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Occurrences of *Amphithalamus* (*Amphithalamus*) *fulcira* (LASERON, 1956) (Mollusca: Gastropoda) in Japanese Waters: The First Record of the Family Anabathronidae from the Northwest Pacific

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Abstract A minute caenogastropod snail, *Amphithalamus* (*Amphithalamus*) *fulcira* (LASERON, 1956) was recorded for the first time from the tropical to temperate regions of Japanese waters. The shell, radula and external morphology of the soft part were described in detail, and the distribution of the species in the Japanese waters was demonstrated. This is the first record of the family Anabathronidae not only from the Japanese waters, but also from the Northwest Pacific.

Introduction

Microgastropods, which are conventionally defined as being less than 2 mm in shell length, in Japanese waters have not been well investigated taxanomically until today, except on some conchologically distinct species found in the beach drifts, because of several reasons. Firstly, there are methodological difficulties in examining microgastropods: *i.e.* the examination of soft part, at least radula, and some recently advanced methods, such as electron micrography, are indispensable to determine generic, or even familial in some case, position of them which usually have simple and rather uniform shell. Secondly, since the Japanese waters can be regarded as parts of the extensive Indo-Pacific faunal region, examination of related species in other parts of the Indo-Pacific is necessary for the identification of Japanese species. Furthermore, presence of numerous ambiguous microgastropod species described in the 19th century by Arthur ADAMS from Japanese and adjacent waters makes the taxonomic studies of these regions very difficult. Consequently, numerous minute gastropod species of various taxonomic groups may have been treated as a whole as unidentified species or juveniles, or even been ignored, in previous faunal and ecological studies.

In this brief report, a caenogastropod snail, *Amphithalamus* (*Amphithalamus*) *fulcira* (LASERON, 1956) of the family Anabathronidae, the family having not been hitherto recognized in Northweat Pacific, is to be introduced for the first time to the Japanese molluscan fauna, although it had been preliminarily reported

as *Amphithalamus* sp. by HASEGAWA (1992), which was subsequently cited by HIGO and GOTO (1994: 691). Since the species has never adequately been described and illustrated, the shell, operculum and external morphology of the soft part are here described in detail, with details of the distribution in the Japanese and adjacent areas.

Material and Methods

The material was obtained by washing various littoral and sublittoral algae from more than 70 localities throughout the Japanese waters by my colleagues, as well as by myself, mentioned in the *material examined.* The algal washing residue was primarily fixed in 10% formalin or 75% ethanol, and sorted in the laboratory. At several localities where marine biological laboratories are accessible nearby, the residue was sorted without fixation in order to examine the external morphology of living animals. The radula was extracted by macerating the soft part in 10% solution of a bleach, Kitchen Highter, Kao Co. Ltd., Japan. The radulae were then rinsed with distilled water, cleaned with ultrasonic cleaner and directly dried on a piece of cover glass. Radulae, shells and opercula were coated with gold and observed with scanning electron microscope (SEM), JEOL JSM-5300 at the Tsukuba Research Center of the National Science Museum, Tokyo. All the material examined in the present study was preserved in 75% ethanol and deposited in the National Science Museum, Tokyo unless otherwise mentioned, although only a part of it has been registered untill today.

Abbreviations. AMS: Australia Museum, Sydney; NSMT: National Science Museum, Tokyo; coll.: collected by.

Taxonomy

Family Anabathronidae PONDER, 1988

Remarks. This group has been reviewed by PONDER (1983), who originally recognized it as a subfamily of Barleeidae GRAY, 1857 but subsequently regarded it as a separate family group (PONDER, 1988). Since the general anatomy of the group has also been described in detail by PONDER (1983, 1988), it is not mentioned further in the present study.

Although this family contains numerous species that are assigned to eight genera in the Southern Hemisphere particularly in Australasia (PONDER, 1983), it has only a few representatives in the genus *Amphithalamus* in the Northern Hemisphere.

Genus *Amphithalamus* CARPENTER, 1864

Amphithalamus CARPENTER, 1864: 656. Type species: *Amphithalamus inclusus* CARPENTER, 1864,

by monotypy. Recent, California.

Subgenus *Amphithalamus* s.s.

Microfossa LASERON, 1950: 267. Type species: *Subanaea* [sic! = *Sabanaea*] *incidata* FRAUENFELD, 1867, by original designation. Recent, southeastern Australia (*fide* PONDER, 1983).

Obescrobs IREDALE, 1955: 81. Type species: *Rissoa jafcksoni* BRAZIER, 1895, by original designation. Recent, southeastern Australia (*fide* PONDER, 1983).

Remarks. This subgenus has one Recent representative each in the west coast of America, Caribbean Sea, South Africa, and Tropical western Pacific, respectively, and one fossil record from Miocene of Europe, although it has more than ten representatives in Australasia (POWELL, 1979; PONDER, 1983).

