NOTES ON THE BREEDING HABITS AND EARLY DEVELOPMENT OF *MACROPODUS CUPANUS* (CUV. & VAL.), WITH SPECIAL REFERENCE TO THE CEMENT GLANDS OF THE EARLY LARVAE.

By S. JONES, *M.Sc.*, *Central Research Institute, University of Travancore, Trivandrum.*

INTRODUCTION.

Macropodus cupanus (Cuv. & Val.), originally included in the genus *Polyacanthus* (K. & v. H.) Cuv. & Val., is the only representative of the genus *Macropodus* Lacépède in Indian waters. It is a small-sized fish, common in tanks, lakes, ditches and streams, and is capable of living in foul waters which are very deficient in oxygen. Like the other members of the family Anabantidae, it is capable of breathing atmospheric air. It is a shy fish with peculiarly graceful movements, and hides by burrowing in the mud when frightened. It is considered a valuable mosquito larvivore. As our knowledge of the breeding and development of Indian Anabantoids is very meagre, it is hoped that this paper will be of some interest. The presence of cement glands in the early larvae, recorded here for the first time in the family, is of special significance.

BREEDING AND DEVELOPMENT.

Eggs of *M. cupanus* have been collected from a number of tanks in and around Trivandrum (Travancore) during the months of January, February, May, July, September, October and November. As the search for the eggs has never been cotinuous or exhaustive it is quite possible that the fish is a perennial breeder. Intensive breeding has been noticed during the advance monsoon rains when there are intervals of bright sunshine. According to Thomas (1870), in South Canara, its breeding season is May and June.

The nest[1] consists of a small clear space near the water edge, about 5″ in diameter, devoid of all weeds and grasses, except a single stalk of a weed or grass in the middle, which serves as an anchorage for the floating egg mass. Egg masses have also been collected from the under surfaces of the leaves of water-lily and from fallen leaves in the water close to the margins of tanks.

The nest is always guarded by the male fish which remains just below the egg mass. The fins of the male are beautifully coloured and its eyes are red. There is no open communication between the nest and the main body of water except through the algae or decaying vegetable

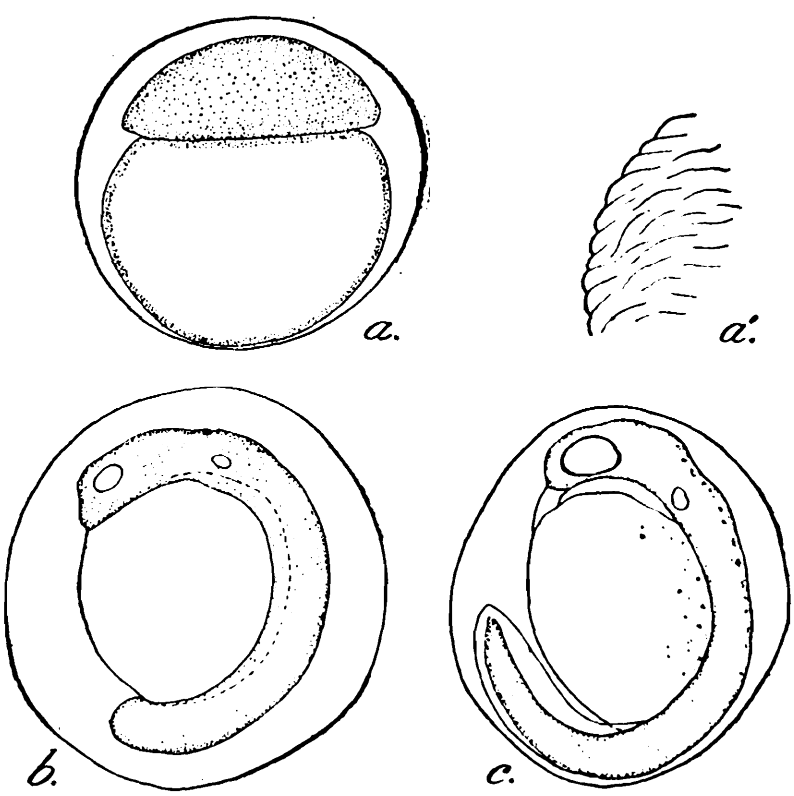
[1] In connection with the nest-building, mating and egg-laying habits of the "Labyrinth Bubble-nest Builders" reference may be made to Innes' excellent descriptions and figures in his "Exotic Aquarium Fishes" (pp. 338-361, Philadelphia: 1935) of fishes of the genera *Macropodus, Trichopsis, Betta, Colisa, Trichogaster, Osphronemus, Helostoma* and *Anabas*. His accounts are based on observations made in aqueria.

