Bull. Natl. Mus. Nat. Sci., Ser. C, 39, pp. 7–15, December 22, 2013

A New Species of *Sagmatocythere* (Crustacea: Ostracoda: Loxoconchidae) from the Pleistocene Kawachi Formation in Central Japan

Hirokazu Ozawa[1] and Takahiro Kamiya[2]

[1] Earth Sciences Laboratory, College of Bioresource Sciences, Nihon University, Kameino, Fujisawa, Kanagawa 252–0880, Japan
E-mail: ozawa.hirokazu@nihon-u.ac.jp
[2] School of Natural System, College of Science and Engineering, Kanazawa University, Kakuma-machi, Kanazawa, Ishikawa 920–1192, Japan

Abstract The ostracod genus *Sagmatocythere* is known widely from marine environments on continental shelves and slopes and as fossils in the Upper Cenozoic strata. We describe *S. sawanensis* sp. nov., from the Lower Pleistocene Kawachi Formation on the coasts in Niigata Prefecture in the central Japan. Its geological and geographical distribution suggests that *S. sawanensis* sp. nov. is originated from the semi-isolated Sea of Japan and endemic during the Early Pleistocene, around 2.0 Ma. This is the first report on the genus *Sagmatocythere* in Japan and its adjacent areas.
Key words : Ostracoda, *Sagmatocythere*, new species, Sea of Japan, Pleistocene

Introduction

Sagmatocythere (Podocopida, Loxoconchidae) was proposed by Athersuch (1976) as a genus from modern deposits of the northern Adriatic Sea coast. It is commonly and widely found in marine sediments of continental shelves and slopes from the Miocene to Recent (e.g., Athersuch and Horne 1984; Athersuch *et al.* 1989; Brouwers 1993; Milhau 1993). On the Japanese coasts along the Sea of of Japan, carapaces and valves of benthic ostracods are found abundantly in Pleistocene and modern sediments (e.g., Hanai 1957; Ishizaki and Matoba 1985; Irizuki 1993; Ozawa and Kamiya 2005a). Yet many species from the Pleistocene have neither been investigated systematically nor described. The Pleistocene ostracod faunas were highly diversified, containing many taxa endemic to the Sea of Japan (Tabuki 1986; Cronin and Ikeya 1987; Ozawa and Kamiya 2005b; Ozawa 2010a, 2013).

Sagmatocythere is probably the oldest recorded genus, Late Mesozoic in age, among the Loxoconchidae, which is one of the most diversified podocopid families (Athersuch and Horne 1984; Horne 2003; Ishii *et al.* 2005). Its fossil records are still sporadically. The description of a new fossil species of *Sagmatocythere* is very significant for clarifying the worldwide evolutionary history of podocopids since the Mesozoic.

In this paper, we describe a new species of *Sagmatocythere* from the Pleistocene strata on the Sea of Japan coasts of Niigata Prefecture in central Japan, and discuss biogeography and ecology of the new species.

Materials and Methods

Fossil specimens of a *Sagmatocythere* species were extracted from a sediment sample taken from an exposure in Sado Island, Niigata Prefecture, central Japan (37°59.4′N, 138°15.9′E; leg. Dr. A. Tsukagoshi, Shizuoka University, Japan) of the Lower Pleistocene (ca. 0.9 Ma; Kato *et al.* 1995) Kawachi Formation (Figs. 1 and 2). This sample was studied by Tsukagoshi and Ikeya (1987). In order to ascertain the geological and geographical ranges of this species, fossil ostracods from 64 previously analysed samples of

