Short Notes

Feeding of *Neomenia yamamotoi* Baba, 1975 (Mollusca: Solenogastres) on a Sea Anemone

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Nearly 240 species have been taxonomically described in the Class Solenogastres. Despite their world-wide geographic distribution and non-negligible body size (up to 30 cm), little is known of the biology of the majority of species.

It is well acknowledged that Solenogastres feed on various groups of Cnidaria, with few exceptions (Salvini-Plawen, 1981, 1985: 78). Their feeding habits have been confirmed chiefly by midgut contents (Salvini-Plawen, 1981: table 2) and also inferred from ecological association. Some vermiform groups (e.g. *Nematomenia*, *Strophomenia* and *Epimenia*) are epizoic, clinging around colonial cnidarians (Salvini-Plawen, 1985: fig. 14). In this case, the Solenogastres use their cnidarian hosts both as food and as substrate. Direct observations of feeding, however, have not been well documented so far. A few direct observations have been recorded only for large epizoic *Epimenia* species (Baba, 1940; Salvini-Plawen & Benayahu, 1990; Scheltema & Jebb, 1994).

During the cruise of R/V *Tansei-maru*, the first author (TS) fortunately collected a live specimen of *Neomenia yamamotoi* Baba, 1975, possibly in its feeding position. In this paper we describe this interesting specimen and record the feeding habit of this species.

Material and Methods

The material was collected in the sea area Enshu-nada along the Pacific coast of middle Honshu, at depths of 763–796 m (R/V *Tansei-maru*, cruise KT-04-6, station KN1(3), from 33° 59.56′ N, 136°55.12′ E to 33°58.95′ N, 136° 55.86′ E) on May 1, 2004, using a 3 m wide Oregon-type beam trawl. It was observed in living condition on the ship and then fixed in 10% formalin. A week after the fixation, the specimen was washed in tap water and transferred into 70% ethanol. Sclerites were extracted from the mantle of the lateral part of the body and observed with a scanning electron microscope (SEM). Both the whole animal (UMUT RM28962) and the sclerites on a SEM stub (UMUT RM28963) are registered in the Department of Historical Geology and Paleontology, The University Museum, The University of Tokyo.

Observations

External morphology: A fresh specimen of *N. yamamotoi* was collected with the head part firmly attached to the upper body wall of a sea anemone (Hormathiidae identified by Dr. K. Yanagi) on a branch-like object (Fig. 1A). Immediately after collection, the animal was transferred into sea water on a plastic tray, but no movement was observed for more than ten minutes. The animal was then fixed in formalin.

The animal is strongly curled in a C-shape (Fig. 1A–C) and stiffened possibly by muscle contraction induced by mechanical shock when being trawled. Its total length is 43.2 mm, and body width is 22.8 mm. The anterior half is noticeably thicker than the posterior half. The pedal groove is apparent along the ventral midline (Fig. 1B). The pedal pit is not discernible between the mouth and the anterior end of the pedal groove. The mantle cavity on the posterior end is tightly closed, and its interior was not observable.

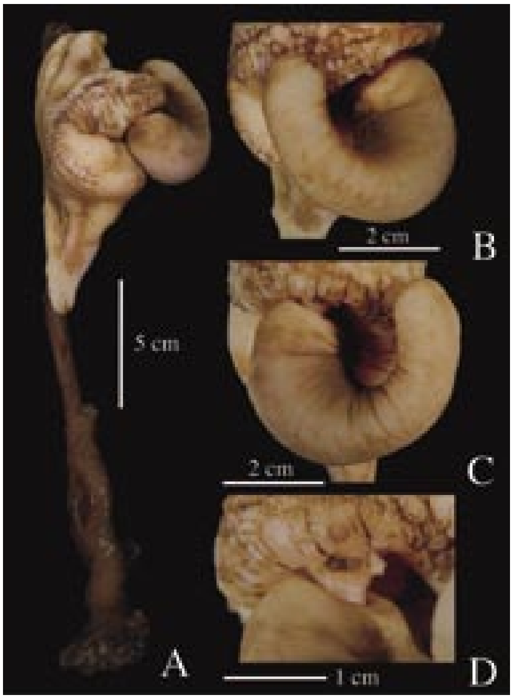

Fig. 1. *Neomenia yamamotoi* attached to a sea anemone. **A.** Whole view of the specimen with the sea anemone. **B.** Left lateral view of *N. yamamotoi*. The pedal groove is visible along the ventral midline. **C.** Right lateral view of *N. yamamotoi*. **D.** Enlarged view of oral region, showing the body wall of the sea anemone sucked into the mouth of *N. yamamotoi*.