No members of this genus have hitherto been reported from the Japanese waters, except *Rissoa* (*Amphithalamus*) *edogowensis* [typographical error, = *edogawensis* (*fide* KURODA, 1960)] YOKOYAMA, 1937, which was later transferred to *Stenothyra* BENSON, 1856 in the family Stenothyridae (KURODA & HABE, 1952; KURODA, 1960), and a Pleistocene fossil species, *Amphithalamus*? *tumukiensis* OTUKA, 1935, which can be assigned to *Ceratia* H. & A. ADAMS, 1852 in the family Iravadiidae, judged from the fine figure in the original description.

Amphithalamus (*Amphithalamus*) *fulcira* (LASERON, 1956)

[Japanese name: Ochoboguchi-tsubo]

(Figs. 2–18)

Scrobs fulcira LASERON, 1956: 443–444, figs. 154, 155.

Amphithalamus (*Amphithalamus*) *fulcira*: PONDER, 1983: 252 (name only).

Materials examined. Pacific coast of Central Honshu. Amatsu-Kominato, Awa County, Boso Peninsula, Chiba Prefecture, on *Gelidium* sp., ca. 10 m (SCUBA) (10 exs.), and on *Gelidium* spp., low tide (30 exs.), 20 March 1993, coll. K. HASEGAWA; Banda, Tateyama, Boso Peninsula, Chiba Prefecture, on various algae, intertidal zone, 7 Junuary 1992, coll. S. SEGAWA (5 exs.), on *Laurencia* sp., lower intertidal zone (2 exs.), on *Gelidium* spp. on boulders, lower intertidal zone (9 exs.), on *Corallina pilulifera*, middle-upper tidal zone (5 exs.), and on various algae, intertidal zone (2 exs.), 21–24 May 1993, coll. K. HASEGAWA, on various algae, 0–2 m deep, 4 June 1992, coll. K. HASEGAWA (30 exs.), on coralline algae, intertidal zone (6 exs.), on *Sargassum* spp., intertidal zone (30 exs.), 3 June 1992, coll. T. SASAKI, and Okinoshima, on coralline algae, intertidal zone, 18 April 1991, coll. H. FUKUDA (30 exs.); Amagasaki, Miura Peninsula, Kanagawa Prefecture, on various algae (mainly *Gelidium* spp.), intertidal zone, 25 Augast 1991 (30 exs.), and Kohama, on *Gelidium* spp., in tidal pool in middle-upper intertidal zone, 26 September 1992 (10 exs.), coll. K. HASEGAWA; Jyogashima, Miura Peninsula, Kanagawa Prefecture, on various algae, 30 June

1992, coll. T. SASAKI (10 exs.); Kurosaki, Miura Peninsula, Kanagawa Prefecture, on various algae, intertidal zone, 10 September 1991, coll. K. HASEGAWA (30 exs.: 2 shells, 2 opercula, and 2 radulae examined with SEM, stub no. 001 and 011), on coralline algae on boulders, middle-upper intertidal zone, 25 April 1992, coll. S. HORI (6 exs.); Shibasaki, Miura Peninsula, Kanagawa Prefecture (1 ex.); Manazuru, Kanagawa Prefecture, Mitsuishi, on small red algae (mainly *Gelidium* spp.), low tide (15 exs.), Mitsuishi, on *Corallina pilulifera*, in tidal pool in middel-upper intertidal zone (100 exs.: 5 shells, 2 opercula, and 4 radulae examined with SEM, stub no. 212), Mitsuishi, on various algae, in tidal pool in lower intertidal zone (7 exs.), and Akakabe, on various algae, low tide (23 exs.), 20 March 1992, coll. K. HASEGAWA; Ito, Izu Peninsula, Shizuoka Prefecture, north of Ito City, on various algae (mainly *Sargassum* spp.), middle intertidal zone (30 exs.), and Teishi-jima near Shiofukiiwa, south of Ito City, on red algae (mainly *Gelidium* spp.), lower intertidal zone (30 exs.), 15 May 1992, coll. K. HASEGAWA; Near the Marine Biological Laboratory of the University of Tsukuba, Nabeta, Shimoda, Izu Peninsula, Shizuoka Prefecture, on small algae in draining ditch from experimental seawater pools, 14–15 April 1991, coll. H. FUKUDA (60 exs.), on small algae, draining ditch from experimental seawater pools, 24–25 February 1993 (10 exs.), and sheltered area of Nabeta Bay, on coralline algae, in tidal pool, 24 February 1993 (10 exs.), coll. K. HASEGAWA; Aiai-misaki, east side of Irôzaki, Minamiizu-Town, Izu Peninsula, Shizuoka Prefecture, on *Gelidium* spp., lower intertidal zone (1), and on brown algae, lower intertidal zone (30 exs.), 16 May 1992, coll. K. HASEGAWA; Uchikoshi, Minamiizu-Town, Izu Peninsula, Shizuoka Prefecture, on various algae (mainly *Gelidium* sp.), in tidal pool in middle intertidal zone (10 exs.), on algae (*Sargassum* spp. and *Gelidium* spp.), lower intertidal zone (30 exs.), on various algae (mainly *Sargassum* sp.), upper intertidal zone (10 exs.), and on green and coralline algae on partly burried boulders, intertidal zone (2 exs.), 16 May 1992, coll. K. HASEGAWA; Dôgashima, Nishiizu-Town, Izu Peninsula, Shizuoka Prefecture, Sanshiro-jima, on *Gelidium* spp. on boulders in intertidal zone (30 exs.), Futo-Beach, on *Gelidium* spp. on boulders, lower intertidal zone (30 exs.), on brown algae on boulders, 0–2 m (10 exs.), on coralline algae on boulders, middele intertidal zone (40 exs.), and on *Sargassum* spp. on boulders, middle intertidal zone (20 exs.), 17 May 1992, coll. K. HASEGAWA; Ôsezaki, Izu Peninsula, Shizuoka Prefecture, on coralline algae, 5 m (SCUBA), 3 October 1993, coll. S. Hori (3 exs.).

