STUDIES ON THE DEVELOPMENT OF THE INDIAN GARFISH *TYLOSURUS STRONGYLURUS* (VAN HASS.) WITH NOTES ON THE YOUNG STAGES OF *HEMIRHAMPHUS GAIMARDI* CUV. & VAL.

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Tylosurus strongylurus (van HASS.)[1]

While searching for Teleostean eggs in October 1937 in the Adyar river, Madras, we came across a few large sized eggs, attached singly by very long filamentous threads to algae consisting mainly of *Chaetomorpha*. The external features of the eggs, especially the long filamentous anchoring threads showed clearly that in all probability they would belong to one of the Synentognathi. Opportunity was taken to follow their development, since the Synentognathi, " although all extremely specialised ", as Breder (1934) remarks, " form an interesting and not unimportant link in the ecological complex of warm seas." Breder believes that observations on the development and life-habits of the fishes of this group " when coupled with anatomical and other studies will be of service in interpreting the nature of the origin of flight as well as other specialisations, not as spectacular but at least equally fundamental."

The eggs were brought to the Laboratory and kept under observation in clean brackish-water, which was renewed daily. The larvae hatched out after a week, and the characters were sufficiently well established to admit of easy identification.

Subsequently, early in December, we were able to obtain several gravid female specimens of *Tylosurus strongylurus* from the Adyar. Evidently the fish frequent the river-mouth for breeding purposes. The ovaries are asymmetrical, one of them (more often the right) being much better developed than the other. In the earlier stages of the ova (text-fig. 1*a*) the filaments remain in close apposition to the egg-surface. In the ripe ovarian eggs, however, the filaments become free (text-fig. 1*b*). The largest ova measure 2·5 mm. in diameter and resemble closely the laid eggs obtained by us from the Adyar, thus confirming beyond doubt that the eggs, the development of which has been traced, are those of *T strongylurus*.

The eggs of the European Synentognathi have attracted the attention of previous workers, especially owing to the presence of anchoring threads on them. There are several references to these fishes laying eggs attached to weeds, floating pieces of wood, etc. Day (1884) records the eggs of *Belone* attached to a mackerel net by " tentacular filaments", which were observed by Dunn (cited by Day) to adhere even to polished metal.

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[1] *Belone strongylura* of Day and other authors (*vide* Weber and de Beaufort, 1922.)

