LIFE-HISTORY AND FEEDING HABITS OF THE SPOTTED SEER *SCOMBEROMORUS GUTTATUS* (BLOCH & SCHNEIDER)*

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Introduction

The available information relating to marine fish eggs and larvæ of Madras is covered by the accounts given by John (1951) and Nair (1952 *a* + *b*). In the present paper, which deals with part of the results of the investigation undertaken by the author at the Zoological Research Laboratory, University of Madras, for three years (1950–53), on fish eggs and larvæ occurring in Madras plankton, the methods of collection, of hatching of the eggs and of rearing the larvæ in general are given, together with observations on the life-history of *Scomberomorus guttatus* with its food and feeding habits. Our knowledge of the life history of this fish is confined to Delsman's (1931) description of its eggs and larvæ reared up to the third day.

Day (1889) records five species of *Cybium* as occurring in Indian seas of which *C. guttatum* (synon. *Scomberomorus guttatus* [Bl. Schn].) is the commonest in Madras. Seer fishes have a high market value in Madras and are caught with hand lines and boat seines in offshore waters between February and June, when they do not occur inshore. From July to January, especially during the last five months, mature adults and spawners are landed from the coastal waters with the shore seines.

Materials and Methods

All the eggs and larvæ studied were obtained from the inshore plankton brought to the laboratory every morning and from the fortnightly vertical and horizontal hauls taken approximately ten miles off the Madras coast, from a motor fishing vessel.

The larvæ were examined alive and were sketched immediately after fixing. While considering the number of myotomes in describing the larvæ, it has been observed in the present study, as well as by other workers, that the post-anal myotome counts are not reliable since they become more and more

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ndistinct toward the caudal peduncle. One cannot say with certainty if all the post-anal myotomes have been counted. In the present paper therefore, only the pre-anal myotomes are taken into consideration.

The prolarvæ hatched in the laboratory were fed with different items of food such as the larvæ of copepods, cirripedes, bivalves, gastropods, etc., to determine the particular food of the larvæ. Pure cultures of different diatoms were maintained for feeding the larvæ.

It is known that the prolarvæ hatched from pelagic fish-eggs retain the yolk even up to three days when most of them do not feed, but that when they become postlarvæ with the absorption of yolk, they begin to feed. It was found that even if the particular item of food they prefer is available, most larvæ die in the laboratory, during the first week or two. Attempts to rear the larvæ in the laboratory during this critical period have met with different degrees of success. It is felt worthwhile to give an account of the methods used in keeping these larvæ although they are modifications of procedures described by Garstang (1900), Crawshay (1915) and Gross (1937), adapted to rear the larvæ under tropical conditions.

As the temperature of the laboratory ranged between 30° C. and 35° C., it was necessary to determine the optimum temperature suitable for the development of the larvæ. Twenty hatchlings of *Anchoviella tri* were introduced into four finger bowls containing sea-water maintained at 15° C., 20° C., 25° C., and 30° C. respectively. The larvæ which hatched in the sea, where the water had a temperature of 28·6° C., were thus subjected to the above temperatures for 8 hours. At the end of this period only five and four larvæ survived in bowls kept at 15° C. and 30° C. respectively, while 17 survived at a temperature of 20° C. Since none of the 20 larvæ died at a temperature of 20° C., even at subsequent repetition of the test, in the present study the larvæ were reared at 20° C.–25° C.

In rearing the larvæ, the temperature was kept between 20° C. and 25° C. by the following method. Containers of 12 cm. diameter and 1,000 c.c. capacity were covered with layers of filter paper with a small hole at the top for the plunger and narrow slits on the sides to let in light. The filter paper was kept moist, and by adjusting the ventilation of the room and evaporation of the water from the filter paper, the temperature of the sea-water in the containers was regulated. As the larvæ are affected by sudden changes of temperature, care was taken when renewing the water or washing the larvæ, that the water was always at optimal temperature.

