BREEDING HABITS, EGGS AND EARLY LIFE HISTORY OF THE INDIAN SHAD, *HILSA ILISHA* (Ham.), IN THE NARBADA RIVER.

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INTRODUCTION.

Interest in the life history of Hilsa was first aroused by the preliminary investigations of Francis Day (1873) and by the recommendation of K. G. Gupta (1908). Later on, the Fisheries Departments of Bengal and Bihar and Orissa, and Madras also undertook more detailed investigations on the subject, including artificial fertilization of the eggs. In Bengal, the eggs could not be reared into larvae on account of large quantities of mud held in suspension in the river water and fungus attacks (Southwell and Prashad, 1918), whereas Sundara Raj (1917) records hatching of Hilsa eggs by Wilson as well as by himself. Devanesen (1939) also asserts that the collection and hatching of Hilsa eggs continue as a routine at Madras. It is unfortunate, however, that despite these statements, no detailed description of the eggs and early larvae of Hilsa has ever been published. Nair (1939) described a series of early stages of Hilsa, but the youngest stage described by him is 14 mm., the earlier life history of the fish being yet unknown.

The existence of this lacuna in our knowledge induced the writer to obtain precise data on the nature of the eggs, larvae and breeding habits of this important food fish. Accordingly, eggs were collected in plankton nets from the Narbada river which flows into the Gulf of Cambay on the west coast of India. A few eggs and larvae were obtained in this way, but their identity was not certain. Attempts were, therefore, made to strip ripe fish and to fertilize the eggs artificially in order to determine the identity of the eggs collected in the plankton. A comparison of these eggs with those taken from plankton has not only confirmed their identity but has also strengthened belief in the correctness of the hypothesis advanced by Hora (1938) regarding the spawning grounds of Hilsa. Results of these operations have been detailed in the following pages.

SPAWNING GROUNDS OF HILSA.

Investigations made by Hora (1938) have indicated that the spawning grounds of Hilsa in Bengal are located in the river Hooghly in the neighbourhood of the Pulta waterworks near Calcutta. Hora's findings were based on the occurrence of

Hilsa in the tanks of the municipal waterworks at Pulta. The present observations, on the other hand, are based on the occurrence of fertilized eggs as well as gravid females with oozing eggs in a particular stretch of the river Narbada. Moses (1942) records that in the Narbada, Hilsa are found in its lower reaches during the monsoon months, but he does not state anything regarding their spawning migrations. Investigations were, therefore, undertaken in that river, near the villages of Nicora and Jhanor, about 40 miles up-stream from the sea along the course of the river (*vide* map) and about 12 to 15 miles east of the town of Broach, 200 miles north of Bombay. This area is slightly under the tidal effect, though the water of the river here is entirely fresh (sweet) at all times of the year. The water level of the river rises by about a foot during the highest spring tide.

Inspection of the catches in this area, during July 1949, revealed that some of the gravid females had reached such stage of ripening of their gonads that the eggs were oozing out of the vent. This indicated that they had almost reached their desired breeding grounds and that they would have actually spawned within a short time. Some of these fish were caught in small hand nets, locally known as 'Jamda' nets, and others in ordinary gill nets.

The occurrence of such ripe females (with oozing eggs) in this area may be a satisfactory proof to regard the locality as a spawning ground, but this inference cannot be taken as finally conclusive. A search for fertilized eggs in the water of the river in the same area was, therefore, undertaken. On August 22, 1949, plankton was collected in the five-mile stretch of the river between Niccra and Jhanor with an ordinary tow net with double mosquito curtain netting. In the four hauls which were made, each of 20 minutes duration, no eggs were found in the first two, but, in the last two hauls 75 eggs were collected. Out of these, 25 were dead and unfertilized and the rest were fertilized and of normal shape and size as could be made out from the eggs which were stripped and fertilized artificially on a previous occasion. The eggs were carefully isolated from a large amount of floating debris and hatched in large petre dishes by changing the water at regular intervals and keeping the eggs free from mud particles suspended in the river water. The collection of the eggs was made between the hours of 7 and 8 p.m. when the area was under tidal influence and the temperature of the water was 27·5°C., the river being at its normal flood level.

