MALACOLOGIA, 1982, 22(1-2): 197-204

PROC. SEVENTH INTERNATIONAL MALACOLOGICAL CONGRESS

Colloque Sexualité et Reproduction

ON EGGS AND EMBRYOS OF CIRROMORPH OCTOPODS

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ABSTRACT

Six eggs and embryos of cirromorph octopods from different parts of the world are described. Differences in egg size and structure suggest that these specimens belong to at least five different species, none of which can be identified now. One differs markedly from all the others by having a large space filled with gelatinous material between the chorion and the outer, rigid egg case. The body shape of the embryo in this specimen is also distinctive. Only clearly recognizable embryos, all at advanced embryonic stages, have been taken into account. Features common to all specimens are described and discussed.

INTRODUCTION

Among the recent cephalopods, one of the most peculiar but poorly known groups is the octopodan sub-order of the Cirrata (= cirromoprh octopods; also known as finned octopods). Deep water photograpy in recent years has shown the swimming behaviour of these animals (Roper & Brundage, 1972), but little is known of their habits in general. Their reproductive biology is virtually unknown.

The embryonic development of the Cirrata has been mentioned only briefly by Verrill (1885) who observed some eggs and embryos, but did not present figures of them. More recent descriptions do not exist (cf. Boletzky, 1978).

The present paper describes a collection of six cirrate embryos from different parts of the world (Table 1). They have been collected by the Danish vessel "Galathea" during its voyage in 1950–52, by the French vessels "Cryos" and "Jean Charcot" on the cruises BIOGAS 5 and 6 in 1974 (organized by the Centre Océanologique de Bretagne), and by the French vessel "Marion-Dufresne" during the antarctic operations MD/Benthos in 1977.

The state of preservation of the embryos, which have been stored in ethanol or formalin, does not allow the histological work desirable for a detailed description. However, paraffin sections have

TABLE 1

Specimen	Station	Position	Depth in m
A	CENTOB BG 5	47°33′ N 09°01′ W	2860
B	CENTOB BG 6	46°28′ N 10°24′ W	4715
C	Galathea 279	01°00′ N 76°17′ E	4425
D	Galathea 663	36°31′ S 178°38′ W	4520
E	Galathea 664	36°34′ S 178′57′ W	4625
F	MD/Benthos	46°48′ S 70°30′ E	1218

provided some interesting information on the internal anatomy and the structure of the integument (Boletzky, 1978).

In addition to the embryological aspects, the structural features of the outer, rigid egg cases are particularly interesting. In contrast to the "naked" incirrate eggs, which are brooded by the mother octopus, cirrate eggs are enclosed in a tough shell produced by the oviducal gland (in incirrates, the corresponding material is used as "cement" for fixing the eggs by their characteristic chorion stalk). This outer shell is more or less distinctly sculptured. The differences in colour and structure allow one to distinguish different forms, particularly among eggs of similar size. No species identification is possible at present.

OBSERVATIONS

Specimen A

This specimen from the western Gulf of Biscay is incomplete in that part of the outer brown shell is missing. Thus the over-all size of the egg can only be estimated; it probably measures between 12 and 15 mm. The sculpture is very distinct and consists of high, sharp ridges arranged in a roughly hexagonal pattern. This arrangement is brought about by transverse connection between longitudinal ridges that merge into stem ridges on the preserved end of the egg case (Figs. 1, 2). The hexagons are subdivided by smaller ridges (Fig. 2).

The embryo has a body length of about 4 mm, bluntly ending arms about 1 mm long, each with a single row of sucker rudiments. Only the left fin is preserved; it measures about 3 × 2 mm (Fig. 1A).

Specimen B

This specimen comes from the same area as A, but was collected at greater depth. The outer egg case (12 × 9 mm) has the shape of a hen's egg; its colour is beige and it has a coarse surface, with very inconspicuous longitudinal ribs (Fig. 3A); an irregular ridge pattern marks both ends.

The embryo has a body length of about 6 mm (ca 5 mm dorsal mantle length ML), the arms are about 1.5 mm long and show the single row of sucker rudiments already mentioned for specimen A. The buccal mass is still in a position anterior to the dorsal arms. Through the translucent tissues, one can recognize the simple inner yolk sac and, on the ventral side, the visceral complex. The fins are similar to A (Figs. 4).

