7

STUDIES ON THE LIFE-HISTORY, BIONOMICS AND FISHERY OF THE WHITE SARDINE, *KOWALA COVAL* (CUV.)*

by

R. VELAPPAN NAIR**

ABSTRACT

An account is given of the breeding habits, egg, larval development, food, age and rate of growth, sexual maturity and sex composition, methods of fishing and fluctuations in the fishery of the white sardine, *Kowala coval*, a shoaling clupeoid fish of the West Coast of India.

The white sardine, *Kowala coval* (Cuv.), is one of the few economically important clupeoid fishes of the West Coast of India, the fisheries of which have assumed importance in recent years owing to the decline of the fishery of the valuable and much esteemed oil sardine, *Sardinella longiceps*. The highly fluctuating nature of the oil sardine fishery and its undependability, coupled with its failure during the last decade, are the main factors responsible for the present commercial exploitation, though on a moderate scale, of the fisheries of the white sardine and the other sardines, which were almost neglected in former years when the oil sardines occurred in plenty. It is not surprising, therefore, that very little attention has been paid in the past to the study of the biology and the fishery of the white sardine and practically no information is available on these subjects.

Devanesan and John (1941) gave a brief account of its food, sizes, maturity and spawning season with special emphasis on its gonads and eggs. Chidambaram and Venkataraman (1946) have published brief notes on the fishery, sizes, food and spawning season of this fish along with tabular statements of the natural history of certain other marine fishes of the Madras Presidency. Devanesan and Chidambaram (1948) have briefly dealt with the bionomics and economic importance of the white sardine in their popular account of the common food fishes of the Madras Presidency. Recently Mookerjee and Bhattacharya (1950) contributed some valuable information about the distribution of this species and its growth rate based on material collected from the Canning River where the availability of the white sardine has been observed to be restricted to the April–October period of the year.

MATERIAL AND METHODS

The study of the early life-history is based on live planktonic eggs collected from the bi-weekly surface plankton hauls made from the foreshore waters off West Hill with an organdie townet. The healthy living eggs were isolated from these collections and reared in clean sea water in the laboratory aquarium for the study of development. In spite of repeated attempts made during the course of the last three years, difficulty was experienced in rearing the larvae beyond yolk absorption. Consequently the early stages in the life-history alone are described here.

The size frequency studies are based on random samples of white sardines collected regularly during the course of the last three years. These samples were taken from the commercial catches made from the West Hill area and from the bi-weekly laboratory collections made from the foreshore waters off West Hill up to a depth of four fathoms. The laboratory catches as well as the commercial ones have been analysed irrespective of the gears employed for the purpose since it was thought that this would give a truer picture of the population of the white sardine of the West Hill region. However, mention may be made that the majority of the analysed catches were made with the boat seine and the gill net which constitute the important gears used along this coast for the capture of pelagic shoaling fishes. The length frequency data presented in the tables are based on total length measurements of almost all the specimens in the catches, and whenever they were heavy, random samples of 100 to 300 alone were measured. For the analysis of size frequencies, half centimetre groups have been employed in view of the small size of the white sardine (example : 9 cm size group includes specimens measuring from 9.0 to 9.4 cm in total length). Sex determination of most of these samples was carried out for the last two years.

For the study of the food, feeding habits and other aspects of the white sardine, selected representative

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samples alone were examined. The results of the quantitative and qualitative analyses of the stomach contents made during the last three years are given in tabular form. For the purpose of these analyses a fourth of the stomach contents alone has been utilised. The numerical groupings followed in the table are purely arbitrary ; but it is hoped that this will serve to give an idea of the important seasonal changes in the dominant constituents of the food.

LIFE-HISTORY

Egg

In 1926, Delsman described two types of clupeoid eggs collected from near Batavia and a few stages in their development. He identified the smaller of the two with a diameter varying from 0.7 to 0.82 mm and with three to twenty small oil globules as that of *Dorosoma chacunda* and the larger with a diameter of about 1 mm and with six to twelve similar oil globules as that of *Dorosoma nasus*. In 1933 he pointed out that these identifications were not correct since he found the small egg to be very common north of Surabaya, where *Clupeoides lile* (*Kowala coval*) was a common fish in the fishermen's catches. He, therefore, suggested that the smaller type might belong to *Clupeoides lile* (*Kowala coval*) and ascribed the larger one to *Dorosoma chacunda*. Devanesan and John artificially fertilised eggs of the white sardine ; these eggs had a diameter of 0.8 mm and yellow oil globules varying in number from four to eight ; but the authors failed to trace the development.

The egg of the white sardine is the most abundant fish egg in the coastal waters of West Hill. It first appears by October and continues till February, but the November-January portion of the period is the best when it occurs in enormous numbers to constitute the bulk of the fish eggs in the plankton. The results of the study of the gonadial condition have also shown that the ovaries of most of the females become well-developed with mature eggs—a few of them translucent—by the month of October. Spawning females, with almost all the eggs in the transparent condition and provided with oil globules in the clear segmented yolk, have been collected from November onwards. By February the bulk of the adult females were spent and recovering. From the evidence provided by the abundant occurrence of the eggs in the plankton and by the changes in the gonadial condition at maturity it can be assumed with a fair amount of certainty that intensive spawning usually takes place from November to January. Maximum occurrence of eggs, sometimes in swarms, has been noted only in the six to eight fathom foreshore waters and their scarcity in the deeper offshore waters indicates that the white sardine is a coastal breeder with the relatively shallow inshore waters as their breeding grounds. Spawning usually takes place at midnight or in the early hours of the morning as judged from the stage of development of the embryos in the planktonic eggs.

