ON THE SPAWNING SEASON AND EARLY LIFE HISTORY OF OIL SARDINE *SARDINELLA LONGICEPS* (CUVIER AND VALENCIENNES) AT VIZHINJAM

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ABSTRACT

Spawning and spent-recovering oil sardines *Sardinella longiceps* (Cuvier and Valenciennes) unusually occurred in May 1976 at Vizhinjam, far south of the limit of the traditional fishery for the species. It was also possible to collect the egg, though a single one, from the same locality coinciding with this occurrence. That there was considerable spawning activity of the species around this place was indicated by the occurrence of postlarvae and juveniles in sufficient abundance to form a minor fishery, during the immediately following period.

Illustrated descriptions of some important stages of early life history based on the collections are given.

INTRODUCTION

Oozing, just-spawned or spent specimens of *Sardinella longiceps* (Cuv. & Val.) had been reported by Devanesan (1943) from off Quilandy, by Nair (1959) from off Calicut and by Lazarus (1976) from off Vizhinjam. Planktonic eggs had, likewise, been reported from Quilandy by Devanesan (1943), from Tanur-Tellicherry belt by Nair (1953), from Kasargod and Cochin by the Pelagic Fishery Project (Anon., 1974), and from Cochin by Gupta (1972). So also, larvae of oil sardine have been collected from Kasargod, Cochin, Cape Comorin and Tuticorin by the Pelagic Fishery Project (Anon. 1974 & 1976), fry from Tanur-Tellicherry belt by Hornell (1910), Nair (1953), Raja (1967), and juveniles from Mangalore by Prabhu and Dhulkhed (1967), from Calicut by Raja (1972) and from Cochin by Reghu (1973). Besides, a few stages of the life-history of the species have been described by Nair (1959), Kuthalingam (1960) and the Pelagic Fisheries Project (Anon. 1976).

The observations on the occurrence of spawners and spent-recovering fish, as well as planktonic egg and larvae, during May 1976, succeeded by postlarvae and juveniles in the first week of June and a regular fishery of late

juveniles till August at Vizhinjam are presented as the centre usually supports no oil sardine fishery.

Material and Methods

While examining the biological samples from the gill net catches on 6-5-1976 from the waters off Vizhinjam, oil sardines were noticed in the pre-spawning and spawning stages (V and VI, the stages correspond to the maturity scale given by the International Council for the Exploration of the Sea). A vigorous search was therefore made on the succeeding days for the planktonic eggs and larvae of the species. The effort was successful, and the eggs and larvae identified as those of oil sardine were isolated. A second set of spawners (Plate I) along with spent and spent-recovering individuals were subsequently observed during a search on 17th night and through 11th. This time, artificial fertilization was tried on board, but in vain. Though plankton also was collected from different depths and from a wide area where the spawners were caught, no eggs or larvae could be collected. However, on 13-5-1976, eight days after the first appearance of spawners, 42 larvae (Plate II) measuring 7-8-mm total length were found in the plankton collected around 4 a.m. from a depth of about 2 fathoms. Daily collections of postlarvae and juveniles were also made from boat seine and shore seine catches. Boat seines were operated outside the bay at a depth of about 8 fathoms and shore seines, locally known as *'Thondam Madi'* and used for fishing *'nonnau'* (postlarvae and juveniles), were operated inside the bay up to a depth of about 5 fathoms. Samples were taken from the commercial catches whenever there was fishing. Each sample consisted of 20 to 158 fish. Lengths of postlarvae and early juveniles were measured in preserved condition, whereas older juveniles were measured in fresh condition. Temperature and salinity of sea water were also recorded on the day on which the spawners were caught. For describing the larval pigmentation, the terminology of Anon (1976) was followed.

Spawning Season and Abundance of Spawners

The oil sardine spawners first recorded at Vizhinjam on the morning of 6-5-1976 were landed by surface gill nets which had operated on the previous night in the waters outside the bay. Specimens in advanced stages of maturity continued to occur up till the end of May. There was a heavier concentration of spawners on 6th and 17th May and of spent-recovering on 10th, 17th, 18th and 27th May. As evidenced by the occurrence of spawners, the following occurrence of planktonic egg and larvae, and the occurrence of a regular fishery soon afterward of postlarvae and juveniles, all in the same place, it was reasonably inferred that the spawning had occurred in the first and third week of May some where about Vizhinjam.