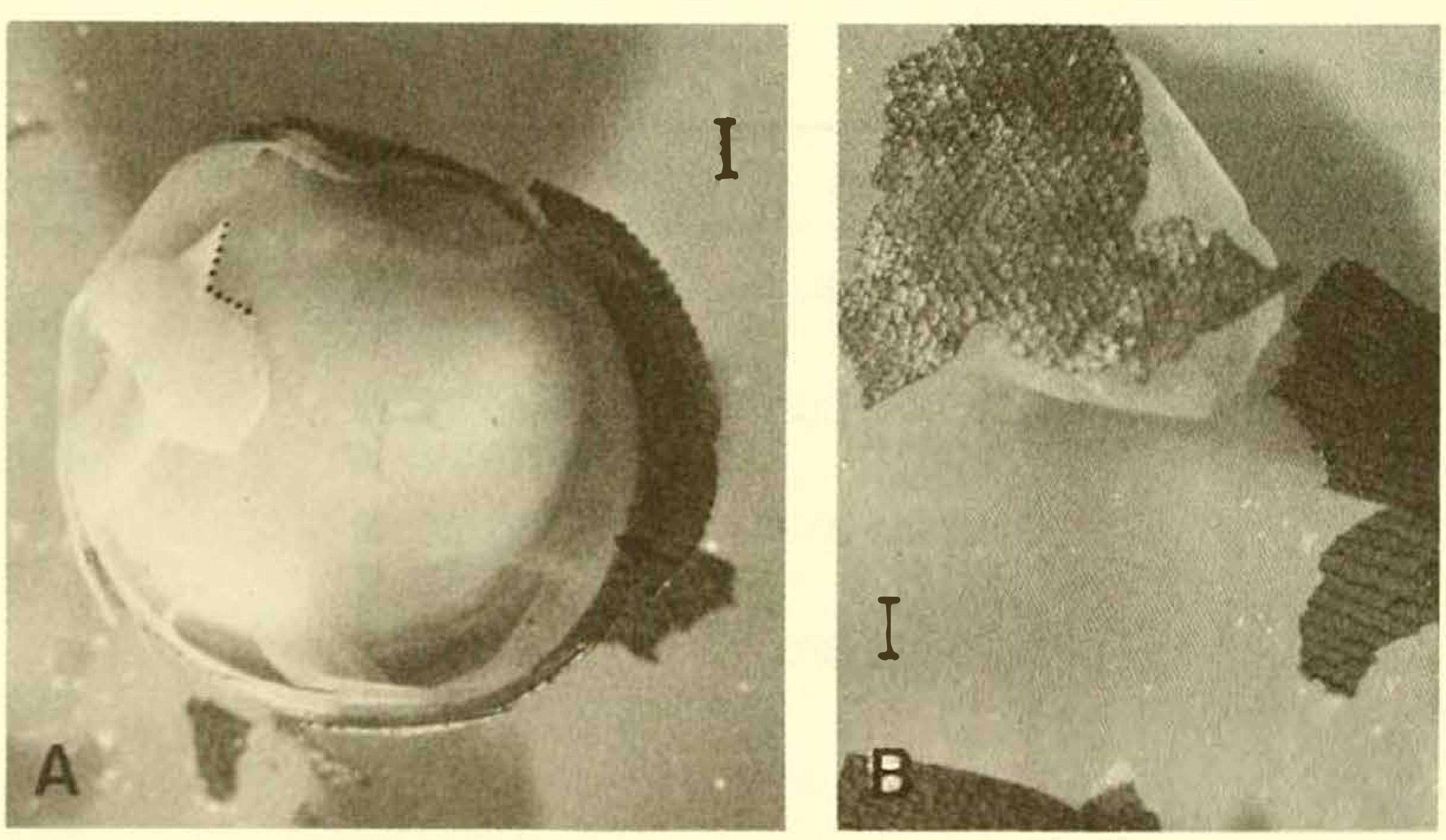

FIG. 1. Specimen A with incomplete outer egg case and chorion (arrow) opened up (A). Fragments of the outer case showing the roughly hexagonal ridge pattern (B). The scale bar represents 1 mm.