Izu Islands. Akinohama, Senzu, Izu-Oshima Island, on various short algae, 28 March 1993, coll. H. SAITO (7 exs.); Okata Bay, Okata, Izu-Oshima Island, on algae, 0–2 m deep, 30 July 1991, coll. K. HASEGAWA (30 exs.); Yunohama, Motomachi, Izu-Oshima Island, on various algae, lower intertidal zone, 20 July 1992, coll. K. HASEGAWA (30 exs.); Okataura, Hachijo Island, on red algae, low

tide (1 ex.), and on *Sargassum* sp., in large tidal pool in lower intertidal zone (46 exs.), 18 April 1992, coll. K. HASEGAWA.

Pacific coast of southern Honshu. Shirahama-Town, Nishimuro County, Kii Peninsula, Wakayama Prefecture, on various algae, low tide, 25 February 1993 (10 exs.), and near the Seto Marine Biological Laboratory of Kyoto University, on coralline algae, intertidal zone, 26 February 1993 (8 exs.), coll. H. SAITO.

Sea of Japan. Yumegahama, Tsuno-shima Island, Toyoura County, Yamaguchi Prefecture, on various algae (mainly *Gelidium* sp.), intertidal zone, 4 May 1992 (2 exs.), and on *Gelidium* spp. in lower intertidal zone and coralline algae in upper intertidal zone, 4 May 1993 (10 exs.), coll. S. HORI.

Kyushu. Mogushi, Ushibuka, Kumamoto Prefecture, on various algae, middle-upper intertidal zone (3 exs.), and on various algae, lower intertidal zone (30 exs.), and on coralline algae, lower intertidal zone (10 exs.), 27 March 1994, coll. K. HASEGAWA; Tsuji-jima Island, Reihoku-Town, Amakusa, Kumamoto Prefecture, on various algae (mainly *Sargassum thunbergii*), middle intertidal zone (50 exs.), and on *Gelidium amansii*, near low tide (10 exs.), 28 March 1994, coll. K. and C. HASEGAWA, and on red algae, 5 m (SCUBA) (10 exs.), on coralline algae, 5 m (SCUBA) (10 exs.), 28 March 1994, coll. K. HASEGAWA; Tomioka, Reihoku-Town, Amakusa, Kumamoto Prefecture, Magarisaki, on coralline algae, low tide (10 exs.), Magarisaki, on red algae, low tide (2 exs.), 29 March 1994, Shikizaki-misaki, on red algae, low tide, 30 March 1994 (20 exs.), coll. K. and C. HASEGAWA; Kumanoe, Nobeoka City, Miyazaki Prefecture, on coralline algae, tidal pool in middle intertidal zone (2), and on *Gelidium* spp., tidal pool in middle intertidal zone (1 ex.: empty shell), 10 March 1994, coll. H. NAMIKAWA.

Nansei Islands. Nagakubo, Yaku Island, Osumi Islands on coralline algae on boulders, 5 May 1992, coll. T. SASAKI (4 exs.); Yo, Amami-Oshima Island, Amami Islands, on sponge-like algae, in tidal pool in upper intertidal zone (6 exs.), and on vaious algae, 15 m (SCUBA) (1 ex.), 30 July 1992, on spongy algae on fine sandy bottom within reef, 31 July 1992 (1 ex.: empty shell), coll. K. HASEGAWA; Bise, Motobu-Town, Okinawa Island, Okinawa Island, under stones, 2–3 m deep within reef, 3 August 1993, coll. K. HASEGAWA (1 ex.: empty shell); Sunayama Beach, Miyako Island, Sakishima Islands, on coralline algae (7 exs.), and on *Sargassum* sp. (30 exs.), 21 May 1993, coll. H. SAITO; Shigira Beach, Miyako Island, Sakishima Islands, under stones, 23 May 1993, coll. H. SAITO (50 exs.: 5 shells, 2 opercula, and 4 radulae examined with SEM, stub no. 203 and 210); Kabira, Ishigaki Island, Sakishima Islands, on various algae, 1.5 m deep, 30 September 1992, coll. T. IZUKA (1 ex.).

