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Spawn and larval development of *Pleuroploca aurantiaca* (Lamarck, 1816) (Gastropoda: Fasciolariidae) from northeast Brazil*

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SUMMARY: Spawn and larval development stages of *Pleuroploca aurantiaca* from northeast Brazil are described. The reproductive period lasted from August to December, with a peak in November. Spawn masses were composed of 29 ± 3 vase-shaped capsules which measured 9 ± 1 mm (n = 30) in length and 4.5 ± 0.5 mm (n = 30) in width. The exit plug was located on the apical area and measured 2.5 ± 0.5 mm (n = 30) in diameter. Each capsule had 353 ± 59 (n = 10) eggs that measured 240 ± 1 μm (n = 15) in diameter. On the tenth day, the intracapsular veliger stage was observed. The intracapsular pediveliger stage was observed on the twenty first day, when the individuals had a functional foot and a reduced velum. Hatching occurred on the thirtieth day, when the early juvenile measured 3 to 5 mm in length and there was no remaining velum. Only 1% of the eggs developed to the hatching stage. The rest were nurse eggs used by embryos as a food resource. *Pleuroploca aurantiaca* has an intracapsular metamorphosis development type.

Keywords: reproduction, development, Mollusca, Fasciolariidae, *Pleuroploca*, *Pleuroploca aurantiaca*.

RESUMEN: PUESTA Y DESARROLLO LARVARIO DE *PLEUROPLOCA AURANTIACA* (LAMARCK, 1816) (GASTROPODA: FASCIOLARIIDAE) DEL NE DE BRASIL. – Se describe la puesta y los estadios de desarrollo larvario de *Pleuroploca aurantiaca* del NE de Brasil. El período reproductivo se extiende desde agosto a diciembre, con un pico en noviembre. Las masas de puesta están formadas por 29 ± 3 cápsulas en forma de vaso de 9 ± 1 mm de longitud (n = 30) y 4.5 ± 0.5 mm (n = 30) de anchura. El orificio de salida está localizado en el área apical y mide 2. 5 ± 0.5 mm (n = 30) de diámetro. Cada cápsula tiene 353 ± 59 (n = 10) huevos de 240 ± 1 ?m (n = 15) de diámetro. El estadio veliger intracapsular fue observado al décimo día. El estadio pediveliger intracapsular fue observado al vigésimo primer día, cuando los individuos ya tienen un pie funcional y un velum reducido. La eclosión tuvo lugar el día 30 y los primeros juveniles midieron entre 3 y 5 mm de longitud. No se observaron restos de velo. Sólo un 1% del total de huevos se desarrollaron hasta el estadio de eclosión. El resto fueron usados por los embriones como fuente de alimento. *P. aurantiaca* presenta un tipo de desarrollo metamórfico intracapsular.

Palabras clave: reproducción, desarrollo, Mollusca, Fasciolariidae, *Pleuroploca, Pleuroploca aurantiaca*.

INTRODUCTION

The gastropod family Fasciolariidae is represented by seven genera in Brazil: *Colubraria* Schumacher, 1817; *Fasciolaria* Lamarck, 1799; *Fusinus* Rafinesque, 1815; *Latirus* Montfort, 1810; *Leucozonia* Gray, 1847; *Metula* H. and A. Adams, 1853 and *Pleuroploca* Fischer, 1884 (Matthews-Cascon *et al*., 1989; Rios, 1994). According to Matthews-Cascon *et al*. (1989), all fasciolariid species are predators that usually prey on other gastropods and bivalves.

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Pleuroploca species generally complete their development within an egg capsule (with no planktonic stage), with the embryo ingesting nurse eggs and hatching as crawling juveniles (D'Asaro, 1970a, 1970b, 1986, 2000; Miloslavich and Penchaszadeh, 1997). *Pleuroploca trapezium* (Linnaeus, 1758) cited by Gohar and Eisawy (1967) as *Fasciolaria audouini*, is the only reported *Pleuroploca* species that hatches as a veliger larva.

Pleuroploca aurantiaca is common in the West Indies and Brazil (Rios, 1994), living upon coral and rocks with calcareous algae in shallow waters (Matthews-Cascon *et al*., 1989). In this work, the spawn mass and larval development of *P. aurantiaca* are described.

