

Crassatellid and Mactrid Bivalves from the Lower Miocene Kurosedani Formation in Toyama City, Toyama Prefecture, central Japan

Kazutaka Amano^{1*}, Toshikazu Hamuro² and Masui Hamuro²

¹ Department of Paleontology and Anthropology, National Museum of Nature and Science, Tokyo, 4-1-1 Amakubo, Tsukuba, Ibaraki 305-0005, Japan

² Toyama Paleontological Research Club, 100 Nishitakagi, Imizu, Toyama 939-0303, Japan

*Author for correspondence: amano@juen.ac.jp

Abstract Many well-preserved specimens of *Nipponocrassatella osawanoensis* (Tsuda, 1959) and *Pseudoxyperas osawanoense* (Tsuda, 1959) have been collected from the hitherto unknown locality of the Lower Miocene Kurosedani Formation in Toyama Prefecture. As a result of examination, *Nipponocrassatella osawanoensis* herein described is one of the oldest species of undoubted *Nipponocrassatella* and was widely distributed in western Honshu during the Miocene Climatic Optimum (MCO). *Oxyperas osawanoensis* [sic] Tsuda, 1959 is herein allocated to the genus *Pseudoxyperas*. This species was distributed in the central part of Honshu and Okinawa Prefecture during the MCO. No species of *Pseudoxyperas* and *Oxyperas* have been found from the upper Middle Miocene formations in Japan probably because of subsequent climate cooling during the Middle Miocene Climatic Transition (MMCT).

Key Words: *Nipponocrassatella*, *Pseudoxyperas*, Kurosedani Formation, Early Miocene, Miocene Climatic Optimum

Introduction

The crassatellid *Crassatellites osawanoensis* Tsuda, 1959 and the mactrid *Oxyperas osawanoensis* [sic] Tsuda, 1959 have been known from the Lower to lower Middle Miocene formations in Honshu (Masuda and Noda, 1976). Both species were first described from the Kurosedani Formation in Toyama Prefecture by Tsuda (1959). The age of the Kurosedani Formation in Toyama Prefecture was assigned to the Early Miocene (about 17–16 Ma; Yanagisawa, 1999; Sato *et al.*, 2010; Nakajima *et al.*, 2019) and corresponds to the Miocene Climatic Optimum (MCO; *ca.* 17 to 14.7 Ma) (Methner *et al.*, 2020; Sangiorgi *et al.*, 2021).

When Matsubara (2011) examined the Miocene fossils from the Hokutan Group in Hyogo Prefecture, he concluded that *Crassatellites*

osawanoensis should be included in the genus *Crassatina* Kobelt, 1881 which is not acceptable to Japanese malacologists. The subgenus of *Oxyperas osawanensis* [sic] was considered by the authors as *Pseudoxyperas* Sacco, 1901 (Amano *et al.*, 2014). At that time, we gave a brief explanation why this species was under the subgenus *Pseudoxyperas*. Matsukuma (2000a, 2017a) treated *Pseudoxyperas* as an independent genus. Many specimens of both species were collected from the new locality hitherto unknown. In this paper, we describe both species in detail and examine their generic positions.

Materials

Many molluscan fossils were recovered from the right bank of Ida River, about 200 m downstream from the Jusangoku Bridge in Fukushima, Yatsuo-machi, Toyama City, Toyama Prefecture (36°35'7"N, 137°8'31"E) by the river channel

improvement in 2006 (Amano *et al.*, 2025b). The Kurosedani Formation herein consists of mudstone intercalating some beds of muddy coarse-grained sandstone yielding granule and shells.

All specimens treated here are stored at the institutions as follows.

Institutional abbreviations: JC, Kyoto University Museum, Kyoto, Japan; NMNS, Department of Paleontology and Anthropology, National Museum of Nature and Science, Tsukuba, Japan; UMUT, The University Museum, The University of Tokyo, Tokyo, Japan.

Systematic Paleontology

Class Bivalvia Linnaeus, 1758

Family Crassatellidae A. Férussac, 1822

Genus *Nipponocrassatella* Kuroda and Habe
in Kuroda, Habe and Oyama, 1971

Type species: *Crassatella nana* Adams and Reeve, 1850 (original designation). Recent, “Eastern Sea”.

