

Thyasirid and Vesicomylid Bivalves from the Lower Pleistocene Umegase Formation in Kimitsu City, Chiba Prefecture, Central Honshu

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Abstract Two bivalve species belonging to the chemosymbiotic families Thyasiridae and Vesicomylidae are reported from the Lower Pleistocene Umegase Formation in Chiba Prefecture of central Honshu, Japan. Of these, the thyasirid *Thyasira inflata* Yabe and Nomura, 1925 is here assigned to the genus *Maorithyas*. This is the second record of this species. As the Recent Atlantic species *Thyasira (Mendicula) inflata* Payne and Allen, 1991 is a junior primary homonym of Yabe and Nomura (1925)'s species, *Mendicula angolensis nom. nov.* is herein proposed for *T. (M.) inflata* Payne and Allen, 1991. The vesicomylid is assigned to the extant species *Archivesica okutanii* (Kojima and Ohta, 1997). This makes *Archivesica okutanii* the third extant vesicomylid with a fossil record in Japan.

Key Words: Bivalvia, Chemosynthesis, Early Pleistocene, *Mendicula angolensis nom. nov.*, Umegase Formation

ZooBank registration:

<https://www.zoobank.org/urn:lsid:zoobank.org:pub:BBEEB0E4-DD6B-437A-B5CE-4D84B348355D>

Introduction

The bivalve families Vesicomylidae and Thyasiridae are well known for their chemosymbiotic life style and are commonly found living in and around deep-sea hydrocarbon seep deposits (e.g., Taylor and Glover, 2010; Amano *et al.*, 2022). Many Recent and fossil species and genera of the two families have been recorded in Japan (e.g., Yabe and Nomura, 1925; Sasaki *et al.*, 2005; Hryniewicz *et al.*, 2017; Amano *et al.*, 2019). However, only a few Pleistocene fossils are known. From Pleistocene deposits in Japan, two vesicomylid and five thyasirid species have been described; *Calyptogena pacifica* Dall, 1891 and *Archivesica kawamurai* (Kuroda, 1943) among the vesicomylids (Amano and Kiel, 2010;

Amano and Jenkins, 2011), and *Conchocele bisecta* (Conrad, 1849), *Thyasira tokunagai* Kuroda and Habe, 1951, *Parathyasira kawamurai* Habe, 1951, *Conchocele* sp. and *Thyasira* sp. among the thyasirids (Baba, 1990; Majima *et al.*, 2005).

The fossil collections of Dr. Katsuyoshi Baba (Minato Ward, Tokyo Met.) and the late Mr. Tadashi Nishiide (Kōka City, Shiga Prefecture) are stored in the Department of Paleontology and Anthropology, National Museum of Nature and Science, Tsukuba (NMNS) and include material from the Lower Pleistocene Umegase Formation at Higashihigasa in Kimitsu City, Chiba Prefecture, central Japan. Careful screening of these collections discovered the following species: the thyasirid described as *Thyasira inflata* Yabe and Nomura, 1925 and the vesicomylid *Archivesica okutanii* (Kojima and Ohta, 1997). As

the result of examination of the type specimens of *T. inflata*, it has become clear that *Thyasira* sp. described by Baba (1990) is conspecific with *T. inflata* and this species belongs to *Maorithyas* Fleming, 1950. In this paper, these thyasirid and vesicomyid species are described, and the significance of these occurrences is discussed.

Materials

Seven fossil specimens of “*Thyasira*” *inflata* and three specimens of *Archivesica okutanii* were examined. They were collected from the lowest part of the Umegase Formation, on the river bank below the Miaki Bridge in Higashihigasa, Kimitsu City (Loc. Higashihigasa-I of Baba, 1990; 35°13'40"N, 140°0'0"E). According to Baba (1990), this locality corresponds to the “Tsuji gamori Fossil Zone” (Sakakura, 1935). The age of the boundary between the Umegase Formation and the underlying Otadai Formation was dated as 1.011 to 1.017 Ma, based on oxygen isotope stratigraphy using benthic foraminifers (Tsuji *et al.*, 2005). Recently, *Megacardita ommaensis* Ogasawara, 1977, one of the characteristic bivalve species of the Pliocene to Early Pleistocene Omma-Manganji fauna (Otuka, 1939) in the Japan Sea borderland has been found at the Higashihigasa locality (Amano, 2025).