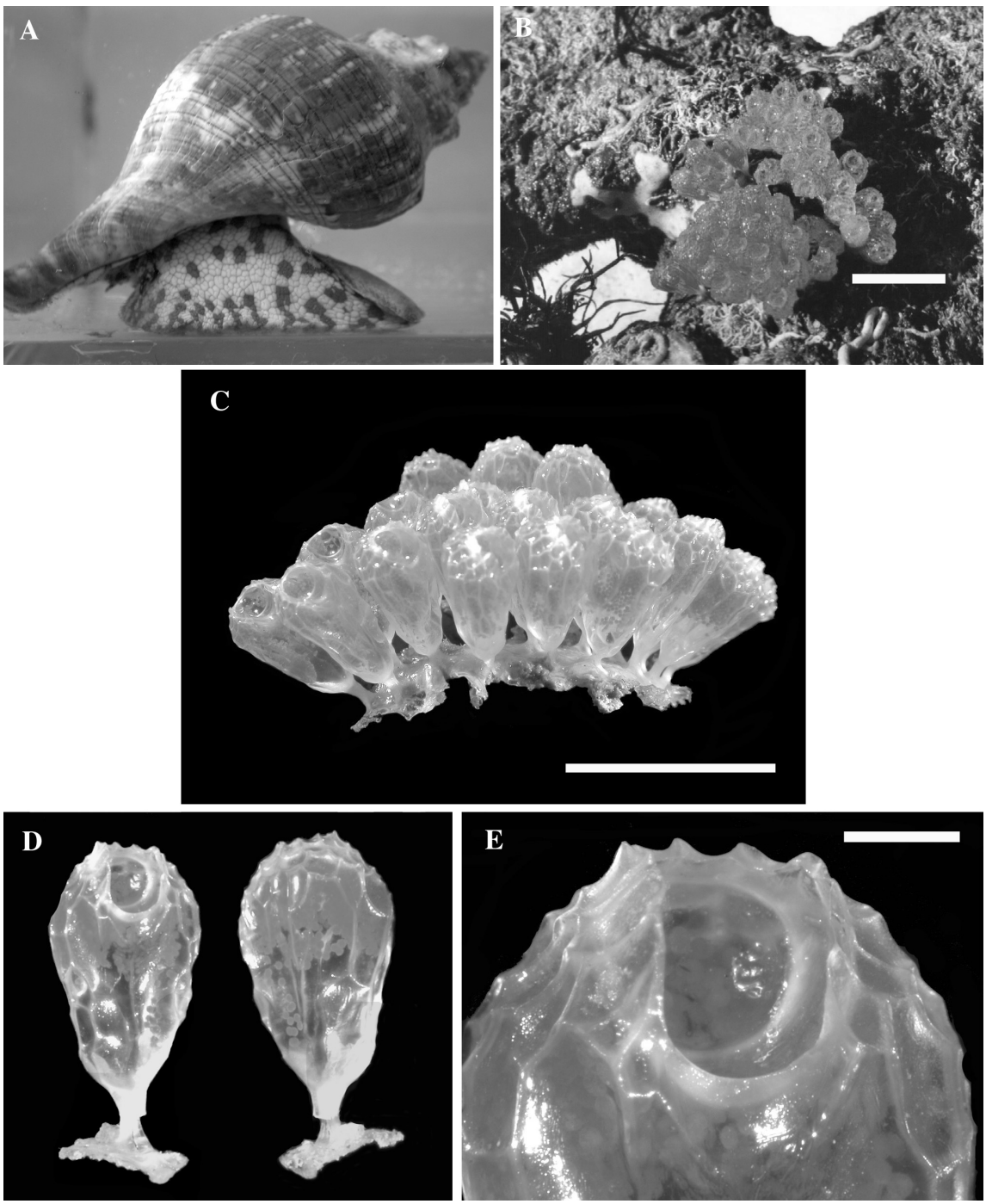

FIG. 1. – *Pleuroploca aurantiaca*: individual and egg mass. A. *Pleuroploca aurantiaca* adult individual (shell length: 75.4 mm). B. Egg mass on beach rock (scale bar: 15 mm). C. Egg mass detail (scale bar: 10 mm). D. Egg capsules, 9 mm in length and 4.5 mm in width. E. Detail of the exit-plug (scale bar: 2 mm).

MATERIAL AND METHODS

Four egg masses of *Pleuroploca aurantiaca* were collected between September 2000 and November 2001 during low tide in the intertidal zone at Pacheco Beach (3º41'S, 38º37'W), located in Caucaia County, Ceará State, northeast Brazil. The material was maintained in an aerated, non-circulating seawater 60-litre tank at 26-28ºC and a salinity of 35 ppt. Another *P. aurantiaca* egg mass was spawned by a female in the laboratory.