Fish larvæ are easily susceptible to the attack of ciliates, especially when the prolarvæ change to postlarvæ. The ciliates flourish on dead eggs and cast off membranes and under tropical conditions even the few which may have escaped into the filtrate (when sea-water is filtered through Whatman No. 1 filter paper) multiply to large numbers rapidly. All vessels, pipettes and glass plungers were cleaned with sulphuric acid chromate solution, and washed repeatedly with distilled water. The sea-water was boiled, cooled and left overnight to regain the normal gaseous content. And yet it was found difficult to protect the larvæ from ciliates, for any considerable period. 1/1,000 solution of Brilliant green was found as harmful to the fish larvæ as to the ciliates. Hence every day the larvæ were transferrred to sterilized vessels containing fresh sea-water filtered several times and maintained at optimum temperature.

Agitation of water in the containers has been considered by many (Cunningham, 1893; Garstang, 1900; Gross, 1937; Budd, 1940) as useful in not only aerating the water but also in keeping the larvæ moving about and preventing them from resting at the bottom where ciliates and bacteria may be teeming round decaying bodies. The larvæ of *Decapterus russelli*, *Engraulis grayi*, *Anchoviella tri*, *Scomberomorus guttatus*, *Saurida tumbil* and *Cynoglossus* sp. were left in six separate bowls with glass plungers working at the rate of 4 to 5 strokes per minute (it was found that if the bottom plate of each had a conical form like an inverted stopper 2 cm. across, the water was stirred smoothly). Hatchlings of these species were chosen, since they retain the yolk for two days and the experiment could be performed without involving the food factor. Larvæ from the same batch of eggs were left in six other bowls, without stirring, for purposes of control. Within 25 minutes of starting the experiment, the prolarvæ of *Anchoviella tri* were struggling to maintain their balance, and in about five hours sank to the bottom and died at the end of six hours. The larvæ in the control bowl were normal. On the other hand all the larvæ of *Saurida tumbil* and *Cynoglossus* sp., left in the control bowls died in 36 hours though the larvæ of these species in the experimental bowls survived, obviously because of the agitation of water. The larvæ of *Decapterus russelli*, *Engraulis grayi*, and *Scomberomorus guttatus* in the control bowls died at the end of 48 hours while those in the experimental containers lived till the end of the third day of experiment. It was also found that the former two species of fish withstood even more vigorous agitation.

Widely different types of food, such as extracts and bits of fish yolk, fish meal etc., were tried for feeding the fish larvæ but without success. Organisms selected from the plankton after a study of the stomach contents of the different fish larvæ collected from the sea were useful for feeding the larvæ hatched in the laboratory. Small-sized copepods, nauplii, copepodites, larvæ of microcrustacea, veligers and larval bivlaves could generally be used and could be picked from the day's plankton collection, but the algæ and diatoms which could not be so easily collected had to be cultured using Foyn's "Erdschreber" as the medium. Fairly pure cultures of *Coscinodiscus gigas*, *C. lineatus*, *Rhizosolenia* sp., *Pleurosigma* sp., *Asterionella japonica*, *Nitzschia sigma*, *N. closterium* and *Trichodesmium* sp., were prepared every fortnight.

In describing the eggs and larvæ the terminology recommended by Hubbs (1943) was adopted.

LIFE-HISTORY

Eggs

Several transparent spherical eggs of an average diameter of 1·17 mm. occurred in the surface townet collections between September and January. These eggs (Fig. *a*) superficially resemble those of *Decapterus russelli* along with which they occur in the plankton, but differ from them in the uniform unsegmented character of the yolk and in the single oil globule being situated ventrally within the yolk in the newly hatched larva. The oil globule, which had an average diameter of 0·34 mm., was covered on the outer half by yellow stellate cells and on the inner half, which faces the embryo, by black pigment spots. Yellow pigment spots similar to those of the oil globule as well as minute black spots covered almost the entire embryo. Eyes and auditory vesicles were well marked. The head and the tail of the embryo were not free from the yolk mass. All the eggs collected appeared as if they had been spawned several hours earlier and development was so rapid that within 2 or 3 hours of their being brought to the laboratory (*i.e.*, by 11 to 12 A.M.) the embryo started wriggling inside the egg, the tail having become free from the yolk mass.