The eggs are pelagic, transparent and perfectly spherical with the diameter varying in the living condition from 0.7 to 0.8 mm. The yolk is transparent and spherical and shows distinctly the vacuolation characteristic of clupeoid eggs. A fairly wide perivitelline space is present. Shining transparent spherical oil globules are present in the yolk mass and their number usually varies from six to eight. Extreme variations from three to twenty-seven have also been noted in exceptional cases. The oil globules show a tendency to crowd on the ventral periphery of the yolk mass.

Embryonic Development

Eggs collected at 4 a.m. show the blastodermal cap fully formed as a dome-shaped structure projecting somewhat above the spherical contour of the yolk mass (Fig. 1). The oil globules occupy the

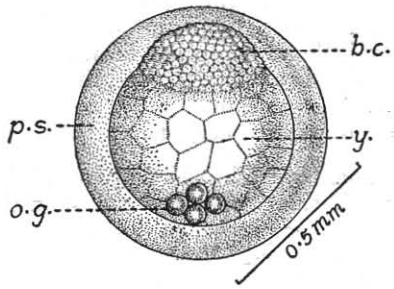

FIG. 1. Egg of *Kowala coval* at 4 a. m. b. c. : blastodermal cap ; p.s. : perivitelline space ; o. g. : oil globule ; y. : yolk.

opposite side of the yolk mass where they are concentrated at one place in the peripheral region. With the advancement of the development of the embryo, the oil globules become scattered in the yolk mass.

Development is rapid and by 10 a.m. the embryo is well formed and occupies a little more than half the circumference of the yolk mass. The eyes, otocysts and the heart have formed, though the last is not yet functional (Fig. 2). The myotomes have also differentiated and about eighteen of them are present in the embryo in this stage. Unlike other clupeoid eggs, pigment is laid in the white sardine egg even in the early embryonic stage in a characteristic manner. Black unbranched chromatophores

have formed and these are scattered uniformly on the dorsal side of the developing embryo.

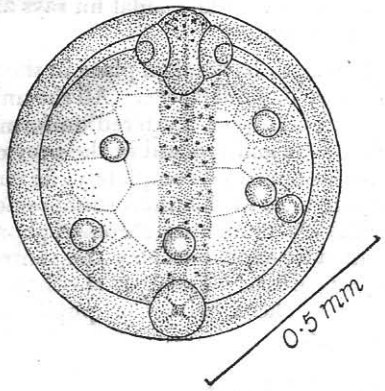

FIG. 2. Egg of *Kowala coval* at 10 a. m.

Embryonic development is usually completed by 2 p.m. when the egg is ready for hatching. At this stage the embryo occupies about three-fourths of the circumference of the yolk mass and performs frequent twitching movements inside the egg membrane with the aid of the caudal portion which is free from the yolk mass (Fig. 3). The full complement of myotomes is developed in this stage.

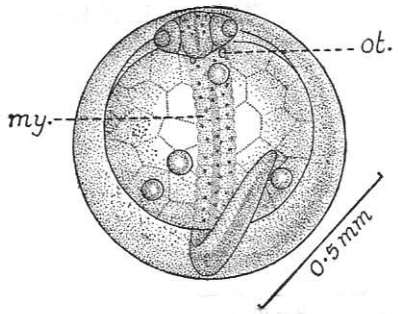

FIG. 3. Egg of *Kowala coval* at 2 p. m. ot. : otocyst; my. : myotome.

Hatching

The abundant occurrence of the eggs has made it possible to make a close study of the process of hatching which is rapid and takes only a very short time. The first sign of hatching is the slight, but quick, elongation of the spherical yolk mass along the embryonic axis to assume a cylindrical shape. The two rounded ends of the elongated yolk mass press against the egg membrane which becomes stretched, losing its spherical shape. The egg membrane splits open at the region of the head owing to the gentle pressure exerted by the elongated yolk mass. The opening thus formed is large enough for the head to be thrust out, but the aperture enlarges by the side to side twitching movement of the larva. The larva slips out quickly through this widened opening up to the caudal portion and by a few lashing movements of the tail rids itself of the shrivelled egg membrane. The process of hatching, as observed in the laboratory aquarium, is accomplished in a very short time, from one to two minutes. The duration is likely to be less under natural conditions of the sea where the process of hatching is accelerated by water movements.

Newly Hatched Larva

The newly hatched larvae are very inactive and float on the surface of the water upside down due to the buoyancy of the yolk and its oil globules. They measure 1.5 mm in length. The ellipsoidal yolk mass occupies about half the length of the larva (Fig. 4). The free caudal portion of the newly hatched larva is curved but becomes straight gradually in about an hour. The myotomes are distinct and about forty-two of them are seen in the newly hatched larva. The alimentary canal is long and straight and the vent which is situated far behind the yolk mass opens to the exterior below the thirty-fourth or the thirty-fifth myotome. The fin-fold is continuous and entire and originates dorsally from the anterior third of the larva. No change in the