Three aspects of the spawns were observed: number and size of egg capsules, number and size of eggs and time of egg development to hatching. Egg capsules were measured with a slide under a stereoscopic microscope. The eggs were measured with an ocular micrometer under an optical microscope. Development from egg to hatching was observed daily with a stereoscopic microscope. The terminology used in the capsule and development description was based on that used by D'Asaro (1970a) and Miloslavich and Penchaszadeh (1997).

The egg capsules were photographed with a camera linked to a stereoscopic microscope and the hatching stage juvenile's shell with a (SEM) PHILLIPS XL30 scanning electron microscope.

RESULTS

The reproductive period of *Pleuroploca aurantiaca* (Fig. 1A) at Pacheco Beach lasted from August to December with a peak in November. This site has a rocky substratum and the egg masses were found under beach rocks (Fig. 1B).

The five studied *Pleuroploca aurantiaca* egg masses were composed of 29 ± 3 vase-shaped capsules (Fig. 1C). Each capsule was linked by a peduncle to a common basal membrane. They measured 9 ± 1 mm (n = 30) in length and 4.5 ± 0.5 mm (n = 30) in width and showed a slightly concave side and a concave apical plate. Strong horizontal lines in the concave lateral side (from the peduncle area to the apical ridge) and strong horizontal and vertical lines in the total area of the convex lateral side (sometimes only from the apical ridge to about half the capsule length) (Fig. 1D). The exit plug (Fig. 1E) had a circular shape, was covered by a transparent concave membrane and was located on the apical area. It measured 2.5 ± 0.5 mm (n = 30) in diameter.

The number of eggs per capsule was 353 ± 59 (n = 10). The eggs were pink and measured 278 ± 11 (n = 15) μm in diameter (Table 1). Only 5 to 7 eggs became embryos in each capsule. The remaining eggs were nurse eggs used by the embryos as a food resource (Fig. 2A). By the sixth day, it was possible to see some changes in the embryos' shape: they had a kidney-like shape with a ciliated mouth. On the tenth day, the intracapsular veliger (Fig. 2B) stage was observed for the first time and it was possible to see it feeding on the nurse eggs. It had a translucent and not calcified shell and transparent and long velar lobes, with two large and thin lobes with small cilia (Fig. 2C).

TABLE 1. – Developmental time of *Pleuroploca aurantiaca*.

Stage	Time of development (day)	Size (μm)
Egg	0	278 ± 11 (n = 15)
Embryo	4-6	786.5 ± 23.5 (n = 20)
Intracapsular Veliger	10	2015.6 ± 231.0 (n = 18)
Intracapsular Pediveliger	20-21	2432.5 ± 155.2 (n = 22)
Prehatching	25	3105.2 ± 112.5 (n = 15)
Hatching	30	3884.5 ± 354.2 (n = 15)

By the twenty first day, the intracapsular pediveliger stage had been registered for the first time, when the individuals had a functional foot and reduced velar lobes. The orange shell had a small anterior siphonal canal. At the prehatching stage, reached by the twenty-fifth day, the foot and shell had a dark orange colour, a well-developed anterior siphonal canal and degenerated velar lobes. Five days later, on the thirtieth day, we observed the hatching stage, when the juvenile detached the exit aperture membrane. It had a well-calcified, light brown and smooth shell, with 1.75 to 2.0 whorls (Fig. 2D, 2E, 2F). The shell measured 3884.5 ± 354.2 (n = 15) μm in length (Table 1). The egg capsules that had 6 or 7 embryos showed hatching juveniles with smaller shells than the ones that had 5 embryos. The foot was dark orange and the operculum light brown and very thin. There was no remaining velar lobe. Only 1% of the eggs developed to the hatching stage (3-5 juveniles). *P. aurantiaca* has an intracapsular metamorphosis development type (Bouchet, 1989). Table 1 shows the duration of the developmental stages and embryo sizes.

