OBSERVATIONS ON BREEDING IN BRACKISH-WATER ANIMALS OF MADRAS

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(From the Department of Zoology, University of Madras)

Received February 15, 1939

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Introduction

In a previous issue of these Proceedings, we gave a general account of the brackish-water fauna of Madras in which the general trend in the breeding habits of the majority of the species observed by us was indicated in a brief summary (Panikkar and Aiyar, 1937). The following account is a continuation of the same topic that was but lightly treated in that paper. We submit here the biological notes with special reference to breeding in the more common species of brackish-water organisms of Adyar. The period of observation extended to a little over three years. These records are by no means exhaustive, and, having not made intensive studies on every species encountered, all that is attempted by us in this paper is to give a preliminary account of the reproductive periods of some of the very common forms in so far as we have been able to observe them during the period of our faunistic survey. We have thought this account worth while in view of the growing importance of the subject of breeding in tropical marine animals and of the fact that, in some of the species noted, we have new information on their biology.

The criteria on which the active spawning seasons have been determined are different for the different species, depending upon the spawning habits of the organisms in question. Detailed examination of gonads of specimens collected during different months has been made in the case of Anemones, and to a certain extent in the bivalves and the Polychaetes. The presence or absence of ovigerous females formed the main criterion for judging the breeding seasons of Decapods (excepting the Penaeidae), while in the case of
certain Gastropods, the occurrence of spawn masses was mainly relied upon. The presence of embryos in the brood pouches provided the necessary information so far as Amphipods, Schizopods and Isopods were concerned. These observations were made whenever specimens were collected from the backwater or the river at Adyar and from Cooum. Plankton collections from the Adyar backwater and the river have appreciably supplemented these observations. The general conclusions that may be arrived at from these records are summarised in this paper. There is not the least doubt that a considerable amount of variation does take place depending upon variations in climatic changes in successive years (as for example, the beginning of the Monsoon) and no study of breeding seasons may be considered complete unless observations have been continued for a number of years. Further studies carried out for a much longer period than the present one may be expected to bring further corrective data bearing on the subject; but the purpose of this paper is to indicate the breeding seasons in broad outlines which in itself may facilitate a later detailed study.

Environment

For a detailed description of the brackish-water areas of the City of Madras reference may be made to our previous paper. In addition to the information given there, we give below the tables showing the monthly rainfall at Madras for the years during which these observations were made, because there is reason to believe that rainfall plays a significant rôle in the habits of many of the organisms that we have observed in the peculiar brackish-water habitats.

*Tables showing monthly rainfall at Madras*

<table>
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<th>Month</th>
<th>Total rainfall for the month (Inches)</th>
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<tr>
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<tr>
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<tr>
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<tr>
<td>December</td>
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### Observations on Breeding in Brackish-Water Animals of Madras

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1935

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1936

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<td>0.93</td>
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Observations on Breeding

**Phylum** .. *Cælenterata.*  
**Class** .. *Hydrozoa.*

*Cephalodiscus ceylonensis* (Browne)

This is one of the *Hydrozoans* that may be considered as a permanent inhabitant of the brackish-waters of Madras; the species is also common on the Madras coast, Chilka Lake and Gangetic delta. The medusæ are frequently observed in the backwaters at Adyar, pools adjoining the mud-flats near the Elphinstone Bridge, the Cooum, and in certain seasons even in the Buckingham Canal. Though found throughout the year as evidenced by our plankton records, the specimens were obtained in large numbers only from June to October. Most of the individuals collected during this period had well-developed gonads and ripe germ cells. October to February collections of the plankton showed that their numbers considerably fall during these months, but ripe individuals were observed even during this period. The medusæ collected during the summer months from March to June were not in a perfectly healthy condition since most of them were without tentacles; and all the specimens collected during March–May period of 1934 and March–June period in 1935 were without well-developed gonads and ripe germ cells. We have not so far discovered the *Hydroid* generation of this species in the locality studied. Annandale (1922) reports that the *Hydroid* which is very minute and found attached to bricks and rocks is an exceedingly delicate organism unlike the medusa which in spite of a somewhat fragile appearance is extraordinarily hardy. From our records it appears that the sexual reproduction of the medusæ takes place from June to February, showing a great intensity during the July–September period. The asexual reproductive activity of the *Hydroids* also seems to be well marked during June–August. Large numbers of young ones of the medusoid generation appears a day or two after the few showers at the end of summer.

*Dicyclocoryne filamentata* (Annandale)

As in the previous species only the medusoid generation has been discovered by us. The species is rather rare and specimens have been collected by us only during August 1936. But the fact that very young medusæ have been collected during this period suggests that asexual budding of the *Hydroid* must have been taking place at this period.

