A PRELIMINARY STUDY OF THE PELAGIC FISH EGGS AND LARVÆ OF THE GULF OF MANNAR AND THE PALK BAY

By S. V. Bapat

*(Central Marine Fisheries Research Station, Mandapam)**

Introduction

A study of the occurrence, distribution and development of fish eggs and larvæ as an integral part of a fishery research programme serves as a valuable aid in the proper management of fisheries. Although there are several practical difficulties in studies of this nature, some progress has been made in this direction during the last few years in India. Devanesan and John (1940, 1941) have reported the occurrence of the eggs of *Rastrelliger kanagurta* and *Kowala thoracata* off the West Hill coast. Devanesan and Chidambaram (1941) gave a brief account of the eggs and newly hatched larvæ of *Anodontostoma chacunda* and *Caranx crumenophthalmus*. A few eel eggs from the Madras coast have been recorded by Aiyar *et al.* (1944—abstract). In a tabular statement Chacko (1950) gave the salient features of the eggs and larvæ of 16 species of fishes collected from the waters around the Krusadai Island, based on the observations of Delsman (1925–38). It has been, however, noticed that there are some variations in the descriptions given by Chacko and by Delsman. Nair and Bhimachar (1950) described three forms of eel eggs from the Gulf of Mannar. An account of the eggs and larvæ of *Sardinella sirm*, *Anchoviella tri*, *Thrissocles* sp. and *Solea ovata* was given by John (1951). Descriptions of the eggs and larvæ of the genera *Thrissocles*, *Anchoviella*, *Cynoglossus*, *Caranx*, *Saurida* and a pelagic egg mass from the Madras plankton were given by Nair (1952). The present paper deals with the pelagic fish eggs and larvæ occurring in the Gulf of Mannar and the Palk Bay off Mandapam.

Material and Methods

The material for the present study consisted of 238 samples of plankton collected from the Gulf of Mannar and the Palk Bay. For the sake of uniformity all samples were collected between 6·00–7·30 in the morning. A total number of 43,352 fish eggs, 36,839 collected in 122 samples of plankton from the Gulf of Mannar (78 during October 1949 to September 1950 and 44 during July 1951 to

* *Present Address :* Mackerel Fisheries Research Unit of the Central Marine Fisheries Research Station, Karwar.

June 1952) and 6,513 from 116 samples from the Palk Bay during May 1951 to June 1952, were examined.

The fish eggs were identified as follows :—The eggs were hatched in the laboratory and the larvæ reared to a stage at which they could be identified specifically. The larvæ remained healthy and active until almost all the yolk was absorbed, but further growth was retarded probably due to lack of natural food, which resulted in their death after one or two days. Larvæ fed on various items of artificial and natural food and eggs reared in cages in the natural environment did not yield satisfactory results. Artificially fertilised eggs of some common species of local fish were also allowed to develop into the identifiable larval stages.

Fish eggs in plankton samples were picked out, sorted, counted and kept in troughs in the laboratory for hatching and further developmental studies as a routine measure. The plankton samples were then preserved for subsequent sorting of eggs. The eggs from each sample were separated into lots, *viz.*, *A*, *B*, *C*, *D*, *D*1, *E*, *F*, *G*, *H*, *I*, *K*, *L*, *N* and *S* according to the size of the egg capsule, the egg comprising the yolk and the developing embryo, the nature of the yolk, the presence or absence of oil globule or globules and their sizes, the pigmentation on the oil globule, yolk or the developing embryo, the markings on the surface of the egg capsule etc. A record of the total number of eggs and the number of eggs of each type in a sample with their range in sizes was maintained. As the number of samples collected varied from month to month, monthly averages were calculated by dividing the total number of eggs collected in a month by the number of samples with fish eggs, to make the results comparable. Tables I and II show the average number of fish eggs of different types collected in each month from the Palk Bay and the Gulf of Mannar. Table III gives in detail the characteristic features of the different types of eggs and larvæ with the provisional identifications.

Spawning Time and the Period of Incubation

It may not be out of place here to indicate the probable time of spawning and the period of incubation of these eggs in the Gulf of Mannar and the Palk Bay off Mandapam. The eggs of the type *B*, *D*, *H*, *C* and *I*, taken in plankton collections in the morning, were in fairly advanced stages of development and hatched in the laboratory after about 8–10 hours from the time of collection, whereas similar varieties of eggs, taken in plankton samples collected at night between 10–11 P.M., were in an early stage of development. Hence it appears that the spawning takes place some time late in the evening or early part of the night and the incubation period extends over 18–20 hours approximately. The type *E* eggs, present in the samples collected in the morning, were in a very early stage of development. These eggs were not taken in night plankton samples, indicating perhaps that spawning took place in the early hours of the day. They hatched in the laboratory after

TABLE I

The average number of fish eggs in the Gulf of Mannar during 1949–50

Month	A	B	C	D	E	F	G	H	I	K
October 1949	0·50	0	18·00	0	0	0	0	0	6·00	0
November „	3·50	32·50	10·50	0	8·00	0	0	0	9·00	0
December „	0·33	0	1·33	0	2·00	0	0	0·33	29·33	0
January 1950	0	0·33	18·83	1·16	0·83	0·16	0	0·50	52·50	0
February „	3·12	8·25	255·25	56·50	51·87	0	0·12	0·25	27·25	0
March „	3·80	22·60	572·70	353·80	33·50	0·10	0·20	0	44·80	0·10
April „	0·50	8·66	32·83	23·50	8·83	0	0	0	4·00	0
May „	0·14	11·85	0·14	0	5·14	0	0·14	0	0·28	0
June „	1·33	69·15	0·66	1·33	3·50	0	0	0	2·50	0
July „	0·12	8·25	10·75	0	3·50	0	0	0	6·62	0·37
August „	0	2·00	3·50	0	0·50	0	0	0	1·50	0
September „	0	0	7·25	0	4·50	0	0	0	0·25	0·25

TABLE II

The average number of fish eggs in the Gulf of Mannar and the Palk Bay during 1951–52

Type of eggs	May 1951		June 1951		July 1951		August 1951		September 1951		October 1951		November 1951	
	Gulf of Mannar	Palk Bay	Gulf of Mannar	Palk Bay	Gulf of Mannar	Palk Bay	Gulf of Mannar	Palk Bay	Gulf of Mannar	Palk Bay	Gulf of Mannar	Palk Bay	Gulf of Mannar	Palk Bay
A	–	4·22	–	0	0	1·28	0·50	0	0·50	0·14	0	0·66	0·75	3·00
B	–	0	–	0	2·50	0·28	3·50	0	0·50	0·42	0·20	0	2·00	0
C	–	7·11	–	0	0	10·57	83·75	36·66	316·25	65·85	35·40	103·66	181·25	101·00
D	–	0·11	–	0·50	1·00	2·42	0·50	3·00	6·00	3·57	0·40	3·66	0·25	2·33
*D*1	–	0	–	0	0	0	0	0	0	0	0	0	0	0
E	–	3·88	–	0	27·00	2·85	18·25	3·55	186·50	5·00	94·40	2·50	152·25	16·16
F	–	0·33	–	0	0	0·57	0	0·33	0·75	8·42	1·00	5·50	0	0
G	–	0	–	0	0	0·57	0	0	0	0	0	0	0	0
H	–	0	–	0	0	0	0	0	0	0	0	0	0	0
I	–	0·33	–	1·50	1·50	6·00	5·00	6·00	71·25	22·85	53·40	13·00	4·00	15·33
K	–	0	–	0·25	0	0·14	0·25	0·11	0	0·14	0	0	1·00	0
L	–	0	–	0	0	0·28	0	0	0	0	0	0·16	0	0
S	–	0	–	0	0	0	0	0	0	0	9·40	0	1·25	0

TABLE II—(*Continued*)

