NOTES ON THE SPAWNING HABITS AND EARLY LIFE-HISTORY OF THE OIL SARDINE, *SARDINELLA LONGICEPS* CUV. & VAL.

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Introduction

Our knowledge of the breeding habits and early life-history of the two commercially important pelagic fishes of India, namely, the oil sardine and the mackerel, is very meagre, even though investigations on these and allied aspects of their biology were initiated about the beginning of this century. The first attempt to determine the spawning habits and the factors which control the migration of the oil sardine was made by Hornell (1910) who made some general observations and at the same time stressed the need for intensive investigations on the problems connected with the food, life-history and seasonal migration of the oil sardine and the mackerel for the proper development of these two major fisheries. Several years later, Hornell and Nayudu (1924) published an account of the life-history of the oil sardine in which they gave the results of an year's intensive study on the rate of growth, spawning habits and migration of the oil sardine. Devanesan (1943) artificially fertilised the eggs of the oil sardine and this enabled him to isolate them from the plankton collections made at Quilandy, Malabar; but the early life-history of the oil sardine was not traced by him. The author (1953) made a detailed biological study of the oilsardine and its fishery extending over four seasons from 1948–52 and traced the regular changes in the age composition encountered in the fishery and pointed out that the fishery always commences after the onset of the s.w. monsoon with the appearance of the spawners which enter the coastal waters for spawning and the stimulus for such activity is given by the lowered temperature-salinity conditions existing during this period while the spent and recovering individuals appear in the coastal waters generally during the closing stages of the fishery.

It may be mentioned here that a few attempts to trace the life-history of the other species of *Sardinella* were made during the last one decade and John (1951) gave an account of the egg, newly hatched larva and one-day old larva of *Sardinella sirm* collected from the Madras Coast. Chacko

(1946) recorded the egg of *Sardinella gibbosa* and later (1950) gave additional information about the egg and larva of the same species obtained from the waters around the Krusadai Island, Gulf of Mannar. Chacko and Mathew (1955) gave a brief account of the egg and larval development of *Sardinella albella*, a common sardine of the west coast of India. Bapat (1955) gave short notes on the egg and larval stages of *Sardinella fimbriata* found in the Gulf of Mannar.

In this paper general notes on the egg, early life-history, spawning season and spawning habits of the oil sardine are given based on the continuous observations carried out at Calicut from 1948–57 when the author was in charge of the sardine investigations. The author is thankful to Miss M. Dharmamba and Mr. Egbert Dawson for assistance in measuring and counting the ovarian eggs respectively.

Spawning Season

There is some divergence of opinion among the earlier workers regarding the duration of the spawning season of the oil sardine and this general study extending over several years has made it possible to determine the spawning season fairly accurately from the presence of active spawners in the fishery and also of the eggs in the plankton collections made from the fishing grounds. In an earlier paper dealing with the biology and fishery of the oil sardine it was pointed out that there is a regular pattern in the appearance of the spawners and juveniles every year in the coastal waters which was mainly influenced by the changes in the hydrological conditions brought about by the s.w. monsoon (Nair, 1953). The changes in the age composition of the oil sardine fishery were given in detail and it was shown that during the 1948–49 season, the spawners with a modal size of 19 cm. appeared in the fishery in large numbers during August 1948 and they continued to be present in the commercial catches in relatively smaller numbers in September 1948 also; but disappeared from the inshore waters by the end of the month. The occurrence of oil sardine eggs was noticed in the plankton collections brought from the sardine fishing grounds during these months. In the next season, the spawners with a modal size of 17 cm. entered the fishery in September 1949 and the ovaries of almost all the females were well developed and in stages V and VI.* The spent fishes were seen in the fishery during the closing stages in March 1950. During the 1950–51 season, the spawners with a modal size of 19 cm. entered the coastal waters in July 1950 and were

* The stages mentioned in this paper correspond to the maturity scale given by the International Council for the Exploration of the Sea.

observed to be present in the commercial catches till the end of November 1950 which indicated a fairly protracted spawning season. However, planktonic eggs were observed in large numbers during August and September 1950 only, especially during the former month. This obviously showed that the intensity of spawning was high during these months even though the spawners were present in the fishing grounds for a longer time. The 1951–52 season showed the presence of the spawners in the fishery for a short period only in August 1951.

Apart from these recorded observations, the unpublished data collected during the subsequent seasons also show a similar pattern in the appearance of the spawners and in the age composition of the fishery. The oil sardine fishery of the 1952–53 season commenced early in July 1952 after the commencement of the monsoon and as usual the three-year old mature adults with a modal size of 18 cm. and with the gonads in stage V and occasionally in stage VI constituted the bulk of the catches during the month. The fishery showed the usual changes in the age composition during the subsequent months and the immature one-year old sardines with the modal size ranging from 10–11 cm. appeared erratically in the inshore waters and yielded occasional good catches up to the end of September 1952. The fishery showed a remarkable improvement in October 1952 and heavy landings were made during the month. These shoals were mainly composed of one and two-year old oil sardines the modal sizes of which varied from 10–16 cm. An abrupt set-back in the fishery was noticed by the end of the month when the shoals which were frequenting the inshore waters suddenly moved away and they were not encountered in the fishing grounds during the subsequent months. The absence of the juvenile shoals in the fishing grounds resulted in the complete failure of the fishery during the peak period. However, stray shoals reappeared in the coastal waters in January 1953 and the fishery terminated by the end of the month.