An unusual fishery was noticed at Vizhinjam during May, with an estimated catch of 66,296 kg forming 40.17% of the total fish catch of the month.

Of this, 65,540 kg were captured by gill nets. And, even among gill net landings, 89% of the catch (= 29% of the month's catch) was recorded on 17th and 18th, the days on which greater congregation of spawners and recently-spent fish were observed (Table 1). During the month, however, oil sardine was very poorly caught (756 kg) in the shore seines, indicating that the sardines had congregated outside the bay. On 18th May, when I was on board collecting samples for trying artificial fertilization, I had observed the shoals moving easterly

TABTE 1. *Oil sardine landed at Vizhinjam by gill net during the month of May* 1976.

Dates of observation	Total catch (kg)	No. of units operated	Catch per unit effort (kg)
3-5-76	240	80	3.0
6-5-76	456	60	7.6
10-6-76	696	60	11.6
17-5-76	1290	150	8.6
18-5-76	17500	350	50.6
20-5-76	—	—	—
24-5-76	—	—	—
25-5-76	—	50	—
27-5-76	660	150	4.4
31-5-76	300	50	6.0
Total (kg)	21142	950	—
Estimated total for the month (kg)	65540	17500	—

from the direction at which the nets were being drifted by the fishermen. Good concentration of shoals was seen in and around places where there was more foam. As these spawners ranged in length between 145 and 205 mm, with a mode at 165 mm, the fish might be more than one year old (Raja 1972). There were more males (66.6%) than females (33.4%) during the month. There were no females in any maturity stage below IV, though a few males were observed in maturity stage III. Temperature and water salinity were respectively 26.2°C and 35 ‰ on 18-5-76, the day on which there was the heaviest sardine landing including large percentage of spawners.

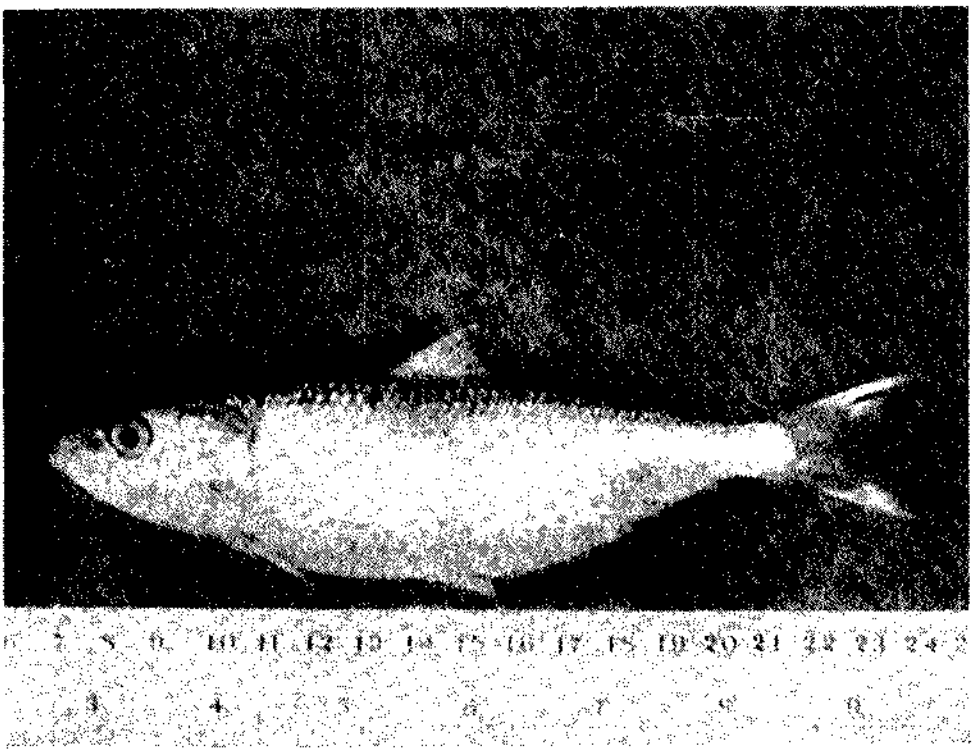

PLATE 1. An oil sardine, *Sardinella longiceps*, (175 mm TL) in the oozing condition collected at Vizhinjam.

