and that is, it is not a single physical, chemical or biological factor that controls breeding, but these factors in varying degrees contribute for a successful reproduction, the requirements varying with species and to some extent individuals. The importance of temperature in spawning has probably been exaggerated and other possible causes have not been properly examined. Wimpenny (as quoted by Lucas, 1949) found the eggs and very young stages of certain zooplankters and fish, usually in large numbers, in the midst of some phytoplankton patches. He suggested that the abundant oxygen supply of such waters may be advantageous to the young. Lucas, in this connection, remarked: "One can also imagine other by-products of such growth to which adaptations might have been developed", obviously referring to the effects of external metabolites. Devanesan (1942) observed that mackerel along the west coast of India spawn among patches of *Noctiluca* and remarked: "The spawning mackerels have probably exercised a choice in selecting an area where the inedible *Noctiluca* abounded for laying their eggs. Fishes feeding on fish-eggs would be loath to enter an area where the inedible *Noctiluca* abounded. Thanks to the instinct of the Mackerel spawners, their eggs thus derive protection and have a better chance of hatching . . ." This, as in the other case recorded by Wimpenny, may be an adaptation developed to certain by-products of the growth of *Noctiluca* rather than a careful choice of the spawning area by the mackerel as this necessarily assumes a freedom of choice on the part of the mackerel, which it is doubtful whether our present knowledge would admit. Thorson (1946) cited examples in which spawning on large scale sets in simultaneously with a sudden increase in the

phytoplankton. He also referred to the observations of Miyazaki who in Japan induced spawning in males of *Ostrea gigas* by adding an extract of the green algae *Ulva pertusa* and a species of *Enteromorpha* to the water. The same author tried several other spawning stimuli but all without success, and mentions that the extract of 1 mgr wet leaf of *Ulva* is sufficient to induce spawning. The active substance was found to be soluble in water and it tolerates boiling for 30 or 40 minutes without losing its activity. Thorson concluded: "Thus it is not excluded that an increase in the stock of phytoplankton may induce spawning in marine vertebrates. There seems also to be a possibility that the temperature and the phytoplankton maxima may act together as inducements to spawning."

There is not sufficient basis in the present investigation to draw positive conclusions regarding the relation between larval maxima and phytoplankton production. The general cycle of phytoplankton production in the Gulf of Manaar may be described as follows. During the years covered by this investigation, although there were minor variations in the exact time of maxima and minima, it was observed that there were sudden outbursts of phytoplankton during January to March predominantly composed of *Rhizosolenia alata* or *R. imbricata*. In April the diatoms are relatively low but the Dinophyceae attain a peak. Immediately following this will be the summer bloom in May composed mainly of several species of *Chaetoceros*, *Rhizosolenia*, and *Pleurosigma*, *Asterionella japonica*, *Thalassiothrix frauenfeldii*, *Thalassionema nitzschioides*, *Biddulphia sinensis*, *B. mobiliensis*, *Bacteriastrum varians*, *Bacillaria paradoxa*, etc. In June-July there is an appreciable decimation in the phytoplankton succeeded by an increase reaching a peak sometime between August and November, the exact month in which the highest level is reached varying slightly from year to year. This autumn bloom, like the one in summer, is the result of several species of diatoms flowering simultaneously. Thus, there seem to be definite pulses in the production of phytoplankton, the seasons of abundance being January to May and August to November.

Comparing this phytoplankton cycle with the distribution of various larval groups and the total pelagic larvae of the Gulf of Manaar one finds that there is reason to believe that periods of larval maxima coincide somewhat with those of abundant phytoplankton production. In the