The 1953–54 oil sardine fishery commenced early in June 1953 and an exceptional feature of the fishery was the early appearance of the mature shoals composed of adults with a modal size of 18 cm. even before the onset of the monsoon which commenced only by the middle of the month. It may be mentioned here that the monsoon was active in the southern regions at that time and it is likely that the temperature-salinity conditions of the coastal waters were lowered due to the monsoon currents. The plankton collections made during this period also showed the abundant occurrence of the different common diatoms which are usually seen during the monsoon months. These mature sardines dominated in the catches

during July and August 1953 and their ovaries were well developed in stage V and occasionally in stage VI. The second week of September 1953 showed a sudden change in the composition of the fishery and the spawners disappeared completely from the fishing grounds and a new stock composed of juveniles with the modal size varying from 9–11 cm. in the different shoals entered the fishing grounds in enormous numbers and exceptionally heavy catches were made till the middle of October 1953. The fishery came to a close by the end of November 1953 when the spent oil sardines appeared in the commercial catches.

During the 1954–55 season, the spawners with a modal size of 17 cm. appeared in the coastal waters during the last week of August 1954 immediately after the cessation of the monsoon. The spawners in oozing condition were caught from the inshore waters during night time and attempts at artificial fertilisation proved successful but the developing eggs could not be reared beyond the cleavage stages since good sea water was not available at that time.

Hornell (1910) while discussing the spawning season and migration of the oil sardine stated that the shoals arriving by the end of June consist entirely of adult individuals with well developed roe and milt and that they are seen till the end of August after which the shoals consist of spent individuals. He inferred that the spawning period is one of considerable duration and stated that the sardine after spawning rapidly grow fat and these fat-laden sardines are caught in enormous quantities during the months October–December. He noted that in January the body fat begins to decrease and by the end of March they are practically free from fat. While recording these changes Hornell has apparently not taken into consideration the size composition of the sardines and consequently appears to have mixed up the age classes and assumed that the adult individuals after spawning feed and grow fat and contribute to the fishery during the peak period extending from October to December and that they become devoid of fat during March due to scarcity of planktonic food. As pointed out by the author in 1953, these conditions are shown by the sardines belonging to different year classes and it is now known that the spawners which enter the foreshore waters immediately after the commencement of the monsoon disappear during the post-monsoon period for spawning in deeper waters, when the fat-laden juveniles enter the fishery to form the bulk of the commercial catches during the peak period. The spent and recovering oil sardines devoid of fat generally appear during the closing stages of the fishery.

Hornell and Nayudu (1924) carried out detailed investigations on the biology of the oil sardine for one year and they arrived at certain conclu-

sions relating to the breeding habits of the fish. According to them, the oil sardine attains sexual maturity and full adult size at the age of one year when they measure 15 cm. in standard length. They leave the inshore waters just prior to spawning which takes place once a year from June to August. After spawning mortality is considered by them to be very high particularly among the females and only very few survive to spawn a second time. They also believed that the juveniles which they noticed in the fishery were the recruits of the same spawning season and consequently a high rate of growth was estimated by them during the first year. It was pointed out by a study of the length frequency of the oil sardines in the commercial catches that the juvenile stock found in the fishery every year is the result of the previous year's spawning (Nair, 1953). Devanesan (1943) who collected active spawners and planktonic eggs during September and October doubted the accuracy of Hornell and Nayudu's conclusion that the intensive spawning period is short and limited to June and July since these authors were unable to explain the occurrence in September and October of a considerable percentage of the males and females with large gonads. The s.w. monsoon is an important factor influencing the entry of the spawners into the coastal waters and consequently the spawning period shows a tendency to shift depending on the early or late commencement of the monsoon (Nair, 1953). This is clearly supported by the observations carried out during the subsequent years also, especially during the season 1953–54 when the spawners appeared in the coastal waters even before the outbreak of the monsoon in Calicut due to the changes in the hydrological conditions brought about by the monsoon currents from the southern regions where the monsoon was active at that time. This observation is also corroborated to some extent by the length frequency data which show differential rate of growth during the first year (Nair, 1953). The spawners enter the coastal waters after the commencement of the monsoon generally during June and July and intense spawning usually takes place during August and September. The gonadial conditions of these spawners range from stage V to VI in the different shoals seen during these months. It was not possible to determine the actual spawning ground of the oil sardine since the violence of the monsoon at that time makes it impossible to undertake exploratory field trips with the existing facilities. However, judging from the relative scarcity of the planktonic eggs in the townet collections made from the fishing grounds, it is presumed that the spawning grounds are situated beyond the present fishing zone.