matter which presumably serve either as a place of hiding or the means of escape by the guardian fish when disturbed. The eggs are attached to the under side of a circular froth of air bubbles, which is about an inch and a half in diameter and is located in the middle of the clear space.

Mating and egg laying, which follow the preliminary acts of courtship and nest building, have been observed by the present writer under natural conditions. The breeding male, which is larger in size than the female, has its body and fins vividly coloured in different beautiful shades giving it a brilliancy seldom found under normal conditions. The female is less attractive and is of a dark dull colour. Eggs are laid in batches and during the intervals between the laying of the successive batches of eggs the female remains quietly in one place a few inches away, usually at the bottom, in a completely exhausted condition. The male is very active and busies himself with the work of substituting fresh bubbles of air in place of those lost from the bubble nest by taking occasional gulps of air and blowing it on to the under side of the nest. Once or twice it goes near the female and 'noses' it so as to create excitement. Finding no response from the female it goes under the nest and after making a brief survey inspects the mud for any egg that might have fallen down by accident. The exact procedure by which stray eggs at the bottom are brought up to the nest could not be clearly seen, though it was observed that the male remains at an angle at the bottom probing the mud for eggs. Probably the eggs are blown up. While the male is thus engaged the female begins to show signs of activity as if awakened from slumber and the male quickly noting the changed disposition of its mate approaches and touches it with confidence and the latter quickly responds to the invitation of the male and accompanies it to the under side of the nest where both make a few circles and exhibit some sort of a playful love chase for a few seconds. Suddenly the male bends round in an arch converting its body into a ring around the female which remains motionless and submissive. During this act the head of the male touches its tail, and the vent of the male comes into close apposition with that of the female. Simultaneously with this both turn over describing a semi-circle so that the female now remains with the ventral side up. They remain quiet in this condition for about 10 to 15 seconds. The beautifully coloured pelvic fins of the male stand erect in a conspicuous manner and the anterior portion of the dorsal fin shows some sign of movement. The male now relaxing its grip moves to one side and the female with the ventral side still up, before resuming the normal position, sends up a stream of about 10 to 15 eggs, which are shot up towards the mass of air bubbles by the force of the ejection and there they float with the other eggs. After this act the female steadies herself slowly with signs of complete exhaustion, just like a half dead fish that has lost its equilibrium. While the female rests at a side the male is busy looking after the nest and the eggs. This act is repeated a number of times till roughly about 300 eggs are laid. The combined weight of the eggs submerges a portion of the comparatively large mass of air bubbles, but the dorsal surface of the nest projects like a dome above the surface of water.

As indicated above, the actual nest building and mating prior to egg laying have not been observed by the present writer. Probably these actions are similar to those of the Indian Rainbow-Fish, *Colisa fasciata* (Bl. & Schn.) (=*Colisa vulgaris* Cuv. & Val.), more popularly known as the Striped Gourami, a graphic description of which was published by Carbonnier (1876). His observations were made at Paris where the temperature of the aquarium was kept at 23-25°C. (=73·4-77°F.). A large number of the Anabantoids are bubble-nest builders (Jones, 1939), whereas some have much different nesting habits. The Giant Gourami, *Osphronemus goramy* Lacépède, builds a nest of water plants (Raj, 1916 and Roxas & Umali, 1937), and *Betta picta* (Cuv. & Val.) and *B. brederi* Myers are oral brooders (Myers, 1939). In all cases parental solicitude is restricted to the male.

