OBSERVATIONS ON THE PLANKTON OF THE COCHIN BACKWATERS

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Introduction

Considerable work, both qualitative and quantitative, has been done on the plankton of Indian coastal waters in recent years. But the plankton of Indian backwaters has received little attention so far. Sewell (1913, 1924 and 1934) has studied plankton, more especially the copepods, of the Chilka Lake and the salt lakes of Calcutta. The brackish water fauna of Adyar backwaters was studied by Panikkar and Aiyar (1937). Chacko *et al.* (1953, 1954 *a*, 1954 *b* and 1954 *c*) have made brief references to planktonic organisms also in their studies on the hydrobiology and fisheries of various lakes and estuaries of Madras. A preliminary study of the plankton of the Chilka Lake has been made recently by Devasundaram and Roy (1954).

The study of the plankton of the bunder canal at Narakkal in Kerala State, where the Prawn Research Unit was located from October 1951 to August 1955, was commenced in 1952, mainly with a view to determining the occurrence of larvæ and post-larvæ of Penæid prawns in the canal waters. The richness of the zooplankton in quantity, but not so much in variety, and the marked seasonal fluctuation in the occurrence of some of these organisms prompted the author to undertake a detailed study, in the hope that it might reveal some interesting relationship between such fluctuations and factors relating to the hydrology of the canal water. During the first year only qualitative study was carried out; and in the following year, from March 1953 to February 1954, quantitative study was also attempted. Hydrological features like salinity and surface temperature of the water were also studied during the two years.

Topography of the Canal

Narakkal is an important fishing village in the island of Vypeen. The latter stretches northwards for a distance of about 19 miles from the Cochin Harbour entrance (Fig. 1). It is washed by the Arabian Sea on the west and on the east by the Cochin backwaters. The distance from coast to coast, at the widest point of the island may not exceed about 3 miles; it may be reduced to about a couple of furlongs at the narrowest. Traversing

the island from east to west are a number of canals running perpendicular to the backwaters, most of them connecting at their inner ends with canals that run parallel to the length of the island and thus forming a complex network. All of them join the backwaters at their eastern extremities: but none reach the sea on the other side. They are sufficiently wide and deep to permit canoes and other country crafts and small powered boats to ply on them practically throughout the year. Bunder canal at Narakkal is one such transverse canal passing westwards for a little over 3 furlongs to join a long canal running north to south (also called Bannerji Canal). The plankton was collected from the western half of the bunder canal and the adjoining part of the Bannerji Canal on the north. The advantage of making the collections in the canal is that a much larger volume of water would be strained through the net owing to the velocity of the tidal current as explained in the next section.

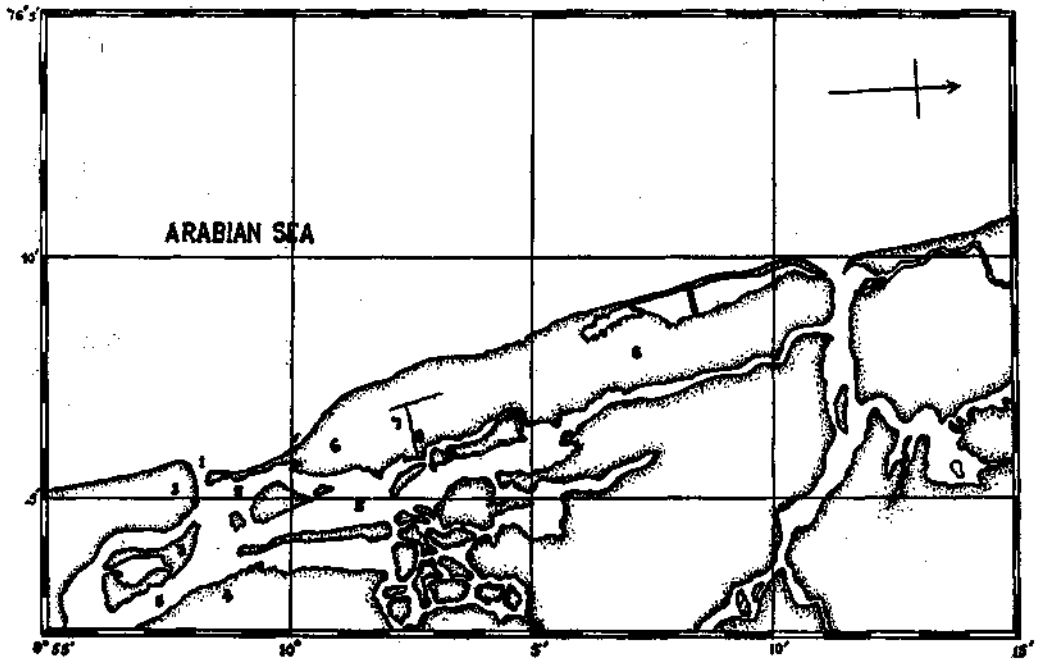

FIG. 1. Showing the location of the Vypeen Island.
(1) Cochin Harbour entrance. (2) Cochin. (3) Willingdon Island. (4) Ernakulam. (5) Backwaters. (6) Vypeen Island. (7) Narakkal. (8) Narakkal bunder canal.

MATERIAL AND METHODS

The material for the quantitative study includes 52 weekly samples of plankton collected from the above-mentioned area. The samples were

collected with a ½ metre tow net made of fine organdie (36 strands/cm.), operated from an ordinary canoe, the speed of which was kept as constant as possible during the time of the hauls. Invariably throughout the year the collections were made during high tide, the canoe being rowed by two men against the flow of the tide. For each sample two horizontal surface hauls were made. The total distance over which the two hauls were made together was kept constant at 3860 ft., that of the first haul being 1610 ft. and the second 2250 ft. The duration of the hauls depended to some extent, upon the strength of the tidal flow. But care was taken as far as possible to make the hauls at the time when the flow of the tidal current in the canal reached more or less a uniform strength, in order to minimise the effect of flow of the current on the duration of the hauls. Due to the situation of the canals the force of the tidal current is stronger in the east to west (transverse) canal but is much reduced in the rest of the network. So the first hauls of each sample, which were made at places where the current is not strong, were naturally of shorter duration. The average time taken for the first haul was 20 minutes and for the second haul 30 minutes.

An attempt was made to determine roughly the average rate of flow of the tidal current at the stage of the tide at which collections were made, by floating an empty stoppered bottle, and allowing it to drift with the current. The rates of flow of the current at the two places were different. The average rate at the first was 750 ft. per hour and that at the latter 4050 ft. per hour.

After a preliminary examination of the samples in the fresh condition each was strained and then made up to a fixed volume, — 150 c.c. or rarely multiples of 150 c.c. when the quantity was very large—by adding sufficient 5% formaldehyde. This was allowed to stand in a measuring cylinder for about 24 hours so as to allow time for the organic elements to settle and then the total volume was noted. The contents of the cylinder were then stirred to ensure even distribution of the organisms and then 1 c.c. was removed with a wide mouthed pipette. The macroplanktonic elements in this were picked out and counted. The rest were counted under a microscope by spreading them on a ruled slide. The total numbers of the different species, or higher taxonomic groups in some cases, were then estimated by multiplying by 150. On days when the plankton was made up to multiples of 150 c.c., for taking the sub-sample first of all 150 c.c. was measured out from the whole quantity and then the 1 c.c. sub-sample taken out from that. Those organisms which were present in very small numbers were counted by examining the entire sample.

Surface water samples for salinity determinations were taken at 6 A.M. on each collection day from a station opposite the departmental farm located in the middle of the total distance covered by the two hauls. The surface temperature of water and atmospheric temperature directly above were also noted at the same place and time. It has to be mentioned that collections of plankton and water samples were not made at the same time on all days, plankton being collected invariably during high tide only. But the difference in salinity of the canal water between consecutive high and low tides is very little.

Hydrological Conditions

Salinity:

The salinity of the canal water varies from that of fresh to practically that of sea-water, during the course of the year. The data for the year 1953 have been observed to closely follow that of 1952, except for a slight fall in April of the former year due to rain (Fig. 2).