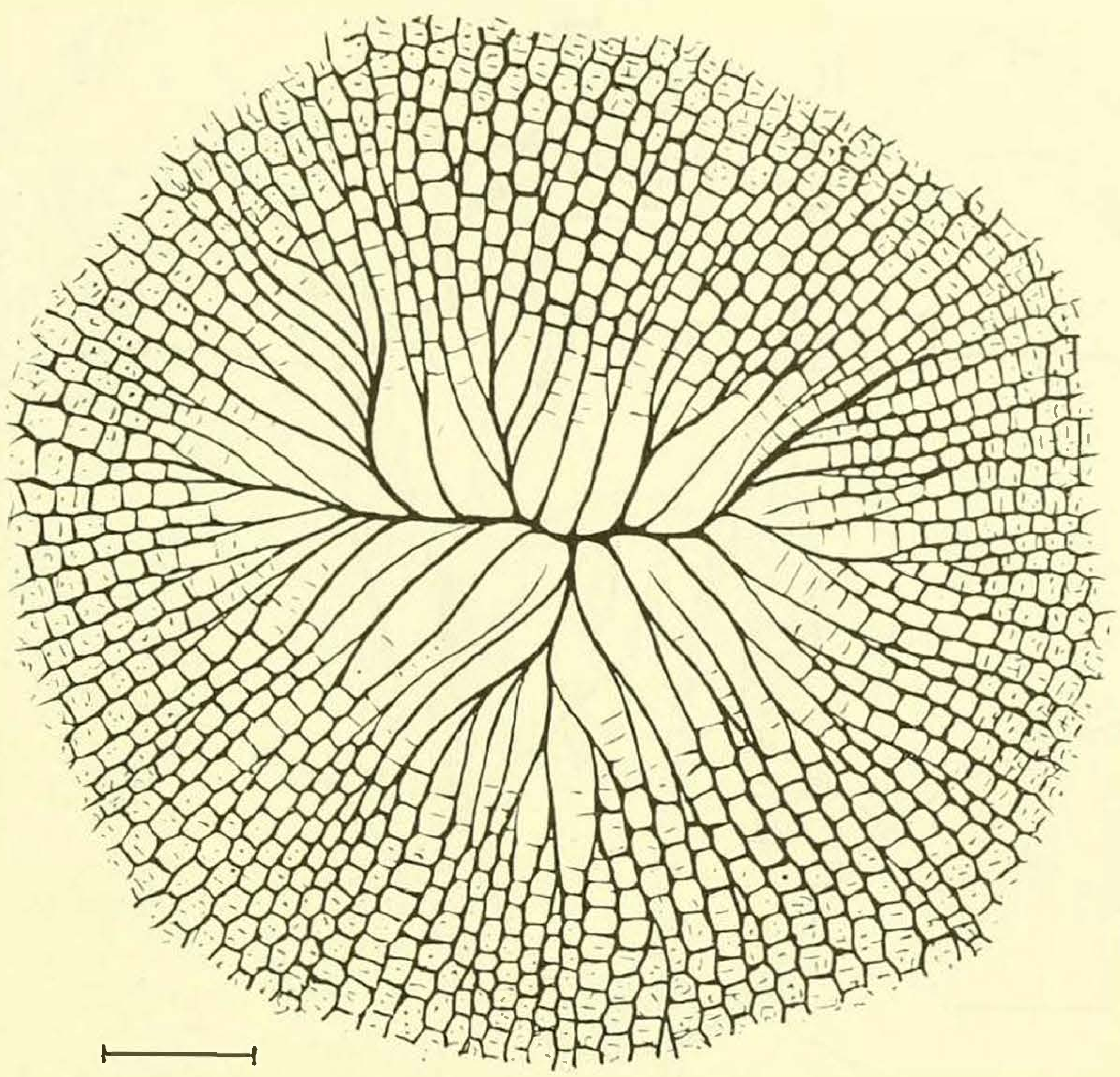

FIG. 2. Detail of the ridge pattern on one end of the egg shell of specimen A. Scale bar = 1 mm.

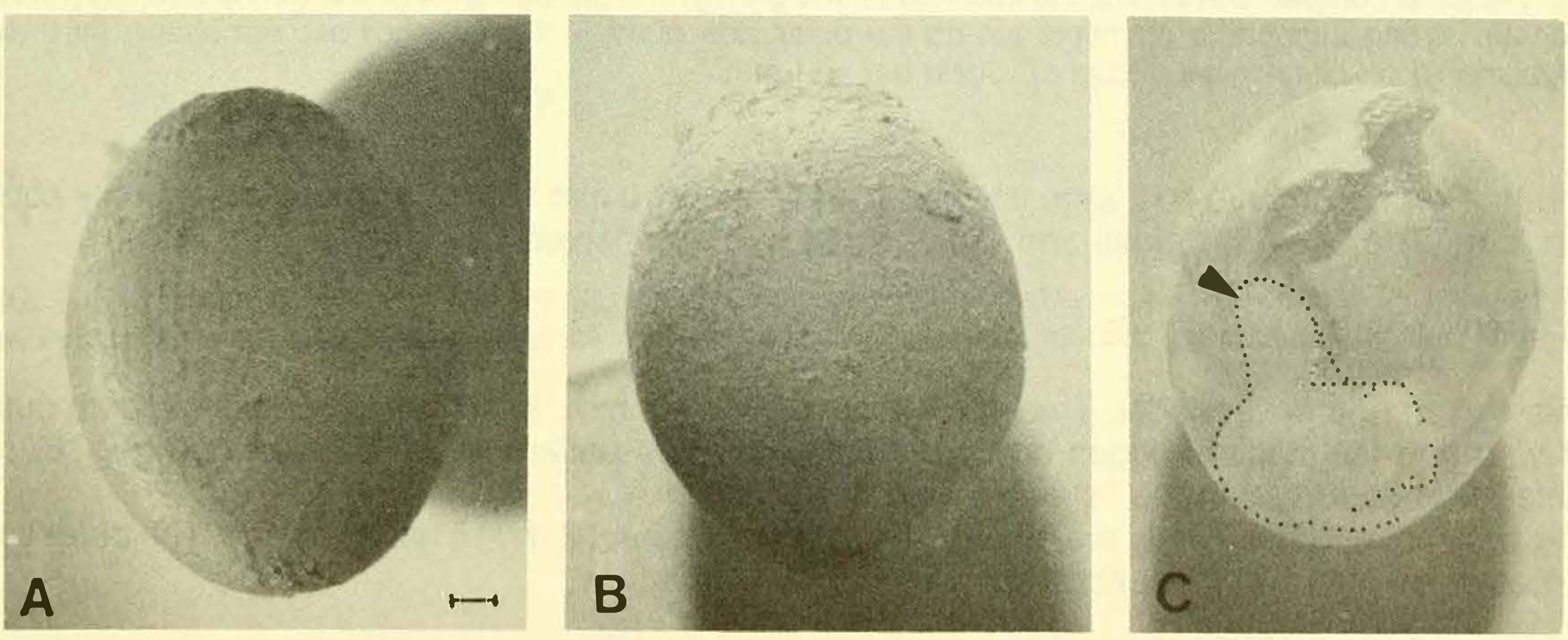

FIG. 3. Specimen B. Photographs A and B show slightly different aspects of the outer shell, with the longitudinal ribs distinguishable only under lateral illumination (A). C shows the egg after removal of the outer case; the chorion is broken on one side. The outline of the embryo is marked by the dotted line; the arrow head points at the left fin (cf. Fig. 4). Scale bar = 1 mm.