The occurrence of females with oozing eggs and the presence of fertilized eggs in the plankton indicate beyond any doubt that this area is part of the spawning grounds of Hilsa; detailed observations are, however, necessary to ascertain the extent of these spawning grounds. Further, as stated before, the females with oozing eggs were caught in hand nets, the 'Jamda', operated at a depth of about 3 or 4 feet from the surface. A few were caught in gill nets fixed at about 15 feet below the surface and almost near the bottom. It would appear from this that the ripe females do not necessarily swim at lower depth but can be found travelling very close to the surface also.

Range of Migration of Hilsa in the Narbada.

Hilsa is known to ascend hundreds of miles, in large schools, into rivers, such as, the Ganges, the Indus, etc., but its migration in the Narbada, according to the present investigations, is limited to about 80 miles only from the sea. Observations made along the course of the river have shown that there is hardly any large-scale Hilsa fishing in the river a few miles above the village of Jhanor (40 miles from the sea), as the shoals do not seem to ascend beyond this area. Nevertheless, smaller schools are known to ascend another 40 miles or so up to the village of Garudeshwar (*vide* map). Beyond this village, the river bed is rocky and steep and consequently the current is much stronger. The high velocity of the river current may probably be the main factor that restricts the range of migration of Hilsa in this river. Deter-

mination of velocity at this point would have yielded important data on the swimming powers of the fish in regard to the construction of fish passes in the dams and weirs obstructing upward migration of Hilsa, but the work could not be accomplished during the last season.

It is reported that Hilsa is not known to ascend higher than about five miles in the Purna river on the Gujarat coast. Similarly, in the Ulhas river, north of Bombay, it is known to ascend only about 25 miles. It is thus of interest to note that while the fish travels very long distances in the Ganges, the Indus, etc., its migration to rivers on the western coast is very much limited. Further investigations may reveal precise reasons for this restricted migration and may indicate the possible means of solving the problems arising from restriction of range of migration of this important fish due to the construction of dams across some of the large rivers of India. One important fact which emerges from these observations is that Hilsa is capable of adapting itself to variable environments and of breeding even within 50 miles from the sea, depending on several factors, such as, the strength of the current, salinity, volume, depth of water, etc.

Lunar Periodicity in the Hilsa Fishery.

Majumdar (1939) recorded that Hilsa fishing is done in the Sundarbans during the neap tide. It is reported that on the Balasore coast Hilsa fishing is done from the 11th day of the moon till the 3rd day after the full moon, i.e., during the spring tide and again during ebb tide from the 11th day after the full moon (Prashad, Hora and Nair, 1940). A similar lunar periodicity has also been observed in the Narbada, where Hilsa fishing is done from the 12th day of the moon to the first day after the full moon or the new moon in each lunar fortnight. Thus, the fishing is done only during the two spring tide periods in each month. The catches during the neap tide period are so low that practically all fishing is suspended during this period. From the observations made at most of the fishing villages along the Narbada, as well as from the experience of coastal and estuarine fishing of a general nature, it seems that the 'neap tide' mentioned by Majumdar (*Loc. cit.*) and the 'ebb tide from the 11th day after the full moon' reported by Prashad *et al.* (*Loc. cit.*) may be language errors. The reporters probably had in mind only the spring tide periods commencing from the 11th day of the moon in the second fortnight of the lunar month. The matter would, however, require additional data from the same places to settle this point.