Remarks: Matsubara (2011) synonymized *Nipponocrassatella* with *Crassatina* Kobelt, 1881. However, the type species of *Crassatina*, *Crassatella triquetra* (Reeve, 1842) from West Africa differs from the type species of *Nipponocrassatella* by having a triangular shell with no radial ridge from beak to postero-ventral corner and a very short truncated posterior margin. Therefore, we treat *Nipponocrassatella* as an independent genus from *Crassatina* as do most Japanese malacologists (*e.g.*, Habe, 1977; Matsukuma, 2000b, 2017b) and Huber (2010).

Eucrassatella Iredale, 1924 is easily distinguished from *Nipponocrassatella* Kuroda and Habe, 1971 by having a smooth ventral margin.

Nipponocrassatella osawanoensis (Tsuda, 1959)

[Japanese Name: Osawano-moshio-gai]

(Fig. 1)

Crassatellites heteroglyptus Pilsbry. Otuka, 1937, p. 31,

fig. 5. [*non Crassatellites heteroglyptus* Pilsbry]
Crassatellites osawanoensis Tsuda, 1959, p. 74; Sasaki and Ogasawara, 1986, pl. 5, figs. 5a, b.
Crassatellites toyamaensis Tsuda, 1959, pl. 2, figs. 3–5. [*nom. nud.*]
Crassatellites suyamensis Oinomikado. Masuda, 1966, pl. 35, fig. 12; Masuda, 1982, p. 246, pl. 123, fig. 1164. [*non Crassatellites suyamensis* Oinomikado]
Eucrassatella (*Nipponocrassatella*) *osawanoensis* (Tsuda). Itoigawa *et al.*, 1974, p. 73, pl. 18, figs. 1a, b.
Eucrassatella osawanoensis (Tsuda). Itoigawa and Shibata, 1977, pl. 25, fig. 2.
Crassatella pauxillus (Yokoyama). Katto and Masuda, 1979, p. 101, pl. 5, figs. 17–20. [*non Crassatella pauxilla* Yokoyama]
Nipponocrassatella osawanoensis (Tsuda). Itoigawa *et al.*, 1981, pl. 11, figs. 7a, b; Itoigawa *et al.*, 1982, p. 56–57; Nakagawa, 1998, p. 131–132, fig. 24–24; Amano *et al.*, 2004, fig. 5.8.
Crassatellites (*Crassatellites*) *pauxillus* (Yokoyama). Tsuru, 1983, p. 58–59, pl. 9, figs. 7–9. [*non Crassatella pauxilla* Yokoyama]
Crassatellites suyamensis Oinomikado. Kobayashi and Ueda, 1991, pl. 2, fig. 11. [*non Crassatellites suyamensis* Oinomikado]
Crassatellites (*Eucrassatella*) *osawanoensis* Tsuda. Kaneko and Goto, 1992, p. 14, pl. 6, figs. 5a, b, 6a, b.
Eucrassatella osawanoensis (Tsuda). Kaneko, 1994, pl. 1, figs. 23, 24.
Eucrassatella osawanoensis Tsuda. Kaneko and Goto, 1997, p. 11, pl. 8, figs. 15a, b, 16a, b, 17a, b.
Crassatella (*Nipponocrassatella*) *toyamaensis* (Tsuda). Matsuura, 2009, pl. IV-7, fig. 27. [*nom. nud.*]
Crassatina pauxillus (Yokoyama). Matsubara, 2011, p. 74–75, pl. 7, figs. 5–8. [*non Crassatella pauxilla* Yokoyama]

Type specimens: Holotype, JC 1400014; Paratype, JC 1400015.

Type Locality: Tsuzara, Toyama City, Toyama Prefecture; Kurosedani Formation.

Material: Twenty-eight specimens were examined and measured (NMNS PM 68933).

Dimensions: see Table 1.

