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Halicardia toyamaensis (Bivalvia: Verticordiidae), a new flexed sea-heart clam, from the Miocene Kurosedani Formation, Yatsuo-machi, Toyama City, Toyama Prefecture, central Japan

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Abstract

A well-preserved fossil bivalve is here described as a new species, *Halicardia toyamaensis* sp. nov., collected from a calcareous nodule within gray mudstone of the latest Early to earliest Middle Miocene Kurosedani Formation at Kashio, Yatsuo-machi, Toyama City, central Japan. The genus *Halicardia* is represented today by twelve living species that inhabit the upper bathyal to abyssal zones. In the Kurosedani Formation, most molluscan fossils occur as scattered articulated and disarticulated shells within mudstone; this taphonomic mode indicates a para-autochthonous assemblage. Considering the habitat depths of the associated molluscan fossils and the depositional environment inferred from benthic foraminiferal fossils, the depositional depth of the Kurosedani Formation at the study site is estimated to have been within the upper bathyal zone.

Key words: *Halicardia*, Yatsuo Group, new species, Verticordiidae, Miocene

1. Introduction

A well-preserved fossil bivalve was collected from the late Early to early Middle Miocene Kurosedani Formation at Kashio, Yatsuo-machi, Toyama City, Toyama Prefecture, central Japan. This fossil specimen can be identified with the genus *Halicardia* which is one of the representative genera of archibenthal and abyssal living bivalves. Twelve living species of the genus *Halicardia*, *H. angulata*, *H. carinifera*, *H. ferruginea*, *H. fischeri*, *H. flexuosa*, *H. gouldi*, *H. houbricki*, *H. maoria*, *H. nipponensis*, *H. perplicata*, *H. philippinensis* and *H. saharica*, are reported and described from the archibenthal and/or abyssal zones (Poutiers and Bernard, 1995). And several fossil species (including one living species, *H. nipponensis*) have previously been recorded in the world. All of them are reported in Japan only (Table 1). The fossil *Halicardia* is not only very rare, but very interesting in its distribution and paleoenvironmental circumstances. This article describes a new halicardian species and discusses paleoenvironments of the fossil locality.

2. Geological Setting

The Miocene Kurosedani Formation, exposed in and around Yatsuo-machi of Toyama City, constitutes the upper part of the Yatsuo Group. The Kurosedani Formation mainly consists of shallow marine sediments and is well known for yielding molluscan fossils

abundantly (Oyama, 1950; Tsuda, 1959, 1960; Kaneko, 1994; Amano et al., 2019). The specimen of *Halicardia toyamaensis* (sp. nov.) in this study was collected from the outcrop exposed in the floor of Kubusu River at Kashio, Yatsuo-machi (Fig. 1). It occurred in one of the calcareous nodules dispersed in the gray mudstone bed of the upper Kurosedani Formation (Fig. 2). These nodules frequently yield finely preserved shells of molluscs including planktonic pteropods. On the basis of the previous studies of magnetostratigraphy (Tamaki et al., 2006) and diatom biostratigraphy (Yanagisawa, 1999) in the Yatsuo Group, the depositional age of the present locality is referred to the latest Early or earliest Middle Miocene (around the Early/Middle Miocene boundary) and to 16.5 Ma approximately in age.