DISCUSSION

According to Bouchet (1989), the non-planktotrophic development in mollusks is observed in two different situations: when the larva hatches as a

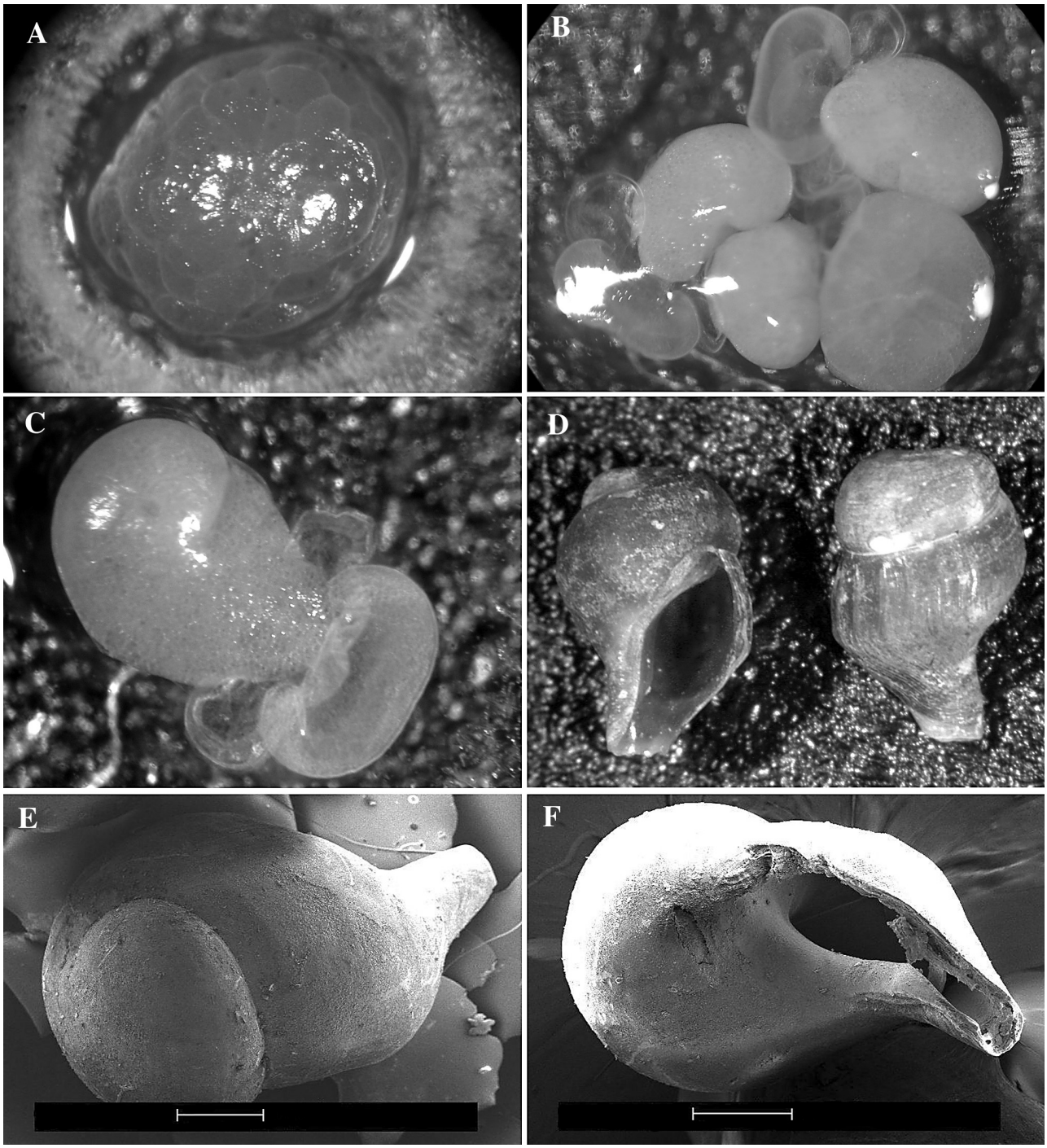

FIG. 2. – Development of *Pleuroploca aurantiaca*. A. Nurse egg (443.4 μm). B. Intracapsular veliger stage (veliger length: 2145.4 μm). C. Detail of an intracapsular veliger, showing the transparent and long velar lobes (veliger length: 2065.6 μm). D. *Pleuroploca aurantiaca* early juvenile shell (length: 3987.5 μm). E. SEM dorsal view of the protoconch (scale bar: 500 μm). F. SEM ventral view of the protoconch (scale bar: 500 μm).

swimming non-feeding veliger and metamorphosis will occur after a few hours to a few days in the plankton (lecithotrophic development), and when metamorphosis occurs before hatching (as we see in *Pleuroploca aurantiaca*), often improperly said to be direct. This terminology is embryologically incorrect (Fioroni, 1982), the term intracapsular metamorphosis being more suitable (Bouchet, 1989).

The egg capsule structure shows some variations within the Fasciolariinae. According to Pilkington (1974), bulliform egg capsules with an escape aper-

TABLE 2. – Enumeration of egg capsules, embryos, dimensions of the capsules and development type of 7 species of *Pleuroploca*. (IM = intracapsular metamorphosis; ND = not determined; NE = nurse eggs; PV = planktotrophic veliger; * = uncertainty).