Type of eggs	December 1951		January 1952		February 1952		March 1952		April 1952		May 1952		June 1952	
	Gulf of Mannar	Palk Bay	Gulf of Mannar	Palk Bay	Gulf of Mannar	Palk Bay	Gulf of Mannar	Palk Bay	Gulf of Mannar	Palk Bay	Gulf of Mannar	Palk Bay	Gulf of Mannar	Palk Bay
A	0	0	0·60	0	12·25	0·14	6·25	2·00	0	0	15·00	1·25	0	1·28
B	2·75	0	9·20	0	9·20	0	187·75	0	7·00	0·28	501·50	0	0·33	0
C	16·00	0	49·40	5·00	673·25	24·00	1768·00	335·00	22·00	10·28	23·00	2·25	2·33	0
D	0	0·50	0	0	17·00	0	175·25	0	0	0	0	0	0	0
*D*1	0	0	0	0	4·25	0	26·00	0·37	0	0	0	0	0	0
E	168·00	8·00	37·00	0·33	76·50	0	129·75	1·12	11·00	0	71·00	0·25	34·00	6·14
F	0	0	0	0·33	0	0·14	0	0·50	0	1·00	0	0·25	0	1·28
G	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H	0·75	0	21·40	0	0	0	1·50	0	0	0	0	0	0	0
I	73·00	9·50	43·80	0	55·50	4·42	9·50	21·37	0	4·14	0	0·25	1·00	1·00
K	0	0	0·20	0	0	0	0·50	0·25	0	0·28	0	0	0·66	0
L	0	0	0	0	0·75	0	0	0	0	0	0	0	0	0·28
S	7·25	0·50	12·80	0·33	3·25	2·71	0	2·00	0	0·42	0	1·00	0	2·00

— Data not available ; 0 Eggs absent.

TABLE III. *Showing the characteristic features of the different types of eggs and larvæ with the provisional identifications*

Type and range of size in mm.	Characteristic features of the egg	Characteristic features of the larvæ	Remarks, references and provisional identification
1	2	3	4
A Major axis 1·112–1·361 mm. Minor axis 0·514–0·660 mm.	Ellipsoidal. Yolk transparent, colourless and coarsely vacuolated. Single, transparent, colourless oil globule ranging from 0·099–0·116 mm. Perivitelline space at the two poles. No pigment on embryo, yolk or oil globule—Fig. 1.	Newly hatched larva: 2·20 mm. long. Yolk tapers posteriorly with the oil globule near posterior extremity of yolk sac. Eyes not pigmented. Anus opens below 27th myotome. Auditory vesicles appeared. Heart functioning. Muscle fibres on body show characteristic crossed arrangement, typical of clupeid larvæ. Two-day old larva: 3·00 mm. Position of anus not changed. 12–13 post-anal myotomes. Eyes pigmented, black. Mouth open. Buds of pectoral fins visible. Body unpigmented—Fig. 2.	Delsman (1931), Chacko (1950), John (1950) and Nair (1952) have assigned similar eggs to the genus *Anchoviella*. During February–March, 1952 it was possible to collect *Anchoviella indicus* specimens with mature ova without the terminal knob described by Delsman (1931). From the studies on the intra-ovarian ova of this species made by Prabhu (personal communication) it is likely that these eggs belong to *A. indicus* as this is the most common mature anchovy occurring in this area during February–March when these eggs are common in plankton collections. Provisionally identified as **Anchoviella** sp.
B 0·8 .6–1·248 mm.	Spherical, without oil globule. Majority size between 0·929 and 1·162 mm. Egg membrane thin without markings. Yolk colourless and coarsely vacuolated. Developing eymbryo with yolk 0·747–0·830 mm. Large perivitelline space. No pigment on yolk or embryo—Fig. 3.	Newly hatched larva: 3·35 mm. long. Anus below the 31st myotome. 10 post-anal myotomes. Muscle fibres show a crossed arrangement. Yolk sac tapering posteriorly. Eyes developed with a few melanophores at the posterior end; heart functioning; auditory capsules visible. Larva transparent—Fig. 4. 1st day: 3·75 mm. Eyes brownish. Buds of the pectoral fins have appeared. Few melanophores along	Delsman (1929 and 1931) has said that the eggs of the Indian species of *Engraulis* are round and the myotomes in the newly hatched larva vary in number between 41 and 45. John (1951) has described the egg and larva of *Thrissocles* from the Madras plankton as having 1·05 mm. diam., 32 pre-anal and 13 post-anal, while Nair (1952) has recorded 0·92 mm., 30 pre-anal and 13 post-anal myotomes.

		the ventral side of the alimentary canal and yolk sac—Fig. 5. 2nd day: 4·182 mm. Eyes deep brown. 3rd day: Eyes completely black. Yolk completely absorbed: mouth open. Pectoral fins have developed. Anus below the 30th myotome. 14 post-anal myotomes. Pigmentation along the entire length of the alimentary canal has increased —Fig. 6. 4th day: Similar to three-day except pigmentation has increased. Striations of the future caudal fin rays are distinct. 5th day: Bifurcation of the caudal fin has taken place. Striations of pectoral fin rays have appeared—Fig. 7.	Chacko (1950) has described the eggs of *Engraulis dussumieri* from around Krusadai Island as having 0·85–0·95 mm. diameter and the newly hatched larva has 17 pre-anal myotomes. From the descriptions of Delsman, John and Nair it appears that these eggs and larvæ belong to the genus *Thrissocles*. Provisionally identified as Thrissocles sp.
D 0·713–0·864 mm.	Spherical in shape with a large perivitelline space. Yolk colourless, transparent and vacuolated, 6–12 small colourless transparent oil globules ranging from 0·033–0·066 mm. present. Melanophores are seen on the dorsal side of the developing embryo—Fig. 8.	Eight-hour old larva: 2·88 mm. Head detached from yolk sac. Anus opens below the 30th myotome. Yolk sac round, with 4–6 oil globules at the posterior end. Auditory vesicles and eyes have appeared. Muscle fibres on the myotomes show a crossed arrangement. Melanophores seen on the head and along the dorsal periphery of the myotomes—Fig. 9.	The egg and the larva agree with Delsman's (1926) description of *Dorosoma chacunda* entirely, except the position of anus which opens below 34th myotome. Delsman (1933) assigned these to *Clupeoides lile*. Devanesan and Chidambaram (1941) identified similar eggs as those of *Dorosoma chacunda* from West Hill. They have reported that these eggs swell up as the development progresses from 0·82–1·14 mm. during three hours. 35 pre-anal and 12 post-anal myotomes have been observed in the newly hatched larva. Chacko (1950) recorded these eggs from Krusadai area as 0·95–1·2 mm. The anus opened below the 26th myotome in the newly hatched larva. Nair (1952) has identified similar eggs as those of *Kowala coval*. The anus in the newly hatched larva

