LIFE-HISTORY AND BIONOMICS OF THE SPINY EEL, *MASTACEMBELUS PANCALUS* (HAMILTON), WITH NOTES ON THE SYSTEMATICS OF THE MASTACEMBELIDAE.

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INTRODUCTION.

In the course of field studies on larvicidal fishes at Ulubaria, in the Howrah District, the author found numerous specimens of *Mastacembelus pancalus* (Hamilton), both adult and young, thriving in the large borrow pit extending between Telegraph-posts 19/6 and 19/10 down, between Ulubaria and Fuleshwar. Examination of the gut-contents of the fish showed that in the young stages the species sometimes consumes mosquito larvae and cyclops besides other aquatic micro-organisms. The presence of young fish naturally suggested the possibility of the species breeding in the borrow pit. Hence a search was made for the eggs of the species with a view to study its life-history, which would be of interest, for the development of no member of the Mastacembelidae, which is a family of uncertain relationships, is as yet known. After several weeks of unsuccessful attempts, eggs were discovered on the 12th of July, 1940 ; these consisted of 21 eggs forming a more or less loose mass entangled in a thick mesh of the submerged portion of a floating tuft of algae consisting mainly of *Spirogyra*. The eggs, with portions of the associated algae were carefully removed to the Malaria Inspector's Laboratory near-by, and the development followed in the water from the same borrow pit in conditions similar to those described for *Aplocheilus panchax* (*vide* Job, 1940, p. 57). Subsequently on several

occasions eggs in smaller numbers were found similarly attached up to the month of November. Larvae and post-larvae of different stages were also collected and examined for comparison with identical stages among those that lived in the laboratory. The bionomics of the species was studied both in an aquarium and in the natural habitat. In connection with the relationships of the Mastacembelidae the collection of Percomorphi in the Zoological Survey of India was examined.

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LIFE-HISTORY OF THE SPINY EEL.

General.—Mastacembelus pancalus, popularly known as the Spiny Eel, is distinguished by its compressed, eel-like shape ; elongated, non-protractile snout ; upper jaw terminating in a moveable appendage with a trilobed tip ; long, spiny dorsal and anal fins ; distinct, rounded caudal fin ; absence of ventrals ; and characteristic colouration. It is olive green along the back, lighter olivaceous on the sides, grading into yellowish white ventrally, with numerous irregularly scattered greyish white spots over the sides and small dark grey transverse blotches scattered along the mid-dorsal surface and extending downwards as irregularly vertical stripes along the sides ; there are a few dark spots and blotches over the operculum and snout with a conspicuous dark grey band on either side from the tip of the snout to the eye and behind it over the opercle. The cheeks are golden and the nostrils bluish. The fins have a greenish yellow ground colour with many dark spots and blotches, the latter being comparatively more conspicuous in the median fins. Usually the colouration is brighter in the young. It becomes duller with age, and the vertical stripes often fade, except in the posterior third or so.

Day (1889, p. 334) has recorded the species from the large rivers of India, but says that he has not seen it along the Coromandel Coast south of the Kistna. Sundara Raj (1916, p. 290), however, has observed the fish thriving in tanks all over Madras and in the Cooum. Its local names are *Pangkal, Gochi, Gaugr-Gongli*, Bengali ; *Tu-rah*, Assamese ; *Turi, Bahru*, Ooriah ; *Chen-du-la, Gurchee, Gro-age*, Punjabi ; *Ju-gar*, pashtu ; *Bamni*, Urdu ; *Par-pa-ral*, Telugu ; and *Pil Aral*, Tamil.

Breeding.—Young specimens of *Mastacembelus pancalus* measuring about 30 mm. were found in the Spur Tank,[1] Madras, in the month of February by Sundara Raj (*op. cit.*, p. 290), and he surmised that the species "breeds during the cold weather" D'Abreu (1925, p. 30), obtained 28 mm. fry from the Ambajheri Tank at Nagpur in April, while Prashad and Mukerji (1930, p. 16) found 50 mm. specimens in the Manchar Lake, Sind, in November. In the Railway borrow pits at Ulubaria the fish breeds from May to November[2], with the peak period at the commencement of the monsoon.

The mature female of *M. pancalus* is, as a rule, stouter, but less brightly coloured than the male. The ovaries are paired, elongated, strap-shaped sacs, of which the right one is slightly longer than the left. They hold an enormous number of ova in various stages of growth. The ovaries unite posteriorly into a short common oviduct which leads out through a slit-like opening situated on an elevated urinogenital papilla behind the anus, just in front of the anal fin.

The fish builds no true nest; but at spawning time it selects a sheltered portion of some algal mass below the surface, where proper aeration and sunshine would be ensured. There it lays a varying number of eggs, usually ten to twenty at a time, which are fertilised by the male as they are being laid. The eggs are demersal, and left to themselves would sink to the bottom. But being laid on algal meshes they remain suspended on them (text-fig. 1*a*), though on shaking violently, the eggs get detached and drop to the bottom. No parent was ever seen to guard the eggs.

Egg and Embryonic Development.—The newly laid egg is more or less spherical and transparent; its diameter varies from 1·3 mm. to 1·35 mm. It is highly yolk-laden, and in general appearance resembles the egg of *Aplocheilus panchax* (Job, 1940, p. 57-59); but the cluster of adhesive threads so conspicuous in the egg of *A. panchax* is absent here. The egg membrane, however, bears certain irregular striations, which probably contribute towards making the egg stick to the algal tuft by friction. As in the case of *A. panchax* the egg is heavy, though provided with cospicuous oil globules of varying number and size in the yolk. The protoplasm in the fertilised egg stands out as a convex granular blastodisc. The early stages of cleavage (text-fig. 1*b*) and embryonic development are typically teleostean. It is, however, noteworthy that despite the presence of a large amount of yolk, the embryonic development is short, the eggs usually hatching a day and a half after they are laid. Text-fig. 1*c* shows an egg six hours after fertilisation. The blastoderm has spread over more than two-thirds of the transparent yolk, the uncovered portion of which remains protruding out as it were beyond the blastoderm rim, and encloses four large and several small oil globules.