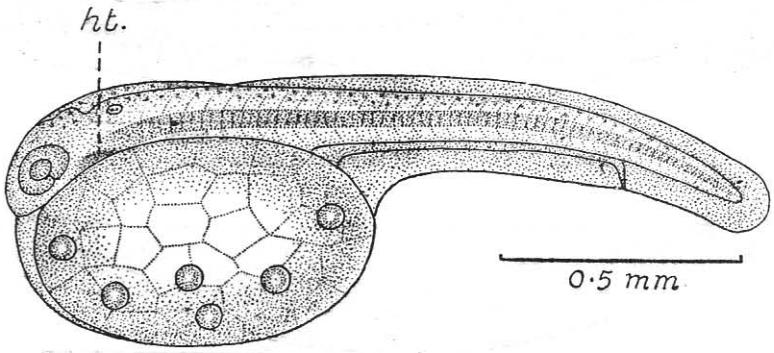

FIG. 4. Newly hatched larva of *Kowala coval*. ht. : heart.

pigmentation from that of the embryo is noticed, except an increase in the number of black chromatophores which are uniformly scattered over the entire dorsal side of the larva.

One Day Old Larva

The day old larvae are very active, the slightest disturbance making them dart from place to place. The usual stretching of the larvae has taken place and they measure 2.25 mm in length. The yolk mass is reduced in size considerably with the segmentation still seen distinctly (Fig. 5). The oil globules in the yolk mass have disappeared completely in some larvae while in others they have become very small. The auditory capsule has increased slightly in size. The pectoral fin has begun to develop and is seen in this stage as a small bud-like prominence above the yolk mass. The fin-fold has become wider and a slight anterior shifting of its origin has taken place. Indications of the formation of the caudal fin rays are seen in this stage.

Two Day Old Larva

These larvae are very active and swim at the bottom of the aquaria. They have grown in size and measure 3.1 mm in length. The yolk mass has disappeared in most of the larvae and its remnants alone are seen in some (Fig. 6). The mouth has formed and this synchronises with the disappearance of the yolk mass. The pectoral fin has grown into a transparent circular flap-like structure. The otocysts are larger. The caudal fin rays are clearly seen in this stage.

Marked changes have taken place in the pigmentation of the two day old larvae. All the unbranched black pigment cells seen scattered uniformly on the dorsal side of the embryo and in the previous larval stages have disappeared completely, leaving only a few ramifying ones in the interorbital region. New linear irregularly branching chromatophores of the same colour have appeared along the ventral side of the alimentary canal. The eyes also have assumed a bluish-green sheen with the pupils appearing dark in colour.

Three Day Old Larva

The larvae, which have become active swimmers on the third day, have been observed to frequent the bottom of the aquarium pecking at the sediments. They have increased in length and measure 3.5 mm. The pectoral fins have become larger in size (Fig. 7). The caudal fin rays have increased in number and are seen more prominently. A few more black, branching chromatophores have appeared in the vicinity of the heart and also along the base of the post-anal fin-fold. The eyes have become silvery-white in colour with deep black pupils.

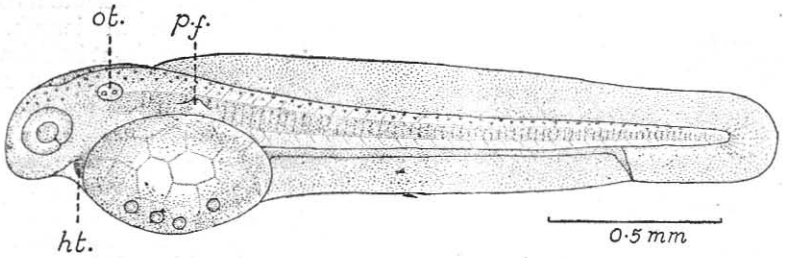

FIG. 5. One day old larva of *Kowala coval.* ot.: otocyst; p. f.: pectoral fin; ht.: heart

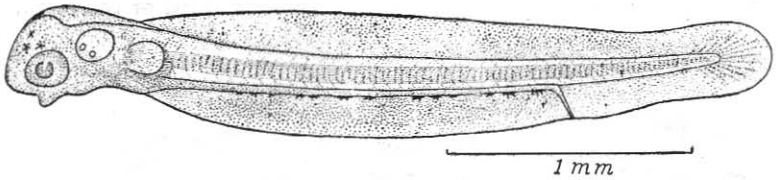

FIG. 6. Two day old larva of *Kowala coval.*

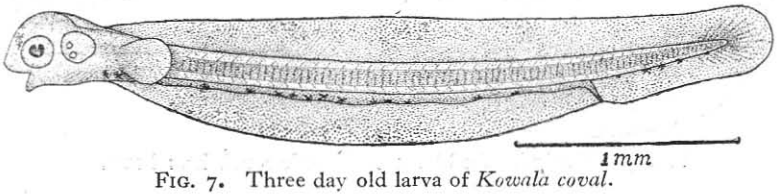

FIG. 7. Three day old larva of *Kowala coval.*

Four Day Old Larva

The larvae on the fourth day show no important changes except a slight increase in their length to 3.75 mm (Fig. 8). Most of the larvae in this stage have become inactive and emaciated in appearance, with the stomach region curved in, evidently due to lack of proper food. In this condition they are easily susceptible to attacks by the ciliates found in large numbers in sea water in spite of precautionary measures, causing a very high mortality. The few remaining ones become shrivelled up the next day, making it impossible to make any further observations. Many attempts were made to rear the larvae beyond this stage by providing them with carefully selected fresh plankton for food, but these proved futile and in all cases the larvae died during this critical transition period in their life-history.

