Use of crustacean burrows as habitat by the marine snail *Circulus cinguliferus* (Gastropoda: Truncatelloidea: Vitrinellidae)

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Abstract: The family Vitrinellidae is a group of tiny marine snails that generally occur in shallow waters of temperate and tropical seas. The biology of most vitrinellid species remains poorly understood. In this study, we report that *Circulus cinguliferus* (A. Adams, 1850) (Vitrinellidae), distributed widely in the warm shallow waters of the Pacific, inhabit crustacean burrows, including those of the mud shrimp *Neaxius acanthus* (Strahlaxiidae) and snapping shrimp *Alpheus rapax* (Alpheidae), in the intertidal and subtidal flats of the Okinawa Islands, southern Japan. They exhibited highly clumped distribution among the host burrows, suggesting that they are attracted by conspecifics. Although the biology of most *Circulus* species remains unknown, *Circulus texanus* (D. R. Moore, 1965) is known to inhabit stomatopod burrows in the western Atlantic. Our findings suggest that such a commensal habit may be more widespread in this genus than previously thought.

Key words: *Alpheus*, symbiosis, commensalism, sexual size dimorphism, yabby pump
to the east of Okinawa Island (Fig. 1B), on March 10, 2020, and (4) three individuals from a burrow, likely of *Alpheus* sp., in the subtidal soft mud bottom (ca. 6–7 m depth) of Ohura Bay, eastern Okinawa Island (Fig. 1B), on June 13, 2020. The host was collected with the gastropods only at Hamahiga Island, and was released after identification. The exact number of crustacean burrows (mostly those of *N. acanthus* and *A. rapax*) surveyed by the yabby pump was not recorded; however, roughly 20% of the burrows contained *C. cinguliferus* individuals.

All the specimens of *C. cinguliferus* were brought back to the laboratory, except for those collected in Kin Bay, which were released on site after identification. The soft body of eight specimens, including one from Urasoe, four from Hamahiga, and three from Ohura, were withdrawn from the shells for observation after being boiled for 30 s, and then fixed with 10% formalin solution or 99.5% ethanol. We measured the shell diameter and height of all the collected specimens using digital calipers, which were as follows: 5.4×3.0, 5.6×3.0, and 6.2×3.0 mm (Urasoe); 4.9×2.9, 5.1×3.4, 5.3×3.4, 5.5×3.3, and 5.9×3.4 mm (Hamahiga); and 4.3×2.4, 4.5×2.5, and 4.6×2.8 mm (Ohura). These specimens were then deposited in the collections of the Seto Marine Biological Laboratory, Kyoto University.

The living specimens collected from Urasoe, Hamahiga, and Ohura were observed in petri dishes filled with seawater. The head–foot bore a pair of long, blackish cephalic tentacles with immobile terminal bristles and with eyes in a small swellings at the bases (Fig. 2). A snout protruded between the cephalic tentacles (Fig. 2). As reported in other vitrinellids (e.g., Fretter 1956; Bieler & Mikkelsen 1988; Ponder 1994), two pallial tentacles projected from the right side of the mantle edge through the posterior corner of the shell aperture (Fig. 2A): the upper tentacle was whitish with terminal bristles, whereas the lower tentacle was blackish without bristles (Fig. 2A). The foot was elongated and flattened (Fig. 2A). The anterior end of the foot projected laterally (Fig. 2A), whereas the posterior end was slightly indented at the middle and lacked a metapodial tentacle (Fig. 2A). A circular, multispiral operculum was present on the posterodorsal side of the foot (Fig. 2B). The external anatomy of the visceral mass (Fig. 2C, D) was similar to that reported for other vitrinellids in previous studies (e.g., Bieler & Mikkelsen 1988).

Of the eight individuals whose soft body was examined, only the two smallest specimens collected from Ohura (maximum shell diameter: 4.3 and 4.5 mm) possessed a penis, which was large and located posteriorly to the cephalic tentacles and covered by the mantle (Fig. 3). It originated from the slightly right of the dorsal midline and was directed posteriorly (Fig. 3). The testes were orangish in color (Fig. 3A). Larger specimens from Ohura (4.6 mm), Urasoe (6.2 mm), and Hamahiga (4.9, 5.3, 5.9, and 5.5 mm) did not possess a penis, suggesting that females may be larger than males in *C. cinguliferus*. In contrast, males and females appear to be similar in size in *Circulus striatus* (Philippi, 1836) and *Circulus mortoni* Ponder, 1994 (Fretter 1956; Ponder 1994).

Our field collections suggest that *C. cinguliferus* inhabits crustacean burrows, although further ecological studies are required to confirm whether it is an obligate or facultative burrow commensal. Multiple individuals of *C. cinguliferus* were recorded in the same burrow, despite their relatively low occurrence across the burrows (roughly 20%). It is pos-

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Fig. 1. Sampling sites of *Circulus cinguliferus*. (A) Geographic location of Okinawa Island. (B) Okinawa Island.
Circulus cinguliferus from crustacean burrows

Fig. 2. Female Circulus cinguliferus (maximum shell diameter: 5.5 mm) collected from a burrow of Alpheus rapax at Hamahiga Island, Okinawa, Japan. (A) A crawling individual in dorsal view. (B) A living individual in ventral view. (C) Right side of the soft body withdrawn from the shell and not fixed. (D) Left side of the soft body. Abbreviations: cpt, cephalic tentacle; ct, ctenidia; dg, digestive gland; lpf, lateral projection of the anterior end of foot; lpt, lower pallial tentacle; me, mantle edge; op, operculum; ov, ovary; pf, posterior end of foot; sn, snout; um, umbilicus; upt, upper pallial tentacle. Scale bar = 1 mm.