Specimen C

This specimen from the area of the Maldive Islands is the largest cirrate egg observed; it has an overall length of 24 mm (ca 11 mm in diameter). The beige coloured shell has an irregular, coarse surface structure without recognizable ridges. There are only very inconspicuous round depressions. This outer shell tightly encloses the chorion, except at one end (possibly due to shrinkage during preservation).

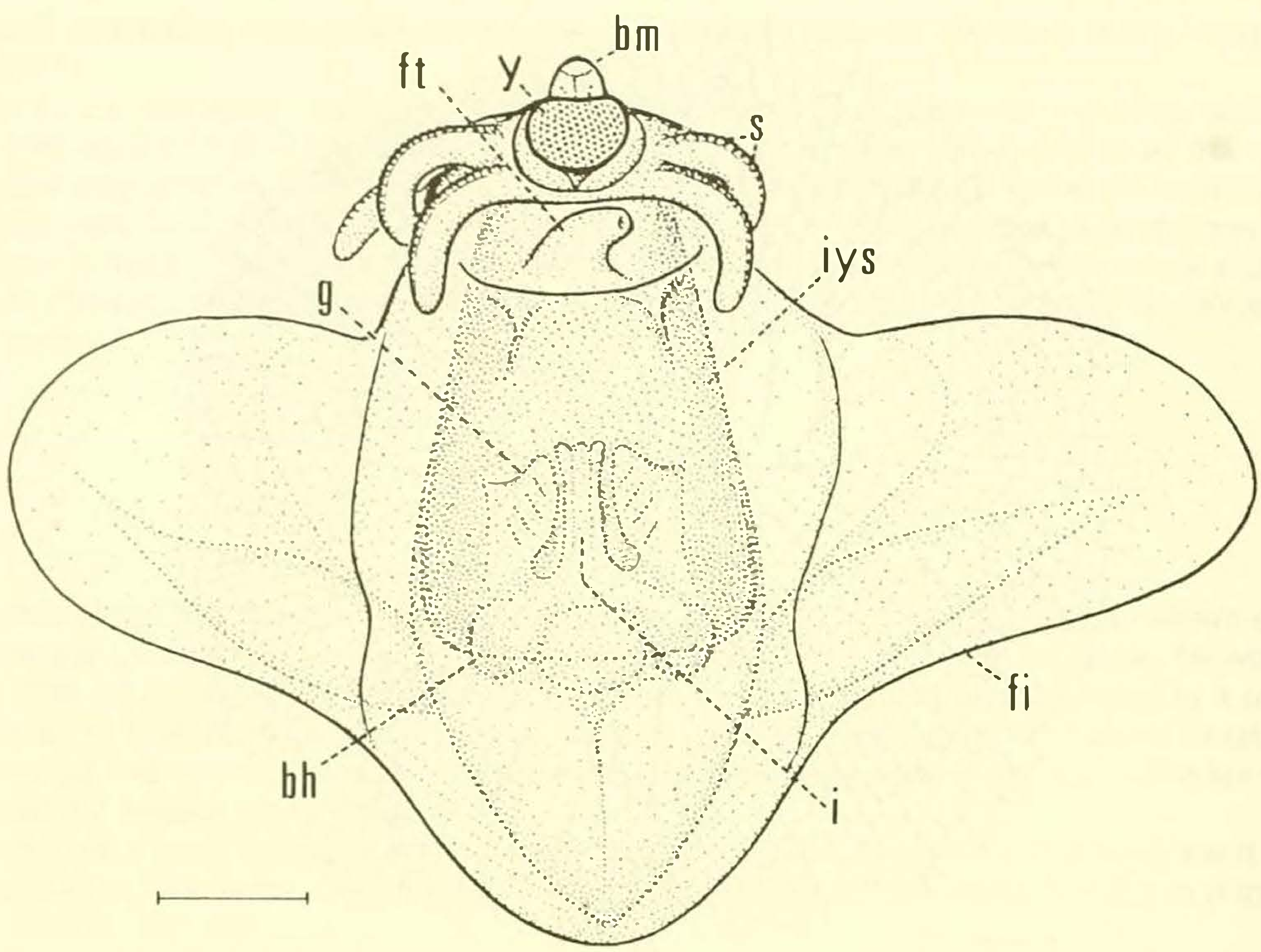

FIG. 4. Detail of embryo in specimen B, in a ventral view. The buccal mass (bm) lies on the connection of outer and inner yolk sac (iys); the outer yolk sac is removed, and the yolk is seen in section (y). Each arm has a single row of sucker (s) rudiments. The funnel tube (ft) is prominent. On the posterior ventral surface of the inner yolk sac, the visceral complex comprising the intestine (i), the gills (g) and the branchial hearts (bh) is distinct. The fins (fi) contain strong supporting elements set on the outer side of the u-shaped shell sac not shown here (but distinguishable on histological sections). Scale bar = 1 mm.

The half-grown embryo has large fins and a body about 10 mm in length. The arms are only about 1 mm long. The eyes are small and are covered by the reflected lateral arms (Fig. 5).

Specimen D

This egg from the Kermadec Trench measures 12.5 × 8 mm. It has a brown, fairly smooth outer shell with fine longitudinal ridges on both ends. The ridge pattern at the broader end (Fig. 6) resembles that observed in the "stem" ridges of specimen A.