Hornell (1910) and Hornell and Nayudu (1924) have stated that the shoreward migration of the spawners and the juveniles is to feed upon the immense quantities of microplankton produced towards the close of the

s.w. monsoon. The food and feeding habits of the juveniles, adult, spawners and spent and recovering oil sardines have been studied in sufficient detail (Nair, 1953) and the conclusions are in general agreement with those made by these authors except in the case of the spawners which always show an empty stomach indicating the cessation of feeding activity at the time of spawning. The shoreward migration of the spawners is, therefore, believed to be for spawning only.

According to Hornell and Nayudu (1924) the females preponderate among the juveniles and the spawners while they found that the males predominated slightly over the females in the case of the spent sardines and this was attributed by them to a considerably higher rate of mortality of the females than the males after spawning. On the other hand, Chidambaram (1950) noticed equal proportion of the sexes in the oil sardines measuring less than 20 cm. while the females predominated in the fishes measuring more than this size. This study has shown that there is considerable agreement in the proportion of the sexes in the different size categories. The spent and recovering oil sardines re-entering the fishery are very few and their relative scarcity and the virtual absence of the four-year old oil sardines in the commercial catches indicate that mortality is high among both the sexes after spawning.

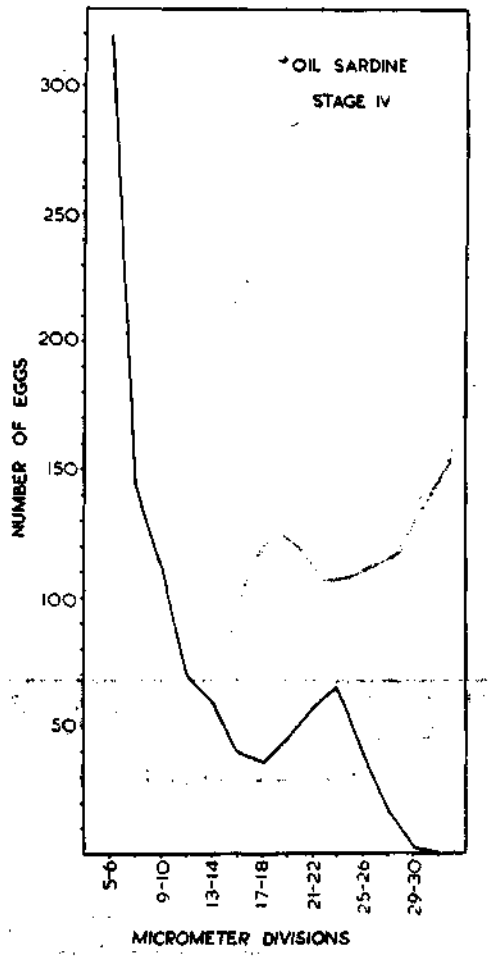
Spawning Habits

Frequency of Spawning.—The author pointed out in 1953 that the oil sardine spawns only once during the breeding season and this statement was mainly based on the regular gross and microscopic examinations of the ovaries in the different stages of development extending over a few years. Ova diameter studies were undertaken subsequently with a view to get additional information, if any, and also to test the reliability of this method in a tropical fish with known breeding habits as done by Hickling and Rutenberg (1936) in the case of a few temperate zone fishes. For this study, three successive advanced maturing and mature ovaries in stages IV–VI alone were utilised. It was found that the gonads of the oil sardine generally do not exhibit any apparent difference in the distribution of the maturing or mature eggs either in the different regions of the same ovary or in the two ovaries of the same fish. However, to obviate any possibility of error due to the uneven distribution of the eggs, samples were taken from the anterior, middle and posterior regions of both the ovaries and in this manner 1,000 eggs were measured for each of the selected ovaries. No doubt the maximum and minimum ova diamater measurements reduce the variance as pointed by Yuen (1955); however, the 'chance' or 'random' diameter of the ova was measured, for

convenience, by keeping the micrometer in a fixed position. But a high number of eggs was measured to minimise the variance and at the same time to get a good representation of all the different size categories present in the ovary. Ova measuring 5 microns and above alone were taken into consideration and the frequency curve was drawn using class intervals of 2 microns. It was noticed that the ova diameter frequency of the ovaries of the different oil sardines in the same stage of maturity did not show any appreciable difference in the pattern of distribution of the size categories and consequently a single ovary representing a typical maturity stage was examined in this study.