Palk Bay the cycle of phytoplankton production is distinctly different. Starting from a low level in January, the production increases rapidly, reaching a peak in May or June. This outburst is caused chiefly by several species of *Chaetoceros*, *Rhizosolenia*, *Pleurosigma*, *Nitzschia* and *Bacteriastrum varians*, *B. hyalinum*, *Thalassiothrix frauenfeldii*, *Thalassionema nitzschioides*, *Asterionella japonica*, *Leptocylindrus minimus*, etc. Normally this bloom is followed by a slight decrease in the phytoplankton population, but once again there is an increase leading to high level in September-October. By November the diatoms show a tendency to disappear but the Dinophyceae are still relatively abundant. During December the area is extremely poor in phytoplankton. As already stated, the planktonic larval stock is low in January and shows an increase, attaining different levels of intensity, during February-May. During June the larvae are scarce but in July they show tendencies to increase and most of the larval groups become less abundant by December. Therefore, it will be noticed that there is a crowding of the planktonic larvae during the seasons when the phytoplankton production is sufficiently high. But it should be added that certain instances of an inverse relation between larval population and phytoplankton have been noticed in the areas under study, particularly so when the phytoplankton production happens to be exceedingly high. Aiyar (1933) in his report on the polychaete larvae of the Madras plankton remarked: "It will be seen that November to March are crowded months and this is the period when the phytoplankton is also abundant." Here again the larval maximum did not coincide with the season when the phytoplankton of the area was at its highest, which is between April and July (Ref. Menon, 1931).^{*} In a recent paper Ramamurthy (1953) has stated: that "The continual occurrence of most of the planktonic larvae of the invertebrates suggested that, to some extent, breeding takes place throughout the year. However, in certain months, it was more intensified, as indicated by increase in the larval population, which coincided mostly with the period of diatom abundance or followed the period of diatom outbreak."

A reference in passing may be made about the correlation with temperature. As already mentioned earlier in this report, regular temperature data are available only for the Gulf of Manaar. The temperature curves show a double oscillation in

^{*} Unfortunately Thorson (1950) has misinterpreted Aiyar (1933) and stated: "In plankton off the Madras coast larvae of polychaetes occurred throughout the year though with a maximum during the season (November to March) with the richest production of phytoplankton (Aiyar, 1933)." According to Aiyar the larval maximum was at a time when the phytoplankton was abundant but not when it was the richest.

the course of the year. Similarly the curves for the total larvae also show a bimodality, the peaks of these two curves somewhat coinciding.

The possible effect of the monsoon on the breeding in marine invertebrates of this locality, either direct or indirect, cannot be overlooked. In general it appears that the intensity of spawning is rather low during the months when the monsoon is vigorous and shows a tendency to increase with the weakening of the monsoon and consequent resumption of calm conditions. To put down anything beyond broad generalities a more detailed study is essential. The relations between the phytoplankton production and breeding in marine invertebrates are likely to be specific and, therefore, the study will have to be carried out in terms of relationships between particular species of larvae and phytoplankton. However, from the present preliminary study the author is inclined to believe that the optimum temperature conditions together with the presence of abundant phytoplankton of the proper species (the stimulus may probably be an ectocrine of the species concerned) act as the important stimuli for initiating spawning in many marine invertebrates. The problem although complex is one of fundamental importance in understanding marine life. The scope of the present investigation unfortunately does not permit a more detailed discussion of the problem and no doubt a systematic study of breeding in at least some of the common species with particular reference to their food requirements and important environmental factors will throw more light on the subject. Nevertheless, the present investigation has provided reasons to believe that there are still some misconceptions or slightly exaggerated ideas regarding the breeding in marine animals of tropical waters and the problem needs careful study.

SUMMARY

The paper is based on larvae collected from the coastal waters of the Gulf of Manaar (January 1950, to December 1952) and the Palk Bay (May 1951, to April 1952,) off Mandapam.

A brief account of the environment and data on rainfall, surface temperature and salinity of the areas under investigation has been given.

The distribution and fluctuations in the composition and intensity of the dominant elements of larval population such as Polyzoan, Polychaete, Echinoderm, Decapod, Lamellibranch and Gastropod have been discussed in some detail. The seasonal occurrence of other groups of larvae has been briefly mentioned. Wherever possible information on the season of occurrence, maxima and minima of individual species has also been given.