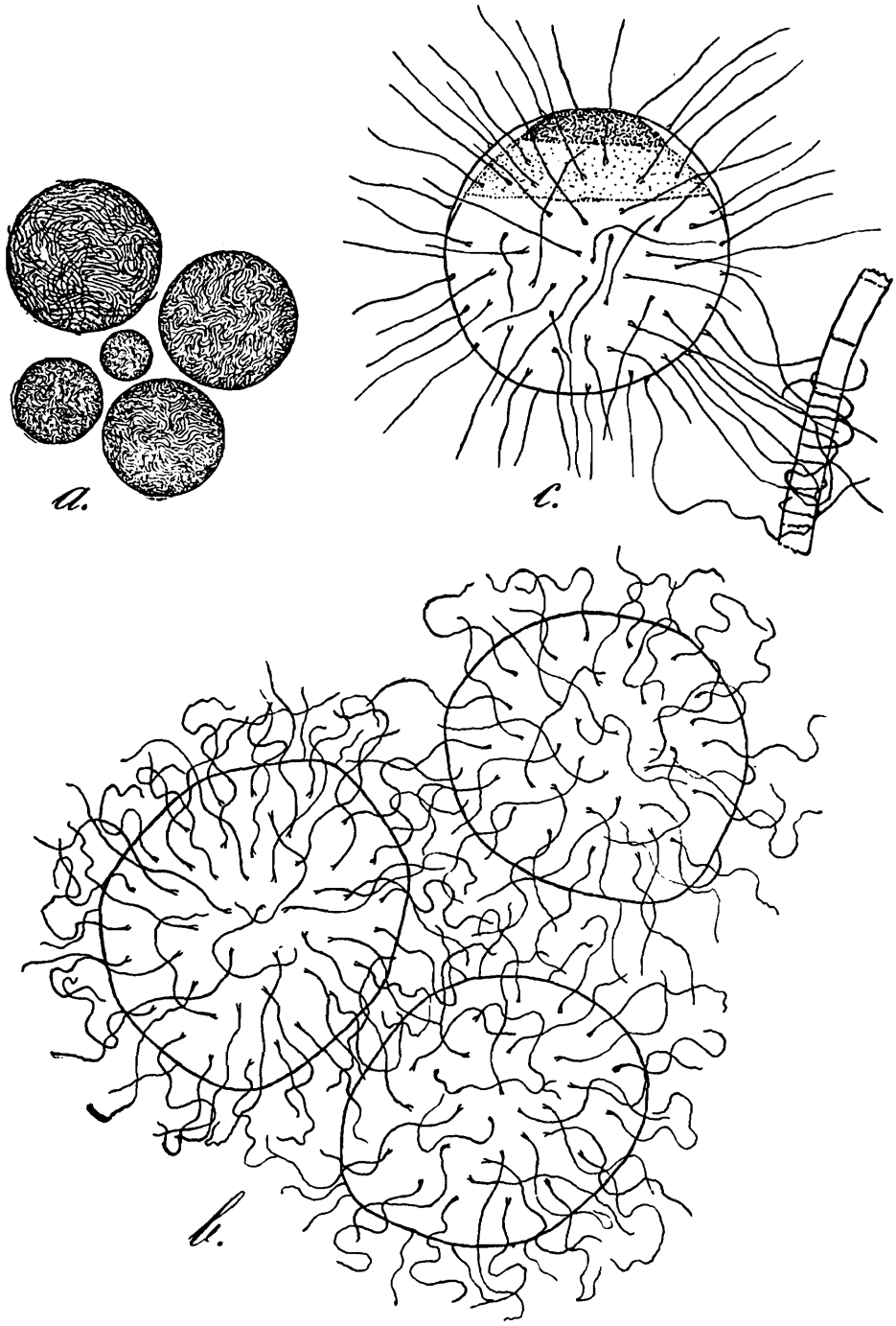
Williamson (1893) artificially fertilised some eggs of *Belone* and followed their development at Naples, where they are abundant in the month of May. McIntosh and Masterman(1897) give a number of extracts dealing with the breeding habits and development of the European garfish, *Rhamphistoma belone* L. It seems that the breeding season there is from April to July. Aflalo and Marston (1904), when dealing with the spawning of the garfish, says that the threads, " some of them 1 cm. (or $\frac{2}{3}$ inch) long, grow all over the surface of the eggs " and " look as if they were capable of anchoring the eggs not only to each other, but also to any other support with which they come in contact." They also refer to the opinion of Scandinavian workers that the eggs must be deposited close to the shore among the weeds as the adults have always been caught from there during the spawning season. Cunningham (1912) gives a photomicrograph of two eggs of *Belone acus* attached by their threads to algal filaments. In this connection it may be mentioned that the form referred to as *Rhamphistoma belone* by McIntosh and Masterman and as *Belone acus* by Cunningham is considered as *Tylosurus acus*, and its occurrence at the Tortugas in early June is recorded by Breder (1934). In the same paper Breder records his observations on the young stages of the other American garfish, *Tylosurus raphidoma*. He observes that ripe specimens of *T raphidoma* were obtained from the Tortugas in the months of June and July, but suggests that the spawning season " is apparently protracted as is indicated by the large variety of sizes obtainable during the summer in the West Indies ", and adds that the species attains maturity in two years.