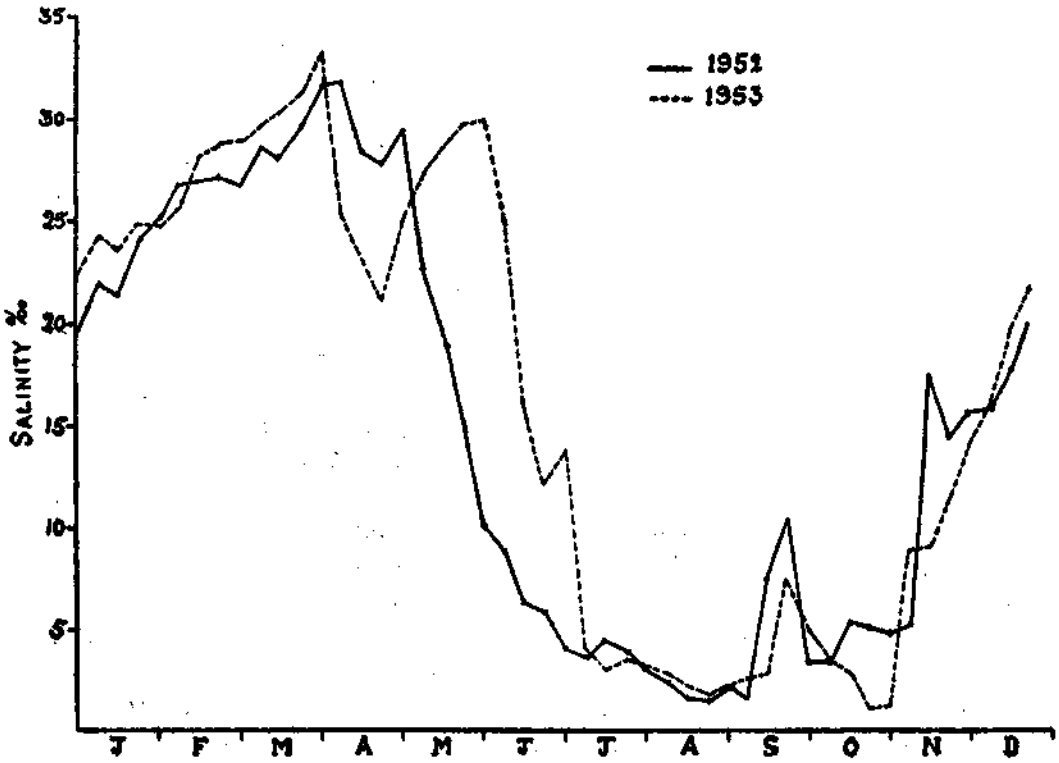

Fig. 2. Fluctuation in salinity for 1952 and 1953.

Two factors, namely, (1) the connection of the canal with the sea through the backwater area throughout the year and the consequent effects of admixture with large volumes of sea-water brought in by the regular tidal action, and (2) the large volume of fresh-water pouring into the backwaters directly and indirectly through rivers, etc., especially during the monsoon period seem to influence the salinity profoundly. During the hot months it almost reaches that of the sea outside. In the monsoon months however, there is such a large influx of fresh-water that, in spite of the connection with the sea and the tidal influence, the water of the canal, and especially of the upper layers of the backwaters, becomes almost fresh.

The highest salinity of 31·98‰ and 33·24‰ for the first and second years respectively was recorded in the month of April and the lowest salinity of 1·47‰ and 1·2‰ in the months of August and October respectively. An examination of the readings for the two years clearly shows that the important factor influencing salinity variation is the monsoon rain and thereby inflow of fresh-water. In 1952 from 19·89‰ in the beginning of January the salinity regularly mounted up to 31·98‰ by the middle of April. With the onset of the S.-W. monsoon it slowly declined and reached the lowest reading for the year, namely, 1·47‰ by the end of August and then again began to increase steadily and recorded 21·33‰ at the end of December. Likewise, for 1953 also from 22·41‰ in the beginning of January the salinity rose up to 33·24‰ by the beginning of April. But after this due to sudden rain for about a week in that month there was a decline to 20·25‰ by the end of that month and then again rose and reached 29·99‰ by the beginning of May. After that with the onset of the S.-W. monsoon regular decline was noted reaching 1·84‰ by the end of August. Thereafter it rose and reached 22·41‰ in December. In both years during the steady rise from the month of August onwards a slight fall was seen in October due to the N.-E. monsoon rains. In the second year the lowest level of 1·2‰ was recorded during this period. In the inshore waters of the Arabian Sea the highest salinities recorded by Bal *et al.* (1946) at Bombay and George (1953) at Kozhikode were 38·4‰ and 36·65‰ respectively in the summer months of April and May. The lowest recorded were 23·56‰ and 21·54‰ respectively and occurred during the monsoon months of July and August.

Temperature:

Surface temperature (Fig. 3).—The average monthly surface temperature of the water varied from 28·25° C. to 31·5° C. In the hot months February to May the temperature was high. After the commencement of

the S.-W. monsoons there was a lowering of temperature and the lowest was recorded in June, July. From August the temperature showed an upward trend. As in the case of salinity a slight fall was noted in October during the N.-E. monsoon period. In 1953, a slight fall in surface temperature was recorded in February also.

Atmospheric temperature (*Fig.* 3).—The atmospheric temperature also shows more or less similar trends in variation. It varies between 24° C. and 28·25° C. But in the case of atmospheric temperature, although the maximum was recorded in March, April and May, the minimum was in January and February. In June–July also the atmospheric temperature was low.

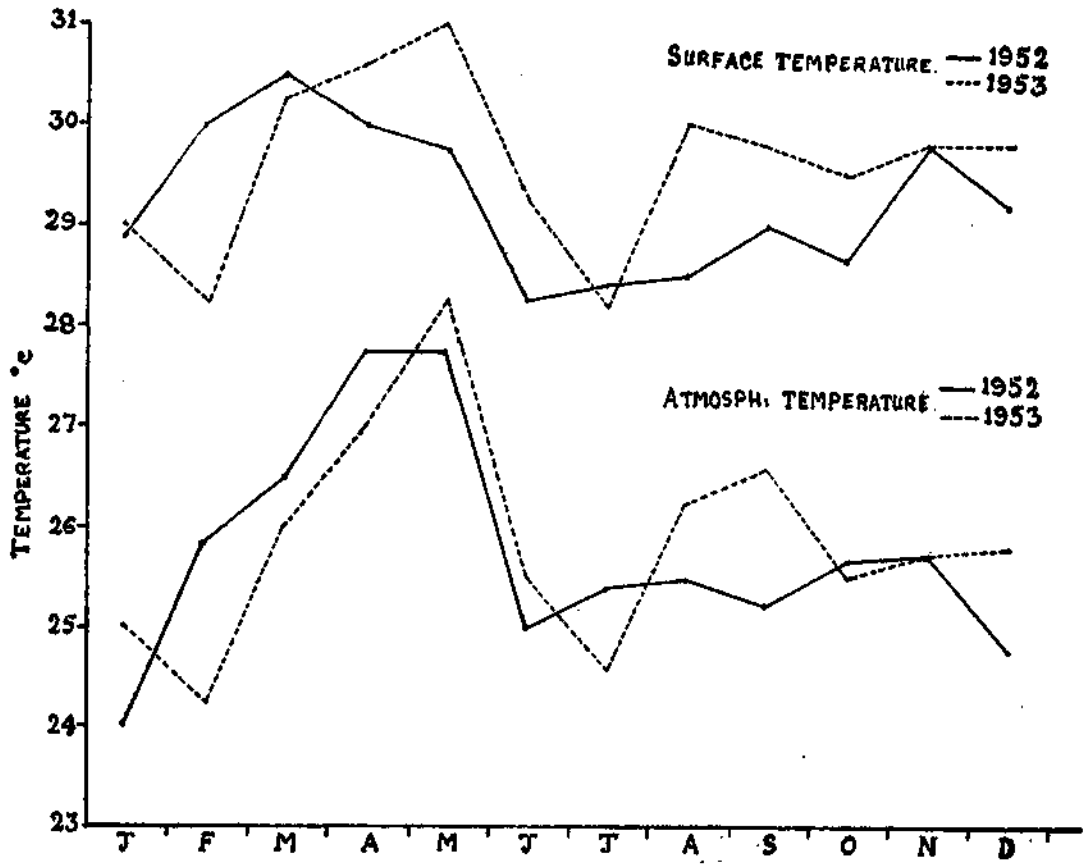

FIG. 3. Average monthly surface water and atmospheric temperatures for 1952 and 1953.

