SOME POST-LARVAL AND JUVENILE STAGES OF THE INDIAN MACKEREL, *RASTRELLIGER KANAGURTA* (CUVIER), WITH NOTES ON THE CHANGES IN BODY FORM*

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The Indian mackerel, *Rastrelliger kanagurta* (Cuvier), belonging to the family Scombridae, is one of the commercially important food fishes of India and a few other countries bordering the Indo-Pacific. The life history of this species has not been fully investigated so far.

The earliest description of a *Rastrelliger* egg is by Delsman(1926) from the Java Sea. Subsequently, Delsman (1931) expressed doubts about the correctness of his earlier identification. Manacop (1956) has described, from the Philippine waters, two specimens of *R. chrysozonus* measuring 26 mm and 48 mm in length. Devanesen and John (1940), Balakrishnan (1957) and Kuthalingam (1956) have recorded the occurrence of eggs and larvae of *R. kanagurta* from the Indian waters. Jones and Kumaran (1964) have given figures of two juveniles measuring 34 mm and 65 mm in length. A single larva measuring 9.3 mm collected from the Andaman Sea during *Vityaz* Expedition has been described by Gorbunova (1963). The eggs and larvae of *Rastrelliger*, collected from the Gulf of Thailand, have been described by Boonprakob (1962, 1965) and the *Rastrelliger* larvae collected from the same area during the *Naga* Expedition have been described by Matsui(1963).

In this paper a series of early stages of the Indian mackerel is presented. However, this does not include the pro-larvae reported earlier (*vide* Balakrishnan, 1957) as the material is not available now.

MATERIAL AND METHODS

The material, except for eleven specimens collected from Cannanore (Lat. 11° 50'N; Long. 75°25'E), was collected during 1956-'59 from the inshore waters off Vizhingam (Lat. 08° 22'N; Long. 76° 59'E) on the south-west coast of India

* After preparation of the present report for publication, a note dealing with *Rastrelliger* larvae (measuring 2.7 mm, 3.1 mm, and 5.3 mm) collected from the northern part of the Arabian Sea, Red Sea and Bay of Bengal during the International Indian Ocean Expedition was published by K. J. Peter (*Curr. Sci.*, 36 (10): 273-74, 1967).

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and consisted of several post-larvae and early juveniles. Our collections comprised 210 specimens ranging from 8.7 mm to 53.7 mm in body length. Of the total, only 179 specimens were measured and studied in detail, as the rest were in a damaged condition. Details regarding the date of collection, size range etc. of the specimens examined during the present study are summarised in Table 1.

TABLE 1. *Details of the specimens of* Rastrelliger kanagurta *examined.*

Sample No.	Date of collection	Place of collection	Net *	Number of specimens	Size (body length) range (mm)
1	25. 2.'56	Vizhingam	S.S.	6	21.76 — 30.91
2	4. 4.'56	Do	S.S.	9	37.81 — 51.07
3	13. 5.'56	Do	B.S.	3	9.82 — 15.72
4	19. 5.'56	Do	S.S.	3	22.62 — 27.19
5	21. 5.'56	Do	B.S.	39	10.02 — 15.26
6	23. 5.'56	Do	B.S.	51	8.69 — 22.75
7	23.11.'56	Do	S.S.	22	26.00 — 34.09
8	25. 1.'57	Do	S.S.	5	20.16 — 26.13
9	7. 3.'57	Do	S.S.	2	22.22 — 24.74
10	29. 3.'57	Do	S.S.	3	30.18 — 33.23
11	21. 6.'57	Do	B.S.	13	25.47 — 35.42
12	22. 5.'58	Do	B.S.	10	48.16 — 53.73
13	1. 7.'58	Do	B.S.	9	33.10 — 36.80
14	10. 7.'58	Do	B.S.	21	36.68 — 47.36
15	15.12.'59	Do	S.S.	3	15.72 — 20.43
16	26. 6.'63	Cannanore	B.S.	11	28.65 — 48.75

* S. S. - Shore Seine; B. S. - Boat Seine

The measuring technique adopted while taking various body proportions is indicated schematically in Fig. 1. Measurements were taken on material preserved in 5% formalin. Since the material was in this state for a considerable period of time, the pigmentation of the specimens appears to have faded out to some extent. In some cases, it was necessary to keep them in glycerine medium to study the pigmentation.

DESCRIPTION

A selected series of stages of post-larvae and juveniles are figured and briefly described below:

8.7 *mm stage* (Fig. 2)

This is the smallest specimen of the series. Length of head is 2.78 and body depth 3.35 in body length. Snout is 4.24 and eye 3.15 in head length.

The specimen has a typical scombroid shape. It has a comparatively longer head, deeper body and bigger eyes which are completely pigmented at this stage. Snout is blunt. Maxilla reaches to below anterior 2/3 of eye. There are five

anteriorly placed sharp teeth on each side of the jaws. Supra-orbital region of the head is high and dome-shaped. The preopercle is unarmed, unlike that of the other scombroid larvae of comparable size. All the fins, except the first dorsal, are well developed with full complement of rays. The first dorsal is low and has