Newly hatched larva (Fig. *b*)

The larvæ hatched out by about 2 P.M. on the same day and floated with the yolk above and the oil globule uppermost. There were 14 preanal myotomes and the larvæ had an average length of 2·8 mm. The yellow pigment cells on the body of the prolarvæ were not arranged in any definite pattern. Black branching chromatophores were seen on the anterior end of the head, behind the eyes, and a few were scattered almost dorsally along the myotomes. The eyes were not pigmented. The gut was not visible posteriorly and was bent, following more or less the posterior margin of the yolk sac.

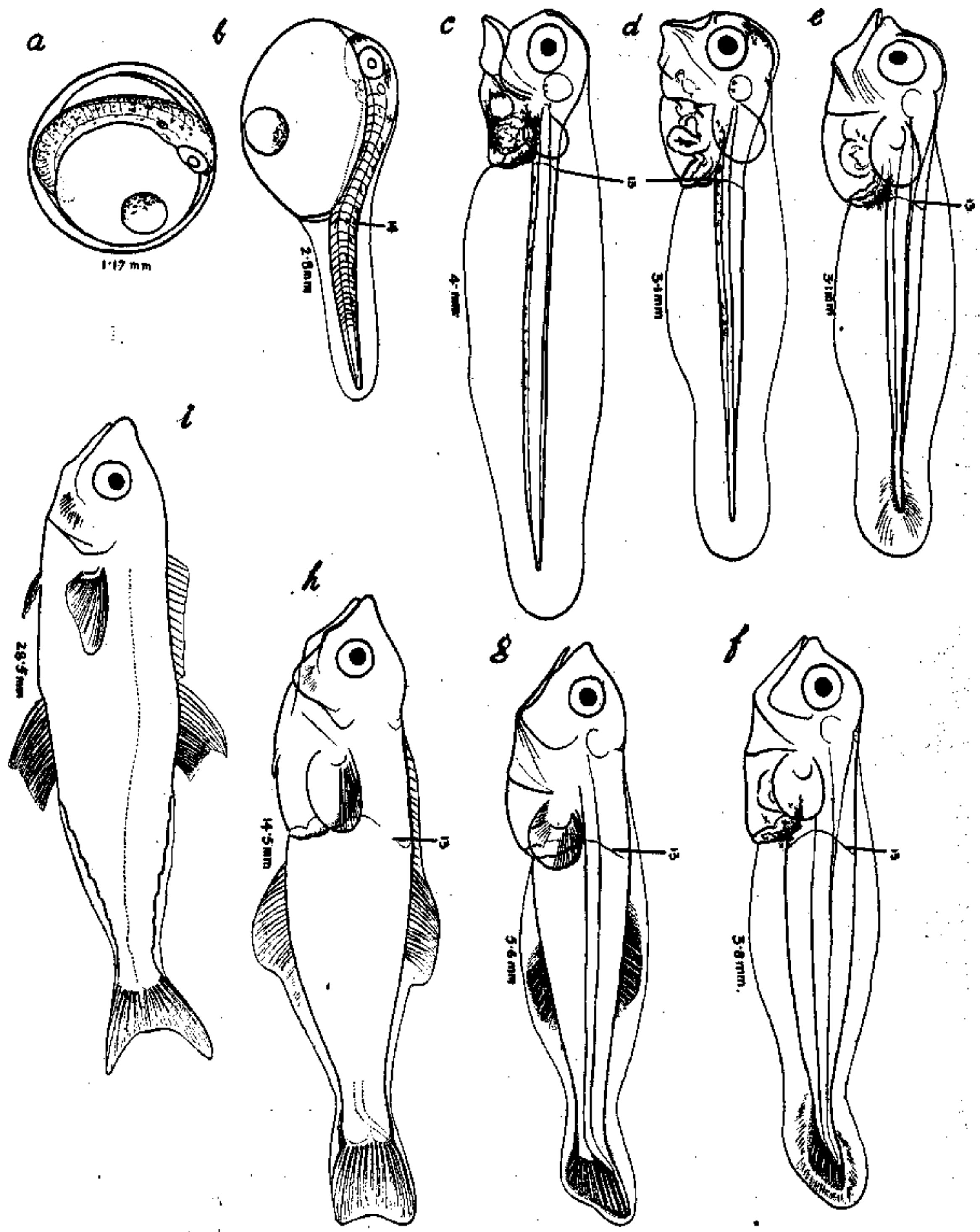

FIG. 1. Developmental stages of *Scomberomorus guttatus* (Bl.Schn.).
a, Egg. *b* and *c*, Prolarvæ. *d–h*, Postlarvæ. *i*, Juvenile.
(Pigmentations other than black have not been indicated owing to the difficulty in showing them in print.)

24 hours after hatching (Fig. *c*)

There was a marked increase in length, the prolarvæ becoming 4·0 mm. long, but the number of the preanal myotomes became reduced to 13 owing to the anus shifting forward. The mouth was well formed but was not in communication with the alimentary canal. The eyes were silvery and the iris was pigmented black. The black pigmentation in the body became reduced to a few black spots along the ventral side of the myotomes, but black ramifying chromatophores appeared along the dorsal margin of the alimentary canal and the ventral region of the yolk mass. Yellow pigmented cells had disappeared from the trunk but were present dorsally posterior to the head. The yolk mass was very reduced in size though the oil globule was unabsorbed.

48 hours after hatching (Fig. *d*)