TABLE III—*Contd.*

1	2	3	4
			opens below the 34th or 35th myotome as against the 30th in an eight-hour old larva observed. Provisionally identified as **Kowala coval.**
D 1 0·864–1·056 mm.	Spherical. Yolk colourless, transparent and minutely vacuolated. Small oil globules 4–8 in number with diameters varying between 0·038 and 0·076 mm. Narrow perivitelline space. Most of the eggs in advanced stage of development. Eyes and auditory vesicles have been demarcated. 35–40 myotomes visible. Melanophores in three rows on the dorsal surface of the embryo—Fig. 10.		Similar eggs have been described by Delsman (1926, 1933) and have been recognised as those of *Dorosoma chacunda.*
G 1·41–1·67 mm.	Spherical. Yolk colourless, transparent, minutely vacuolated and almost fills the egg capsule. Perivitelline space narrow. Single colourless oil globule 0·113–0·182 mm. near the vegetative pole. No pigment on embryo, yolk or oil globule—Fig. 11.	Ten-hour old larva: 5·00 mm. Eyes have appeared. Yolk sac tapering posteriorly with the oil globule at the far end. Anus below 48th myotome. 4 post-anal myotomes. Heart functioning. Auditory vesicles visible. Crossed muscle fibres on myotomes. Melanophores on the head and along the body above alimentary canal—Fig. 12.	Delsman (1925) described similar eggs as those of the genus *Dussumieria* and in all probability, *D. hasseltii.* Only two species, namely *D. hasseltii* and *D. acuta,* have been described and it is still undecided as to whether they should be grouped as one species or kept separate as they are. Both the species are represented in the local waters. According to Delsman the anus opens below 49–50th myotome in newly hatched larvæ. Eggs of *Dussumieria hasseltii* have been recorded by Chacko (1950) around Krusadai Island with 0·88 mm. diameter. Anus in newly hatched larva opening below 45–48th myo-

			tome. Provisionally referred to as **Dussumieria sp.**
H 1·328–1·339 mm.	Spherical. Yolk colourless, transparent and coarsely vacuolated. Single oil globule 0·099 mm. in diameter. Yolk mass and embryo occupy nearly half the egg capsule leaving a large perivitelline space. No pigment on embryo, yolk or oil globule—Fig. 13.	Larva 18 hours old: 3·08–3·14 mm. 38–39 pre-anal and 7–8 post-anal myotomes. Yolk sac tapering posteriorly with oil globule on the anterior side. Eyes and auditory vesicles visible. Heart functioning. Muscle fibres on myotomes show crossed arrangement. No pigment. —Fig. 14. Larva 48 hours old: 4·15–4·25 mm. Yolk almost absorbed. Buds of the pectoral fins developed. Mouth open. Eyes getting pigmented. Streaks of pigment along alimentary canal—Fig. 15. 5th day: Eyes deeply pigmented. Mouth open with developed jaws. Pigmentation along the entire alimentary canal deepened—Fig. 16.	Delsman's descriptions (1926) of egg and larvæ of *Clupea fimbriata* agree with this except that these eggs are smaller in size by 0·11 mm. and the newly hatched larva has 40 pre-anal myotomes. Two months after the occurrence of these eggs, there is a sardine scoop net fishery, off Monakkad near Mandapam to which *S. fimbriata* measuring 30–40 mm. contribute to the extent of 50%. *S. gibbosa* also occur. Eggs of *S. gibbosa* described by Chacko (1950) have a diameter 0·68–0·84 mm. with frothy yellowish yolk and a small oil globule. The newly hatched larva has 29 pre-anal myotomes. Provisionally identified as **Sardinella fimbriata.**
C 0·531–0·697 mm.	Spherical. Yolk coarsely segmented, colourless and transparent. Single, colourless, transparent oil globule 0·116–0·149 mm. in diameter. Perivitelline space narrow. No pigment on yolk, oil globule or developing embryo—Fig. 17.	Newly hatched larva: 1·85 mm. Anus opens just behind the yolk sac below the 12th myotome. 16 post-anal myotomes. Oil globule located in the middle of yolk sac on ventral side. Eye and auditory vesicles appeared. Heart pulsating. Melanophores and xanthophores are seen on head in front of eye and in two vertical patches on the body. Melanophores unevenly distributed on the body and oil globule—Fig. 18. 1st day: 2·15 mm. Eyes deep brown. Most of the yolk absorbed and oil globule become small. Buds of pectoral fin appeared. Post-anal myotomes 18. Pigmentation in three vertical bands, on the head, trunk and tail—Fig. 19. 2nd day: 2·33 mm. Eyes black.	The segmented yolk, short alimentary canal opening just behind yolk sac are characteristic of the Genus *Caranx*, Delsman (1926). *Caranx leptolepis* was the most common carangid fish with ripe ova at Rameswaram Road, Dhanushkodi and Kundagal Pt. during January–March 1952. Size of ripe intra-ovarian ova and oil globule and the nature of yolk agreed well with the eggs. Attempts at artificial fertilisation were not successful. Studying the intra-ovarian ova of this fish, Prabhu (personal communication) has suggested that this species spawns in February and in August. This agrees with the occurrence of these eggs in two peaks in March and September. Chacko (1950) recorded eggs of

TABLE III—*Contd.*

1	2	3	4
		Mouth opened. Lower jaw slightly longer than upper. Pectoral fins more developed. Gill slits visible. Two more small pigment patches on the posterior side of the larva appeared—Fig. 20. 3rd day: Pectoral fins with striations of the rays. Anus shifts slightly forward, opening below the 11th myotome. 20 post-anal myotomes. Pigmentation increased showing six vertical bands beginning from the head—Fig. 21.	*Caranx hippos* from Krusadai area during August–September only. They are larger in size (0·7–0·9 mm.). Provisionally referred to as **Caranx leptolepis.**
I 0·747–0·990 mm.	**Spherical.** Yolk colourless and coarsely segmented. Large, yellow, oil globule 0·116–0·215 mm. in diameter profusely pigmented with melanophores. Narrow perivitelline space. Few melanophores on ventral side of developing embryo—Fig. 22.	Newly hatched larva: 1·54 mm. Anus opens just behind yolk sac, below 12th myotome. 10–12 post-anal myotomes. Yolk sac round and the oil globule located at the posterior side of yolk sac. Auditory capsules visible. Eyes not pigmented. Stellate pigment spots on head, oil globule and a vertical band comprising of xanthophores and melanophores on the body behind anus—Fig. 23.	Eggs and larva have the characteristic features of the Genus *Caranx* (Delsman, 1926). Provisionally referred to as **Caranx** sp.
E 0·630–0·818 mm.	Spherical, without oil globule. Yolk colourless, transparent and granular. Perivitelline space very narrow. Melanophores on the dorsal side of the developing embryo—Fig. 24.	Newly hatched larva: 40 mm. Anus opens just behind yolk sac, below 13th myotome. 8–10 post-anal myotomes. Eyes and auditory vesicles have appeared. Light brown pigment spots on the head—Fig. 25. Twelve-hour old larva: Head detached from the yolk sac, heart pulsating. Pigmentation on head deepened; pigment has appeared on the	

		dorsal periphery of yolk sac and ventral part of body—Fig. 26. 2nd day: 2·00 mm. Eyes black. Yolk absorbed. Mouth open. Buds of pectoral fins developed. 13 post-anal myotomes. Position of anus not changed. Large branched brown pigment spots along alimentary canal and ventral part of the body—Fig. 27.	
F 1·00–1·28 mm.	Spherical. Yolk colourless, transparent and granular. A large oil globule 0·215–0·231 mm. near the posterior end of the developing embryo. Perivitelline space large. 18 myotomes on the developing embryo. Melanophores on the ventral side of embryo and on the oil globule—Fig. 28.	..	..
K 1·195–1·267 mm.	Spherical, with bold hexagonal markings on egg capsule. The side of each hexagon is 0·172 mm. Distance between two opposite sides 0·288 mm. Thickness of hexagons 0·0288 mm. Minute striations on the sides of the hexagon. Yolk colourless and granular. 20–24 small oil globules 0·038–0·076 mm. irregularly distributed in the yolk. Perivitelline space narrow. Few melanophores on the dorsal side of developing Embryo—Fig. 29.	Newly hatched larva: Anus below the 10th myotome; 10–12 post-anal myotome. Yolk sac round with oil globules. Optic capsules and auditory vesicles visible. Buds of pectoral fin appeared. Heart pulsating. Brownish-black pigment form of patches along the body. 2nd day: 2·88 mm. Most of the yolk absorbed, mouth open, with thick sucker-like lips. Alimentary canal convoluted. Eyes pigmented. Melanophores mixed with greenish-yellow pigment spots along the margins of finfold and body in four vertical bands and in small clusters on the dorsal and ventral side of the body and on head—Fig. 30.	Fish eggs with hexagonal markings on the surface have been described by Delsman (1938) and Nair (1952) as belonging to the genus *Saurus*, but these eggs do not resemble them.
L 1·319–1·343 mm.	Large and spherical. Yolk colourless and granular. Oil globule large 0·323–0·340 mm. Narrow perivitelline space. Embryo and	Newly hatched larva: 2·58 mm. Yolk sac with round oil globule. Anus opens just behind the yolk sac. Heart pulsating, eyes visible and	

