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ON THE EMBRYONIC DEVELOPMENT OF THE SQUID (?*SEPIOTEUTHIS ARCTIPINNIS* GOULD) FROM THE GULF OF MANNAR *

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THE present account describes the embryonic stages of a squid, the egg capsules of which were obtained by the author from the Gulf of Mannar. From the nature of the capsules and the characteristics of the newly hatched young ones, it has been possible to assign them to a myopsid decapodan, dibranchiate cephalopod. The species of the squid that is most common and contributes to a minor fishery in the Gulf of Mannar and Palk Bay is *Sepioteuthis arctipinnis* Gould (Rao, 1954). Rao (*loc. cit.*) has observed that this species begins spawning in January in the offshore waters and then migrates into the inshore waters and the coastal lagoons where it continues to spawn from February to June or July. Egg capsules of this squid were met with in the Gulf of Mannar and the Palk Bay from January to June (Rao, *loc. cit.*). In the present instance the egg capsules were collected in March. These observations lend corroborative evidence to suppose that the species dealt with here is *Sepioteuthis arctipinnis* Gould.

The egg capsules in a single large cluster were collected from the inshore waters of the Gulf of Mannar, near the Central Marine Fisheries Research Institute on March 9, 1960 at about 7 a.m. They were brought to the laboratory and left in the aquaria having a continuous circulation of sea water. The temperature of water in the aquaria ranged from 27° to 29° C. during the period of observations. Periodically a few capsules were cut open to liberate the embryos and observations and camera lucida sketches were made of live embryos.

THE EGG CAPSULES AND THE EGGS

The egg capsules were attached to the sea weed (*Sargassum* sp.) by means of a central gelatinous matrix which formed the base from which the capsules radiated. When the whole cluster was removed from the sea weed and left in a bowl of sea water the capsules spread out into a circular form with a radius of about 8.5 cm. There were 53 capsules in the cluster. Squids are known to prefer the egg masses of squids that are already present in the environment for depositing their own egg capsules. As a result of this huge columns of egg masses are formed. It is interestng to note that McGowan (1954) during one of his dives in the La Jolla submarine canyon found an egg mass of 40 ft. in diameter.

The egg capsules were fingerlike in appearance and slightly broad about the distal end (Fig. 1). They were attached to a central gelatinous matrix by small stalks. The capsules were jelly-like in consistency with a firm translucent outer

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layer. They ranged in length from 62 to 68 mm., in width 10 to 11 mm. at the mid region and 12 to 13 mm. at the broadest region. Squid egg capsules are known to enlarge in size from the time of laying by taking in water (McGowan, 1954). In the present case the egg capsules did not show any increase in dimensions after they were left in the aquaria and it is presumed that they were already in an enlarged state when they were collected.

There were either 6 or 7 eggs in each capsule arranged in a well spaced single row and visible through the translucent gelatinous capsule. The egg was embedded in a cavity within the capsule. The eggs per capsule are very few in the present instance when compared to the number in *Loligo opalescens* which is about 200 (Fields, 1965).

The egg, as in other cephalopods, are large, elongately oval, telolecithal and heavily yolked. The nucleus of the ovum is situated in a restricted area of cytoplasm at the animal pole. The ovum is encased in the chorion with the micropyle at the egg's animal pole and a perivitelline space surrounding the ovum. With the chorion the egg measures about 6 mm. in length and 4.6 mm. in breadth.

Development of the Egg

The most recent works on the subject of cephalopodan development are those of Arnold (1965) and Fields (1965) on *Loligo pealii* and *L. opalescens* respectively. The development of the present species generally follows the pattern described for these species. While tracing the development, embroys showing progressive advancement with marked changes in morphological features have been chosen and described. The rate of development differed in individual cases and for the purpose of sketching the commonest of them at the time of examination was selected. Descriptions are based on the structures visible when viewed under the microscope and no histological study of tissues has been attempted. Since the embryos were transparent it was possible to obtain almost all the details of the various morphological features.

The early cleavage stages followed the usual cephalopodan pattern, that is, the meroblastic type, and resulted in the 64-celled stage of the embryo. By further marginal divisions of the blastomeres the blastoderm was formed (Fig. 2). The marginal cells (blastocones) then ceased proliferating blastomeres, but some of them migrated away from the blastoderm retaining only a thread of cytoplasm with the blastoderm. In Fig. 2 these appear as a ' series of narrow, spoke-like pillars radiating from the blastoderm ' (MacBride, 1914). This stage was obtained on March 9 at 9 p.m. Since the time of deposition of the capsules is not known it is not possible to directly ascertain the age of the embryos. However, considering that the eggs when examined soon after they were collected at 7 a.m. on the same day, were fresh and did not show any development, it may be presumed that the capsules could have been laid sometime during the preceding night.