The length of the larva underwent a reduction to 3·1 mm. With the absorption of a small part of the oil globule between 43 and 48 hours after hatching, the transformation of the prolarva into the postlarva was completed. The alimentary canal was prominently visible especially due to the yellow and brownish pigmentation and the anus opened under the 13th myotome. A few branching pigment cells also were scattered on the abdominal wall. Black chromatophores were found between the eyes and along the ventral side of the myotomes as far as the middle of the caudal region. Pectoral fins were transparent and membraneous, while the median fins were continuous. There was no indication of the fin rays in any of the fins.

72 hours after hatching

There was no appreciable change in size, colouration or any other feature of the postlarva.

96 hours after hatching (Fig. *e*)

The postlarvæ continued to be of the same size, *i.e.*, 3·1 mm. long, and the preanal myotomes had broadened dorsoventrally and were still 13 in number. The lower jaw appeared prominent. The body had lost all pigmentation, except on the walls of the gut and abdomen. The posterior margin of the alimentary canal, where it curved down to the anus, had a few ramifying black chromatophores. The brownish colour of the abdominal wall became intensified along its dorsal side and obscured the intestine. The eyes had a greenish metallic lustre.

It was not possible to keep the postlarvæ alive in the laboratory beyond this stage. But later stages, ranging from 3·8 mm. to 14·5 mm., and juveniles of 24 to 28·5 mm. were collected from the sea and are described in the following groups.

Postlarvæ of 3·8 mm. (Fig. *f*)

The postlarvæ had 13 preanal myotomes and in their general appearance and the pigmentation also they were not much different from the 3·1 mm. long, 96 hour-old postlarvæ reared in the laboratory. The median fins were continuous and narrower. In the caudal fin, which had become heterocercal, developing rays were visible, though not in the pectoral fins. Rudiments of the operculum were visible.