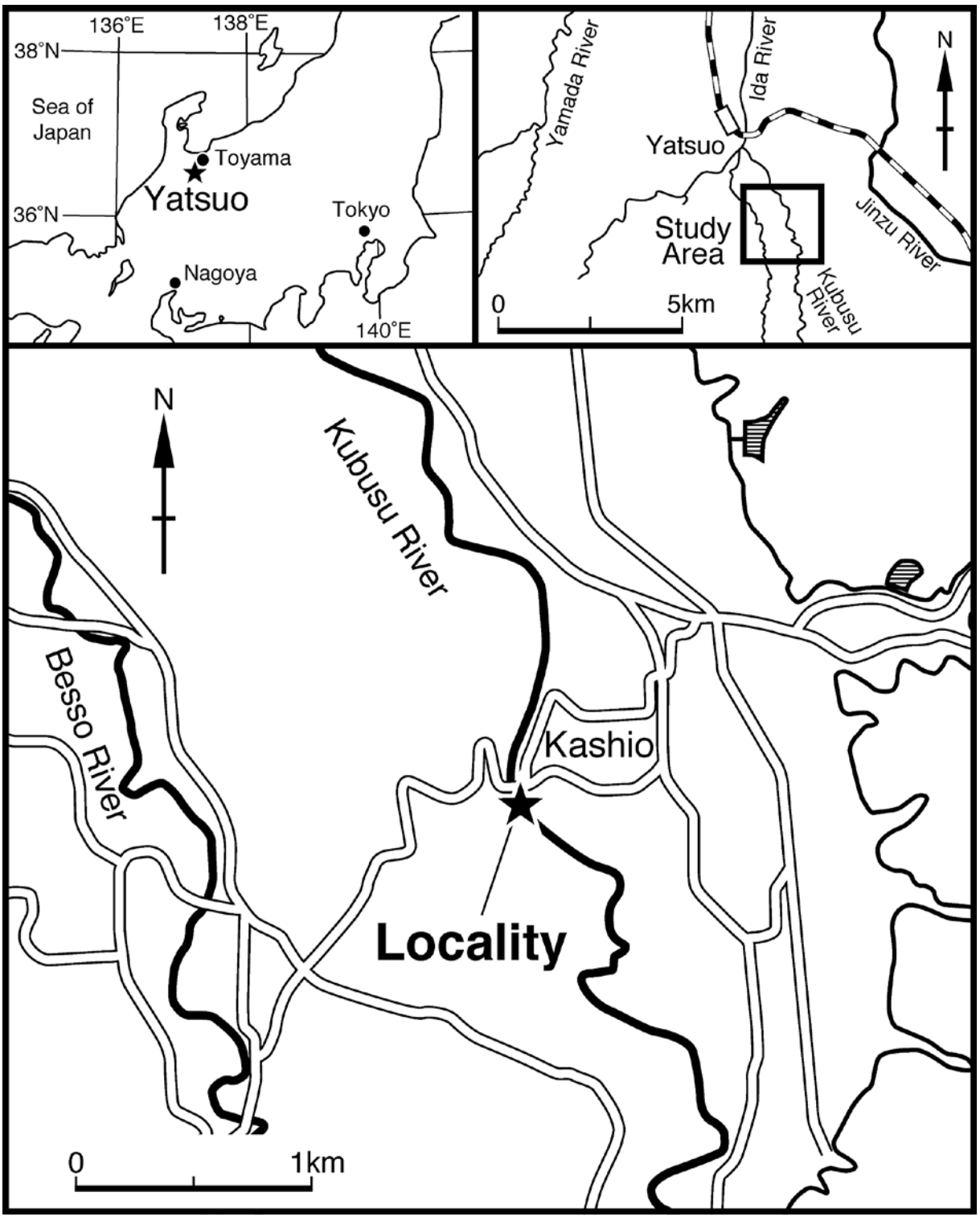

Fig. 1. Map showing the collection locality of *Halicardia toyamaensis* sp. nov.

Table 1. Fossil records of *Halicardia* from Japan.

Scientific Name	Author	Geological Age	Formation
H. *akitaensis*	Ogasawara & Takayasu, 1982	Late Early–Early Middle Miocene	Sunakobuchi F.
H. sp.		Early Pliocene	Kiwada F.
H. *nipponensis*	Tomida, 1989	Early Pliocene (Lower Pliocene)	Ochiai F.
H. *nipponensis*	Baba, 1990	Lower Pliocene	Umegase F.
H. aff. *akitaensis*	Majima, 1991	Early Pliocene (Lower Pliocene)	Kawabaru F.
H. *miyagiensis*	Fujiwara, 1992	Late Miocene	Nanakita F.
H. sp.	Kurihara, 2002	Middle Miocene	Niwaya or Haraichi F.
H. *akitaensis*	Tomida & Okumura, 2008	Lower Miocene	Oi F.
H. sp. cf. *houbricki*	Kurihara and Tokita, 2010	Late Miocene	Amatsu F.
H. *nipponensis*	Utsunomiya & Majima, 2012	Plio–Pleistocene	Urago and Nojima F.
H. *toyamaensis* sp. nov.	this study	Late Early–Early Middle Miocene	Kurosedani F.