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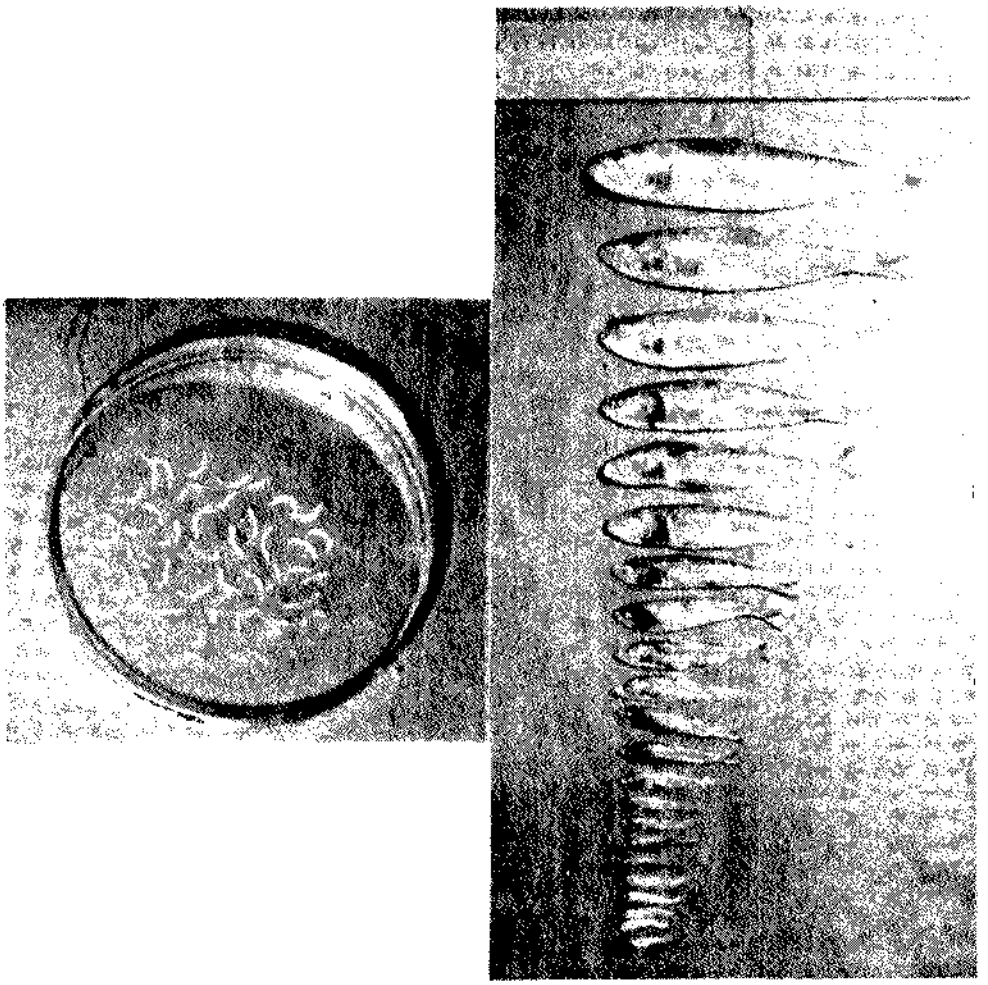

PLATE II. Left: Oil sardine larvae (7-8 mm TL) collected at Vizhinjam. Right: Oil sardine of different sizes (115-130 mm TL) collected during June-September 1976.

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EGG AND LARVAE

Intra-ovarian egg: The intra-ovarian egg just before spawning was completely transparent and spherical with a diametre of 0.98-1.23 mm. The egg membrane was not distinguishable from the yolk and there was no perivitelline space. The yolk was segmented and honeycomb-like. There was a single shining yellow oil-globule, almost in the centre, and its diametre ranged from 0.118 to 0.137 mm. Apart from this, a few very minute and shining oil particles were seen in the yolk, which could not be projected in the figure apart from the yolk granules (Fig 1) as both were almost equal in size.