*Companularia nokiformis* McCrady

*Laomedea* (*Obelia*) *spinulosa* Bale

Only the *Hydroid* generations of the above two species have been collected; they were found attached to the boulders of the Elphinstone
Bridge and of the small bridge near San Thome. During the January-March period of 1934 and 1935, fairly luxuriant growths of these Hydroids were observed and both the species showed gonosomes during the months January and February. The first species disappeared with the advent of summer; but colonies of *O. spinulosa* were found on dead oyster shells, stones, etc., even during the month of April; none of these however, showed gonosomes. The species was very rare in the month of June; but a month hence specimens could not be found. The next time they were observed again was in the succeeding season of high salinity after the bar had opened and the monsoon had ceased.

Our observations lead to the view that both the species have not permanently established in the backwater in the sense that the colonies do not survive and actively reproduce throughout the year. In all probability they are only casual migrants, entering the backwater every year when the bar is open and the colonies thus started (and which may attain sexual maturity) almost completely perish with the advent of summer. Both these Hydroids are known from the brackish-waters in other parts of India (*vide* Leloup, 1932). Luxuriant growths of these may be observed in the Madras Harbour.

**Class . . Scyphozoa.**

*Acromitus flagellatus* (Haeckel)

This is the only Scyphozoan that occurs in the Adyar, the Cooum and the Buckingham Canal. The species enjoys a wide distribution throughout the coasts of India and is found in the sea, brackish-water, and even in water that is of very low salinity (Rao, 1931). Rao considers that *A. rabanchatu* described by Annandale from the Chilka Lake may after all be only a variety of *A. flagellatus*. At Madras the jelly-fish is found in the backwater all through the year; and we have collected specimens measuring from 5 mm. to 200 mm. across the bell.

**Ephyrae.**—During the November-January periods of 1934-35 and 1935-36 a number of ephyrae were obtained in the tow-net collections taken from the river as well as the backwater. During these years the ephyrae were not collected in any other season. As they were capable of surviving considerable lowering of salinity and were common in the backwater during this season the ephyrae were considered as belonging to *Acromitus flagellatus*; but their exclusive occurrence during the period when the bar is open, led us to think that these were brought down from the sea. No evidence was available at that time to prove that the process of strobilisation takes place in the brackish-water, but definite data bearing on this point was obtained in 1936. In describing the fauna of isolated brackish-water pools in our
previous paper we have specially referred to a large salt pool situated near the Adyar Boat Club. During June and July 1936, adult jelly-fishes were completely absent from this pool, and the water was but a few inches deep. The rains during August increased the level of water: and the plankton collections made in August and September brought in plenty of ephyrae from the pool that was not at all directly communicated to the Adyar river at that time, in a season when the bar was closed. There is not the least doubt therefore that asexual phase of reproduction takes place in the brackish-water. In spite of careful search we have not so far obtained the strobila. Young specimens of the jelly-fish were observed in the pool by about October and November. So far as we are aware there is no previous record of the ephyrae of this species.

The ephyrae are about 1 to 2 mm. across; they are perfectly transparent and unpigmented. In essential features they are very similar to those of *Aurelia* usually figured in text-books. The sense organs at the points of bifurcation of the arms are quite distinct in live specimens. In none of them were the canal system and other structures developed.

Very young individuals of the jelly-fish have been collected during the months of November, December, January and February. These were immature and the terminal filaments of the arms were well developed, similar to the condition reported by Annandale (1915) in *Acromitus rabanchatu*. Large specimens of the jelly-fish are found all through the year, but they are commoner in March and April and later in August and September, than at other times of the year. Several specimens collected at this time had well-developed gonads with ripe eggs or sperms as the case may be. We have not seen them spawn; nor have we found planulae in the tow-net collections. Menon (1930) finds that they begin to appear in August till some time in November. His record of the largest specimen (which was immature) was in October. There is a certain amount of variation in the time of their appearance, but summing up the records, it seems probable that both the asexual and sexual phases of reproduction take place in the brackish-water, the asexual phase being produced during the months August-January, and the sexual phase probably taking place during the other half of the year. It must also be admitted that large numbers of jelly-fish enter the back-water from the sea when the bar is open.

The observations of Annandale are noteworthy in this connexion. In Chilka Lake, he says that probably the fixed stage of *A. rabanchatu* occurs on rocks or weeds near the south end of the Lake, where the young were found in April, July, September and November, but not in January or February. If this were so, it would mean that at Madras, the liberation of the
ephryrae takes place much later in the year than it does in the Chilka Lake. Annandale also says that the main breeding season of *A. rabanchatu* as judged by the condition of gonads in the specimens occurs towards the end of the cold weather, *i.e.*, February and March (p. 102).

**Phytocætes gangeticus** Annandale

This anemone breeds all through the year; young ones, post-larval stages, and sexually mature individuals have been observed during all months (*vide* Panikkar, 1937). In addition to the information given in the above-mentioned paper, an interesting point to be noted here is that concerning the proportion of sexes. In all collections made, the anemones were either exclusively females, or the majority of them were so, male anemones having been somewhat rare.