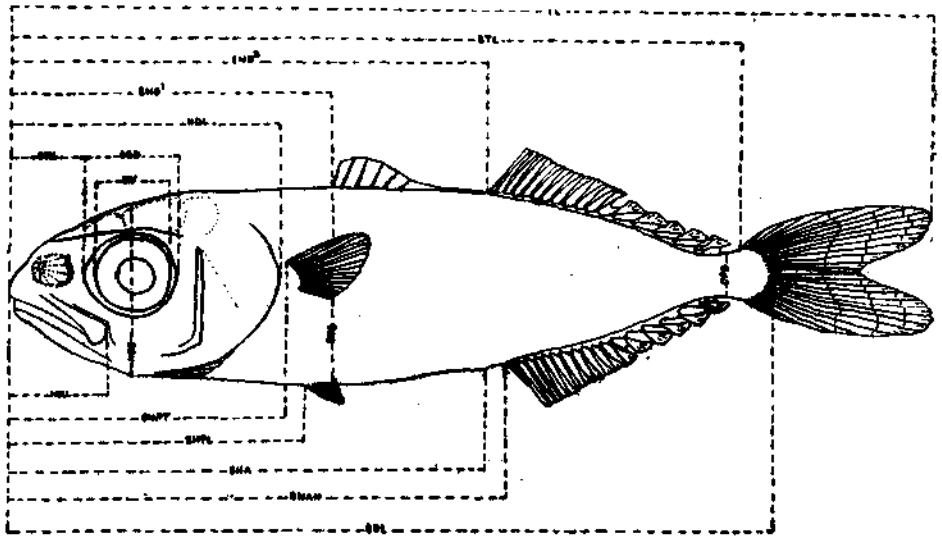

FIG. 1. Schematic diagram of a mackerel larva showing methodology used in taking body measurements. TL - Total length; BDL - Body length; STL - Standard length; HDL - Head length; HDD - Head depth; SNL - Snout length; ED - Eye diameter; OBD - Orbital diameter; MXL - Maxilla length; SND^1 - Snout to first dorsal insertion; SND^2 - Snout to second dorsal insertion; SNPT - Snout to pectoral insertion; SNPL - Snout to pelvic insertion; SNA - Snout to anterior border of anus; SNAN - Snout to anal fin insertion; BDD - Body depth; and CPD - Caudal peduncle depth.

only five spines at this stage. There are six dorsal and anal finlets of which the two nearest to caudal are so close that they appear as a single finlet. Its duality can, however, be recognized externally by the supporting bases. Pectoral is fan-shaped. Pelvic is small and thoracic in position. Finlets are interconnected by a membrane.

Pigmentation is localized characteristically to the tip of snout, mid-brain region, side of body adjacent to the visceral cavity and the base of the vertical fins. In addition there are chromatophores, one on the tip of the lower jaw, two on the fore-brain, two to three on the hind-brain region and four on the opercle. Similarly four chromatophores in a row on the mid-lateral side of the caudal region and a single one in the middle of the ventral fluke of the caudal fin are present.

11.4 *mm stage* (Fig. 3)

Head is 2.87 and body depth 3.74 in body length. Eye 3.52 and snout 3.77 in head. Supra-orbital is still dome-shaped. At this stage six teeth on the upper and seven on the lower jaw are present. Six spines are discernible in the first dorsal. Pectoral is more elongated than in the previous stage. Dorsal and anal finlets are still interconnected by a thin membrane.

At this stage, further increase in the pigmentation on the tip of snout, dorsal side of head and opercle is recognizable. Four chromatophores have developed on the upper jaw. A single chromatophore in the pre-orbital area and a row of four in the post-orbital are present. Interspinous membrane of the first dorsal is pigmented to the extent of 5th spine. The intensity of pigmentation is a little more than in the previous stage.

13.9 *mm stage* (Fig. 4)

It is comparatively more fusiform than the previous stage. Head is 3.02 and body depth 4.10 in body length. Snout is 4.00 in head length. Supra-orbital area is less dome-shaped at this stage. Upper and lower jaws are provided with 7 and 8 teeth respectively on each side.

Pigmentation has spread from snout dorsally towards the frontal region and also from head to nape. Chromatophores from the dorsal profile of the body below first dorsal have spread anteriorly into the pre-dorsal area and posteriorly towards second dorsal. Dorsal side of the caudal peduncle is more intensely pigmented. Pigmentation from the mid-lateral side of the body at the caudal region has increased and spread more cephalad. Finlets are separated. Seven spines are evident in the first dorsal fin which is more intensely pigmented at this stage. Apart from these changes, pigmentation remains the same as in the previous stage.

16.9 *mm stage* (Fig. 5)

At this stage the supra-orbital region of head has further shrunk and consequently the head assumes a fusiform shape. Body is also comparatively slender. Length of head is 3.07, depth of head 4.72 and body depth 4.55 in body length. Snout is 3.99 and eye 3.59 in length of head. An additional tooth is discernible on each side of the jaws. Pectorals have assumed a more characteristic shape. Ten spines are discernible in the first dorsal.

Pigmentation on the snout has spread dorsally towards head and ventrally to maxilla. Head is intensely pigmented. Chromatophores have increased in number both on the opercle and post-orbital region. The process of intensification and spreading of the pigmentation is carried further along the entire dorsal profile and the mid-dorsal side of the body. The pigmentation in the latter area has