The embryo, which is poorly preserved, has a length of about 5 mm; it has large fins. The outer yolk sac measures about 7.5 mm across.

Specimen E

The second specimen from the Kermadec Trench resembles specimen B in egg shell size, colour and structure.

The embryo is already very large, with a dorsal ML of about 9 mm; the arms are about 2.5 mm in length and show the typical cirrate arm structure with blunt ends (Fig. 7).

It is conceivable that this is a later embryonic stage of the species represented by specimen B. It is certainly not the same species as specimen D, because the egg shell is beige in colour and has a rough, "sandy" surface.

Specimen F

This specimen from the area of the Kerguelen Islands differs from all the other specimens in at least two respects. One concerns the size difference between outer shell and chorion. The latter is sur-

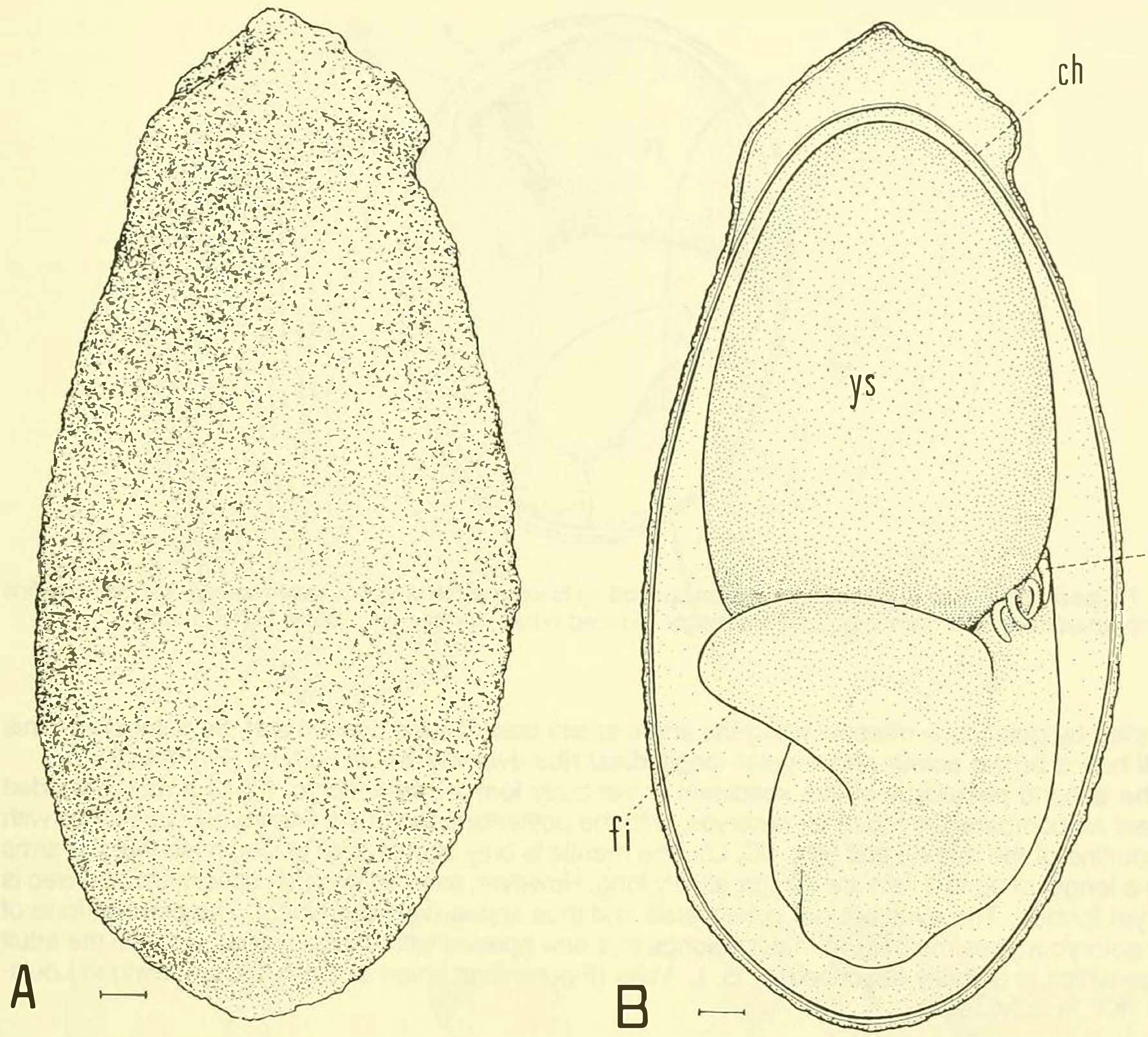

FIG. 5. Specimen C. A: aspect of outer egg case. B: egg case opened up to expose the chorion (ch) containing the embryo with its large fins (fi), very small arms (a) and a large outer yolk sac (ys). Scale bar = 1 mm.