GENERAL REVIEW OF THE PLANKTON

The total plankton volume varied considerably from week to week (Fig. 4). The highest volumes were recorded in some weeks in February,

March and April, mostly due to the presence of large numbers of medusæ. In two weeks in October also the volumes were very high due to swarms of copepods. Low volumes were recorded in the monsoon months June, July and August.

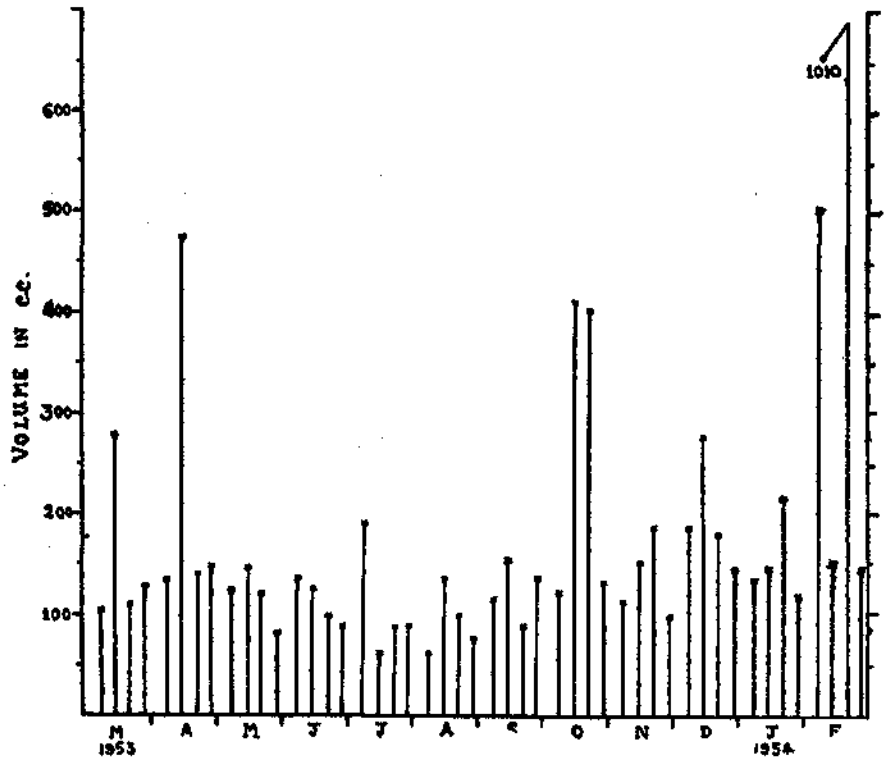

FIG. 4. Variation in total plankton volume.

As a result of the connection of the canals with the sea through the main backwater area the tidal action is quite conspicuous throughout the year. Along with the tidal current several planktonic organisms are certain to enter the backwaters and thence the connected chain of canals regularly. The nature of the plankton of the canal water has proved it. Several of the forms present are marine forms that have been recorded from the coastal waters of this region. Some of the copepods are forms with very wide distribution in almost all the seas of the world. There are others which have been recorded from marine as well as brackish water environments. Forms like the Mysid *Mesopodopsis orientalis* (Tattersall) and the Tanaid *Apseudes gymnophobia* are strictly brackish water forms. The diatoms present are also mostly marine as in the plankton of the Chilka Lake (Devasundaram and Roy, 1954). The marked fluctuation in abundance

of the various typically marine forms is easily explained when linked up with the widely varying salinity of the canal water.

ZOOPLANKTON

Cœlenterata.—Cœlenterate medusæ form a major component of the macroplankton during certain months of the year as is the case with the plankton of the inshore waters of Trivandrum (Menon, 1945) and Kozhikode (George, 1953). Most of the forms belong to the Hydromedusæ. They begin to appear by the end of December when the salinity of the water is above 20‰. Thereafter, as the salinity mounts up steadily their number also slowly increases reaching the maximum in February, March and April, the average salinity for the three months being 27·19, 30·23 and 25·91‰ respectively. After April a considerable reduction in their numbers takes place and finally they vanish completely by the first week of July when the salinity falls below 15‰. During the next four months when the water is practically fresh, they are completely unrepresented (Fig. 5).

Ctenophora.—*Pleurobrachia globosa* (Moser) occurred in the canal plankton in fairly good numbers in some months. It is a marine form which has been occasionally recorded from brackish waters. The species was observed in the plankton of Adyar and Vellar estuaries by Chacko *et al.* (1954*c*, 1954*a*). It has been recorded from the inshore plankton of both the east and west coasts by various authors. From January to April the species is common in the plankton here.

It begins to appear in the plankton in January when the average salinity is 22·77‰ and was represented up to April, recording the maximum in February. In all these months the salinity is above 20‰. From June to December, both inclusive, months in which the average salinity of the water is below 20‰, they were completely absent (Fig. 5). In this case also the relationship with salinity is direct, appearing when salinity is high, but dwindling and disappearing with lower salinities. George (1953) has observed *Pleurobrachia* sp. in the inshore plankton of Kozhikode almost throughout the year and in large numbers from February to May which are months of very high salinity there.

Chætognatha.—The most common species of Chætognath which occurs in the canal plankton is *Sagitta enflata* Grassi. *S. bedoti* Beraneck and *S. robusta* Doncaster also occur in small numbers.

They make their first appearance in the plankton by the beginning of December and were caught in gradually increasing numbers, reaching their maximum in the months of January, February and March. From April

onwards their number decreases and after the middle of June they completely vanish from the plankton (Fig. 5).

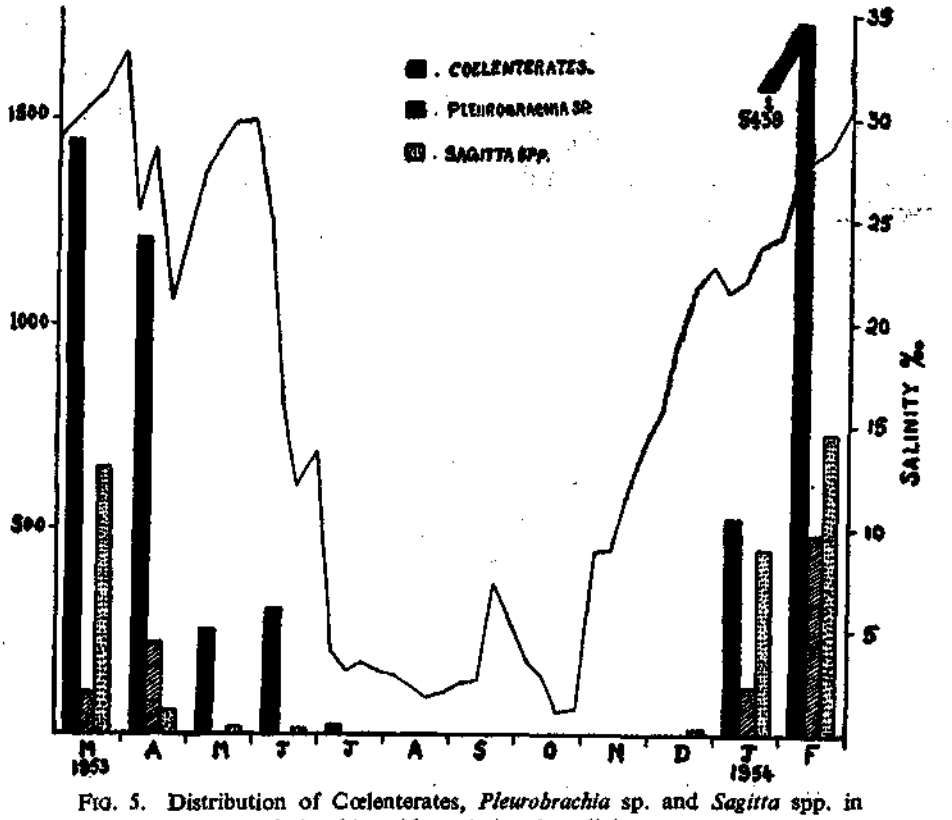

FIG. 5. Distribution of Cœlenterates, *Pleurobrachia* sp. and *Sagitta* spp. in relationship with variation in salinity.