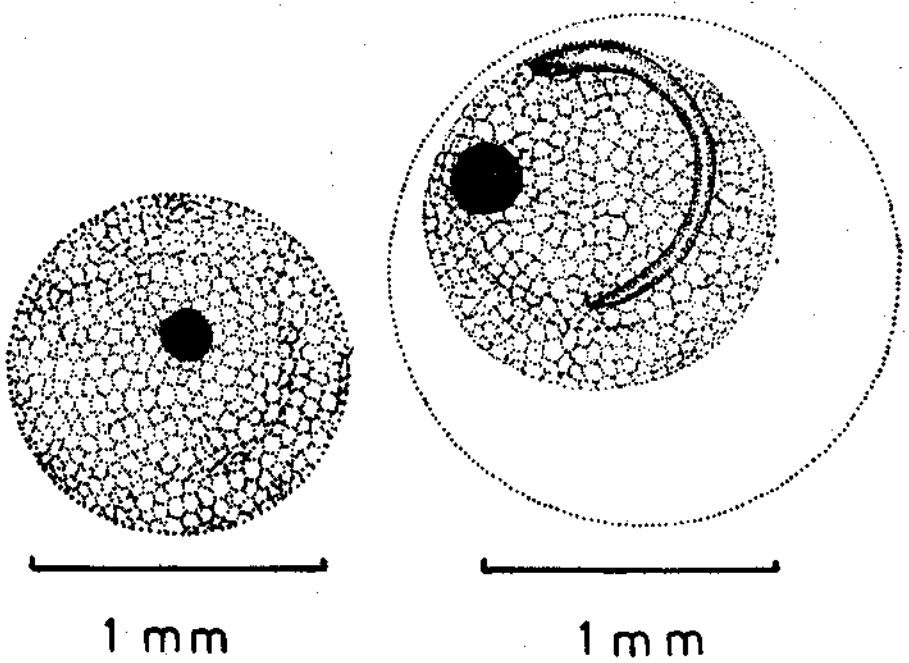

FIG. 1. Intraovarian egg (left) and planktonic egg.

Planktonic egg: The single planktonic egg (Fig. 1), collected on 7-7-1976, was pelagic, transparent and spherical, having a diametre of 2.43 mm. The yolk was highly segmented and had a diametre of 1.22 mm. There was one oil globule, which was glistening, golden-yellow in colour. The perivitelline space was wide. The embryo was with an unpigmented narrow trunk region and a somewhat oval-shaped head region with optic cups. Since there was only a single egg, it was preserved immediately and so the description that is given above is based on the preserved material.

7.64 *mm larva* (Fig. 2): This was a postlarva having well-developed mouth and eyes. Yolk had disappeared totally. The body was elongated and tapered posteriorly behind the dorsal. The head was elongated and less than 1/5 of the total length of the body, the upper and lower jaws were prominent. The eyes were almost oval with the long axis vertically oriented. The larval fin-fold was considerably reduced and appeared as a narrow stretch of very thin membrane (it was seen only in low power 5 x 2.5x) along the dorsal and ventral sides of the body. This stage was characterised by the appearance of the anal fin behind the region of the vent and dorsal fin a little in front of the level of the anal origin. The fin rays in all the fins were under progressive growth; but their precise number could not be ascertained owing to the absence of clear-cut demarcations. There was no indication of a pelvic fin at this stage. The crossed nature of the muscle fibre was very clear. On the ventral margin some myotome-like structures indicating the future ventral scutes were seen. There were 39 pre-anal and 8 post-anal myotomes at this stage and the anal opened behind the 39th myotome. The myotomes in the pre-anal and post-anal regions developed discernible boundaries and the number of myotomes at this stage corresponded with the total number of vertebrae in the adult.

FIG. 2. Oil sardine larva of 7.64 mm total length.

The pre-bladder pigmentation consisted of 9 dashes, but the post-bladder pigmentation was feeble and roundish. Sub-guttal pigmentation appeared as a broken paired line on the under side of the posterior half of the gut. Caudal streaks were found only on the vertical lobe of the caudal fin. Neck spot was not seen, but there was one pectoral spot seen on the right-hand side. Two elongated pigment concentrations were seen over the end of the gut and also at the opercular border. No pigmentation was seen on the head. Length of various regions of the body were: notochord 7.25 mm, head 1.37 mm, snout 0.33 mm, eye diametre 3.39 mm, post-orbital 0.69 mm, depth at dorsal origin 0.69 mm and depth at anal origin 0.35 mm.