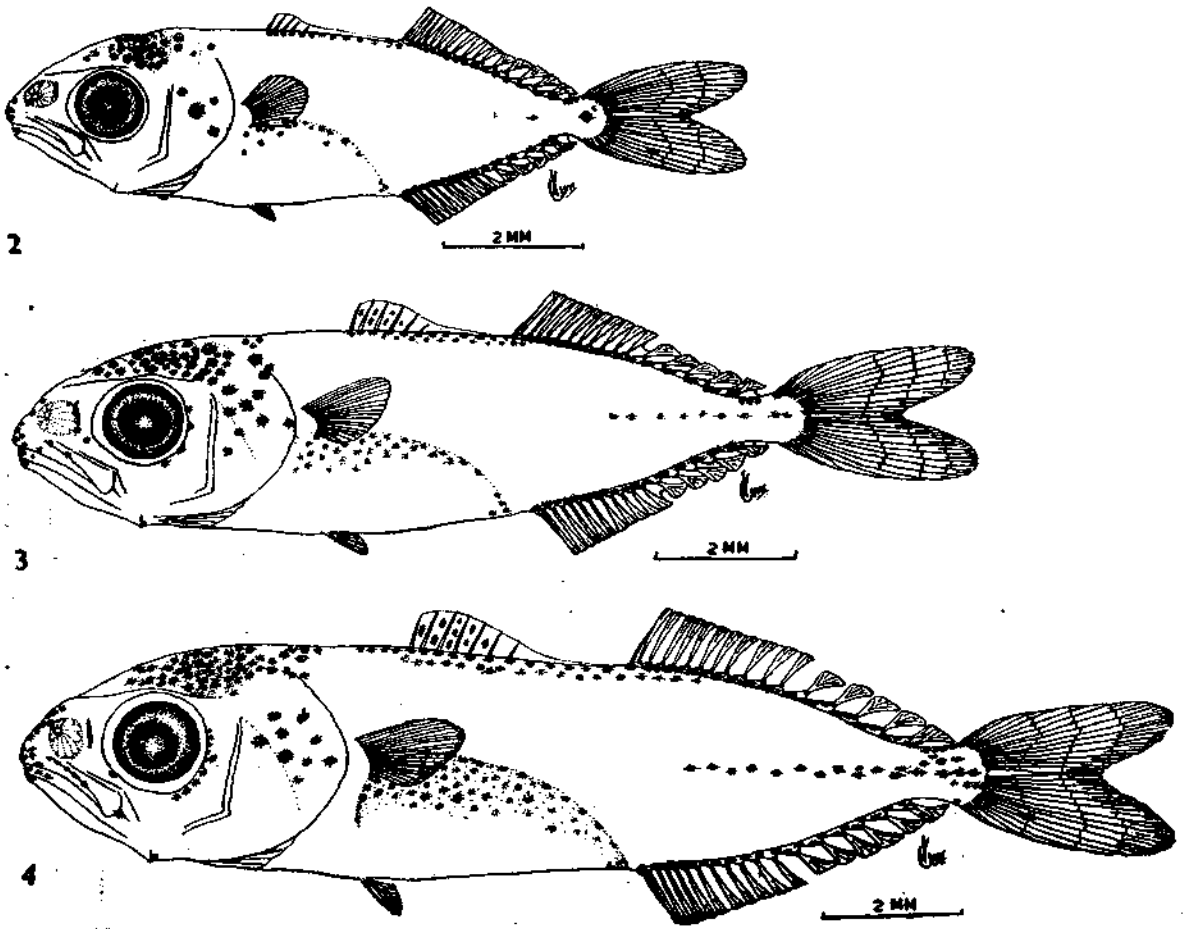

FIG. 2-4. 2. Indian mackerel, 8.7 mm stage; 3. 11.4 mm stage; 4. 13.9 mm stage.

extended cephalad a little beyond the vertical from the insertion of the second dorsal. Caudal peduncle is now fully pigmented dorsally. In addition to the pigmentation at the base of the caudal fin, there are two chromatophores on its ventral fluke. Pigmentation of the body in the vicinity of gut, anal fin and finlets remains the same as in the previous stage.

19.3 *mm stage* (Fig. 6)

Body depth is 4.41, head length 3.16, its depth 5.20 in body length. Eye is 3.67 and snout 4.00 in head. Supra-orbital is characteristically flattened; body is fusiform as in juvenile. Upper and lower jaws are endowed with 9 and 10 thin and sharp teeth respectively on each side. First dorsal has assumed, more or less, sail-shape due to increase in length of the 2nd and 3rd dorsal spines. It has 12 spines and is intensely pigmented.

In the area between the eye and maxilla a patch of nine chromatophores is present. Pigmentation from the post-orbital region has spread ventrally a little into the infra-orbital area. Dorsal half of the body is fairly covered with pigments, more so at the caudal region. Proximal region of the caudal fin is slightly pigmented. Other fins are still unpigmented. The first signs of the development of adipose eyelids are recognizable.

22.4 *mm stage* (Fig. 7)

Head is 3.18 and body depth 4.63 in body length. Eye is 3.66 and snout 3.76 in head length.

At this stage, further development of the adipose eyelids is noticeable, the posterior adipose eyelid having grown forward covering a little over posterior border of the eye. The number of teeth on each side of the upper and lower jaws has increased to 12 and 14 respectively.

Further spreading of the pigmentation on the snout, head, opercle and the dorsal and mid-lateral sides of body is noticed. On the snout three additional chromatophores have developed just below the posterior nostril. Dorsal half of the body is more or less, fully pigmented. There is a row of 5 to 6 chromatophores at the base of pectoral which has now assumed a typical shape. First dorsal has 12 spines and is pigmented up to the limit of 9th spine.

31.4 *mm stage* (Fig. 8)

The proportions of head and body depth at this stage are 3.29 and 4.34 respectively in body length. Snout is 3.99 and eye 3.87 in head length. The number of teeth has increased.

First dorsal is as high as the second and has 11 spines. The 12th spine, however, can be seen beneath the body wall if cleared and dyed. The entire area