Description. Shell (Figs. 6–13): The shell is minute, ovate-conic, yellowish brown to dark brown in color, with well-developed pit between the inner lip and

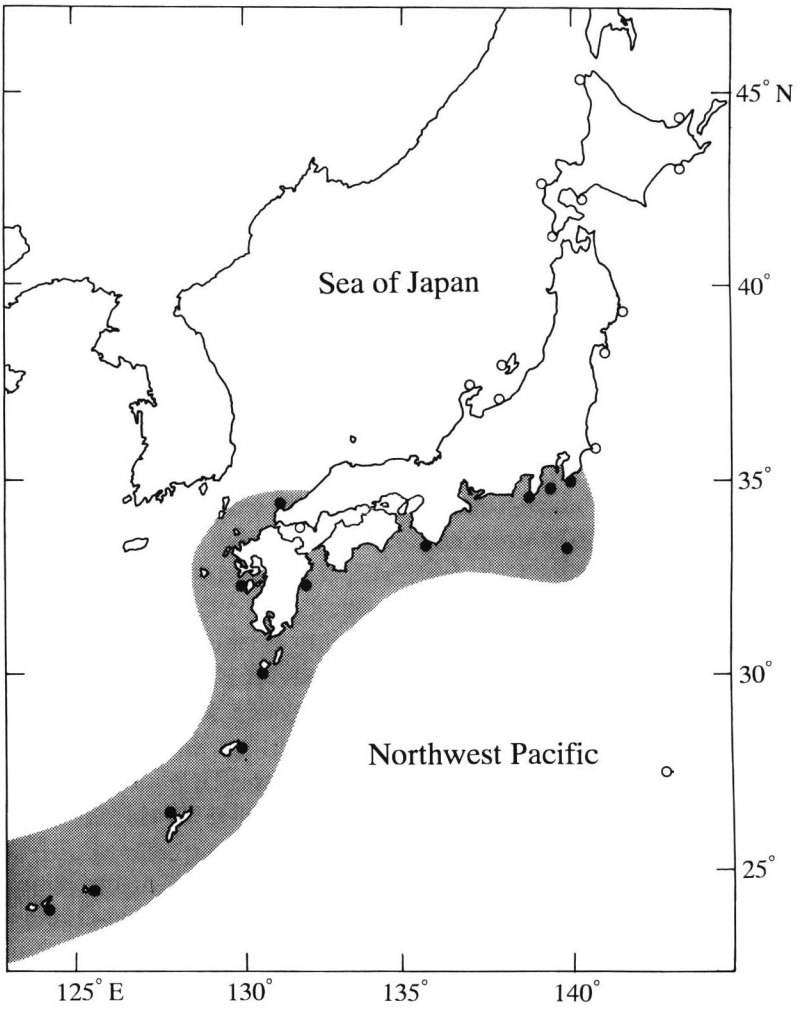
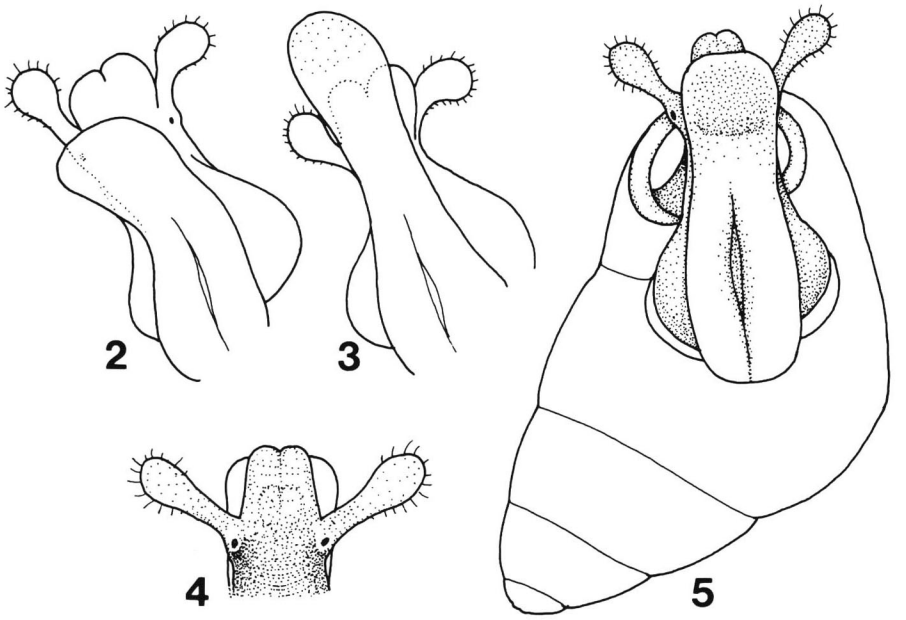