In the case of *S. enflata* George (1952) and Muthu (1955) have both recorded a decline in numbers due to sudden lowering of salinity in the coastal waters of Kozhikode and Madras respectively. Ganapati and Rao (1954) also noted a direct relationship between the number of chætognatha and salinity. That these organisms are incapable of withstanding very low salinities is evident from the observations made during the present study also. Their occurrence in the canal plankton was noted to depend on the variations in salinity of the water.

Annelids.—Annelids were not represented in the plankton in appreciable numbers. Only one or two species of pelagic polychætes belonging to the family Nereidæ were met with in the collections. In all months except in October their average number was below 10. But in October when the salinity was at the lowest point their number rose up to 34.

Crustacea.—The bulk of the zooplankton is contributed almost throughout the year, except when medusæ are abundant, by adults and larvæ belonging to this group.

Cladocera.—The common cladoceran of the canal plankton is *Evadne tergestina* Claus. It is a marine form with very wide distribution. The species was noted in the plankton here in considerable numbers during the three months July to September and in small numbers in October. It has thus a short and sharp maximum during these months and were absent from November (Fig. 6).

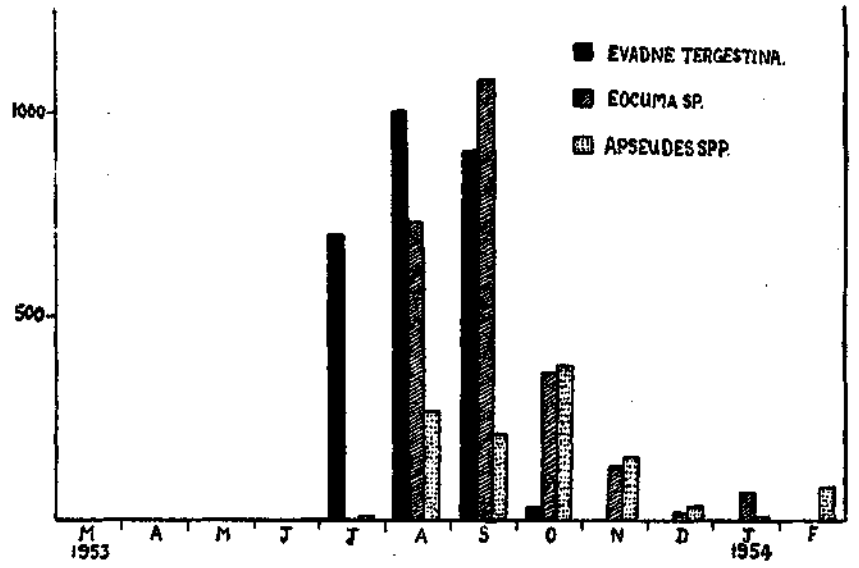

FIG. 6. Variation in abundance of *Evadne tergestina* Claus, *Eocuma* sp. and *Apseudes* spp.

Ostracoda.—One species of Ostracoda has been noted to occur in quite small numbers mostly in months of low salinity, the maximum having been observed in September and October.

Copepoda.—Copepods form the major component of the zooplankton all through the year. The following are the more important species.*

Schmackeria annandalei (Sewell); *Schmackeria tollingeri* (Sewell); *Acartia* (*Acartiella*) *gravelyi* Sewell; *Acartia* sp.; *Paracalanus aculeatus* Giesbrecht; *Labidocera pectinata* (Thompson and Scot); *Labidocera kroyeri* var. *gallensis* Thompson and Scot; *Calanopia elliptica* (Dana); *Acrocalanus monachus* Giesbrecht; *Eucalanus crassus* Giesbrecht; *Canthocalanus*

* I am indebted to Dr. S. Krishnaswamy, Zoology Laboratory, Madras University, for help in identification of these Copepods.

pauper (Giesbrecht); *Centropages* sp.; *Candacia* sp.; *Canuella* (*Canuella*) *furcigera* Sars; *Euterpina acutifrons* (Dana); *Stenhelia* sp.; *Halicyclops* sp.; *Oithona* sp.; *Hemicyclops* sp.; *Caligus* sp.

Most of these species are either marine or both marine as well as brackish water in habitat. Exclusively brackish water forms were very few. Species like *P. aculeatus, E. crassus, C. pauper* and *E. acutifrons* are typical marine forms with very wide distribution in most of the oceans of the world (Krishnaswamy, 1953). Species like *C. elliptica* and *A. monachus* are also marine forms confined to tropical Pacific and Indian oceans. Others like *L. kroyeri* var. *gallensis, L. pectinata* and *C.* (*Canuella*) *furcigera,* are equally at home in marine as well as brackish water environments.

The species occurring in the canal plankton can be grouped into three categories. Firstly those species which are present invariably throughout the year in spite of the noted variation in salinity, with definite maximum and minimum periods of abundance, *e.g., Acartia* sp., *Schmackeria* sp., *Oithona* sp. and *Halicyclops* sp., secondly those which occur only during certain months but are absent in the other months apparently directly depending on salinity, *e.g., A.* (*Acartiella*) *gravelyi* and *P. aculeatus* and thirdly those which are occasional visitors like *Labidocera* spp., *C. elliptica, A. monachus, E. crassus, C. pauper, Centropages* sp., *Candacia* sp., *C.* (*Canuella*) *furcigera, E. acutifrons, Stenhelia* sp., *Hemicyclops* sp. and *Caligus* sp.

As a whole the copepods have a minor peak period in May. From June onwards their number declines and reaches its lowest point in August. The major peak is in October, mostly due to swarms of *Acartia* sp. Following this there is an abrupt fall in November before again registering a second maximum in December, also due to swarms of the same species. In later months there is a general decline in their number (Fig. 7). Taking the entire group into account the variations in abundance have not clearly shown any relationship with variations in salinity, their maxima and minima having occurred during periods of both low and high salinities. However one or two species were found to exhibit such a corrleation with salinity.

Acartia sp. (Fig. 7).—This is the most common Calanoid copepod found in the plankton of these waters, contributing the major portion of the copepod population throughout the year, so much so the maximum and minimum of the group is more or less the same as the maximum and minimum of this species.

The species occurred in swarms here in October and December, with an abrupt fall in November. The minimum is recorded in August. The occurrence of this species cannot be correlated with the salinity of the water since both maximum and minimum periods of abundance occur in months of very low salinity, minimum in August in which average salinity is 2·56‰ and maximum in October, salinity being 3·21‰. The secondary maximum was recorded in December, a month of slightly higher salinity.