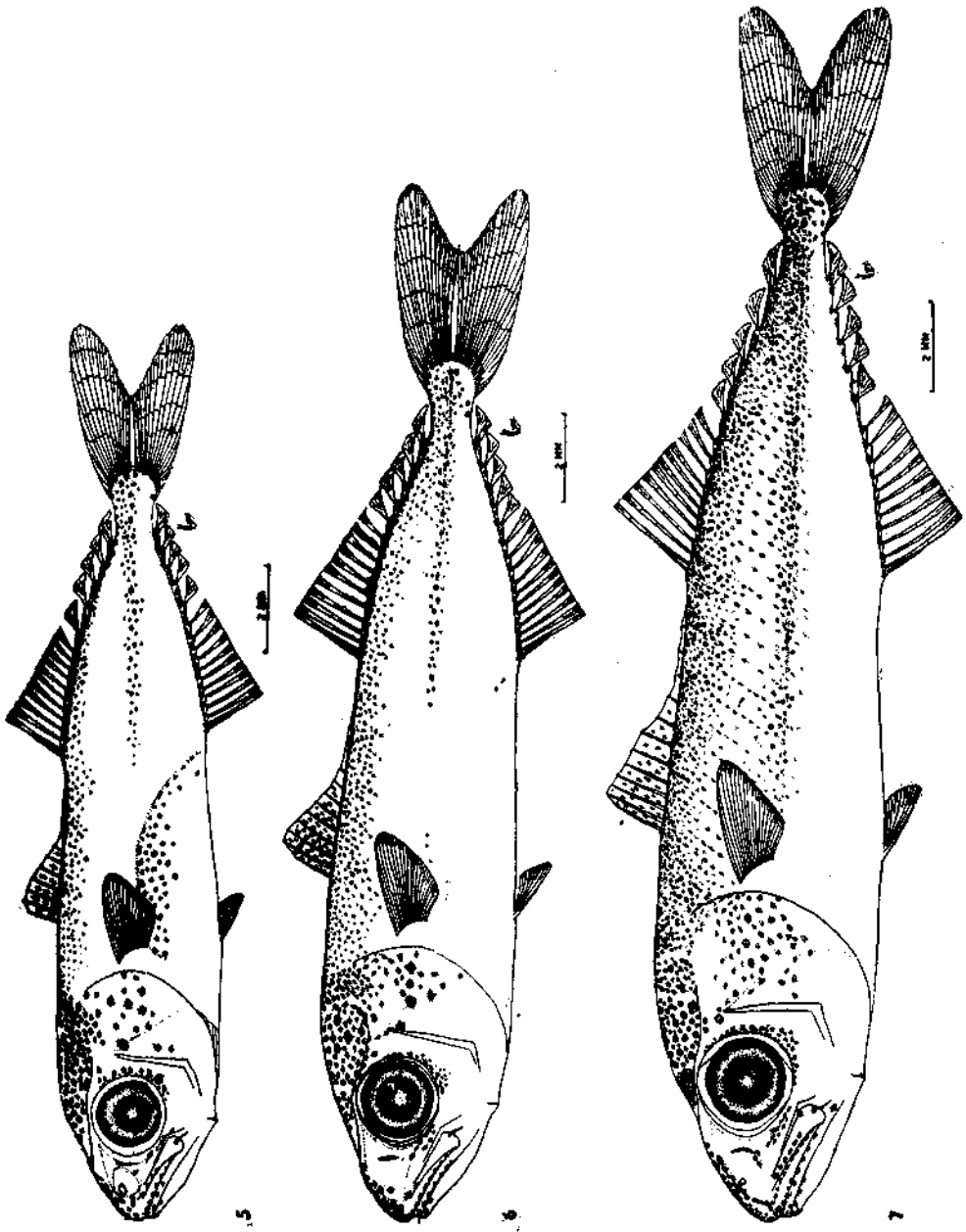

FIG. 5-7. 5. Indian mackerel, 16.9 mm stage; 6. 19.3 mm stage; 7. 22.4 mm stage.

of the gill-cover, in line with maxilla, is now completely pigmented. Supra-orbital area of the head is conspicuously low and flat at this stage. The post-and infra-orbital areas are fully pigmented. Adipose eyelids have grown covering more area of the eye. A row of pigment spots is present covering the entire base of the pectoral. Body pigmentation has spread a little from the midlateral aspect of the body ventrally. Caudal fin is fairly pigmented. Inter-radial membrane of the second dorsal is also faintly pigmented anteriorly.

52.7 *mm stage* (Fig. 9)

It represents a typical juvenile possessing all the adult characters though its body proportions are still not quite comparable with those of the adult. Head length is 3.49, its depth 6.91 and body depth 4.70 in body length. Snout is 4.10 and eye 4.22 in head length.

Head and body have assumed fusiform shape characteristic of the juvenile. Supra-orbital area of the head is flat as is characteristic of the adult. On each side of the upper and lower jaws there are about 20 and 25 sharp teeth respectively. Adipose eyelids have grown fully and cover the eye typically as in the adult.

First dorsal fin has developed to the typical adult shape and is higher than that of the second dorsal. There are only eleven spines in the first dorsal. Caudal, first dorsal, second dorsal and dorsal finlets are dusky. Head and dorsal aspect of the body are fully pigmented. Lateral line is discernible at this stage. First anal spine seen in the earlier stages has now been resorbed to a large extent into the ventral body wall.

Changes in Body Form

Altogether 179 specimens ranging in body length from 8.7 mm to 53.7 mm were measured to study the changes in body form. In Table 2 the summarized data for 1 mm size groups are presented. The various body proportions in percentage of body length are shown in Table 3. Gill raker counts were taken from 15 specimens varying in length from 11.5 mm to 51.2 mm. A statement of the gill raker counts is given in Table 4.

In its early post-larval stage the Indian mackerel is comparatively deep-bodied and chubby than at the juvenile stage. As it approaches the juvenile stage, it assumes a fusiform shape. The number of gill rakers increases with the increase in size of the fish (see Table 4).

The juvenile stage of *Rastrelliger kanagurta* may be considered to begin when (1) the full complement of spines and rays are developed in the fins, (2) the supra-orbital region of the head, which is dome-shaped in the post-larval stage, flattens characteristically as in the adult, and (3) the first signs of scales appear on the body. This occurs when the fish grows to a body length of about 20-25 mm.