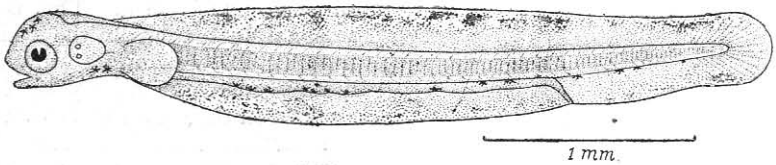

FIG. 8. Four day old larva of *Kowala coval.*

BIONOMICS

Distribution

The white sardine, *Kowala coval*, which is easily distinguished by its yellowish-white colour and silvery lateral band, is a widely-distributed species attaining a maximum size of 13 cm and is recorded from India, Pakistan, Ceylon, Burma, Malaya, Malay Archipelago and China (Misra, 1947). It is a shoaling species inhabiting the shallow coastal waters. Shoaling in vast numbers is known only from the West Coast of India. Recently Mookerjee and Bhattacharya have reported its occurrence in swarms even in the East Coast. Species of Leiognathus and Stolephorus have frequently been observed to occur in large numbers in association with the shoals of white sardine.

Food and Feeding Habits

The food of the white sardine consists exclusively of plankton. The results of the detailed quantitative and qualitative analyses carried out during the period of investigation have been briefly summarised in Table I in which among the different dominant organisms of the stomach contents, the maximum occurrence of each in a particular month alone has been given, following the arbitrary groupings indicated in the Table. It will suffice to give an idea of the relative seasonal abundance of the different generic constituents and their importance in the dietary of the fish. It is apparent that the most favoured food is the cladoceran, Evadne which, whenever it occurs in swarms in the foreshore waters, has been noticed to constitute the bulk of the food of this fish. This tendency to feed on Evadne is particularly pronounced in the young. Penaeid larvae, larvae of other crustaceans, Lucifer and the common copepods of the genera Acartia, Corycaeus, Temora, Oithona and Euterpina are the other important zooplanktonic forms contributing to their food. Occasionally fish eggs, mostly those of Caranx, have been observed in the stomach contents in fair numbers but no fish larvae have so far been observed. Of the phytoplanktonic elements, large numbers of Thallassiothrix (*T. frauenfeldii* and *T. longissima*) occasionally constitute the main food, but other genera like Nitzschia, Fragilaria, Coscinodiscus, Chaetoceros and Rhizosolenia have also been observed to contribute regularly to the food of the white sardine.

It has also been observed that intensive feeding takes place in the post-monsoon months, when there is rich production of plankton and this active feeding results in the accumulation of large quantities of fat with its characteristic sparkle in the abdominal cavity enveloping the viscera. This fat is utilised during the spawning period and no trace of it is seen in the spawners and spent white sardines.

Age Determination

The three methods usually employed for the age determination of fishes were adopted in this investigation. The scales and otoliths, particularly the latter, were subjected to intensive study by employing also the method adopted for the study of the otoliths of the oil sardine (Nair, 1949). Very early during the course of the investigation it became apparent that there is no indication of the presence of annual rings on these structures.

Therefore, Petersen's method alone was followed. During the three years of study 6,510 specimens belonging to 66 different samples were measured and analysed. The length frequency analyses for the years 1948, 1949, 1950 and for the entire period of investigation are given in Tables II, III, IV and V respectively. The length frequency polygons prepared separately for the three years and for the

entire period are given in Figs. 9 and 10. A study of these tables and figures shows the striking feature of the presence of only one mode represented by the 10.5 cm size-group which formed about a third of the total measured during the period of investigation. The unimodal nature of the size frequency polygon clearly shows that there is only one age-group represented in the fishery. This year-class which dominates the fishery every successive year can only be the stock recruited during the previous spawning season. The rapid growth-rate is evident from the progressive increase in the proportion of the different size-groups up to the 6.5 cm group after which a slight fall in the next three groups is seen. This is mainly due to the seasonal fluctuations in the availability of the juveniles in the area under study. The smaller fish usually enter the fishery by May and a gradual increase in their number is seen up to August when the maximum number occurs in the fishing area. Their complete disappearance from the foreshore waters in the succeeding months is mainly due to certain environmental factors caused by the South West monsoon. The intensification of the monsoon in June and July results in the formation of ' mud banks ' in the foreshore areas when the sea water becomes heavily laden with fine mud which gradually settles down after the cessation of the monsoon. This is followed immediately by the occurrence of swarms of Noctiluca imparting a red colour to the sea water to constitute the ' red water phenomenon ' which is known to affect adversely the general fishery conditions. These factors particularly affect the post-larval and juvenile fishes which completely disappear from the foreshore waters during the August-October post-monsoon period. The repopulation of the area by these fish is gradual depending on the species. Though the white sardine fishery commences immediately after the monsoon, the juveniles take a much longer time to enter the foreshore waters. In spite of the fact that these factors have caused an insufficient representation of certain size-groups in the data, the absence of any other distinct mode to constitute another year-class leads to the inference that the average life span of the white sardine is about a year with only a relatively very small number surviving for a longer period as suggested by the sudden fall in the proportion of the higher size-groups. The new stock produced during the intensive spawning period extending from November to January apparently grows to a size of about 10 to 11 cms and dominates the best part of the white sardine season from September to November.