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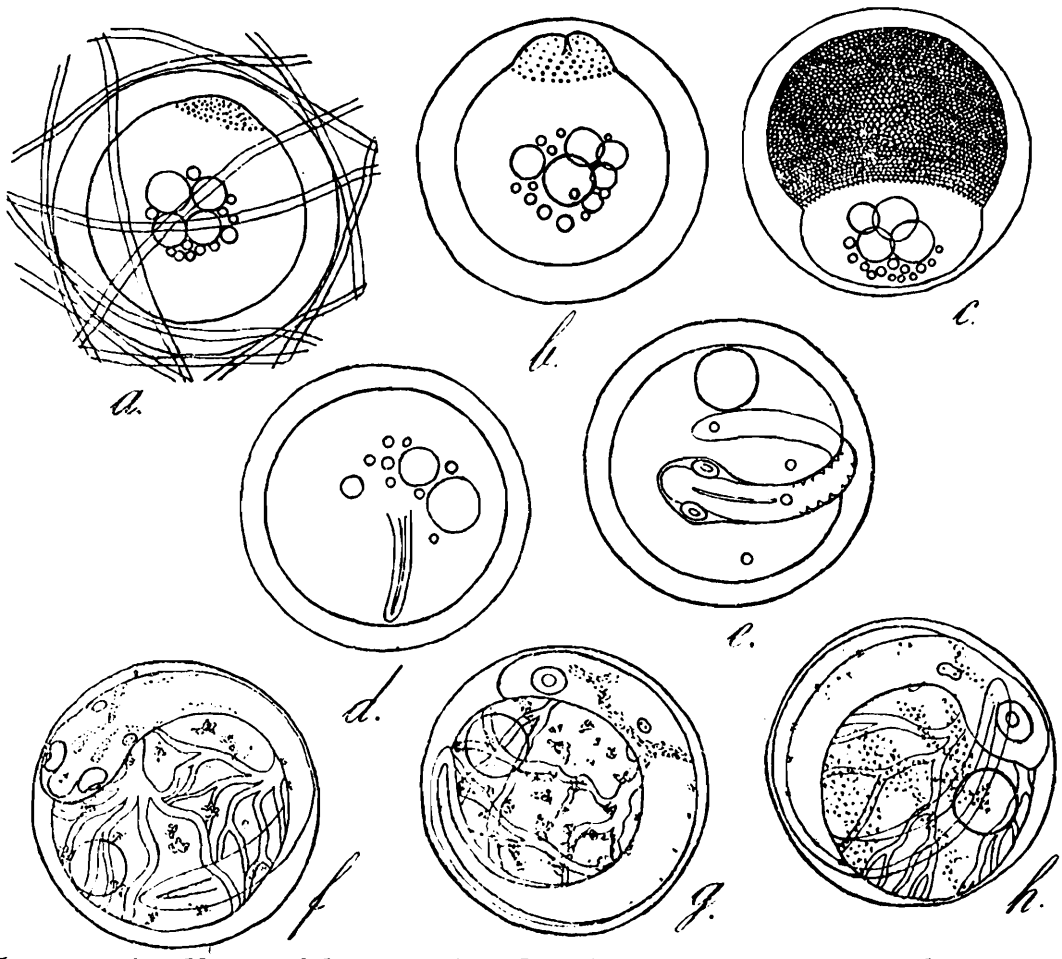
[1] The Spur Tank has since been reclaimed.

[2] Eggs of the species were collected for the first time in July; but the presence of 18 mm. fry noticed in the month of June showed that breeding had commenced in May.

Nine hours old egg.

In a nine hours old egg (text-fig. 1*d*) the embryo has begun to be differentiated. The number of the oil globules is reduced, but one of them increases in size.



TEXT-FIG. 1.—*Mastacembelus pancalus* (Hamilton), segmentation of the egg and embryonic development: × *ca.* 22.

a. Unsegmented egg; *b*. Two-celled stage; *c*. About six hours after fertilisation; *d*. Nine hours after fertilisation; *e*. Twelve hours after fertilisation; *f*. Twenty-four hours after fertilisation; *g*. Thirty hours after fertilisation; *h*. Thirty-five hours after fertilisation.

Half a day old egg.

In another three hours the embryo (text-fig. 1*e*) is well differentiated with clearly marked optic vesicles. The yolk contains a single large oil globule and four to six tiny ones. The embryo is not yet free, but remains partly embedded in the yolk.

A day old egg.

In the course of the next twelve hours the embryo (text-fig. 1*f*) grows larger at the expense of a portion of the yolk. Circulation is established; chromatophores appear on the yolk and on the embryo, the chief pigment patches being a pair of irregular, elongated bands behind the eyes. The single large oil globule is conspicuous, while a few tiny ones are scattered about in the yolk. The auditory vesicles have appeared.

A day and a quarter old egg.

In a thirty hours old egg (text-fig. 1*g*) the pectoral fin buds begin to appear; the embryo grows larger, pigmentation increases, and the

median fin-fold makes its appearance. The hind region of the embryo gets freed from the yolk-sac, and at intervals the embryo twists and turns along with the yolk. The otoliths are quite clear. The circulation is active ; the heart beats about 160 times per minute. The chromatophores on the yolk form conspicuous patches. The body also is more pigmented. The pigment bands behind the eyes converge posteriorly towards the mid-dorsal side. The large oil globule remains while the others have been absorbed.

Hatching.

The egg hatches when about 36 hours old, the hatching taking place usually in the evening of the second day after the egg is laid. Text-fig. 1*h* shows an egg which is just about to hatch. Hatching is a quick process, the tail coming out first, and the larva smartly wriggling itself out of the egg membrane. This first energetic act apparently exhausts the larva which is burdened with a massive yolk-sac, and hence it reaches a near-by mesh and rests there in any pose, horizontal or inclined, generally with the belly turned upwards.