The only information we have of the spawning habits of Indian garfish is the note by Hornell (1922) who writes, " Some species of the closely allied genus *Belone* appear to have the same habit, for Mr. Ramaswami Nayudu has shown me eggs attached by long and slender filaments to a small feather which the fisherman who brought them stated belonged to a fish of this genus " The eggs are mentioned as having been found attached to a piece of floating wood. Statements made by fishermen have to be taken with considerable reserve and should whenever possible be verified by actual observations. Some early developmental stages of the Madras flying-fish, *Cypsilurus* have been figured and described by Ramaswami Nayudu (1922).

Tylosurus strongylurus is one of the common marine garfishes found along the Madras Coast. It frequents estuaries and backwaters and has been recorded from the Chilka Lake, where it is not supposed to breed (Chaudhuri, 1917). While it cannot " fly " like *Cypsilurus*, it performs characteristic darting movements near the surface of the water. Moses (1922) remarks that the garfish is said by fishermen to be the herald and companion of the mackerel. The eggs were collected by us from the Adyar in the middle of October during the monsoon rains when the bar was open. All the eggs were discovered within a few square feet, close to the stone embankment between the Theosophical Society Buildings and the Elphinstone Bridge.

The eggs are large, 2·5 mm. in diameter, round and transparent with numerous fine threads of which those arising from one or two regions are longer than the rest, and by means of these long threads they are attached

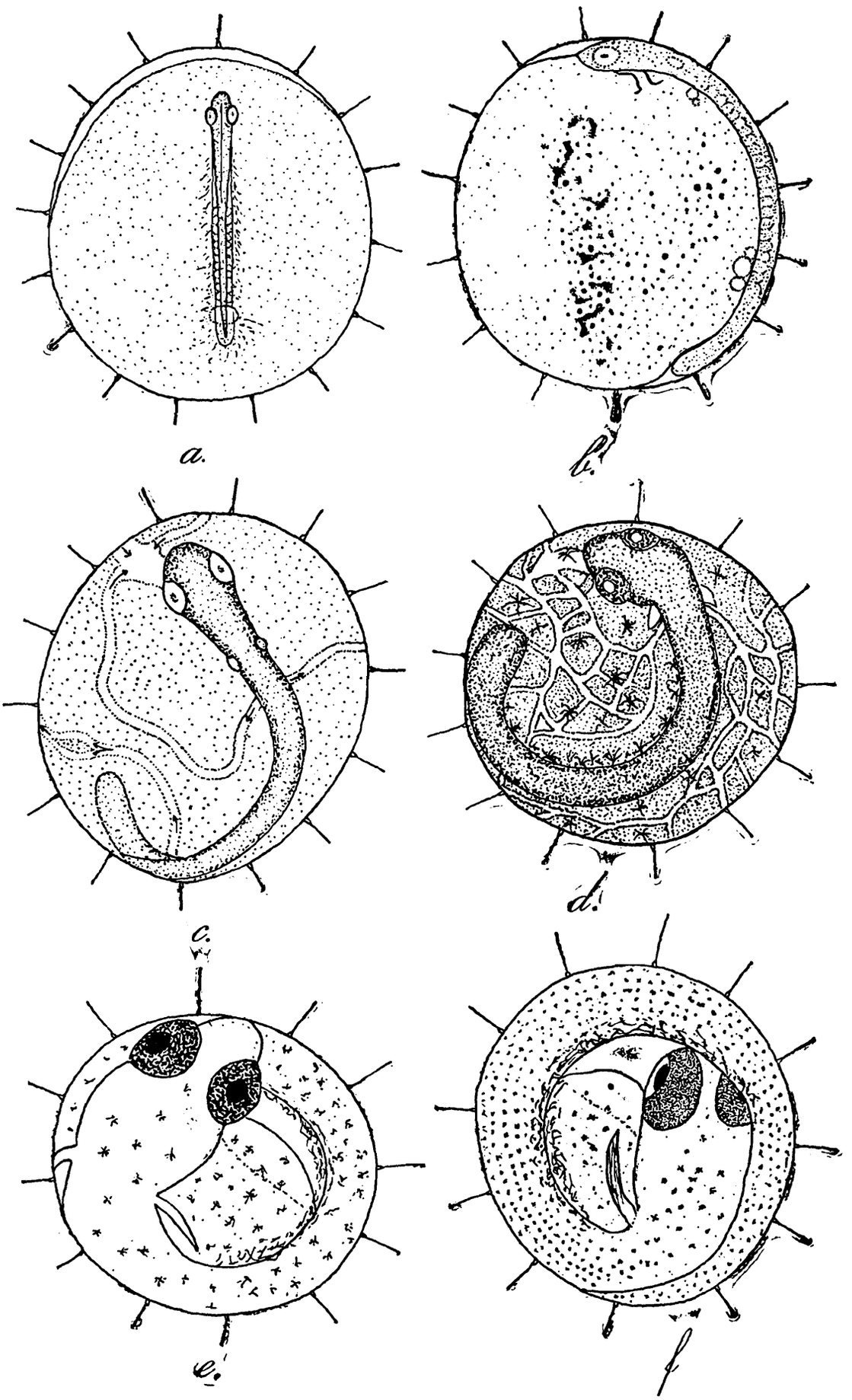
to the algae. In the earliest developing stage (text-fig. 1*c*.) the germinal disc could be seen on one side with a thin layer of blastoderm around.