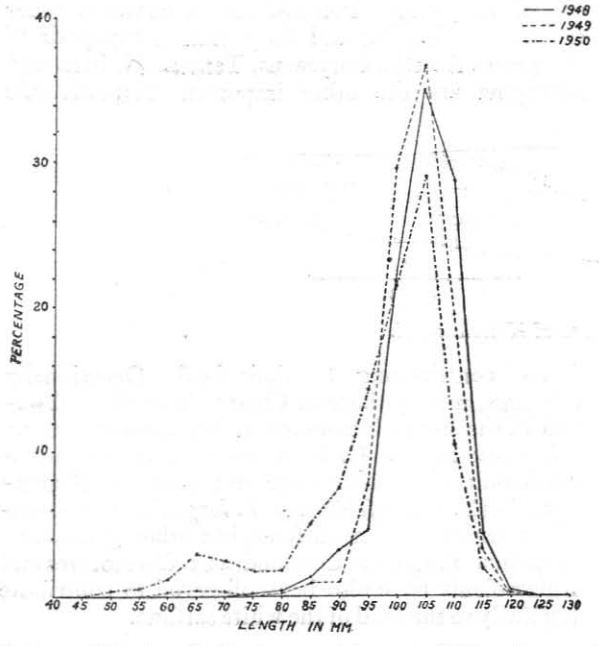

FIG. 9. The length frequency polygons of *Kowala coval* for the years 1948, 1949 and 1950.

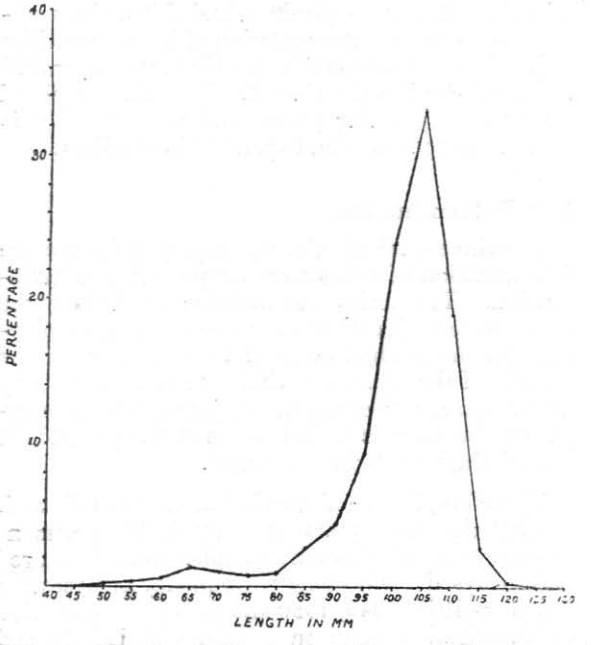

FIG. 10. The length frequency polygon of *Kowala coval* for the entire period of investigation (1948 to 1950).

The results of the investigation on the white sardines of the East Coast done by Mookerjee and Bhattacharya for a restricted period of seven months give corraborative evidence in support of the conclusion arrived at by the Petersen's method of age determination. These authors have shown by a study of the younger stages obtained from the Can-

ning River where they migrate in shoals that the average length of the juvenile fish increases from 25.5 mm in April to 72 mm in October.

Sex Ratio

The sex composition of the random samples examined in 1949 and 1950 was determined and there were 1,392 males and 1,374 females with a negligible number constituting the indeterminates. The size frequency of the males and the females in 5 mm range of total length is given in Tables VI and VII and in Figure 11. Sex differentiation takes

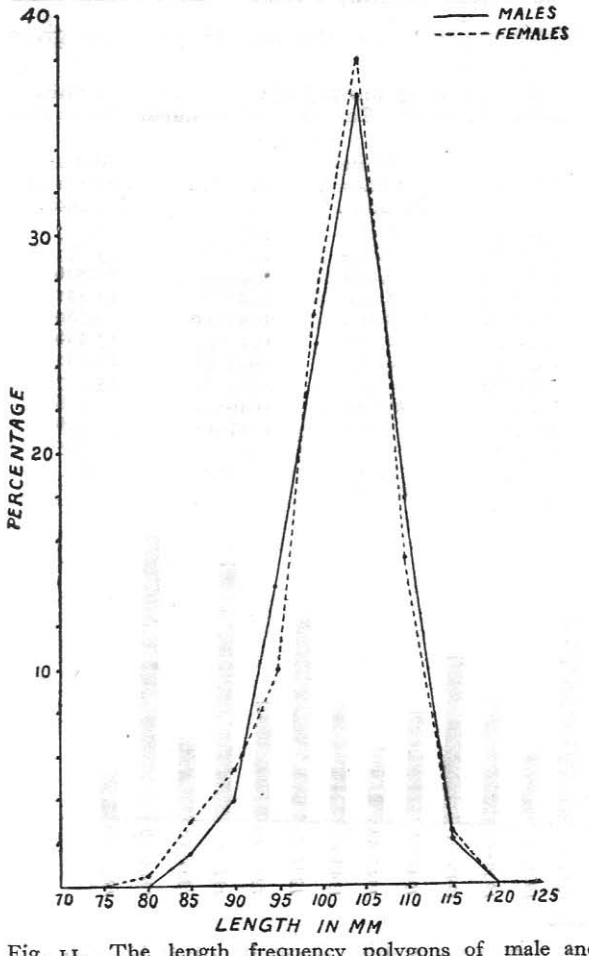

Fig. 11. The length frequency polygons of male and female *Kowala coval*.

place when the white sardines are small and the females become recognisable when they measure 7.5 cm while the males could be distinguished only when they measure 8 cm. It is also noticed that the females form a slightly higher percentage than the males in most of the size groups. The juveniles formed about 19 per cent of the total of each sex while the mature ones and spawners found within a narrow range between 10 and 10.9 cm constituted about 61 and 64 per cent of the total of males and females respectively. The higher groups were represented by about 20 per cent in the case of males whereas an appreciable fall to about 17 per cent was seen in regard to females. It is likely that this reduction in the number of females is caused by a higher rate of spawning mortality than in the males.