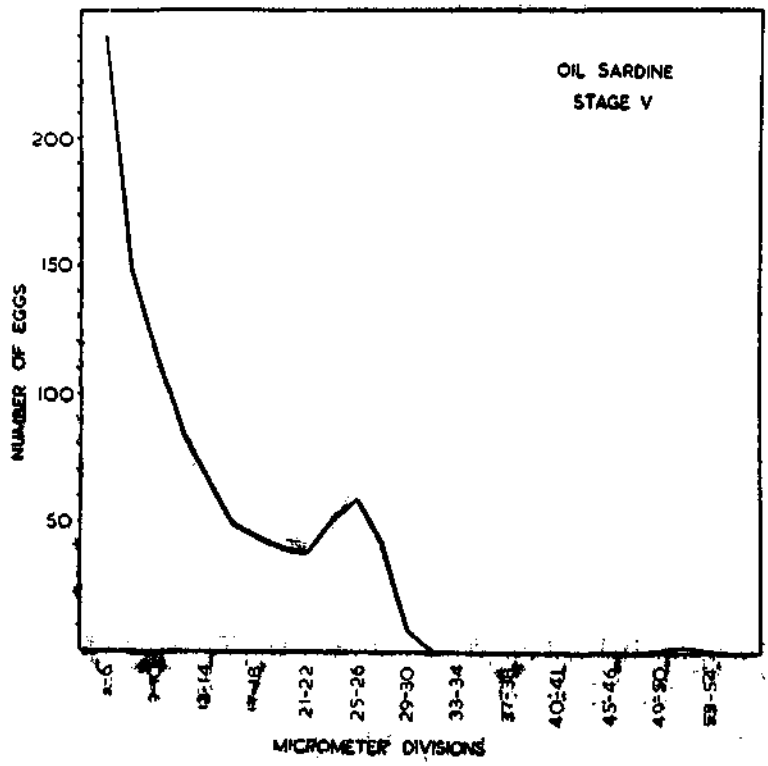
Three successive advanced maturing and mature ovaries in stages IV–VI were utilised for this study. In stage IV, the ovaries fill nearly two-thirds of the body cavity and the compactly arranged maturing ova are clearly visible to the naked eye. In the other two stages the ovaries completely fill the body cavity of the fish. The ovaries in stage V are filled with medium-sized, opaque, mature ova and in addition a few large, transparent, ripe eggs provided with a segmented yolk and an oil globule are also present. It may be mentioned here that in sardines with the ovaries in this stage, the visceral fat is almost used up presumably for the maturation of the gonads. In the spawning oil sardines with the ovaries in stage VI the belly is rounded and bulges considerably owing to the ripening of the mature eggs of the ovaries and an abdominal incision makes the latter come out readily because of their tense condition. The other visceral organs of the spawners are usually crowded together owing to the pressure of the ovaries which fill practically the entire visceral cavity. The spawners are devoid of visceral and body fat and such fishes present a very emaciated appearance when the gonads are taken out. The ovaries in stage VI are soft, jelly-like and filled with large transparent eggs which ooze out from any small cut or rupture in the ovarian wall. Figs. 1 and 2 (Plate III) show the general appearance of typical oil sardine ovaries in stages V and VI and the regions marked in them with circles are magnified and shown in Figs. 3 and 4 (Plate III) which show the compactly arranged opaque mature and transparent ripe eggs in these two ovarian stages respectively.

Text-Figs. 1–3 show the ova diameter frequency in these three ovarian maturity stages of oil sardine. In stage IV the small immature eggs constituting the general egg stock form a high percentage and the withdrawal for maturation of one batch of eggs with a modal diameter of 23–24 microns (0·45–0·47 mm.) from this stock is clearly seen. The distinct demarcation of the maturing batch of eggs from the general egg stock indicates that only



TEXT-FIG. 1. Ova diameter frequency of oil sardine ovary in stage IV.

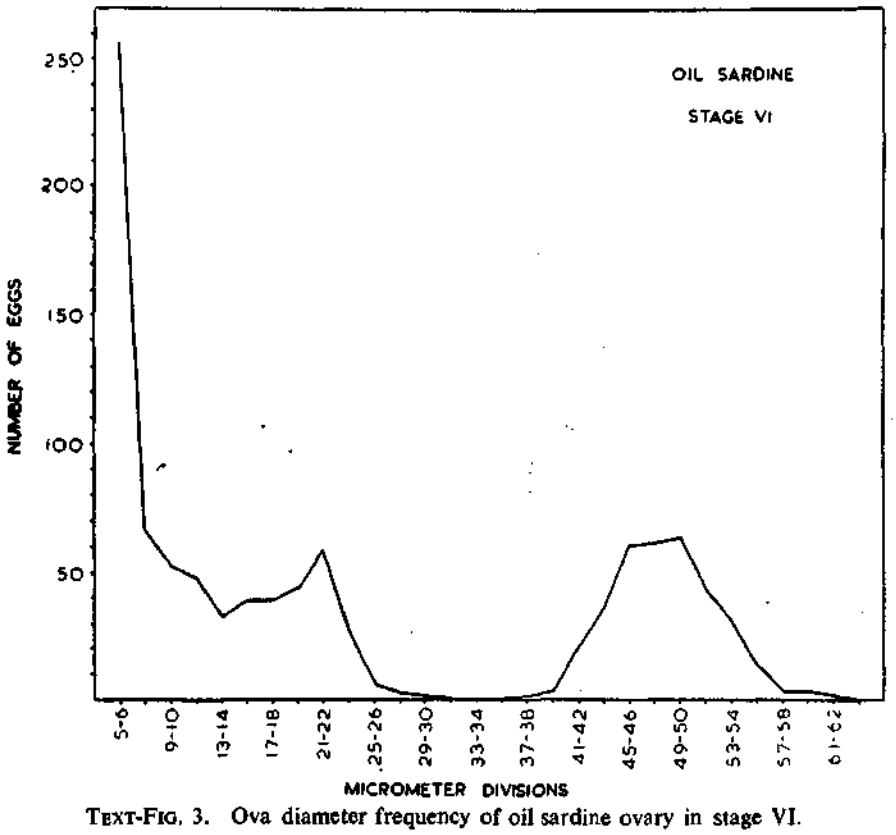
one batch of eggs is spawned during the ensuing spawning season. A similar pattern of ova diameter frequency is also seen in stage V where the eggs of the differentiated batch have become mature with a modal diameter of 25–26 microns (0·49–0·51 mm.). It is also seen that a few eggs belonging to this mature batch of eggs have become ripe and show a modal diameter of 51–52 microns (1·00–1·02 mm.). These ripe eggs are large and transparent and the yolk which is clear and segmented is provided with a single golden yellow oil globule. The ripening of the eggs which is the final phase in the maturation prior to extrusion and fertilisation as well as an adaptation for flotation is accomplished very quickly. During this process of ripening the eggs increase in size considerably owing to the absorption of water during the transformation of the yolk spherules in the opaque mature eggs into large