TABLE III—*Contd.*

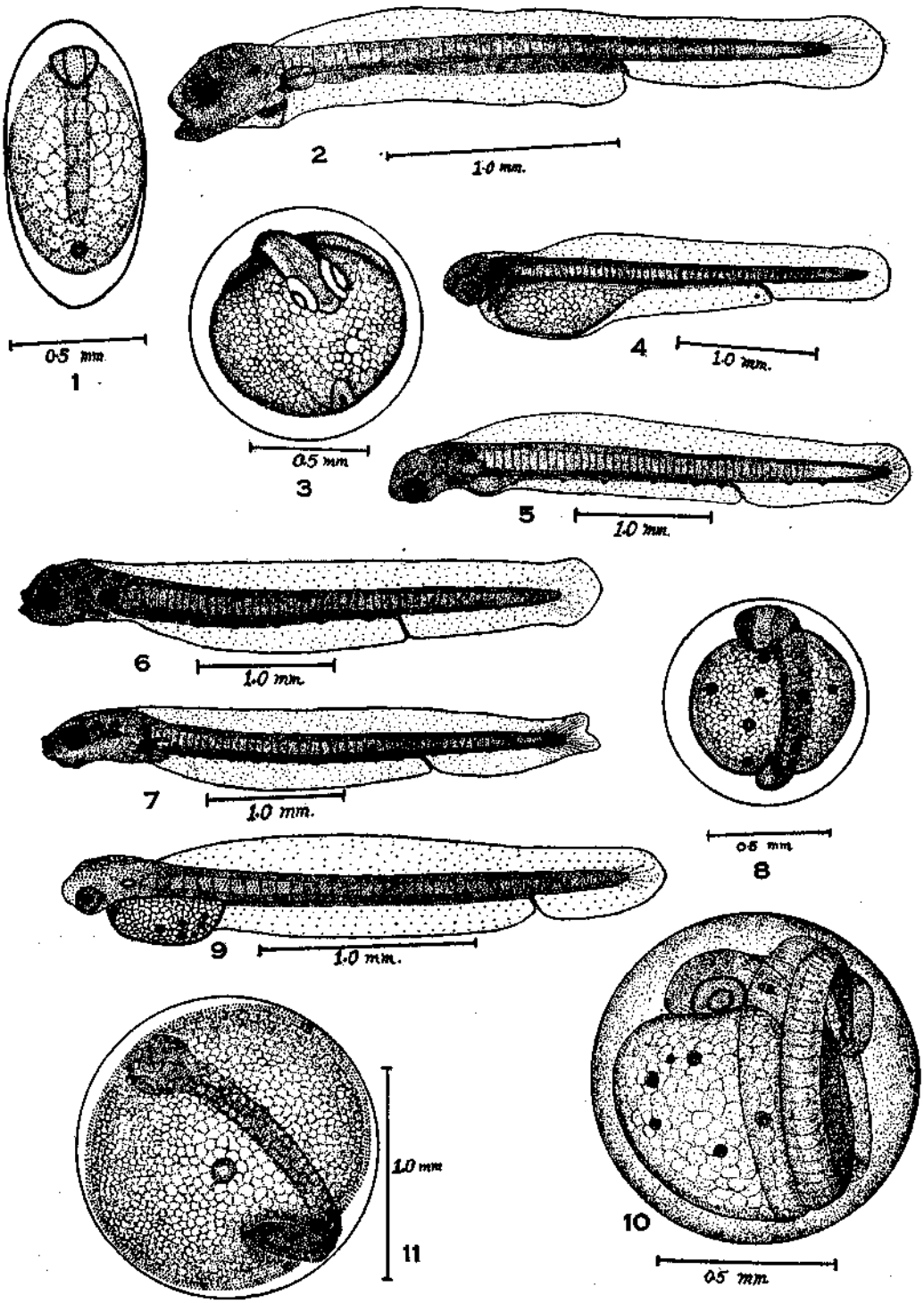
1	2	3	4
	oil globule profusely pigmented with melanophores—Fig. 31.	partly pigmented. The entire larva is pigmented black. 2nd day: 2·975 mm. Yolk present with the oil globule reduced. Eyes black. Mouth indicated but not yet open. Auditory vesicles visible. Buds of pectoral fins appeared. Pigment on head and dorsal portion of trunk disappeared; remaining part of body deep black—Fig. 32.	..
N 3·14–3·22 mm.	Spherical. Largest collected locally. Yolk colourless, transparent and coarsely vacuolated without oil globule. Narrow perivitelline space. No pigment on yolk or embryo. Eggs collected in an advanced stage of development. Eyes demarcated, heart pulsating, 58–62 myotomes could be counted—Fig. 33. After about 28 hours from the time of collection the embryo occupied all the space, the tail end reaching the head.	Newly hatched larva: 6·2 mm. Yolk almost absorbed. Anus opens below 59th myotome; 45 post-anal myotomes. Eyes not pigmented. Mouth open.	Nair and Bhimachar (1950) described three types of eel eggs from the Gulf of Mannar, off Tuticorin—resembles the one described by them as Egg II. Provisionally referred to as Eel egg.
S 0·835–1·035 mm.	Spherical. Yolk colourless and transparent. 20–30 small light yellow oil globules with diameters 0·04 – 0·08 mm. Perivitelline space very narrow—Fig. 34.	Newly hatched larva: Yolk mass rounded. Anus opens below 12th myotome, 10–11 post-anal myotomes. Eyes not pigmented. Auditory vesicles visible. Xanthophores on head, finfold and yolk sac and a small vertical band near the tail—Fig. 35. 4th day: Mouth open. Eyes black. Yolk absorbed. Fan-like pectoral fins with striations of rays. Large tentacle on head. Head, tentacle and body pigmented with xanthophores—Fig. 36.	Two types of *Cynoglossus* eggs are described by Nair (1952)—the one described here resembles the 2nd type. Provisionally referred to as Cynoglossus sp.

about 14 hours from the time of collection. It is noteworthy that all the eggs taken in a sample were more or less in the same stage of development, suggesting thereby that spawning in these cases took place only once a day. The eggs of the type *A*, taken in a sample, were found in various stages of development, indicating thereby that spawning may take place more than once a day in this particular species. As the types *K*, *G*, *L* and *N* were collected in very small numbers and the information at hand is scanty, it is difficult to fix the probable spawning time. Although in advanced stages of development at the time of collection, they have a prolonged incubation period, judging from the fact that they hatched in the laboratory after about 14, 26, 32 and 48 hours from the time of collection.

Seasonal Variations in the Abundance of Fish Eggs

Fig. 37 shows the occurrence of fish eggs in the Gulf of Mannar during 1949–50 and 1951–52 and the fluctuations of surface salinity and temperature. It will be noticed that during 1951–52 there was a higher concentration of fish eggs than in 1949–50, but the general trend of distributions is similar in the two years with the number of eggs increasing from January until they reach the peak in March, followed by an abrupt fall in April. From April onwards the eggs are relatively scarce, but there may be a slight increase in their number sometimes during September–November. Certain types of eggs were collected throughout the year with definite peak or peaks in particular months, indicating a protracted spawning season. The presence of fish eggs of one kind or another throughout the year is observed, but the maximum spawning takes place during March as judged from the total number of eggs present.