**Phytocæteopsis ramunnii** Panikkar

**Stephensonactis ornata** Panikkar

Repeated examination of the gonads of both these species were made for about a year and a half from December 1933. The gonads were both examined in the fresh state and also from sections. Ripe ova and spermatozoa have been observed all through the year, both when the bar was open and when closed (Panikkar, 1936). Artificial fertilizations were not, however, successful; nor have we collected larval and post-larval stages.

**Pelocætes exul** Annandale

Ripe sperms and ova have been observed throughout the year. One of us has already pointed out that Annandale's view that the species is hermaphrodite is not supported by careful anatomical investigation (Panikkar, 1938).

**Boloceractis gopalai** Panikkar

The species reproduces both by asexual and sexual methods as has been described in a previous paper (Panikkar, 1937).

**Phylum** . . *Annelida.*
**Class** . . *Polychæta.*

**Lycastis indica** Southern

This polychæte is almost amphibious in habits; and it has been taken from localities where the water is almost fresh. One of us (Aiyar, 1935) has noted that the species is hermaphrodite and probably protandrous as judged by the size of the worms either preponderatingly male or female. Mature
specimens with fully developed eggs and sperms have been observed all through the year; the developmental stages have not so far been collected.

*Diopatra variabilis* Southern

The development of the eggs of this species takes place inside the tubes of the parent worm (Krishnan, 1936). Taking the records of the past three years, tubes with embryos of *Diopatra* have been taken from the Adyar backwaters during all the months of the year. This would mean that the species breeds all through the year, though we have no information whether there is an intensive spell during any particular period.

*Marphysa gravelyi* Southern

The worm breeds all through the year (Aiyar, 1931) and the characteristic spawn masses of this worm are extremely common all along the mud flats, shallow pools, banks of the Adyar river and backwater, Cooum and the Buckingham Canal throughout the year. The largest amount of spawn masses occurs from August–February, especially during the few weeks that follow any outbreak of monsoon. There is an appreciable decline in the number of the spawn during the period of drought (April–June).

*Lumbriconereis* sp.

The species is different from all other members of the genus known from India and is being described in detail separately by one of us (R.G.A.). They are exceedingly common in the mud, especially in the surface zone. Worms having fully developed ova have been noted during all times of the year.

*Scoloplos* sp.

The species has not so far been settled; but it is specifically distinct from *S. marsupialis* recorded from the Chilka Lake by Southern (1921) and *S. latus* and *S. kergulensus* the two other species recorded from other parts of India by Fauvel (1932). The worm has been obtained all through the year. Like *Marphysa* the eggs are collected into gelatinous masses, though the spawn is much smaller being only 8 to 10 mm. across. They are fairly common in the backwater during the period when the bar is closed, from August–October (1934, 1935); in 1936, they were also found between March and July. Details of habits and development of this Polychaete are dealt with in another paper (Aiyar, R. G., unpublished, 1938).

*Hydroides norvegica* Gunnerus

This species seems only to be a casual migrant to the river and backwater since live specimens were not observed in the brackish-water during all months of the year. The worms begin to appear along the boulders of
the Elphinstone Bridge attached to oyster shells and stones, about a month after the opening of the bar and they are observed here for a few of the succeeding months. By about May, only the empty calcareous tubes of the polychaete are observed. The species is abundant throughout the Madras coast and is very common in the Madras Harbour. Every year the larvae are probably washed into the Adyar river and backwater when the bar is open, and they establish on suitable substrata; but a very high percentage of worms perish with the onset of low salinity conditions and drought. M. D. Paul (unpublished) has found out that in the Madras Harbour the worm is a continuous breeder and that sexual maturity is attained rapidly within a few weeks after the attachment of the larva.

*Pontodrilus bermudensis* Beddard

Specimens collected during December 1934, February 1934 and January 1935 had well-developed clitella. Unfortunately we have not collected worms during other months of the year and hence no definite information on breeding could be given here. However, the above records are in conformity with Stephenson’s observations (1915) on the specimens of the Chilka Lake, that the breeding time appears to be late in winter and early in spring.

**Phylum** . . Arthropoda.
**Class** . . Crustacea.
**Order** . . Cirripedia.

*Balanus amphitrite* Darwin

As in the case of *Hydroides norvegica* the species is common only during the months when the bar remains open. They are found attached to stones, boulders of the two bridges, shells of hermit crabs, and oysters. From the plankton records given in our account of the Adyar fauna, it will be apparent that the larvae are brought down from the sea when the bar is open and they settle down on suitable substrata. The individuals survive in the brackish-water for some months; and most of them perish with the advent of drought when the level of water falls down from the situations where they have settled. It is probable that they are able to reproduce in the brackish-water during the few months of their annual existence. In the Madras coast the species is a continuous breeder (Paul, 1938, unpublished).

