

ON THE BIONOMICS OF THE RAINBOW SARDINE,
DUSSUMIERIA HASSELTII (BLEEKER).¹

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(Communicated by Rai Bahadur S. L. Hora, D.Sc., F.N.I.)

(Received August 24, 1943.)

Dussumieria hasseltii contributes to one of the commercial fisheries of the Gulf of Manaar and Palk Bay. It shoals regularly in large numbers from February to November.

Food:—The diet of this sardine consists mainly of plankton and occasionally of fingerlings of White-bait (*Stolephorus* sp.). The following organisms have been found in its stomach-contents:

I.—**Zooplankton**: (1) Copepods consisting chiefly of *Paracalanus* sp., *Acartia* sp., and *Oithona* sp., (2) *Rhopalophthalmus egregius*., (3) *Leucifer hanseni*., (4) Crab-Zoea and Megalopa larvae, (5) Larvae of *Squilla*, (6) *Acetes* sp., (7) *Creseis acicula*, (8) *Spiratella* spp., (9) Larval bivalves, and (10) *Sagitta* spp.

II.—**Phytoplankton**: (1) *Coscinodiscus* chiefly *C. jonesianus*, *C. nobilis*, *C. oculusiridis* and *C. gigas* var. *dioramma*, (2) *Rhizosolenia*, (3) *Thalassiothrix*, (4) *Trichodesmium*, and (5) algal filaments.

Size:—The specimens examined generally ranged in length from 9 to 16 cm., but in rare cases the maximum length recorded is 20 cm. (Day, 1889). Young specimens less than 9 cm. long have not been found in the commercial catches, which mainly consisted of fish 13 to 15 cm. long. Sexual maturity seems to be attained for the first time when the fish reach a length of 14 cm.

Spawning season:—March to December roughly constitute the breeding season. Specimens with fully mature transparent ovarian eggs were obtained in April, June, September and October. Specimens partly or fully spent were seen in April, May, July, September and November.

Eggs of *Dussumieria hasseltii* were found in plankton collected from the Kundugal Channel on the 3rd and 8th of October, 1941, 3rd and 7th November, 1941, and 1st and 2nd April, 1942. These days fall on or around Full Moon days. Specimens, partly or fully spent, were also observed on Full Moon days and on the following one or two days. It, therefore, seems that *Dussumieria hasseltii* prefers to spawn during Full Moon, unlike the Oil Sardine, *Sardinella longiceps*, which spawns during New Moon (Devanesen, 1943).

The gonads:—The right ovary is long and pear-shaped reaching to the heart while the left is very short and contains a smaller number of eggs. The testes are thin whitish structures, the right placed far forwards and the left far behind in the abdominal cavity. The vasa deferentia are long conspicuous structures. It is only the right ovary and the right testis which are fully developed. The reduction of one of the gonads is noticeable in the organisation of several animals, such as the echinoderm larvae, birds and monotremes. Among fishes, in the White Sardine, *Kowala thoracata* (Devanesen and John, 1941), the right gonads are vestigial, whereas in the Rainbow Sardine the left gonads are affected.

Eggs:—On an average, the right ovary contains 420 to 500 eggs, and the left ovary 25 to 80 eggs. This is the lowest figure for a clupeoid fish. Even in *Kowala thoracata* (Devanesen and John, 1941) in which only the left ovary is functional, the number of eggs

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on an average is about 8,000. The mature ovarian egg measures 0.84 mm. in diameter. Besides, all the ovarian eggs do not ripen at the same time. About 50 to 100 only become mature and transparent at a time. Thus several weeks should elapse before a spawner can discharge all the eggs, at intervals. The advantages of this kind of protracted and intermittent spawning are twofold, namely, to give a much wider area for distribution, and a series of gradations in the growing young fish (McIntosh and Masterman, 1897).

Description of the eggs found in the plankton.—The eggs of *Dussumieria hasseltii* found in the plankton measured 0.88 mm. in diameter. The yolk is clear and frothy as in all clupeoid eggs. There is a single slightly yellowish oil-globule, 0.26 mm. in diameter at the vegetative pole.

The eggs found in the plankton at 7 a.m. on 1st April, 1942, about 30 in number, were isolated and reared in the laboratory. They were found in an advanced stage of development suggesting that the eggs had been laid overnight. The embryo was formed and had already curved over half the yolk-mass. The optic vesicles were developed; and about 29 to 31 myotomes were visible. The embryo showed occasional wriggling movement within the egg. The perivitelline space was rather narrow when compared with other clupeoid eggs. But as development proceeded the perivitelline space increased in area; but the diameter of the egg remained the same.

At 9.30 a.m. the tail of the embryo was found to oscillate within the egg at the rate of 20 times per minute. At 10 a.m. the tail was found to have increased in length, and the curved embryo had embraced the yolk-mass almost completely. The perivitelline space increased still further, perhaps owing to absorption of yolk by the growing embryo. At 10.30 a.m. the formation of the lens of the eye was noticeable.