TEXT-FIG. 2. Ova diameter frequency of oil sardine ovary in stage V.

vesicles in the transparent ripe eggs. In stage VI most of the mature eggs have become ripe with a modal diameter of 49–50 microns (0·96–0·98 mm.) and since the actual process of ripening is completed rapidly it is to be expected that the remaining mature eggs also will become ripe and extruded along with the already differentiated ripe eggs.

Hickling and Rutenberg (1936) suggested the utility of ova diameter measurements for determining the spawning period in fishes and tested their hypothesis with hake, haddock, pilchard, herring and the Cornish sucker. They stated that "where the spawning period is short and definite, the batch of transparent yolkless small eggs, destined to mature and be spawned, will be withdrawn from the general egg stock in a single group, sharply distinguishable, at least in the later stages of maturation, from the stock of small eggs from which it was derived". It is obvious that the oil sardine spawns only once during the short spawning season as shown clearly by the maturation of one batch of eggs only and this is in agreement with



TEXT-FIG. 3. Ova diameter frequency of oil sardine ovary in stage VI.

Hickling and Rutenberg's generalisation and also with the general observations made on the spawning habits of the oil sardine (Nair, 1953).

The actual spawning has not been observed in the oil sardine, but it is presumed that all the ripe eggs are liberated within a short time. It may be mentioned here that the individuals of the different shoals and sometimes even within the same shoal show variations in the maturity of the ovaries and this obviously suggests that spawning will not be strictly simultaneous in all the individuals of the same shoal and much less so in the different shoals. However, it is believed that the majority of the individuals of the spawning stock breed during the August–September spawning season.

Fecundity.—In the oil sardine, the estimation of the number of eggs liberated during the spawning season is simple since the ovary contains only one batch of eggs undergoing maturation. Ovaries in stage VI alone were utilised for estimating the fecundity and samples were taken from the anterior, middle and posterior regions of both the ovaries. The number of eggs

comprising the mature and ripe groups was counted in these samples and the fecundity was estimated by dividing the weight of the ovary by the weight of the samples and by multiplying the product by the number of eggs present in the samples. This method is found to give a fairly reliable estimation of the number of eggs spawned during the spawning season and the estimated number of eggs present in three specimens belonging to different size groups is given in the following table.

Total length of fish in cm.	Weight of ovary in gm.		Number of ripe and mature ova		Total
	Left	Right	Left	Right	
17·0	6·535	5·184	34,675	33,001	67,676
18·1	8·520	7·290	39,908	37,966	77,874
19·3	7·800	6·900	45,848	42,670	88,518
Average ..	7·618	6·458	40,144	37,879	78,023