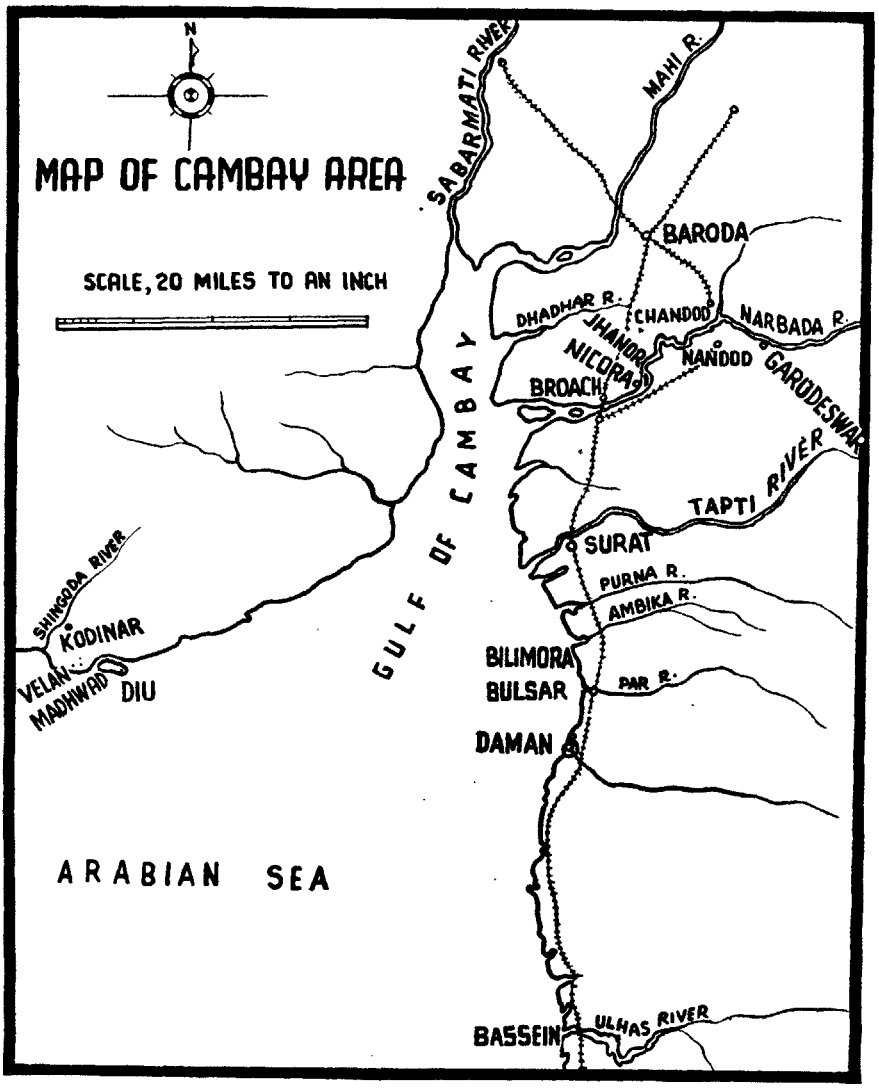
The analysis of the catches of the fishermen made at Jhanor and Nicora showed that the proportion of ripe females (oozing eggs) is very small and that such ripe fish are usually caught during the high tides. Catches of 25 fishermen were examined on July 22 and 23 (13th and 14th days of the moon) and again on August 7 and 8 (12th and 13th days of the moon). Out of the total catch of 350 fish examined in July there were 6 ripe females, whereas in the catch of 3,000 fish caught in August, 70 ripe females were recorded. Their number on other days was much smaller. This would indicate that during spring tide the mature fish ascend the river in larger numbers for spawning and there is thus a lunar periodicity in the reproduction of this fish. The fact that fertilized eggs were obtained in the plankton collected on the 14th day of the moon (August 22, 1949) also lends support to this view.

Ovarian Eggs of Hilsa.