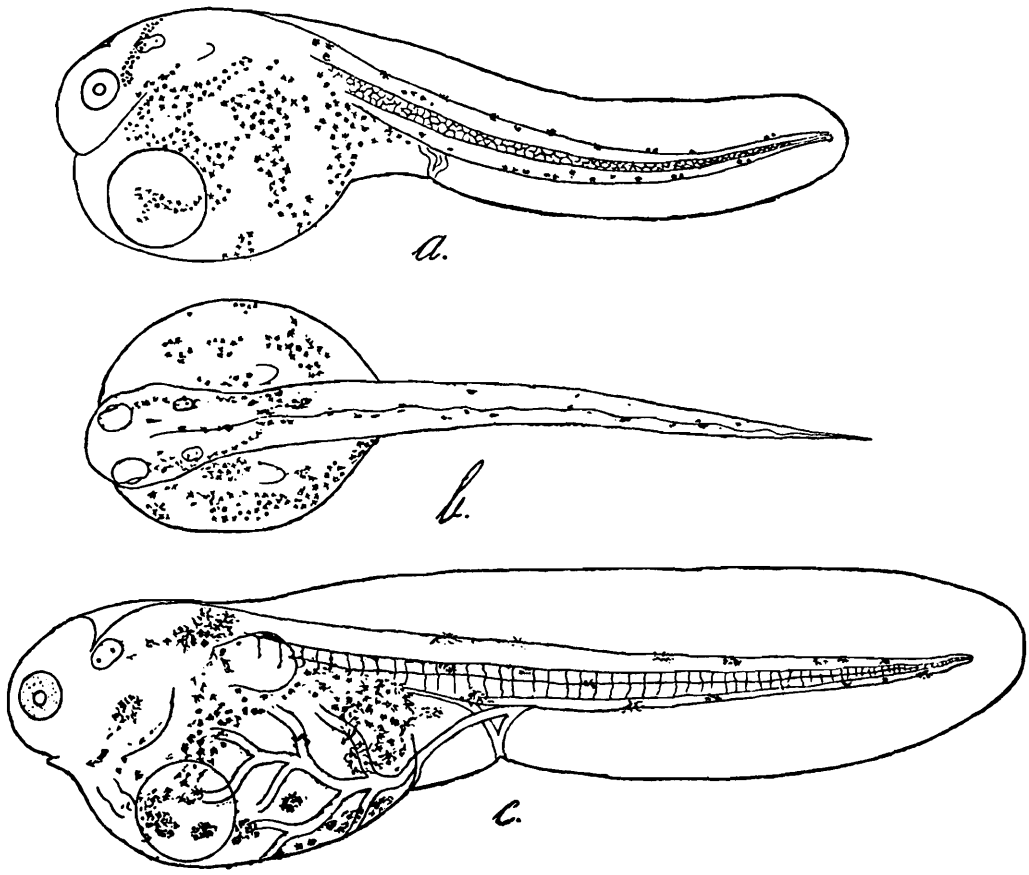
Newly Hatched Larva.—The newly hatched larva (text-fig. 2 *a*, *b*) is about 3·4 mm. long, and looks very much like a tiny tadpole. It is transparent and delicate, with well developed dark grey pigmentation. The pigment is disposed in an irregular patchy network on the large, projecting, rounded yolk-sac and on the head. It also extends in the form of small, sparingly scattered patches to the tapering body, especially towards its dorsal and ventral aspects. The head has a depressed appearance, and remains adpressed to the yolk. The body is slender, and narrows posteriorly into a straight tail. There is a wide, delicate, median fin-fold which commences at the nape and extends over the back and round the tail right up to the yolk-sac below. Against the anal region the fin-fold is marked by a very faint notch at its margin and a loop of a blood vessel through its width. The pectoral fin buds are laterally disposed, and stand out in the thoracic region over the yolk-sac. The notochord is simple and unsegmented. Occasionally the larva moves about briskly by quick, side to side movements of its wide tail to short distances, but soon resumes its motionless posture.

Metamorphosis.—As described above, the larva is remarkably different from the adult. Metamorphosis has been found to be a prolonged process, and it takes about a month for the characters of the young adult to be established. However, as the period of embryonic development inside the egg is short, the early larval development of the hatchling is fairly quick.

Twelve hours old larva.

In the course of twelve hours after hatching a fair portion of the yolk is absorbed, though much of it still projects (text-fig. 2*c*) as a pear-shaped structure on the ventral side. The head is distinct from the yolk-sac, and the small mouth appears as a crescentic pit on its ventral aspect. The opercular flaps also get differentiated. The pectoral buds grow out into broad fins, which though without rays, are very active, and keep on flapping even when the larva is stationary. The pigmentation

on the body becomes denser; paired lateral patches make their appearance. The eyes begin to grow dark. The notochord becomes



TEXT-FIG. 2.—*Mastacembelus pancalus* (Hamilton), early larval forms.
a. Lateral view of a newly hatched larva: × *ca*. 24; *b*. Dorsal view of the same *c*. Lateral view of a larva twelve hours old: *ca*. 28.

