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Embryology and Larval Development of *Haminoea vesicula* Gould (Opisthobranchia: Cephalaspidea)

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Introduction

Large populations of *Haminoea vesicula* Gould, 1855, are common in muddy bays and eel grass beds along the northeastern Pacific coast (MORRIS *et al.*, 1980). However, the development of this species has not been described, with the exception of observations of early cleavage stages (LEONARD, 1918) and synchrony of embryological development within an egg mass (CHAFFEE & STRATHMANN, 1984). The high fecundity of this planktotrophic species suggests that *H. vesicula* veligers potentially constitute a large proportion of the planktonic community within adult-inhabited bays. In this note, we present a brief description of the embryology and larval and juvenile development of *H. vesicula*.

Materials and Methods

Adults and egg masses were collected from Grappler and Bamfield Inlets, Barkley Sound, British Columbia, Canada, periodically from May 1985 to July 1986. Adults were maintained in glass aquaria with a continuous flow of seawater at seawater-table temperatures (12–15°C), and supplied with *Zostera marina* and *Ulva* sp. as food.

Egg masses were collected immediately after oviposition and maintained in Pyrex dishes. Culture water was replaced daily with 1-μm filtered seawater. Flakes of cetyl alcohol were added to each culture one day prior to the onset of hatching to prevent the veliger shells from being caught in the surface tension (HURST, 1967). Hatched veligers were removed daily and cultured as described by KEMPF & WILLOWS (1977), at concentrations of 0.8 veligers/mL. Larvae fed a 1:1 mixture of *Isochrysis galbana* (Tahitian strain) and *Pavlova lutheri* (at concentrations of 10^5 cells/mL) showed the greatest growth and survival rates, although, in the laboratory, veligers would also ingest *Cyclotella cryptica*, *Dunaliella* sp., *Tetraselmis* sp., and *Thallossiosira* sp. Veliger growth was determined according to HURST (1967) in 10 individuals in each of 10 cultures every second day.

Attempts were made to induce metamorphosis in competent veligers. Veligers were identified as being competent when they showed a well-developed propodium, maximum shell growth (length 180 μm, depth 130 μm), behavioral changes such as swimming at the bottom of the culture

Table 1

Summary of developmental events in *Haminoea vesicula* Gould from oviposition to metamorphic competence. Time is listed in hours (h) and days (d; 12–15°C).

Time (h, d)	Developmental event
0 h	—oviposition
10 h	—1st cleavage (holoblastic and equal)
13 h	—2nd cleavage (holoblastic and equal)
23 h	—blastula
26–35 h	—gastrula
3.5 d	—prototroch, embryos irregularly rotating in capsules
4 d	—flat cephalopedal rudiment visible, embryos rotating regularly, invagination of shell gland visible
4.5 d	—shell growth evident, velar and pedal rudiments distinct
5.5 d	—velum bilobed, shell growth over posterior half of yolk mass
6 d	—metachronic beating of cilia; larval shell has grown to base of velum; further shell growth not evident until after hatching
7 d	—yolk decreased, larval gut rudiments visible
8 d	—stomach and intestine visible, digestive glands still yolky, red nephrocyst apparent
8.5 d	—larval retractor muscles functional, intestine connects with mantle cavity
9–12 d	—hatching
	—morphology similar to other planktotrophic veligers, distinguished by bright red larval kidney; newly hatched veligers with a shell length of 123 ± 12 μm (comprising ¾ of a whorl), shell type 1 (THOMPSON, 1961)
	—yolk reserves finished and unicellular algae visible in the stomach 2–3 d post-hatching, veligers actively swimming
17 d	—stomach and left digestive gland enlarged, left digestive gland curved ventrally over the stomach to reach the larval right, shell length 146 ± 12 μm
	—high mortality at 18–21 d (9–12 d post-hatching)
24 d	—nephrocyst darker red in color, metapodium thicker, shell length 156 ± 9 μm
	—veligers actively swimming high in culture dishes
31 d	—anterior metapodium thicker, eyespots visible, nephrocyst darker and eventually turning black, shell length 160 ± 23.4 μm
	—high mortality at 27–33 d (18–24 d post-hatching)
40–45 d	—veligers competent to metamorphose; *i.e.*, with well-developed propodium, and maximum shell size (180 ± 11.25 μm; 1.5 turns in whorl); mantle did not withdraw from shell aperture
	—veligers swimming near bottom of culture dish (THOMPSON'S, 1958, "searching" behavior), velar lobes fully extended

