

## Anterior pallial tentacles of *Solen gordonis* (Bivalvia: Solenidae) from Sasebo Bay, northwestern Kyushu, Japan

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### Abstract

Many species of Solenidae (Bivalvia) have a pair of tentacles, termed as anterior pallial tentacles, on the anterior pallial crest of their mantle. The presence/absence of the tentacles is one of the key characters useful for species identification in this group. The primary objective of this study was to investigate the presence/absence of anterior pallial tentacles in *Solen gordonis*, which had not been reported to date. A total of 143 specimens (4.2–93.2 mm in shell length) of *S. gordonis* collected from Sasebo Bay (northwestern Kyushu, Japan) were examined. The presence of two anterior pallial tentacles was confirmed in 124 specimens. Seventeen specimens lacked one or both of their tentacles. Two specimens had three tentacles, which is the first record of such an intraspecific variation in Solenidae. The occurrence frequency of the three-tentacled clams was estimated to be 2.1% calculated from the results of a set of samples in 2019.

*Key words:* anterior pallial tentacle, intraspecific morphological variation, *Solen gordonis*

The species of family Solenidae, a dominant group of coastal marine bivalve mollusks, are distributed in tropical to temperate coastal waters around the world,<sup>1)</sup> inhabiting from intertidal to subtidal zones with sandy mud to gravelly sand sediments.<sup>2-5)</sup> Solenid razor clams can burrow rapidly and deeply into the sediments,<sup>6, 7)</sup> using their well-developed foot. They are important as prey for various predatory animals in coastal marine food webs [e.g., seabirds,<sup>8)</sup> fishes,<sup>9-11)</sup> crabs,<sup>12)</sup> and gastropods<sup>13)</sup>] and as resources for human consumption in several European, African, and Asian countries.<sup>7, 14-18)</sup> Despite their ecological and economic importance, studies on the biological characteristics of solenid bivalves are scarce in comparison to those of other marine bivalve groups, e.g., venerid and mytilid bivalves.

Many species of Solenidae have a pair of tentacles on the anterior pallial crest of their mantle, which are termed as anterior pallial tentacles.<sup>2, 4, 19-21)</sup> Such a tentacle is unique to this taxonomic group and found first by Morton,<sup>2)</sup> who described the morphological and histological characteristics of the anterior pallial tentacles of *Solen* aff. *exiguus* from Hong Kong in detail. The tentacles can be extended and retracted flexibly and may function as a sense organ to search for predators in the sediments. In fact, some field observations confirmed that razor clams including *Ensis* are often attacked from beneath the surface of the substrate by naticid snails and nemertean worms targeting the foot of the clams.<sup>13, 22, 23)</sup>

From another perspective, recent studies suggest that information about the presence/absence of anterior pallial tentacles is an additionally useful morphological character for the species identification in Solenidae.<sup>4, 21)</sup> For instance, Saedi<sup>21)</sup> compared the presence/absence of the tentacles among 26 *Solen* and 1 *Solena* species and showed that 74% of the species had anterior pallial tentacles and the tentacle presence/absence was not

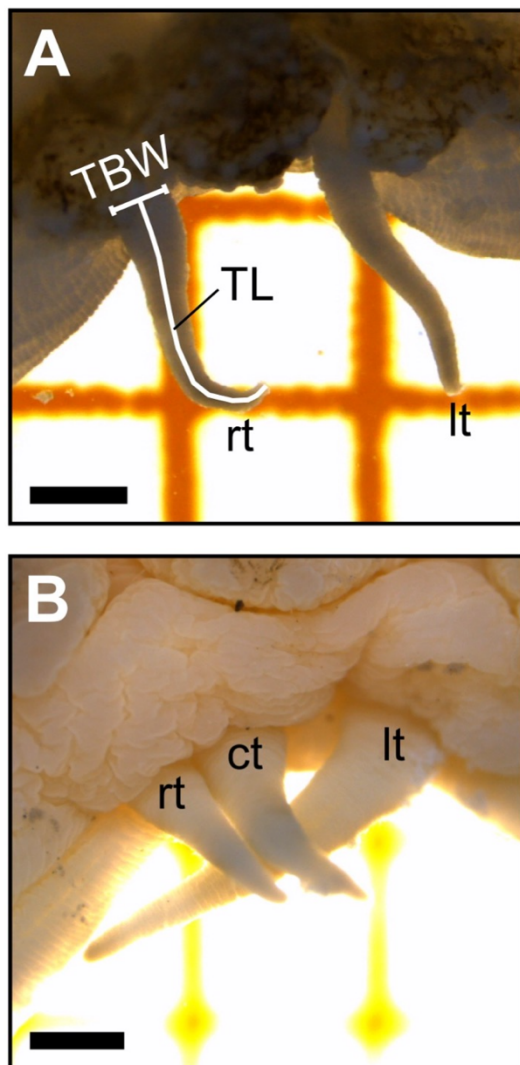
related to habitat type (i.e., substrate and water depth) of the species. Relevance between the presence/absence of anterior pallial tentacles and the phylogenetic relationships in Solenidae is unknown, because of the insufficient data of tentacle presence/absence for solenids.