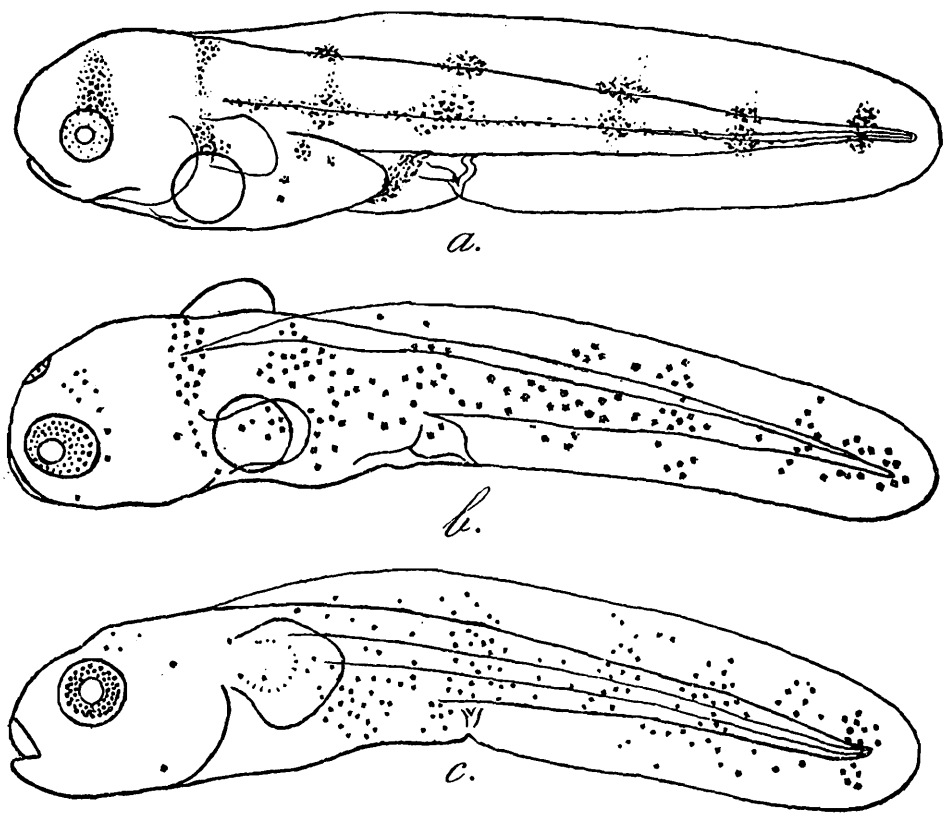
segmented, and rudiments of vertebrae begin to appear. The heart beats about 175 times a minute. The larva continues to be of inactive habits, resting on the algal mesh or lying on its back or side at the bottom for long intervals. When disturbed, or sometimes even of its own accord, it suddenly darts up and briskly jerks about for a short while.

Two days old larva.

A two days old larva (text-fig. 3*a*) is 4·8 mm. long, with the yolk further reduced, but with the oil globule still present. The head is quite pronounced, being stout and nearly truncate, dorsally sloping backwards. The mouth is well formed and subterminal in position. The mandibles are clearly marked off from the buccal floor. The operculum is well differentiated. The heart-beats are 175 per minute. The eyes are only slightly darker than before. In the median fin-fold there is not much change except that the portion in front of the anal region is slightly reduced. The pectorals are firmer, though still without rays. The pigment patches are conspicuous on the body. They are concentrated in dark areas above the eyes, at intervals on the body, especially towards the dorsal and to a less extent on the lateral aspect of the body, and on the abdomen. Some of the patches extend slightly to the fin-fold also. The larva is more agile than before, and at intervals, between periods of rest, it lashes about briskly.

Four days old larva.

A four days old larva (text-fig. 3*b*) is 5·1 mm. long. Most of the yolk is absorbed. The pre-anal fin-fold is reduced. The pectoral fins are larger. The chromatophores are more scattered in their arrangement; but in some areas they are in fairly dense patches, one occipital, one thoracic, one abdominal and five caudal—all extending to the median fin-fold.



TEXT-FIG. 3.—*Mastacembelus pancalus* (Hamilton), larval forms in the early stages of metamorphosis.

a. Two days old larva: × *ca.* 19½; *b*. Four days old larva: × *ca.* 18½; *c*. One week old larva: × *ca.* 16¾.

A week old larva.

By the seventh day the larva (text-fig. 3*c*) grows to 5·7 mm. in length. The contour of the head begins for the first time to show a slight indication of the future conical snout. The yolk is completely absorbed, and with the well formed mouth which is now terminal, the larva starts feeding on microplankton in the water. The eyes are well developed and look black with a beautiful brownish yellow ring around the central black area. The operculum appears ribbed owing to the formation of branchiostegals. The hyaline looking body of the larva begins to assume a faint yellowish opacity, which is due to (1) development of denser musculature, (2) more blood vessels and (3) the chromatophores scattered as lighter specks all over the body. The pre-anal part of the fin-fold has been completely absorbed, and the hind portion of the abdomen reaches up to the anus, which is fairly posterior in position. The posterior vertebrae of the long tapering tail are slightly upturned at this stage. The pectoral fins are large and firm with a basal cartilage. Radiating folds from the basal cartilage give a false appearance of rays, but true rays

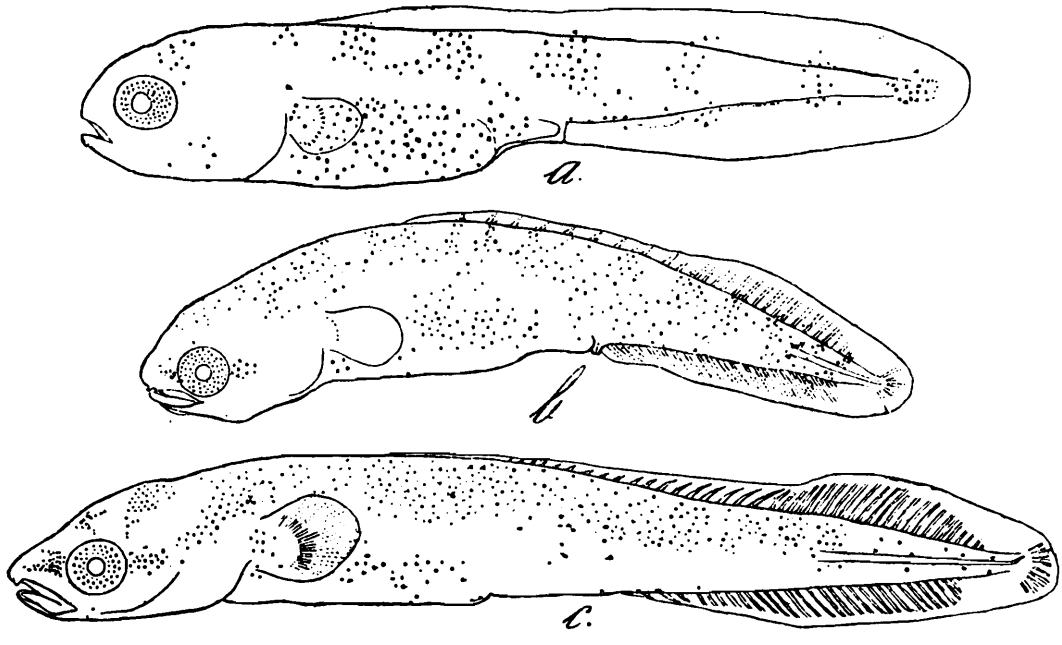
are yet absent. Though stronger than before, the larva still exhibits only intermittent activity, and indulges in frequent periods of rest in various postures in the algal mesh. Sometimes, when at the bottom, it creeps about or shoots smoothly forward and glides with its crest-like median fin-fold erect, the body being slightly arched as shown in the figure.