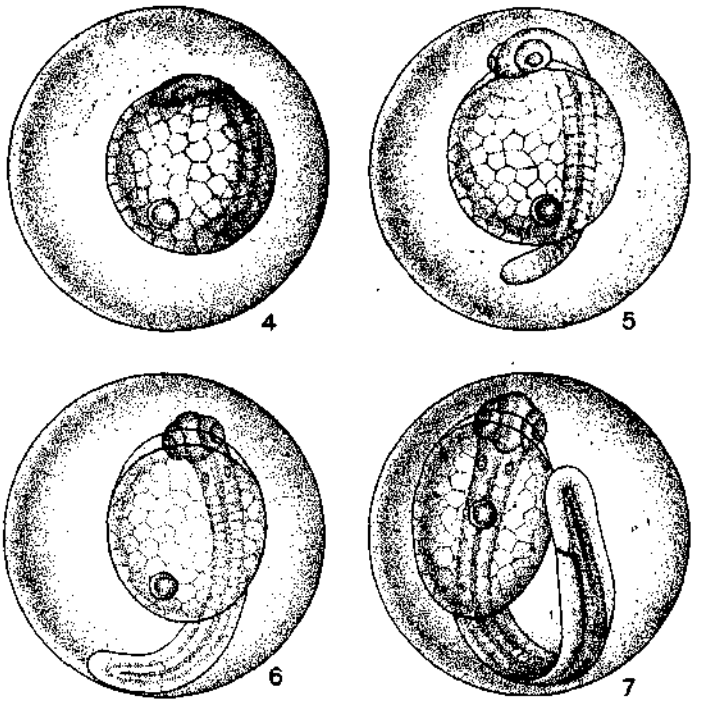
It is seen from the above table that the left ovary which is slightly larger than the right produces more eggs, the number depending on the difference in size. The fecundity of the oil sardine was estimated as 75,000 by Nair and Chidambaram (1951) and this analysis also gives an approximately similar figure of 78,000 eggs. It may be mentioned here that the fecundity is generally proportional to the size of the ovary which in turn is related to the size of the fish.

Early Life-History

The Egg.—The eggs of the oil sardine are pelagic, transparent, perfectly spherical with an average diameter of 1·4 mm. and possess a very wide perivitelline space. The yolk is colourless and the segmentation, which is a characteristic feature of the clupeoid eggs, is seen distinctly. The yolk is roughly spherical with an average diameter of 0·85 mm. Most of the eggs are provided with a single oil globule which is golden yellow in colour and spherical with an average diameter of 0·1 mm. It may be mentioned here that occasionally two and in rare instances three oil globules have been noticed in the eggs of the oil sardine.

The embryonic development of the oil sardine is very rapid and is usually completed within 24 hours and in the earliest stage obtained from

the plankton collections made at Calicut, the embryo is in a very early stage of development and it extends a little more than half the way round the yolk mass (Text-Fig. 4). The optic vesicles alone are faintly indicated in this stage. The oil globule is situated near the tail of the developing embryo.



TEXT-FIGS. 4–7. Fig. 4. Egg of oil sardine at 4 a.m. Fig. 5. Egg of oil sardine at 8 a.m. Fig. 6. Egg of oil sardine at 11 a.m. Fig. 7. Egg of oil sardine prior to hatching at 2 p.m.

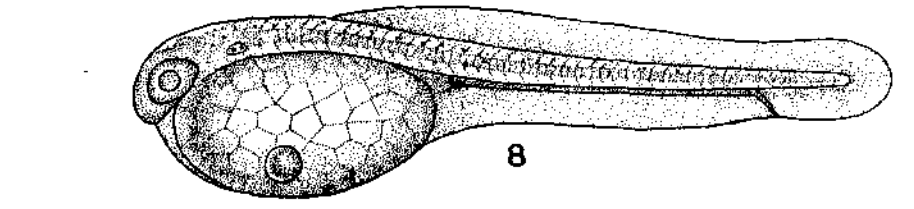
In the next stage, the embryo is well developed and elongated with the tail end free from the yolk mass (Text-Fig. 5). The tip of the tail is round and the fin-fold is hardly recognisable. The myotomes have become distinct in the anterior region of the embryo. The optic vesicles are clearly seen and the heart is functional in this stage.

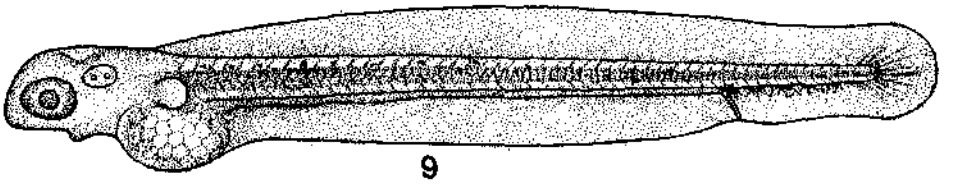
In the next stage the embryo has become longer and approximately its posterior third is free from the yolk mass (Text-Fig. 6). The auditory vesicles are distinctly seen in this stage. The myotomes have increased in number and the tail myotomes are faintly indicated. The yolk mass has assumed an oval shape. The fin-folds are seen distinctly in the curved caudal portion.