Fig. 1. Distribution of *Amphithalamus* (*A.*) *fulcira* (LASERON) in the Japanese waters. Solid circle: present in the algal washing sample. Open circle: absent in the algal washing sample. Shaded area represents possible distribution of this species.

the parietal wall. The protoconch is dome-shaped with about 1.5 whorls, and clearly demarcated from the teleoconch. There are numerous small pits arranged in about 13 spiral lines on the protoconch. The teleoconch has about 2.3–2.5 rather flattened whorls, with weakly impressed suture, and is generally smooth except very weak and indistinct spiral sculptures and irregular growth lines. The body whorl is large, with a rather distinct angulation at the periphery, which sometimes becomes a strong peripheral cord (Fig. 9). The base of the body whorl carries two to three basal cords, and this portion is paler in color than the rest of

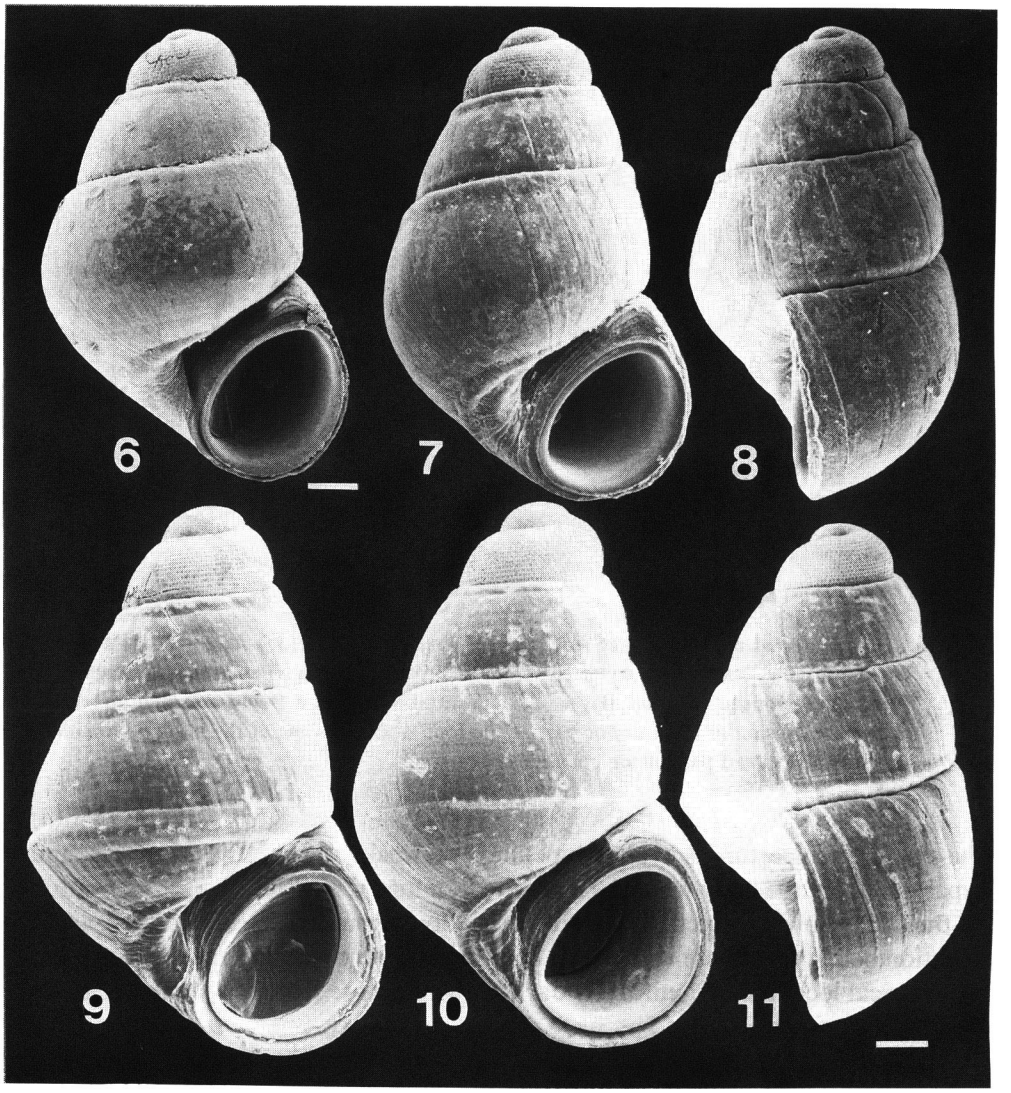


Figs. 2–5. External morphology of soft parts of *Amphithalamus* (*A.*) *fulcira* (LASERON), based on the specimens collected from Kurosaki, Miura Peninsula, Kanagawa Prefecture, Honshu (Sagami Bay). 2, 3, Ventral views of a freely crawling animal, showing extension of the anterior part of the foot; 4, dorsal view of the head; 5, ventral view of the exposed part of the body.

the shell. The aperture is oval, orthocline with weakly duplicated peristome, and separated from the body whorl by a groove terminated by a callus. The coloration of the shell shows distinct intraspecific variations from light yellow with a white striation below the suture and brown spot behind the outer lip in specimens from the tropical localities, to uniformly dark brown in those from temperate localities in Japanese waters.