Ten days old specimen.

By the tenth day (text-fig. 4*a*) the length increases to 7·4 mm. The snout begins to assume a definitely conical shape. The body grows stouter. The median fin-fold in the anterior region of the back gets narrower. The pigmentation retains more or less the earlier pattern. The eyes, which had been flush with the general surface of the head, now stand out from it. A lip-fold appears and grows thick and fleshy at the angles of the mouth.

Twelve days old specimen.

The length is 10 mm. by the twelfth day (text-fig. 4*b*). The lip fold becomes more pronounced. The trilobed tip of the adult snout makes its first indication as the result of the growth of a pair of tiny lateral buds from the sides of the extreme tip of the snout. The anterior nostrils are carried at the ends of these buds. The median fin-fold gets narrower,



TEXT-FIG. 4.—*Mastacembelus pancalus* (Hamilton), intermediate stages of metamorphosis.

a. Ten days old specimen : × *ca*. 12¼ ; *b*. Twelve days old specimen : × *ca*. 8 ; *c*. Two weeks old specimen : × *ca*. 8¼.

as the body including the tail grows stouter. The future spinous portion of the dorsal fin gets markedly narrower than the rest of the fin-fold in which rays begin to make their appearance. Eighteen true rays appear in the region of the soft dorsal, twenty-one in that of the soft anal and five in that of the caudal. All the three spines in the anterior part of the anal and ten spines in that of the dorsal also begin to appear. The pectorals are larger, but still devoid of true rays. The anus becomes

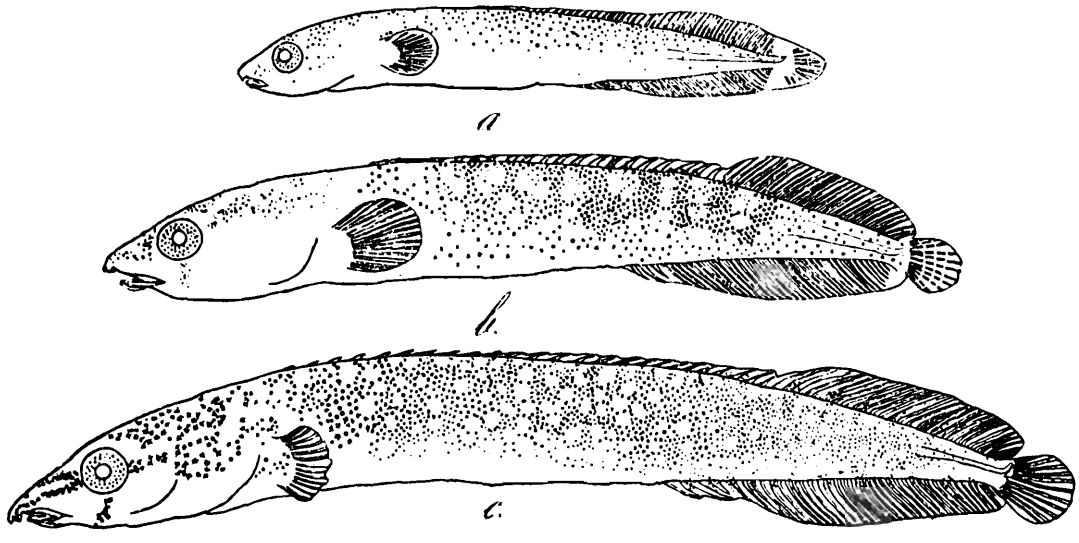
more posteriorly placed as the abdomen elongates. The pigmentation begins to show for the first time slight indications of the adult bands. Along the back the chromatophores are arranged in the form of irregular bands leaving large ovoid pigmentless patches of which there are about ten to be seen on each side of the body. On the head the adult ocular band is indicated as a discontinuous band in front of and behind each eye.

Two weeks old specimen.

When two weeks old, the specimen (text-fig. 4*c*) is 12·9 mm. long. The snout is more conical, and the terminal lobes of the upper jaw grow out making the mouth sub-terminal. The fleshy lip-folds at the angles of the mouth are more conspicuous. The preopercle can now be distinguished. The three anal spines are well formed, the second being the longest. Twenty-five rays are developed in the soft dorsal, twenty-seven in the soft anal and nine in the caudal, which last, however, is still confluent with the rest of the fin-fold. Indications of about twelve true rays are present in the pectoral. Eighteen spines of increasing length from front backwards appear in the anterior part of the dorsal fin-fold. The latter becomes narrower and the anteriormost part of it is absorbed. The faint pigment spots on the body begin to spread, leaving small, clear, circular patches, which are fore-runners of the greyish white spots of the adult fish. The ocular band of pigment becomes more extensive and darker.

Two and a half weeks old specimen.

By the middle of the third week the length reaches 15·2 mm. (text-fig. 5*a*). The pigmentation gets deeper in shade on the dorsal aspect.



Text-fig. 5.—*Mastacembelus pancalus* (Hamilton), juvenile forms in the final stages of metamorphosis.

a. Two and a half weeks old specimen : × *ca.* 4 ; *b*. Three weeks old specimen : × *ca.* 4¾ ; *c*. One month old specimen : × *ca.* 5.