Text-fig. 1.—Eggs of *Tylosurus strongylurus* (van Hass.). × *ca.* 12.

a. Young stages of ovarian eggs, in which threads have not become free.
b. Fully grown ovarian eggs showing well developed free threads from the same fish as in *a*. The large eggs are angular owing to their being closely packed within the ovary.
c. A single " laid " egg as found attached to an algal filament, showing the earliest stage in development observed.

Six hours later the blastoderm covers three-fourths of the yolk, the embryonic shield being visible on one side. Twelve hours after the first stage the blastoderm completely envelops the yolk mass and the embryo is distinctly marked out with neural groove, optic vesicles and several somites (text-fig. 2*a*). One interesting feature observed in this and some subsequent stages is the presence, on the ventral aspect of the



TEXT-FIG. 2.—Development of *Tylosurus strongylurus* (van Hass.) within the egg-membrane × *ca.* 16.

a. 12 hours after the first stage ; *b.* 24 hours after the first stage ; *c.* About 30 hours old ; *d.* 3 days old ; *e.* 5 days old ; *f.* 7 days old.

embryo, of one or more clear vesicles projecting into the yolk. These are not, however, true oil globules found usually in Teleostean eggs, but resemble closely the " compound vesicles " referred to by McIntosh and Prince (1890) in the gurnard, *Trigla gurnardus*, where they are found in connection with the Kupfer's vesicle. In the case of *Tylosurus strongylurus* no definite Kupfer's vesicle has been noticed, and all the clear vesicles disappeared before the embryo developed sufficiently to come out. Further observations on these vesicles could not be made owing to lack of fresh material.

When the embryo is about 20 hours old[1] the auditory pits are formed, and the yolk contains one, or more often numerous, clear vesicles. Twenty four hours after the first stage the embryo is considerably larger, with the tail end free and the heart pulsating (text-fig. 2*b*). A few hours later blood corpuscles appear in large numbers and a slow circulation is established, with three large blood vessels traversing the yolk (text-fig. 2*c*). At 40 hours the embryo wriggles gently inside the egg-membrane, and 48 hours after the first stage described above, chromatophores become visible and the lens is formed. In some the vitelline vessels have formed a net work. In the 3 days old embryo rudimentary marginal fins appear while the pectoral fins arise as buds, and the vitelline blood vessels form a closely anastomosing net work (text-fig. 2*d*). The eyes are pigmented ; concretions appear in the auditory vesicles and chromatophores increase in number in the body of the embryo.