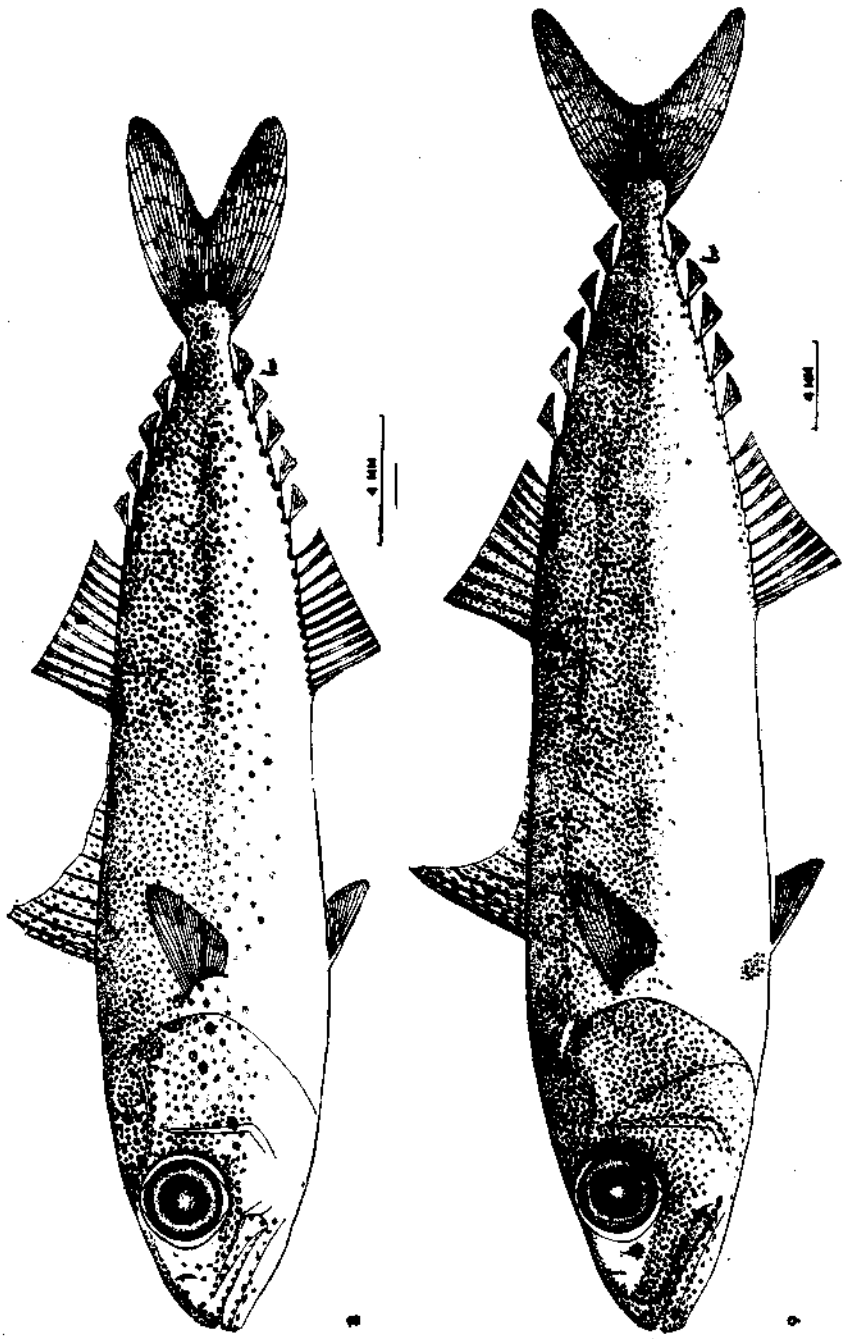

FIG. 8-9. Indian mackerel, 31.4 mm stage; 9. 52.7 mm stage.

TABLE 2. *Morphometric measurements of post-larvae and juveniles of* Rastrelliger kanagurta.

Size groups of body length (mm)	No. of specimens	Average morphometric measurements (mm)																
		BDL	TL	STL	HDL	SNL	ED	OBD	MXL	HDD	SND^1	SND^2	SNPT	SNPL	SNA	SNAN	BDD	CPD
8.00 - 8.99	1	8.69	10.68	8.22	3.12	0.73	0.99	1.13	1.19	2.25	3.65	5.50	3.25	3.45	5.37	5.57	2.59	0.60
9.00 - 9.99	2	9.82	11.34	9.25	3.50	0.83	1.06	1.36	1.39	2.35	4.08	6.02	3.74	3.48	6.07	6.20	2.58	0.60
10.00 - 10.99	5	10.33	12.52	9.91	3.69	0.89	1.11	1.42	1.45	2.52	4.40	6.59	3.86	3.61	6.34	6.57	2.76	0.62
11.00 - 11.99	11	11.59	13.68	10.94	4.00	1.02	1.15	1.42	1.57	2.57	4.78	7.35	4.21	4.10	7.22	7.44	2.76	0.67
12.00 - 12.99	7	12.65	15.14	11.97	4.27	1.13	1.24	1.47	1.68	2.86	5.17	8.03	4.51	4.57	7.87	8.12	3.02	0.69
13.00 - 13.99	4	13.88	16.50	13.23	4.64	1.18	1.28	1.49	1.69	2.95	5.47	8.79	4.86	4.99	8.57	8.99	3.13	0.77
14.00 - 14.99	7	14.45	17.21	13.85	4.85	1.21	1.34	1.48	1.79	3.09	5.53	9.04	4.97	5.12	9.00	9.36	3.13	0.76
15.00 - 15.99	9	15.54	18.28	14.77	5.00	1.32	1.44	1.66	1.93	3.15	5.59	9.48	5.26	5.52	9.37	9.37	3.70	0.77
16.00 - 16.99	6	16.51	19.44	15.72	2.24	1.34	1.53	1.69	2.22	3.34	6.27	10.05	5.48	5.93	10.08	10.45	3.63	0.80
17.00 - 17.99	2	17.77	21.06	17.08	5.73	1.49	1.59	1.82	2.12	3.51	6.89	11.21	6.11	6.80	10.91	11.34	3.78	0.83
18.00 - 18.99	6	18.57	21.92	17.83	5.96	1.55	1.65	1.88	2.18	3.71	7.22	11.77	6.30	6.68	11.53	11.90	4.03	0.85
19.00 - 19.99	3	19.61	23.44	18.93	6.32	1.59	1.70	1.92	2.17	5.82	7.58	12.49	6.46	6.99	12.07	12.80	4.27	0.86
20.00 - 20.99	5	20.43	23.83	19.51	6.39	1.65	1.82	2.00	2.39	4.05	7.49	12.57	6.75	6.99	12.40	12.90	4.27	0.89
21.00 - 21.99	3	21.41	25.36	20.56	6.74	1.77	1.81	2.01	2.54	4.00	7.80	13.00	7.03	7.50	12.65	13.33	4.62	0.96
22.00 - 22.99	6	22.41	26.43	21.35	7.01	1.81	1.91	2.12	2.50	4.11	8.14	13.82	7.38	7.97	13.33	14.07	4.83	0.95
23.00 - 23.99	2	23.25	27.06	22.22	7.26	1.92	1.90	2.15	2.68	4.44	8.29	14.09	7.72	8.12	13.99	14.34	4.94	0.96
24.00 - 24.99	2	24.61	28.75	23.45	7.79	1.95	2.15	2.38	2.72	4.61	9.12	15.15	8.16	8.82	15.19	15.62	5.44	1.02
25.00 - 25.99	3	25.71	29.98	24.34	8.00	1.99	2.21	2.43	3.03	4.66	9.17	15.55	8.36	9.13	15.57	12.12	5.53	1.03
26.00 - 26.99	7	26.41	30.70	25.27	8.15	2.02	2.14	2.39	2.87	4.52	9.66	16.10	8.59	8.89	16.04	16.71	5.44	1.10
27.00 - 27.99	5	27.35	32.01	26.08	8.64	2.20	2.25	2.51	3.13	4.95	9.94	16.87	9.10	9.88	16.70	17.31	6.11	1.09
28.00 - 28.99	2	28.75	33.48	27.36	8.82	2.05	2.25	2.43	3.15	5.17	10.31	17.58	9.18	9.75	17.74	18.17	6.17	1.19
29.00 - 29.99	6	29.54	34.25	28.18	8.72	2.10	2.27	2.54	3.08	5.01	10.54	17.63	9.29	9.93	17.60	18.36	6.18	1.17