**Order** . . Schizopoda.

*Mesopodopsis orientalis* (Tattersal)

Females with embryos are observed during all months of the year in collections made from the Adyar backwaters and the Cooum, and the species is capable of reproducing in brackish-water as well as sea water. Details
of the development and life-history of this Mysid are given in another paper by Mr. K. B. Nair (1939).

*Rhopalophthalmus egregius* Hansen

Swarms of this Mysid were found during November and December 1933, and collections included plenty of females with embryos of different stages in the brood pouches. The bar was open at this time and as the species was absent in subsequent plankton collections we were inclined to consider that the species is only a casual migrant from the sea. But there is not the least doubt that the species is capable of surviving and breeding in the brackish-water since we have obtained specimens on one occasion when the bar was closed (12th August 1935). A few males and females with embryos were obtained in the tow-net from the middle zone of the backwater. Though a number of plankton collections have been made within the course of our study, there has never been any further record of this Mysid from the brackish-water. The species is common in the Madras coast during February, March and April (*vide* Aiyar, Menon and Menon, 1936).

**Order** .. *Amphipoda.*

*Grandidierella megna* (Giles)

*Grandidierella gilesi* Chilton

There is considerable difficulty in determining the two species since systematists are not agreed on the synonymy of these and allied species; we have followed only the descriptions given by Chilton (1921). As judged by the females carrying embryos, both the species breed all through the year.

*Paracalliope fluvialtilis* (Thomson)

Females with embryos have been noticed irrespective of seasons.

**Order** .. *Isopoda.*

*Cymothoa indica* Schiodte and Meinert

Embryos of this parasitic Isopod have been taken from females during all months of the year (Panikkar and Aiyar, 1937a). In addition to the host-fishes recorded before by us, we wish to add the goby *Acentrogobius viridipunctatus* (Day) and *Macrones* spp. in which also the parasites are occasionally found.¹

*Cirolana* sp.

Eggs and embryos have been noted during November and December 1935. There are no records for other periods.

¹ Kindly brought to our notice by Mr. T. J. Job.
Observations on Breeding in Brackish-Water Animals of Madras

*Ligia exotica* Roux.

This is a completely terrestrial Isopod, but never occurs far away from the water edge. Young specimens as well as large females with eggs in brood pouches have been recorded during the months of July, September, October, December and January. There is a decrease in the number of individuals from February onwards; and during May they are apparently absent from their usual haunts on the boulders of the bridges, but may be observed between stones and crevices. An individual with eggs was once noted even during May. It is probable that the species breeds during the major portion of the year; though the summer months are presumably less favourable than winter and spring.

Sub-order . . Macrura.
Order . . Decapoda.

*Periclimenes indica* (Kemp)

The species is a regular breeder in the backwaters since ovigerous females are commonly obtained during the months when the bar is closed, especially during April, June and July. In 1936, ovigerous females have also been obtained during September and October. In Chilka Lake ovigerous females are found in February, March, July, September; and Kemp (1915) says that the species breeds only in water containing some trace of salinity. From the backwaters of Ennur, the same author has recorded females with eggs in January (p. 229). From all these records it is not possible to say whether there is a well-marked breeding season for the species. The total absence of ovigerous females during the months when the bar is open at Adyar suggests that the species does not breed when the salinity is high.

*Alpheus malabaricus* Fabricius

Though the species is a permanent inhabitant of the backwater and may be obtained all through the year, ovigerous females have been noted only during December and January. Young specimens are quite common in the backwater during January and February. As regards other alpheids, no ovigerous female has been collected by us from the brackish-water.

*Penaeus carinatus* Dana

*Penaeus indicus* Milne Edwards

Specimens of these two species of marine prawns which enjoy a wide distribution in the Indo-Pacific, may be collected from the brackish-water.

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2 These observations are also true of certain other *Palamondes*, the ovigerous females of which we have collected, but have not been able to identify.
at any time of the year. As suggested by Annandale (1922) for the Gangetic
delta, Kemp (1915) for the Chilka Lake, Dakin (1935) for the New South
Wales coast and Panikkar (1937) for the Malabar coasts, these species do
not breed in the brackish-water but only in the sea. They enter the back-
waters and lakes during their larval or post-larval stages and grow there for
about an year, after which they go back to the sea to breed. At Madras
the matter has been investigated in detail by Mr. M. A. John (1936, unpublished) with reference to the conditions at Adyar and in the Cooum. He
finds that migration takes place when the prawns are half-an-inch to one
inch long and grow in the backwaters to a maximum size of five inches, while
the sexually mature adults from the sea are about 9 inches long. Our
plankton records for the Adyar backwaters (vide pp. 311–13, Panikkar
and Aiyar, 1937) show that the post-larval individuals enter the backwaters
during all months when the bar is open.