The percentage composition of the planktonic larval population has shown that Decapods, Lamellibranchs and Gastropods constitute the three important groups. The three together account for more than 60 per cent of all larvae and sometimes as much as 90 per cent. Marked variations in the composition and intensity of the larval stock from year to year, especially in the major elements, have been noticed. The polychaete and echinoderm larvae show the minimum annual variation.

The distribution of larvae belonging to the different groups treated in this paper has revealed distinct maxima and minima and so also the total larval population. While certain groups have shown similarities in the pattern of distribution, others vary from year to year, but on the whole it can be said that within an area the general trend is somewhat the same from one year to another. Similarly some groups have similarities in distribution and fluctuations between the two areas but others have exhibited striking differences.

The breeding season of invertebrates in this area has been very briefly discussed and the following three types have been recognized, based on the occurrence of larval forms in the plankton: (1) protracted breeding season extending over several months of the year or even the whole year but with distinct intensive period or periods, (2) breeding restricted to some definite part of the year and (3) discontinuous breeding occurring almost throughout the year, breeding taking place at irregular intervals with periods of quiescence in between. No instance of a species reproducing continuously at a uniform rate throughout the year has been observed so far in this locality.

In general the study has indicated that there is possibly a relation between the phytoplankton production and the larval maxima, the latter coinciding somewhat with periods of abundant phytoplankton. However, it has been noticed that when the production of phytoplankton is exceedingly high there is usually a low larval population. The present findings are not final and this aspect requires further careful study.

The study has, however, provided reasons to believe that there are still some misconceptions or slightly exaggerated notions regarding breeding of marine invertebrates in tropical areas. The inadequacy of detailed data in the present instance permits only to speak in broad generalities. For a better and proper understanding of the problem, a careful study with particular reference to the food requirements of individual species of larvae and their physico-chemical and biological environments, is necessary.

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Table 1

Monthly rainfall in inches for the locality

Months	1950	1951	1952	1953
January	2.1	3.8	5.4	0.6
February	1.7	1.1	1.8	1.1
March	2.2	0.3	0.0	0.0
April	1.1	8.4	2.0	1.9
May	0.4	0.4	0.9	..
June	0.0	0.0	0.2	..
July	0.0	0.2	0.8	..
August	1.3	0.0	0.3	..
September	0.0	2.5	0.0	..
October	5.8	1.8	0.4	..
November	8.6	15.3	5.5	..
December	3.0	6.5	0.8	..

Table 2

Mean monthly salinity and surface temperature

Months	Gulf of Manaar						Palk Bay					
	1950		1951		1952		1951		1952		1953	
	S ‰	Surf. Temp. °C	S ‰	Surf. Temp. °C	S ‰	Surf. Temp. °C	S ‰	Surf. Temp. °C	S ‰	Surf. Temp. °C	S ‰	Surf. Temp. °C
January	29.49	24.30	29.10	25.53	29.29	25.19	..	..	28.53	..	25.52	24.85
February	30.33	25.55	30.37	26.07	30.62	26.60	..	..	29.58	..	27.25	24.60
March	30.80	26.89	31.54	27.90	32.40	28.26	..	..	30.88	..	29.98	27.32
April	33.63	29.50	33.08	29.48	32.81	29.62	..	..	32.01	28.25	31.60	29.10
May	36.41	29.10	..	29.32	34.67	28.57	..	..	33.04	..	..	..
June	35.21	27.30	..	27.66	35.27	27.58	..	..	33.75	..	..	..
July	35.77	27.40	35.80	27.72	34.78	28.02	..	..	33.96	26.75	..	..
August	36.34	27.94	35.78	28.80	36.42	28.08	..	..	35.21	27.00	..	..
September	35.84	27.30	36.02	28.88	36.47	28.17	35.76	28.00	35.91	27.60	..	..
October	35.93	27.60	35.99	28.13	36.45	28.26	36.07	28.02	36.39	28.13	..	..
November	32.55	27.65	33.95	27.81	31.77	27.25	33.21	27.53	33.12	25.87	..	..
December	29.44	25.65	29.49	25.97	27.47	25.74	29.43	25.95	27.59	..	..	..