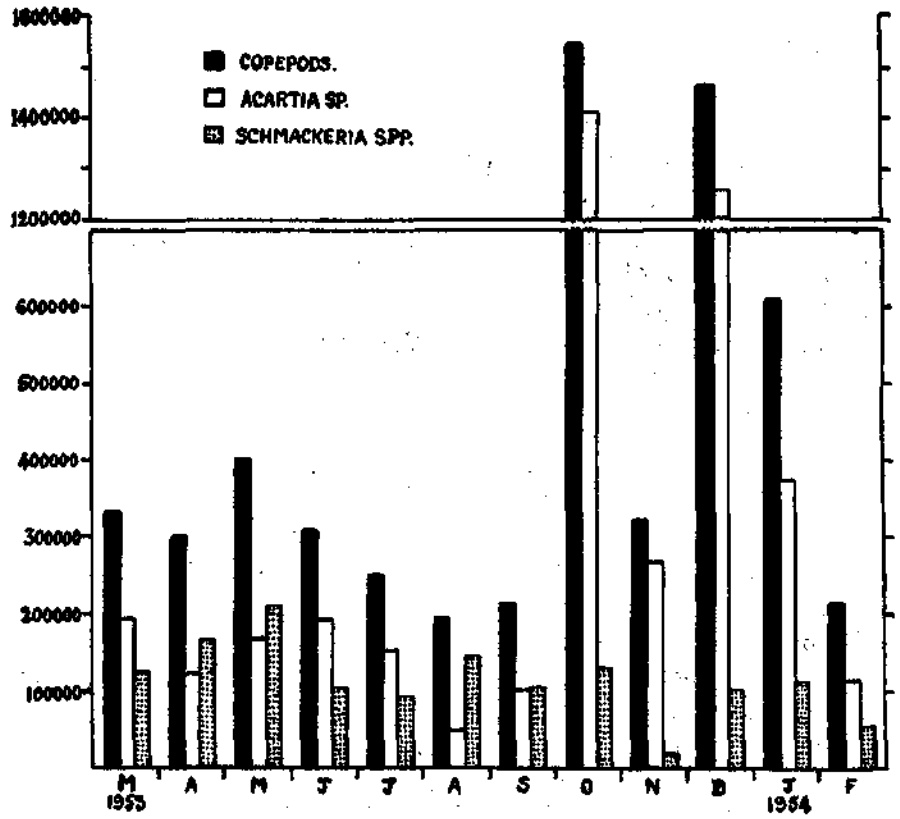

FIG. 7. Variation in abundance of total copepods, *Acartia* sp. and *Schmackeria* spp.

Schmackeria spp. (Fig. 7).—Two species of this genus, *S. annandalei* (Sewell) and *S. tollingeri* (Sewell) were commonly met with. Both are brackish water forms and *S. annandalei* has been recorded in the plankton of the Cooum (Krishnaswamy, 1953), Pulicat Lake and the estuaries of Vellar and Vamsadara by Chacko *et al.* (1953, 1954 *a* and 1954 *b*) and from the Chilka Lake by Devasundaram and Roy (1954).

Both species were found in the plankton throughout the year and no marked fluctuation in their numbers has been noticed. The number slightly

increases from March onwards and reaches the maximum in May. Thereafter it comes down slightly and the minimum is recorded in November. A slight rise is noted in August also. Since they occur throughout the year they should be hardy enough to withstand the wide changes in salinity.

Large numbers of adult females of *S. annandalei* carrying eggs were seen in the plankton all through the year. The presence of these adult females and also large numbers of immature forms and nauplii of the species indicates that active breeding takes place in these waters.

Paracalanus aculeatus Giesbrecht (Fig. 8).—Being a typical marine form the occurrence of the species in brackish water may be naturally influenced by the variation in salinity of the medium. Their incapacity to withstand very low salinities is evident from the fact of their absence from

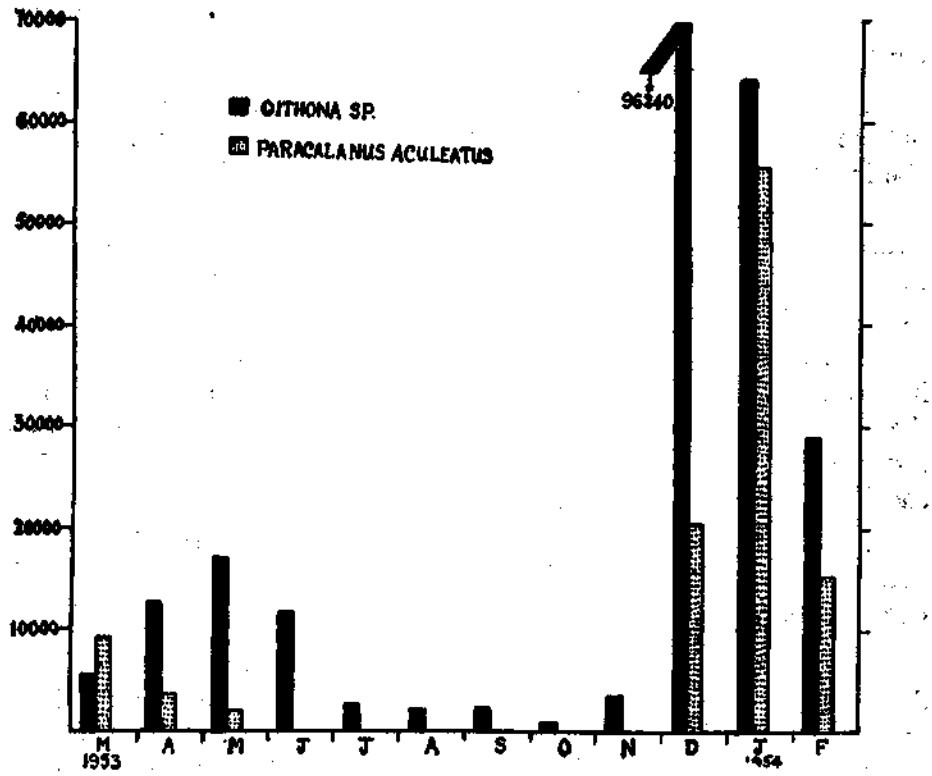

FIG. 8. Variation in abundance of *Oithona* sp. and *Paracalanus aculeatus* Giesbrecht.

the plankton in months of low salinities, namely, June to November. They begin to occur from the fourth week of December onwards when the salinity reaches above 20‰. They are increasingly present in the subsequent months

of high salinities and reach a maximum in January. With the onset of the monsoon and consequent fall in salinity their number diminishes and ultimately in June when salinity falls below 20‰ they disappear.

Acartia (*Acartiella*) *gravelyi* (Sewell) (Fig. 9).—This species beigns to appear in very small numbers in August and September, then gradually increases, reaches the peak in November and then declines and disappears altogether in January. From February to July it is completely absent. It is therefore a species that prefers water of low salinity as in August to December.

Oithona sp. (Fig. 8).—Different species belonging to this genus have been observed from the plankton of the West Coast by Menon (1945), Jacob and Menon (1947) and George (1953). Sewell (1913) and Devasundaram and Roy (1954) observed *Oithona* spp. in large numbers in Chilka Lake and one species of the genus was noted by Chacko *et al.* (1954 *b*) in the plankton of Vamsadara Estuary.

Although this Cyclopoid occurs in the plankton of the canal throughout the year the number is very low in certain months. There is an abrupt rise in their number in December and the peak period is during the months December, January and February, with the maximum in December. Though steadily declining, appreciable numbers continued to be present up to June. From June onwards the fall in number is steep and from July to November, both inclusive, their number is quite insignificant.

The months July to November in which the minimum of the species has been recorded are months in which the salinity of the water is at or near the lowest level. The peak period of the species recorded here is more or less the same as that observed for different species by Menon (1945) and Jacob and Menon (1947) on the West Coast.

Females carrying eggs were plentiful during its peak, indicating the possibility of their breeding in these waters. Sewell (1913) also observed *Oithona* sp. actively breeding in the Chilka Lake.

Halicyclops sp. (Fig. 9).—May to August which is the period of the S.W. monsoon and low salinity is the period when this species is most common, registering the maximum in the month of June. From October to April when the salinity is on the increase they were present very rarely.

Cirripedia.—Cirripede nauplii have been observed to occur almost throughout the year in the inshore plankton of Kozhikode by George (1953). The nauplii were found in large numbers in the canal plankton during certain months of the year, namely, December to July. Maximum numbers have

been recorded in January and February. From March to July their numbers dwindled markedly with a small rise in June (Fig. 13). Excepting stray individuals in the last week of September and first week of October they were almost completely absent from the end of July to the third week of November.