The anterior part of the dorsal fin is narrower and has twenty spines. The number of rays increases in the fins. The portions of the vertical fin-fold just in front of the caudal, above and below, are devoid of rays, and begin to show signs of atrophy.

Three weeks old specimen.

By the end of the third week the length becomes 18 mm. (text-fig. 5*b*). The snout gets elongated with well pronounced lobes at the tip. The posterior nostrils are now distinctly marked. Twenty-three spines are well marked in the anterior part of the dorsal fin ; the interspinous membrane nearly stops short of the ends of the spines. The portions of the fin-fold immediately in front of the caudal have been absorbed and as a result the caudal is quite separate from the dorsal and the anal. There are thirty-two soft rays in the dorsal, thirty-five in the anal, eleven in the caudal and sixteen in the pectoral.

A month old specimen.

Metamorphosis is practically complete by the end of the first month. The length reaches about 22 mm. (text-fig. 5*c*). The snout, though still proportionately shorter than in the adult, assumes more or less the characteristic shape of the adult with a well defined, mobile, trilobed tip. Twenty-five spines are seen in the spinous dorsal, the anterior spines being short, sharp and devoid of any interspinous membrane. Thirty-three rays are present in the dorsal and thirty-seven in the anal. The caudal fin is rounded and has twelve rays. The pectoral has eighteen rays. The colouration, though not fully developed, is bright and approaches the adult pattern, the bands being well indicated and extending even to the dorsal and anal fins. Thus in a month's time the fish practically becomes a young adult.

As the fish grows the full adult features are gradually assumed. When ten months old the fish[1] reaches a length of 96 mm., and the gonads begin to mature. Evidently, as suggested by D'Abreu (*loc. cit.*), the species attains sexual maturity in the course of a year.

BIONOMICS.

Habits.—Mastacembelus pancalus lives in clear as well as muddy fresh waters of tanks, rivers, lakes, borrow pits, etc., but is an occasional immigrant to slightly brackish waters. It prefers a bottom of soft mud in which it can easily burrow, for which purpose its body is admirably adapted. In the natural habitat the young often glide about among algae and fine-leafed water plants, while the adults frequent the loose mud or lurk in narrow crevices near the banks. In the aquarium the fish spends most of the day time buried in the sand, part of the head alone usually protruding out. In this position, especially when silt accumulates on the exposed part of the head it easily escapes notice. This habit provides a perfect camouflage for both attacking its prey and escaping from its natural enemies. At night, however, it freely swims about, mostly at the bottom. But like other nocturnal fishes it can be trained to eat in day time, though, as soon as it has had its meal, it quickly returns to its shelter below. The act of burrowing was closely observed on several occasions. The fish glides about the bottom, nosing the substratum with its mobile, trilobed, sensitive snout and, selecting

[1] This description is based on those specimens which developed from the 18 mm. arvae collected in June.

a suitable spot, wriggles itself into the substratum by a brisk side to side and forward movement, until most of the body and tail are concealed. Sometimes the tail sticks out as also the tip of the head. On being disturbed from its burrow, it darts about for a while, and selecting another spot, makes a fresh burrow or sometimes returns to its original burrow. Half buried reeds and hollows are often its favourite resorts and this accounts for its habit of lurking about in cracks and crevices near the banks. Hence a common method of catching the fish is by leaving old, cast-off pipes or hollow bamboos here and there in pools and lifting them out along with the fish in them. The fish, however, is sometimes caught on rod and line, and villagers capture it also by raking the mud with a bent trident.

Hibernation and Aestivation.—Being capable of aerial respiration[1], the Spiny Eels burrow in the soil when the waters dry up. Specimens of *Rhynchobdella aculeata* have been exhumed (Day, 1877, p. 214) from the dried beds of ponds. A pair of *M. pancalus* were found deep under the mud in a drying pool at Ulubaria. In the cold winter months even in the presence of water in the aquarium *M. pancalus* was often noticed to bury the greater portion of its body including its snout in the mud and remain inactive for longer or shorter periods, the opercular flaps, when visible, being seen to exhibit no respiratory movement. The fish thus appears to be capable of resorting to longer or shorter periods of hibernation during which even the breathing movements are suspended.

Food.—The gut-contents of seventy specimens of the fish, ranging from 1 cm. to 14·5 cm. were studied more or less along the lines of those of the Perches and of the Killifish (Job, 1940, pp. 293-295 ; 1941). In the young stages the fish is found to subsist mainly on Entomostracan Crustacea, the items in the order of preponderance being Daphnids, like *Macrothrix orientalis*, Ostracods and traces of Cyclops, and larvae of insects such as *Ceratopogon* sp. and other Chironomids, Coleopterans and occasionally larvae of mosquitoes and other Dipterans. As the fish grows larger the proportion of insect larvae increases, and larger Crustacea begin to form a fair portion of the diet. Only in one instance were Teleostean remains noted among the gut-contents ; these consisted of a single egg and part of a fin.

Economic Importance.

Like the true eels, the Spiny Eels are regarded by many as excellent for the table. One of the congeners, *Mastacembelus armatus*, grows to three feet, and D'Abreu (*op. cit.*, p. 32) lists it as the most important food fish after the murrels in the Ambajheri tank at Nagpur. Hamid Khan (1934, p. 667) notes that its flesh is firm and tough, and said to be invigorating, but adds that in the Punjab, the Spiny Eels are shunned like snakes and are eaten mostly by low caste and poor people. More or less the same may be said about true eels as well ; for, while considered a delicacy by many, they are equally shunned in several districts

[1] For details of aerial respiration in the Spiny Eels, *see* Dobson, 1874, p. 312 ; Day, 1889, p. 332 ; Deraniyagala, 1932, p. 266 ; Ghosh, 1934, pp. 328, 329 ; and Hora, 1935, p. 8.

owing to popular prejudice due to their snake-like shape[1]. *M. pancalus* grows only to seven inches, and though edible, is of less market value than its congeners. As fish remains were found only in one out of the seventy specimens of *M. pancalus* examined, the species does not appear to be so piscivorous as *M. armatus*, which has been noted (Hamid Khan, *loc. cit.*) to be " very destructive to eggs and fry of other fish."