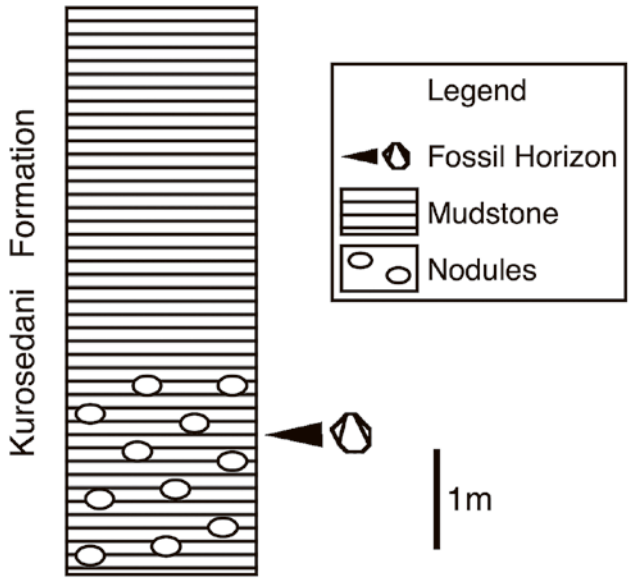

Fig. 2. Columnar section of the Kurosedani Formation at the collection locality with the occurrence horizon of *Halicardia toyamaensis* sp. nov.

3. Systematic description

Family Verticordiidae Stoliczka, 1871

Genus *Halicardia* Dall, 1895

Type species: *Mytilimeria flexuosa* Verrill and Smith, 1881, by monotypy.

***Halicardia toyamaensis* sp. nov.**

(Fig. 3)

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[New Japanese Name: Toyama-Otohimegokoro-Gai]

Diagnosis: Globular in shape, strongly inflated, beaks prominent. The entire valve surface is divided into two regions by a shallow groove.

Description: Shell medium in size, equivalve, strongly inflated and globular. Beak prominent, prosogyrated. A hollowed lunule in front of it. A shallow groove running from umbo to postero-ventral corner, demarcating shell into two regions, anterior large and posterior small ones. Anterior and posterior ends round convex, anterior and posterior margin almost semicircular. Ventral margin round convex, antero-dorsal margin deeply hollowed lunule, postero-dorsal margin gently sloping down to the semicircular posterior margin. Surface covered with numerous microscopic granules. Internal surface with pearly lustre. The hinge teeth are not preserved.

Measurements: Single specimen conjoined valve occurs in a calcareous nodule of the Kurosedani Formation. It is slightly compressed, but the shell surface sculpture is well preserved. The specimen is satisfactory as type material. Shell length 36.7 mm. Shell height 39.5 mm.