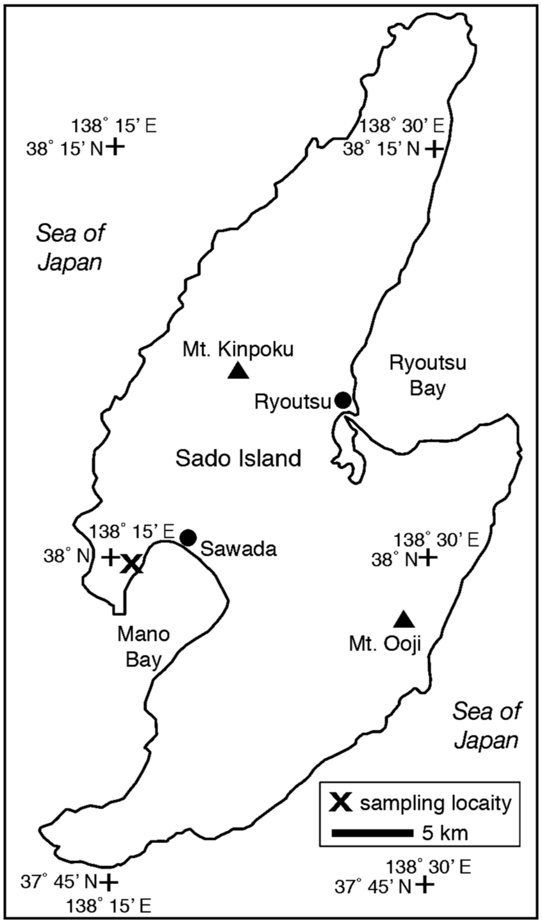

Fig. 1. The map showing the sampling locality (type locality) of *Sagmatocythere sawanensis* sp. nov. on Sado Island in Niigata Prefecture, central Japan.

Pliocene and Pleistocene strata from several prefectures along the Sea of Japan coast of Japan, were reexamied (see Ozawa and Kamiya 2005a, 2005b, 2009).

Valves of all specimens were examined, using a scanning electron microscope (JEOL-JSM-5310) and a binocular microscope. All illustrated specimens are deposited in the collections of the National Museum of Nature and Science, Tsukuba, Japan, identified by numbers with the prefix MPC (Micropaleontology Collection).

The following abbreviations are used in the text: RV, right valve; LV, left valve; L, length; H, height.

Systematic Paleontology

Family Loxoconchidae Sars, 1926

Genus ***Sagmatocythere*** Athersuch, 1976

Sagmatocythere sawanensis sp. nov.

(Figs. 3A–H, 4A, B)

Loxoconcha sp.: Ikeya *et al.*, 1992, p. 348, fig. 10-1a, b; Ozawa *et al.*, 1999, p. 115, table 2.

Palmoconcha sp.: Ozawa and Tsukawaki, 2008, p. 37, table 3b; Ozawa, 2010b, p. 33, pl. 3, fig. 17; Ozawa and Domitsu, 2010, p. 8, table 1.

Type series: Holotype: female RV, MPC-25002 (Fig. 3C). Paratypes: female LV, MPC-25003 (Fig. 3D); male LV, MPC-25004 (Fig. 3B); male RV, MPC-25005 (Fig. 3A); female LV, MPC-25006 (Figs. 3E, 4B); female RV, MPC-25007 (Figs. 3F, 4A).

Type locality: The Lower Pleistocene Kawachi Formation, Sado Island (Fig. 1), along the Hanyu River about 250 m west of Hanyu, Sado City, Niigata Prefecture, central Japan (37°59.4′N, 138°15.9′E). This locality is the same as the Loc. 4 of Tsukagoshi and Ikeya (1987), and is the same as the type locality of *Cythere hanaii* Tsukagoshi and Ikeya, 1987.

Other material examined: The following specimens from the same sediment sample as the type series were used for illustrations and measurements: A-1 juvenile LV, MPC-25008 (Fig. 3G); A-2 juvenile LV, MPC-25009 (Fig. 3H).

Diagnosis: Carapace medium-sized, quadrangular in lateral view, truncate posteriorly; dorsal and ventral margins slightly curved and parallel. Valve surface covered with strong reticulation except for heavily calcified median area; pore conuli on conjunction of reticulation's net and intermural pores on murus of reticulation; fine pits in anterior and posterior marginal areas. Flattened flanges along anterior and posterior margins. Prominent ridge in weakly-arched in postero-dorsal area. Hingement gongylodont; in RV, anterior hingement area single tooth surrounded by horseshoe-shaped depression; median hingement area smooth; terminal hingement area one comma-shaped tooth with large socket.

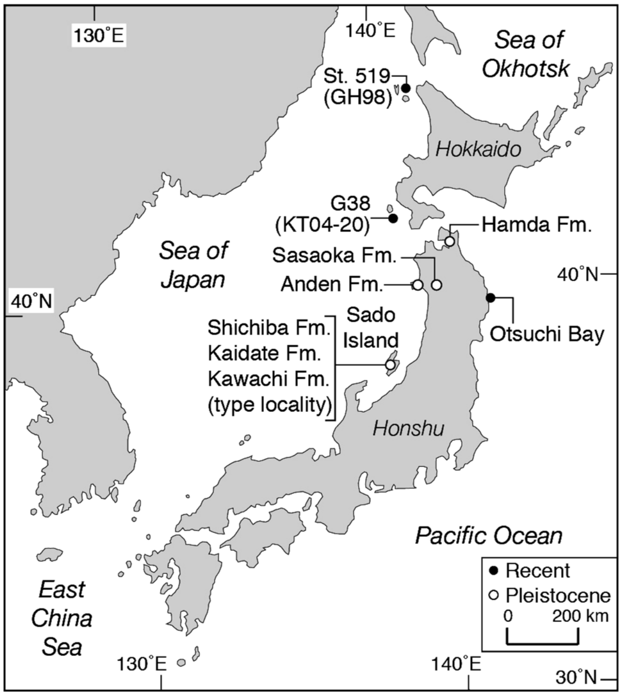

Fig. 2. The map showing localities of *Sagmatocythere sawanensis* sp. nov.