*Peneopsis monoceros* (Fabricius)

Specimens of *Peneopsis monoceros* are common in the backwater during
all months of the year. Young specimens 15 to 20 mm. long have been
obtained in tow-net collections taken in September and October when the
bar is closed. Slightly older examples 20 to 30 mm. long are also obtained
in the ordinary nets. Judged from their size, these individuals could not be
more than one to two months old, while about six months had elapsed since
the bar closed. This would point to the conclusion that the species can
breed in brackish-water unlike the other two species of Penaeids and breeding in this particular years (1935–36) must have taken place when the bar
remained close. It is hoped that further investigations will result in the
larval and post-larval stages also being collected when the bar is closed.
It is noteworthy that in the Chilka Lake, Kemp (1915) thinks it improbable
that any of the species of *Peneopsis* breed there.

**Sub-order** .. **Brachyura.**

*Matuta victor* Fabricius

Ovigerous females of this species have not so far been collected.

*Ocypoda cordimana* Desmarest

Ovigerous females have been collected during January and February
from Adyar, and during December–March from the Cooum bar, but not
in any other month of the year.

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3 "Migration of Penaeid Prawns of Madras."
Ocypoda macrocera Milne Edwards

Ovigerous females noticed in December, January and February. Megalopæ belonging to this species and identical in appearance with the figures given by Kemp (1915) have been collected during January 1933 and 1934.

Uca (Gelasimus) annulipes (Latreille)

The species is extremely common both at Adyar backwaters and near the bar of the Cooum river near the Laboratory. Several specimens have been collected and observed during all months of the year, but ovigerous females have been found only during the months of October, November, December and January.

Metaplax distincta (Milne Edwards)

The species is not so common as the other crabs and we have collected specimens only from November and April. The only two ovigerous females so far obtained (both from an island in the Adyar river near the Elphinstone Bridge) were found in the month of January 1935.

Varuna literata (Fabricius)

Ovigerous females have not been collected by us; but the species is one that commonly breeds in the brackish-water even if the salinity be very low as evidence by Annandale’s findings in the Gangetic delta (1922).

Sesarma tetragonum (Fabricius)

The species is common all through the year and the records of ovigerous females are for the months of October, November, December and January. During these months the crabs, especially the males, are beautifully coloured; the species is rarely seen out of the burrows in the summer months and the brilliant coloration is not noticed in specimens that are dug out.

Sesarma quadratum (Fabricius)

Ovigerous females are quite common during November, December and January. In 1937 the season extended even to February. The ripe females were absent from the collections made in the other seasons.

Scylla serrata (Forskal)

Neptunus pelagicus (Linn.)

Neptunus sanguinolentus (Herbst.)

None of these crabs is represented in our collections by ovigerous females. The last two species are no doubt casual migrants since specimens have been noted only when the bar was open, and that not far away from
the bar. *Scylla serrata*, however, is a permanent inhabitant common all through the year from the bar to about three miles up the river. Specimens are also met with in the Cooum and the Buckingham Canal. Within the period of our study we have examined over 200 specimens but the collections do not contain a single ovigerous female. There is also a marked disproportion in the number of males and females since female individuals are encountered much less frequently than the males.

**SUB-ORDER . . Anomura. Paguridea.**

*Clibanarius olivaceus* Henderson

*Clibanarius padavensis* De Mann

Both these species of hermit crabs are perennial breeders in the Madras brackish-waters. Subramaniam (1935) has noted that in *C. olivaceus* the reproductive activity is highest from September–March; he has also brought in evidence to show that the sizes of the eggs and their cytoplasmic components are different in the January–February and April–June periods. Fully mature sperms have been noted during all months of the year in *Clibanarius padavensis* (Ratnavathi, unpublished observations). Judged by our collections of berried females we are inclined to consider that though both the species are continuous breeders, the breeding is especially intense during the time when the bar remains open.

**PHYLUM . . Mollusca. Lamellibranchiata.**

*Ostrea arakanensis* Sowerby

The species has been known under various names as *O. virginica*, *O. madrasensis*, etc. (*vide* Winckworth, 1931). At Adyar the oysters occur below the Elphinstone Bridge and in the embankments of the Theosophical Society's quarters, and occasionally near the small bridge. The only observation that we have to record is the occurrence of specimens with motile sperms during November 1934, and October and November 1935. Hornell (1922) mentions that in the Coromandel coast the chief spawning period is from August–September, with a secondary period during March and April. He also observed that under normal conditions the Indian Oyster is a most irregular spawner and that ripe individuals may always be found except when the floods are on.