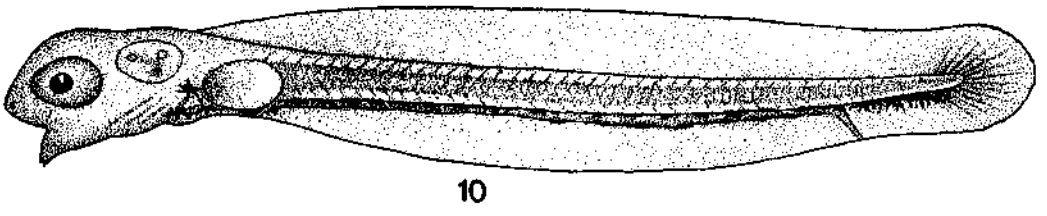
The last stage in the embryonic development is shown in Text-Fig. 7 which shows the embryo prior to hatching. The embryo has grown very long and is curled up inside the egg membrane with the tip of the tail almost

reaching the head. The yolk mass has assumed a distinct oval shape and the oil globule is now located in its mid-ventral region. The alimentary canal and the vent are distinctly seen and the full complement of myotomes which extend up to the tip of the tail is formed in this stage. The caudal portion is pointed and the fin-fold has become wider in the fully developed embryo. The embryo is pigmented and uniformly distributed unbranched black chromatophores are present on the dorsal side. In this stage the embryo frequently changes its position by performing wriggling movements inside the egg membrane.

The Newly Hatched Larva.—The newly hatched larva generally floats passively on the surface of the water owing to the buoyancy of the yolk and the oil globule. When disturbed, it moves away by the undulating movements of the tail. The newly hatched larva measures 2·75 mm. in average length. The yolk, which occupies nearly two-fifths the length of the larva, is ellipsoidal and its segmented nature is seen clearly (Text-Fig. 8). The oil globule generally occupies a central position near the ventral periphery of







TEXT-FIGS. 8–10. Fig. 8. Newly hatched larva of oil sardine. Fig. 9. One-day old larva of oil sardine. Fig. 10. Two-day old larva of oil sardine.

the yolk mass. The pre-anal myotomes are seen distinctly and 41 muscle segments are present in this region. The post-anal myotomes are not very distinct; however, 12 myotomes could be made out with some difficulty. The total number of myotomes, namely 53, present in the newly hatched larva, is higher than the vertebral number of the oil sardine which varies from 46–48. The number of myotomes decreases and gets stabilised in the later larval stages when it corresponds with the number of vertebræ in the adult. Delsman (1926) observed a similar condition in the case of *Sardinella fimbriata*. He noticed 51–52 myotomes in the newly hatched larva while the adult shows only 45–46 vertebræ. The muscle fibres of the myotomes show the usual crossed arrangement characteristic of the clupeoid larvæ. This arrangement is not distinct in the last few post-anal myotomes where the fibres tend to show a parallel arrangement. The alimentary canal of the newly hatched larva is very long and straight and the vent is situated below the 41st myotome. The fin-fold is continuous and entire and originates dorsally from the anterior fourth of the larva.

The pigmentation of the newly hatched larva is very feeble and is confined to the dorsal side of the body in the form of unbranched, black pigment cells which are arranged somewhat closely in the anterior region while they are relatively few in number in the posterior region.

One-Day Old Larva.—The one-day old larva is very active and even the slightest disturbance makes it swim from place to place in a serpentine manner. The larva has elongated considerably and measures 3·35 mm. in average length. A few important changes have taken place in the one-day old larva, the most significant of which is the reduction in the size of the yolk mass the segmentation of which is seen somewhat faintly only (Text-Fig. 9). The oil globule has disappeared in this larval stage. The auditory vesicles have become larger in size. The pectoral fin has begun to develop and is indicated as a flap-like structure behind the auditory vesicle. The formation of the mouth is seen with the lower jaw appearing as a bud-like projection. The one-day old larva possesses only 50 myotomes of which 10 are post-anal in position. There is no change in the alimentary canal except in the position of the vent which is located below the 40th myotome. The origin of the dorsal fin-fold has shifted anteriorly and it is opposite the base of the pectoral fin. Indications of the formation of the caudal rays are seen in this stage.

The black chromatophores which were confined to the dorsal side of the newly hatched larva have become larger and stellate and they have begun

to migrate to the ventral side of the larva as observed in the case of Californian sardine and in several other teleostean fishes (Miller, 1952; Orton, 1953). This migration of the chromatophores commences from the posterior end and a linear group of highly branching chromatophores is seen on the ventral side of the post-anal region. The actual process of vertical orientation of the pigment cells is seen in the middle portion of the larva where several pigment cells are present on the lateral sides of the myotomes. There is no change in the pigmentation of the anterior portion of the larva. The eye in this stage has become golden yellow in colour. A few yellow pigment cells are present in the caudal region without any regularity in their arrangement.

Two-Day Old Larva.—These larvæ are very active and they have been observed to swim most of the time. The two-day old larva is longer and measures 3·7 mm. in average length. Several important changes have taken place in this stage. The yolk has completely disappeared and the mouth is well formed (Text-Fig. 10). The auditory vesicles have become very large and are about the size of the eyes. The pectoral fins have become larger and show faint indications of the formation of the rays. The larva possesses only 48 myotomes of which 38 are pre-anal in position. The alimentary canal continues to be straight and slight widening of the posterior half of the gut is seen in this stage.