Table 3

Percentage of larvae occurring in different months during 1950-1952 : Gulf of Manaar

Animal groups	Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
<i>Cyphonautes</i>	1950	2.1	2.6	0.4	0.3	13.7	3.7	12.2	3.4	14.4	7.6	1.9	27.0
	1951	31.0	3.2	0.0	0.8	x	x	2.1	27.0	0.0	27.0	0.0	2.3
	1952	14.4	0.3	0.8	0.0	7.6	16.0	2.1	5.6	0.0	0.0	17.2	75.0
Polychaetes	1950	2.9	3.3	2.4	1.3	3.5	2.5	7.4	2.4	3.1	3.6	0.0	2.7
	1951	0.9	10.6	2.1	3.5	x	x	8.8	5.4	9.5	2.2	11.3	0.0
	1952	18.7	1.9	2.5	10.5	3.8	0.0	8.4	2.8	4.3	0.0	7.6	1.2
Echinoderms	1950	0.2	0.0	0.7	0.4	7.6	1.4	3.0	0.5	26.4	0.2	1.0	5.5
	1951	1.9	3.9	0.6	0.2	x	x	4.3	0.0	15.8	3.1	0.0	1.1
	1952	1.1	2.2	0.4	17.1	9.7	4.2	2.1	0.0	0.0	0.0	7.6	0.8
Decapods	1950	9.6	9.4	15.7	3.4	8.9	21.3	6.3	2.5	3.9	1.0	28.0	29.1
	1951	61.2	49.1	58.9	61.7	x	x	37.8	18.9	42.8	45.1	59.5	79.1
	1952	37.4	19.2	39.6	67.1	31.3	34.0	40.3	37.9	13.9	67.8	27.1	7.4
Lamellibranchs	1950	59.3	23.5	46.8	56.9	44.6	36.5	46.5	17.1	27.9	61.1	36.3	22.5
	1951	2.6	9.1	17.8	7.7	x	x	13.3	10.8	19.0	5.3	11.3	6.1
	1952	8.9	56.7	32.7	5.1	19.0	22.6	17.8	27.5	12.9	18.8	13.7	3.6
Gastropods	1950	25.6	60.3	33.3	37.1	21.5	34.4	22.6	73.0	23.6	25.5	32.6	13.2
	1951	3.2	23.5	20.2	25.2	x	x	33.3	37.8	12.6	15.6	17.0	10.3
	1952	16.3	19.5	23.8	0.0	28.5	19.3	27.2	25.8	68.6	13.3	26.7	11.8
Other larvae	1950	0.3	0.9	0.7	0.6	0.2	0.2	2.0	1.1	0.7	1.0	0.2	0.0
	1951	0.0	0.6	0.4	0.9	x	x	0.4	0.1	0.3	1.7	0.9	1.1
	1952	3.2	0.2	0.2	0.2	0.1	3.9	2.1	0.4	0.1	0.1	0.1	0.2

x No data available.

Table 3a

Mean number of larvae occurring in different months during 1950-52 in the Gulf of Manaar
and May 1951 to April 1953 in the Palk Bay
(Figures in italics refer to Palk Bay)