Description: Valves quadrangular in lateral view, moderately robust; dorsal and ventral margins slightly curved and parallel. Greatest length near mid-height. Greatest height at anterior cardinal angle. Anterior margin obliquely rounded. Posterior margin truncated obliquely in both upper half and lower half to form blunt angle slightly near mid-height. Flattened flanges along anterior and posterior marginal rims. In dorsal view, elongate pentagonal in shape.

Valve surface covered with distinct reticulation of various sizes, with fine pits along anterior and posterior margins, excepting heavily calcified central area. Reticulation in males larger than females, especially in mid-dorsal area. Sparse reticulation with small fossae and smooth surface areas in middle part, in and around adductor muscle field. Reticulation pattern concentric along anterior margin and irregular elsewhere. One conspicuous ala on postero-ventral margin. One robust ridge in ventral area extending laterally, and one prominent short ridge slightly arched in postero-dorsal area. Two short vertical ridges extending from postero-dorsal to mid area with vertical elongate fossae. Eye tubercle rounded and distinct. Fine pits along anterior and posterior margins. Pore conuli in conjunction of reticulation's net. Intermural pores on murus of primary reticulation. 106 pores (92 sieve-type pores and 14 marginal pores) present in adult stage. 84 and 69 pores present in A-1 and A-2 stages, respectively (Fig. 5).

Hingement (Fig. 4A) gongylodont-type and straight; In RV, single tooth surrounded by horseshoe-shaped depression in anterior element; smooth median element; one comma-shaped terminal element, with large socket opening ventrally. Four adductor muscle scars in vertical row, median two longitudinally elongate, frontal scar U-shaped and fulcral point present. Vestibule present along anterior and posterior margins, relatively deep along antero-ventral and postero-ventral margins. Inner margin moderately broad, especially in anterior half.

Sexual dimorphism distinct especially in LV; male form more elongated than female.