Clupeoid fishes, of which Hilsa is a member, are known for the large number of ova they produce, but precise information regarding Hilsa is lacking.* Hilsa has

* Since writing this, Chacko and Ganapati, *Journ. Madras Univ.*, XVIII, 1949, estimated 1,282,110 eggs in *H. ilisha*.

a bilobed ovary which grows and fills the entire body cavity when fully developed. The weight of such a gonad in a large female 512 mm. in total length (437 mm. standard length) and 4·5 lb. in weight, is 13·7 oz. A part of this roe along with its mesenteries was cut, weighed and the number of ova counted. This showed that the ovary contained about 1,864,000 ova. All these ova are almost in the same stage of development and appear to be intended for a single spawning season. If a small piece of ovary is teased out and examined under a microscope, it will be apparent that along with the aforesaid developed ova there is also another category of very small undeveloped ova (Text-fig. 2*a*) attached to the mesenteries which appear to be intended for the next season. Each developed ovum is roughly 1 mm. in diameter, but all of them being held together in a compact mass in the ovary, are not

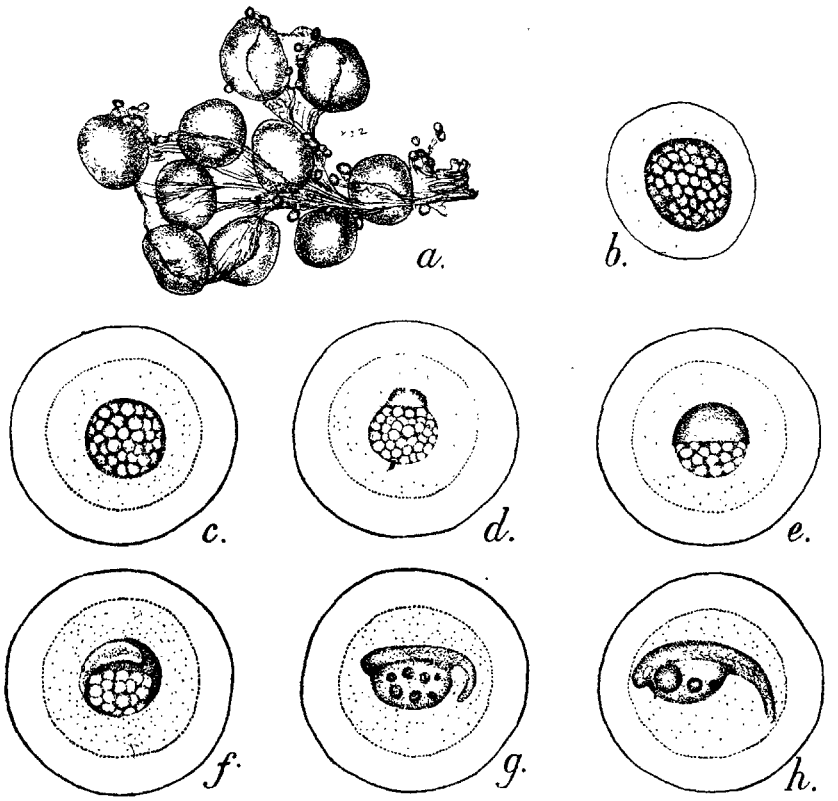


TEXT-FIG. 1.—Map to show the rivers discharging into the Gulf of Cambay.

completely round or spherical until they ripen and are ready to be shed. The yolk of the ova is opaque at this stage and the compact mass of the ovary can be said to be comparatively hard (hard roe). However, when the ova ripen, the yolk becomes more or less fluid and transparent and the eggs become soft. They then get disentangled from the mesenteries and flow out through the genital aperture even on a very slight pressure on the abdomen. Such ripe, unfertilized eggs are almost spherical and their diameter is about 1·3 mm. (Text-fig. 2*b*).

Eggs and Embryonic Development.