The complete atrophy of the right gonads is a characteristic feature of the white sardine. The left testis and ovary alone are functional and this is partly responsible for the very low fecundity. The estimated number of eggs in a mature female is about 8,000. Even though sex differentiation takes place at a very early size, the gonads attain full development only when the fish measure about 10 cm. In view of its short life span it is possible that each fish passes through the breeding season only once in its lifetime and the appearance of numerous small eggs in the ovaries of the spent and recovering individuals suggests the possibility of more than one spawning during the season.

Parasite

An unidentified cymothoan ectoparasite has been frequently noticed under the operculum of the white sardine.

FISHERY

The white sardine supports an important fishery along the West Coast, and the fishing season extends approximately from July to March. Very heavy catches, constituted mainly by fish ranging in length from 8 to 11 cm, frequently occur during the September to November portion of the season. The most important white sardine centres along the South Kanara and Malabar Coasts are :—Malpe, Kizhur, Puthiappa, Kadalundy, Parappanangadi, Tanur, Kootayi, Veliengode, Palapetty, Edakkazhiyur, Vadanapalli, Nattika, etc.

Fishing Methods

The white sardine fishery is confined to a narrow five to seven-mile strip of the coastal waters mainly due to the small size of the craft, namely the dugout canoe, commonly used by the fishermen along this Coast. The gear, however, has become efficient for the capture of these pelagic shoaling fishes during the course of several years. The most common nets used in the white sardine fishery are the gill net 'Chooda vala' and the boat seine 'Paithu vala'. Other types of gill nets like 'Mathichala vala' and boat seines like 'Nethal vala'

suited for the capture of oil sardine and whitebait are also used whenever the white sardine shoals are encountered unexpectedly while fishing for these shoaling fishes. The dimensions of the gill net 'Chooda vala' and the boat seine 'Paithu vala' are given below :—

Net	Length	Breadth	Size of mesh	Material
Gill net, 'Chooda vala'.	60′	10′	2/5″	Cotton
Boat seine, 'Paithu vala'.	Bag—40-45′ Platform—60′ Wings—160′	.. .. ..	1/5—1/2″ 8—9″ 3′	Cotton Coir Do.

The method of operation of these nets is similar to that of the gill nets and boat seines employed in the oil sardine fishery (Nair and Chidambaram, 1951). The boat seine 'Paithu vala' is usually employed during the peak of the fishery when large shoals frequently enter the coastal waters and immense catches are obtained with this net which, with its wings and platform, is ideally suited for the capture of the pelagic shoaling fishes. On the other hand the gill net 'Chooda vala' used exclusively for the capture of this fish, as the name implies, is used during the rest of the season for the capture of smaller shoals.

Fluctuations in the Fishery

The estimated total landings of white sardines from the fish-curing yards in the South Kanara and Malabar Coasts for the last 25 years are given below[1] :—

Table showing the estimated landings of white sardine in South Kanara and Malabar from 1925 to 1950

Seasons.	White sardines in Maunds.[2]	Seasons.	White sardines in Maunds.
1925-26	23,086	1938-39	9,783
1926-27	37,803	1939-40	15,873
1927-28	8,249	1940-41	21,826
1928-29	8,412	1941-42	14,421
1929-30	6,504	1942-43	9,789
1930-31	20,608	1943-44	15,286
1931-32	4,283	1944-45	27,981
1932-33	20,473	1945-46	15,617
1933-34	21,721	1946-47	33,488
1934-35	4,535	1947-48	10,836
1935-36	2,356	1948-49	36,845
1936-37	2,670	1949-50	6,263
1937-38	26,828		

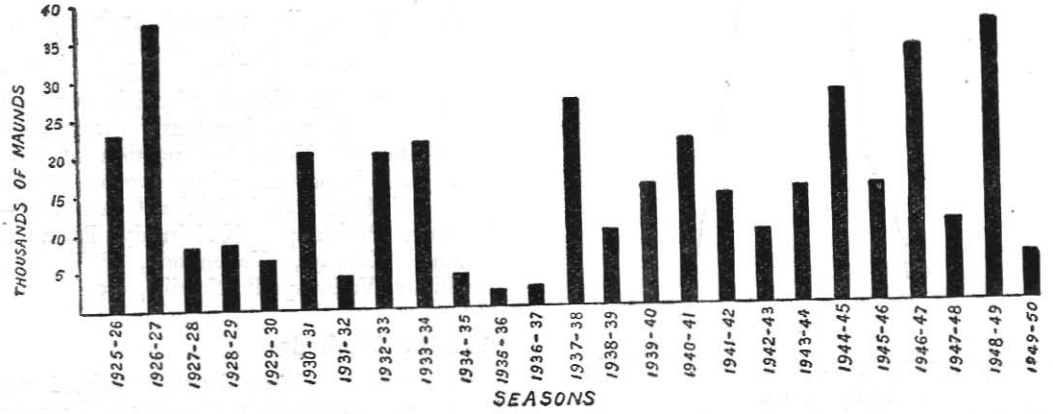

FIG. 12. The annual landings of *Kowala coval* in the South Kanara and Malabar Coasts from 1925 to 1950.