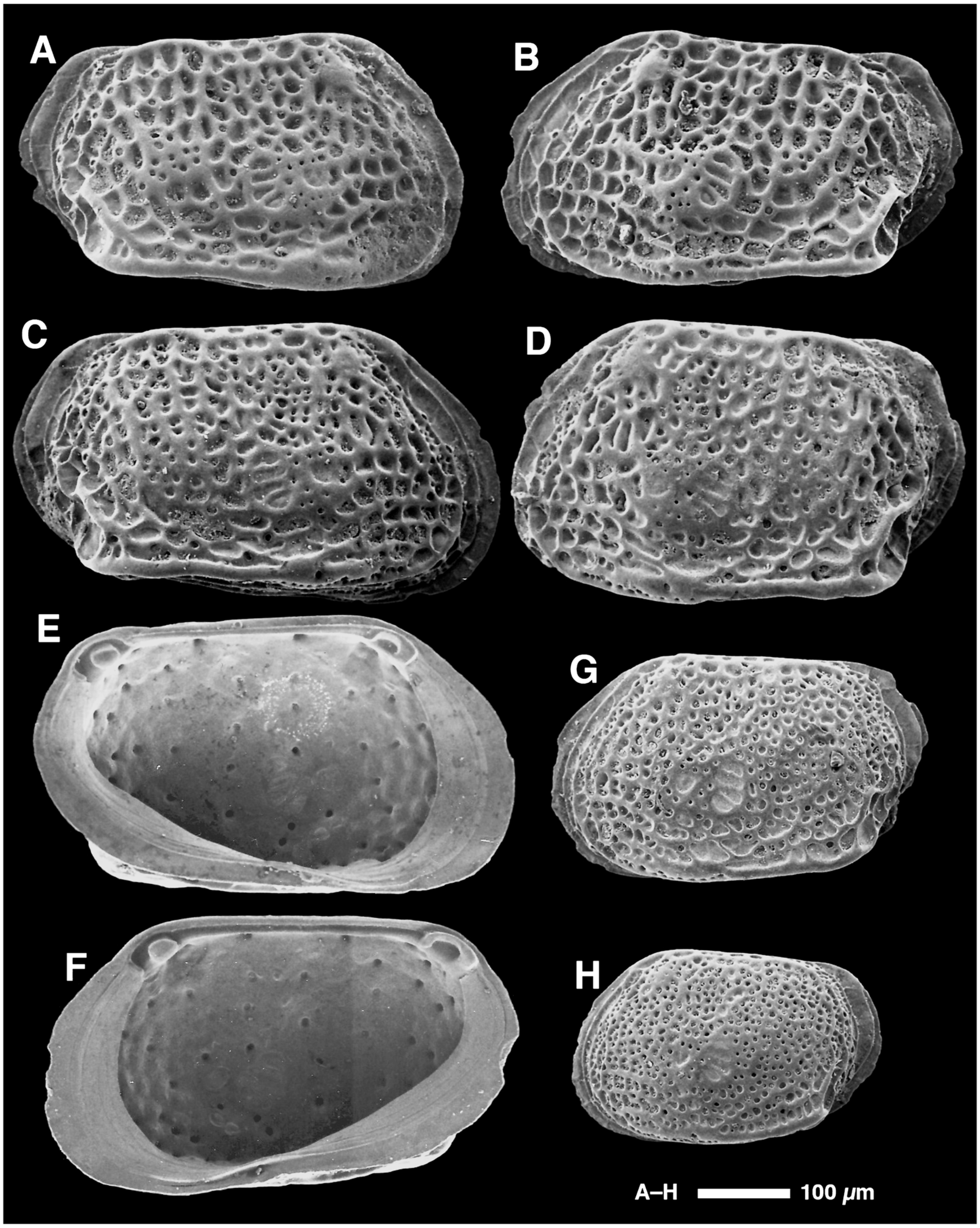

Fig. 3. SEM images of *Sagmatocythere sawanensis* sp. nov. **A**, male RV, external lateral view (paratype, MPC-25005). **B**, male LV, external lateral view (paratype, MPC-25006). **C**, female RV, external lateral view (holotype, MPC-25002). **D**, female LV, external lateral view (paratype, MPC-25003). **E**, female LV, internal lateral view (paratype, MPC-25006). **F**, female RV, internal lateral view (paratype, MPC-25007). **G**, A-1 juvenile LV, external lateral view (MPC-25008). **H**, A-2 juvenile LV, external lateral view (MPC-25009).

Table 1. The occurrence list and references for *Sagmatocythere sawanensis* sp. nov.

Area/Formation	Age	Reference
Otsuchi Bay	Recent	Ikeya *et al.* (1992)
off Hokkaido (St. 519 of GH98)	Recent	Ozawa *et al.* (1999)
off Hokkaido (St. G38 of KT04-20)	Recent	Ozawa and Tsukawaki (2008)
Anden Formation	L. Pleistocene	This study
Shichiba Formation	M. Pleistocene	Ozawa (2010b)
Hamada Formation	E. Pleistocene	Ozawa and Domitsu (2010)
Kaidate Formation	E. Pleistocene	This study
Kawachi Formation	E. Pleistocene	This study
Sasaoka Formation	E. Pleistocene	This study

Abbreviations: E., Early; L., Late; M., Middle.

Table 2. The dimensions (mm) of *Sagmatocythere sawanensis* sp. nov. in the adult stage.

Object		Length			Height		
		Av	OR	N	Av	OR	N
Male	RV	0.49	0.49	1	0.28	0.28	1
	LV	0.50	0.50	1	0.28	0.28	1
Female	RV	0.53	0.52–0.53	2	0.31	0.30–0.31	2
	LV	0.51	0.50–0.52	2	0.31	0.30–0.31	2

Abbreviations: Av, average; LV, left valve; N, number of specimens; OR, observed range: RV, right valve.

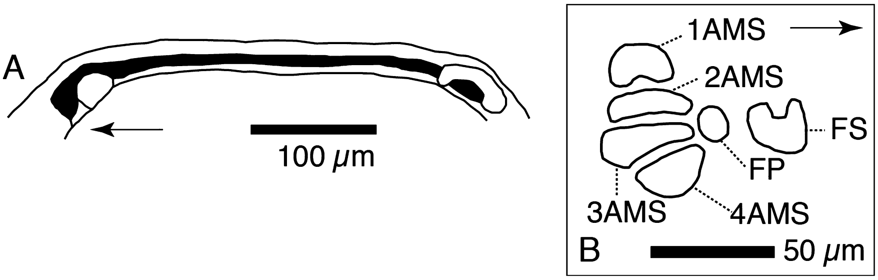

Fig. 4. The outlines of the hingement, muscle scars, and a fulcral point in the adult stage of *Sagmatocythere sawanensis* sp. nov. **A**, hingement in female LV (paratype, MPC-25007). **B**, muscle scars with fulcral point in female RV (paratype, MPC-25006). Arrows indicate anterior. Abbreviations: FP, fulcral point; FS, frontal scar; 1AMS, first-row adductor muscle scar; 2AMS, second-row adductor muscle scar; 3AMS, third-row adductor muscle scar; 4AMS, fourth-row adductor muscle scar.