The salinity of the surface water in both the years increases gradually from 29·18–29·29‰ in January until it reaches 35·16–36·41‰ in May and continues to remain at this level until the end of October. Then it shows a tendency to decrease in November and abruptly falls to 29·38–29·49‰ in December. Hence the period from May to October may be considered as the high salinity period and the remaining months, January to April, November and December as the period of low salinity. Similarly the surface temperature of sea water shows an upward trend from January until it reaches the maximum in April–May and then registers a slight fall in June. By August it again rises, but from then on it gradually falls to a minimum in December. Therefore, the months from April to August excluding June may be regarded as the high temperature period and the remaining months as the low temperature period. It is seen from Fig. 37 that the main peak of fish eggs in March falls during the low surface salinity-temperature period.

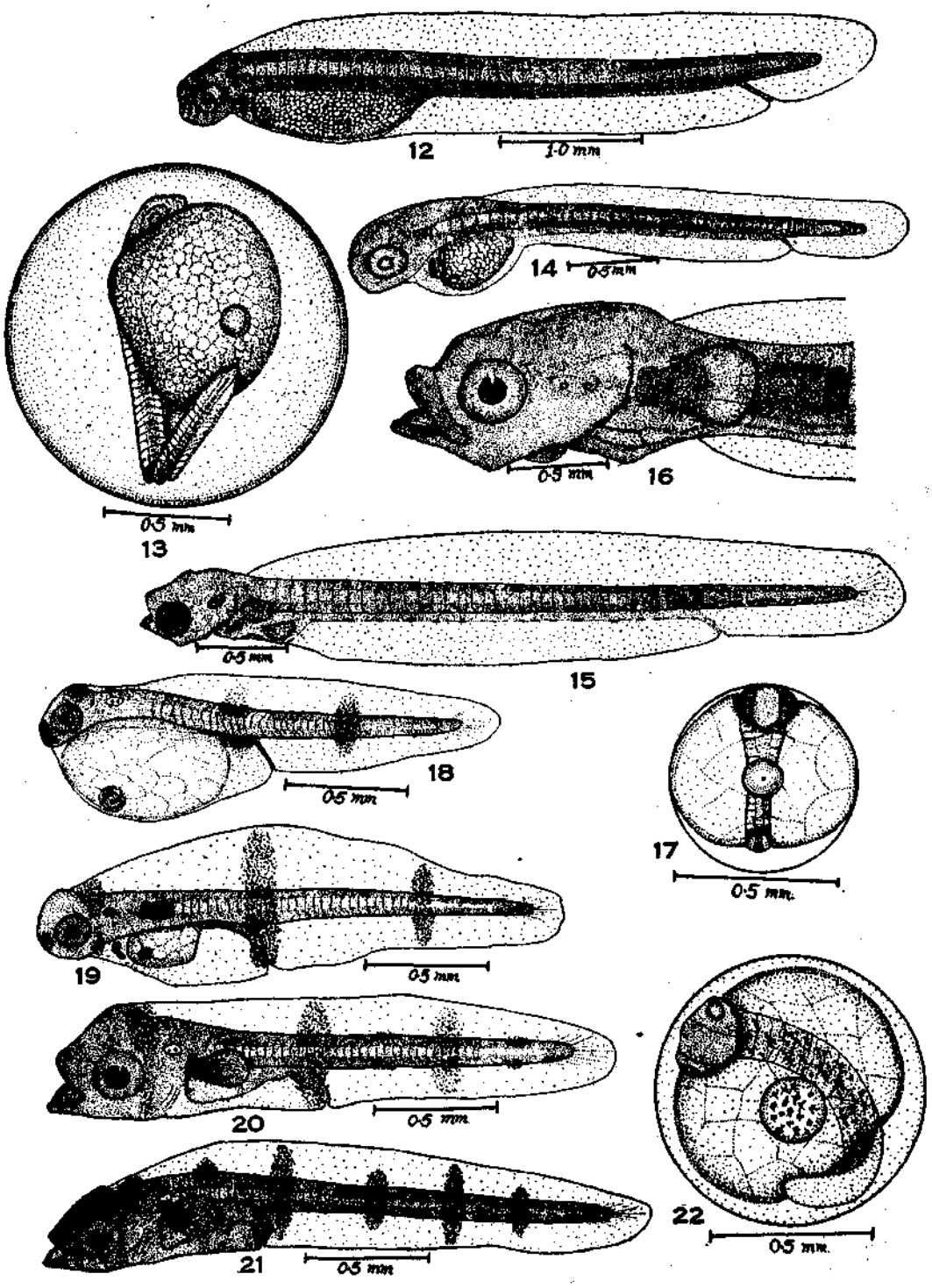


FIGS. 1–11. Fig. 1. Egg of type *A* (*Anchoviella* sp.). Fig. 2. Two-day larva of Egg A. Fig. 3. Egg of type *B* (*Thrissocles* sp). Fig. 4. Newly hatched larva of *B*. Fig. 5. One-day old larva of *B*. Fig. 6. Three-day old larva of *B*. Fig. 7. Five-day old larva of *B*. Fig. 8. Egg of type *D* (*Kowala coval*). Fig. 9. Eight-hour old larva of *D*. Fig. 10. Egg of type *D*1. Fig. 11. Egg of type *G* (*Dussumieria* sp.).

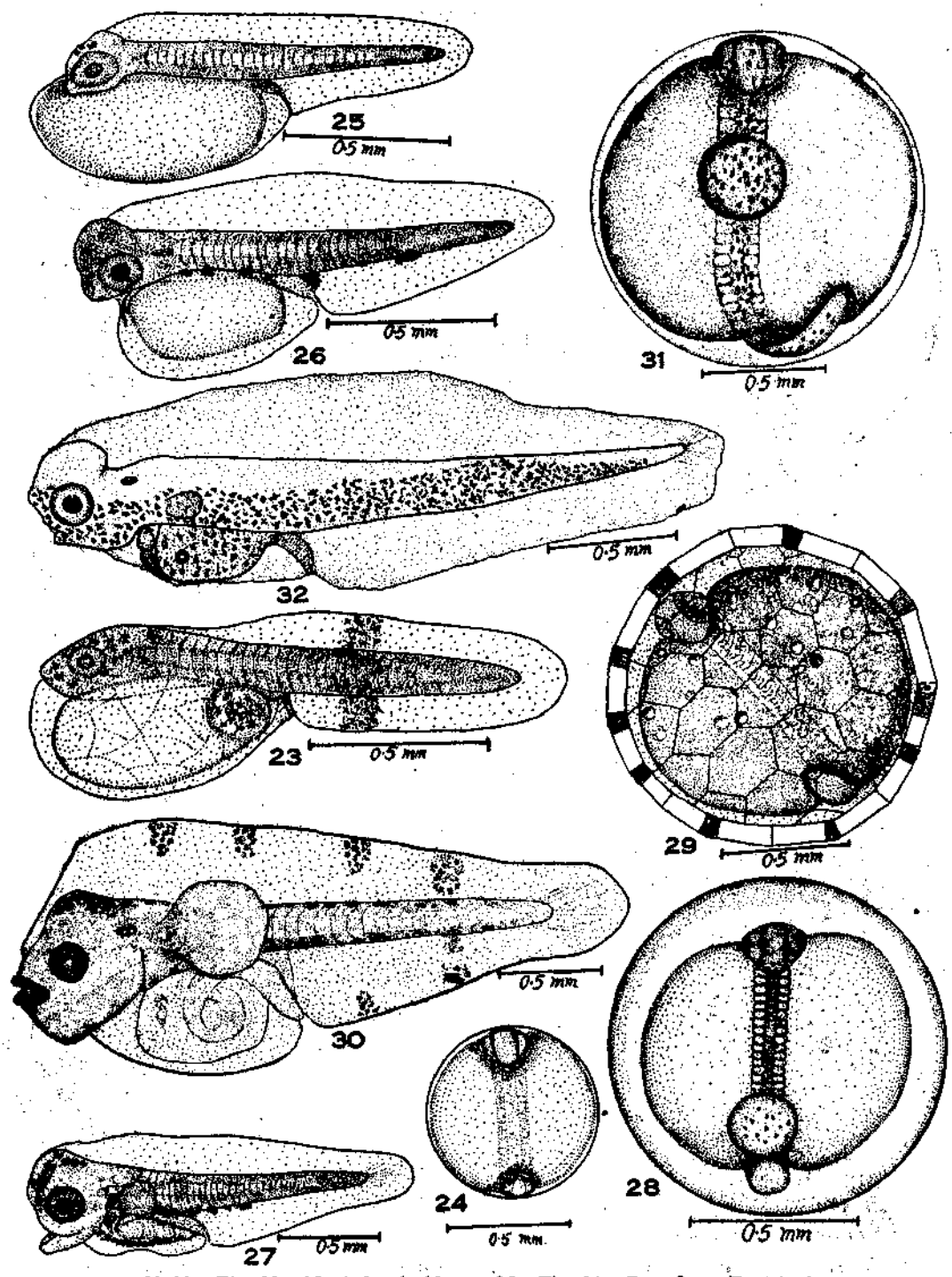
Again, in September–November two more low modes are seen when both the salinity and the surface temperature show a tendency to decrease gradually.