The color of the animal was light reddish brown in living condition.

It was not easy to remove the animal from the sea anemone, even in fresh condition. The sea anemone's body wall is sucked into the inside of the mouth of *N. yamamotoi* (Fig. 1D). The part of the anemone wall that is being sucked in is distorted and pulled into a strange form.

Sclerites: The sclerites from the lateral part of the mantle were examined to confirm the identification of the specimen. They are transparent, variable in size, and classified into three types based on their outline, cross-sectional form, and size: (1) Type 1 sclerites (Fig. 2A–B) are thin, elongate, circular in cross section, and slightly asymmetrical in outline. They are basally tapered and distally sharply pointed. (2) Type 2 sclerites (Fig. 2C–F) are grooved with one side concave and the opposite side convex. Their bases and tips are variable: bases are either tapered or as wide as the middle part; tips are symmetrical or asymmetrical. In some sclerites, the groove is present only in the distal half (Fig. 2E). This variety is uncommon but might be regarded as an intermediate between Type 1 and typical form of Type 2. (3) Type 3 sclerites (Fig. 2G) are stout and the shortest among the three types, circular in cross section, and apparently asymmetrical; the base is not tapered, and the tip is gently curved and acutely pointed.

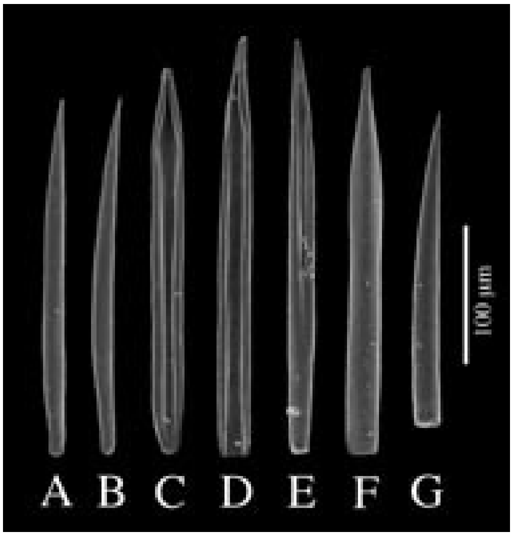

Fig. 2. Sclerites extracted from middle lateral part of the body. **A-B.** Type-1 sclerites. **C-F.** Type-2 sclerites. **G.** Type-3 sclerite.

Discussion

Although the feeding behavior was not observed *in situ*, the specimen was in its feeding position. Our observations revealed that *N. yamamotoi* sucks the tissue of a sea anemone forcefully, probably by the control of the strong sphincter muscles of the foregut. This suctorial mode of feeding is predictable from the anatomical organization in Solenogastres without a radula (Salvini-Plawen, 1985: 78; Scheltema *et al.*, 1994: 38), and partly confirmed in this study. Species of *Neomenia* lack a radula and possess a protrusible foregut, which is controlled by various numbers of sphincter muscles (Salvini-Plawen, 1988; Salvini-Plawen & Paar-Gausch, 2004). Based on the absence of the ventral foregut glands usually present in Solenogastres and the possession of numerous unicellular glands (Salvini-Plawen &

Paar-Gausch, 2004), together with the results of above observations, species of *Neomenia* are inferred to suck the sea anemone's tissue into the pharynx to begin digesting it chemically by enzymatic secretion from the unicellular glands. The digestive function of secretions from the pharyngeal gland cell has been suggested by Todt & Salvini-Plawen (2004).

It is uncertain how the present specimen approached the oral disk of the sea anemone and what posture it took during feeding in undisturbed circumstances. As burrowing using the proboscis is known in *Neomenia carinata* (Wirén, 1892 *fide* Salvini-Plawen, 1985: 78), the present species may live in the muddy substratum around the sea anemone. Considering the body size of the present specimen and the sea anemone, the present specimen could have left the posterior part of its body in the substratum and stretched the anterior body upward to crawl up the body wall of the anemone. In case the sea anemone in natural condition was much higher than the body length of the present specimen, it would have had to crawl up with the whole body, leaving the substratum to reach the upper part of the sea anemone. In this case, the movement might be achieved by muscular and hydrostatic activities, for the ciliary locomotion seen in small-sized Solenogastres (Salvini-Plawen, 1985: 76) is unlikely for the large bulky *Neomenia*. However, we do not eliminate the possibility of ciliary locomotion because Scheltema and Jebb (1994) observed the rather large *Epimenia australis* gliding by ciliary action alone. *E. australis* individuals secrete a sticky mucus in the pedal pit and along the entire pedal groove to use the mucus as a "monorail" along which the foot, remaining within the groove, glides.