Remarks: The present species is characterized by a small triangularly ovate, moderately inflated shell (attaining 24.4 mm length; avg. Height/Length = 0.86, avg. Thickness/Length = 0.29; Table 1) with a straight postero-dorsal margin, a blunt ridge running from beak to postero-ventral corner, and a truncated posterior margin. The surface of shell sculptured by many fine

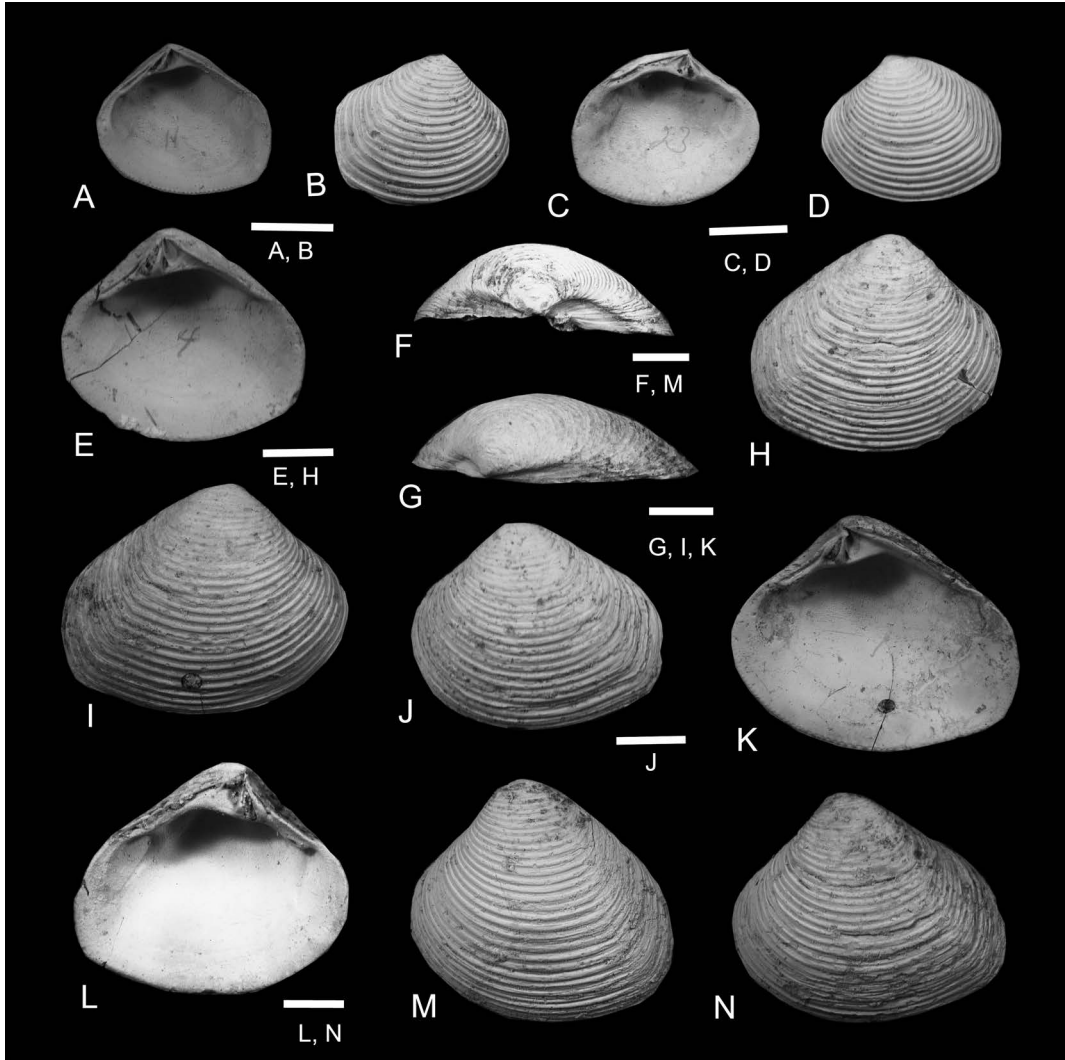


Fig. 1. *Nipponocrassatella osawanoensis* (Tsuda, 1959). A, B. NMNS PM 68933-11, right valve. A, inner view; B, outer surface. C, D. NMNS PM 68933-23, left valve. C, inner view; D, outer surface. E, H. NMNS PM 68933-4, right valve. E, inner view; H, outer surface. F, M. NMNS PM 68933-16, left valve. F, dorsal view; M, outer surface. G, I, K. NMNS PM 68933-1, right valve. G, dorsal view; I, outer surface; K, inner view. J. NMNS PM 68933-17, right valve, outer surface. L, N. NMNS PM 68933-26, left valve. L, inner view; N, outer surface. All scale bars represent 5 mm.

commarginal ribs (about 18 per 1 cm in the central part of the disc from the beak), separated by nearly equal interspaces. The lunule is deeply depressed and wide. Moreover, the inner ventral margin is finely crenulated which is a characteristic of *Nipponocrassatella*.

When Tsuda (1959: 74) proposed and described this species as *Crassatellites osawanoensis*, he

mistakenly spelled it as *C. toyamaensis* in the caption of the plate (pl. 2, figs. 3–5). Although Masuda and Noda (1976) pointed out that the latter name was invalid, Matsuura (2009) illustrated the present species as *Crassatella (Nipponocrassatella) toyamaensis* (Tsuda).