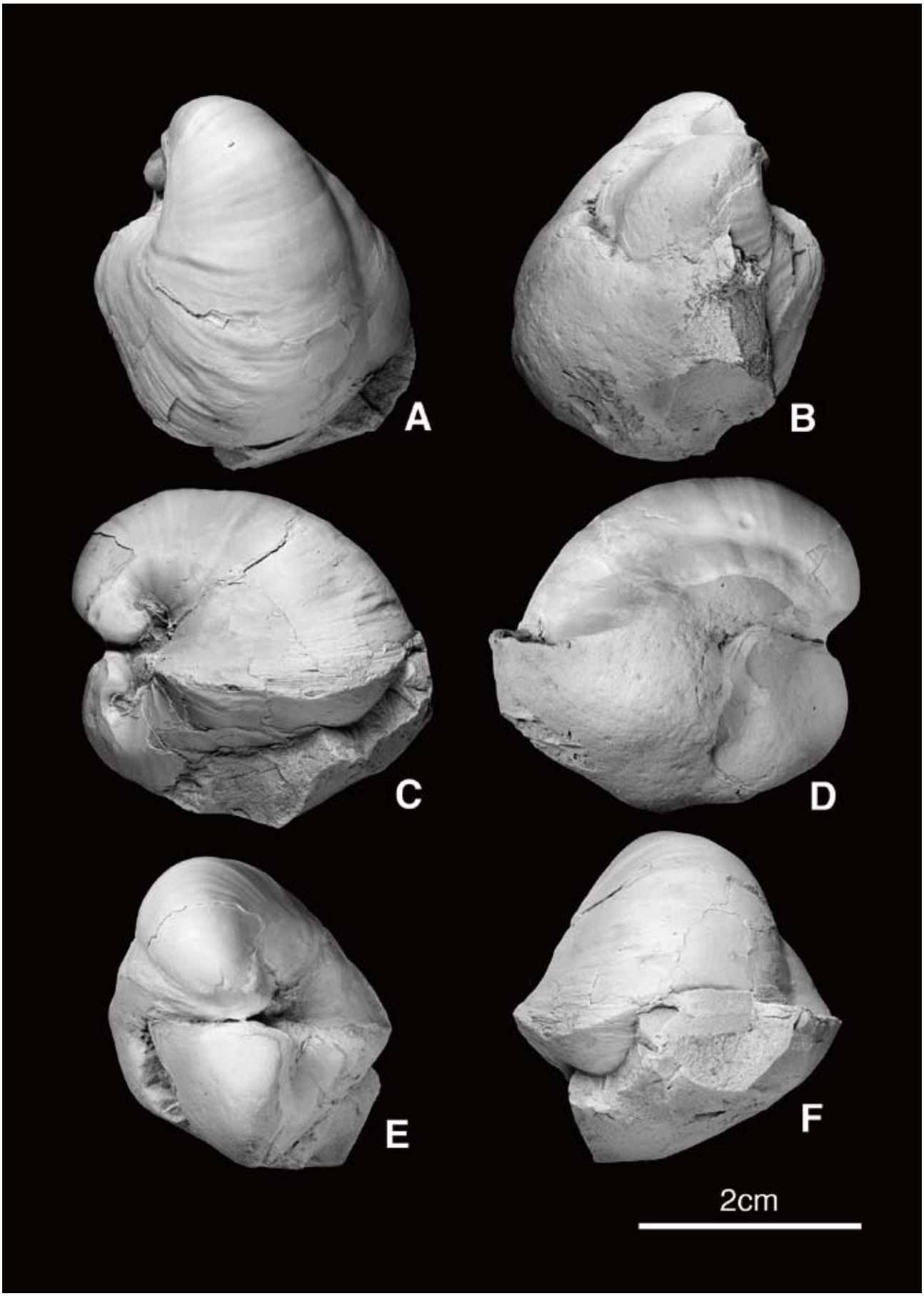

Fig. 3. ***Halicardia toyamaensis*** **sp. nov.** from the Kurosedani Formation, MFM40020 (holotype). A, Left lateral view. B, Right lateral view. C, Anterior view. D, Posterior view. E, Apical view. F, Ventral view.

Material examined: MFM40020 (holotype). Specimen is housed in the Mizunami Fossil Museum.

Comparisons and Affinities: This new species is very similar to *Halicardia* sp. (Watanabe, 2004) obtained at a depth of 400–600 m off Choshi Inubozaki (Katagai Canyon), but this species is distinguished by its much smaller size and more prominent anterior portion. The present species is allied to *Halicardia gouldi* Dall, Bartsch and Rehder, 1938 living in bathyal sea around the Hawaiian Islands, but it has a more strongly inflated shell. And *Halicardia gouldi* has longer postero-ventral margin than the present species. This specimen is distinguished from *Halicardia nipponensis* Okutani, 1957, *Halicardia akitaensis* Ogasawara and Takayasu, 1982, *Halicardia* sp. Ogasawara and Takayasu, 1982 and *Halicardia miyagiensis* Fujiwara, 1992 by its two regions divided by the groove.

Associated Fauna: Associated molluscan fossils are as follows: *Ennucula osawanoensis* (Tsuda), *Bathymalletia inermis* (Yokoyama), *Portlandia* (*Portlandella*) *lischkei* (Smith), *Neilo* (*Multidentata*) *multidentata* (Khomenko), *Lucinoma acutilineatum* (Conrad), *Periploma mitsuganoense* Araki, *Teredo* sp., *Euspira meisensis* (Makiyama), Buccinidae gen. et sp. indet., *Boreotrophon osawanoensis* (Tsuda), *Musashia* sp., *Eoscaphander corpulenta* (Yokoyama), *Fissidentalium yokoyamai* (Makiyama). These specimens were recovered from mudstone around the calcareous nodules.