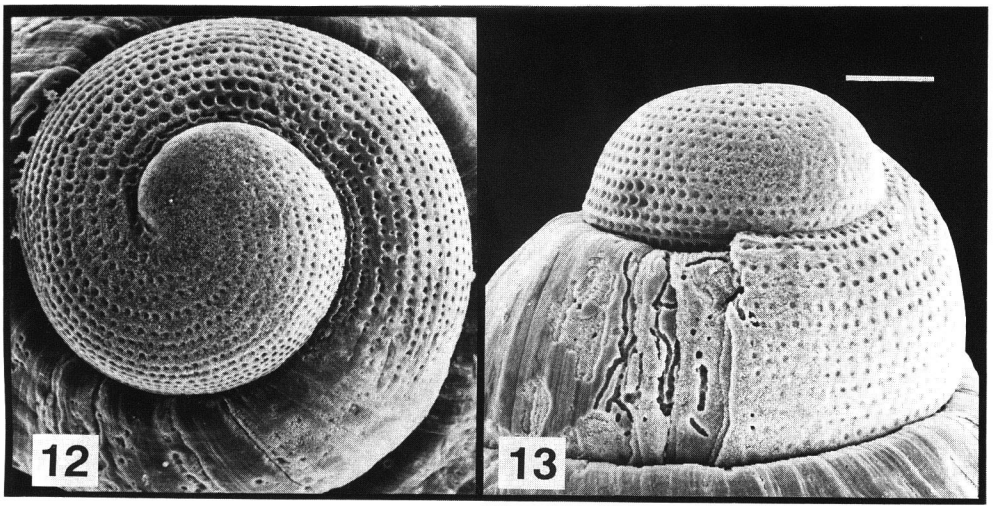
Operculum (Figs. 17–18): The operculum is light yellow in color, elongated oval, rather thick for the size, and distinctly double layered, the inner layer being slightly smaller than the outer one. It possesses a raised lamella on the columellar side on the inner surface, and this portion is usually opaque and white. Neither peg nor ridge is present.

Radula (Figs. 14–16): The radula is taenioglossate. The central tooth is rectangular, and more than twice as wide as high. The cutting edge has five cusps. The central cusp is the largest, with tongue-like blunt tip, the shape and width of which is slightly variable among and between populations. Two pairs of flanking cusps are small and rather sharply pointed, the inner ones being larger than the outer ones. The lateral margins of the tooth are narrowly thickened. A pair of



Figs. 6–11. Shells of *Amphithalamus* (*A.*) *fulcira* (LASERON). 6, Topotype, AMS C. 300048, Liodeman Island, Central Queensland, Australia; 7, 8, Shigira Beach, Miyako-Jima Island, Ryukyu Islands, NSMT-Mo 70326; 9–11, Manazuru, Kanagawa Prefecture, Honshu (Sagami Bay), NSMT-Mo 70327. Scale bar for 6=100 μm; 7–11=100 μm.

short, hook-like basal cusps are present on the base, with broad, tongue-like projection in the center. The lateral teeth are angular in shape, with a formula of 2+1+3–4. The inner and outer marginal teeth have hook-like apices with slender and straight stalk. The inner marginal teeth has 8–9 blunt cusps, whereas the