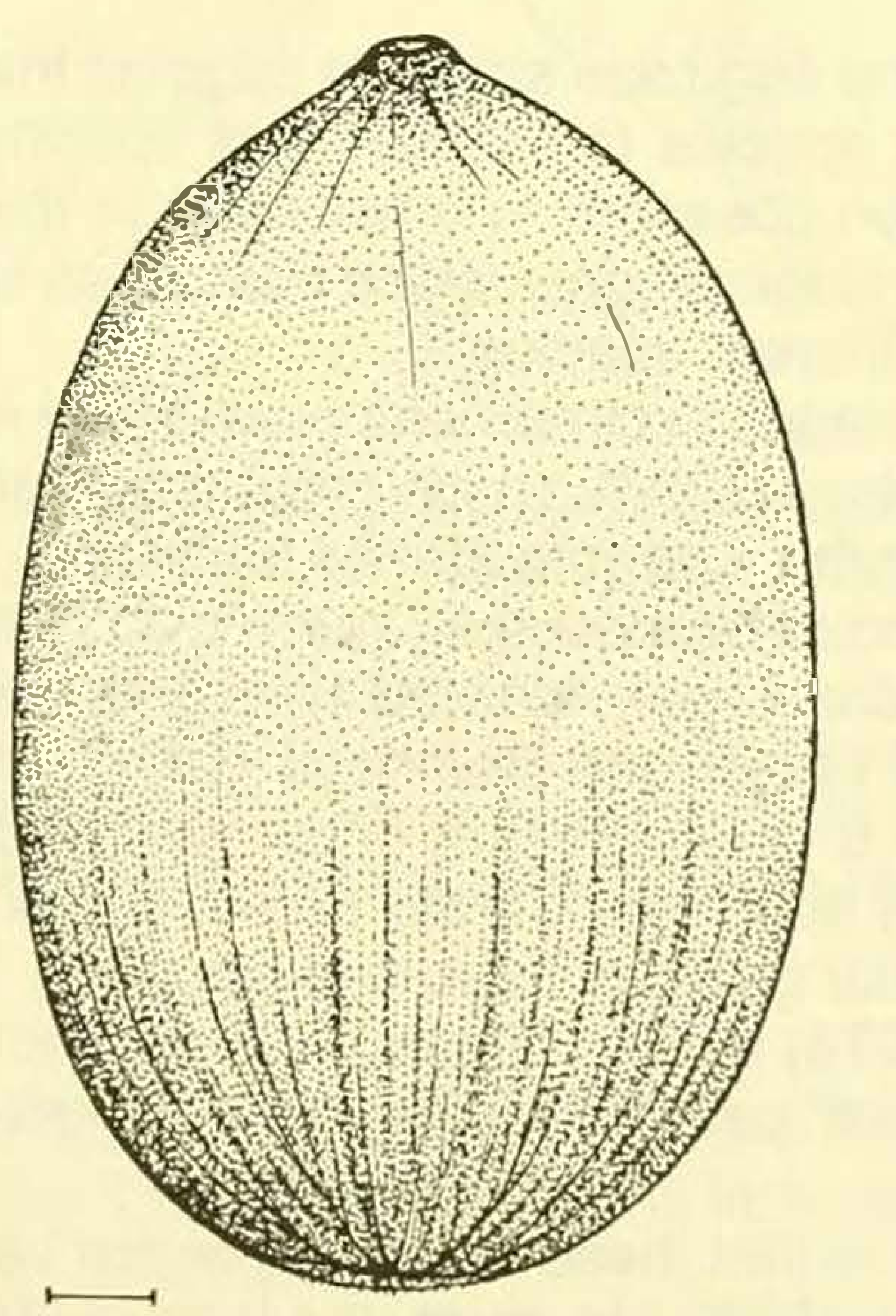

FIG. 6. Specimen D. Aspect of the outer egg case (see text). Scale bar = 1 mm.

