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The Protoconch of Two Scaphopod Species from Japan

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Abstract: Juvenile specimens of two scaphopod species with the protoconch intact were collected from Wakayama Prefecture, Japan. One has a hexagonal cross-section with six longitudinal keels and is identified as *Dentalium octangulatum*; the other is of an unidentified species. *Dentalium octangulatum* differs from other known species in having a smaller protoconch A and an extremely long protoconch B. The protoconch of the unidentified species matches the type 1 protoconch of Dentaliida. The differences in protoconch morphology may reflect those in larval ecology, but this hypothesis should be tested by developmental studies.

Keywords: protoconch, *Dentalium octangulatum*, Dentaliida, Scaphopoda, Japan

Introduction

In contrast to gastropods and bivalves, knowledge of the protoconch is considerably limited in the class Scaphopoda. As reviewed by Steiner (1995: 88), the protoconch morphology of only 20 species had been examined before 1995. Since then, the early teleoconch and protoconch of further four (Steiner, 1995) and three (La Perna, 1997) species have been illustrated (for review, see also Reynolds, 2002: 200–204). In Japan, at least 59 living species of scaphopods are distributed in the Recent fauna (Higo *et al*., 1999: 532–537), but no one has observed their protoconch.

The author collected juvenile examples of two species of scaphopod during the research cruise of the R/V *Tansei-Maru* off Wakayama Prefecture, Japan. In this paper the morphology of their protoconch and early teleoconch is described and compared with that of previously examined species.

Materials and Methods

The material was collected by dredging at station SH-2 of cruise KT-99-17 of the R/V *Tansei-Maru*, off Shirahama, Wakayama Prefecture (33˚40.700´ N, 135˚19.170´ E – 33˚40.629´ N, 135˚19.231´ E) at depths of 41–42 m on November 30, 1999. All specimens were observed with a scanning electron microscope (SEM: Hitachi S-2250N) and registered in The University Museum of The University of Tokyo (UMUT). Terminology used in the descriptions follows Engeser (1993) and Steiner (1995) (see Steiner, 1995: fig. 1).