In this context, the primary objective of this study is to investigate the presence/absence of anterior pallial tentacles in *Solen gordonis* (Yokoyama, 1920), which have never been reported to date, in Sasebo Bay, Japan. In South Korea and Japan, *S. gordonis* is a fishery resource.<sup>7, 14)</sup> The present study area of Sasebo Bay in northwestern Kyushu is the most major fishing ground of the species in Japan, and *S. gordonis* clams occur abundantly in bottoms covered by gravelly sand sediments with plenty of shell fragments.<sup>5)</sup> They can reach a maximum shell length of about 110 mm and become sexually mature at a length of 45 mm in this population (S. Takeuchi unpublished data).

### Materials and Methods

Presence/absence of anterior pallial tentacles was examined for 143 specimens in total. Of them, 47 specimens were collected by SCUBA-equipped divers at a site (33°05'28.3"N, 129°43'25.1"E) in Sasebo Bay on 8 October 2019; and 96 specimens, which were collected by Takeuchi et al.<sup>7)</sup> from the bay during 2014 to 2015 and preserved in 70% ethanol, were used. For each clam, shell length (SL), height (SH), and width (SW) were measured, and the number and size of anterior pallial tentacles were recorded. The SL, SH, and SW of the specimens of SLs  $\geq$  8 mm were measured to the nearest 0.01 mm by use of a digimatic caliper. Shell dimensions of the other specimens were measured through the following three steps: (i) an image of each clam put in a water-filled Petri dish with a scale was taken by use of a

digital camera mounted on the stereomicroscope; (ii) from the image, SL and SH of each clam were measured to the nearest 0.001 mm by use of the software ImageJ (<http://imagej.nih.gov/ij>); and (iii) the measurement value was rounded to two decimal places. After measurement, the soft body part of each clam was dissected from the shell, and the presence/absence of the anterior pallial tentacles was examined microscopically. When the tentacles were present, they were dissected from the soft body part by use of a dissecting needle, under a stereomicroscope (at 20–40× magnification); and for each of them, tentacle length (TL) and tentacle basal width (TBW) were measured using the image measurement method mentioned above (for definition of these dimensions, see Fig. 1A).



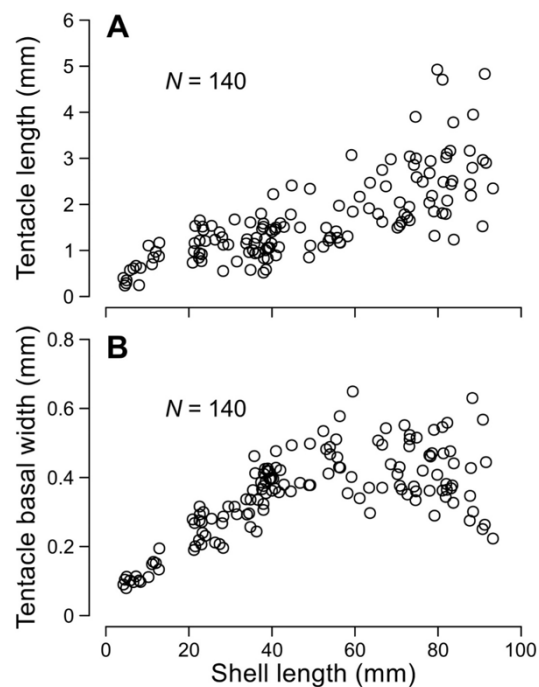
**Fig. 1.** (A) A pair of anterior pallial tentacles (a specimen of 34.8-mm shell length), and the definitions of the measurements for tentacle length (TL) and tentacle basal width (TBW). (B) Case of three-tentacled specimen (a specimen of 67.5-mm shell length). Scale bars: 500 µm. Abbreviations: ct, central tentacle; lt, left tentacle; rt, right tentacle.