An annular depression was noticed in an embryo examined on March 12 at 9 p.m. just below the blastoderm separating the embryonic and non-embryonic (external yolk sac) regions. In *Loligo opalescens* the depression appears about the equator of the egg on the sixth day (Fields, *loc. cit.*), whereas in the present species the same appears very near the margin on the fourth day.

On the fifth day (March 13) the organ forming areas are noticed (Fig. 3). The shell gland appears as a shallow depression surrounding which there is a ridge, the primordium of the mantle. Just below this in the depression the primordia of the ctenidia are present. Encircling the depression on the anterior aspect are the funnel folds which converge on the ventral surface. Anterolaterally on either side the eye rudiments are present as shallow depressions. The stomodaeum appears anteriorly. The primordia of the ventral arms (2 pairs) also make their appearance as thickenings at the lower edge of the blastoderm.

On the sixth day (March 14) the shell gland depression has closed. The mantle has grown and covered the internally lying primordia of the various organs. More arms are budded off and the eye bulbs increase in proportion. The funnel folds have fused medially (Fig. 4).

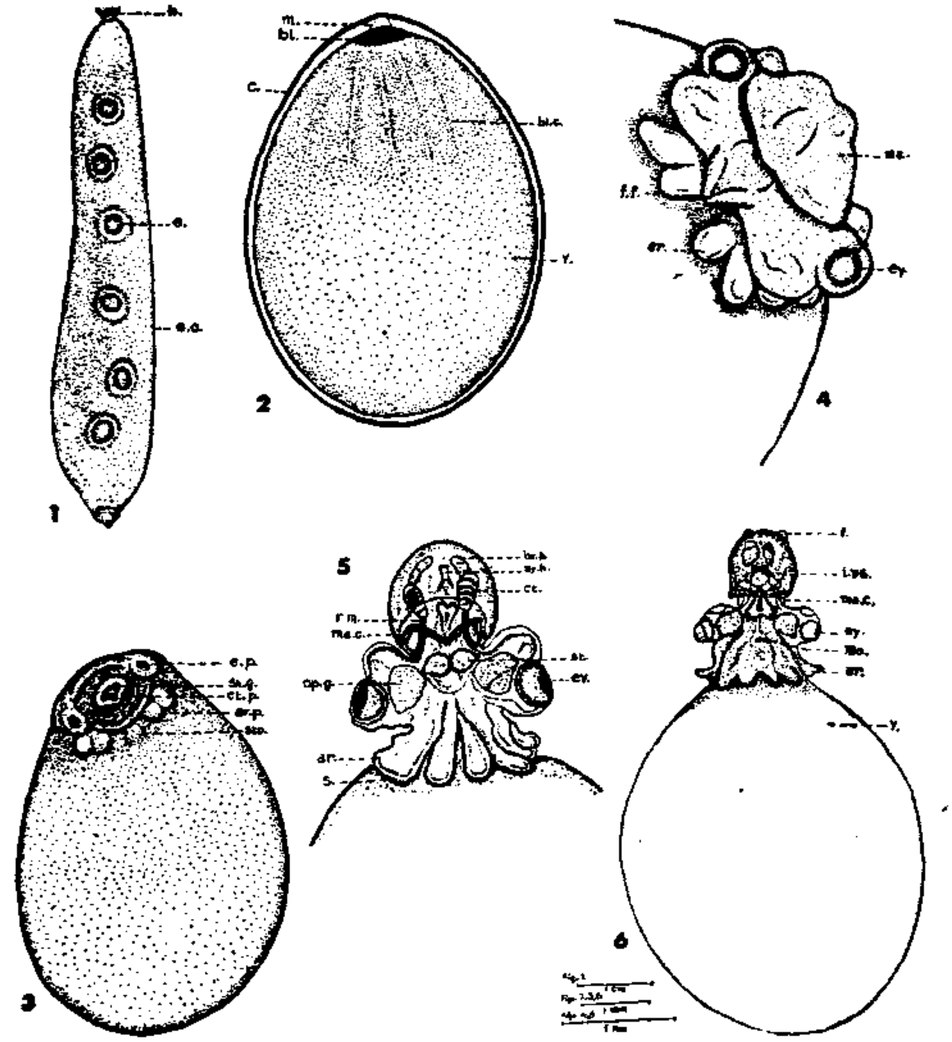
The embryo is far advanced in development and more organs have developed (Fig. 5) on the seventh day (March 15). The embryo is distinctly separate from the external yolk sac. The ctenidia are elongate and plume like. The systemic and branchial hearts are well developed. The retractor muscles stretch from the middle of the funnel to the mantle. The corneal fold envelopes the eye. A pair of optic ganglia and a pair of statocysts are present. The arms have grown in length and their ends are provided with suckers. A pair of funnel cartilages is present. At this stage due to the contraction of the circum-oral muscles, the branchial hearts often move towards each other and separate, describing an ' arc '.