Fig. 38 shows the distribution of fish eggs in the Palk Bay and the values of salinity for different months. The primary peak appears here also in March, followed by a steep fall in the number of eggs in April, reaching the minimum in May. From June onwards the fish eggs gradually increase until they show a secondary peak in November, followed by decline in December. The salinity of the surface water of the Palk Bay increases slowly from 28·69‰ in January until it reaches the maximum of 36·06‰ in October and drops to 29·19‰ in December. Here again, both the primary and the secondary fish egg peaks are in the low salinity months as in the Gulf of Mannar. Unfortunately no data on the surface temperature for the Palk Bay are available. In both the areas the primary and the secondary peaks invariably precede the setting in of the south-west monsoon and the north-east monsoon respectively. It has also been observed that there is a greater concentration of fish eggs in the Gulf of Mannar than in the Palk Bay, although the general trend in their occurrence in both the areas is very much similar (Figs. 37 and 38).

Of the fourteen types of eggs described earlier, six types, *viz.*, *A*, *B*, *D*, *D*1, *G* and *H*, belong to the sub-order clupeoidei and two types, *viz.*, *C* and *I*, belong to the genus *Caranx*. Of the six types of clupeid eggs *B* and *D* were the most common. Fig. 39 shows that the clupeid eggs occur almost throughout the year in the Gulf of Mannar with prominent modes in March and May, but in negligible numbers in the Palk Bay. The mode in March of both the years was mainly due to the large collection of type *D* eggs and partly type *B* eggs, whereas for the mode in May 1952 the type *B* eggs alone was responsible. All the six types, *A*, *B*, *D*, *D*1, *G* and *H*, were common in the waters of the Gulf of Mannar, whereas these types were comparatively scarce in the Palk Bay, type *H* being entirely absent. The occurrence of the type *A* eggs was very erratic. The types *B* and *D* showed slight variations in their occurrence. The maximum number of the former was taken in June 1950 and May 1952 and the latter in March of both the years. The type *B* eggs were taken almost throughout the year and the occurrence of type *D* was restricted to 3–6 months in a year in the Gulf of Mannar. These were obtained in very few numbers from the Palk Bay and it may be of interest to point out that the type *D* eggs were totally absent in the month of March in the Palk Bay, while they were taken in large numbers from the Gulf of Mannar. Eggs of the type *D1* were poor in both the areas and were present only during February–March. During the course of this study a few type



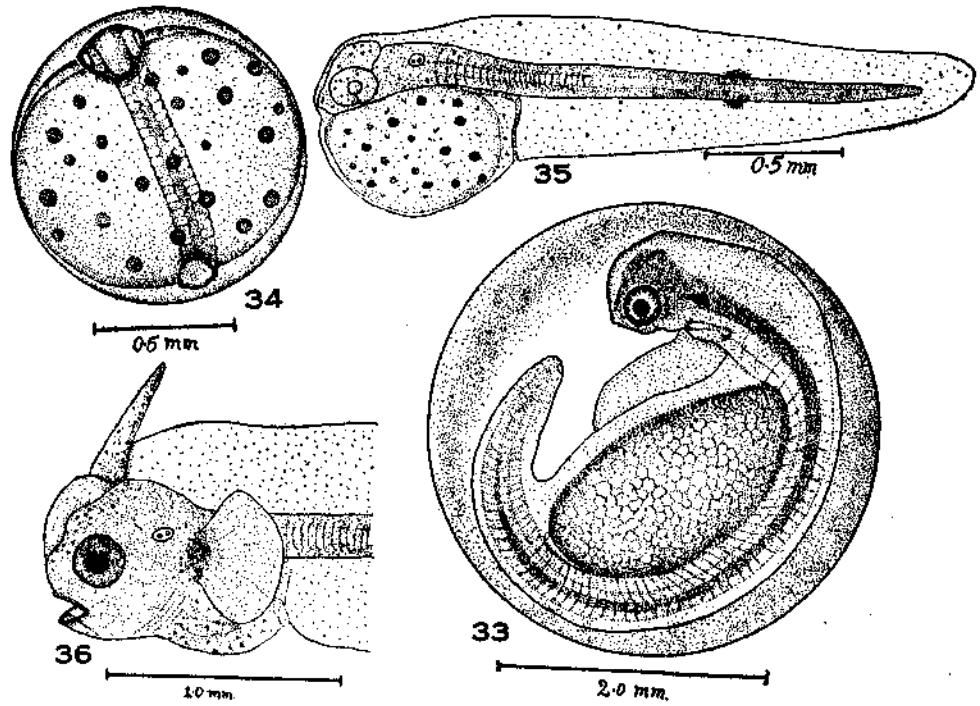
FIGS. 12–22. Fig. 12. Ten-hour old larva of *G*. Fig. 13. Egg of type *H* (*Sardinella fimbriata*). Fig. 14. Eighteen-hour old larva of of *H*. Fig. 15. Two-day old larva of *H*. Fig. 16. Head of a five-day old larva of *H*. Fig. 17. Egg of type *C* (*Caranx leptolepis*). Fig. 18. Newly hatched larva of *C*. Fig. 19. One-day old larva of *C*. Fig. 20. Two-day old larva of *C*. Fig. 21. Three-day old larva of *C*. Fig. 22. Egg of type *I* (*Caranx* sp).



FIGS. 23–32. Fig. 23. Newly hatched larva of *I*. Fig. 24. Egg of type *E*. Fig. 25. Newly hatched larva of *E*. Fig. 26. Ten-hour old larva of *E*. Fig. 27. Two-day old larva of *E*. Fig. 28. Egg of type *F*. Fig. 29. Egg of type *K*. Fig. 30. Two-day old larva of *K*. Fig. 31. Egg of type *L*. Fig. 32. Two-day old larva of *L*.

G eggs were collected from the Gulf of Mannar during February, March, May 1950 and February 1951 and some more from the Palk Bay in July 1951. Eggs belonging to type *H* were restricted to three months in a year, *viz.*, December, January and February during 1949–50 and December, January and March in 1951–52 from the Gulf of Mannar.

It has been pointed out before that the period from January to April has been considered as the low surface salinity-temperature period. If the mode in May 1952 is considered as a slight deviation from the main mode in March observed in both the years under review, it may then be inferred that the clupeids in this area show a definite preference to the low salinity



FIGS. 33–36. Fig. 33. Egg of the type *N*. Fig. 34. Egg of the type *S.* (*Cynoglossus* sp.). Fig. 35. Newly hatched larva of *S*. Fig. 36. Four-day old larva of *S*.

and surface temperature period for spawning and that the spawning takes place mainly once a year.