Postlarvæ of 5·6 *mm.* (Fig. *g*)

There was an increase in width in the anterior half of the trunk, though the number of the preanal myotomes continued to be 13. The abdomen had become opaque due to the intensity of the brown pigmentation and the rest of the body also become less transparent. A few yellowish iridocytes had appeared on the postero-dorsal side of the abdominal wall. There was no pigmentation on any other part of the body. The incipient element of the operculum extended down. The end of the tail curved upwards (Fig. *g*) and had a number of imperfectly defined rays. Half way between the caudal peduncle and the anus, a number of indistinct soft fin rays, which constitute the rays of the anal fin of the more advance postlarvæ, were found rising from the ventral margin. Similarly from the dorsal side, opposite to the anals, were a number of soft fin rays. Developing fin rays were present on the pectoral fins.

Postlarvæ of 11·5 *to* 14·5 *mm.* (Fig. *h*)

The increase in the girth of the postlarva became more pronounced since the height of the body became nearly a fourth of its total length. The cheek region became silvery and the operculum more prominent. Jaws were still toothless. The colour of the abdomen remained the same as in the previous stage. The rays in the pectoral fins were more clearly visible but the ventral fins appeared as small flaps from the middle of the ventral margin of the abdomen. Nearly 19 soft dorsal fin rays of the second dorsal were present and on the ventral margin of the body 18 anal rays were visible. Anterior to the soft dorsals, 15 rays of the spinous dorsal appeared in the margin of the body. These rays were all of the same length. The caudal fin showed signs of becoming forked. All fins were transparent and unpigmented.

Juveniles of 24 *to* 28·5 *mm.* (Fig. *i*)

Although the general shape of the body was different, these juveniles resembled the adult in the unpaired fins and the course of the newly developed lateral line and could be recognised as belonging to the genus *Scomberomorus.*

While in the adult the fin rays are $D^1$15–16 $D^2$4 15–17 or 7·15 + 8–10. A.3 15–17 or 5 15 + 7–9. P.2 17–18 V.1 5 (Beaufort, 1951), in the juveniles we find $D^1$15. $D^2$19 (while D^2 is distinguished into spines and rays in adult fish, in juveniles they exhibited no difference externally) + 8 (which were represented by 8 short nodes). A.18 (here again externally there was no apparent distinction into rays and spines) + 7 (represented by 7 short nodes arising from the ventral margin of the body). P.20 (which are similar and differentiated as in the adult). Faint signs of developing rays are visible in the ventrals.

The myotomes were no more visible. The mouth was large and slightly oblique and the lower jaw did not extend beyond the upper jaw. The preopercle was clearly seen but without the denticulations present in the adult. The body was covered by a thin, whitish and shining skin. The longitudinal rows of dark spots found in the adults, however, were absent.

Delsman (1931) described three types of *Cybium* eggs from the Java sea, which do not differ from one another. Although he had observed notable variation in the size of eggs collected from different localities, considering the salinity of water in which they were found, it was inferred that the variation in size was dependent on corresponding fluctuations of salinity. Such dissimilarities in the size of these eggs therefore could not be ascribed to specific differences. However, they varied slightly in pigmentation and were collected from different regions of the Java Sea where different species of *Cybium*, namely *C. guttatum*, *C. commersonii*, *C. kuhli* and *C. lineolatum*, of Java examined by him did not show any great difference in the number of vertebræ and thus it became difficult for him to say to which of these species the eggs and larvæ belonged.

The eggs described here and the larvæ reared from them, besides bearing a general resemblance to the genus *Cybium*, closely corresponded to Delsman's descriptions of the second type of egg collected from Amphitrite Bay (Figs. 3–6) particularly in the number of pre-anal myotomes. He assigns this egg as belonging to *C. kuhli*. Beaufort (1951) points out the confusion regarding the nomenclature of the species and confirms that the specimens identified as *C. kuhli* and *C. guttatus* are paratypes and that they both belong without doubt to *C. guttatus*. Hence the eggs under question, namely Delsman's 'Amphitrite Bay' egg as well as the present ones, belong to *C. guttatus*. Further, in Madras *C. guttatus* is the commonest species and spawning adults occur in the coastal waters when these eggs occur in the inshore plankton.