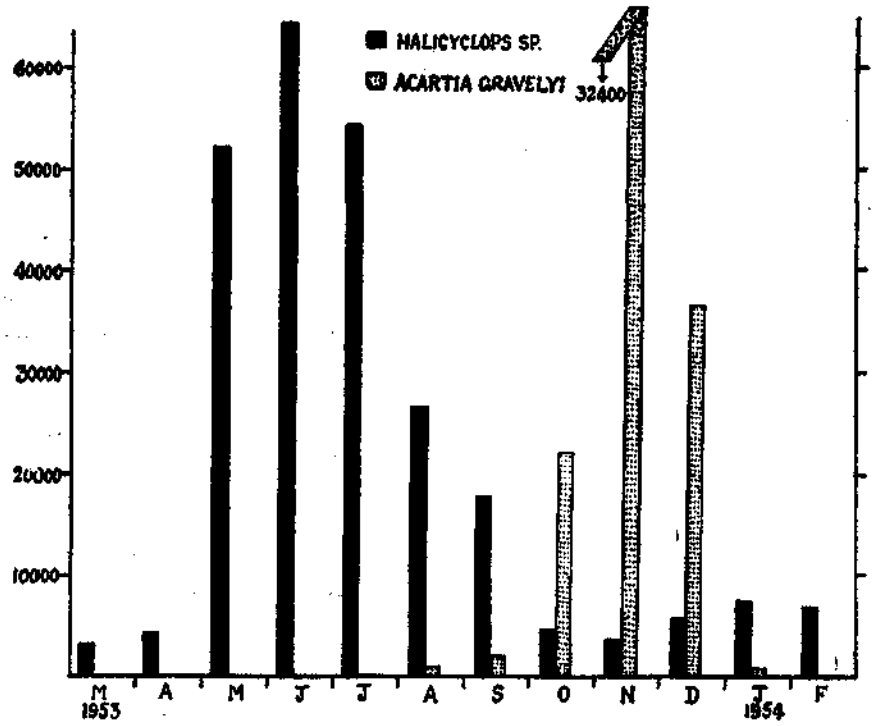

FIG. 9. Variation in abundance of *Halycyclops* sp. and *Acartia* (*Acartiella*) *gravelyi* Sewell.

Mysidacea.—Two species of Mysids were found to occur in the canal plankton. The commonest among these is *Mesopodopsis orientalis.* This species is a brackish water form. Chacko *et al.* (1953, 1954 *b* and 1954 *a*) have observed the species in the plankton of Pulicat Lake, and Vamsadara and Vellar estuaries. It has also been recorded in the plankton of the Chilka Lake by Devasundaram and Roy (1954).

In the canal this species occurred in maximum numbers in August, September and October (Fig. 10). From November onwards a steady decline in their numbers takes place and the lowest level is reached in the hot months January, February and March. In the next two months a slight, but abrupt rise was noted though the salinity was higher, which may very

likely be due to a lowering of the salinity for a brief while consequent on a few showers.

On the contrary another unidentified species, although represented in the plankton in small numbers, exhibit a maximum period in months in which the salinity is high and were almost absent in months of low salinity.

Eggs and developmental stages of *M. orientalis* were observed in large numbers during the same period and often along with the adults. The presence of these and also large numbers of berried females show that active breeding of the species takes place in these waters.

Cumacea.—Though bottom dwelling these animals were noted in the plankton during certain months of the year. *Eocuma* sp. is the common form present here. Different species of *Eocuma* have been noted in the plankton of the West Coast by Kurien (1951) at Trivandrum and George (1953) at Kozhikode. Kurien (1951) has given a list of the Cumacea of Travancore and has remarked "Though the Cumaceans are generally marine they have been observed in fresh-water as well. From the Chilka Lake *Paradiastylis culicoides* was collected when the water was almost fresh and not observed when the water was 'as saltish as the sea outside'. But from the Trivandrum Coast a few female specimens of this species were collected from the open sea."

The species begins to appear in very small numbers in July and reach the maximum in September. After this there is a reduction in numbers and finally vanish completely from the plankton by February (Fig. 6). From February to June they are unrepresented.

Like *P. culicoides* of the Chilka Lake the present species also shows a definite preference for water of low salinity, disappearing during the warm months of high salinity.

Tanaidacea.—Two species of Tanaidacea were commonly met with in the plankton, both belonging to the genus *Apseudes*, *A. gymnophobia* Barnard, a brackish water form recorded by Barnard (1935) from the backwaters of Vypeen and *Apseudes* sp.

Like the Cumaceans these also have a maximum period during the less saline months, August to November (Fig. 6). They begin to appear in very small numbers in July. From August to November they have been observed in fairly good numbers. From December their number declines and in the months of very high salinities March to June they are almost absent, though a few individuals may be noticed sporadically.

Isopoda.—*Sphaeroma* sp. was caught in the plankton in very small numbers on several days.

Amphipoda.—Amphipods contribute to an appreciable portion of the zooplankton. The more important species* met with are:

Corophium triænonyx Stebbing; *Photis longicaudata* (Bate and Westwood); *Perioculodes longimanus* (Bate and Westwood); *Eriopisa chilkensis* (Chilton); *Grandidierella* sp.; *Hyperia* sp.

The Amphipods were at the maximum in the post-monsoon months and at the minimum from March to August. Their discarded skins, more especially that of *C. triænonyx*, were found in plenty in the plankton regularly from the end of August onwards. One interesting fact regarding their occurrence is that on several days they (the skins) contributed to well over half the entire plankton.

Corophium triænonyx Stebbing.—This is the most common species occurring in the canal plankton. It was found to occur throughout the year although in small numbers during certain months and seems to be hardy enough to withstand the variations in salinity. It has a maximum period from September to February, both inclusive. The minimum was recorded in March–August (Fig. 10). Being able to tolerate a wide range of salinity the species has been caught from the canal when the salinities were almost at the two extremes.

Photis longicaudata (Bata and Westwood).—This species also occurred throughout the year but has a short maximum period in the monsoon months and were represented in quite small numbers in the other months.

A few specimens of a Caprellid were also noted in the plankton in the months January and February.

Decapoda:

Post-larvæ of penæids.—Post-larvæ of *Metapenæus dobsoni*, *M. monoceros* and *Penæus indicus* occurred in varying numbers in the collections. Those of *M. dobsoni* has a maximum period from August to November both inclusive, and a minimum period in March, April and June. *M. monoceros* is present throughout in very small numbers. In the case of *P. indicus* the maximum is recorded in November. Post-larvæ of *P. carinatus* were also present but in insignificant numbers on one or two occasions. Since the occurrence of these post-larvæ is the subject of a detailed study an account of it will be published later.

* I am indebted to Shri K. Nagappan Nair for identification of species.

Larvæ of caridea.—Larval stages of different species belonging to the tribe Caridea like *Periclimenes* sp., *Palæmon* sp. and Alpheids were present in the plankton throughout the year in varying numbers.

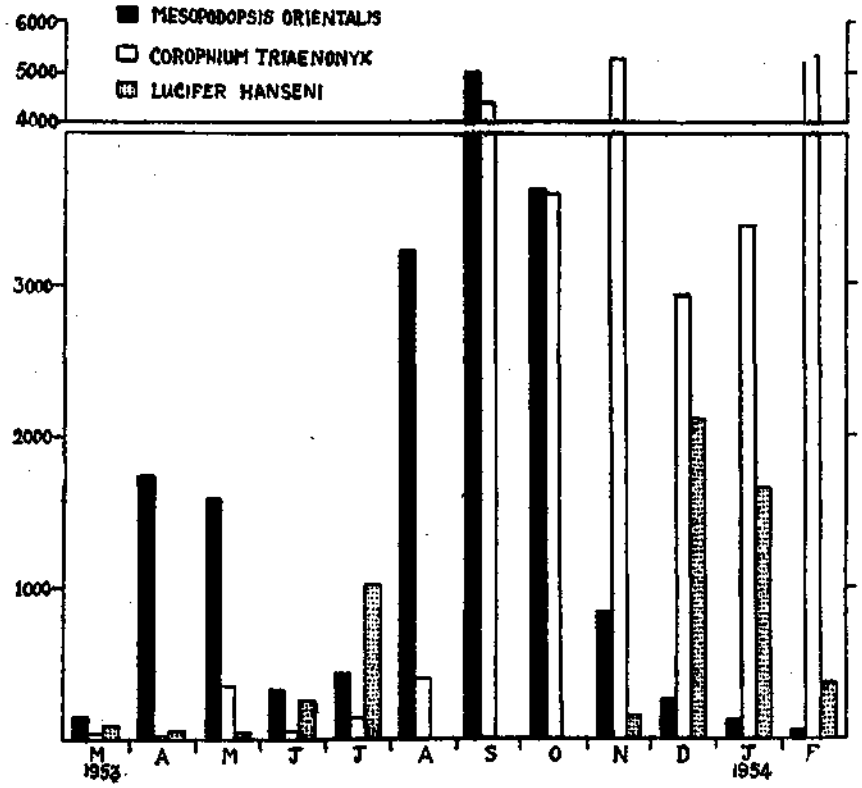

FIG. 10. Variation in abundance of *Mesopodopsis orientalis* (Tattersal), *Corophium triænonyx* Stebbbing and *Lucifer hanseni* Nobili.