*Modiolus undulatus* (Dunker)

*Modiolus striatulus* Hanley

Specimens of both these bivalves with ripe sperms and ova have been noted during January, March, April, May, August and September. For other
months we do not unfortunately have any records. Numerous young individuals belonging to the first species were common during March-May in 1935. *Meretrix casta* Chemnitz

Specimens with ripe eggs and sperms are obtained during all months of the year (Rama Varma, unpublished observations). The species therefore probably breeds during all the seasons, but there is not the least doubt that the reproductive season is at its height during the early summer months. We have not noted actual spawning of the live clams; but large numbers of very young individuals are to be found during April, May and June. Hornell (1922) observes that spawning appears to take place twice a year, the first during April–May and then again about September. It is probable that these two periods noted by Hornell represent active phases of spawning in the clams with much less reproductive activity during the intervening period. *Gastropoda.*

*Stenothyra blanfordiana* Nevil

*Amnicola (Alocimna) stenothyroides* (Dohrn)

Ripe individuals and very young ones of the above Gastropods are to be noticed at any time of the year, but here also there is a marked intensity of reproduction during the summer months, when the bar is closed. The intensity of reproduction in these two species is so high during this season that they constitute dense animal communities, numbering even up to about a hundred individuals per square inch.

*Potamides cingulatus* Gmelin

Individuals with ripe sperms have been noted during all months, but here active breeding does not take place all the year round. The species produces characteristic vermiform spawn masses consisting of mucus, mud and sand grains, in which are imbedded the eggs. Each egg is closely agglutinated to a sand grain. The spawns left by the animals are quite common in the mud and shallow pools during the summer months of the year; as many as 20 spawn threads per square foot have been collected on an average during the months March, April and May 1936. The spawn begins to appear on the mud flats during January and the number increases with the gradual onset of summer, the maximum observed being in April–July. Their numbers fall very considerably after July and they are almost completely absent in the November–January period.

*Stiliger gopalai* Rao

Rao (1937) reports that mature individuals of this Nudibranch (Asco-glossa) are obtained at all times of the year and that therefore no definite
breeding period is clear; but since low salinity conditions have been found to be essential for metamorphosis, the breeding is to a great extent determined by the periods of rainfall. The species is frequently noted during the warmer months of the year, crawling amidst the alga *Chaetomorpha* which abounds in this season. The animals are not so common during other periods and are not observed at Adyar when the bar is open. The development and metamorphosis are accomplished within a short period and several generations of actively reproducing specimens may be observed in any favourable season.

**Unidentified Spawn Masses**

Spawn masses belonging to other species of Gastropods have been found from February–June during all the three years of our study. We have not been able to refer them to their adult species. The egg ribbons of *Natica* sp. similar to the figure given by Hornell (1922) have been observed at Adyar in March 1934, March and April 1935, and April 1936; and near the Cooum bar in March 1936. They are found along with the spawn of *Potamides cingulatus*. Adults of *Natica* have not so far been collected by us either from the Adyar or from the Cooum.

**Vertebrata**

**Teleostei**

Notes on the breeding habits of the brackish-water fishes of Madras are contained in the papers of Raj (1916), Aiyar (1935) and Jones (1937). In the following account we give a summary of observations contained in those papers along with the notes that we have been able to gather during our period of study.

**Sub-order**  
**Malacopterygii**

Larval and post-larval stages belonging to the genera *Engraulis stolephorus* and *Elops* have been collected in the tow-nets during the months of November, December and January. These belong mostly to the groups of species usually noticed in the local marine plankton and are mostly forms entering the backwater with the opening of the bar. Our records are insufficient to conclusively say that any species of the Malacopterygii breeds in the brackish-water. However, Raj (1916) says that in Madras, *Elops indicus* is an essentially estuarine fish that easily acclimatises to fresh-water and that young fish are quite common in the Cooum, the breeding season being the cold weather. As regards *Megalops cyprinoides* he reports that larvae are common in the Cooum in October and November in fresh-water. Among

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4 The following species may be added to the list of fishes given in our paper on the Adyar fauna.
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the Clupeidae, he finds the larvae of *Engraulis* purava* in the Cooum in October and November, which according to him is the breeding season.

**SUB-ORDER . . Ostariophysidae.**

The breeding season of *Barbus* sophorae is mentioned by Raj to be the cold weather, *i.e.*, from November-January. We have collected numerous young ones of this fish during this season. Among the Siluridae, *Arius falcarius* Richardson is mentioned by Raj as a common estuarine species and that one of the breeding grounds of the fish in Madras is the mouth of the Adyār river, the season extending from September to November. He also records ripe females with eggs for the species *Macrones vitatus*.

**SUB-ORDER . . Anguillidae.**

*Anguilla elphinstonei* is recorded by Raj, who found large numbers of elvers measuring 2 or 3 inches in length ascending the Adyār and Cooum in November. The species is not represented in our collections.