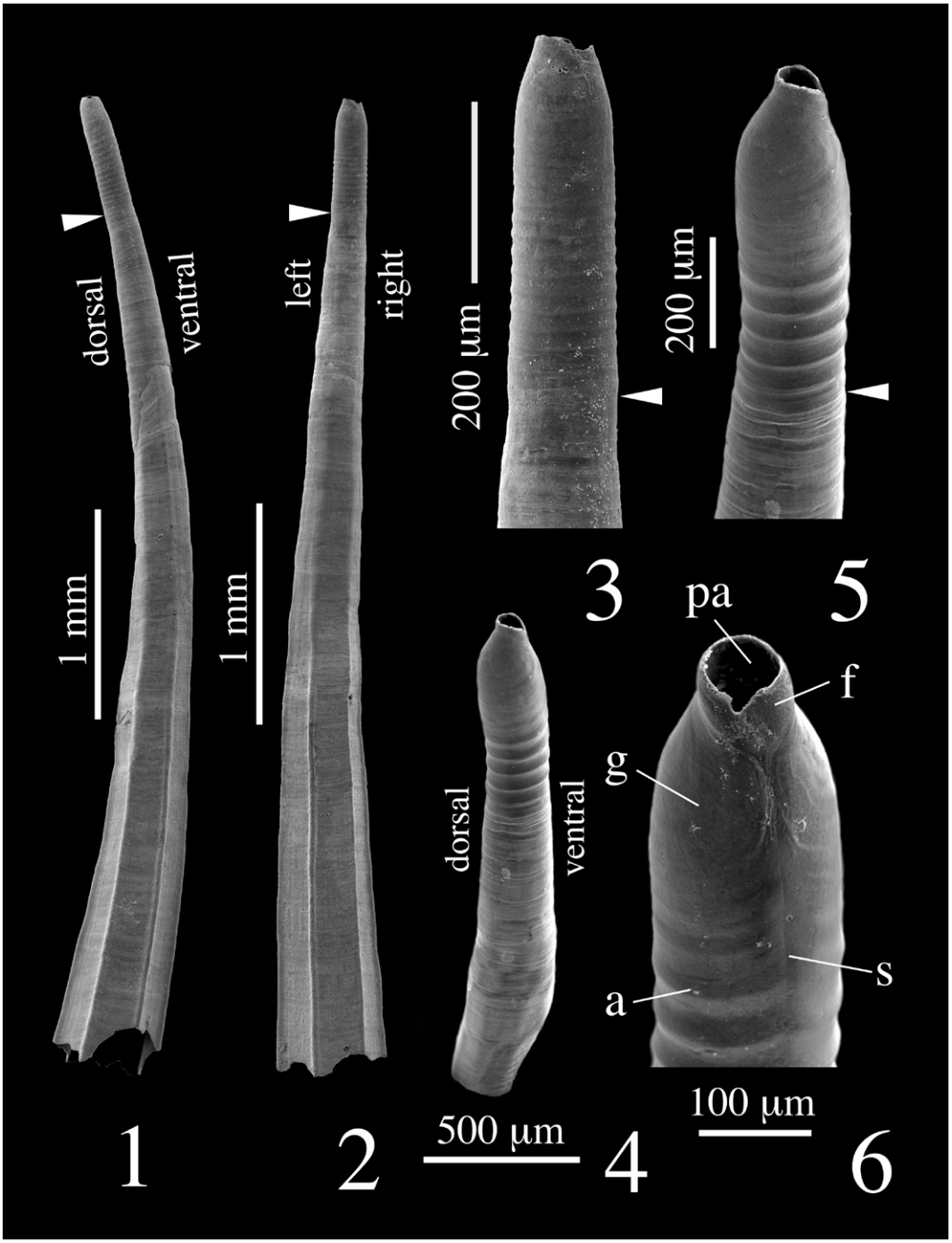
Descriptions

Order Dentaliida
Family Dentaliidae Gray, 1834

Dentalium octangulatum Donovan, 1804

(Figs. 1–3)

Early teleoconch: The early teleoconch is weakly arched dorsoventrally (Fig. 1) and bilaterally



Figs. 1–3. *Dentalium octangulatum*. **1.** Lateral view from left side. **2.** Dorsal view. **3.** Lateral view of protoconch. **4–6.** Unidentified species of Dentaliida. **4.** Lateral view from left side. **5.** Lateral view of protoconch. **6**. Enlarged anterior part of protoconch from ventral side. Abbrevbiations: a, annulation; f, fumarium; g, gena; pa, posterior aperture; s, suture. All arrowheads indicate protoconch-teleoconch boundary. 1: UMUT RM29203; 2–3: UMUT RM29204; 4–6: UMUT RM29205.

symmetrical (Fig. 2). The surface is completely smooth initially. Longitudinal angulations appear after 1.4–1.6 mm in shell length and become prominent keels at 2.3–2.5 mm (Figs. 1-2). The interspaces of the keels are smooth. The cross-sectional form is hexagonal.

Protoconch: The protoconch is straight, 387 μm in length and 123 μm in diameter (Fig. 3). The anterior tip narrows toward the anterior end. The protoconch 1 is small, about 35% of the protoconch length. The surface is sculptured by twelve annulations at nearly constant intervals. The protoconch-teleoconch boundary is defined by the disappearance of annulations.

Remarks: The identification of the specimens as *D. octangulatum* was confirmed by the hexagonal cross sectional form of teleoconch with six prominent keels and smooth interspaces between the keels.

Unidentified species of Dentaliida

(Figs. 4–6)

Early teleoconch: The early teleoconch of 1.5 mm shell length is slightly curved dorsoventrally (Fig. 4). The surface is nearly smooth except for concentric growth lines. The cross-sectional form is circular.

Protoconch: The protoconch is 650 μm in length, 200 μm in diameter, and clearly divided into three regions (Figs. 5–6): posterior tubular extensions (fumarium), a smooth bulbous protoconch A, and an annulated protoconch B (cf. Fig. 7B). The fumarium (Fig. 6: f) is short and attenuated posteriorly with a narrow posterior aperture (Fig. 6: pa). The protoconch A consists mostly of smooth, weakly inflated genae (Fig. 6: g). The ventral and posterior sides of the genae are subtly striated with growth lines which are parallel to the annulations in the protoconch B and fused ventrally with the suture (Fig. 6: s). The protoconch B is made strongly undulate by five annulations that are crossed by the suture anteriorly (Fig. 6).

Remarks: It is not possible to identify this species with confidence. The specimen examined has only the very young stage of the teleoconch and lacks any distinctive conchological characters for identification.

Discussion

The protoconch of the two species examined conforms to the morphology of previously illustrated scaphopod protoconchs (Engeser *et al*., 1993; Steiner, 1995; La Perna, 1997) in the following respects: (1) the protoconch is bilaterally symmetrical, (2) the posterior terminal is attenuated with a tubular fumarium (= posterior extension of protoconch B), (3) a bulbous protoconch A with a smooth surface constitutes the main or posterior part of the protoconch, (4) curved growth lines are fused ventrally to form the suture, and (5) the protoconch is separated from the teleoconch by a sculptural change.

Within the above generalization, three morphotypes have been proposed (Steiner, 1995: fig. 11; Fig. 7).

(1) The type 1 protoconch consists of a smooth bulbous protoconch A and an annulated protoconch B. The lengths of protoconchs A and B are nearly equal, and the number of annulations is about five. This type is limited to the Dentaliida.
(2) The type 2 protoconch is characterized by the absence of annulations on the protoconch B. The protoconch A is similar to that of type 1. This type is known in the Gadilida except for species of *Cadulus*.
(3) The protoconch is missing or assumed to be uncalcified in the gadilomorph genus *Cadulus*.