Animal groups	Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
<i>Cyphonautes</i> ...	1950	5.3	4.7	1.3	2.3	33.4	7.6	9.6	11.7	25.8	25.8	2.7	28.0
	1951	33.6	3.3	0.0	1.3	(*)	(*)	1.0	10.0	0.0	35.0	0.0	2.0
	...	...	...	...	...	0.0	1.0	0.7	0.0	0.5	0.0	0.5	0.0
	1952	10.6	1.0	2.0	0.0	16.0	11.3	1.0	4.0	0.0	0.0	11.2	376.2
	1953	67.0	0.5	0.0	0.0	...	...	...	...	...	...	...	...
Polychaetes ...	1950	7.3	6.0	8.2	8.1	9.7	5.3	5.8	8.5	5.6	12.2	0.0	2.9
	1951	1.2	10.6	3.6	5.2	(*)	(*)	4.0	2.0	3.0	3.0	12.0	0.0
	...	...	...	...	...	4.3	11.3	13.8	14.1	4.0	27.3	10.2	5.6
	1952	13.8	6.0	6.0	8.0	8.0	0.0	4.0	2.0	2.0	0.0	5.0	6.0
	1953	2.4	0.0	6.2	14.1	28.5	5.3	2.5	16.0	4.5	2.0	4.0	4.0
Echinoderms ...	1950	0.6	0.0	2.3	2.8	18.5	3.0	2.5	2.0	47.5	0.7	1.5	1.8
	1951	2.8	4.0	1.0	0.4	(*)	(*)	2.0	0.0	5.0	4.2	0.0	1.0
	...	...	...	...	...	4.9	2.0	6.1	0.3	1.0	3.8	7.4	0.0
	1952	0.8	7.0	1.0	13.0	20.5	3.0	1.0	0.0	0.0	0.0	5.0	4.0
	1953	0.0	1.2	1.0	2.2	10.2	11.1	0.5	1.7	0.5	0.0	4.0	0.8
Decapods ...	1950	23.5	16.8	53.1	20.0	23.5	43.6	5.0	8.7	7.0	3.5	38.5	30.1
	1951	85.2	49.6	97.5	89.2	(*)	(*)	17.0	7.0	13.5	58.4	63.2	69.2
	...	...	...	...	...	11.0	11.6	36.6	42.9	67.0	66.0	67.0	52.3
	1952	27.6	59.7	94.5	51.0	66.0	24.0	19.2	26.5	7.5	15.2	17.7	37.2
	1953	29.0	34.1	44.5	24.5	48.4	16.4	70.6	83.7	196.2	41.8	70.2	32.5
Lamellibranchs ...	1950	144.5	41.8	156.9	332.3	108.8	74.3	36.7	59.0	50.1	205.8	50.0	14.1
	1951	3.6	9.3	29.8	10.6	(*)	(*)	6.0	4.0	6.0	7.0	12.0	5.2
	...	...	...	...	...	16.1	7.0	26.9	12.7	8.5	22.8	52.5	0.0
	1952	6.6	176.0	78.0	4.0	4.0	16.0	8.5	19.2	6.0	4.2	9.0	18.2
	1953	0.8	36.6	391.2	10.8	20.5	3.5	4.0	26.4	5.5	0.0	6.4	30.0
Gastropods ...	1950	62.6	107.0	111.3	217.3	53.1	70.3	17.7	250.7	42.3	85.8	44.8	13.6
	1951	4.4	25.3	33.4	36.5	(*)	(*)	10.0	14.0	4.0	20.2	18.0	36.0
	...	...	...	...	...	8.5	4.6	14.1	20.3	12.5	21.5	107.1	4.0
	1952	12.0	60.7	57.0	0.0	60.0	13.6	13.0	18.0	32.0	3.0	17.5	59.0
	1953	10.2	56.8	165.7	119.5	158.8	7.3	31.3	40.0	19.7	4.0	16.3	205.0
Total larvae ...	1950	244.5	177.3	334.6	584.3	243.8	204.6	79.0	342.2	179.3	136.4	337.6	103.5
	1951	139.0	100.9	165.5	144.6	(*)	(*)	45.0	37.0	31.5	129.4	106.0	87.5
	...	...	...	...	...	44.9	39.0	98.4	93.0	94.0	143.0	246.2	62.0
	1952	73.8	310.5	238.5	76.0	210.5	70.6	47.7	69.7	46.5	22.5	65.5	498.7
	1953	43.2	133.0	613.1	173.8	279.4	44.3	121.3	192.7	226.7	47.9	109.0	350.5

*No data available.