On July 22nd, 1949, one ripe female caught in a hand net was stripped in an enamel dish and the eggs were immediately fertilized artificially with the milt obtained from a freshly caught male. The eggs were very soft and smooth and appeared to be pale dirty brownish in colour. When freshly laid, they are 1·3 to 1·5 mm. in dia. with semi-fluid vitelline material (Text-fig. 2*b*). On immersion in water, the eggs begin to absorb water till they are 2·1 to 2·3 mm. in dia. (Text-fig. 2*c*). At this stage they are demersal in still water, but their density is so close to that of the water, that even with a slight current, they keep on drifting and appear pelagic



Text-fig. 2.—Eggs and Embryonic Development of *Hilsa ilisha* (Ham.)

a. Piece of an ovary showing fully developed and undeveloped ova along with mesentery × 11; *b*. A ripe unfertilized ovum × 13; *c*. A fertilized egg after absorption of water × 13; *d*. Blastodisc formation after ½ hour of fertilization × 13½; *e*. A stage 4 hours later × 13½; *f*. Formation of embryonic shield after 8 hours × 13½; *g*. An embryo formation 12 hours later × 13½; *h*. 17 hours later embryo ready to escape from the egg × 13½.

in nature. The egg membrane, when distended with absorbed water, appears smooth and devoid of any processes or corrugation. Inside this outer membrane, there is another very thin and delicate inner membrane. Thus the egg membrane of Hilsa is double-layered as in the English herring (McIntosh and Masterman, p. 410). These two membranes, according to Hoffman (as quoted by McIntosh and Masterman, *op. cit.*) form the zona radiata of the egg. The water absorbed and stored in the perivitelline space serves as a very useful cushioning for the delicate embryo growing over the yolk. The yolk appears to be composed of a number of small oil globules which form a large conglomeration in the centre of the egg. This gives the appearance of segmented yolk which is considered by Delsman (1926) as characteristic of all clupeoid eggs.

The development of the egg starts immediately after fertilization. Within half an hour, the streaming movement of the protoplasm towards the lower pole is completed and a blasto-disc is formed (Text-fig. 2*d*). Segmentation of the blasto-disc takes place quite rapidly and within the following four hours a cap of cells covering up to about half the conglomerate oil globule is developed (Text-fig. 2*e*). After another four hours, an embryonic shield is visible (Text-fig. 2*f*). Development at this stage appeared to be quite rapid and after twelve hours a distinct embryo with a prominent protrusion representing the head still attached to the yolk sac and a tail free from the sac (Text-fig. 2*g*) is visible. A few muscle segments can be made out, but the formation of the optic vesicle is not discernible. Contractions of the body of the embryo begin after about 15 hours and they become more frequent after another two hours. These contractions help to coalesce the small oil globules into larger and fewer ones reducing them finally to three or four. After 17 hours, the embryo becomes restless within the egg membrane. Its struggle indicated that it was attempting to escape from the egg membrane and appeared to exert pressure on it with its head and tail (Text-fig. 2*h*). This struggle was continued for some time with an intermittant period of rest. After full 18 hours, the larva burst out of the egg membrane and swam out vigorously vibrating its tail. The temperature of the river water was 28°C. and that of the water in which the eggs hatched out was 28·5°C., there being some slight fluctuation when the water of 27·5°C. cooled in earthen pots was being added. All eggs do not necessarily hatch out after 18 hours but require different periods ranging up to 26 hours, the period depending probably on the temperature, oxygenation of the water, etc.

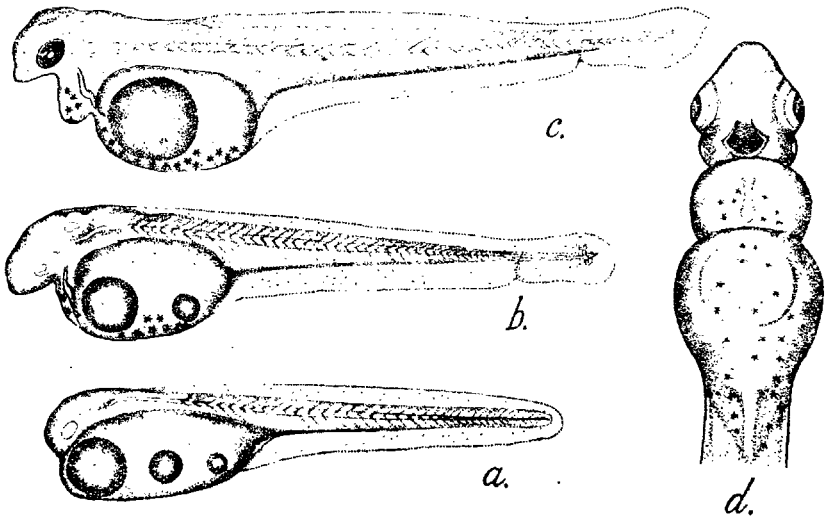
Larval Development of Hilsa.