The sediment at this locality is composed of fine-grained sandstone and yields the *Nemocardium* [= *Keenaea*]-*Glycymeris* assemblage, consisting of many warm-water and lower sublittoral species such as *Keenaea samarangae* (Makiyama), *Glycymeris (Tucetilla) pilsbryi* (Yokoyama), *Cryptopecten vesiculosus* (Dunker) and *Profundiconus tuberculatus* (Tomlin) (*see* Baba, 1990).

In addition to the fossil specimens from the Umegase Formation housed at NMNS, fossil thyasirid specimens stored at the Tohoku University Museum, Sendai (IGPS) and Recent type specimens of vesicomyids stored at the Department of Zoology, National Museum of Nature and Science, Tsukuba (NSMT) are also

examined for comparing with the specimens from the Umegase Formation.

Taxonomy

Class Bivalvia Linnaeus, 1758

Family Thyasiridae Dall, 1900 (1895)

Genus *Maorithyas* Fleming, 1950

[New Japanese name: Maori-hanashi-gai Zoku]

Type species: Maorithyas marama Fleming, 1950 (Original designation). Recent, Fiordland in New Zealand (12 fathoms in depth).

Remarks: Conchocele Gabb, 1866 is the most closely related genus in having a medium sized shell with a posterior sulcus and no marginal sulcus. However, *Maorithyas* has a smaller and thin shell. Although *Parathyasira* Iredale, 1930 is also similar to this genus in having a thin shell with only a posterior sulcus, it differs from *Maorithyas* by having a much smaller and less inflated shell (attaining 5.5 mm in the type species, *Parathyasira resupina* Iredale, 1930).

Two species of *Maorithyas* had been recorded at some point from the Recent seas of Japan (Habe, 1951; Okutani *et al.*, 1999), but neither appears to belong to this genus. *Thyasira (Maorithyas) miyadai* Habe, 1951 has a transparent, weakly inflated small shell (Holotype, NSMT Mo-38581; length = 7.4 mm, height = 6.9 mm, thickness = 2.8 mm) with a rather protruded anterior margin, unlike *Maorithyas*. Hence, this species has been excluded from *Maorithyas* and was placed in *Thyasira* as treated by Huber (2015). However, the holotype of *T. miyadai* has no auricle, which is the most important characters of *Thyasira*. Thus, further work on its taxonomic placement is needed. The Japanese name of *Maorithyas* was “Usu-hanashi-gai Zoku” (originally as a subgenus) by Habe (1951), based on *T. (Maorithyas) miyadai* (Japanese name: Usu-hanashi-gai). As this species does not belong to the genus *Maorithyas*, “Maori-hanashi-gai Zoku” in Japanese is newly proposed for the genus *Maorithyas*. *Maorithyas hadalis* Okutani, Fujikura and Kojima, 1999,

described from the great depth in the Japan Trench (7,336–7,434 m), was recently designated as type species of the genus *Tartarothyasira* Oliver and Chen, 2024.

***Maorithyas inflata* (Yabe and Nomura, 1925)**

[New Japanese Name: Baba-maori-hanashi-gai]

(Figs. 1A–J)

Thyasira inflata Yabe and Nomura, 1925, p. 93, pl. 23, figs. 5a, b; Sato *et al.*, 2016, p. 53, pl. 29, fig. 4.

Thyasira sp. Baba, 1990, p. 269, pl. 31, fig. 6.

?*Thyasira tokunagai* Kuroda and Habe. Narita-sou Kenkyū Kai, 2004, pl. 5, fig. 2.

Type material: IGPS no. 17251-1 (Fig. 2), the left valve illustrated by Yabe and Nomura (1925: pl. 23, figs. 5a, b) and Sato *et al.* (2016: pl. 29, fig. 4) was herein designated as the lectotype. This specimen has long been treated as the “holotype” (Hatai and Nisiyama, 1952; Ogasawara, 2001; Sato *et al.*, 2016). However, Yabe and Nomura (1925) did not fix the type specimen in the original description, mentioning at least two specimens under the single lot IGPS no. 17251. This means that multiple specimens from this lot were syntypes, but no valid lectotype designation has been made until now.