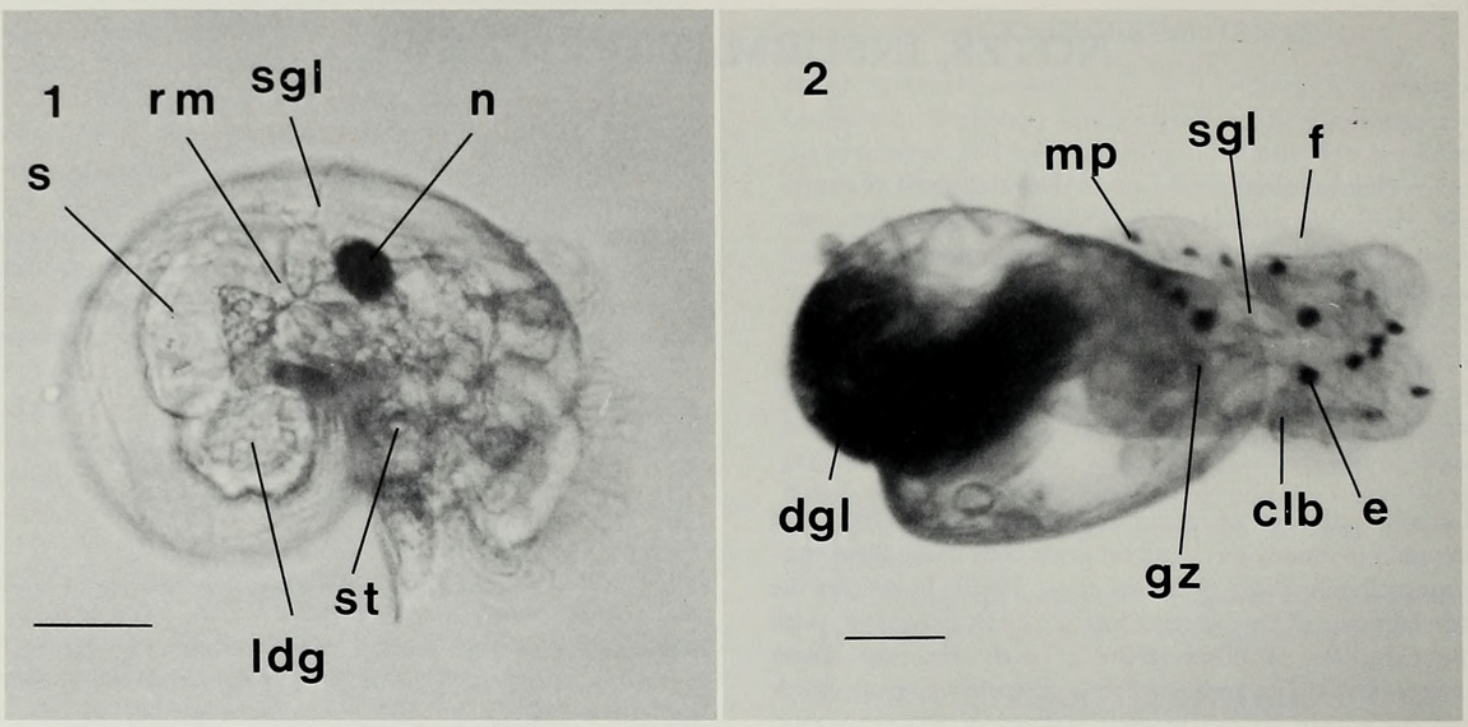

Figure 1

Haminoea vesicula veliger 14 days after hatching. Scale bar = 35 μm. Legend: ldg, left digestive gland; n, nephrocyst; rm, retractor muscle; s, stomach; sgl, shell growth line; st, statocyst.

Figure 2

Haminoea vesicula juvenile approximately 12 days after metamorphosis. Scale bar = 20 μm. Legend: clb, cephalic lobe bud; dgl, digestive gland; e, eye; f, foot; gz, gizzard; mp, mantle pigment; sgl, salivary gland.

dish, etc. These veligers were placed, either individually or in groups of up to 100, in culture chambers containing one or a combination of potentially inducing substrata, all of which were freshly collected from the adult habitat. Substrata used were adult *Haminoea vesicula, Zostera marina, Ulva* sp., surface sediment, and culture dishes with bacterial film. Cultures were maintained at 12–15°C, and were either cleaned and observed daily, or were left undisturbed for 2–5 days. Cultures were maintained until metamorphosis had occurred, or until all veligers had died.

Small juveniles were maintained in 60 × 15-mm Pyrex dishes, then transferred to Tripour beakers with 542-μm mesh vents, both kept at 12–15°C. Juveniles were fed *Zostera marina, Ulva* sp., and bacterial film.

Observations

Ribbonlike egg masses (Hurst's, 1967, type A) were attached in a "C" shape to any solid substratum. A typical mass was 36 × 5 × 1 mm in size (as produced by a 42-mm adult) and contained a mean of 76.50 eggs/mm² egg mass (±33.68, n = 30 egg masses), for a total of 4000 to 60,000 eggs/mass.