Two varieties of carangid eggs designated as types *C* and *I* were present in the collection. In both the Gulf of Mannar and the Palk Bay their numbers increase from January onwards and reach the maximum in March followed by an abrupt fall in April and continues to remain at that level during the next two or three months. Again, from August there is a gradual

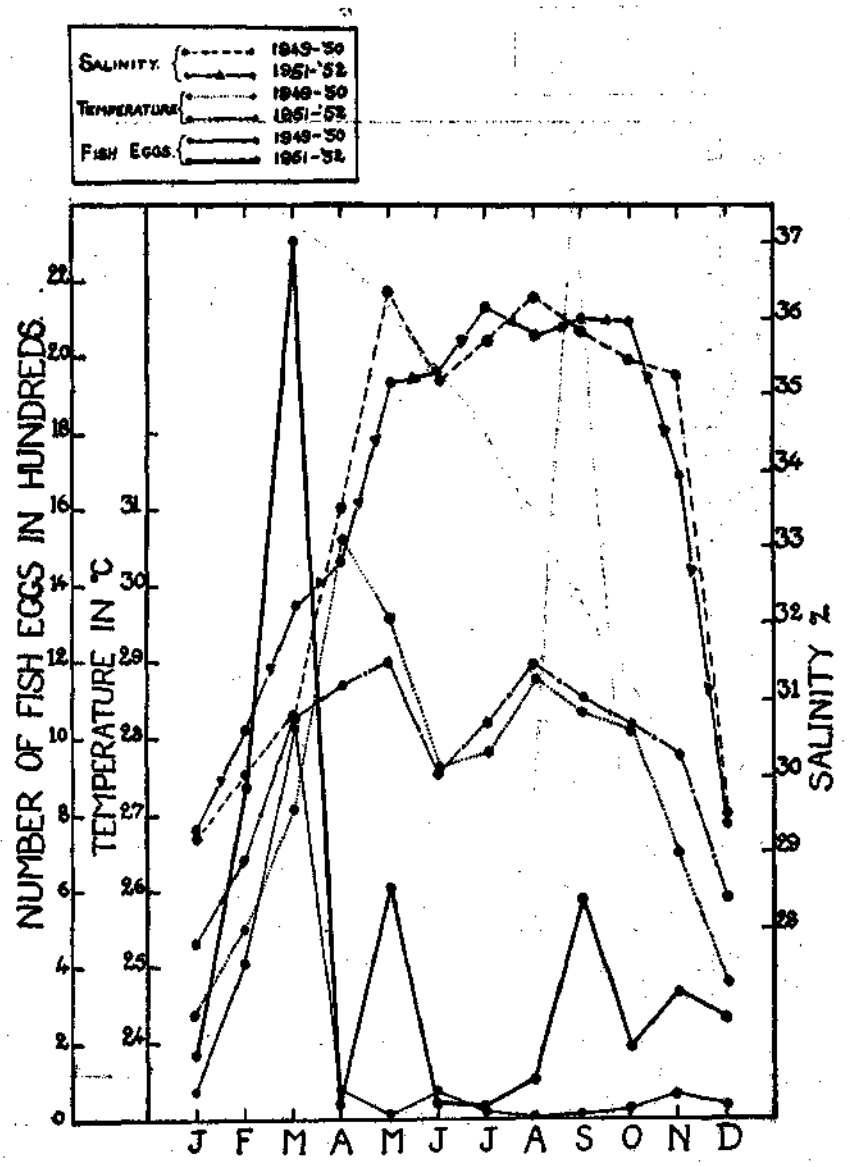


FIG. 37. Average number of fish eggs collected from the Gulf of Mannar, the surface salinity and surface temperature.

increase in their number until they reach the secondary peak some time in September–November (Fig. 40). Of these, type *C* was the most common and has been recorded almost throughout the year with a bimodal occurrence, the primary peak falling in March and the secondary in September in the Gulf of Mannar, and in March and October respectively in the Palk Bay.

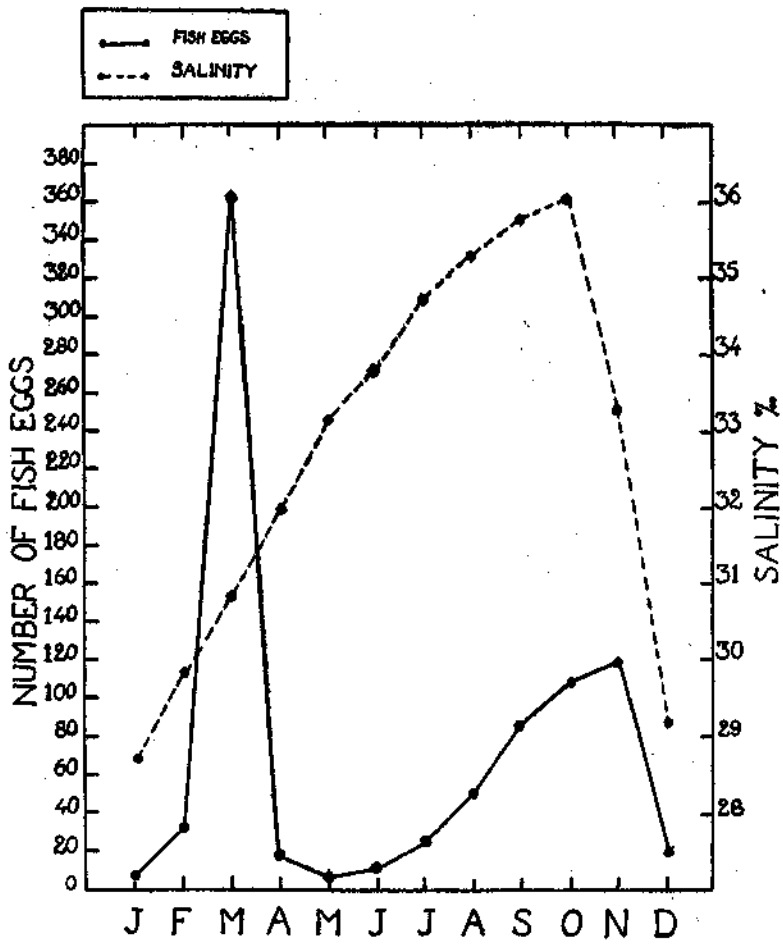


FIG. 38. Average number of fish eggs collected from the Palk Bay during July 1951 to June 1952 and the fluctuations in surface salinity.

The type *I* eggs were common from September–March in the Gulf of Mannar and in November in the Palk Bay. In general the collections from the Gulf of Mannar were also richer in the carangid eggs than the Palk Bay.

The eggs of the type *E* were collected during the major part of the year from both the areas, but were fewer in the Palk Bay. They were common in the Gulf of Mannar in the months of February, 1950, September–December, 1951 and March, 1952. The type *F* eggs have been recorded throughout the year, except November and December, from the Palk Bay with a maximum in September 1951, and were not taken in appreciable numbers from the Gulf of Mannar. The types *K*, *L* and *S* were few and irregular in their occurrence in both the areas.