Another question is how *N. yamamotoi* copes with the stinging defence of sea anemones. During feeding, ingested nematocysts are kept intact within the gut (Salvini-Plawen, 1972; Salvini-Plawen, 1985: 78). Externally the cuticular layer in the mantle with dense layer of packed upright sclerites may be effective protection (Salvini-Plawen, 1969). Although the members of the suborder Aplotegmentaria, to which *Neomenia* are allocated, have a rather thin cuticular layer, *Neomenia* are known to have a thick layer of "subepidermal matrix" or "ground substance" below a thin cuticular layer and epidermis. The function of the ground substance has not been clearly identified, but we hypothesize that it has a protective function against nematocysts of sea anemones.

The identification of the observed specimen as *N. yamamotoi* is supported by the external morphology of the animal, the size, the locality and the depth of habitat. Because detailed morphology of the epidermal sclerites has not been described in any Japanese species, our observations using SEM cannot corroborate the identification by comparison. A detailed comparative anatomical study is necessary for confirmation of the identification and for further discussion on the taxonomy of Japanese *Neomenia*.

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サンゴノフトヒモ（溝腹綱）による イソギンチャクの捕食

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要　旨

溝腹類は世界中から240種が知られているが，その生態についての情報は乏しい。溝腹類は少数の例外を除いて刺胞動物を食物としていることが知られているが，摂餌の様子が直接観察された例は大型で細長い体をもつカセミミズ属 *Epimenia* のみで，他の多くは消化管内容物に見られる刺胞から判断されたものである。また刺胞動物の種類も宿主であるヒドロ虫類やヤギ類などに絡みついて採集されもの以外は殆ど分かっていない。著者の1人佐々木は淡青丸による遠州灘沖の生物調査において，イソギンチャクに付着した溝腹類を採集した。溝腹類がイソギンチャクを摂餌する様子を直接観察した例はこれまでないと思われるのでここに報告する。

採集された個体はトロール網曳網の刺激によって急激に強く収縮したため，イソギンチャクをくわえたまま引揚げられたと思われる（図1）。採集された種は太短く，体表に中実の針状小棘と，樋状の小棘（図2）をもつことからサンゴノフトヒモ属 *Neomenia* の種であることは間違いなく，体の大きさや採集された位置，深度（水深763～796 m）からおそらくサンゴノフトヒモ *Neomenia yamamotoi* Baba, 1975と同定される。またイソギンチャクは千葉県立中央博物館の柳研介博士に同定を依頼し，クビカザリイソギンチャク科Hormathiidaeの種であることがわかった。

イソギンチャクは海底では上部口盤側は海底から上方に伸びていたと考えられる。したがってサンゴノフトヒモは海底から口盤まで体を起こした状態あるいは這い上がって，摂餌していたと思われる。さらに付着している様子を観察すると，サンゴノフトヒモはイソギンチャクの口盤の縁，触手の密生する部分を吻ではさんでいる。サンゴノフトヒモ属は歯舌や顎板のような食物を切り取る硬い組織を欠いているが,口から突出可能な吻（前腸）をもち，これには種類によって数の異なる複数の括約筋が附属する。また，対になった腹部前腸腺を欠くものの，吻部には多数の単細胞腺が附属する。このようなことから，サンゴノフトヒモ属はSalvini-Plawen（1985）が歯舌を欠く溝腹類の摂餌様式として推測した方法，すなわち餌を消化酵素で溶かしながら吸引する方法によってイソギンチャクを摂餌することが想像される。サンゴノフトヒモ属は外套膜のクチクラ層が薄いがその下にsubepidermal matrix又はground substanceと呼ばれる厚い層をもっている。この組織の性質については知られていないが，今回の観察から，イソギンチャクの触手や槍糸などの刺胞に対する防御機能があることが考えられる。