Rearing of the larvae.—At 11 a.m. hatching commenced. The eggs spin rapidly for about 3 minutes, and then the embryos emerge out breaking open the egg-membrane. Out of the 30 eggs isolated from the plankton 25 hatched out within 20 minutes, the first egg at 11 a.m. and the last at 11.20 a.m. The salinity and temperature of seawater in which the larvae hatched out are $34.65^{\circ}/_{\infty}$ and 29.4°C . The newly hatched out larva measures 1.70 mm. in length. The following clupeoid characteristics are noteworthy: (1) the backward situation of the anus under the 48th myotome; (2) the yolk is vacuolated; (3) the muscle fibres show the peculiar crossed arrangement; and (4) the yolk tapers into the gut posteriorly. The larva shows 48 myotomes in front of the anus and 9 behind it. The heart exhibits rhythmic beating movements. There are two rows of brown pigment on either side of the larva. The larva floats at the surface in a slanting position. The lens of the eye is very clear and unpigmented. The auditory vesicles are also differentiated behind the eyes.

12 noon.—One hour after hatching, the larva has a straight body 1.86 mm. long.

2 p.m.—Three hours after hatching the larva is 1.92 mm. long. The anus has shifted slightly forwards; there are 46 myotomes in front and 11 behind it. The rudiments of the pectoral fin has developed. A patch of brown chromatophores at the anterior portion of the dorsal fin-fold, and three branched chromatophores at the hind end of the yolk mass are observed.

3 p.m.—After four hours the larva has grown to 2.14 mm. in length. The yolk-mass is diminishing with a tapering end posteriorly. The anus has shifted further forwards to below the 45th myotome. The oil-globule has broken up into 7 smaller ones, each 0.04 mm. in diameter; but they remain collected together at the posterior portion of the yolk-mass. The larva shows a preference to a lower layer of water.

5 p.m.—Six hours after hatching the length of the larva is 2.70 mm. The brain folds appear. In addition to chromatophores already described, others have appeared around the anus. Fin-rays have appeared in the caudal region. There are 44 preanal and 13 postanal myotomes.

2.4.1942, 6 a.m.—Eighteen hours after hatching, the larva has increased to 3 mm. in length. The yolk-mass is reduced to 0.54 mm.; and the oil-globules break up into smaller ones before finally disappearing. The heart beats vigorously. Fin-rays have appeared all along the fin-fold, which has differentiated posteriorly into the caudal fin. There are two rows of brown pigments along the side of the body. The anus has shifted

further forwards, being now placed below the 41st myotome. The larva creeps at the bottom but frequently darts to the surface and swims.

11 a.m.—The larva is now 3.12 mm. long. The yolk is further reduced to 0.42 mm. The otocyst has become larger. Rudiments of the lower jaw appear.

3 p.m.—After 27 hours the length of the larva is found to have increased to 3.24 mm. Two gill-slits are clearly seen. The upper jaw is also differentiated. The eyes measure 0.22 mm. in diameter, but are still unpigmented. The yolk-mass is reduced to 0.34 mm. The anus is still moving forwards, there being 39 myotomes before it and 18 behind it.

3-4-1942, 9 a.m.—Forty-five hours after hatching, the larva swims very actively at the surface with the help of the pectoral fins which are now well developed, each measuring 2.9 mm. in length. Yolk has completely disappeared. The eyes are pigmented black and bluish green. Mouth is wide open. The chromatophores on the fin-folds have disappeared; and there are now two rows of black pigment on the sides of the larva. The larva is 3.28 mm. long. No further shifting of the anus is observed.

5 p.m.—After 53 hours, the larva is 3.46 mm. long. Its open mouth is 0.28 mm. wide, showing a strong dentition on the lower jaw (Delsman, 1925). This feature is not observed in other clupeoid larvae. The S-shaped heart pulsates regularly. Three gill-slits are seen. The clearly pigmented eyes are 0.2 mm. in diameter. The larva died at this stage in spite of adequate aeration. Feeding the larvae after the absorption of the yolk-mass could not be attempted for want of seawater circulation in the aquaria.

To conclude, the larva of the Rainbow Sardine shows the following clupeoid characteristics: the backward situation of the anus and its subsequent forward movement, the posterior crossed arrangement of its muscles, and the coincidence of the complete using up of yolk and the eyes becoming pigmented. The single oil-globule disappears by breaking into smaller ones. The larva keeps to the surface of water till the oil-globule disappears, when the yolk is also nearly used up. Thereafter the larva creeps at the bottom, only occasionally coming to the surface, until the pectoral fins become sufficiently well developed and strong to enable the larva to remain swimming at the surface. The larva has a wide gaping mouth with strong dentition (Delsman, 1925).

*Enemies of *Dussumieria hassellii*.*—Specimens of this sardine have been recorded in the stomach-contents of the following fishes: (1) *Chirocentrus dorab*, (2) *Scomberomorus commersonii*, (3) *Lactarius lactarius*, and (4) *Sciaena albida*. These fishes follow in the wake of shoals of the Rainbow Sardine and feed on it. This may adversely affect the fishery of this fish.

SUMMARY.

(1) The planktonic food of the Rainbow Sardine has been analysed; (2) The spawning season has been delimited. There seems to be a lunar periodicity in spawning, round about the Full Moon. (3) The suppression of the left gonads is remarkable. (4) The larvae hatched in the laboratory were kept under observation for fifty-three hours. (5) As the anus shifts forward during the growth of the larva, the demarcation between the trunk and the tail is indistinct.

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