The basic pigmentation of the larva of the oil sardine has become stabilised in this stage and all the pigment cells noticed on the dorsal side of the newly hatched larva have migrated to the ventral region. The post-anal pigmentation has become very conspicuous owing to the accumulation of highly dendritic chromatophores. A few large stellate pigment cells are present in the region of the heart. The pigmentation of the alimentary canal is composed of highly elongated black chromatophores which are arranged on the dorsal side throughout the length of the alimentary canal while similar chromatophores found on the ventral side are confined to the posterior half of the gut. The coloration of the eye is similar to that of the adult in having a silvery white shine.

The larva survived only for one more day and the three-day old larva did not show any change from the previous stage except in the reduction in the total length which is normally seen after the complete absorption of the yolk mass. All attempts to feed them with carefully selected planktonic food and boiled yolk of hen's egg were not successful and all the larvæ died the next day.

Delsman (1926) described 6 types of sardine eggs collected from the Java Sea and all of them showed wide perivitelline space and segmented yolk which are characteristic features of the eggs of sardines. The larvæ which hatched out of these eggs showed the same general appearance with the anus situated far back and the crossed arrangement of the muscle fibres. He found that the vertebral number of the different adult species varied only slightly and consequently found it impossible to identify the eggs and larvæ on the basis of this character. Confronted with such difficulties Delsman appealed for International co-operation and wrote "*Clupea longiceps* seems to be a very common form in certain parts of British India. What would be more obvious than for the investigators there to try and discover its eggs? Species less common in one country may be common in another. If their life-history be studied in the latter, this may also help to eliminate in other countries uncertainties like those exposed above". However, relying more on the neritic pelagic distribution and the relative abundance of the adults, he referred eggs A, B and C collected from within the Bay of Batavia to *Clupea fimbriata, Clupea kanagurta* and *Clupea brachysoma*, while out of the three types of eggs collected from outside the Bay, D alone was referred by him to *Clupea leiogaster*.

Studies on the fish eggs and larvæ occurring in our waters have been attempted only in recent years mainly owing to want of proper facilities and also of information relating to the distribution of adult fishes and above all due to the difficulties encountered in such investigations. However, John (1951) made use of Delsman's account of the eggs of *Clupea leiogaster* (= *Sardinella sirm*) for identifying the eggs collected by him from the Madras coast. He referred the eggs to *Sardinella sirm* even though it was considerably larger and showed a size difference of 0·49 mm. and also showed differences in the pigmentation and size of the larva. The eggs and larvæ collected by Delsman and John resembled one another in the absence of the oil globule and also in the pre-anal myotome number.

In regard to the identification of the egg of *Sardinella gibbosa* Chacko (1946) stated that "The ripe ova measures 0·56–0·60 mm. in diameter. Eggs obtained from the plankton measured 0·58–0·64 mm. in diameter". In a later account he (1950) gave the diameter range of the planktonic eggs from 0·68–0·84 mm. and also stated that a small oil globule is present. It is obvious from the measurements of the ovarian eggs and the planktonic eggs collected by him that the eggs assigned by him to *S. gibbosa* is not a sardine egg since they do not possess the wide perivitelline space which is an important character of the sardine eggs. The small size of the egg and

the anterior position of the anus below the 29th myotome in the larva also show that the eggs described by Chacko belong to some other fish.

Chacko and Mathew (1955) described the eggs and larval development of *Sardinella albella* and their accounts do not tally with the descriptions of those of *Clupea brachysoma* (= *Sardinella albella*) given by Delsman (1926). The double egg membrane, wide perivitelline space and the absence of larval pigmentation are distinctive features of the eggs and larvæ assigned by Delsman to *Sardinella albella*.

Bapat (1955) also appears to have identified the eggs of *Sardinella fimbriata* based on the account given by Delsman (1926) since the former's statements relating to the methods of identification are rather contradictory. There is fair agreement in the accounts of the eggs and larvæ of *Sardinella fimbriata* given by these authors, barring minor differences in their size and pigmentation.

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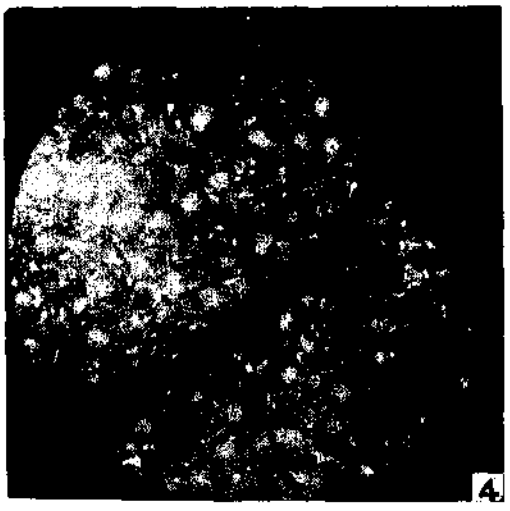

FIGS. 1–4

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Explanation of Plate III

Fig. 1. Ovary of oil sardine in stage V, × *ca.* 1·3.

Fig. 2. Ovary of oil sardine in stage VI, × *ca.* 1·3.

Fig. 3. Enlargement of circled area of ovary in stage V.

Fig. 4. Enlargement of circled area of ovary in stage VI.