Other material examined: NMNS PM 29045, a left valve, coll. K. Baba (voucher specimen of Baba, 1990: 269, pl. 31, fig. 6, as *Thyasira* sp.). NMNS PM 68925, a right valve; NMNS PM 68926, a right valve; NMNS PM 68927, a left valve; NMNS PM 68928, a right valve; NMNS PM 68929, a left valve; NMNS PM 68930, a right valve; coll. the late T. Nishiide.

Type locality: Sea cliff south of Tsurushizaki [=Cape Tsurukubi], Hitachi City, Ibaraki Prefecture. Lower Pliocene Hitachi Formation.

Measurements: see Table 1.

Original description: “Shell rather large, thin, ovately subrhomboidal, strongly swollen; very inequilateral, with small and subacute beaks; antero-dorsal margin almost perpendicularly truncated, postero-dorsal broadly convex, and ventral evenly arcuated. Surface with irregular concentric

lines of growth, otherwise being smooth. Lunule elongate-ovate, defined behind by impressed lines; lunular area becoming gradually obscure toward the ventro-dorsal corner; escutcheon broad and expanded, provided with two weak radial furrows, the anterior one being more distinct than the posterior, especially on the upper half of the shell” (Yabe and Nomura, 1925).

Supplementary description: Specimens from the Umegase Formation attain 38.2 mm in maximum length and have higher shells than type specimens (H/L = 0.93–1.12; avg. 1.01). Young shells very thin, inflated, ovate with very shallow posterior sulcus. Sulcus obsolete in small shells but becoming more distinct with growth. Lunule distinctly depressed, demarcated by weak groove.

Remarks: *Thyasira* sp. from the Umegase Formation described by Baba (1990) is here identified as *Maorithyas inflata* because it has the same size as the type specimens (38.2 mm in max. length) and a more inflated shell than *Thyasira* Lamarck, 1818, some irregular concentric ribs on the surface, and lacks an auricle. Another thyasirid from the Hitachi Formation (from which *M. inflata* had originally been described) was reported as *Thyasira tokunagai* Kuroda and Habe by Narita-sou Kenkyū Kai (2004). This large subquadrate specimen with a thin shell and without auricle is rather unlike the extant *T. tokunagai*, but might instead represent *M. inflata*.

Maorithyas inflata resembles *M. humptulipensis* Hryniewikz, Amano, Jenkins and Kiel, 2017 from the middle Eocene Humptulips Formation in Washington State, USA in its thin and subquadrate shell. However, *M. inflata* is different from *M. humptulipensis* by having a smaller (max. length of *M. humptulipensis* = 62 mm) and higher shell with more produced umbo. Images of the holotype of the type species, *M. marama*, were illustrated by Valentich-Scott *et al.* (2014). This species can be distinguished from *M. inflata* by having a smaller (max. length = 18.7 mm) subcircular shell with rather wide posterior fold and well-rounded anterior margin.