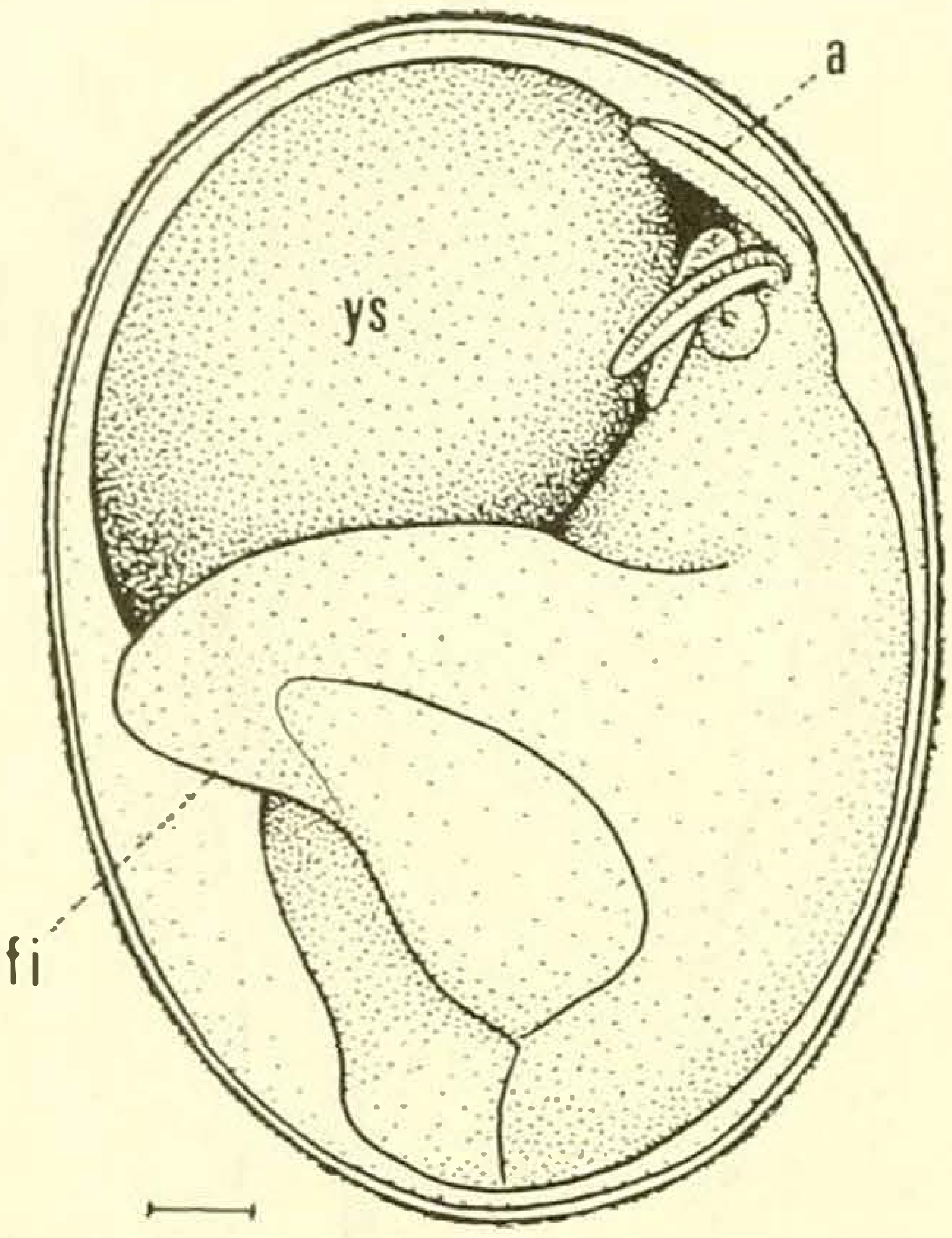

FIG. 7. Specimen E, with egg shell and chorion opened up to expose the fairly advanced embryo with its large fins (fi), comparatively short arms (a) and a strongly reduced outer yolk sac (ys). Scale bar = 1 mm.

rounded by gelatinous material filling the entire space between the chorion and the outer shell. This shell has a brown colour and regular longitudinal ribs over the whole surface (Fig. 8A, B).

The second peculiarity of this specimen is the body form of the embryo. It has a more rounded aspect as compared to the other embryos, with the posterior edge of the fins nearly continuous with the outline of the mantle end (Fig. 8C, D). The mantle is only about 3 mm in length, so that the arms with a length of up to 2 mm are comparatively long. However, as in all the other specimens, the web is not yet formed. The eyes are not yet covered and thus appear very prominent. The peculiar form of this embryo makes me believe that it belongs to a new species with a very similar aspect in the adult stage which is actually described by G. L. Voss (Figures presented at the A.M.U. meeting in Louisville, KY in July 1980).

DISCUSSION

The differences in egg size and egg case structure suggest that the six specimens described here belong to at least five different species (cf. similarity of specimens B and E). Recognizable early embryonic stages have not been observed in other eggs in the collections studied. It is therefore impossible to draw actual embryological conclusions from these specimens, which represent different post-organogenetic stages in different species.

In order to define embryonic stages in cirrate embryos and to relate the staging to known systems, in particular to the staging of Naef (1928), much more material from identified species is needed. Unfortunately there is little hope that spawning in the laboratory will ever be achieved by any cirrate species, so further details will probably become known only from more eggs collected in the field.

The cirromorph octopods were largely ignored by the scientific world until fairly recent times. Observations such as those of Roper and Brundage (1972), the morphological analyses recently published (Young, 1977; Nixon & Dilly, 1977) or under way (Aldred, pers. communication), and the systematic revision of the entire sub-order Cirrata (Voss, presentation at the A.M.U. meeting 1980) draw new attention to this peculiar group of deep-sea octopods. The observations reported here and in an earlier paper (Boletzky, 1978) tend to emphasize their peculiarity in developmental terms also. The cirrate embryos show "typical" cephalopod features, but are recognizable at once as representatives of the finned octopods.

One of the intriguing aspects is that these embryos are not yet "cirrate"; the arm cirri appear only later in juvenile life (cf. Boletzky, 1978). However, the form of the arm rudiments with their invariably rounded ends still differs markedly from the embryonic arms of incirrate octopods. The most striking