Etymology: The specific epithet toyamaensis refers to Toyama Prefecture, where the new species was discovered.

Type Locality and Horizon: Kashio, Yatsuo-machi, Toyama City, Toyama Prefecture, central Japan. The late Early to early Middle Miocene Kurosedani Formation of the Yatsuo Group. (Figs. 1, 2).

4. Discussion

At the present study site in the Kurosedani Formation, many molluscan fossils occurring as articulated and disarticulated valves are scattered within the mudstone. Based on this mode of occurrence, the molluscan assemblage, including the new halicardian species, is considered to be para-autochthonous. The bathymetric range of the molluscan fossil assemblage at the present study site is inferred to be approximately 100–200 m or deeper than 200 m, mainly based on a combination of the depth ranges of living genera and species corresponding to the associated molluscan fossils. The depths of these molluscan fossils show a relatively wide range, making it difficult to estimate an exact water depth. However, the depositional environment of the upper Kurosedani Formation, as indicated by benthic foraminiferal fossils, shows that the water depth increases from the upper to the middle bathyal zone (Nishimatsu and Ujihara, 2020). Therefore, the depositional environment at the present study site is estimated to be the upper bathyal zone, and *Halicardia toyamaensis* sp. nov. can be regarded as an indicator species of bathyal environments. This interpretation is also consistent with the bathymetric ranges of extant species of the genus *Halicardia*, which inhabit the bathyal to abyssal zones.

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6. References

Amano, K., Y. Miyajima, K. Nakagawa, T. Hamuro, and M. Hamuro. 2019. Chemosymbiotic bivalves from the lower Miocene Kurosedani Formation in Toyama Prefecture, central Honshu, Japan. Paleontological Research 23(3): 208–219. DOI: 10.2517/2018pr022

Baba, K.1990. Molluscan Fossil Assemblages of the Kazusa Group, South Kwanto, Central Japan. 445

pp., 40 pls. Keio Yochisha. Tokyo. (in Japanese with English description of new species)

Dall, W. H. 1895. Scientific results of exploration by the U. S. Fish Commission steamer "Albatross" XXXIV. Report on Mollusca and Brachiopoda dredged in deep water, chiefly near the Hawaiian Islands, with illustrations of hitherto unfigured species from northwest America. Proceedings of the United States National Museum 17: 675–733, pls. 23–32.

Dall, W. H., P. Bartsch, and H. A. Rehder. 1938. A Manual of the Recent and Fossil Marine Pelecypod Mollusks of the Hawaiian Islands. Bernice P. Bishop Museum Bulletin 153: 1–233.

Fujiwara, O. 1992. A new species of *Halicardia* (Bivalvia) from the Late Miocene of Miyagi Prefecture, Northeast Honshu, Japan. Saito Ho-on Kai Museum of Natural History Research Bulletin 60: 9–21.

Kaneko, K. 1994. Molluscan fossils from the Tochizu Member of the Kurosedani Formation in Tateyama-cho, Toyama Prefecture, Central Japan. Bulletin of the Tateyama Museum of Toyama 1: 3–11, pls. 1–2. (in Japanese with English abstract)

Kurihara, Y. 2002. First occurrence of deep-water bivalve *Halicardia* (Verticordiidae) from the Miocene of Gunma, central Japan with a discussion on its life orientation. Bulletin of Gunma Museum of Natural History 6: 33–38.

Kurihara, Y., and T. Tokita. 2010. Occurrence of *Halicardia* sp. cf. *houbricki* Poutiers and Bernard, 1995 (Bivalvia: Verticordiidae) from the Miocene of Japan. Venus (Japanese Journal of Malacology) 68(3–4): 179–182.
DOI: 10.18941/venus.68.3-4_179

Majima, R. 1991. First occurrence of *Halicardia* (Bivalvia: Verticordiidae) from the Lower Pliocene Kawabaru Formation of the Miyazaki Group, Pacific side of central Kyushu, Japan. Venus (Japanese Journal of Malacology) 50(1): 81–84.