The present species was confused with *Nipponocrassatella pauxilla* (Yokoyama, 1925)

Table 1. Measurements of *Nipponocrassatella osawanoensis* (Tsuda, 1959), NMNS PM 68933. AL = anterior length, CR = Number of commarginal ribs per 1 cm from beak in the central part of disc, H = shell height, L = shell length, T = thickness of shell.

No.	Length (mm)	Height (mm)	Thickness (mm)	AL (mm)	CR	H/L	T/L	AL/L	Valve
1	22.8	18.5	6.7	9.1	18	0.81	0.29	0.40	right
2	19.7	16.7	5.4	7.9	—	0.85	0.27	0.40	right
3	21.7	19.6	—	11.0	—	0.90	—	0.51	right
4	18.7	16.6	5.8	8.2	—	0.89	0.31	0.44	right
5	17.6	16.3	5.2	7.5	17	0.93	0.30	0.43	right
6	17.0	14.5	4.9	6.4	—	0.85	0.29	0.38	right
7	18.0	14.3	4.7	6.4	17	0.79	0.26	0.36	right
8	16.2	14.7	4.5	7.7	19	0.91	0.28	0.48	right
9	17.2	15.0	5.6	7.2	15	0.87	0.33	0.42	right
10	16.4	13.4	4.6	7.0	15	0.82	0.28	0.43	right
11	13.0	11.1	4.0	4.1	17	0.85	0.31	0.32	right
12	12.5	10.9	3.6	5.5	17	0.87	0.29	0.44	right
13	10.3	9.4	3.4	3.7	—	0.91	0.33	0.36	right
14	10.5	8.9	3.0	4.8	—	0.85	0.29	0.46	right
15	9.6	8.3	2.8	3.5	—	0.86	0.29	0.36	right
16	24.4	20.1	7.2	8.0	—	0.82	0.30	0.33	left
17	18.7	16.9	6.0	7.4	—	0.90	0.32	0.40	left
18	19.0	15.9	5.3	7.7	—	0.84	0.28	0.41	left
19	18.3	16.2	5.7	8.6	19	0.89	0.31	0.47	left
20	16.6	14.9	4.7	8.4	19	0.90	0.28	0.51	left
21	18.8	13.8	4.6	6.1	—	0.73	0.24	0.32	left
22	16.0	13.6	4.1	7.2	21	0.85	0.26	0.45	left
23	11.9	9.8	3.1	4.1	19	0.82	0.26	0.34	left
24	22.0	18.7	6.3	7.0	—	0.85	0.29	0.32	right
25	19.1	17.6	6.3	8.2	19	0.92	0.33	0.43	right
26	23.8	20.6	7.3	7.7	—	0.87	0.31	0.32	left
27	18.5	16.0	6.2	5.7	—	0.86	0.34	0.31	left
28	16.7	14.1	4.7	5.2	—	0.84	0.28	0.31	left