30.00 - 30.99	8	30.67	35.43	29.41	9.16	2.21	2.43	2.65	3.31	5.06	10.73	18.65	9.68	10.44	18.45	19.32	6.61	1.18
31.00 - 31.99	5	31.69	36.88	30.33	9.43	2.36	2.50	2.76	5.46	5.33	11.32	19.14	10.04	11.01	19.18	19.74	6.68	1.24
32.00 - 32.99	2	32.17	37.50	30.81	9.95	2.32	2.52	2.78	3.61	5.77	11.74	19.56	10.18	11.08	19.43	20.26	7.32	1.22
33.00 - 33.99	10	33.51	38.78	32.03	10.13	2.50	2.55	2.81	3.80	5.58	11.89	20.37	10.69	11.57	20.09	21.23	7.19	1.30
34.00 - 34.99	3	34.14	39.51	32.39	10.19	2.52	2.54	2.85	3.89	5.57	12.27	20.69	10.85	11.85	19.59	21.24	7.16	1.31
35.00 - 35.99	2	35.28	41.02	33.73	10.84	2.78	2.68	3.08	3.98	5.90	12.66	21.52	11.55	12.23	20.53	22.35	7.66	1.39
36.00 - 36.99	2	36.68	42.78	35.15	10.84	2.65	2.72	3.05	4.04	5.57	12.76	22.38	11.49	12.24	20.89	22.88	7.79	1.39
37.00 - 37.99	2	37.51	44.94	35.98	11.60	2.88	3.02	3.35	4.37	6.36	13.76	23.14	11.97	12.54	21.89	23.65	7.85	1.36
38.00 - 38.99	2	38.27	43.94	36.41	11.08	2.72	2.75	2.98	3.98	5.64	13.43	23.21	11.77	12.63	22.55	23.88	7.63	1.39
39.00 - 39.99	1	39.93	47.76	38.14	11.61	2.79	2.79	2.98	4.31	6.30	13.93	24.21	12.47	12.60	23.88	25.54	8.49	1.46
40.00 - 40.99	3	40.31	46.92	38.58	11.83	2.92	2.87	3.18	4.29	6.41	14.37	24.30	12.53	13.71	23.88	25.47	8.76	1.46
41.00 - 41.99	1	41.32	49.61	39.53	12.47	3.05	2.92	3.25	4.64	6.83	15.06	25.54	13.46	13.60	25.20	26.54	9.75	1.53
42.00 - 42.99	6	42.28	48.74	40.54	12.64	3.07	3.04	3.29	4.54	6.43	15.03	25.68	13.36	14.04	25.81	27.04	9.00	1.55
43.00 - 43.99	4	43.39	50.49	41.55	13.36	3.18	3.10	3.45	4.86	7.08	15.59	26.53	13.75	15.09	26.56	27.84	9.77	1.64
44.00 - 44.99	1	44.44	51.02	42.78	13.86	3.32	2.98	3.51	4.97	6.96	15.92	27.19	14.26	14.59	26.53	27.86	10.28	1.66
45.00 - 45.99	5	45.54	52.86	43.98	13.73	3.38	3.30	3.61	4.96	6.92	16.38	28.04	14.46	15.59	27.59	28.94	10.24	1.67
46.00 - 46.99	1	46.63	54.05	44.64	14.06	3.18	3.55	3.98	5.31	7.30	16.58	28.52	14.59	15.92	27.19	29.18	9.95	1.59
47.00 - 47.99	2	47.29	55.05	45.60	14.69	3.58	3.58	3.94	5.77	7.53	17.81	29.35	15.15	16.51	28.02	29.78	10.91	1.62
48.00 - 48.99	4	48.70	55.96	46.69	13.91	3.43	3.37	3.66	5.47	6.99	16.72	29.40	14.66	15.75	28.93	30.26	10.49	1.67
49.00 - 49.99	1	49.08	56.71	47.09	14.92	3.38	3.45	3.65	4.97	7.36	17.25	30.18	15.59	16.25	30.18	31.70	10.28	1.66
50.00 - 50.99	3	50.23	57.49	48.35	14.06	3.38	3.36	3.78	5.15	7.34	16.52	29.94	14.44	16.14	29.29	30.20	10.88	1.73
51.00 - 51.99	5	51.10	58.81	49.23	14.59	3.51	3.45	3.85	5.64	7.34	17.45	30.58	15.07	16.75	30.05	31.47	11.21	1.75
52.00 - 52.99	1	52.73	60.36	50.61	15.12	3.65	3.58	4.05	5.64	7.63	17.91	31.37	15.26	17.25	31.84	33.03	11.21	1.79
53.00 - 53.99	1	53.73	61.48	51.41	15.26	3.71	3.65	4.18	5.57	7.76	17.91	32.17	15.59	17.58	31.51	33.16	11.61	1.99

TABLE 3. *Body proportions of post-larvae and juveniles of* Rastrelliger kanagurta.

Size group (mm)	Body length (mm)	Body proportions in percentage of body length									
		HDL	SNL	ED	MXL	HDD	SND^1	SND^2	SNPT	SNA	BDD
8.00 - 9.99	9.44	35.38	8.47	11.02	13.98	24.58	41.74	61.97	37.92	61.75	27.44
10.00 - 11.99	11.20	34.82	8.75	10.18	13.66	22.86	41.60	63.48	36.61	62.05	24.64
12.00 - 13.99	13.09	33.69	8.71	9.55	12.91	22.08	40.34	63.48	35.37	62.11	23.38
14.00 - 15.99	15.06	32.73	8.43	9.29	12.42	20.72	38.31	61.69	34.13	61.15	21.65
16.00 - 17.99	16.83	31.85	8.20	9.15	13.07	20.08	38.09	61.44	33.51	61.14	21.81
18.00 - 19.99	18.92	32.13	8.24	8.77	11.47	19.82	38.79	63.42	33.56	61.36	21.72
20.00 - 21.99	20.79	31.36	8.13	8.75	11.74	19.38	36.60	61.23	33.00	60.08	21.16
22.00 - 23.99	22.65	31.25	8.13	8.44	11.23	18.52	36.12	61.40	33.02	59.68	21.48
24.00 - 25.99	25.27	31.34	7.79	8.66	11.48	18.36	36.21	60.90	32.77	61.02	21.73
26.00 - 27.99	26.80	31.16	7.83	8.77	11.12	17.54	36.45	61.27	32.83	60.89	21.43
28.00 - 29.99	29.34	29.82	7.12	7.74	10.56	17.21	35.72	60.05	31.56	60.12	21.06
30.00 - 31.99	31.06	29.81	7.31	7.92	10.85	16.64	35.29	60.66	31.62	60.30	21.38
32.00 - 33.99	33.28	30.14	7.42	7.63	11.32	16.85	35.67	60.82	31.85	60.31	21.66
34.00 - 35.99	34.60	30.20	7.60	7.51	11.36	16.47	35.92	60.78	32.17	57.72	21.27
36.00 - 37.99	37.09	30.25	7.47	7.74	11.29	16.09	36.75	61.36	31.57	57.67	21.11
38.00 - 39.99	38.82	29.00	7.06	7.11	10.53	15.09	35.03	60.66	30.94	57.52	20.40
40.00 - 41.99	40.56	29.61	7.27	7.10	10.80	16.05	35.85	60.68	31.46	59.69	22.19
42.00 - 43.99	42.73	30.26	7.30	7.16	10.93	15.66	35.69	60.89	31.64	61.10	21.76
44.00 - 45.99	45.36	30.31	7.43	7.16	10.93	15.28	35.93	61.53	31.79	60.43	22.60
46.00 - 47.99	47.07	30.76	7.34	7.69	11.94	15.83	36.97	61.76	31.80	58.95	22.50
48.00 - 49.99	48.78	28.92	7.01	6.93	11.00	14.49	34.50	59.82	30.42	59.82	21.42
50.00 - 51.99	50.77	28.34	6.81	6.77	10.75	14.46	33.68	59.76	29.21	58.62	21.82
52.00 - 53.99	53.23	28.54	6.91	6.78	10.51	14.45	33.65	59.68	28.97	59.50	21.43