The proportion of mosquito larvae in the gut-contents of the fish is insignificant and hence it is clear that though to a small extent the fish may help to reduce the numbers of larvae in marshy pools, it is not of any cognizable value in the control of mosquitoes. Again, as explained elsewhere (Job, 1941*a*), the proportion of Cyclops met with in the food of the species is too small to have any significance in the control of guinea-worm.

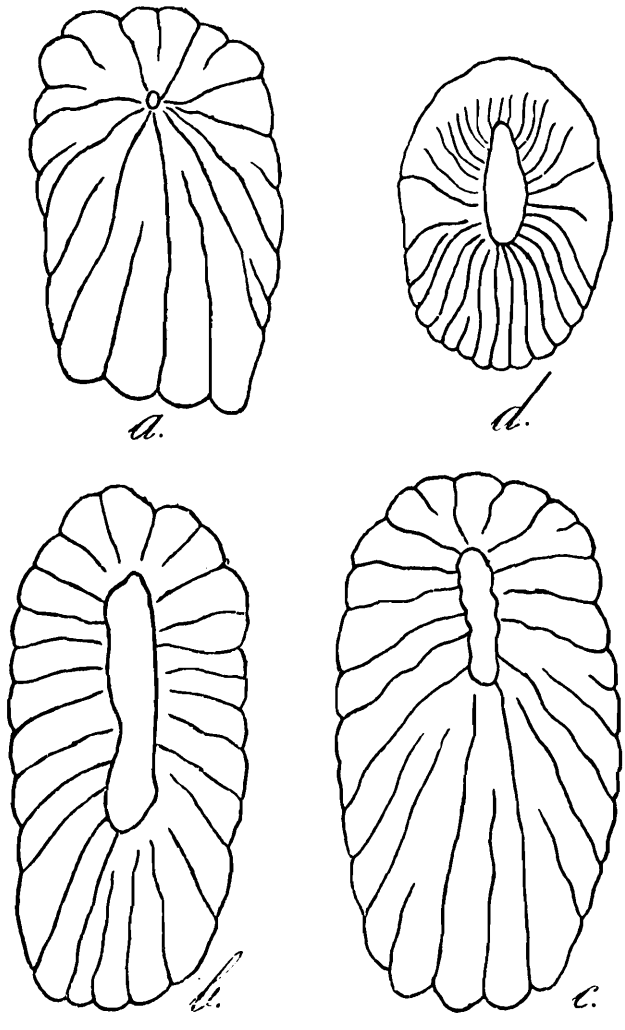
As far as parasites are concerned, while Rahimulla and Das (1935, p. 34), who studied collections of the fish from Hyderabad, report that " no parasites have been found " in the specimens examined by them, in several adult specimens from Ulubaria examined by the writer, numerous Trematodes and Nematodes, free as well as encysted, were observed. No parasites were seen in the younger stages of the fish.

SYSTEMATICS OF THE MASTACEMBELIDAE.

Günther (1861, p. 539) writes, " The structure of the mouth (not of the bones of the upper jaw) and of the gill-apparatus, the separation of the humeral arch from the skull, the absence of ventral fins, the anatomy of the internal parts, and the whole habit, afford ample proof that these fishes are eels, in which a part of the dorsal fin is spinous " He, however, mentions the presence of the air-bladder and pyloric appendages in the Mastacembelidae, while they are absent in the true eels. Besides, as Deraniyagala (*op. cit.*, p. 265) states, " the presence of dorsal and anal spines, normal ovisacs, oviducts and spawning in fresh-water " exclude these fishes of uncertain relationship from the Apodes. Again, whereas the eels are considered to be of ancient origin, being represented not only in all fresh waters and seas of the temperate and tropical zones of modern times, but also in fossils like those of Monte Bolca, Aix and Oeningen (*vide* Günther, 1880, p. 670), the Mastacembelidae are comparatively less ancient, being specialised for life in muddy bottom ecology, and, as mentioned by Meek (1916, p. 314), not known to be represented as fossils. It is believed (*vide* Chaudhuri, 1916, pp. 12, 13) that the Mastacembelidae evolved originally in India and spread over to China in the east and to Africa in the west, as " the most primitive forms are found only in this country and the extreme forms in China and Africa, with the intermediate forms in the intervening countries." From the external characters and the indications of the skeleton, Regan (1912, p. 218) concludes that " these fishes are related to, but more specialized than, the Percomorphi ", though he could not trace their affinity to any particular group of Percomorph fishes. The general percoid

[1] Hamilton (1822, p. 27), has however, stated, " The fishes of the *Macrognathus* [*Mastacembelus*] genus have less of a disgusting appearance than those called *Muraena*, and are more sought after by the natives; the highest of whom in Bengal make no scruple of eating them; and by Europeans they are esteemed the best of the eel kind ".

appearance, so marked in the early larvae of *M. pancalus*, lends support to Regan's surmise. Further, the similarity in distribution, the presence of dorsal and anal spines, and the similarity in the scale pattern seem to indicate that the Mastacembelidae might have originated from a Percoid fish remotely allied to Nandidae. The scales of Mastacembelidae are longer than broad, with basal, apical and lateral radii as in those of *Plesiops* Cuvier, a genus of Nandidae. While the nuclear area is very



TEXT-FIG. 6.—Outline diagrams of typical scales from the broad sides of fishes of the Mastacembelidae and *Plesiops* Cuvier (Nandidae).

a. Mastacembelus pancalus (Hamilton); *b. Mastacembelus armatus* (Lacép.); *c. Rhynchobdella aculeata* (Bloch); *d. Plesiops nigricans* Rüpp. (*a*, *b* and *c* are magnified about 32 times and *d* about 4½ times. The circuli are not represented).

small and narrow in *M. pancalus*, it is wider in *M. armatus* and *Rhynchobdellaaculeata*, and very wide in *Plesiops* (text-fig. 6). The margins of the scales of all these are scalloped in varying degrees. The narrow nature of the scales of the Mastacembelidae may be a modification necessitated by their burrowing habits. The modification of the pelvic fins, which are absent in *Mastacembelus*, is also apparent in *Plesiops*, where there are fewer rays in the pelvics. The general resemblance of the twelve days old larva of *M. pancalus* to *Plesiops* is again striking. In the absence of a detailed knowledge of the anatomy of the Mastacembelidae and the Nandidae it is not possible, however, to arrive at any more precise conclusions in regard to their relationships. The above is merely a tentative suggestion.