Fig. 3. Male Circulus cinguliferus (maximum shell diameter: 4.5 mm) collected from a burrow, likely of Alpheus sp., in Ohura Bay, eastern Okinawa Island, Japan. (A) Right side of the soft body withdrawn from the shell and not fixed. The mantle was partially dissected to show the penis, which is indicated by an open rectangle. (B) Close up of the penis. Abbreviations: bp, base of penis; dep, distal end of penis; pe, penis; te, testis. Scale bar = 1 mm (A) and 0.5 mm (B).
sible that they were attracted by conspecifics for the purpose of mating. Barnes and Laurie (2018) investigated the spatial patterns of the entire macrobenthic assemblage in the intertidal seagrass beds in subtropical Moreton Bay, Queensland, Australia, by extensive core sampling, and noted that C. cinguliferus were extremely patchily distributed in terms of abundance. Although it is necessary to confirm that C. cinguliferus from Queensland are truly conspecific to those from Okinawa, it is possible that each patch of C. cinguliferus observed by Barnes and Laurie (2018) corresponded to a cluster of individuals inhabiting the same crustacean burrow.

The genus Circulus includes approximately 30 species (WoRMS 2020). Although the biology of most species remains unknown, at least C. texanus (Moore, 1965) is known to inhabit burrows of the stomatopod crustacean Lysiosquilla scabricea (Lamarck, 1818) in Florida (Bieler & Mikkelsen 1988). In addition, C. mortoni is possibly associated with the burrowing holothurian Protankrya bidentata in Hong Kong (Woodward & Barrett, 1858) (Ponder, 1994). Taking our findings into consideration, it is probable that numerous species of Circulus occur as commensals of burrowing invertebrates. In addition to Circulus, some truncatelloidans (mostly tormids) are known to form commensalistic associations with other invertebrates; for example, Cochliolepis parasitica Stimpson, 1858 is an ectocommensal of acocid annelids (Moore 1972); Cyclostremiscus beani (P. Fischer, 1857) inhabits stomatopod burrows (Bieler & Mikkelsen 1988); Sigaretornus planus (A. Adams, 1850) inhabits echinuran burrows (Morton 1988; Ponder 1994); Sigaretornus sp. inhabits stomatopod burrows (Yamashita et al. 2011; Fukuda 2020); Teinostoma sp. inhabits ghost-shrimp burrows (Goto et al. 2014); and Vitrinella oldroydi Bartsch, 1907 is an ectocommensal of chitons (Eernisse et al. 2007). Molecular phylogenetic studies are required to understand their evolutionary relationships and the origin(s) of the commensalistic lifestyles in these groups.

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References

Adams A (1850) Monograph of Cyclostrema, Marrayt, and Separatista, Gray; two genera of gastropodous mollusks. Proc Zool Soc Lond 18: 41–45.

Barnes RSK, Laurie H (2018) Seagrass macrofaunal abundance shows both multifractality and scale-invariant patchiness. Mar Environ Res 138: 76–83.

Bieler R, Mikkelsen PM (1988) Anatomy and reproductive biology of two western Atlantic species of Vitrinellidae, with a case of protandrous hermaphroditism in the Rissoacea. Nautilus 102: 1–29.

Bouchet P, Rocroi JP (2005) Classification and nomenclator of gastropod families. Malacologia 47: 1–397.

Bouchet P, Rocroi JP, Haasdorf B, Kaim A, Kano Y, Nützel A, Parkhaev P, Schrödl M, Strong EE (2017) Revised classification, nomenclator and typification of gastropod and monoplacophoran families. Malacologia 61: 1–526.

Fukuda H (2020) Sigaretornus aff. planus. In: Red Data Book of Oka-

ymarine animals, Volume 2. CRC Press, Taylor & Francis Group, Boca

Raton.

Rubio F, Fernández-Garcés R, Rolán E (2011) The family Torndiae (Gas-

tropoda, Rissooidea) in the Caribbean and neighboring areas. Iberus 29: 1–230.

Rubio F, Rolán E (2018) The genus Pseudolotti Tate, 1898 (Gastropoda, Vitrinellidae) in the Tropical Indo-Pacific. Iberus suppl 7: 1–117.

Sasaki T (2008) Micromolluscs in Japan: taxonomic composition, habi-
tats, and future topics. Zoosymposia 1: 147–232.

Takeo T, Kano Y (2014) Molecular phylogenetic investigations of the relationships of the echinoderm-parasite family Eulimidae within Hypogastropoda (Mollusca). Molecul Phylogenet Evol 79: 258–269.

WoRMS (2020) Genus Circulus. World Register of Marine Species. Available at: http://www.marinespecies.org/aphia.php?p=taxdetails&id=137626 (accessed on 18 June 2020)

Yamashita H, Haga T, Lützen J (2011) The bivalve Divariscintilla toyohiwakensis n. sp. (Heterodonta: Galeommatidae) from Japan, a commensal with a mantis shrimp. Venus 69: 123–133.