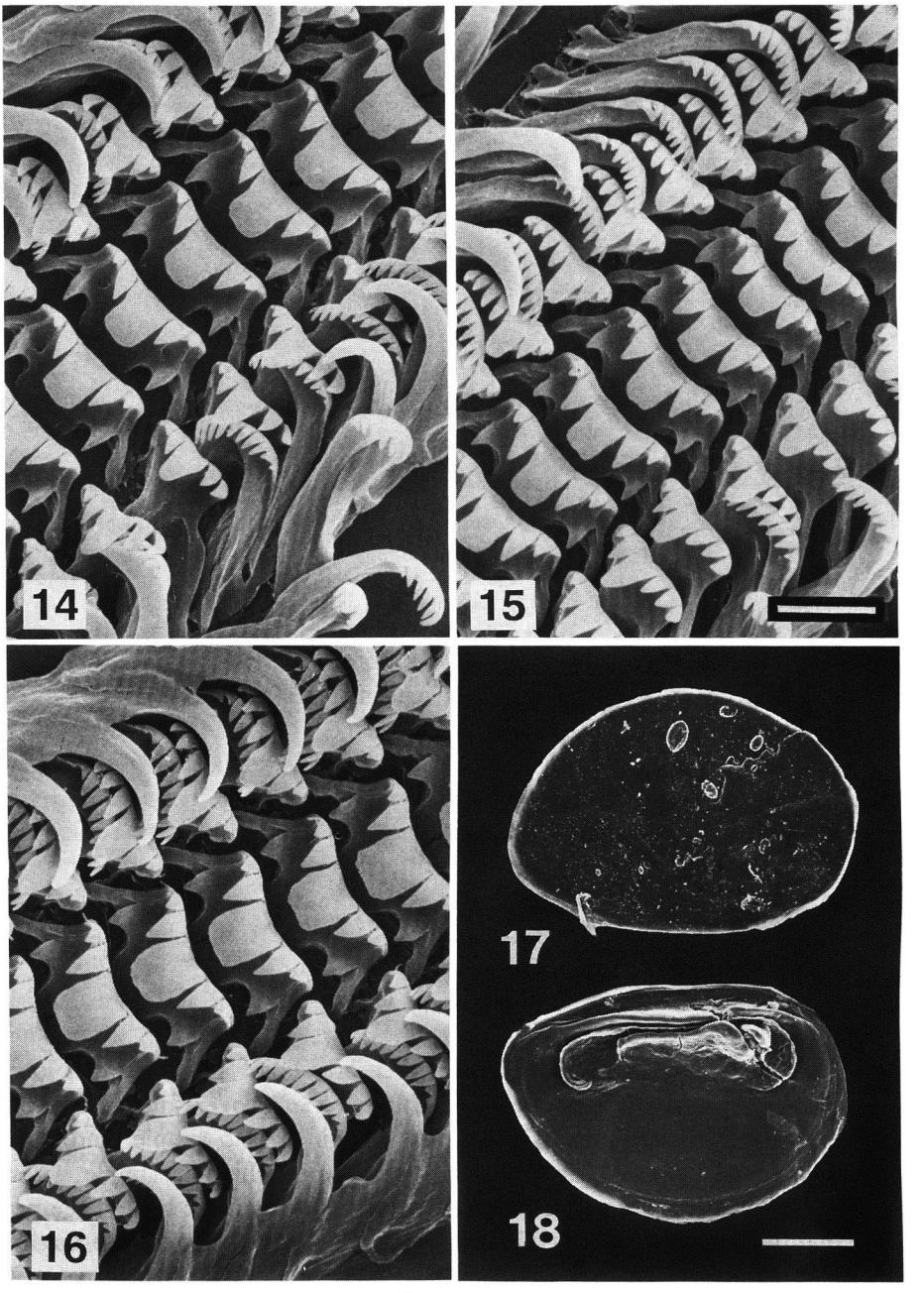


Figs. 12–13. Protoconch of *Amphithalamus* (*A.*) *fulcira* (LASERON). 12, Apical view; 13, frontal view, Manazuru, Kanagawa Prefecture, Honshu (Sagami Bay). Scale bar=50 μm.

outer marginal lacks cusps. No sexual differences were observed in radula morphology, although geographical comparison of the radular morphology was made on female specimens (Figs. 14–16).

External morphology of soft part (Figs. 2–5): The dorsal side of the exposed part of the body is pigmented in black, except the snout, tentacle and small portions around the eyes, which are paler in color. The head has rather long and blunt snout, and paddle-shaped cephalic tentacles with a number of long, immobile setae. The black and rather distinct eyes are situated on the outer bases of the tentacles. The foot is rather small for the size of shell, reaching less than 60% of the shell length when extended. The anterior margin of the foot is duplicated and possesses a slit-like opening of anterior pedal gland, and there is a distinct slit on the posterior half of the length of the sole, with a large opening of the posterior pedal gland at its center, which is visible when crawling. The opercular lobe is black in color, simple without opercular tentacles, and covers most part of the ventral side of the operculum. The pallial margin is also simple, and do not possess pallial tentacles. The male carries a penis which is simple without appendages, coiled counterclockwisely and attached to midline behind the head. On the mantle, there are clusters of black pigments, which can be seen through the translucent shell. The degree of pigmentation is ranging from less pigmented ones, in which black pigment is restricted to the body whorl, to heavily pigmented ones, in which the whole mantle is uniformly black.

Dimensions: Height 0.93 mm, breadth 0.63 mm (Fig. 6: Topotype, Liode-



Figs. 14–18.

man Island, Central Queensland, Australia, AMS C. 300048); height 0.90 mm, breadth 0.57 mm (Fig. 7), height 0.89 mm (Fig. 8) (Figs. 7–8: Shigira Beach, Miyako Island, Ryukyu Islands, NSMT-Mo 70326); height 1.04 mm, breadth 0.68 mm (Fig. 9), height 1.03 mm, breadth 0.68 mm (Fig. 10), height 0.95 mm (Fig. 11) (Fig. 9–11: Kurosaki, Miura Peninsula, Honshu, NSMT-Mo 70327).

Type locality. Liodeman Island, Central Queensland, in weed washings.