The eggs (text-fig. 1*a*) of *M. cupanus* are small, about 0·9 mm. in diameter, and the bubbles of air constituting the froth help them to



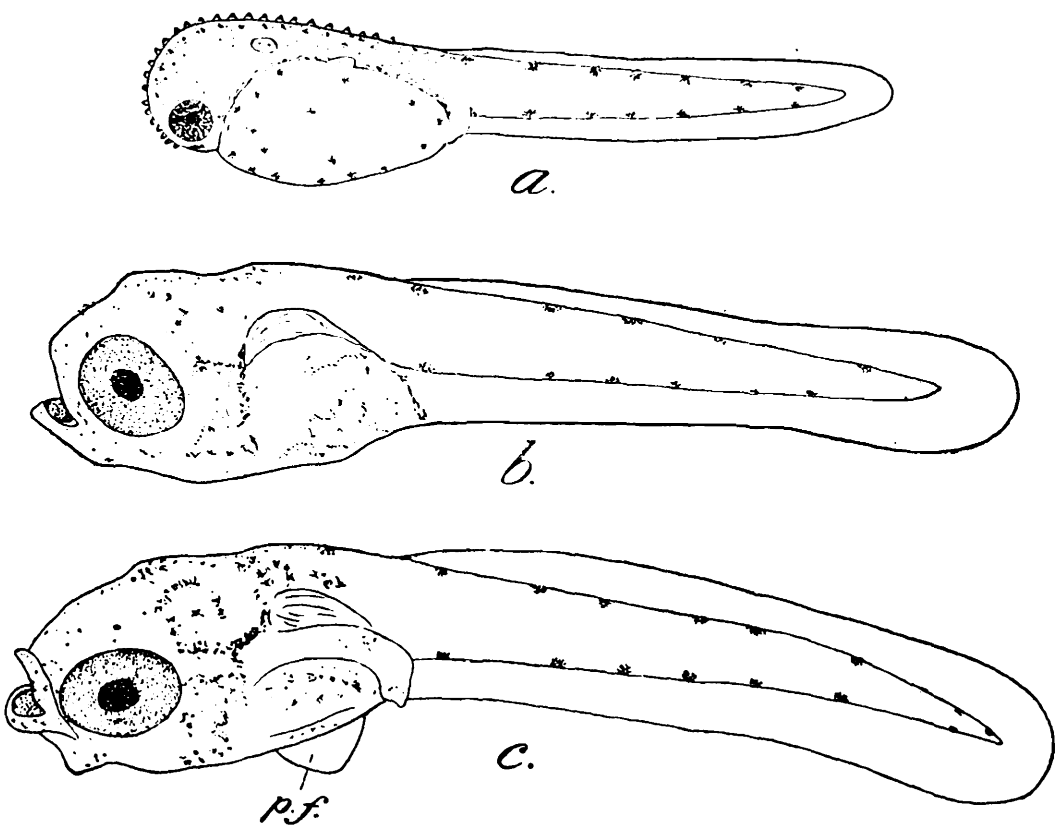
TEXT-FIG. 1.—Embryonic stages of *Macropodus cupanus* (Cuv. & Val.). All the figures are from preserved specimens.

a. Egg about 6 hours old, showing the blastoderm above and the yolk below : ×40 ; *á*. A portion of the egg-membrane highly magnified to show the surface ridges ; *b*. Embryo 24 hours old : ×40 ; *c*. Embryo 36 hours old : ×40.

float. Unlike the eggs of many other Indian fishes, the egg-membrane in *M. cupanus* is not rigid, but is of a jelly-like consistency. The surface continues to be sticky for a long time and it is thrown into a series of folds or ridges (text-fig. 1*a'*). The eggs, though not lighter than water, are capable of floating as a result of the attached air bubbles and due to surface tension. The large mass of air bubbles constituting the froth is of a transitory nature and under natural conditions fresh bubbles are supplied by the guardian fish in place of those that have burst.