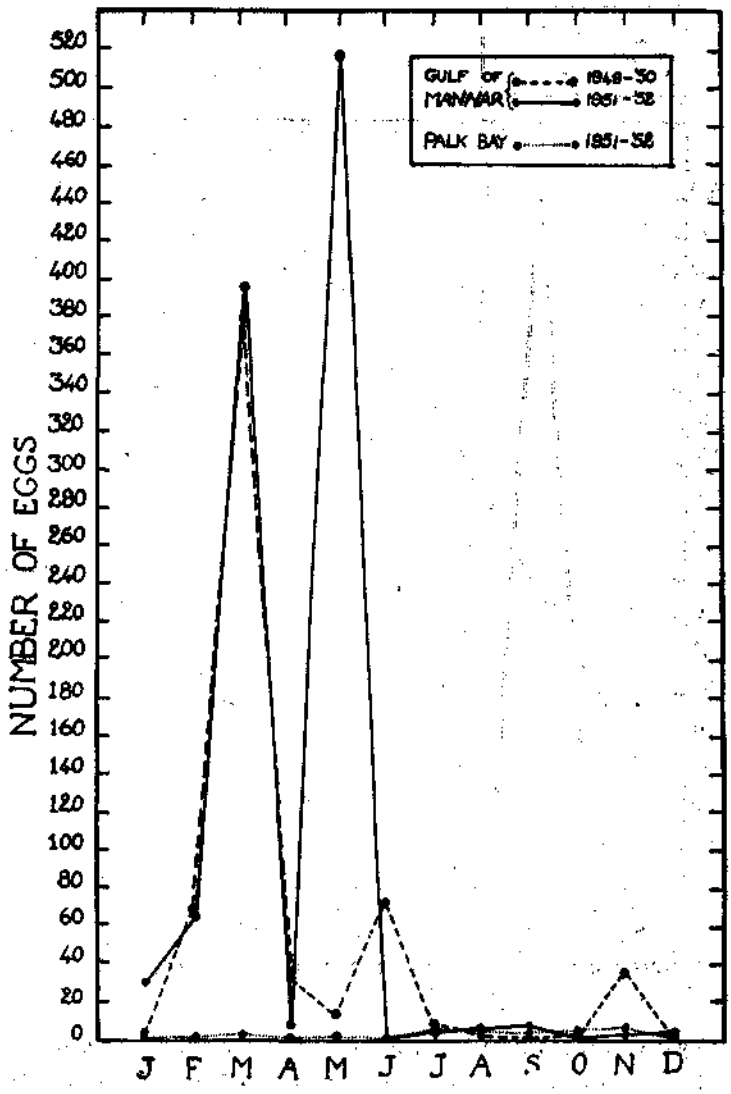


FIG. 39. Distribution of clupeid eggs in the Gulf of Mannar and the Palk Bay.

It has been suggested by certain authors that in the tropics where the temperature variations are negligible and the constant availability of plankton and other food exist throughout the year, there are no marked breeding seasons in marine animals. But some naturalists have pointed out that the changes in salinity may influence the breeding activity to a certain extent. But recent researches in tropical countries have shown that there are marked intensive spawning periods, though stray individuals breed almost throughout the year. Panikkar and Aiyar (1939), in a study of the breeding of

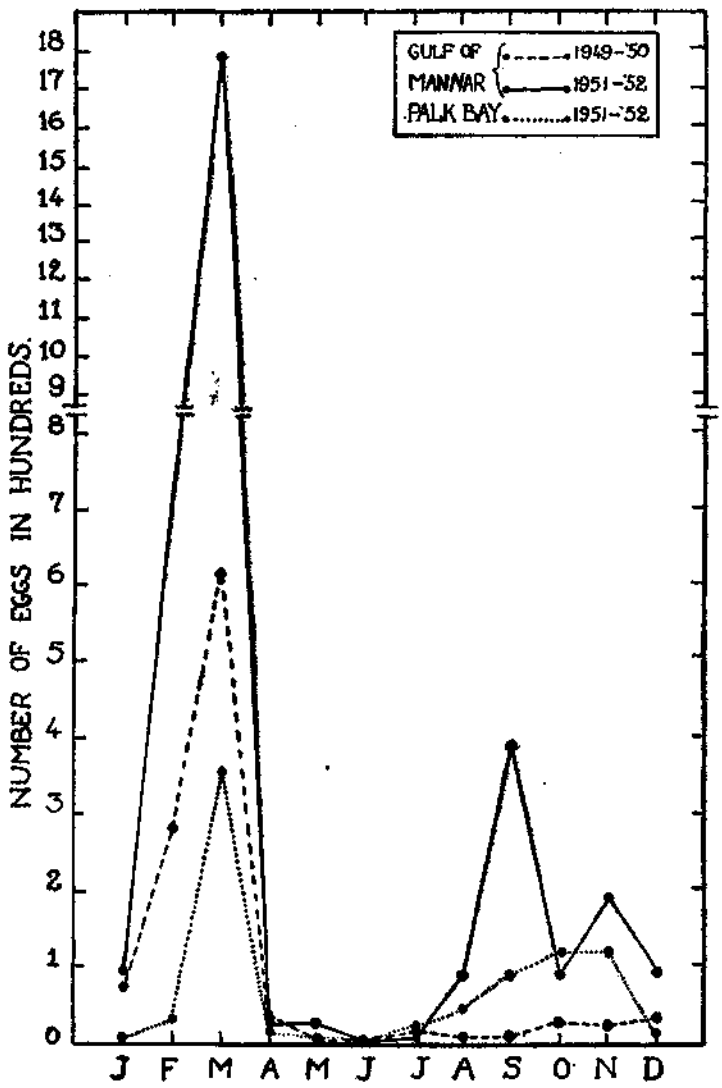


FIG. 40. Distribution of carangid eggs in the Gulf of Mannar and the Palk Bay.

brackish water animals of Madras, have observed that many species of fish spawn actively during the monsoon and that the changes caused by the outbreak of rains influence the spawning activity considerably even in continuous breeders. Panikkar (1949) suggested " Spawning seasons in the warm water species are, nevertheless, conditioned by external factors like suitable salinities and temperature for the dehiscence of the sexual products and availability of food and favourable environs for the growth of the young. Consequently even though a primary periodicity based on internal rhythms

tends to become obliterated, a secondary periodicity based on changes in environment is often noticed". Nair (1952) has observed that there is increased breeding activity during the cold months from September onwards until the end of January, when it is at the maximum after the setting of the north-east monsoon. The results of the present investigation also show that the maximum spawning takes place during the low salinity-temperature period which suggests that these factors may considerably influence spawning. The presence of majority of the types of eggs in varying numbers during a greater part of the year indicates a protracted breeding season in many species.

SUMMARY

The present paper reports on the occurrence, distribution and fluctuation of pelagic fish eggs in the Gulf of Mannar and the Palk Bay near Mandapam. The results are based on an examination of 43,352 fish eggs from 238 samples of plankton collected from the Gulf of Mannar and the Palk Bay.

Experiments conducted in rearing the larvæ to a stage when they can be identified did not yield satisfactory results. Artificial fertilisation proved helpful in deciding the identity in one species.

Fourteen types of fish eggs and larvæ have been described in detail, of which six belong to the sub-order Clupeoidei, two to the genus *Caranx*, one to *Cynoglossus* and one to the family *Muræniдæ*. Eight types have been tentatively identified up to the genus or species, namely, *Anchoviella* sp., *Thrissocles* sp., *Kowala coval*, *Dussumieria* sp., *Sardinella fimbriata*, *Caranx leptolepis*, *Caranx* sp. and *Cynoglossus* sp.

Spawning appears to take place in types *B*, *D*, *H*, *C* and *I* late in the evening or early in the night and in *E* in the early hours of the day.

It has been observed that fish eggs occur in both of the areas studied almost throughout the year, the maximum number being taken in the month of March when the surface salinity-temperature in the Gulf of Mannar and the surface temperature in the Palk Bay were fairly low. There was greater concentration of fish eggs in the Gulf of Mannar than in the Palk Bay, although the general trend of their occurrence was similar in the two areas.

The clupeid eggs were encountered mostly in the waters of the Gulf of Mannar, the waters of the Palk Bay being very poor in them. They were taken in large numbers in the months of March. The trend in the occurrence of carangid eggs in both the areas was similar throughout the year,

although the eggs were found in greater abundance in the Gulf of Mannar. They showed two peaks in their distribution, the primary peak falling in March and the secondary one some time during September–November.

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