Occurrence: Fossil, Pleistocene, Japan; Lower Pleistocene Sasaoka, Kawachi, Kaidate, and Hamada Formations, Middle Pleistocene Shichiba Formation, Upper Pleistocene Anden Formation of Sea of Japan coast. Recent, off northern Japan; northeastern Sea of Japan east of Rebun Island off Hokkaido from surface sediment obtained at 60 m water depth, south of Okushiri Island off Hokkaido from surface sediment obtained at 100 m depth, and in Otsuchi Bay area of northeastern coast of Honshu at Pacific side from surface sediment obtained at 30–90 m depth (See Table 1). For detailed sampling data, see Ikeya *et al.* (1992), Ozawa *et al.* (1999), and Ozawa and Tsukawaki (2008).

Measurements (mm; See Table 2): Holotype, L = 0.53, H = 0.31 (female RV, MPC-25002). Paratypes, L = 0.50, H = 0.31 (female LV, MPC-25003); L = 0.50, H = 0.28 (male LV, MPC-25004); L = 0.49, H = 0.28 (male RV, MPC-25005); L = 0.52, H = 0.30 (female LV, MPC-25006); L = 0.52, H = 0.30 (female RV,

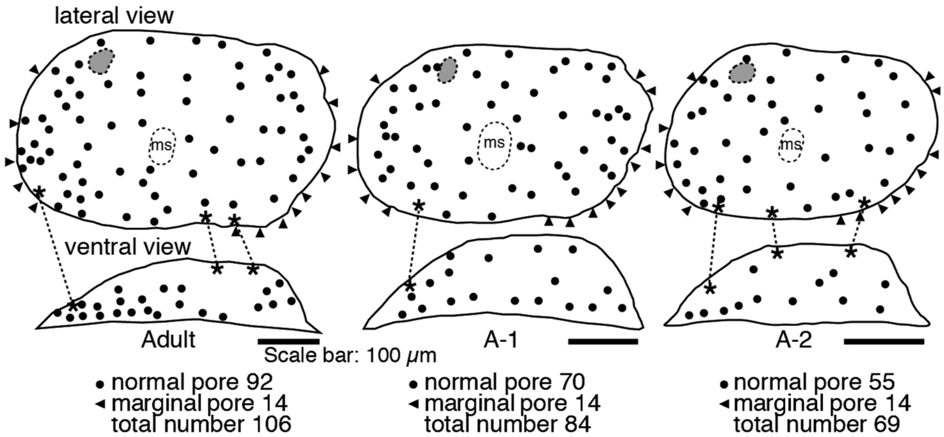

Fig. 5. The distributional pattern of pores in LV of last three molting stages of *Sagmatocythere sawanensis* sp. nov. with pore numbers. Black spots show normal pores. Asterisks represent normal pores seen in both views. Black triangles show locations of marginal pores in lateral view. A shaded oval represents the eye tubercle. A dotted area oval labelled 'ms' represents the muscle scar area.

MPC-25007).

Remarks: The general carapace morphology and carapace outline of *Sagmatocythere sawanensis* sp. nov. are most similar to those of *S. gombosi* Brouwers, 1993, described from Holocene sediments off Alaska in the northeastern Pacific. The new species is distinguished from the latter by having the hingement with a single round anterior element and a comma-shaped posterior element, more prominent eye tubercle, more apparent reticulation, and a conspicuous short ridge on the postero-dorsal area.

Sagmatocythere sawanensis sp. nov. is distinguished from *S. napoliana* (Puri, 1963), that is the type species of the genus from modern sediments of the Adriatic Sea (Bonaduce *et al.* 1975), in having a single round tooth in the posterior area of the hingement, a smooth median element of the hingement, a large alar projection in the postero-ventral area, and finer reticulations. In contrast, *S. napoliana* has a different hingement with a comma-shaped and lobate posterior element area and a crenulated median element, small tubercles in the postero-ventral area, and ornaments with coarser reticulations.

S. napoliana and *S. versicolor* (Müller, 1894) have the hingement with a comma-shaped and lobate posterior element (e.g., Athersuch and Horne 1984). The other species including *S. sawanensis* sp. nov., *S. concentrica* (Bonaduce *et al.*, 1975) and *S. littoralis* (Müller, 1894), have the hingement with a comma-shaped terminal element and an indistinct or less distinct lobate element. This genus displays intraspecific variation in the lobateness of the posterior terminal elements (e.g., Bonaduce *et al.* 1975).