Though the large bubbles burst soon, a few small ones, which are discernible only under a microscope, remain attached to the egg membrane for a long time and they help the eggs to float. Some of these as a result of surface tension continue to float even after all the bubbles have burst, but a gentle shake wets the upper exposed surface and make them sink. Under laboratory conditions, it has been found that all floating eggs undergo healthy development, whereas most of the demersal eggs do not hatch out, probably due to lack of proper aeration.

Eggs showing early developmental stages have been usually collected in the morning, though egg laying has been observed in the afternoon also. The blastodisc which is found on one side of the yolk mass (text-fig. 1*a*) can easily be distinguished even with the naked eye by its white colour. The yolk is devoid of oil globules and the blastoderm completely envelopes it when about 16 hours old. In the 24 hours old eggs the embryo (text-fig. 1*b*) is visible with rudiments of the optic



TEXT-FIG. 2.—Larval stages of *Macropodus cupanus* (Cuv. & Val.). Figs. *b.* & *c.* are from preserved specimens.

a. Larva about 12 hours after hatching. × *ca* 30 ; *b.* Larva on the 3rd day (cement glands not shown). × *ca.* 32 ; *c.* Larva on the 6th day. × *ca.* 32.

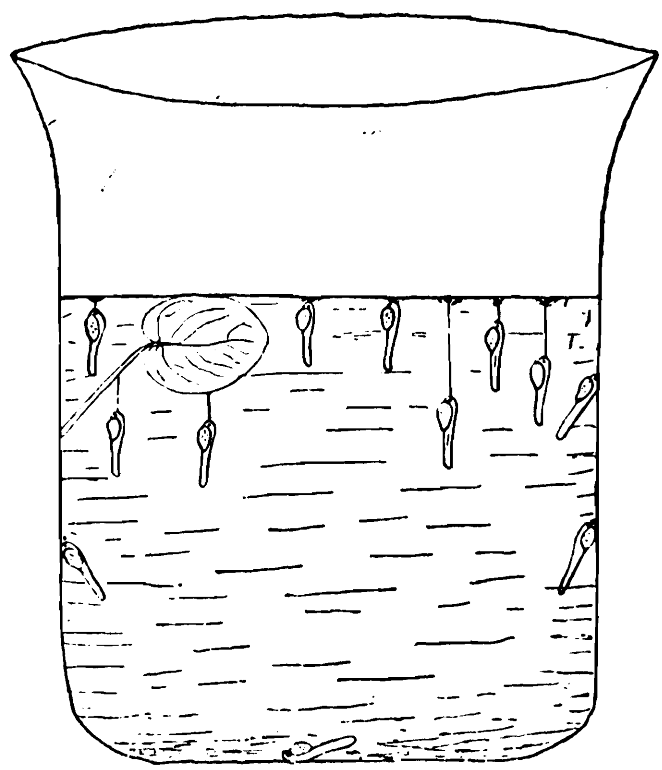
p.f. Pectoral fin.

and auditory organs and the tail still attached to the yolk. Six hours later the tail is free from yolk and the heart begins to pulsate. When the embryo is about 36 hours old (text-fig. 1*c*) chromatophores are formed, the eyes develop the lens, the auditory vesicles have two concretions, the tail is long, the embryo wriggles inside and there is a slow blood circulation. The eyes are devoid of pigment and the median fin-fold is very narrow.

The newly hatched larva (text-fig. 2*a*) is 2·3 mm. in length with a large yolk mass to which the head is closely attached. The mouth, anus and gill slits are absent at this stage. The yolk is devoid of any oil globule and the tail is protocercal. The eyes are lightly pigmented and the auditory organs have two concretions. The most interesting feature is the presence of a large number of minute cement glands all over the head and the nape which produce a mucous secretion by which the larva attaches itself to the surface film or water, to the sides of the aquarium or to floating objects in the water (text-fig. 3).