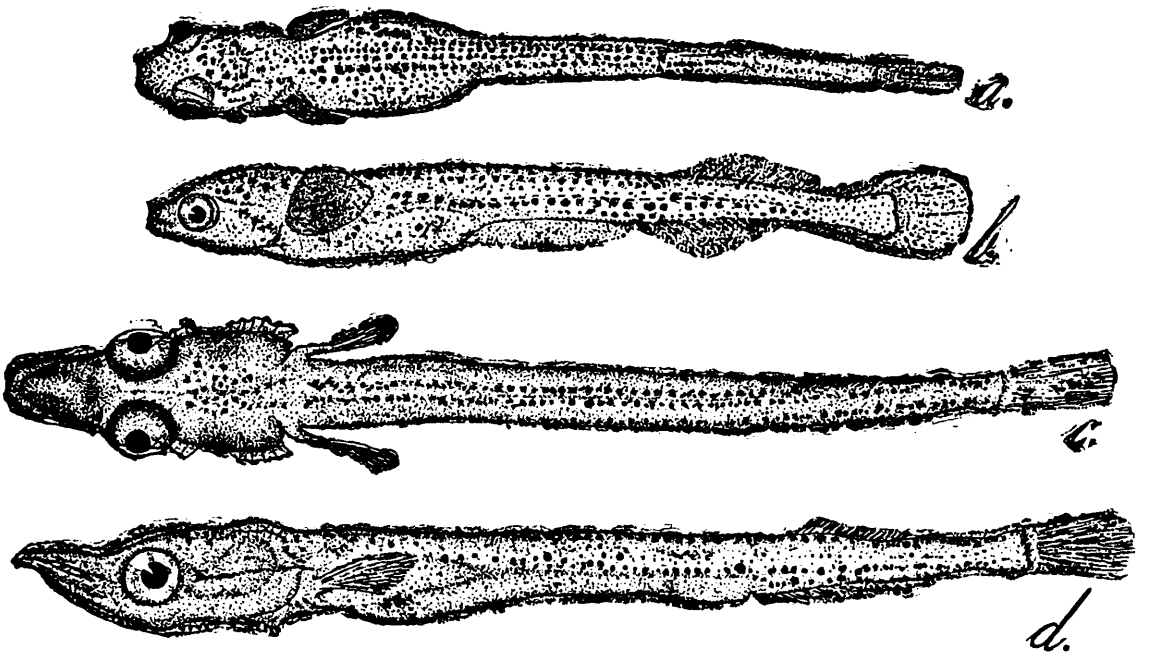
In the 4 days old embryo the eyes are black in colour, yolk is reduced and the pectoral fins are capable of movement. On the next day (text-fig. 2*e*) the mouth opening and the gill-slits are developed and a respiratory current of water is taken through the mouth and sent through the gill-slits, and the fluid inside the egg-membrane is kept in constant motion by the vigorous flapping movements of the pectoral fins. Chromatophores are very dense except in the lower part of the yolk. The embryo, which is $1\frac{1}{4}$ times the circumference of the egg, wriggles actively inside the egg-membrane.

In the 6 days old embryo the eyes are shining, the yolk is considerably reduced and the interior of the abdominal region is very dark. The head appears proportionately large now, and the lower jaw is shorter than the upper. The chromatophores are arranged in definite rows on the body. Hatching takes place when the embryo is 7 days old (text-fig. 2*f*.)

Newly hatched larva.—The larva from the time it comes out (text-fig. 3*a*, *b*) actively swims along the surface of the water, darting off at the slightest disturbance, with a characteristic undulating movement of the body. It is greenish to the naked eye and is 6·75 mm. long. One feature of interest is that the larva even at this early stage possesses well defined anal, caudal and dorsal fins, all with true (though not fully developed) rays. There is a median pre-anal fin fold, and the ventrals are absent. The upper and lower jaws are now of equal length. There are two spiny rudiments of frill-like growths on the sides of the head

[1] The ages given are after the first stage.

behind the eyes. Chromatophores are dense on the head, and on the trunk they are arranged in a series of rows, some discontinuous and merging into one another. Dorsally on each side there is a row of large chromatophores stopping short of the dorsal fin. Below this on each side there are five to seven rows extending as far as the base of the caudal fin. The chromatophores in the middle three rows on either side are small and irregular.