The primordia of the fins have developed by the eighth day (March 16) as paired structures (Fig. 6) at the edge of the mantle. By the eleventh day the ctenidium is well developed and the lens also has been formed in the eye (Fig. 7). By the fourteenth day the developing embryo appears as a miniature adult but with the external yolk sac still attached (Fig. 8). The mantle, fins, arms, eyes and the visceral organs are all well developed. The embryo is seen moving inside the now enlarged chorion.

The Newly Hatched Young Squid

On the fifteenth day (March 23) after the capsules were obtained the first young one hatched out. Before rupturing the covering layers, the chorion and the capsule the young one was observed to be moving back and forth inside the chorion and suddenly darted off. It began to move about freely outside immediately after emerging out. Interesting observations have been made by Hamabe (1960) on the process of drilling a perforation on the membrane with the help of a ' tooth process ' for the liberation of the embryo of *Loligo bleekeri*. The yolk sac in some instances gets detached even when the embryo is inside the capsule ; in others the same falls off as the young one darts out from the capsule ; in yet others the yolk sac is carried along with the embryo into the outside world and then discarded after an hour or so. In *L. pealii* hatching occurs when all the yolk has been consumed or dropped from the larvae (Arnold, 1965). In *L. pealii* the external yolk sac is considerably reduced and is very much smaller than in the present species at the time of hatching.

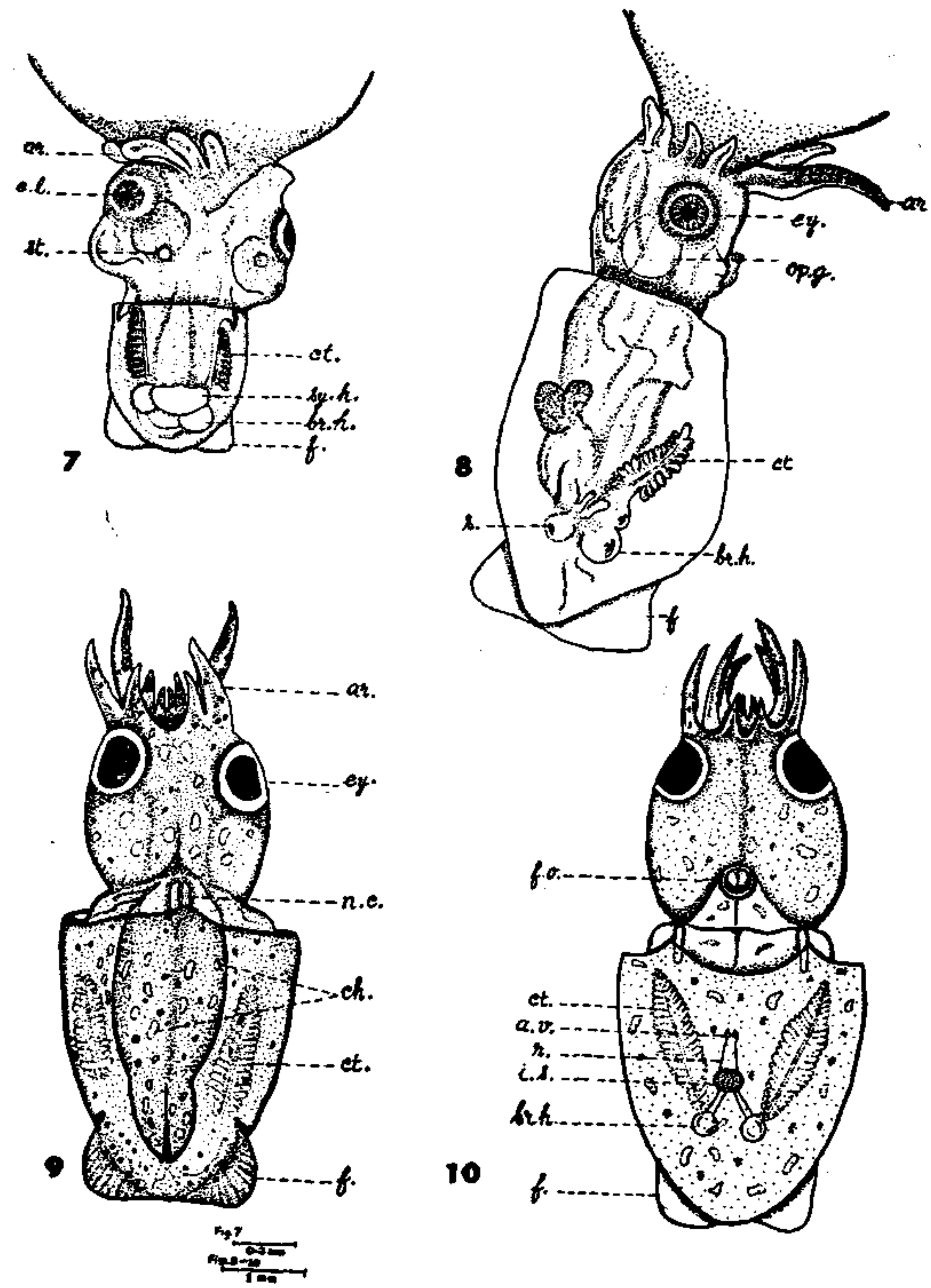
The incubation period, that is, the period from the laying of the capsules to hatching of the young ones, is known to vary in different species, and to be influenced by the temperature of the water. Hamabe (1960) has observed that *L. bleekeri* from the Japanese waters requires from 36 to 43 days at 13° to 17°C. The same species, in the northern part of Japan requires 46 days at a lower temperature of 10° to 12°C. It is interesting to note *L. pealii* takes only 11 or 12 days for hatching in the warmer waters at Woods Hole, Massachusetts (*vide* Fields, *op. cit.*). In the