SUMMARY.

The life-history of *Mastacembelus pancalus* (Hamilton) was worked out by following the development of its eggs collected from a Railway borrow pit between Ulubaria and Fuleshwar in the Howrah District, where the fish breeds from May to November with the peak period during the pre-monsoon rains. The fairly large eggs are laid, scattered in groups among algal meshes. Though the egg is heavily yolk-laden, the embryonic development is very short, and hatching takes place a day and a half after laying. The hatchling looks very different from the adult, and resembles a tiny tadpole. Being still heavily yolk-laden, it seldom moves about, but usually rests belly up for long intervals on the algal mesh. The early larval development is fairly rapid. Metamorphosis, however, is prolonged over a month. The yolk gets fully absorbed in the first week, and the larva begins to feed on microplankton, though active movement is still intermittent. In the course of the next two weeks the conical snout with its trilobed tip is developed, the median fins get differentiated with spines and rays, which latter appear in the pectorals also, and active swimming and wriggling movements commence. By the end of the first month there develops the 22 mm. long young adult with full complement of fin-rays and other characters of the adult fish. Maturity is attained in about one year.

Normally a nocturnal fish, *M. pancalus* usually spends the day time lurking in narrow crevices or in temporary burrows, which it makes in the soft substratum. In the young stage the fish feeds mostly on Entomostracan Crustaceans and certain insect larvae. The ratio of piscine elements in the food is negligible. In very cold and dry seasons the fish hibernates for longer or shorter periods.

Though small in size, and shunned by some owing to the snake-like shape, the fish is regarded good eating by many. Unlike *M. armatus*, *M. pancalus* is not very destructive to eggs and fry of other fishes. Its value in the control of mosquitoes and Cyclops is insignificant. The fish is frequently subject to parasitism by Helminths.

Regarding systematics, the general Percoid appearance of the early larvae of *M. pancalus*, the similarity in distribution, the presence of dorsal and anal spines, the similarity in the scale pattern, the modification of pelvic fins, and the general resemblance of the twelve days old larva of *M. pancalus* to *Plesiops* seem to indicate that the Mastacembelidae might have originated from a Percoid fish remotely allied to Nandidae.

REFERENCES TO LITERATURE.

Chaudhuri, B. L., 1916.—*Fresh-water Fishes of Bengal*, The Indian Association for the Cultivation of Science, Calcutta, pp. 1-14.

D'Abreu, E. A., 1925.—A Survey of the Fish Fauna in the Ambajheri Tank at Nagpur. *Rec. Nag. Mus.*, No. IV, pp. 1-31.

Day, F., 1877.—On Amphibious and Migratory Fishes of Asia. *Journ. Linn. Soc. London* (Zoology) XIII, pp. 198-215.

Day, F., 1889.—*Faun. Brit. Ind.* Fishes II, p. London.

Deraniyagala, P. E. P., 1932.—The Opisthomi of Ceylon. *Spolia Zeylanica* XVI, pp. 265-270.

Dobson, G. E., 1874.—Notes on the Respiration of some Species of Indian Freshwater Fishes. *Proc. Zool. Soc. London*, pp. 312-321.

Ghosh, E., 1934.—An Experimental Study of the Asphyxiation of some Air-breathing Fishes of Bengal. *Journ. As. Soc. Bengal* (N. S.), XXIX, pp. 327-332.

Günther, A., 1861.—*Cat. Fish. Brit. Mus.* III, p. 541.

Günther, A., 1880.—*An Introduction to the Study of Fishes*, Edinburgh.

Hamid Khan, M., 1934.—Habits and Habitats of Food Fishes of the Punjab. *Journ. Bombay Nat. Hist. Soc.* XXXVII, pp. 655-668.

Hamilton, F., 1822.—*An Account of the Fishes found in the River Ganges and its Branches*, pp. 26-30. Edinburgh.

Hora, S. L., 1935.—Physiology, Bionomics, and Evolution of the Air-breathing Fishes of India. *Trans. Nat. Inst. Sci. India* I, pp. 1-16.

Job, T. J., 1940.—On the Breeding and Development of Indian "Mosquito-fish" of the genera *Aplocheilus* McClelland and *Oryzias* Jordan & Snyder. *Rec. Ind. Mus.* XLII, pp. 51-79.

Job, T. J., 1941.—Practical Utility of *Aplocheilus panchax* (Hamilton) in the Biological Control of Mosquitoes. I. Efficiency. (In the course of publication.)

Job, T J., 1941*a*.—Food and Feeding Habits of the Glassfishes (*Ambassis* Cuv. & Val.) and their Bearing on the Biological Control of Guinea-worm Disease. (In the course of publication.)

Meek, A., 1916.—*The Migration of Fish*, London.

Prashad, B. and Mukerji, D. D., 1930.—On the Fishes of the Manchar Lake, Sind. *Journ. Bombay Nat. Hist. Soc.* XXXIV, pp. 164-169.

Rahimullah, M. and Das, B. K., 1935.—On the Biology, Ecology and Bionomics of the Fauna of the Hyderabad State (H. E. H. the the Nizam's Dominions) Pt. IV *Journ. Osmania University* III, pp. 16-38.

Regan, C. T., 1912.—The Osteology of the Teleostean Fishes of the Order Opisthomi. *Ann. Mag. Nat. Hist.* IX, pp. 217-219.

Sundara Raj, B., 1916.—Notes on the Freshwater Fish of Madras. *Rec. Ind. Mus.* XII, pp. 249-294.