The mouth is formed on the second day, the number of chromatophores on the head increases, the eyes get darker and the larva continues to remain attached with the aid of the mucous secretion. When disturbed it darts about for some time, but reattaches itself almost immediately.

On the third day (text-fig. 2*b*)[1] more than half of the yolk is consumed, the gill slits are formed and the air-bladder is developed. The



TEXT-FIG. 3.—Larvae of *Macropodus cupanus* (Cuv. & Val.) under laboratory conditions. Diagrammatic.
The larvae are suspended or attached by the mucous secretion of the cement glands.

alimentary canal is still indistinct. The pectoral fins are larger but not functional at this stage.

On the fourth day, practically the whole of the yolk is absorbed, cement glands disappear, the pectorals develop and the larvae are able to move about. A small quantity of unconsumed yolk is present towards the right side and probably this is responsible for the air-bladder to be slightly disposed to the left side.

The alimentary canal could be seen on the 5th day. During the following 10 days no appreciable changes were observed. As the larvae

[1] The cement glands cannot be seen distinctly in preserved specimens though they can be distinguished without any difficulty in living specimens.

lived in captivity for about a fortnight only, further development could not be followed. The larvae at this stage can be distinguished by a dorsal and a corresponding ventral row of seven or eight chromatophores as shown in text-figure 2c. Raj (1916) refers to eight dark vertical bands in the young (17 mm. size) of *Anabas scandens* (Daldorff) [=*A. testudineus* (Bloch)] which fade away as the fish grows older. To the naked eye the chromatophores of *M. cupanus* appear as bands in the living specimens and it is probable that these may develop into definite bands in the older larvae as a larval character. There are no colour bands in the adult. Some Anabantoids, such as the Striped Gourami (*Colisa fasciata*), have colour bands in the adult also.

CEMENT GLANDS.

In a previous paper (Jones, 1938) dealing with the origin and development of the cement glands in *Etroplus maculatus* (Bloch) the author dealt with the different types of cement glands found in the different groups of vertebrates and also discussed the various views regarding their origin and homology. In conclusion it was stated that

"The origin of the cement organs as endodermal pouches in the Ganoidei has led Kerr (1906) to compare them with the pre-mandibular head cavities of other vertebrates. Reighard and Phelps (1908) are of opinion that that these glands are homologous with the anterior gut pouches of Elasmobranchs, which in turn, have been homologized with the anterior gut pouches of Amphioxus, one of which, is converted into the ciliated organ (Neal, 1898 and van Wijhe, 1914). It is very doubtful if this view could be accepted from the fact that in the Teleostei, Dipnoi and Anura these organs are of ectodermal origin, though the condition in Ganoidei is in support of it. This would mean that the organ would have arisen independently in the different groups of vertebrates as suggested by Eycleshymer and Wilson (1908) who also support the suggestion of Balfour with regard to the origin of the barbels in Teleosts as seen from the fate of the cement organs in *Acipenser*. As against this view Kerr (1919) is of opinion that during ontogeny certain phases in the development of the organs have been slurred over or even omitted giving rise to a condition in Dipnoi and Anura where the organs were known to take their origin from the ectoderm. But instances, wherein different or intermediate conditions in origin within the same group, which would have gone in favour of this theory, are lacking. Still the fact that in Teleostei and Dipnoi, the two intermediate groups of vertebrates possessing cement organs, they are known to originate from the *inner* layer of ectoderm whereas in the more highly evolved Anura the secretary cells of the gland are derived from the *superficial* layer of ectoderm, cannot be without some phylogenetic significance. However, more work on the cement glands in fishes, especially of Teleosts, is required before this and the allied questions can be solved in a satisfactory way."