Species	Capsules in the egg mass	Embryo per capsule	Dimensions of the capsule (mm) Length	Width	Development type	Reference
Pleuroploca aurantiaca	29 ± 3	5-7	9 ± 1	4.5 ± 0.5	IM	Present paper
Pleuroploca filamentosa	1-24	ND	21.9 ± 0.4	6.7 ± 0.6	ND	D'Asaro, 2000
Pleuroploca gigantea	34-140	44 - 61	35.0	18.5	IM	D'Asaro, 1970a
Pleuroploca lignaria	8-33	ND	8-11	5	IM	Barash and Zenziper, 1980
Pleuroploca lugubris	ND	5-7	29.7 ± 8.1	11.0 ± 2.2	IM	D'Asaro, 2000
Pleuroploca salmo	18-54	1900 (NE)	18	13	IM*	D'Asaro, 1970b
Pleuroploca trapezium						
Japan	32	ND	16.2 ± 1.9	6.0 ± 0.5	PV*	D'Asaro, 2000
Sri Lanka	110 - 140	ND	26.6 ± 2	4.8 ± 0.2	PV*	D'Asaro, 2000

ture are known for *Glaphyrina*. *Fasciolaria* and *Pleuroploca* have more or less conical vasiform capsules tapering to a narrow stalk (D'Asaro, 2000). According to D'Asaro (2000), encapsulations produced by *Fasciolaria* spp. from Australia and the western Atlantic have species-specific apical ridges and show a variation in the structure of the escape aperture, but in *Pleuroploca*, he observed conical capsules with simple apical ridges and distinctive horizontal ridges on the sides (or without the horizontal ridges, resembling *Latirus* egg capsules). *Pleuroploca aurantiaca* has a strong suture and associate ridges similar to the ones described by D'Asaro (2000) for *P. gigantea* (Kiener, 1840) and *P. trapezium*, but with more associations between horizontal and vertical lines. Those associations provide a new pattern shape for the egg capsule wall of *Pleuroploca*.

Comparing the egg mass material from *Pleuroploca* species, as we can see in Table 2, *P. gigantea* and *P. trapezium* (from Sri Lanka) have the highest numbers of capsules in the egg mass (34 to 140 and 110 to 140 respectively). *P. aurantiaca* and *P. lugubris* (Reeves, 1847) have the same number of embryos (6 to 7) but the former has the smallest dimensions of the capsule (L = 9.0 ± 1.0 mm and W= 4.5 ± 0.5 mm), like *P. lignaria* (Linnaeus, 1758) (L = 8 - 11 mm and W= 5 mm).

The internal capsule liquid of *P. aurantiaca* is dense, as in *Fasciolaria lilium hunteria* (Perry. 1811) (D´Asaro, 1986) and *Fasciolaria tulipa hollisteri* (Weisbord, 1962) (Penchaszadeh and Paredes, 1996). D´Asaro (1986) regarded this dense liquid as typical of Fasciolariidae and, according to Penchaszadeh and Paredes (1996), it could be relevant for the nourishment of the embryos. Many works on *Fasciolaria*, *Pleuroploca*, *Fusinus* and *Fusus* indicate as a common feature among fasciolariids the high quantity of nurse eggs and the low rate of development of embryos (Amio, 1963; D'Asaro 1970a, 1970b, 1986, 2000; Penchaszadeh and Paredes, 1996 and Miloslavich and Penchaszadeh, 1997), as we could see in the *P. aurantiaca* development.

We observed that embryos of *P. aurantiaca* use one of the adelphophagy mechanisms reported by Fioroni (1967). There is a rotation of the nurse eggs by the embryos with the help of the velum. This rotation, according to Fioroni (1967), detaches some particles from the egg that enter the stomodaeum by ciliary movements. We can see in Figure 2A that nurse eggs are bigger than the normal eggs. According to Fretter and Graham (1962), nurse eggs from some fasciolariids undergo cleavage resulting in a group of cells with haploid nuclei.

As Penchaszadeh and Paredes (1996) indicated for *Fasciolaria tulipa hollisteri*, there seems to exist an inverse relationship between shell size at hatching and the number of embryos per capsule for *Pleuroploca aurantiaca*, i.e. the lower the number of embryos, the larger the shell size of the hatching juvenile. According to the same authors, this could be related to the number of nurse eggs available for ingestion by an embryo.

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