TXET-FIG. 3.—Larvae of *Tylosurus strongylurus* (van Hass.). ×*ca* 12.

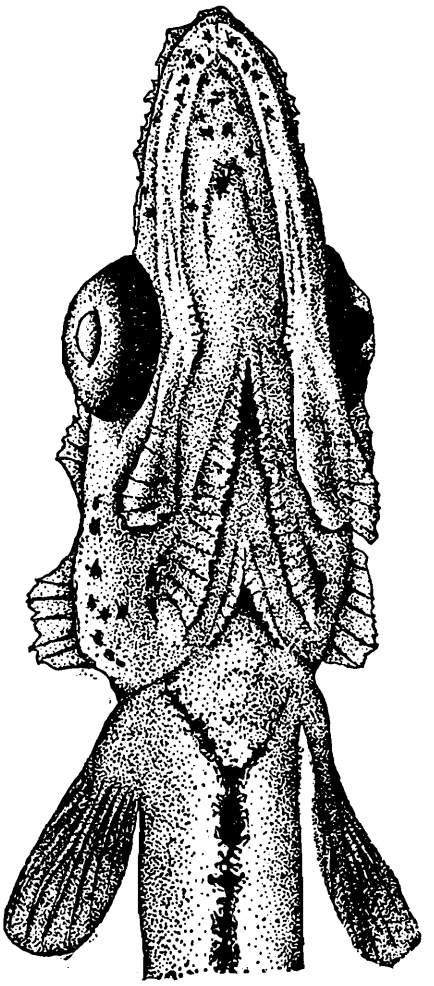
a. Dorsal view of a newly hatched larva ; *b*. Lateral view of same ; *c*. Dorsal view of a larva on the 5th day ; *d*. Lateral view of same.

The larva rapidly grows in size, the fin gets more fully developed and the yolk is reduced. The spiny frills on the head grow in size, and fresh ones develop near the auditory region and on the ventral side of the gular region. The yolk is completely used up by the 4th day. The lower jaw elongates more than the upper, as a result of which it projects beyond the latter.

Text-figures 3*c* and 3*d* are the dorsal and side views respectively of the larva on the fifth day. The chromatophores are more dense, the gut is formed and the lower jaw clearly projects beyond the upper. The pre-anal marginal fin-fold persists. The pectoral fins have fin-rays. The spiny frills (text-fig. 4) deserve particular mention here. They are symmetrically arranged transparent dermal projections with spinular thickenings. There are two dorso-lateral pairs, one pair close to the eyes, their anterior ends risings above the eyes, and the other pair near the auditory organs. On the ventral side there are three pairs of frills on the operculum. Besides, each half of the upper as well as the lower jaw bears a narrow frill on the side. The frills on the upper jaw are but faintly visible. The larva lived in the Laboratory only for a week, by which time it had attained 9 mm. in length.

Williamson (1893, cited by McIntosh and Masterman, 1897) observes in the case of the European garfish the ventrals appearing as undifferentiated buds when the larva is 20 mm. long and as distinct lobes when

about 25 mm. long. There the pre-anal marginal fin persists in a 55 mm. specimen, and the mouth assumes the typical elongated form of the



Text-fig. 4.—Slightly latero-ventral view of head and anterior part of body of a 5 days old larva of *Tylosurus strongylurus* (van Hass.) showing spiny frills, etc. ×*ca.* 30.

garfish when 150 mm. long, though the lower jaw is slightly longer than the upper. According to Breder's description (1934) of the American garfish, the prognathous lower jaw " rapidly lengthens and is overtaken almost at once to nearly the relative proportions of the adult"

Hemirhamphus gaimardi Cuv. and Val.