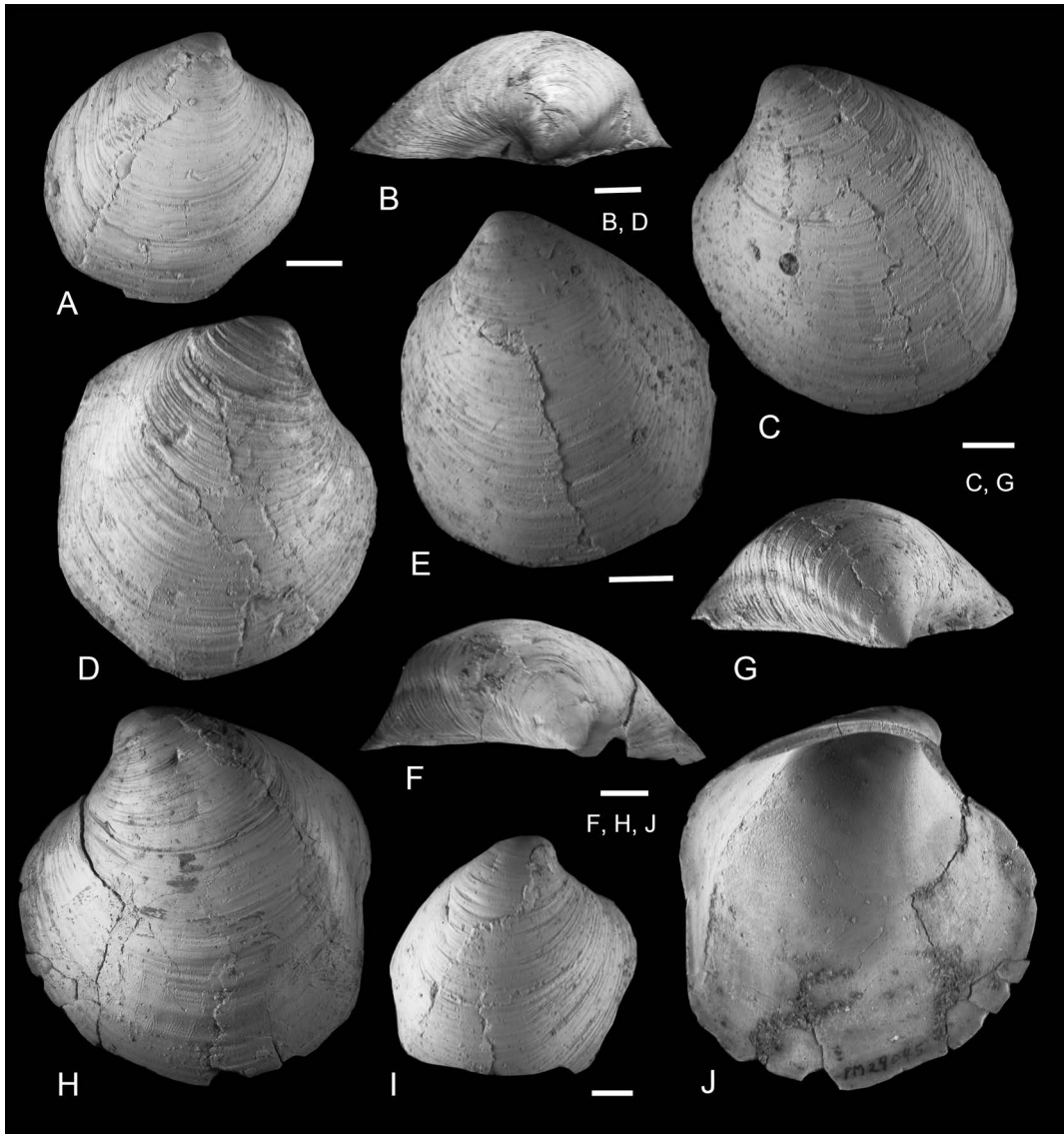


Fig. 1. *Maorithyas inflata* (Yabe and Nomura, 1925) from the Lower Pleistocene Umegase Formation. **A**. NMNS PM 68925, right valve. **B**, **D**. NMNS PM 68926, right valve. **B**, dorsal view; **D**, outer surface. **C**, **G**. NMNS PM 68929, left valve; **C**, outer surface; **G**, dorsal view. **E**. NMNS PM 68927, left valve. **F**, **H**, **J**. NMNS PM 29045, left valve. **F**, dorsal view; **H**, outer surface; **J**, inner view. **I**. NMNS PM 68930, right valve. All scale bars represent 5 mm.

Payne and Allen (1991) introduced *Thyasira* (*Mendicula*) *inflata* for a minute Recent thyasirid from the deep Atlantic Ocean (with the Angola Basin as the type locality), a name that was subsequently adopted as *Mendicula inflata* (Payne and Allen, 1991) by Janssen and Krylova (2014). However, this name is a junior primary

homonym of the fossil *Thyasira inflata* Yabe and Nomura, 1925. Thus, *Mendicula angolensis* *nom. nov.* is herein proposed as a replacement name for *Thyasira* (*Mendicula*) *inflata* Payne and Allen, 1991 whose type locality is off Angola [ZooBank registration: urn:lsid:zoobank.org:act:F4F29C28-C483-4178-A2D1-F7B2FDC9CD47].