The yellow eggs measured 90.00 ± 3.00 μm in diameter (n = 15), and occurred singly per capsule. Development was synchronous within each egg mass (Chaffee & Strathmann, 1984). Veligers began to hatch approximately 9 days after oviposition (12–15°C) with shells approximately 120 μm in length. In the laboratory, veligers remained planktonic for approximately 30 days, during which time they grew to a shell length of approximately 180 μm. The major developmental events from oviposition to metamorphic competence are summarized in Table 1. Figure 1 shows a veliger 14 days after hatching. Note the prominent nephrocyst, larval gut including ventral growth of the left digestive diverticulum, and growth lines in the shell.

We had little success in identifying metamorphosis-inducing substrata for *Haminoea vesicula.* However, metamorphosis occurred in some veligers maintained under the following conditions: competent veligers were placed in 500-mL Pyrex beakers containing a 5-day growth of primary film, *Zostera marina,* and an adult *H. vesicula. Isochrysis galbana* and *Pavlova lutheri* were included as food. Cultures were left undisturbed at ambient temperatures for 4–5 days, then searched for juveniles and remaining veligers. Experiments involving only one or two of the above substrata were unsuccessful. Metamorphosis oc-

curred only when all three substrata were present and the cultures were left undisturbed for several days.

All juveniles that metamorphosed in the laboratory had already begun feeding and growth by the first observation (up to 5 days post-metamorphosis). At this time, the buccal mass, radula, salivary glands, and gizzard plates were visible and functional, and the digestive gland was darkly pigmented. The velar lobes had been resorbed, and the foot flattened to project under the head and posteriorly along the shell aperture. As in other cephalaspideans, post-metamorphic shell growth was heterostrophic and involved centrifugal flaring of the aperture until the elongate shell shape of the adult was achieved. Approximately 12 days after metamorphosis, *Haminoea vesicula* juveniles showed the beginnings of the pallial lobes both anteriorly and posteriorly of the shell, mantle pigment, and the adult orientation of the shell (Figure 2). Two cephalic lobe buds were also present, which fused into one as they grew posteriorly. Juveniles were epiphyte and particle grazers, as were the adults. Juveniles were maintained in the laboratory for 250 days, during which time they grew to a mean length of 9.80 ± 1.63 mm (n = 8).

Conclusion

Haminoea vesicula has a pattern of development typical of that of planktotrophic opisthobranchs (THOMPSON, 1967, 1976), and in particular, is similar to *H. solitaria* Say (HARRIGAN & ALKON, 1978). The nature of the metamorphic inducer(s) is not clear, but it appears that at least a primary film is required as a substratum (as in *H. solitaria*; HARRIGAN & ALKON, 1978) in combination with a period during which the competent veligers are left undisturbed.

Acknowledgments

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Atlantic Records of *Glossodoris sedna* (Gastropoda: Nudibranchia): A Correction

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BERTSCH (1988) documented the first western Atlantic records of the nudibranch *Glossodoris sedna* (Marcus & Marcus, 1967), a species previously known only from the tropical eastern Pacific Ocean. The western Atlantic records were based upon two specimens from Tavernier Key and photographs of specimens from Key Largo and "Biscayne Bay," all locations in south Florida.

I provided the photograph upon which the Biscayne Bay record was based, but that location is incorrect. The specimen of *Glossodoris sedna* in my photograph was one of four specimens that I collected in the northeastern Bahama Islands during 3–9 May 1978. The specimens were found together among gorgonian octocorals and algae on rocks in depths less than 1 m near an islet (26°49′N, 77°20′W) immediately north of Green Turtle Cay, Great Abaco.

BERTSCH (1988:398) found it curious that *Glossodoris sedna* was recorded only from localities within 75 km of each other in south Florida and not from other localities in the Caribbean. The record here corrected to the Bahama Islands (approximately 350 km from south Florida) suggests that *G. sedna* may occur elsewhere in the northern Caribbean region.

The four Bahamian specimens of *Glossodoris sedna* are preserved in alcohol (catalogue number FSBC I 32677) in the Marine Invertebrate Collection of the State of Florida Marine Research Institute at St. Petersburg.

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BERTSCH, H. 1988. Anatomy and zoogeography of *Glossodoris sedna* and *Chromodoris grahami* (Opisthobranchia: Nudibranchia) in the tropical western Atlantic and Caribbean. Veliger 30(4):395–399.

The Anthony D'Attilio Student Research Grant in Malacology

The San Diego Shell Club has announced a one-time single research grant of $1000 through the Anthony D'Attilio Grant.

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The funds are available for the purchase of research materials, usage fees (electron microscope and computer), and travel costs to museums or institutions having resources vital to the research topic.

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