Food and Feeding Habits

Feeding experiments on the postlarvæ reared in the laboratory

A total of 493 prolarvæ which hatched out in the laboratory were supplied with food articles during the last phase of their transformation, *i.e.*, on the morning of the 3rd day. Different batches of prolarvæ were supplied with molluscan larvæ, eggs of *Neptunus sanguinolentus*, copepod nauplii, polychætes and diatoms such as *Coscinodiscus* sp., *Asterionella* sp., *Trichodesmium* sp., and unassorted plankton, in different containers. About 106 prolarvæ were supplied with the nauplii of copepods such as *Oithona* sp., *Temora* sp., and *Euterpina* sp. The nauplii were selected instead of adults since the prolarvæ themselves were only about 3·0 mm. long. As soon as the transformation was completed, the postlarvæ began to feed on the copepod nauplii and did not show preference to nauplii of any particular species of copepod. Although the postlarvæ were feeding throughout, 70% died before the fourth day and at the end of the fourth day even the remaining postlarvæ were dead. The examination of the guts showed that death was not due to starvation since most of them contained copepod nauplii. Another lot of 150 prolarvæ supplied with unassorted plankton also fed exclusively on the copepod nauplii from the plankton, rejecting all other organisms. However, in this case also the postlarvæ did not survive beyond the fourth day. Since the youngest postlarvæ, 3·8 mm. long, collected from the sea were also found to have fed only on the nauplii of copepods, it was inferred that the death of the postlarvæ in the laboratory was due to causes other than the supply of proper food.

Feeding habits of postlarvæ collected from the sea

A total of only 55 postlarvæ ranging from 3·8 mm. to 14·5 mm. were obtained. These 3·8 mm.-long postlarvæ were also found to have fed on copepod nauplii as the 3·1 mm. long postlarvæ reared in the laboratory. It was possible to identify the nauplii as belonging to *Oithona* sp., and *Euterpina* sp. The stomach contents of the postlarvæ, measuring upto 14·5 mm., were also entirely of copepod nauplii. The juveniles of 24 to 28·5 mm. length, probably because of their larger size, were found to have fed on comparatively larger animals of the plankton such as the adult copepods (*Oithona rigida, Oncea conifera, Acartia* sp., *Euterpina* sp., and *Paracalanus* sp.) as well as Megalopa, *Leander* sp., Zoea larvæ and Ostracods. 46·73% of the diet was composed of copepods, mostly adults, though naupli and post-nauplii also formed a part. Adolescent forms, immature fish of the size 114–162 mm., were examined and the analysis of their stomach contents showed that they fed voraciously on the pelagic animals although still, as in the juvenile stages, crustaceans constituted a major portion of their diet. Copepods (*Paracalanus parvus, Pseudodiaptomus* sp., *Oithona rigida, Temora* sp., *Acartia* sp. and *Euterpina* sp.) and *Acetes* spp. were the principal items of food, while megalopa larvæ, *Lucifer* sp., ostracods, *Sagitta* sp. and a few diatoms (*Coscinodiscus* sp., *Rhizosolenia* sp., *Pleurosigma* sp., and *Trichodesmium* sp.) formed the minor items of the menu. During December and January the adolescent fish fed on appreciable number of teleostean larvæ and eggs. Fish (378–485 mm.) obtained in large numbers with the shore seine during November, December and January when the fish came near the shore were caught only in moderate numbers during the rest of the year with the boat seine and hand lines from the offshore waters. Since it was found that the food of the fish caught offshore during March, April and June was markedly different from that of the fish caught in inshore waters during the rest of the year, their food during these two periods are presented separately. From July to February 152 adults netted from the inshore area were examined and they were found to have fed on small crustacea such as the megalopa larvæ, *Penæus* sp., and *Metapenæus* spp. larvæ, adult copepods (*Pseudodiaptomus* sp., *Temora* sp., *Acartia* sp., *Paracalanus* sp., *Oithona* sp., *Eucalanus*, and *Corycæus* sp.), larval stages of *Acetes* sp., Cypris larvæ of *Balanus* sp., and *Gammarus* spp. About 4·68% of the stomach contents were of teleostean larvæ and eggs (probably clupeids) and about 3·73% of diatoms (*Coscinodiscus* sp., *Rhizosolenia* sp., *Planktonella* sp., *Fragilaria* sp. and *Asterionella* sp.). From February to July the fish netted in offshore waters were found to have changed over to a nectonic diet, feeding mainly on young teleosteans (*Leiognathus* spp., *Lates calcarifer, Caranx* spp., *Lactarius lactarius*, and larval eel). The food was also composed of the following items in the order of frequency of occurrence: adult prawns (*Penæus* sp. and *Metapenæus* sp.), a few *Sepia, Acetes* spp., mysids like *Mesopodopsis* spp., copepods (*Pseudodiaptomus* sp., *Acrocalanus* sp., *Oithona* sp., and *Temora* sp.), *Squilla* larvæ, megalopa and Zœa larvæ, Ostracods, cypris larvæ of *Balanus* spp., and *Sagitta* spp. The quantity of diatoms in their gut was very negligible.