Since the publication of the above paper, the author has recorded the presence of a cement gland in a Cyprinid, *Danio malabaricus* (Jerdon) [Jones, 1938*a*]. Here the gland is a large median structure situated just above the mouth and between the eyes ; it is exactly like the one found in the African and South American Characids, *Sarcodaces odōe* (Budgett, 1901) and *Curimatus elegans* (Azevedo, Dias & Vietra, 1938) respectively. The origin of the cement gland in none of the abovementioned forms has yet been worked out and hence little additional light can be thrown on the homology of this organ.

The cement glands of *Macropodus cupanus* are remarkable in that they are unlike those of any other previously recorded types, and their position (distribution) throws considerable light on the origin of the cement glands in the different groups of vertebrates. The cement organs of *M. cupanus* consist of numerous minute conical wart-like projections scattered all over the head and the nape, as far back as the origin of the dorsal median fin-fold. Their peculiar position shows that whatever may be their origin (ectodermal or endodermal) they can hardly be homologized with those found in the Ganoidei which have been regarded as homologous to the pre-mandibular head cavities of vertebrates. The apparently ectodermal origin, according to Kerr (1919), in the other groups of vertebrates is due to the slurring over or omission of certain phases in the development of the glands in the course of ontogenic development, giving rise to the present condition. If that is the explanation advanced for the origin of the different types of cement glands, how can the peculiar distribution of the glands in *Macropodus cupanus* be accounted for ? It would be ridiculous to suggest that the glands of this fish had their origin in the anterior gut pouches, which in the course of early embryonic development were divided up and scattered throughout the head and the nape ! Hence it is only reasonable to conclude that the cement glands in vertebrates are not homologous organs, but are only analogous and have arisen independently in the different groups for an identical function.

The above view of the author about the origin of these glands in vertebrates is further strengthened by the recent discovery of another very interesting type of cement gland, situated as a median cup-shaped organ on the ventral side of the yolk sac, in a Cyprinid. From whichever germ layer this gland may originate it is difficult to conceive a pre-mandibular origin for it. This point is being elaborated by the author elsewhere.

REFERENCES TO LITERATURE[1].

Azevedo, P. de, Dias, M. V and Vietra, B. B., 1938.—Biologia do Saguiru (Characidae, Curimatinae). *Mem. Inst. Oswaldo Cruz* XXXIII, pp. 481-553.

Budgett, J. S., 1901.—On the Breeding-habits of Some West African Fishes, with an Account of the External Features in the Development of *Protopterus annectens*, and a Description of the Larva of *Polypterus lapradei*. *Trans. Zool. Soc. Lond.* XVI, pp. 115-136.

Carbonnier, M. P., 1876.—Nidification of the Indian Rainbow-Fish. *Ann. Mag. Nat. Hist.* XVII, pp. 172-174.

Jones, S., 1938.—On the Origin and Development of the Cement Glands in *Etroplus maculatus* (Bloch). *Proc. Ind. Acad. Sci.* VI, pp. 251-261.

Jones, S., 1938*a*.—On the breeding habits and development of a Cyprinid, *Danio* (*Danio*) *malabaricus* (Jerdon), in Ceylon. *Ceylon Journ. Sci.* (C) VI, pp. 79-89.

Jones, S., 1939.—On the Nesting Habits of the Gourami. (*Osphronemus goramy* [Lacépède]). *Journ. Bombay Nat. Hist. Soc.* XL, pp. 766-771.

---

[1] For a complete bibliography on the cement organs of vertebrates see Jones 1938, and for references on the breeding habits of Anabantoids Jones 1939.

Jones, S., 1940.—Breeding and development of Indian fresh and brackish water fishes. (In press.)

Kerr, J. G., 1919.—*Text-Book of Embryology*. II, London.

Myers, G. S., 1939.—A Possible Method of Evolution of Oral Brooding Habits in Cichlid Fishes. *Stanford Ichthyological Bull.* I, pp. 85-87.

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

Roxas, H. A. and Umali, A. F., 1937.—Fresh-water Fish Farming in the Philippines. *Phil. Journ. Sci.* LXIII, pp. 433-468.

Thomas, H. S., 1870.—*Report on Pisciculture, South Canara.* Madras.