FIGS. 1-6. Developmental stages of ?*Seploteuthis arctipinnis*.

ar.-arm, ar.p.-primordium of arm, b.-base, bl.-blastoderm, bl.c.-blastocones, br. h.-branchial heart, c.-chorion, ct.-ctenidium, ct.p.-primordium of ctenidium, e.-egg, e.c.-egg capsule, e.p.-primordium of eye, ey.-eye, f.f.-funnel fold, i.y.s.-internal yolk sac, m.-micropyle, ma.-mantle, ma.c.-mantle cartilage, mo.-mouth, op.g.-optic ganglion, r.m.-retractor muscle, s.-suckers, sh.g.-shell gland, st.-statocyst, sto.-stomodaeum, sy.h.-systemic heart, y.-yolk.

present species hatching commenced on the fifteenth day at a temperature of about 27° to 29°C. As there was difference in the rate of development hatching continued for about 3 days and at the end of this period all the embryos which had shown healthy development hatched. There were a considerable number of eggs



FIGS. 7-10. Developmental stages of ?*S. arctipinnis* (continued).

a.v.-anal valve, ch.-chromatophores, e.l.-.-eye lens, f.-fin, f.o.-funnel opening, i.s.-ink sac, n.c.-nuchal cartilage, r.-rectum, s.-stomach. (other letterings are as for figs. 1-6).

which had become opaque and did not develop at all. It is not known why when some of the eggs hatched successfully, others in the same capsule, did not develop. It is interesting to note that in *L. opalescens* almost 100 per cent of the eggs developed and hatched under laboratory conditions very similar to the present case (Fields, *op. cit.*).

The young squid upon hatching, very much resembles the adult (Figs. 9 and 10) and begins an independent life. It measures 7.5 mm. in total length (including arms) and 3.0 mm. in width. The young one of *L. opalescens* is much smaller at hatching measuring 5 mm. in total length (Fields, *op. cit.*). The mantle is transparent through which the visceral organs can be clearly seen. The chromatophores develop all over the mantle, head, arms and the dorsal surface of the fins. The ventral surface of the fins are devoid of chromatophores. They range from yellow to dark brown in colour. As a rule those on the dorsal surface are much larger than the ones on the ventral surface. The chromatophores are arranged in two rows on the arms. The movement of the pigments inside the chromatophores is distinctly seen as the latter contracts and expands. The fins are present at the posterior end as a pair of flaps. The characteristic feature of *Sepioteuthis arctipinnis* is the continuous fin bordering quite nearly the entire mantle length. It is likely that this is a feature that is attained as the young one grows. The arms are well developed, five pairs in all including the tentacular arm which is not in any way different from the other at this stage. The third arm is the longest. The suckers are well developed. The funnel is completely formed. The funnel cartilages are well developed, so also the nuchal cartilage. The eyes are iridescent with bright metallic red and green tinge on the upper and lower surface respectively as has been observed in *Loligo opalescens* by Fields (1965). Through the mantle the well-developed ctenidia, the rectum, anal valve, ink gland and the pulsating branchial hearts are all clearly seen.

The young survived for about three days in the aquarium after which they all perished. No feeding was attempted. As the internal yolk which persists even after hatching is known to be used as food by the young squid, it is likely that factors other than food brought about death. Fields (1965) has observed that the young ones died after 10 days due to a fungal infection.

SUMMARY

The egg cluster, egg capsule, egg, developmental stages and the newly hatched young of a squid (? *Sepioteuthis arctipinnis* Gould) from the Gulf of Mannar have been described.

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