Loxoconcha sp. by Ikeya *et al.* (1992; fig. 10-1a, b), from modern sediments of Otsuchi Bay, Pacific coast of northeastern Japan, is here identified as the A-1 stage of *Sagmatocythere sawanensis* sp. nov., because of its carapace size, outline, and surface ornamentation.

Etymology: Named after the old name for the type locality, Sawane.

Discussion

Biogeography

Previously *Sagmatocythere* has never been reported in the northwestern Pacific. Based on our study and reported localities of *Sagmatocythere*, diversification of this genus is modeled as follows: By the Late Cretaceous, *Sagmatocythere* thus appeared on the east coast of North America. The oldest record of *Sagmatocythere* is *S. minardi* (Brouwers and Hazel, 1978) from the Upper Cretaceous (Maastrichtian) of the east coast of the North America (Athersuch and Horne 1984). Since the Miocene, four other species have appeared in the coasts of South Europe and New Zealand (e.g., Athersuch and Horne 1984; Milhau 1993). Our data indicate that *Sagmatocythere* dispersed into Japan as well as Alaska in the Early Pleistocene (Brouwers 1993; this study). Today several species inhabit coastal marine environments in the Northeast Atlantic, Mediterranean Sea, and North Pacific (e.g., Bonaduce *et al.* 1975; Athersuch *et al.* 1989).

The oldest fossil of *S. sawanensis* sp. nov. is recorded from the Lower Pleistocene Sasaoka Formation (ca. 2 Ma according to Yamada *et al.* 2002). Based on its geographical/geological occurrence, *S. sawanensis* was endemic to the eastern part of the Sea of Japan during the Early Pleistocene (Fig. 2), and it appears to have originated there. From the Late Miocene to the Late Pliocene, the Sea of Japan was essentially closed and differed from the present Sea of Japan in that it was not well connected to the East China Sea (e.g., Tada 1994). *S. sawanensis* might have migrated to the Pacific during the Holocene, based on the youngest fossil from the Upper Pleistocene Anden Formation in the Sea of Japan (ca. 0.1 Ma; according to Shirai *et al.* 1997) and the single known occurrence from modern Pacific sediments (Ikeya *et al.* 1992; Fig. 2). Our study is the first report on *Sagmatocythere* from the Sea of Japan and its adjacent areas.

Ecology

Currently, *Sagmatocythere sawanensis* sp. nov. is found on the upper-shelves shallower than 100 m in the Sea of Japan from fine- to medium-grained shelly sand, with one report from the Pacific side of Honshu at a depth of less than 80 m mainly from fine- to medium-grained sand with many shell fragments (Ikeya *et al.* 1992). Fossils of *S. sawanensis* commonly co-exist with the upper-shelf taxa, such as *Baffinicythere*, *Neonesidea*, *Schizocythere*, etc., from Pleistocene calcareous fine- to medium-grained sand along the Sea of Japan (e.g., Ozawa and Domitsu 2010; Ozawa unpublished data). It should, therefore, be able to inhabit the upper shelf off Hokkaido (ca. 42–45°N) and Honshu (ca. 39°N; Fig. 2), where winter water temperatures are lower than ca. 5°C (e.g., Terazaki and Shikama 1979; Ozawa 2003). This is because the Tsushima and Kuroshio Warm Currents control the water temperature of the continental shelves along Honshu, both in the Sea of Japan (ca. 34–41°N) and the northwestern Pacific (south of 35°N), where winter temperatures exceed 10°C (e.g., Ikeya and Cronin 1993; Ozawa 2003). It is assumed that the inhabiting range limit of *S. sawanensis* sp. nov. would be set by warm-tolerance.

Acknowledgments

We wish to thank Y. Tanimura and M. Saito (National Museum of Nature and Science, Japan) for kind assistance in various aspects of preparing the manuscript and the registration of specimens. Thanks are also due to A. Tsukagoshi (Shizuoka University, Japan), S. Tsukawaki, M. Kato, T. Ishii, and T. Sato (Kanazawa University, Japan), T. Yamaguchi (CMCR of Kochi University, Japan), Y. Nakao (Nihon University, Japan), K. Ikehara, H. Katayama (AIST, Japan), E. M. Brouwers (U.S. Geological Survey, U.S.A.), S. Kawagata (Yokohama National University, Japan), the late N. Ikeya and the late Y. Kuwano for supplying sediment samples with ostracod remains, helping to prepare the manuscript, and aiding with access to specimens and literature. Constructive reviews with valuable advice were provided by A. Wood (Coventry University, U.K.), M. J. Grygier (Lake Biwa Museum, Japan), T. Irizuki (Shimane University, Japan) and an anonymous reviewer. We express our sincere gratitude to the captains and crews of the R.V. *Hakurei-maru* (AIST, Japan) and *Tansei-maru* (JAMSTEC, Japan) and all onboard scientists for their help with collecting sediment samples during Cruises GH98 and KT04-20.