† Includes those described under 'other larvae'

Table 4
Percentage of larvae occurring during 1950-1952 :
Gulf of Manaar

Animal groups	Year		
	1950	1951	1952
<i>Cyphonautes</i>	5.6	9.0	27.4
Polychaetes	2.7	4.3	3.4
Echinoderms	2.8	1.9	2.2
Decapods	10.5	56.6	24.1
Lamellibranchs	43.4	9.8	23.1
Gastropods	33.8	18.1	19.3
Other larvae	1.2	0.3	0.5

Table 5
Mean annual number of larvae for 1950-1952 :
Gulf of Manaar

Animal groups	Year			
	1950	1951	1952	
<i>Cyphonautes</i>	..	13.2	10.4	41.2
Polychaetes	..	6.4	4.9	5.1
Echinoderms	..	6.6	2.1	3.3
Decapods	..	24.8	64.4	36.3
Lamellibranchs	..	102.9	11.1	34.9
Gastropods	..	80.2	20.6	29.2
Other larvae	..	1.3	0.8	0.5

Table 6
Percentage of larvae occurring in different months of 1951-53 (May-April) : Palk Bay

Animal groups	Year	Month											
		May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
<i>Cyphonautes</i>	1951-1952	0.0	2.6	0.7	0.0	0.5	0.0	0.2	0.0	3.7	1.2	0.0	0.0
	1952-1953	0.4	0.0	3.0	12.5	0.0	0.0	6.9	21.6	35.5	0.5	0.0	0.0
Polychaetes	1951-1952	9.6	29.4	14.0	15.3	4.3	19.1	4.1	9.1	0.0	2.5	0.3	0.8
	1952-1953	10.2	12.0	2.1	8.4	1.9	4.1	2.8	1.0	1.2	0.0	1.9	5.3
Echinoderms	1951-1952	10.9	5.2	6.2	0.3	1.0	2.7	2.9	0.0	0.0	0.9	0.1	1.4
	1952-1953	3.7	25.1	0.8	0.8	0.2	0.0	2.8	0.5	0.4	0.0	0.3	1.8
Decapods	1951-1952	24.6	30.3	36.9	46.2	71.3	46.4	27.3	84.2	67.1	25.2	7.3	14.8
	1952-1953	17.3	37.1	58.5	43.4	86.6	87.5	64.4	9.3	15.6	25.0	22.4	16.1
Lamellibranchs	1951-1952	35.9	18.2	27.3	13.7	9.0	15.9	21.3	0.0	1.8	27.1	64.3	6.7
	1952-1953	7.4	8.0	3.3	13.7	2.4	0.0	5.8	8.7	5.4	45.9	28.3	8.8
Gastropods	1951-1952	18.8	12.1	14.4	21.9	13.3	15.0	43.5	6.5	23.6	42.1	27.0	72.2
	1952-1953	56.9	16.5	30.8	20.8	8.7	8.2	15.4	58.5	41.0	28.5	45.7	67.7
Other larvae	1951-1952	0.2	2.2	0.5	2.6	0.6	0.9	0.7	0.2	3.8	1.0	1.0	4.1
	1952-1953	4.1	1.3	1.5	0.4	0.2	0.2	1.9	0.4	0.9	0.1	1.4	0.3

Table 7
Percentage composition of larval stock in the Palk Bay (May, 1951 to April, 1953).

Animal groups	Period	
	1951-1952 (May-April)	1952-1953 (May-April)
<i>Cyphonautes</i>	0.4	5.2
Polychaetes	5.9	4.3
Echinoderms	2.0	1.9
Decapods	26.1	35.4
Lamellibranchs	34.4	13.4
Gastropods	30.1	38.3
Other larvae	1.1	1.5

Table 8
Average number of larvae for periods of twelve months from May, 1951 to April, 1953 : Palk Bay.

Animal groups	Period	
	1951-1952 (May-April)	1952-1953 (May-April)
<i>Cyphonautes</i>	0.6	9.1
Polychaetes	8.4	7.5
Echinoderms	2.8	3.3
Decapods	36.9	62.0
Lamellibranchs	48.7	24.4
Gastropods	42.6	67.2
Other larvae	1.6	1.6