## Results and Discussion

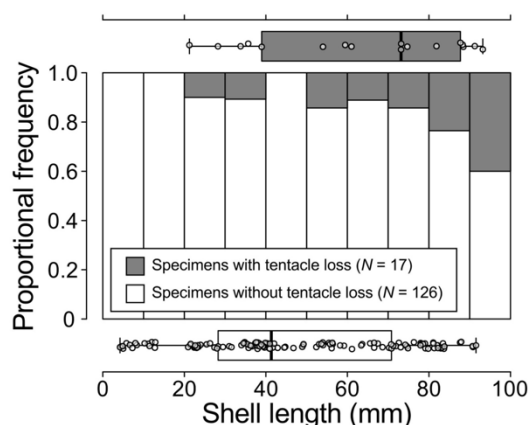
The presence of anterior pallial tentacles was confirmed in most of the specimens examined here. The presence/absence of the tentacles was examined for 143 specimens of *S. gordonis* (4.2–93.2 mm in SL), and 98% of them had at least one tentacle. Ranges of TL and TBW were 0.18–5.07 mm and 0.07–0.65 mm, respectively. Mean (or intact, for one-tentacled specimens) values of TL and TBW for each specimen increased with SL in general (Fig. 2). The growth of TBW, however, seemed to be stopped at 45-mm SL, and this tendency might be associated with their sexual maturity. All the measurements are given in Mendeley Data at <https://data.mendeley.com/datasets/my7tgk5v97/1>.

Some specimens lacked one or both of their tentacles (hereafter, defined as “tentacle loss”). The specimens with tentacle loss were few in the species (i.e., 12% of the specimens). In addition, such specimens appeared to be more frequent in comparatively large-bodied clams than in small-bodied clams (Fig. 3). Median SLs of specimens with and without tentacle loss were 73.2 and 41.3 mm, respectively, and the proportional frequency of specimens with tentacle loss for each 10-mm size class in SL ranged between 0 and 40%. Tentacle loss is assumed to be induced by sediment-loading stress during burrowing similarly as suggested by Alexander and Dietl,<sup>24</sup> and comparatively older clams could undergo such an occasion more frequently than young-aged clams.

This is the first report for the case of three-tentacled clams as an intraspecific variation in Solenidae. The



**Fig. 2.** Relationships between mean (or intact, for one-tentacled specimens) tentacle dimensions [(A) tentacle length; (B) tentacle basal width] and shell length. *N*: number of specimens.



**Fig. 3.** Proportional frequency of specimens with tentacle loss for each 10-mm size class in shell length, and shell-length distributions for the specimens with and without tentacle loss shown as boxplots with individual data points. Each boxplot indicates median (vertical line within a box), 25th and 75th percentiles (left and right sides of a box), and the maximum range (error bars) of shell lengths. *N*: number of specimens.

number of tentacles of each clam without tentacle loss was thought to be two in this family.<sup>2, 4, 19-21</sup>) In the present study, however, two of 143 specimens had three tentacles (Fig. 1B). The SLs of the three-tentacled clams (i.e., 34.5 and 67.5 mm) are within the range of the others, and all of the three-tentacled clams were collected from natural habitats for this species.<sup>5</sup>) The occurrence frequency of the three-tentacled clams was 2.1% calculated from the results of a set of samples in 2019 (i.e., one of 47 specimens had three tentacles). Such a variation in other solenid species has not previously been reported including in the extensive survey by Saeedi et al.<sup>4</sup>) who observed the anterior pallial tentacles of 1,850 specimens of *Solen dactylus* from the northern Persian Gulf, Iran. Veeravaitaya<sup>20</sup>) also did not report any three-tentacled clams in *Solen corneus*, *Solen regularis* (no tentacles), *Solen strictus* [this species identification might be erroneous; for the reasons, detailed in Saeedi et al.<sup>4</sup>], and *Solen thailandicus* from Don Hoi Lot Tidal Flat, Thailand. It remains unclear whether the frequency of 2.1% presented here is high or not in comparison with other species and/or locations, owing to the lack of data for such cases.

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## 佐世保湾産アカマテガイ *Solen gordonis* の前外套触角について

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マテガイ科に属する二枚貝の多くは、外套膜前縁部に通常 2 本の前外套触角と呼ばれる触角を有する。この触角の有無は、本科二枚貝の種同定において有用な分類形質のひとつとされるが、いくつかの種では触角の有無が未記載のままである。アカマテガイ *Solen gordonis* もそのひとつであり、本研究では、佐世保湾より採取された本種の 143 個体（殻長：4.2–93.2 mm）を対象に触角の有無について調べた。その結果、124 個体で 2 本の触角の存在が確認され、17 個体で片方または両方の触角の欠如が確認された。また、2 個体で 3 本の触角の存在が確認された。3 本の触角を有する変異個体の存在は、マテガイ科二枚貝で初めての記録となり、そのような個体の割合は、2019 年のサンプルでの出現頻度から 2.1%と計算された。