by Katto and Masuda (1979), Tsuru (1983) and Matsubara (2011). *Nipponocrassatella pauxilla* was originally described by Yokoyama (1925) from the Lower Miocene Nenokami Sandstone in Chichibu Basin, Saitama Prefecture. However, as a result of examination of the type specimens of *N. pauxilla*, it has a broadly rounded anterior margin and less numerous commarginal ribs. The number of commarginal ribs per 1 cm from the beak in the central part of the disc is about 13 in the lectotype (UMUT CM 22742) and about 9 in the paralectotype (UMUT CM 22739).

Nipponocrassatella osawanoensis was also confused with *N. suyamensis* (Oinomikado, 1938) by Masuda (1966, 1982) and Kobayashi and Ueda (1991). *Nipponocrassatella suyamensis* originally described from the Upper Miocene Itahana Formation has a broadly arched postero-dorsal margin, less depressed lunule and less numerous commarginal ribs (about 13 per 1 cm

from the beak, judging from the original figure) with narrower interspaces.

The Recent species, *Nipponocrassatella nana* (Adams and Reeve, 1850) differs from *N. osawanoensis* by having a larger (40 mm in length; Matsukuma, 2017) and less inflated shell with a narrow lunule, sculptured by less numerous commarginal ribs, separated by wider interspaces.

Stratigraphic distribution: Early to early Middle Miocene, Orito Formation in Niigata Prefecture (Kobayashi and Ueda, 1991), Kurosedani and Higashibessho formations in Toyama Prefecture (Tsuda, 1956; Kaneko and Goto, 1992, 1997; Kaenko, 1994, Amano *et al.*, 2004; Matsuura, 2009), Higashi-innai and Sunakozaka formations in Ishikawa Prefecture (Masuda, 1966, 1982; Sasaki and Ogasawara, 1986), Aratani Formation in Fukui Prefecture (Nakagawa, 1998), Toyo'oka Formation of Hokutan Group in Hyogo Prefecture (Matsubara, 2011), Togane Formation

in Shimane Prefecture (Otuka, 1937; Tsuru, 1983), Oidawara Formation of Mizunami Group in Gifu Prefecture (Itoigawa *et al.*, 1974, 1981, 1982; Itoigawa and Shibata, 1977), Uematsu Formation in Wakayama Prefecture (Katto and Masuda, 1979).

Family Mactridae Lamarck, 1809

Genus *Pseudoxyperas* Sacco, 1901

Type species: Mactra proaspersa Sacco, 1901
(by original designation). Miocene, Italy.

Diagnosis: “Gruppe di forme spiccatamente transverse, affini per varii caratteri (fra cui la leggera striolatura di alcuni denti cardinalii) alle *Hemimactra*, ma molt più allungate per modo di ricordare le *Oxyperas*, dalle quali però differenziano per essere molt gracili, meno triangolari, ecc” [Group of distinctly transverse forms, similar in various characteristics (including the slight striation of some cardinal teeth) to the *Hemimactra*, but much more elongated so as to recall the *Oxyperas*, from which however they

differ in being much slender, less triangular, etc.] (Sacco, 1901; translated herein).

Remarks: Huber (2010) synonymized *Pseudoxyperas* with *Oxyperas*. However, this genus is distinctly different from *Oxyperas* Mörch, 1853 by having a less triangular shell with fine and weak commarginal ribs. In terms of sculpture, there are no intermediate species between these two genera.

Pseudoxyperas osawanoense (Tsuda, 1959)

[Japanese Name: Osawano-hokuro-gai]

(Fig. 2)

Oxyperas osawanoensis [*sic*] Tsuda, 1959, p. 78–79, pl. 3, figs. 2–5; Itoigawa *et al.*, 1974, p. 95, pl. 28, fig. 6; Itoigawa *et al.*, 1981, pl. 18, fig. 5; Itoigawa *et al.*, 1982, p. 92–93; Kaneko and Goto, 1992, p. 17, pl. 8, figs. 5, 6; Kaneko and Goto, 1997, p. 13, figs. 6, 7a, b; Matsuura, 2009, pl. IV-7, fig. 28.