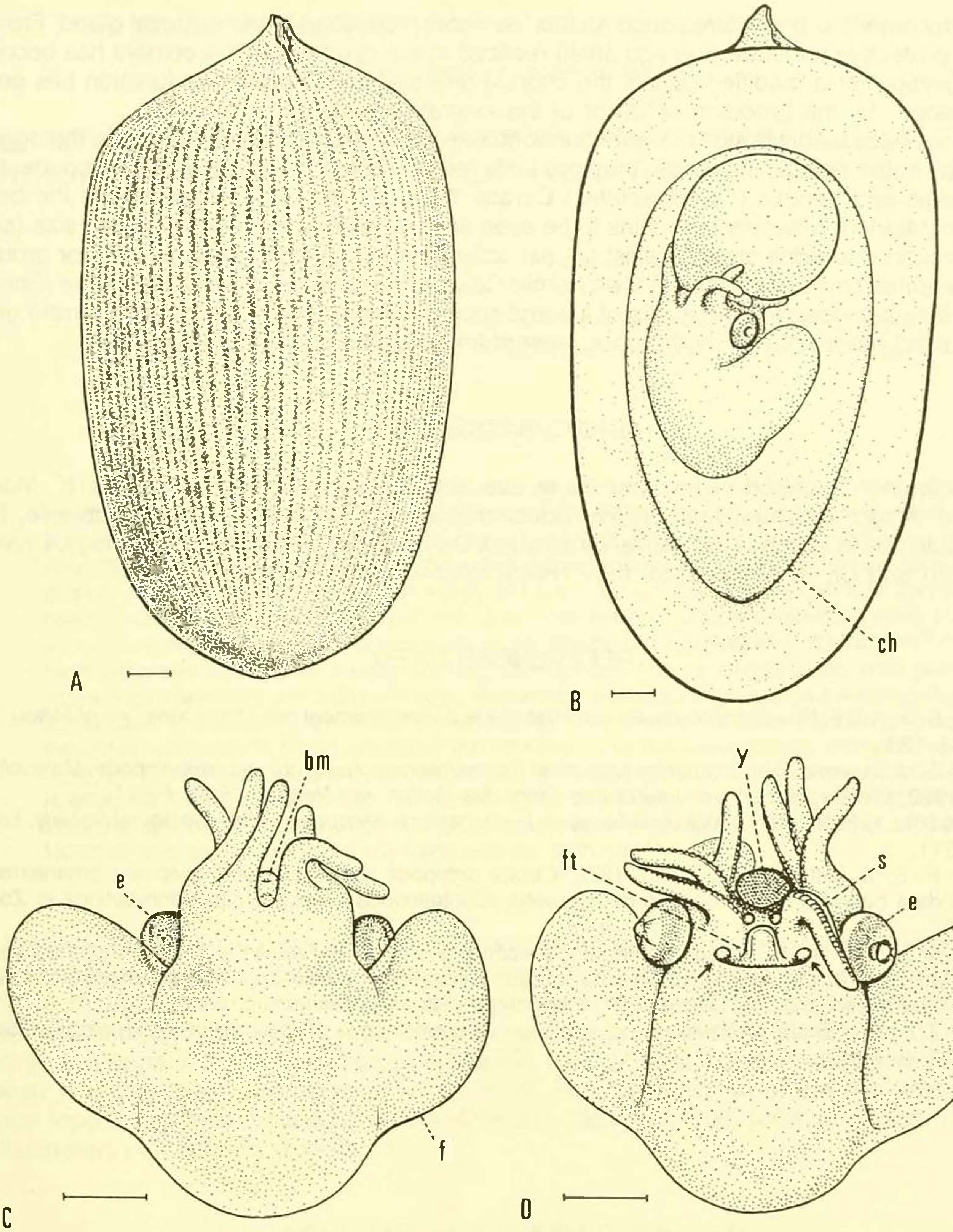

FIG. 8. Specimen F. A: outer aspect of the egg, showing the regular longitudinal ribs of the outer case. B: egg shell opened up to expose the much smaller chorion (ch) surrounded by gelatinous material. The embryo is not tightly enclosed in the chorion; there is a large volume of perivitellinic fluid. C: dorsal view of the embryo (without the outer yolk sac), showing the buccal mass (bm) between the bases of the dorsal arms, the eye balls (e) not yet covered by the corneal skin, and the large fins (fi). D: ventral view of the embryo showing the yolk (y) sectioned, the comparatively long arms with a row of sucker (s) rudiments, the eye balls (e) with the eye lens, the short funnel tube (ft) emerging from the mantle aperture, the lateral ends of which are marked by the olfactory vesicles (arrows). Scale bar = 1 mm.

difference of course is the early differentiation of very large fins in the Cirrata, a condition opposite to the inconspicuous, entirely obliterating fin rudiments in all the incirrate embryos, in which the internal shell is further reduced (cf. Boletzky, in press).

As far as the size and structure of the eggs and their protection are concerned, the differences between Cirrata and Incirrata are very marked, and yet they are variations of a common basic condition, documented by features such as the "cement" production of the oviducal gland. From the essentially protective structure (the egg shell) realized in the cirrate egg, this cement has become a means of fixation for a modified part of the chorion (the stalk). The protective function has entirely been "replaced" by the brooding behavior of the incirrate female parent.

This aspect necessarily draws our attention to the very different egg sizes. Whereas the eggs are always small in the pelagic incirrates, they are fairly large in some benthic incirrate octopods. In the bentho-pelagic and benthic (*Opisthoteuthis*) Cirrata, the eggs are even larger than in the benthic incirrates mentioned. However it remains to be seen whether differences in relative egg size (size of the egg compared to adult size) do exist as distinctive features among cirrate species or groups. If distinct categories could be defined in a way similar to what we observe in the Octopodidae (Boletzky, 1978), questions concerning the mode of life and reproductive tactics in the different cirrate groups could be raised more coherently than our present knowledge would allow us to do.

ACKNOWLEDGMENTS

The specimens described have been made available through the kind help of Dr. K. Mangold (Laboratoire Arago, Banyuls) and Dr. Ph. Bouchet (Muséum National d'Histoire Naturelle, Paris) which I should like to acknowledge here. I also thank Dr. P. Boyle (Department of Zoology, University of Aberdeen) and Dr. K. Mangold for their critical reading of the manuscript.

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