The fluctuating nature of the white sardine fishery is apparent from Fig. 12 prepared with the data given in the above table. The average annual landings for the entire period is about 16,000 maunds.[3] The landings of white sardine were more than 20,000 maunds in ten seasons. In some years the catches were relatively poor and the landings were less than 5,000 maunds in five seasons.

[1] I am grateful to Mr. K. Chidambaram for furnishing me with the data presented in the table.
[2] 27.22 Maunds = 1 Ton.
[3] The present value of a maund of white sardine is about Rs. 7.

Though the fishery varied from 37,803 maunds in 1926-27 to 2,356 maunds in 1935-36, an irregular fluctuation in abundance at intervals ranging from one to three years is seen. This is less when compared with the interval of two to six years in regard to the oil sardine. However, it is significant that both fisheries were good particularly in the years 1925-26, 1926-27, 1933-34, 1937-38 and 1940-41 after which the oil sardine fishery proved to be disastrous while the white sardine fishery showed a steady improvement in the years of abundance which is partly due to the increased exploitation consequent on the complete failure of the oil sardine fishery.

The white sardine is mostly consumed by the local people in the fresh condition and during the glut period the excess is usually cured with salt in proportions ranging from 8 : 1 to 10 : 1. It has very little economic importance on the East Coast because of its supposed non-availability in large numbers. But the recent findings of Mookerjee and Battacharya that it occurs in swarms on the East Coast also suggest the probable existence of an unexploited stock there.

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TABLE I

Analysis of the Food of White Sardine

Months	Rare (1-5)	Few (5-20)	Common (20-100)	Plenty (100-200)	Swarm (200 and above)
January	.. .. ..	Peridinium Prorocentrum Tintinnids Penilia Fish Eggs	Fragilaria Thallassiothrix Chaetoceros Polychaete Larvae	Oscillatoria	Evadne
February	..	Fragilaria Biddulphia Coscinodiscus	..	..	..
March	Biddulphia Fragilaria Coscinodiscus	Planktoniella	..	..	..
April	..	Coscinodiscus Ceratium Peridinium Copepods	..	..	..
May	Ceratium Larval Bivalves	Coscinodiscus Pleurosigma Biddulphia Ornithocercus	Polychaete Larvae	Copepods Crustacean Larvae	Evadne Penaeid Larvae
June	..	Rhizosolenia Coscinodiscus Prorocentrum Evadne Polychaete Larvae	Nitzschia Fragilaria	..	Thallassiothrix
July	..	Fragilaria Bacteriastrum Ceratium Tintinnids Copepods	Coscinodiscus Rhizosolenia Nitzschia	..	Evadne
August	.. ..	Asterionella Pleurosigma Oscillatoria Biddulphia Crustacean Larvae	Fragilaria Nitzschia Evadne Penilia Copepods Fish Eggs	Coscinodiscus Chaetoceros	..
September	Fragilaria Ceratium	Coscinodiscus Penilia Copepods Fish Eggs	..	..	Evadne
October	Planktoniella Prorocentrum	Biddulphia Evadne Copepods Fish Eggs	Nitzschia Lucifer	Coscinodiscus Fragilaria	..
November	Pyrophacus	Biddulphia Coscinodiscus Prorocentrum Penilia Copepods	Thallassiothrix Nitzschia Fragilaria Peridinium	Fish Eggs	Evadne
December	..	Rhizosolenia Copepods	Oscillatoria Fragilaria Coscinodiscus	Evadne	Thallassiothrix

TABLE II

Length Frequency Analysis for the Year 1948

Months	..	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	Total
January	..	..	..	..	..	..	..	..	..	..	..	..	..	..
February	..	..	..	..	..	..	..	..	..	..	..	..	..	..
March	..	..	..	..	..	..	..	..	..	..	..	..	..	..
April	..	..	..	..	..	..	..	..	..	..	..	..	..	..
May	..	..	..	..	..	..	3	20	75	12	..	..	..	110
June	..	..	..	..	..	..	..	..	..	..	..	..	..	..
July	..	..	..	..	1	1	6	21	20	25	3	1	..	78
August	..	1	4	7	23	40	30	53	97	100	16	..	..	371
September	..	..	..	1	3	26	26	53	51	45	3	..	..	208
October	..	..	..	..	..	..	2	9	28	45	15	1	..	100
November	..	..	..	..	..	..	23	211	359	322	54	4	1	974
December	..	..	..	..	..	..	6	89	106	54	..	..	..	255
Total	..	1	4	8	27	67	96	456	736	603	91	6	1	2,096
Percentage	..	0.05	0.19	0.38	1.29	3.2	4.58	21.76	35.11	28.77	4.34	0.29	0.05	..