23 *mm larva* (*Fig.* 3): This was a fairly advanced stage in which almost all the larval features had disappeared. The notable feature in this larva was the full complement of the pelvic fin with its triangular shape. The origin of the pelvic fin was just opposite to the origin of the dorsal fin. The pre-pelvic length of the larva was slightly shorter than the post-pelvic length. The remnants of the larval fin-fold disappeared. The body became wider and the head more massive, the larva was more adult-like than the larvae described above. The narial openings had developed and the mouth had become almost terminal. Minute teeth were present on the lower jaw. The pre-dorsal length of the larva became smaller than that of the 7.64 mm larva. Thirty-eight pre-anal and nine post-anal myotomes were discernible. The fins became thicker, but the presise number of rays in the fins still remained difficult to be ascertained.

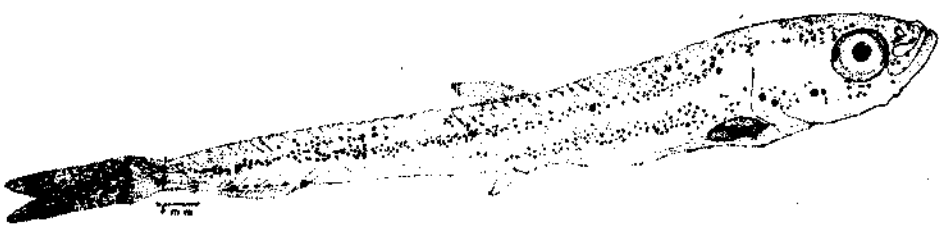

FIG. 3. Oil sardine larva of 23 mm total length.

Pigmentation of the body had increased, and that in the caudal fin had become denser and more extensive with many branching chromatophores. Black pigment spots and stellate chromatophores appeared along the snout, maxilla, above and below the eye, and on the opercle and preopercle regions. Two series of pigments, one along the medio-lateral aspect and the other between the pectoral and pelvic, were found. Pre-bladder, post-bladder and sub-guttal pigmentions disappeared.

The head was longer (more than 175 of the total length of the body) than that in the 7.64 mm stage. Morphometric measurements were: head 4.29 mm, snout 1.07 mm, eye diametre 1.25 mm, predorsal 9.28 mm, depth at dorsal origin 2.32 mm, depth at anal origin 1.54 mm and least depth of caudal peduncle 0.93 mm. Though this stage showed many a juvenile character, it differed from the juvenile in the absence of ventral scutes and in the disposition of the dorsal and pelvic fins.

28 *mm juvenile* (*Fig.* 4): The structure of the body and head, the disposition of the fins, and the appearance of ventral scutes demarcated it as an early juvenile. Moreover, faint conical and irregular markings of the skin, indicating where the scales would soon develop, were present in the belly region.

Pigmentation of the body consisted of a number of black spots on the supra-orbital region, which continued as a zone of pigments on the dorso-lateral part of the body till the caudal end. The ventro-lateral part of the body remained unpigmented. Pigments were also seen on the pre-opercular region and

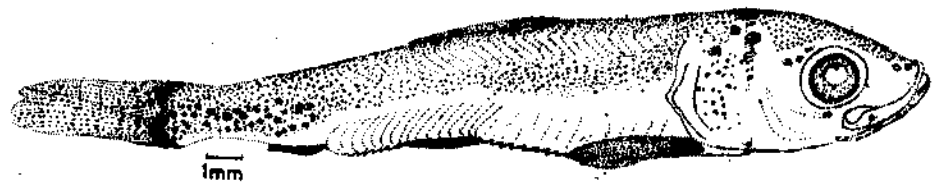

FIG. 4. Oil sardine larva of 28 mm total length.

a few on the maxilla. The pigments on the dorso-lateral part of the body up to a little behind the dorsal fin were arranged in parellel rows corresponding to the boundaries of myotomes. Black chromatophores appeared on the jaws, posterio-dorsal aspect of the orbit, feebly below the eyes, strongly along the mid-lateral aspect of the body (with heavy concentration a little above the anus), on the caudal peduncle, caudal base and caudal fin. The chromatophores on the above two regions were bigger and radiating. The pigments on the caudal fin were arranged serially. The two series, one along the medio-lateral aspect between the head and caudal peduncle and the other along the ventro-lateral aspect between the pectoral and pelvic that were found in the 23 mm postlarva, had disappeared.