May, June and July are the months in which these larvæ are at the minimum. From August onwards they regularly increase and reach the maximum in December, January and February immediately after the N.-E. monsoon. After February there is a considerable fall in their number (Fig. 11).

Brachyuran zœa.—Zœa larvæ of Brachyura occurred in varying numbers and a definite periodicity has been observed in regard to such variations. The minimum numbers were recorded at the beginning of June and continued without much difference up to November, with a slight increase in October. From December to May they were present in quite large numbers reaching the peak in January and February (Fig. 11).

It would seem that in the backwaters crabs prefer water of high salinity for breeding purposes. The large numbers of zœæ caught from December to May and their abrupt decline in June after the onset of the S.-W. monsoon rains is direct evidence for it. The slight increase in numbers noted in October may probably be due to the rise in salinity in the usually warm interval between the two monsoons.

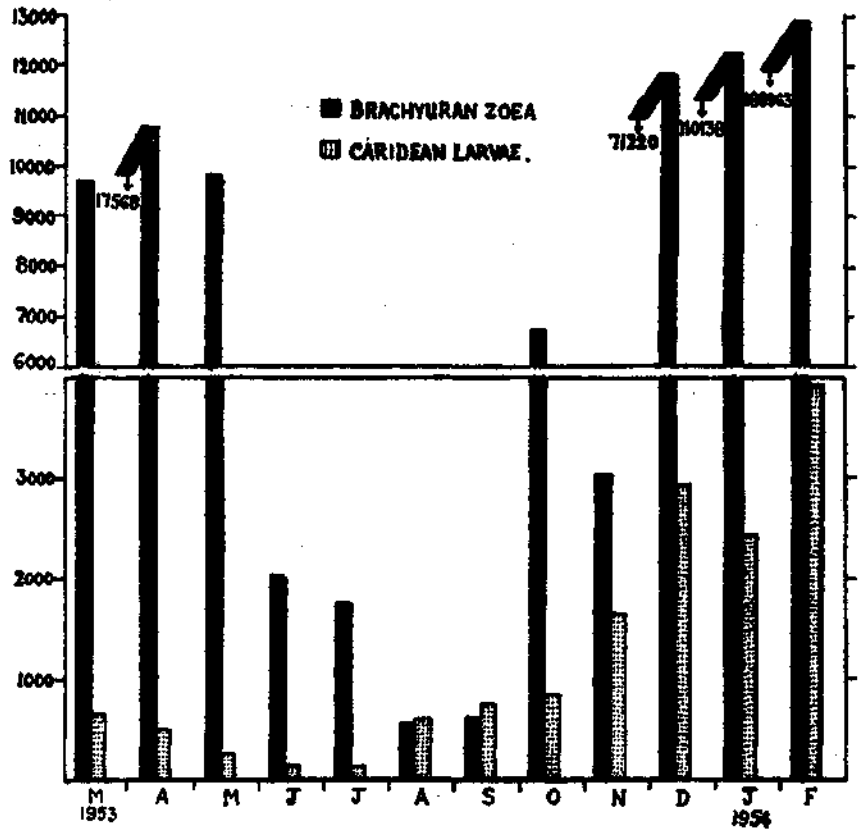

FIG. 11. Variation in abundance of *Brachyuran zœa* and Caridean larvæ.

Adult Decapods like *Lucifer hanseni*, *Ogyrides striaticauda*, *Periclimenes indicus*, *Palæmon rudis* and *Acetes* sp. occurred on several days. Among these, all except *L. hanseni* were represented by a few individuals only.

Lucifer hanseni Nobili.—The species occurred in large numbers in certain months and were completely absent in other months. It did not occur during the period from the middle of July to the first week of November

(Fig. 10). From the second week of November onwards the number increased and continued so up to the middle of July. The maximum period is in December and January. After February there is a considerable fall in number and by July was completely absent. Their occurrence in fairly large numbers coincided with the prevalence of comparatively high salinities.

Large numbers of larvæ also of the species occurred in the plankton in December and January which is the maximum period for the adults also.

Stomatopoda.—Alima larvæ also were caught only when the salinity of the canal waters was fairly high. They started appearing by the end of December and in the following months their numbers steadily increased till February in which month the maximum was recorded. Later there was reduction in their numbers up to May. From June onwards they were not represented. George (1953) has also recorded the complete disappearance of these larvæ from the inshore plankton of Kozhikode during the rainy season.

Mollusca.—Both Lamellibranch and Gastropod larvæ were regularly represented in the plankton in appreciable numbers, with a definite maximum and minimum.

Lamellibranch larvæ (Fig. 12).—Oyster larvæ generally occurred in considerable numbers in the hot months when the water is highly saltish. They become very scarce from the second week of July when the salinity goes below 5‰ and completely vanish in the months of August and September. They seem to be able to tolerate salinities slightly higher than this mark since it was noticed that in the first half of October when the salinity rose to 10‰ (it was about 5‰ at the close of September) fairly good numbers of them were caught and later in the month when the salinity went down their number also dwindled markedly. They seem to have 2 maxima: one in December and the following two months and the other in June. Between February and June there was a drop in numbers especially in April and May. It would seem that these brackish water oysters breed commonly in water the salinity of which varies only within a certain range, extremes markedly retarding this activity.

Gastropod larvæ (Fig. 12).—Larvæ of two species of Gastropods were very common in the collections, namely, those of *Thais* sp. and *Neretina* sp. They are at the minimum during the period March to June. From July they began to appear in larger numbers and reached the maximum in October and November. From December their number gradually diminished and from March became very insignificant.

Although Gastropod larvæ are never completely absent from the plankton of the canal, the periodicity noted above seems to indicate that the adults are quite unlike the oysters in regard to breeding. While the former group prefers water that is of low salinity the latter, as already shown, requires a definitely higher range of salinity.

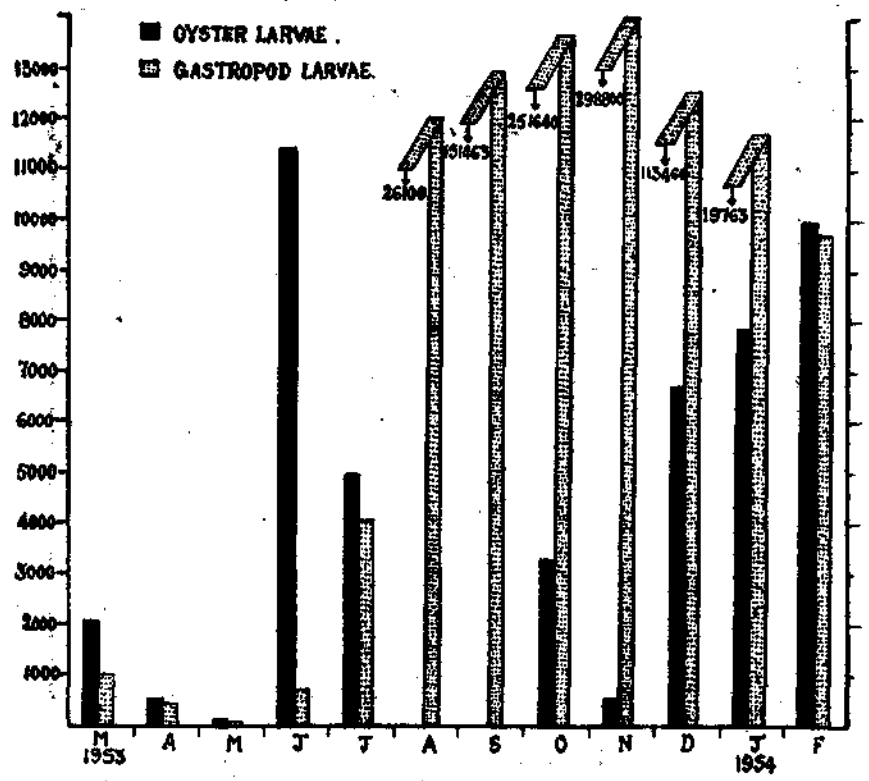

FIG. 12. Variation in abundance of oyster and gastropod larvæ.