Nishimatsu K., and A. Ujihara. 2020. Deep-sea elasmobranch fauna with the first descriptions of genera *Arynchobatis* and *Pseudoraja* from the Miocene Yatsuo group in Toyama, central Japan. Historical Biology 32(8): 1120–1142.
DOI: 10.1080/08912963.2019.1566325

Ogasawara, K., and T. Takayasu. 1982. Fossil *Halicardia* from the Miocene of Akita Prefecture and Pleistocene of Chiba Prefecture, Japan. Venus (Japanese Journal of Malacology) 41(3): 199–216.
DOI: 10.18941/venusjjm.41.3_199

Okutani, T. 1957. Two new species of bivalves from the deep water in Sagami Bay collected by the R. V. Soyo-Maru. Bulletin of the Tokai Regional Fisheries Research Laboratory 17: 27–30, 1 pl.

Oyama, K. 1950. Studies of fossil molluscan biocoenosis, No. 1. Biocoenological studies on the mangrove swamps, with description of new species from Yatsuo Group. Reports, Geological Survey of Japan 132: 1–15.

Poutiers, J. M., and F. R. Bernard. 1995. Carnivorous bivalve molluscs (Anomalodesmata) from the tropical western Pacific Ocean, with a proposed classification and a catalogue of Recent species. In P. Bouchet, ed., Resultats des Campagnes MUSORSTOM. Volume 14. Memoires du Museum National d' Histoire Naturelle 167: 107–187.

Stoliczka, F. 1870–1871. The Pelecypoda, with a review of all known genera of this class, fossil and recent. In T. Oldham, Paleontologia Indica, being figures and descriptions of the organic remains procured during the progress of the Geological Survey of India. Cretaceous Fauna of Southern India. Volume 3. Memoirs of the Geological Survey of India, Calcutta i–xxii, 1–537, pls. 1–50 [pp. 1–222, pl. 1–12; 1870; pp. i–xxii, 223–537, pl. 23–50; 1871].

Tamaki, M., Y. Ito, and M. Watanabe. 2006. Paleomagnetism of the Lower to Middle Miocene Series in the Yatsuo area, eastern part of southwest Japan: clockwise rotation and marine transgression during a short period. Bulletin of the Geological Survey of Japan 57: 73–88.
DOI: 10.9795/bullgsj.57.73

Tomida, S. 1989. Occurrence of fossil *Halicardia nipponensis* from the Neogene in the Tanzawa Mountainland, and its paleontological significance. Venus (Japanese Journal of Malacology) 48(3): 167–173.
DOI: 10.18941/venusjjm.48.3_167

Tomida, S., and Y. Okumura. 2008. A New Occurrence of *Halicardia* (Bivalvia: Verticordiidae) in the Lower Miocene of Mie Prefecture, Central

Japan. Venus (Japanese Journal of Malacology) 66(3–4): 169–173.
DOI: 10.18941/venus.66.3-4_169

Tsuda, K. 1959. New Miocene molluscs from the Kurosedani Formation in Toyama Prefecture, Japan. Journal of the Faculty of Science, Niigata University, Series II 3(2): 67–110.

Tsuda, K. 1960. Paleo-ecology of the Kurosedani fauna. Journal of the Faculty of Science, Niigata University, Series II 3(4): 171–203.

Utsunomiya, M., and R. Majima. 2012. Paleobathymetries of the Plio-Pleistocene Urago and Nojima Formation, Kazusa Group, Miura Peninsula, central Japan: Revision on the basis of molluscan fossils from new localities. Fossils (The Palaeontological Society of Japan) 91: 5–14. (in Japanese with English abstract)
DOI: 10.14825/kaseki.91.0_5

Verrill A. E. 1881. Notice of the remarkable marine fauna occupying the outer banks off the Southern coast of New England, No 2. American Journal of Science Series 3 22: 292–303.

Watanabe, T. 2004. A species of Verticordiidae discovered off the coast of Choshi, Japan. Chiribotan (Newsletter of the Malacological Society of Japan) 35(1): 18–19.

Yanagisawa, Y. 1999. Diatom biostratigraphy of the lower to middle Miocene sequence in the Yatsuo area, Toyama Prefecture, central Japan. Bulletin of the Geological Survey of Japan 50: 139–165.