The number and disposition of the myotomes remained the same as that of the oldest postlarva observed. The number of fin rays became more discernible and there were 14 pectoral, 8 pelvic, 12 dorsal, 10 anal and 32 caudal rays. About 10 pre-pelvic and 8 post-pelvic scutes were visible. The head was about 1/4 of the total length. Depth at dorsal was 3.85 mm and at anal origin 2.31 mm. The lengths of other parts were: head 7.54 mm, snout 1.77 mm, eye diametre 1.92 mm, post-orbital 3.85 mm, pectoral fin 4.23 mm, caudal fin 5.78 mm, depth of caudal peduncle 1.46 mm and height of head 4.38 mm.

38-*mm juvenile* (*Fig.* 5): The pigmentation had increased considerably in this juvenile, particularly in the regions sparsely pigmented in the earlier forms. There were many pigment spots on the snout and chin. Some pigment spots had appeared on the dorsal fin. Pigmentation was denser in the dorsal and dorso-lateral aspects of the body; the ventro-lateral part of the body still remained unpigmented. Chromatophores on the chin, snout, lateral aspect of the body and the lateral and dorsal aspects of the caudal peduncle were prominent. The serial nature of the pigmentation of the caudal fin found in the previous juvenile had disappeared and the pigments were spread in an irregular manner in this juvenile. The areas indicating the development of scales in the belly region became much prominent.

Now there were 15 pre-ventral and 12 post-ventral scutes. The rays of the fins were: pectoral 16, pelvic 9, anal 13, dorsal 14 and caudal 36. Head length more than 1/4 of the total length. Heights at dorsal and anal

FIG. 5. Oil sardine juvenile of 38 mm total length.

origin were 6.38 and 4.17 mm, respectively. Heights of head and caudal peduncle were 6.15 mm and 2.62 mm, respectively. Lengths of other body parts were: snout 2.31 mm, eye diametre 2.69 mm, post-orbital 5.00 mm, anal base 4.00 mm, pectoral fin 5.62 mm, pelvic fin 3.46 mm and caudal lower lobe 7.31 mm.

DISCUSSION

The spawning season of oil sardine has been variously recorded by earlier workers as between June-August (Hornell 1910), May-August (Hornell and Nayudu 1924), June-October (Devanesan 1943; Raja 1967, 1969), June-September (Nair 1953, 1959; Dhulkhed 1967) and June-December (Prabhu and Dhulkhed 1967). These were inferences made by the study of intra-ovarian eggs, or by the collection of planktonic eggs or larvae or juveniles, or by the study of some factors combined. Dutt (1968), while commenting on the report of Prabhu and Dhulkhed (1967), stressed the importance of circumstantial evidence for fixing the spawning season of the fish and mentioned that the collection of eggs and pro-larvae from the plankton, along with the occurrence of mature adults during the period, should be the main criterion. In the present case, collection of spawners on 6-5-1976 was followed by the collection of egg and larvae on 7-5-1976 and 13-5-1976, respectively, and postlarvae and juveniles from 7-6-1976 onward to the middle of August. Hence it may be safely concluded that the spawning season of this species started from early May in this area.

Devanesan (1942) collected oozing specimen and planktonic eggs of oil sardine around new-moon. Raja (1967) also recorded oozing specimens and recently-spawned ones around new moon. So Raja (1972) had provisionally believed that spawning occurred during the darker lunar days, that is, a week before and after the new moon. But, at Vizhinjam the spawners were observed on the 8th and 19th day after the new moon, showing that the fish might spawn during the brighter phase as well.