The change-over from planktonic diet to one composed of midwater or nectonic organisms is undoubtedly associated with the fish changing its habitat from the inshore to the offshore waters. Analysis of the plankton made in this laboratory (Menon, 1931; Menon, 1933 and Ramamurthy, 1953) throw light on the reasons for this change in diet. Madras inshore plankton changes from one of a zooplanktonic character to one in which phytoplankton predominates after January (Ramamurthy). It is possible that these fish which came seven months previously to the inshore waters to spawn and which had been feeding on the zooplankton, are now forced to live on nectonic prey in midwater because the surface plankton becomes phytoplanktonic. It is probable that since the period of spawning is over and since nectonic prey abound in offshore water the fish mig ate to offshore feeding grounds from February to June. Since the fish are fetched to the market throughout the year by the fishermen who cannot go beyond ten miles in their native raft, it is reasonable to suppose that even during February March, April, May and June when they migrate offshore, they are not likely to go beyond 12 miles off the shore. Further, at any part of the year, *i.e.*, whenever and wherever they are netted, the number landed show that they do not move in shoals even when they migrate for spawning and feeding purposes. Seasonal changes in the feeding habits correlated with migratory habits of the mackerel (*Scomber scombrus*) have been observed by Bullen (1912).

The habit of *S. guttatus* of being in the surface waters near the shore from July–February, when they breed, and descending to midwater during summer months of March–June, recalls the demersal and pelagic habits of the European Mackerel (Steven, 1948). Whether this alternation of habits and the inshore and offshore migrations are associated with spawning habits as stated by Steven and Corbin (1939) in the case of the European Mackerel, or are due to changes in the character of the offshore plankton cannot be inferred from the available data. Various aspects of the biology of the Seer fish remain uninvestigated, particularly the question of its food, movements and reproduction. These, when known, would substantially help in placing on a scientific basis the fishery for this highly esteemed food fish of India.

SUMMARY

The various stages in the life-history of *Scomberomorus guttatus* (Bloch and Schneider) are described with observations on its food during these stages. Feeding begins invariably with the transformation of the prolarva into postlarva. The fish begins on a diet of copepod nauplii during larval stages, but gradually changes over to larger pelagic organisms as it grows and finally subsists on planktonic as well as nectonic organisms.

Analysis of the stomach contents of adult fish indicates a change from a pelagic habitat during July–February to life in deep waters during March–June. The breeding season occurs during the pelagic phase, but from the available data, it is difficult to indicate whether the offshore migration is connected with the breeding or feeding habits.

General methods for rearing marine fish larvæ based on experience with this and other species are briefly outlined.

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