**SUB-ORDER . . Haploidae.**

The two common Cyprinodont fishes of the Madras brackish-waters are *Aplocheilus melastigma* and *Panchax parvus*. Both the species are perennial spawners but the intensive period of reproductive activity for the former species is from September to February, and for the latter from January to February (Raj, 1916; Jones, 1937).

**SUB-ORDER . . Perciformes.**

Jones has recorded the larvae of *Hemirhamphus gaimardi* during the month of November and the eggs of *Tylosurus strongylurus* were obtained by Job and Jones in October 1937. They also record gravid females for the month of December.

So far as the Mugils are concerned the active breeding period is mainly the cold weather as evidenced by our collection of large numbers of young ones soon after the monsoon.

**SUB-ORDER . . Acanthopterigii.**

Among the Serranidae, young ones of different species enter the backwaters in their young stages and after they have grown for some time, they go back to the sea. Rao (1934) found that in *Therapon jarbua* the first yearlings are found in the Adyār backwater while sexually mature ones are

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only found in the sea. *Ambassis miops* is a species that breeds in the brackish-water; it is common in the Adyar and the Cooum in November and December, which is the breeding season according to Raj (1916). We have obtained sexually mature individuals in January and February as well. The reproductive habits of the Adyar Gobies are reported by Raj (1916), Aiyar (1935) and Jones (1937). *Acentrogobius neilli* and *Acentrogobius viridipunctatus* are typical perennial spawners, but reproduction is especially active when there are rains, *i.e.*, during September–November. The latter period may be considered as the breeding season for *Glossogobius giuris* and *Eleotris fusca* as judged by our records as well as Raj's statement. In regard to *A. giuris*, Hora (1936) mentions that it is one of the few gobies that migrate to the sea for breeding purposes. It is probable that the Adyar and Cooum river mouths form the spawning grounds of this species which is common in the freshwater localities of Madras.

**Sub-order ... Zeorhombi.**

Among the Blennies, Jones records the eggs of *Petroscirtes bhattacharyae* in January 1936. In the Cichlid fish *Etroplus maculatus*, Raj finds that the spawning season extends from January–April, most fish breeding between February and March. Jones observed the eggs from August 1935 onwards. He also reports that this species (as well as *E. suratensis*) goes up the river into less saline regions when the bar remains open and that it comes back only when the variations in salinity are not sudden. With regard to *E. suratensis* he says that the eggs are not laid when the sea water comes in, developmental stages having not been met with when the bar remains open. Hence both the species are forms that can breed only under low salinity conditions.

Summarising the observations on breeding in fishes inhabiting the Adyar and the Cooum, it may be mentioned that a good many species breed in the cold weather between September and January. In most cases the breeding is especially active during the monsoon. Even perennial spawners like *Acentrogobius neilli*, *Acentrogobius viridipunctatus*, *Apolocheilus melastigma* and *Panchax parvus* exhibit intense reproductive activity during the rainy weather. Further, outbreaks of rain during the summer have been observed to stimulate the reproductive activity of these species as evidenced by the large number of fish fry that may be observed a few days after such showers. Even in the continuous breeders of this type, we have reason to think that egg-laying by the ripe females is very considerably augmented by the rains so much so that intensive spells of spawning might be occasioned by outbreaks of rain, the changes in the environment that they cause probably acting as a definite stimulus.
General Considerations

The study of breeding in marine organisms has come to the fore at the present day and a good amount of field and experimental work is now carried out in different parts of the world on breeding and propagation of marine invertebrates. One of the problems confronting the marine zoologist is the difference in the reproductive behaviour of animals inhabiting different latitudes. In his account of the natural conditions as they affect animal life, Semper (1885) emphasized the difference in reproductive habits of animals living under the tropical and temperate conditions. The effect of tropical climates, where variations in temperature are reduced to a minimum, is, according to him, the obliteration of the periodicity of animal life which is so striking in climates that vary between two remote extremes of winter and summer. The breeding habits of the animals of the North Sea and English Channel have been studied by a number of investigators and the restricted breeding seasons for the majority of species inhabiting these localities is now a well-established fact. Even in the Mediterranean which is warmer than other temperate seas, the extensive researches of Lo Bianco (1909) at Naples showed that the breeding of most animals is confined to certain definite periods of the year varying according to the species concerned. It may be noted that the actual spawning periods of several species are longer in the Mediterranean than the corresponding periods for similar or even identical species found in the Channel or in the North Sea. In many Invertebrates, the periodicity is often eliminated even in colder seas (Semper). Semper states "Nothing in the Philippine Islands struck me so much as to observe that there all true periodicity has disappeared even from insects, land molluscs, and other land animals; I could at all times find eggs, larvæ and propagating individuals in winter as well as in summer. It is true that drought occasions a certain periodicity, which is chiefly perceptible by the reduced number of individuals in the dry months and the greater number in the wet ones; it would seem that a much smaller number of eggs are hatched under great drought than when the air is very moist " (p. 135). " But what was far more striking in these islands was the total absence of all periodicity in the life of the sea animals, particularly the invertebrata; among these I could not detect a single species of which I could not at all seasons find fully grown specimens, young ones and freshly deposited eggs " (p. 136).