TABLE III

Length Frequency Analysis for the Year 1949

Months	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	Total
January	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
February	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
March	..	..	..	..	..	..	..	..	..	7	22	18	3	..	..	..	50
April	..	..	..	..	..	..	..	..	13	23	30	17	..	..	..	..	83
May	..	..	..	..	..	..	..	..	5	26	48	17	5	..	1	..	102
June	..	..	..	2	..	..	..	..	..	1	10	7	3	..	..	..	23
July	1	4	7	4	1	..	..	..	..	..	..	..	..	..	..	..	17
August	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
September	..	..	..	..	..	2	18	15	11	47	78	66	15	1	..	..	253
October	..	..	..	..	..	..	..	1	27	71	188	121	19	..	..	..	427
November	..	..	..	..	..	1	..	2	75	330	257	78	9	1	..	1	754
December	..	..	..	..	..	..	..	..	10	43	47	37	6	1	..	..	144
Total	1	4	7	6	1	3	18	18	141	548	680	361	60	3	1	1	1,853
Percentage	0.05	0.22	0.38	0.32	0.05	0.16	0.97	0.97	7.61	29.57	36.7	19.48	3.24	0.16	0.05	0.05	

TABLE IV

Length Frequency Analysis for the Year 1950

Months	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	Total
January	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
February	..	..	..	..	..	..	..	..	..	..	2	3	6	..	1	..	12
March	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
April	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
May	..	..	..	..	..	2	7	6	10	11	57	77	30	..	..	..	200
June	..	..	..	..	1	..	7	6	16	12	15	31	11	1	..	..	100
July	..	4	6	4	3	..	2	2	2	..	..	..	1	..	..	..	24
August	1	4	7	27	73	62	24	29	83	86	68	141	192	64	4	1	866
September	..	..	..	..	..	..	5	3	16	11	17	23	19	5	1	..	100
October	..	..	..	..	..	..	..	..	2	2	26	184	406	168	17	1	806
November	..	..	..	..	..	..	..	..	..	30	55	36	46	18	..	..	185
December	..	..	..	..	..	..	..	..	..	38	124	58	32	14	2	..	268
Total	1	8	13	31	77	64	45	46	129	190	364	553	743	270	25	2	2,561
Percentage	0.04	0.31	0.51	1.21	3.01	2.50	1.76	1.80	5.04	7.45	14.21	21.59	29.01	10.54	0.98	0.08	

TABLE V

Length Frequency Analysis for the Years 1948-50

Months	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	Total
January	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
February	..	..	..	..	..	..	..	..	..	..	2	3	6	..	1	..	..	..	12
March	..	..	..	..	..	..	..	..	..	..	..	7	22	18	3	..	..	..	50
April	..	..	..	..	..	..	..	..	..	..	13	23	30	17	..	..	..	..	83
May	..	..	..	..	..	2	7	6	10	11	65	123	153	29	5	..	1	..	412
June	..	..	..	..	1	2	7	6	16	12	15	32	21	8	3	..	..	..	123
July	..	4	7	8	10	4	3	2	3	1	6	21	21	25	3	1	..	..	119
August	1	4	7	27	73	63	28	36	106	126	98	194	289	164	20	1	..	..	1,237
September	..	..	..	..	..	..	5	6	37	52	54	123	148	116	19	1	..	..	561
October	..	..	..	..	..	..	..	..	2	3	55	264	622	334	51	2	..	..	1,333
November	..	..	..	..	..	..	..	1	..	32	153	577	662	418	63	5	1	1	1,913
December	..	..	..	..	..	..	..	..	..	38	140	190	185	105	8	1	..	..	667
Total	1	8	14	35	84	71	50	57	174	275	601	1,557	2,159	1,234	176	11	2	1	6,510
Percentage	0.02	0.12	0.22	0.54	1.29	1.09	0.77	0.88	2.67	4.22	9.22	23.92	33.16	18.96	2.70	0.17	0.03	0.02	

TABLE VI

Length Frequency Analysis of Males

Months	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	Total
January	..	..	..	..	..	..	..	..	..	..	..
February	..	..	..	2	1	3	..	.	..	..	6
March	..	..	..	..	3	9	14	3	..	..	29
April	..	..	..	6	14	13	8	..	..	..	41
May	..	..	..	2	13	29	8	2	..	1	55
June	..	..	..	..	1	3	4	1	..	..	9
July	..	..	..	..	..	..	..	..	..	..	..
August	1	19	14	14	52	95	28	2	..	..	225
September	..	..	..	..	8	20	15	5	..	..	48
October	..	..	..	8	50	150	93	11	..	..	312
November	..	..	21	73	145	138	46	4	..	..	427
December	..	..	18	85	58	44	32	2	1	..	240
Total	1	19	53	190	345	504	248	30	1	1	1,392
Percentage	0.07	1.36	3.81	13.65	24.78	36.21	17.82	2.16	0.07	0.07	

TABLE VII

Length Frequency Analysis of Females

Months	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	Total
January	..	..	..	..	..	..	..	..	..	..	..
February	..	..	..	..	..	2	3	..	1	..	6
March	..	..	..	..	..	4	13	4	..	..	21
April	..	..	..	..	7	9	17	9	..	..	42
May	..	..	..	..	3	13	19	9	3	..	47
June	..	..	..	..	..	..	7	3	2	..	12
July	..	..	..	..	..	..	..	..	..	..	..
August	1	5	40	40	27	70	90	34	1	..	308
September	..	..	2	3	..	18	31	28	8	1	91
October	..	..	..	..	12	74	205	69	9	..	369
November	..	..	..	10	40	126	100	31	2	..	309
December	..	..	..	20	49	43	34	18	5	..	169
Total	1	5	42	73	138	359	519	205	31	1	1,374
Percentage	0.07	0.36	3.06	5.31	10.04	26.13	37.77	14.92	2.26	0.07	..