References

Athersuch, J. (1976). On *Sagmatocythere napoliana* (Puri). *Stereo-Atlas of Ostracod Shells*, **3**: 117–124.

Athersuch, J. and Horne, D. J. (1984). A review of some European genera of the Family Loxoconchidae (Crustacea; Ostracoda). *Zoological Journal of the Linnean Society*, **81**: 1–22.

Athersuch, J., Horne, D. J. and Whittaker, J. E. (1989). Marine and Brackish Water ostracods. In: Kermack, D. M. and Barnes, R. S. K. (Ed.) Synopses of the British Fauna (New Series) No. 43. The Linnean Society of London and the Estuarine and Brackish-Water Sciences Association, 343 pp, E. J. Brill, Leiden.

Bonaduce, G., Ciampo, G. and Masoli, M. (1975). Distribution of Ostracoda in the Adriatic Sea. *Pubblicazioni Della Stazione Zoologica di Napoli*, **40** (Suppl. 1): 1–304.

Brouwers, E. M. (1993). Systematic paleontology of Quaternary ostracode assemblages from the Gulf of Alaska, Part 2: Families Trachyleberididae, Hemicytheridae, Loxoconchidae, Paracytheridae. *United States Geological Survey Professional Paper*, **1531**: 1–47.

Brouwers, E. M. and Hazel, J. E. (1978). Ostracoda and correlation of the Severn Formation (Navarroan; Maestrichtian) of Maryland. *SEPM Palaeontological Monograph*, **1**: 1–52.

Cronin, T. M. and Ikeya, N. (1987). The Omma Manganji ostracode fauna (Plio-Pleistocene) of Japan and the zoogeography of circumpolar species. *Journal of Micropalaeontology*, **6**: 65–88.

Hanai, T. (1957). Studies on the Ostracoda from Japan, II. Subfamily Pectocytherinae, new subfamily. *Journal of the Faculty of Science, The University of Tokyo (Section 2)*, **10**: 469–482.

Horne, D. J. (2003). Key events in the ecological radiation of the Ostracoda. In: Park, L. E. and Smith, A. J. (Ed.) Bridging the Gap: Trends in the Ostracode Biological and Geological Sciences. The Paleontological Society Papers 9, Yale University, New Haven, pp. 153–179.

Ikeya, N. and Cronin, T. M. (1993). Quantitative analysis of Ostracoda and water masses around Japan: Application to Pliocene and Pleistocene paleoceanography. *Micropalaeontology*, **39**: 263–281.

Ikeya, N., Zhou, B. C. and Sakamoto, J. (1992). Modern ostracode fauna from Otsuchi Bay, the Pacific coast of northeastern Japan. In: Ishizaki, K. and Saito, T. (Ed.) Centenary of Japanese Micropaleontology. Terra Scientific Publishing Company, Tokyo, pp. 339–354.

Irizuki, T. (1993). Morphology and taxonomy of some Japanese hemicytherin Ostracoda—with particular reference to ontogenetic changes of marginal pores. *Transactions and Proceedings of the Palaeontological Society of Japan, New Series*, **170**: 186–211.

Ishii, T., Kamiya, T. and Tsukagoshi, A. (2005). Phylogeny and evolution of *Loxoconcha* (Ostracoda, Crustacea) species around Japan. *Hydrobiologia*, **538**: 81–94.

Ishizaki, K, and Matoba, Y. (1985). Excursion 5, Akita (Early Pleistocene cold, shallow water Ostracoda). In: Ikeya, N. (Ed.) Guidebook of Excursions for 9th International Symposium of Ostracoda, Shizuoka. Organising committee of 9th ISO, Shizuoka, pp. 1–12.

Kato, M., Akada, K., Takayama, T., Goto, T., Sato, T., Kudo, T. and Kameo, K. (1995). Calcareous microfossil biostratigraphy of the uppermost Cenozoic Formation distributed in the coast of the Japan Sea—"Sawane Formation". *Annals of Science of Kanazawa University*, **32**: 21–38. (In Japanese with English abstract.)

Milhau, B. (1993). Nouveaux ostracodes du Miocène inférieur de nouvelle-zélande. *Geobios*, **26**: 161–200. (In French with English abstract.)

Müller, G. W. (1894). Die Ostracoden des Golfes von Neapel und der angrenzenden Meeres-abschnitte. *Fauna und Flora des Golfes von Neapel Monographie*, **21**: 1–404.