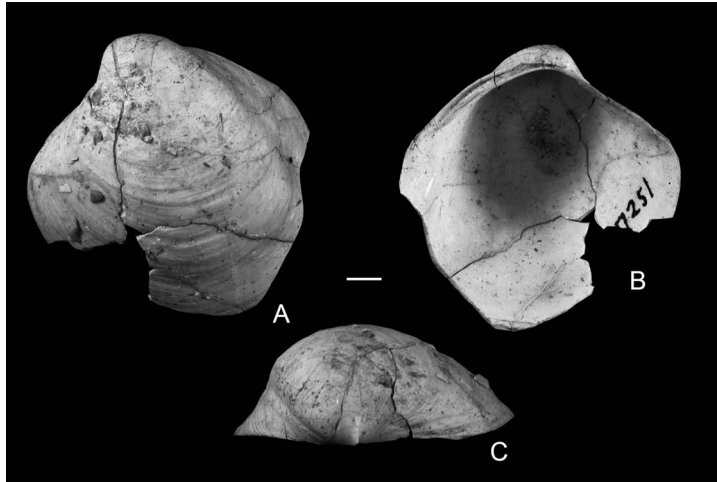


Fig. 2. Lectotype of *Maorithyas inflata* (Yabe and Nomura, 1925) from the Lower Pliocene Hitachi Formation (designated here). Left valve, IGPS no. 17251-1. **A.** outer surface. **B.** inner surface. **C.** dorsal view. Scale bar represents 5 mm.

Table 1. Measurements of *Maorithyas inflata* (Yabe and Nomura, 1925) from the Umegase Formation. AA = apical angle in degrees, H/L = height/length, T/L = thickness/length.

No.	Length (mm)	Height (mm)	Thickness (mm)	AA (°)	H/L	T/L	Valve
NMNS PM 29045	38.2	39.6	14.4	100	1.04	0.38	left
NMNS PM 68925	24.3	23.0	—	105	0.95	—	right
NMNS PM 68926	37.6	39.7	—	75	1.06	—	right
NMNS PM 68927	26.4	29.5	—	78	1.12	—	left
NMNS PM 68928	28.0	29.1	—	78	1.04	—	right
NMNS PM 68929	30.5	29.1	—	79	0.95	—	left
NMNS PM 68930	31.1	28.8	—	108	0.93	—	right

Stratigraphic distribution: Early Pliocene: Hitachi Formation in Ibaraki Prefecture. Early Pleistocene: Umegase Formation in Chiba Prefecture.

Laubiericoncha Cosel and Olu, 2008, and *Akebiconcha* Kuroda, 1943 are synonyms of *Archivesica* (Amano and Suzuki, 2010; Johnson *et al.*, 2017; Amano *et al.*, 2022; Gao *et al.*, 2025).

Family Vesicomylidae Dall and Simpson, 1901

Genus *Archivesica* Dall, 1908

Type species: *Callocardia gigas* Dall, 1896 (original designation). Recent, from the Gulf of California.

Remarks: The present genus is characterized by having three cardinal teeth in the right valve, a subumbonal pit and a shallow pallial sinus. Judging from the molecular data and shell morphology, *Phreagena* Woodring, 1938,

Archivesica okutanii (Kojima and Ohta, 1997)

[Japanese name: Shimai-shirouri-gai]

(Figs. 3A–C, E–K)

Calypptogena okutanii Kojima and Ohta, 1997, p. 192, figs. 3–5.

Calypptogena (Archivesica) okutanii Kojima and Ohta. Okutani *et al.*, 2000, p. 95; Okutani, 2000, p. 997, pl. 497, fig. 9; Sasaki *et al.*, 2005, p. 95, figs. 8I–J; Okutani, 2008, p. 134.

Calypptogena (Phreagena) okutanii Kojima and Ohta. Okutani, 2017, p. 1233, pl. 528, fig. 10.