Mactra sp. Kanno, 1960, p. 296, pl. 43, figs. 3a, b.

Oxyperas okinawaensis [*sic*] Masuda and Sato, 1988, p. 446, pl. 4, figs. 6–14; Masuda and Huang, 1993, p. 271, pl. 5, figs. 5–7.

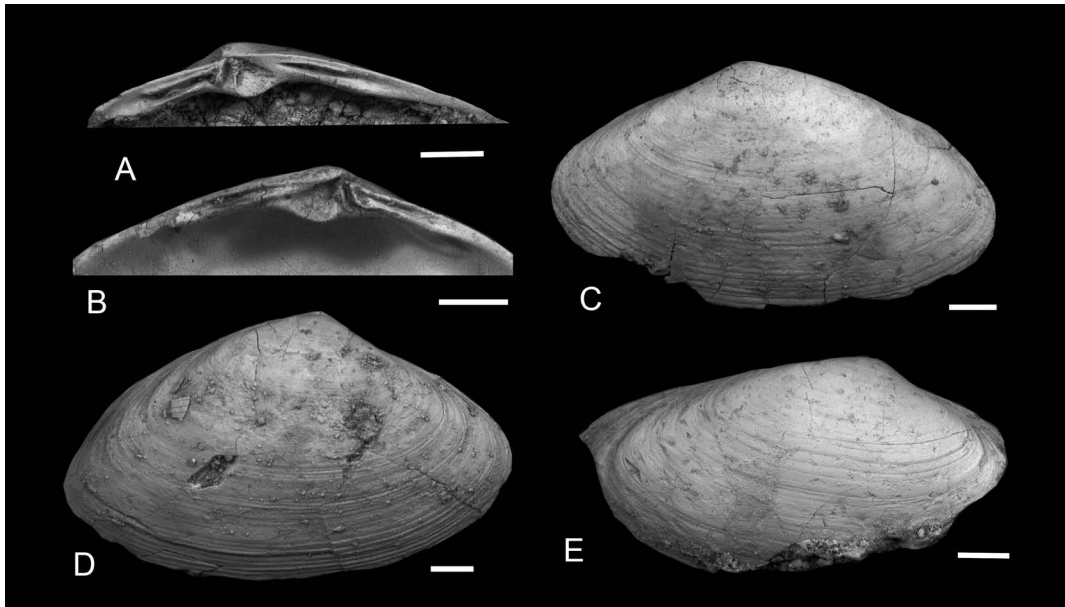


Fig. 2. *Pseudoxyperas osawanoense* (Tsuda, 1959). A, E. NMNS PM 68934-3, right valve. A, hinge; E, outer surface. B, C. NMNS PM 68934-5, left valve. B, hinge; C, outer surface. D. NMNS PM 68934-4, right valve, outer surface. All scale bars represent 5 mm.

Table 2. Measurements of *Pseudoxyperas osawanoense* (Tsuda, 1959), NMNS PM 68934. AL = anterior length, H = shell height, L = shell length, T = thickness of shell.

No.	Length (mm)	Height (mm)	Thickness (mm)	AL (mm)	H/L	T/L	AL/L	Valve
1	53.3	29.5	—	18.7	0.55	—	0.35	right
2	51.9	30.2	9.8	22.2	0.58	0.19	0.43	right
3	43.3 +	—	—	—	—	—	—	right
4	49.7	21.6	9.3	21.3	0.43	0.19	0.43	left
5	46.5	25.4	7.6	20.0	0.55	0.16	0.43	left
6	30.5	15.5 +	5.7	11.8	—	0.19	0.39	left

Type specimens: Holotype, JC 1400024; Paratype, JC 14000125.

Type Locality: Tsuzara, Toyama City, Toyama Prefecture; Kurosedani Formation.

Material: A total of 16 specimens were obtained (NMNS PM 68934). Of these, six specimens are relatively well preserved and measured.

Dimensions: see Table 2.