Newly hatched Larva: As compared to the size of the egg, the first hatchling or the earliest larva of Hilsa is very small, being only 3·1 mm. in total length (Text-fig. 3*a*). The head seems to be yet in contact with yolk sac and the optic vesicles, though fully developed, are indistinct and do not have any pigment in them. Auditory capsule is not yet visible. The yolk sac is large and oblong and is attached to the body along its longer axis. There are three distinct oil globules, the anterior-most is the largest and the remaining two being smaller. In some cases there is a fourth oil globule also. There is a very thin and narrow vertical fin fold which is continuous over the caudal end but it is not differentiated into a caudal lobe. In the living condition the larva is almost transparent and is visible only with difficulty.

As soon as the larva hatches out from the egg it swims violently up to the surface of the water by vibrating its tail and then drops down listlessly on to the bottom for a while. This peculiar movement is repeated intermittently. During these sporadic movements, the larva does not swim in the normal position, but on account of the buoyancy of the yolk and the large oil globules, it swims upside down and rests on the bottom on its dorsal side.

Second day Larva: The larva on the second day (Text-fig. 3*b*) grows to a total length of 3·7 mm. The head portion seems to be further developed and hangs out

prominently and is unattached to the yolk sac. A tubular heart is also visible between the head and the yolk sac on the ventral side. On closer observation, the heart can be seen pulsating rhythmically but no red blood corpuscles could be seen. The eyes have developed but yet there is no pigment. Auditory vesicles are visible. The yolk sac is slightly reduced in size but instead of three oil globules only two are now present. About 42 muscle segments are clearly visible and the rest are indistinct. The anus appears at about 38th segment from the head. The fin membrane is well-formed and the caudal lobe is being differentiated. Very small black chromatophores are present on the throat as well as on the yolk sac but the body is devoid of any such pigment.



TEXT-FIG. 3.—Larval Development of *Hilsa ilisha* (Ham.) ×22.
a. Hatchling of Hilsa; *b*. Larva on the 2nd day; *c*. Larva on the 3rd day; *d*. Ventral view of the anterior part of the larva on the 3rd day.

Although the larva has progressed considerably on the second day, it still swims upside down and rests on the dorsal side as on the previous day. Unlike the first day stage, it does not, however, come to the surface of the water and drop down but swims at intervals on the bottom only.

Three-day-larva: On the third day, the larva (Text-fig. 3*c*) does not seem to increase much in size being only 4·2 mm. in length, but further internal growth seems to have advanced well. The striking feature in the head region is the development of black pigment in the eyes which look quite prominent. Another characteristic feature is that the red blood corpuscles are seen coursing through the tubular pulsating heart. In the ventral aspect (Text-fig. 3*d*) a distinct mouth is apparent which looks like a comparatively large orifice with only the lower or hind lip. The fin membrane is slightly modified in the dorsal region and looks slightly higher in the region of the dorsal fin. The caudal lobe is further differentiated and the dorsal lobe more developed. The anus is distinct and the development of the intestine also is discernible. The position of the anus indicates that it has migrated anteriorly during the course of the day, on the same lines as has been observed by Nair (1939) in later stages of the fish.

In its movements, the larva does not yet assume the normal position but continues to swim in an inverted posture as before. However, while resting on the

bottom, it rests on the side and this development indicates the possibility of the larva assuming its normal position on the fourth day.

Further observations on the larval development were, however, cut short as the larva died of metallic poisoning as a result of the accidental use of water stored in a copper pot.

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