The following morphometric characters were examined to study changes in the body form: snout length, head length and depth, body depth, snout to the insertion of first dorsal, second dorsal and anus. The relationships of the above body dimensions to the body length are shown as size on size regressions based on the data given in Table 2. In all the characters studied, the relations are simple linear ones.

TABLE 4. *Gill raker counts of* R. kanagurta *at different sizes.*

Size (BDE) of specimen (mm)	Gill raker counts			
	Upper limb	Angle	Lower limb	Total
11.47	3	1	12	16
13.93	4	1	14	19
16.25	6	1	15	21
17.58	6	1	15	22
19.90	7	1	16	24
20.89	7	1	18	26
23.02	7	1	21	29
26.13	8	1	22	31
27.86	9	1	22	32
29.71	9	1	23	33
35.42	10	1	25	36
39.93	11	1	26	37
41.32	12	1	27	40
46.63	13	1	29	43
51.21	14	1	30	45

Snout length

The regression of snout length on body length is shown in Fig. 10. It is seen that the snout length increases by approximately 0.065 mm for each millimeter increase in body length. The formula describing the regression line is given along its side.

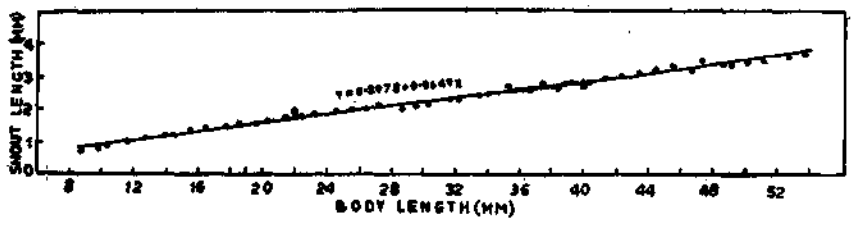

FIG. 10. Regression of snout length on body length. The line is fitted to the data given in Table 2 (see column 7) by the method of least squares. Each point represents the average of 1 mm size groups.

Head length and depth

Regressions of these two dimensions on body length show an increase in head length of 0.278 mm and in depth of 0.124 mm per millimeter increase in the body length. The formulae describing the regressions of these two characters on body length are given in Fig. 11.

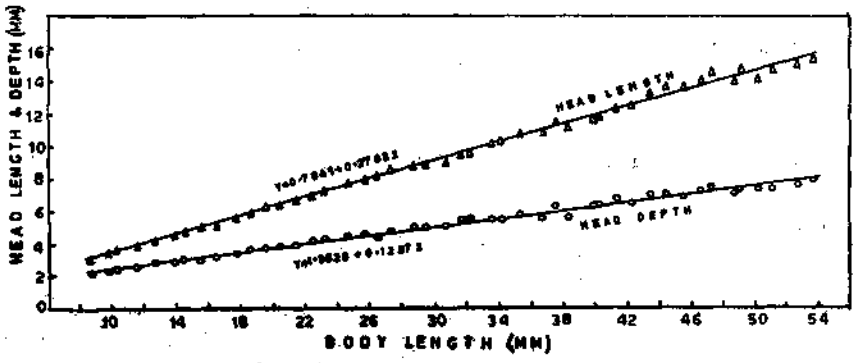

FIG. 11. Regressions of head length and head depth on body length. The lines are fitted to the data given in Table 2 (columns 6 & 11) by the method of least squares. Each point represents the average of 1 mm size groups.

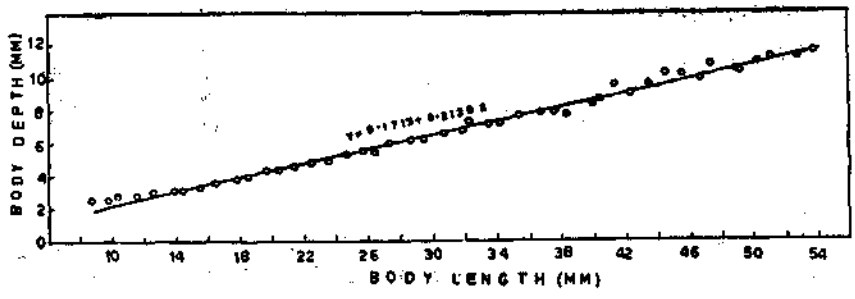

FIG. 12. Regression of body depth on body length. The line is fitted to the data given in Table 2 (see column 18) by the method of least squares. Each point represents the average of 1 mm size groups.

Body depth

The Indian mackerel appears relatively deep-bodied in the larval stage than in the juvenile stage. According to Kramer (1960) this change in the shape of body of the Pacific mackerel, *Pneumatophorus diego*, occurs at a size of 10.7 mm. A similar change in the body shape of *Rastrelliger* larvae at comparable size (8-10 mm) has been indicated (Matsui, 1963). The size at which this change occurs in *Rastrelliger kanagurta* cannot be fixed correctly due to the lack of sufficient specimens below 10 mm size in our collections. However, that such a change occurs in this species at about a size of 9-10 mm is indicated by the comparatively higher proportions of the body depth in the specimens below this size (vide Table 3).

Due to the reasons mentioned above, the relationship of the body depth to its length is shown by a regression line fitted to the whole data (Fig. 12). The formula describing the relationship is given along the side of the regression line. It shows that the body depth increases at a rate of 0.213 mm for each millimeter increase in body length.