The publication of Orton's paper (1920) on sea temperature and breeding in marine animals gave a fresh impetus to the subject. Giving a clear analysis of previous literature and his own observations on the breeding of several species, he emphasized the paramount importance of sea temperature in controlling breeding in marine animals. In an earlier contribution,
Appelhöf (1912) indicated the importance of suitable temperatures for the reproduction of several species of marine animals and also discussed the rôle of temperature in the distribution of the species. Though Orton's conclusions were rather anticipated by Appelhöf, he did not attempt at a definite correlation between the two. Orton arrived at the general conclusion that, in general, a specie breeds for a longer period in the more warmer southern latitudes of its distribution, since the temperature in such situations will remain for a longer period above the lowest temperature at which the particular species can breed. In a series of recent contributions, Runnström (1927–29) has experimentally proved this in regard to the breeding habits of a number of Arctic, Boreal and Mediterranean species.

While we do not wish to enter into a discussion of the topic in this paper a few generalizations in this connexion appear to us as being likely to facilitate a clearer grasp of the problem. This is especially necessary because the observations of Semper (1885) and Orton (1920) have often led to a belief, which is widely prevalent, that all tropical marine animals breed continuously irrespective of the seasons. In a recent paper, Galtsoff (1935) has rightly criticized the indiscriminate remark found in text-books that under stenothermal conditions all marine animals breed continuously. He even asserts that in the tropics as well as in the temperate regions there is no animal that actually breeds continuously, but that always we meet with only periodic breeding. We agree with Galtsoff in affirming that the usual belief in continuous breeding of all tropical marine species is erroneous; but we are unable to accept the view that periodicity is universally observed. First of all it is not clear whether in mentioning the occurrence of periodicity, he really refers to animals considered as individuals or as communities. The development of sexual products in any organism is a periodic phenomenon inasmuch as it occurs during some definite phase which may happen only once or may be rhythmically repeated, and not throughout the life-history of the individual. However, this need not bring about periodicity in breeding. In several species, the individual reproductive rhythms do not coincide and we may find at the same time specimens with ripe eggs and spent gonads as well as those showing the intermediate stages. The periodicity in these individuals is purely individual and not racial; consequently the process of spawning, development and attainment of sexual maturity occur simultaneously if we consider the individuals of any particular species collectively as a single community. The breeding in such animals may be said to be continuous. In the other set of animals the individual reproductive phases of the organisms constituting a community closely approximate so that spawning, development, and attainment of sexual maturity occur in certain well
marked periods: the community may be said to develop, grow and spawn together. In all such animals a definite periodicity will be observed. But this periodicity tends to become obliterated when the reproductive phases appear in quick succession and several generations of the animals are involved in breeding; such species would appear again as almost continuous spawners. It may be emphasized here that both continuous as well as periodic breeders in the sense we have explained above may be met with in nature. The study of breeding in marine invertebrates of the Great Barrier has brought to light the existence of different types of breeding in this tropical habitat—continuous, discontinuous and even discontinuous breeding in relation to lunar phases (Stephenson, 1935). Recent work conducted in this Laboratory by Mr. M. D. Paul has amply borne out this point, for, among the organisms of the Madras Harbour, he has been able to observe continuous and discontinuous breeding among certain sedentary organisms, while we have described discontinuous breeding in relation to lunar phases in a Polychaete from the same environs (Aiyar and Panikkar, 1937). We also wish to mention that to a considerable extent the periodicity in reproduction has something to do with the span of life of the individuals constituting the species. From his study of the rate of growth, age at sexual maturity and duration of life in sessile organisms at Woods Hole, Grave (1933) concludes that some of the most prolific animals were those that live for less than one year. In such organisms several generations are produced in quick succession and the intense reproductive activity observed in them does not reveal regular periodicity.

**Summary and Conclusions**

1. Breeding of animals of the brackish-waters of Madras is not particularly confined to any definite part of the year; actively reproducing species, especially the invertebrates, are met with during all seasons. In a good many forms there is intense reproductive activity during the rainy weather.

2. The following types of breeding were noted:—

(a) Continuous breeding throughout the year occurring more or less uniformly and irrespective of seasons.

(b) Continuous breeding with marked season of higher activity in part of the year than in the remaining period.

(c) Breeding period confined to some definite part of the year.

(d) Discontinuous breeding occurring all through the year, breeding often taking place irregularly, mostly determined by the rains.
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