Remarks: The present species is characterized by its medium-sized thin shell (up to 53.3 mm in length of the examined specimens) and sculptured by some flat-topped commarginal ribs. As the genus names *Oxyperas* and *Pseudoxyperas* are neutral nouns, the species name is not *osawanoensis*, but *osawanoense*.

Kanno (1960) described *Maetra* sp. from the Lower to lower Middle Miocene Saginosu Formation in Saitama Prefecture. Judging from the shell size (Length = 40.0 mm), its outline (Height/Length = 0.53, Thickness/Length = 0.14; Table 2) and indistinct growth lines, Kanno (1960)'s *Maetra* sp. is synonymous with *Pseudoxyperas osawanoense* (Tsuda).

Masuda and Sato (1988) described *Oxyperas okinawaensis* [*sic*] from the upper Lower to lower Middle Miocene Iriomote Formation in Iriomote Island, Okinawa Prefecture. This species is a junior synonym of *O. osawanoense* because it has a similarly sized shell (max. 44 mm in length) and many low flat-topped commarginal ribs. They separated *O. okinawaense* from *O. osawanoense* by its longer shell and surface with low, blunt commarginal sculpture. However, the shell proportion of *O. okinawaense* has a rather higher shell (Height/Length = 0.55 to 0.61, avg. 0.58) than *O. osawanoense* (Height/Length = 0.43 to

0.58, avg. 0.53). There is no distinct difference between these species.

Pseudoxyperas osawanoense is similar to the type species of the genus, *P. proaspersum* (Sacco, 1901) from the Miocene of Italy by having a similar shell with many fine and low commarginal ribs. However, *P. osawanoense* slightly differs from the type species by having a less concave antero-dorsal margin.

The Recent species, *P. aspersum* (Sowerby I, 1825) now lives in 10 to 30 m in depth from Kii Peninsula and southward, Southeast Asia, and northern Australia (Matsukuma, 2000a, 2017a). It differs from *P. osawanoense* by having a more anteriorly located beak and more erect fine commarginal ribs.

Stratigraphic distribution: Early to early Middle Miocene, Kurosedani Formation in Toyama Prefecture (Tsuda, 1956; Kaneko and Goto, 1992, 1997; Matsuura, 2009), Saginosu Formation in Saitama Prefecture (Kanno, 1960), Nataki Formation of Mizunami Group in Gifu Prefecture (Itoigawa *et al.*, 1974, 1981, 1982), Iriomote Formation in Okinawa Prefecture (Masuda and Sato, 1988). Middle Miocene, Kuanyinshan Sandstone in northern Taiwan (Masuda and Huang, 1993).

Discussion

Nipponocrassatella occurs in the Recent warm shallow seas of Japan (*e.g.*, Higo *et al.*, 1999). In the Paleogene, many species of *Eucrassatella* are known (Oyama *et al.*, 1960; Masuda and Noda, 1976). *Nipponocrassatella osawanoensis* herein described is one of the oldest species of

undoubted *Nipponocrassatella*. This species was widely distributed in western Honshu during the Early to early Middle Miocene corresponding to the MCO.

Only one Recent species of *Pseudoxyperas* in Japan, *P. aspersum* is widely distributed from the Kii Peninsula southward to southeast Asia and to northern Australia (Matsukuma, 2000a, 2017a). *Pseudoxyperas osawanoense* was distributed in the central part of Honshu to Iriomote Island in Okinawa Prefecture during the Early to early Middle Miocene. There is no species of *Pseudoxyperas* and *Oxyperas* in the late Middle Miocene in Japan probably because of the subsequent climate cooling after the MCO, Middle Miocene Climatic Transition (MMCT) (e.g., Methner *et al.*, 2020; Sangiorgi *et al.*, 2021; Amano *et al.*, 2025a). In the Late Miocene, the Recent species *Oxyperas bernardi* first appeared in Japan and is widely recorded from Plio-Pleistocene formations in southwestern Japan and the Japan Sea borderland (Amano *et al.*, 2014) while no fossil *Pseudoxyperas* are known since the late Middle Miocene in Japan.

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