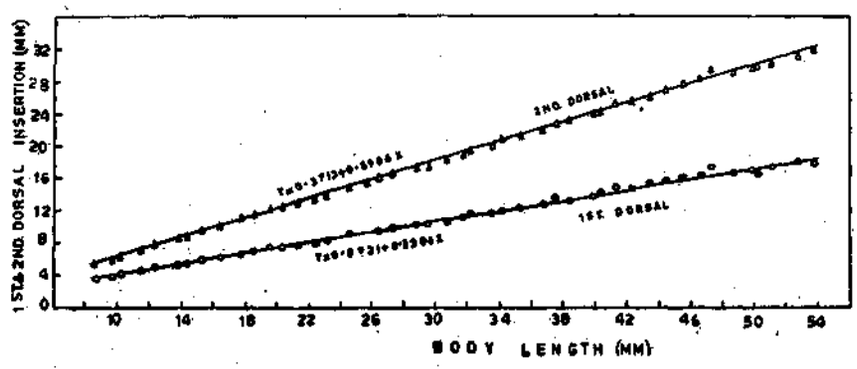

FIG. 13. Regressions of the distances from snout to 1st and 2nd dorsal fins on body length. The lines are fitted to the data given in Table 2 (see column 12 & 13) by the method of least squares. Each point represents the average of 1 mm size groups.

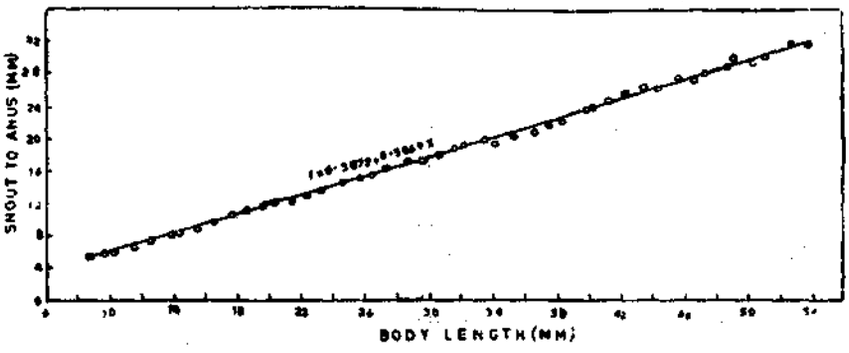

FIG. 14. Regression of the distance from snout to anus on body length. The line is fitted to the data given in Table 2 (see column 16) by the method of least squares. Each point represents the average of 1 mm size groups.

Distance from snout to dorsal fins

The relationships of the distances, from the snout to the first dorsal insertion and to the second dorsal insertion, to the body length are shown as regression lines in Fig. 13. These regressions show that the two characters increase at a rate of 0.331 mm and 0.598 mm respectively for each millimeter increase in body length. The distances from the snout to the origin of the first and the second dorsal fins are approximately 1/3rd and 2/3rds respectively of the body length.

Distance from snout to anus

The distance from snout to anus increases by about 0.587 mm for each millimeter increase in body length. The regression of this dimension on body length is shown in Fig. 14. As in the previous characters, a straight line relationship exists between this character and the body length.

General Remarks

The collection records of the post-larvae and early juveniles (Table 1) would indicate that the mackerel spawns over a number of months with certain peak months. This is in conformity with the earlier observations on the breeding period of the species (Balakrishnan, 1957; Rao, 1962; Rao, 1964 and Jones and Rosa, 1965).

It is reported that the ripe intra-ovarian egg has a diameter ranging from 0.85 to 0.94 mm and possesses a single oil-globule measuring 0.23 mm (CMFRI 1960). It is, therefore, natural to expect that its planktonic egg has a slightly bigger size. The only records of the eggs and larvae of this species from the Indian waters are those of Devanesen and John (1940) from Chaliyam near Calicut, Kuthalingam (1956) from Madras and Balakrishnan (1957) from Vizhingam. While Balakrishnan (*op. cit.*) states that the size of the planktonic egg varies from 0.8 mm to 1.01 mm, Devanesen and John (*op. cit.*) mention a size range of 0.54 - 0.70 mm.

Recently, while reporting the results of fish egg survey from the Gulf of Thailand, Boonprakob (1962) gave the diameter for *Rastrelliger*-type eggs as varying from 0.72 mm to 0.90 mm, with the oil-globule measuring 0.20 - 0.25 mm. Detailed descriptions of the eggs and larvae of *Rastrelliger*, collected from the Gulf of Thailand, were given by Matsui (1963) and Boonprakob (1965).

Interestingly enough the pre-opercular spines, which are present in the larvae and early juveniles of other scombroids, are conspicuous by their absence in *Rastrelliger*. This condition appears to be a rule rather than an exception in all the genera of mackerels (Ehrenbaum, 1923; Sette, 1943; Bigelow and Schroeder, 1953; Uchida *et al.*, 1958; Kramer, 1960 and Matsui, 1963). The absence of pre-opercular spines in the otherwise scombroid-type of larva is a useful criterion in identifying and isolating *Rastrelliger* from other scombroids.

In this connection, it should be pointed out that the 9.3 mm larva described by Gorbunova (1963) as belonging to *Rastrelliger kanagurta* differs from a similar stage described by us in the presence of pointed snout and pre-opercular spines. The pointed snout and the presence of pre-opercular spines described by her would indicate that it is a scombroid larva other than *Rastrelliger*.

SUMMARY

Some of the early stages of the Indian mackerel, *Rastrelliger kanagurta* (Cuvier), not described so far from the Indian waters, are reported. Their size varied from 8.7 mm to 53.7 mm in body length.

Descriptions and figures of a selected series of stages are given. Changes in the body form of mackerel in its early life were studied based on seven morphometric characters. It is indicated that the species is comparatively deep-bodied at the post-larval stage than at the juvenile stage.

ACKNOWLEDGEMENTS

We wish to express our thanks to Dr. S. Jones, Director, Dr. R. Raghu Prasad, Deputy Director, Dr. G. Seshappa, Senior Research Officer, and Mr. L.B. Pradhan, Research Officer, for their encouragement in the preparation of this report. Thanks are also due to our colleagues Mr. S. K. Dharma Raja and Mr. K. N. R. Kartha for their help in the statistical procedures and calculations respectively.

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