Ozawa, H. (2003). Japan Sea ostracod assemblages in surface sediments: their distribution and relationships to water mass properties. *Paleontological Research*, **7**: 257–274.

Ozawa, H. (2010a). Extinction of cytheroidean ostracodes (Crustacea) in shallow-water around Japan in relation to environmental fluctuations since the early Pleistocene. In: Tepper, G. H. (Ed.) Species Diversity and Extinction. Nova Science Publishers, Incorporated, New York, pp. 61–109.

Ozawa, H. (2010b). Preliminary report on occurrences of the middle Pleistocene ostracods from the Shichiba Formation on Sado Island at the eastern Japan Sea, central Japan. *Nihon-Kaiiki Kenkyu, Kanazawa University*, **41**: 15–36.

Ozawa, H. (2013). Chapter 4: The History of Sexual Dimorphism in Ostracoda (Arthropoda, Crustacea) since the Palaeozoic. In: Moriyama, H. (Ed.) Sexual Dimorphism. InTech Open Access Company, Rijeka, pp. 51–80.

Ozawa, H. and Domitsu, H. (2010). Early Pleistocene ostracods from the Hamada Formation in the Shimokita Peninsula, northeastern Japan: palaeo-biogeographic significance of the occurrence for the shallow-water fauna. *Paleontological Research*, **14**: 1–18.

Ozawa, H. and Kamiya, T. (2005a). Ecological analysis of benthic ostracods in the northern Japan Sea, based on water properties of modern habitats and late Cenozoic fossil records. *Marine Micropaleontology*, **55**: 255–276.

Ozawa, H. and Kamiya, T. (2005b). The effects of glacioeustatic sea-level change on Pleistocene cold-water ostracod assemblages from the Japan Sea. *Marine Micropaleontology*, **54**: 167–189.

Ozawa, H. and Kamiya, T. (2009). A new species of *Aurila* (Crustacea: Ostracoda: Cytheroidea: Hemicytheridae) from the Pleistocene Omma Formation on the coast of the Sea of Japan. *Species Diversity*, **14**: 27–39.

Ozawa, H. and Tsukawaki, S. (2008). Preliminary report on modern ostracods in surface sediment samples collected during R. V. *Tansei-maru* Cruise KT04-20 in the southwestern Okhotsk Sea and the northeastern Japan Sea off Hokkaido, north Japan. *Annals of the Research Institute of the Japan Sea Region*, **39**: 31–48.

Ozawa, H., Ikehara, K. and Katayama, H. (1999). Recent ostracod fauna in the northeastern part of the Japan Sea, off northwestern Hokkaido. In: Ikehara, K. and Okamura, Y. (Ed.) Comprehensive Study on Environmental Changes in the Western Hokkaido Coastal Area and Study on Evaluation of Marine Active Faults. Geological Survey of Japan, Tsukuba, pp. 103–117. (In Japanese.)

Puri, H. S. (1963). Preliminary notes on the Ostracoda of the Gulf of Naples. *Experientia*, **19**: 368–373.

Sars, G. O. (1926). Ostracoda, Parts 13, 14. Cytheridae (continued). In: An Account of the Crustacea of Norway with Short Descriptions and Figures of All the Species, Volume 9, Bergen Museum, Bergen, pp. 209–240.

Shirai, M., Tada, R. and Fujioka, K. (1997). Identification and chronostratigraphy of Middle to Upper Quaternary marker tephras occurring in the Anden coast based on comparison with ODP cores in the Japan Sea. *Quaternary Research, Tokyo*, **36**: 183–196. (In Japanese with English abstract.)

Tabuki, R. (1986). Plio-Pleistocene Ostracoda from the Tsugaru Basin, North Honshu, Japan. *Bulletin of the College of Education, University of the Ryukyus*, **29**: 27–160.

Tada, R. (1994). Paleoceanographic evolution of the Japan Sea. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **108**: 487–508.

Terazaki, M. and Shikama, N. (1979). Monthly variation of water temperature and salinity in Otsuchi Bay. *Report of the Otsuchi Marine Research Center*, **5**: 9–14. (In Japanese.)

Tsukagoshi, A. and Ikeya, N. (1987). The ostracod genus *Cythere* O. F. Müller, 1785 and its species. *Transactions and Proceedings of the Palaeontological Society of Japan*, *New Series*, **148**: 197–222.

Yamada, K., Irizuki, T. and Tanaka, Y. (2002). Cyclic sea-level changes based on fossil ostracode faunas from the upper Pliocene Sasaoka Formation, Akita Prefecture, central Japan. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **185**: 115–132.