The protoconch of *Dentalium octangulatum* does not fit any of the above-mentioned types. It is most similar to Steiner's (1995) type 1, but differs in having a relatively smaller protoconch A

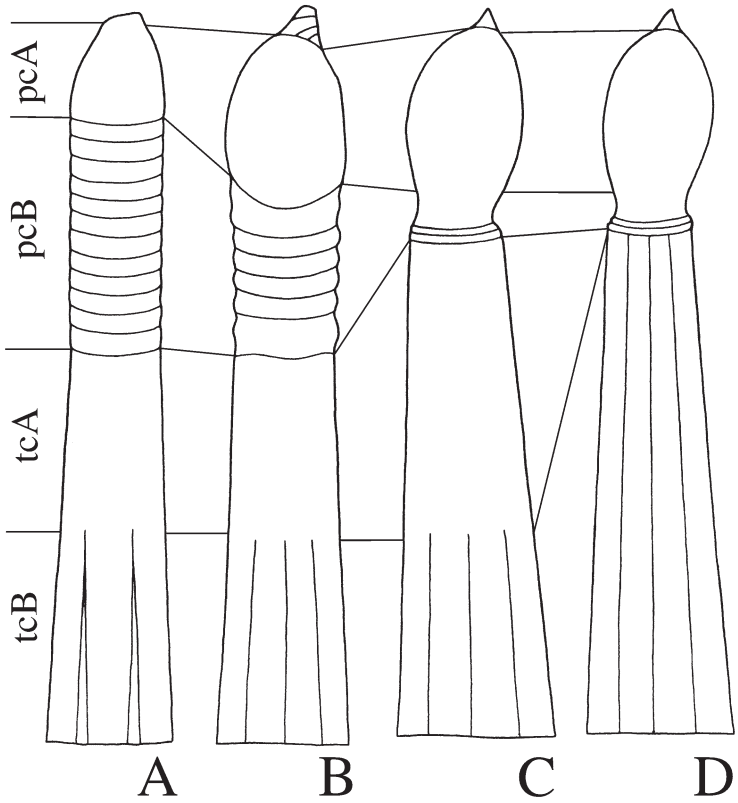


Fig. 7. Schematic illustration of scaphopod protoconchs. **A.** *Dentalium octangulatum*. **B.** Type 1 protoconch of Steiner (1995). **C**–**D.** Type 2 protoconch of Steiner (1995). Abbreviations: pcA, protoconch A; pcB, protoconch B; tcA, teleoconch A; tcB, teleoconch B.

and longer protoconch B. In particular, the number of annulations is greater: twelve in *Dentalium octangulatum* but around five in a typical type 1 protoconch. The protoconch of *Dentalium octangulatum*, however, might be regarded as a modified form of type 1, since the protoconch B with annulations is present anterior to the protoconch A. A similarly elongated form of the protoconch is also illustrated by Engeser *et al*. (1993: 98, fig. 4) as an unidentified dentaliid scaphopod.

The protoconch of the unidentified species (Figs. 4–6) is similar to the typical type 1 protoconch of the Dentaliida. The presence of five annulations in the protoconch B especially confirms it to be a type 1 protoconch. However, the identification of this species is very difficult, as there are few distinctive features in the protoconch or early teleoconch. In addition, there are many possible candidates in a species-rich locality like Wakayama Prefecture. Establishing keys for identification of immature scaphopods is an important subject for the future.

The morphotypes in scaphopod protoconchs may reflect differences in larval ecology, *e.g.* egg size, duration of planktonic life, mode of feeding, *etc.*), as is well known in gastropods and bivalves (*e.g.* Jablonski & Lutz, 1983). One possible hypothesis is that the planktonic larvae of *Dentalium octangulatum* are developed from small eggs and spend a long planktonic life, since it has smaller protoconch A and longer protoconch B than other species. This should be confirmed by actual developmental studies, as attempted in *Antalis entalis* by Wanninger & Haszprunar (2001, 2002).

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日本産掘足類 2 種の原殻

要　約

佐々木猛智

和歌山県田辺沖から掘足類 2 種の原殻付きの幼貝が採集された。1 種は，六角形の断面に強い稜角を持ち，ヤカドツノガイに同定される。別の 1 種は非常に若い個体で，未同定である。これらの種の原殻を過去に報告された掘足類の原殻と比較すると，ヤカドツノガイの原殻は，後方の平滑部分（原殻 A）が小さく，前方の環状彫刻のある部分（原殻 B）が極端に長い点でどの種の原殻とも異なる。一方，未同定種の原殻は Steiner (1995) の type 1 として知られるものに一致する。原殻の形態の違いは，腹足類や二枚貝類と同様に幼生生態の違いを反映することが予想されるが，それは今後発生を観察して確かめる必要がある。