Fish larvæ (Fig. 13).—A definite seasonal abundance of fish larvæ was noted. The maximum period was from July to November, both inclusive, with the peak in September. From December their number steadily declined reaching the lowest point in the months of March, April, May and June. Backwater fish also seem to prefer water of low salinity for breeding purposes.

PHYTOPLANKTON

The amount of phytoplankton is comparatively small throughout the year and it is proposed to point out here only the observed general trend in their occurrence as a whole in the canal waters.

Diatoms were present in the plankton throughout the year, but in very limited numbers on several days. Species of *Rhizosolenia, Chætoceros, Pleurosigma, Coscinodiscus, Pinnularia, Thallassiosira, Biddulphia, Nitzschia* and *Skeletonema* are some of the common diatoms occurring in the plankton. Two major peak periods were noticed for them, the first in consequence of the monsoon bloom occurring in June and July. Two or three

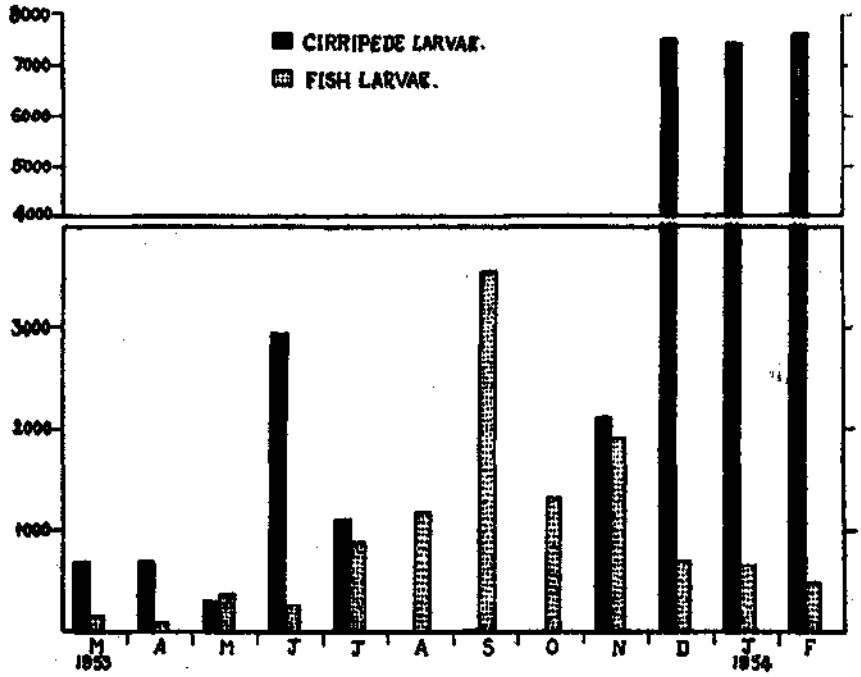

FIG. 13. Variation in abundance of Cirrepede and fish larvæ.

species contribute mostly to give rise to this peak. The second occurred in November and December. A minor peak due to abundance of a single species of *Nitzschia* was also noted in February. These including the minor peak agree more or less with the observations made at Kozhikode by George (1953). Menon (1945) observed a general maximum for diatoms in the Trivandrum Coast from February to September. The peak month for diatoms in the plankton of the Chilka Lake according to Devasundaram and Roy (1954) is June.

Ribbons of *Spyrogyra* were very common in the collections during the period of low salinity from July to November, both inclusive. One species of green alga belonging to the genus *Wolffia* occurred in large numbers in the plankton of September when the water is practically fresh. Swarms

of a species of the blue green alga *Anabænopsis* were present in the hot months of February, March and April, imparting a green tinge to the water and occasionally causing considerable mortality among fish.

Discussion

Owing to the perennial connection with the sea there is a regular ingress and egress of marine planktonic forms into and from the backwaters, caused in part at least, by the tidal flow. This would explain the striking similarity of the canal plankton with that of the inshore waters. Forms which are exclusively brackish water in habitat are few. The others are typically marine forms or those which can live equally well in the sea and in brackish water. Among the former category come the Cælenterate medusæ, *Pleurobrachia globosa*, *Sagitta* spp., *Paracalanus aculeatus*, *Alima* larvae, etc. They do not migrate into the backwaters until the salinity has risen to a level which they can tolerate. They would therefore be naturally absent in months in which the water is hardly or only slightly saltish. The medusæ begin to appear in December and disappear in July and in the subsequent months of low salinity they were absent. *Pleurobrachia globosa* appeared a month later than the medusæ and disappeared a month earlier. The chætognaths were present only from December to June, both inclusive, months of high salinity. Both *Paracalanus aculeatus* and *Alima* larvæ were unrepresented in the plankton from June to November.

Among the latter are those species whose entry into the backwaters is influenced not so much by salinity as by their great abundance in the inshore waters of the sea. *Evadne tergestina* is one among them. The species was present in the canal plankton in large numbers in the months of low salinity, from July onwards, the average salinity having been less than 6‰. In the coastal waters at Trivandrum, Menon (1945) has recorded the maximum period of intensity for the species during July to October. At Kozhikode, George (1953) also recorded more or less the same period as the maximum for the species. This shows that the species is quite abundant in the coastal waters during that period although the salinity of these waters never goes below 20‰. In spite of the difference in salinity the maximum periods for the species both in the sea and the backwaters are the same. So the entry of these forms into the backwaters may be partly due to their great abundance in the coastal waters. Since several females were seen with brood pouches carrying young ones inside, breeding habits might also be another reason for this migration. This might explain the complete absence of the species in the backwaters during months of high salinity.

Quite a number of species are found throughout the year in varying numbers showing thereby a very highly developed adaptability to great differences in salinity. They are *Acartia* sp., *Schmackeria* spp., *Oithona* sp., *Mesopodopsis orientalis*, Amphipods, Caridean larvæ, Brachyuran zoëa, larvæ of Gastropods and fish larvæ. Most of them show definite maxima and minima. Although the fluctuations in abundance of *Acartia* sp. and *Schmackeria* spp. do not appear to be dependent on salinity variations, the occurrence of *Oithona* sp. seems to be influenced by salinity, since it dwindled to very insignificant numbers in the low salinity period and appeared in large numbers when the water was highly saline. *Mesopodopsis orientalis* exhibit an inverse relationship with salinity variation, its maximum coinciding with the lowest salinity and decreasing with the rise of salinity. The number of fish larvæ and larvæ of gastropods *Thais* sp. and *Neretina* sp. also show an inverse relationship which might mean that breeding of these fishes and gastropods takes place mostly during the months of low salinity. Zœæ of Brachyura on the other hand were at the minimum during this period, the maximum occurring in months of high salinity showing the preference of the crabs for waters of high salinity for breeding purposes.

SUMMARY

Qualitative aspects of the plankton of Narakkal bunder canal were studied during the year 1952–53, and quantitative aspects in the second year from March 1953 to February 1954, in order to study the fluctuations in the composition of the plankton.

Great similarity in general trends in the time of occurrence, maxima and minima of the different planktonic elements was noticed for the two years.

Hydrological features like salinity and surface temperature were also studied for the two years and their seasonal fluctuations also were found to be of marked similarity for the two years, being very low during the monsoon months and very high in the hot months.

The seasonal fluctuations in abundance of the variqus planktonic groups, more especially zooplankton, are described and attempt is made to correlate these fluctuations with fluctuations in the salinity of the water. Planktonic elements like medusæ, *Pleurobrachia globosa*, *Sagitta* spp., Stomatopod larvæ, *Lucifer hanseni*, *Eocuma* spp., etc., are found to show distinct relationship with salinity in their appearance and disappearance in the plankton.

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