Type material. Three "syntypes" of *Scrobs fulcira* LASERON, 1956, preserved in AMS (C. 102488) were examined, although LASERON (1956) originally designated "holotype and about 20 paratypes". Two shells, one operculum and one radula of topotype specimens (Figs. 6, 14: AMS C. 300048, T. IREDALE Coll. #3967), were examined with SEM.

Distribution and habitat. Tropical and temperate western Pacific. In Japanese waters, north to the Boso Peninsula on the Pacific coast, and north to Yamaguchi Prefecture in the Sea of Japan (Fig. 1). It inhabits on various algae in littoral to sublittoral zone, down to about 15 m in depth, in rather exposed beach. Preliminary ecological study revealed that it occurs more abundantly in lower littoral zone on *Sargassum thumbergii* and *Gelidium* spp. than in upper littoral zone on *Gracilaria perrucosa* (Table 1), and fourth abundant in number among lower littoral phytal gastropods.

Remarks. Although this morphologically distinct species is commonly, or sometimes even dominantly, found in tropical to temperate Japanese waters, it has not formerly been recorded in this region, possibly because of its minute size and superficial similarity to the juvenile of *Barleeia angustata* (PILSBRY, 1901). Identification of the Japanese form to the Australian species was confirmed by the examination of the type material of *Scrobs fulcira* Laseron.

Two geographical forms of this species, which are rather distinctly different from each other in shell characters, were recognized in tropical and temperate regions of Japanese waters, respectively. The specimens from the tropical area, such as Ryukyu and Amami Islands, have rather smaller and slenderer shell. The color of the shell is more paler with a distinct white striation just below the suture, and darker brown patch behind the outer lip. The peripheral keel is so weak that it never forms a peripheral cord. Also, the basal cord is not prominent in these specimens. These shell characters agree well with the typical Australian specimens. Furthermore, the soft part, especially the mantle, of these specimens is less pigmented. On the other hand, the specimens from Yaku Island, and northward

Figs. 14–16. Radulae of *Amphithalamus* (*A.*) *fulcira* (LASERON). 14, Topotype, female, Liodeman Island, Central Queensland, Australia; 15, female, Shigira Beach, Miyako-Jima Island, Okinawa Group; 16, female, Manazuru Peninsula, Kanagawa Prefecture, Honshu. Scale bar for 14–16 = 5 μm. Figs. 17, 18. Opercula of *A.* (*A.*) *fulcira* (LASERON), Kurosaki, Miura Peninsula, Kanagawa Prefecture, Honshu (Sagami Bay). 17, Outer side; 18, inner side. Scale bar for 17, 18 = 50 μm.

Table 1. Comparison of occurrence of *Amphithalamus* (*A.*) *fulcira* (LASERON) on diffeent algae at Arasaki, Miura Peninsula, Kanagawa Prefecture, Honshu, March 11, 1992.

	On *Sargassum thumbergii* (97.2 g w.w.)	On *Gracilaria rerrucosa* (125.7 g w.w.)
Num.	32	13
Num./100 g w.w.	32.9	10.3
%	7.5	0.9

Num.: Number of specimens collected. Num./100 g w.w.: Number of specimens converted into per 100 g wet weight of algae. %: Ratio of number of specimens of this species among all the gastropod collected. *Sargassum thumbergii* was collected from a rather exposed ledge in lower tidal zone; *Gracilaria rerrucosa* was collected from a tidal pool in upper tidal zone.

localities have slightly larger and wider shell which is uniformly darker in color, without white striation below the suture. The shell possesses strong angulation along the periphery, which often develops to a distinct cord, and rather straight outline with indistinct suture. Nevertheless, the both forms are regarded as geographical variabilities among the same species, because of the overall similarity of the shell, and especially the radula, and occurrences of intermediate forms in the Amami and Okinawa groups.

The present species is more closely related to *A. inclusus* CARPENTER, 1864 from the tropical west coast of America (figured by MCLEAN, 1978: fig. 12-6, and PONDER, 1983: fig. 20A–D), and *A. vallei* AGUAYO et JAUME, 1947 from the Caribbean Sea (figured by DE JONG & COOMANS, 1988: pl. 11 fig. 99), than the species distributed in temperate Australia and New Zealand, on the basis of shell morphology, especially in minute size and possession of basal cord. This may suggest that minute amphithalamid species with basal cord, including the present species, are regarded as descendants of ancestral tethyan species, from biogeographical point of view. Also, the present species is not apparently distributed in the Ogasawara (=Bonin) Islands (FUKUDA, 1993; personal observation), the Mariana Islands (VERMEIJ *et al.*, 1983; KUROZUMI & ASAKURA, 1994), and Hawaii (KAY, 1979), suggesting that the distribution of the present species may be restricted to the shores of continents and continental islands, unlike most other microgastropod groups, such as Barleeidae, Cingulopsidae, and Rissoellidae, which are distributed even in oceanic islands (KAY, 1979).

Acknowledgments

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