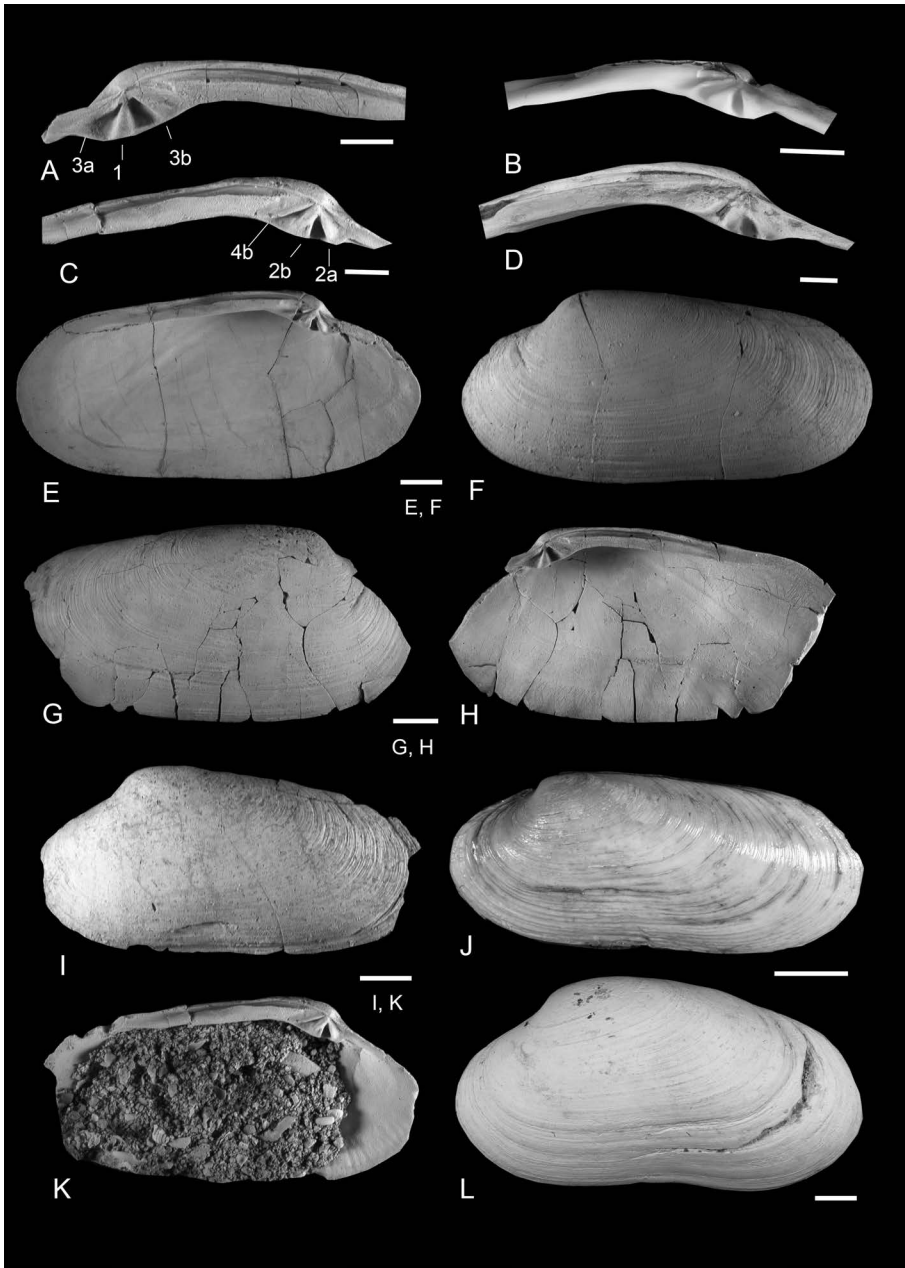


Fig. 3. **A, C, E-I, K.** *Archivesica okutanii* (Kojima and Ohta, 1997) from the Lower Pleistocene Umegase Formation. **A, G, H.** NMNS PM 29869, right valve. **A,** enlargement of hinge; **G,** outer surface; **H,** inner surface. **E, F.** NMNS PM 68931, left valve. **E,** inner surface; **F,** outer surface. **C, I, K.** NMNS PM 68932, left valve. **C,** enlargement of hinge; **I,** outer surface; **K,** inner surface. **B, J.** *Archivesica okutanii* (Kojima and Ohta, 1997), Recent, holotype, NSMT-Mo 70909, left valve. **B,** enlargement of hinge; **J,** outer surface. **D, L.** *Archivesica soyoae* (Okutani, 1957), Recent, holotype, NSMT-Mo 62756, left valve. **D,** enlargement of hinge; **L,** outer surface. Scale bars in **A-D** = 5 mm, in **E-L** = 10 mm.