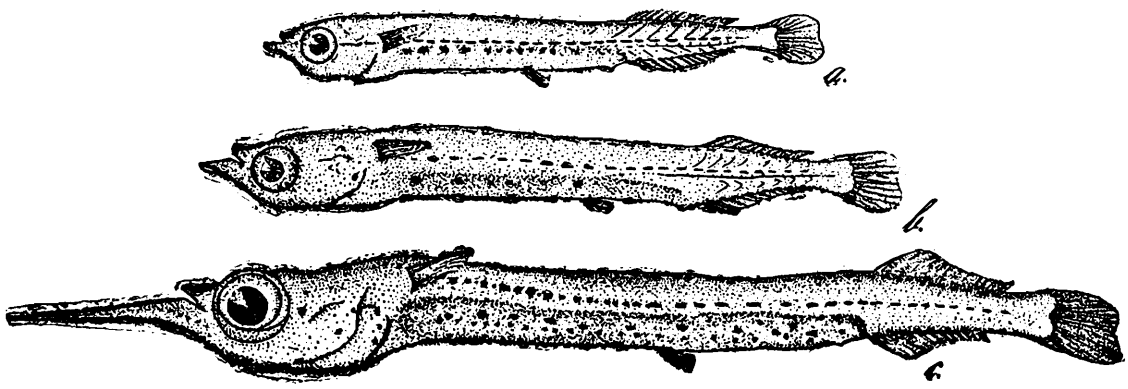
Bhattacharya (1916) has described thirteen young stages of *Hemirhamphus limbatus* from the Chilka lake, of which, stage no. 13 measuring 12 mm. in length is the oldest larva, and it is termed a " young fish in nearly all respects " and according to him " marks the termination of the larval stage", probably on account of the presence of pelvic fins. This species is now regarded (Weber & de Beaufort, 1922) as a synonym of *Hemirhamphus gaimardi* Cuv. & Val. We wish to describe here three postlarval stages leading to the establishment of the essential adult characters.

We were able to collect larvae and post-larvae of *H. gaimardi* from the Adyar River in August 1937 just after a few early showers, when

they were found in fairly good numbers swimming near the surface of the water. Larvae of this form have been obtained from the same locality in July and August 1936 also (Jones, 1937).

The smallest specimen of *Hemirhamphus* collected from the Adyar is 6 mm. long and is similar to the one described by Bhattacharya as stage no. 5. In his stage no. 13 the characteristic elongated " beak " of the adult is absent, all the fin-rays are not distinct and the ventral marginal fin-fold persists. The three post-larval stages described below help to bridge the gap between the adult fish and the oldest stage described by him.

Post-larval Stage 1 (text-fig. 5*a*).—Total length—12·5 mm. ; length of snout—0·5 mm. ; fin-rays more distinct than in the oldest larva described



TEXT-FIG. 5.—Post-larval stages of *Hemirhamphus gaimardi* Cuv. & Val.
a. Stage 1. *b*. Stage 2. *c*. Stage 3. ×*ca* 4 2/3.

by Bhattacharya. Only a trace of the ventral marginal fin-fold is visible as a narrow transparent fringe. There are three definite rows of chromatophores on each side, one dorsal, another lateral and the third ventral.

Post-larval Stage 2 (text-fig. 5*b*).—Total length—15·5 mm. ; snout—0·9 mm. ; the lower jaw has elongated considerably. The ventral marginal fin-fold is no longer visible. Chromatophores on the body are arranged as in the previous stage, but with dark pigmentation inside the abdominal region.

Post-larval Stage 3 (text-fig. 5*c*).—Total length—24·8 mm. ; snout—4·3 mm. ; the fish is now an unmistakable " half-beak " Chromatophores characteristic as before. The abdominal region is opaque with dense pigmentation within its interior.

With further increase in size and elongation of the " beak " the fish grows into the adult.

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