The data presented here indicate that there was considerable spawning activity of oil sardine around Vizhinjam during May 1976 in water very near to the shore, but outside the bay, as appreciable quantities of spawners were taken from there. Chidambaram (1950) had observed good oil sardine fishery when the temperature values were below 29°C. Sekharan (1965), during 1957-58 period, had observed good landings at Calicut when the average temperature and salinity values ranged between 28.5°C and 29.9°C and 33.08 ‰. and 35.05 ‰, respectively. In the present case, too, the surface temperature (26.2°C) and salinity (35.00‰) recorded on the day when there was the unusual landings (17.5 tonnes) fell within the range mentioned as favourable by the earlier workers. The erratic nature of the SW monsoon in 1976 could be one of the reasons for the early appearance of spawners and the unusual fishery that had followed in this centre since there had been a good oil sardine fishery south of Quilon, too, after May this year. Or it may be because, as the late Dr. K. V. Sekharan had once mentioned in one of his personal communications with me, that the area of concentration of oil sardine had become shifted south of the traditional grounds.

The characters of the intraovarian egg such as the maximum size, shape and general appearance described here tally well with those given by Nair (1959) and Raja (1967). However, the oil globule (Fig. 1) was slightly smaller than the one in the fertilized egg. But a number of very minute oil particles were scattered in the yolk, which, according to Dr. P. Vijayaraghavan (personal discussion), might join with the oil globule by the time the egg would be released to form the single oil globule of the size found in the fertilized egg. Nair (1959) and Raja (1967), too, had mentioned the occurrence of the oil globule broken into two or three droplets occasionally in the intraovarian egg. However, since these authors had not given the size of the oil globule it was not possible to make a size comparison.

One of the direct methods of identifying the planktonic egg of sardines is by tallying the size of its yolk, rather than the size of the egg, with that of the yolk in the ripe ovum, because, though with development the egg becomes larger, the size of the yolk remains constant (Bensam 1971). It may be noted in this connection that in the ripe ovum the membrane was not distinguishable and the perivitelline space was absent. The egg membrane would become visible only after the ovum came into contact with water, when it would swell itself pulling from the yolk and leaving a perivitelline space; the egg thus would become larger and larger with advancing development without the yolk taking part in the process (Miller 1952). It was based on this criterion that the present egg had been mainly identified as that of the oil sardine. The yolk diametre of the planktonic egg (1.22 mm) came within the diametre range (0.98-1.23 mm) of the intraovarian egg.

The identification of the larvae and juveniles as belonging to that of oil sardine was based upon not only the circumstantial evidence of coincident occurrences of spawners and larvae or early juveniles, but also the direct evidence of the vital features that are determinably characteristic of *S. longiceps*. The only other sardine that was having advanced gonadial maturity during this period was *S. gibbosa*. But *S. gibbosa* differs in body proportions and number of vertebrae from the oil sardine. The other two species of *Sardinella* having vertebral range overlapping with that of *S. longiceps* are *S. dayi* and *S. fimbriata*. The postlarvae of *S. dayi* have 46 myotomes (Bensam 1973), while the postlarvae of *S. longiceps* have 47 myotomes. Though it has been reported that *S. dayi* spawns from December/January to April/May period along the Tuticorin coast (Bensam 1973) it spawns at Vizhinjam only during December. The number of vertebrae in *S. fimbriata* is 42-46 (Delsman 1926) and 44-46 (Dutt 1959). The 2½-days-old postlarva assigned by Delsman 1926) to *S. fimbriata* has 40 pre-anal and 5 post-anal myotomes only. Thus the postlarvae of *S. fimbriata* differs from the postlarvae of *S. longiceps* in this respect. Out of eight larvae in the size group 7.0-7.9 mm examined by Anon. (1976), four had 39 pre-anal myotomes and three had 8 post-anal myotomes. This is in conformity with the myotome count observed for the 7.64-mm larva of the present study.

In the 7.64-mm larva the head was less than 1/5 of the total length of the body, while in the 23-mm larva it was more than 1/5 of the total length. In juveniles of 25-30 mm total length the head was about 1/4 of the total length, and in 38-mm juvenile it was more than 1/4. So it appears that the head in the postlarval phase of development undergoes a more rapid growth that the rest of the body. Similarly, the pre-dorsal length of the 23-mm larva was proportionally smaller than that in the 7.64-mm larva. This may be due to the forward movement of the dorsal fin as observed by Bensam (1971) in the larvae of *S. jussieu*.

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