Table 2. Measurements of *Archivesica okutanii* (Kojima and Ohta, 1997) from the Umegase Formation. AL = anterior length.

No.	Length (mm)	Height (mm)	Thickness (mm)	AL (mm)	H/L	T/L	AL/L	Valve
NMNS PM 68931	93.4	43.7	16.5	25.8	0.47	0.18	0.28	left
NMNS PM 68932	71.7+	53.5	13.5	19.2+	—	—	—	left
NMNS PM 29869	86.7+	44.0	14.0	—	—	—	—	right

Material examined: NMNS PM 29869, a right valve, coll. K. Baba. NMNS PM 68931, a left valve; NMNS PM 68932, a left valve; coll. the late T. Nishiide.

Measurements: see Table 2.

Remarks: One left valve (NMNS PM 68931) is nearly completely preserved and examined herein. The size is moderately large (length = 92.4 mm, height = 44.2 mm, H/L = 0.48) while the maximum length of the species is 150 mm (see Okutani, 2017). Length to height ratios of the Recent specimens of *A. okutanii* and *A. soyoae* (Okutani, 1957) are 0.42–0.51 and 0.47–0.57, respectively (Okutani, 2008). The ratio of the specimen NMNS PM 68931 (0.48) is included in both ranges of *A. okutanii* and *A. soyoae*. The anterior cardinal tooth (2a) of the left valve of *A. soyoae* is rather long and convex up (Fig. 3D) while that of *A. okutanii* is straight (Fig. 3B). Moreover, the middle tooth (2b) of *A. soyoae* is more steeply sloping than that of *A. okutanii*. Judging from the elongated shell shape and hinge teeth of the left valve, the Umegase specimen can be identified as *A. okutanii*. Usually, both species have a rather concave ventral margin while the specimen herein treated has a very weakly concave ventral margin.

Stratigraphic distribution: Early Pleistocene: Umegase Formation. Recent: Suruga Bay, Nankai Trough, Okinawa Trough; 750 to 2,500 m in depth (Okutani, 2008) or 1,000 to 1,400 m in depth (Okutani, 2017).

Discussion

Maorithyas inflata was described from the Lower Pliocene Hitachi Formation in Ibaraki Prefecture by Yabe and Nomura (1925). It is

shown here that this species survived to the Early Pleistocene in the Kanto area. As no species of this genus has been found in Recent seas, it might have become extinct by the Middle Pleistocene.

Archivesica okutanii is an extant species and here described for the first time as a fossil. Two extant species of Pliocardiinae have been described from the Late Miocene onward in Japan (Amano and Jenkins, 2011; Amano *et al.*, 2019). *Calyptogena pacifica* occurs in Late Miocene to Middle Pleistocene sediments on the Japan Sea side of central Honshu and Hokkaido (Amano *et al.*, 2019). *Archivesica kawamura* has been recorded from Plio-Pleistocene strata from the Pacific side of central Honshu in Japan to Leyte Island in the Philippines (Amano and Jenkins, 2011; Kiel *et al.*, 2020). Thus, this is the third extant pliocardiine species with a fossil record in Japan. All three species now live in the upper to middle bathyal zone and at shallower depths than other large species of pliocardiines (Kojima, 2008; Okutani, 2017). Although the fossil specimens of *A. okutanii* occur in association with a lower sublittoral molluscan assemblage (Baba, 1990), Kitazato (1997) inferred the paleodepth of the Umegase Formation as around 800 m, based on benthic foraminifers. Based on the specimens preserved in the blocks, the fossil specimens of *A. okutanii* occur as disarticulated shells in mudstone yielding granules. Judging from these occurrences, all molluscan species including *A. okutanii* were transported to deeper sites. As *A. okutanii* now lives at middle bathyal depths, the fossil occurrence is concordant to the upper limit of the species.

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