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Article

Fossil Ostracoda from the lower Pleistocene Masuda Formation, Tanega-shima Island, southern Japan

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Abstract

Eighty-four species of fossil ostracodes are described for the first time in four sediment samples from the lower Pleistocene Masuda Formation (ca. 1.4–1.0 Ma), Tanega-shima Island, southern Japan. The dominant species are *Neonesidea oligodentata*, *Aurila corniculata*, *Xestoleberis hanaii*, *Schizocythere kishinouyei*, and *Cytheropteron miurense*, which live on near-shore sand or algae under the influence of open water currents. Upper to middle sublittoral species, such as *Argilloecia* spp., *Cytheropteron uchioi*, and *Cytherelloidea hanaii*, are also present. Therefore, the depositional environment of the Masuda Formation was an upper to middle sublittoral zone under the strong influence of open near-shore currents. The fossil ostracode assemblages are more similar to Recent warm temperate water assemblages found around the Honshu and Shikoku Islands than to the tropical water assemblages found in the Pleistocene to Holocene deposits of the Ryukyu Islands.

Key words: Lower Pleistocene Masuda Formation, Ostracoda, Tanaga-shima Island

Introduction

Many paleontologists and neontologists have focused on small islands surrounded by deep straits or seas to study allopatric speciation. One such area extends from Kyushu Island to the Ryukyu Islands, southern Japan. Its paleogeography has changed with glacial sea-level changes and local tectonic events during the late Tertiary to Quaternary periods (e.g., Ujiié, 1994; Kimura, 2002). During the glacial periods, the Eurasian Continent, Taiwan Island, the Ryukyu Islands, and Kyushu Island were partly connected, whereas many straits developed between them during the interglacial periods. The Tokara Strait, which is situated between the Tanega-shima and Amami-ohshima Islands in southern Japan, now forms a barrier to many terrestrial animals called the Watase's line, but was not deep enough to prevent the immigration of terrestrial animals during the late Tertiary to early Quaternary periods (Otsuka and Kuwayama, 2000). Many evolutionary studies of vertebrate fossils have been conducted because strata containing these fossils occur around the Kyushu and Ryukyu Islands (e.g., Kimura, 2000). Benthic ostracodes are minute crustaceans with no planktonic periods in their life cycles. Their capacity for dispersal is inferred to be low, and speciation and disappearance events occurred during the Pleistocene to Holocene epochs (e.g., Ishizaki, 1990; Irizuki et al., 2004). I focused on fossil ostracodes from the lower Pleistocene Masuda Formation on Tanega-shima Island, which is to the north of the Tokara Strait, to study the relationships between the paleogeography of southern Japan and the migration, speciation, and disappearance of ostracodes during the Pleistocene to Holocene epochs. In this study, I report fossil ostracode faunas and the depositional environments inferred from them.

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General Geology

On Tanega-shima Island, south of Kyushu, Neogene deposits are composed of, in ascending order, the Paleogene Kumage Group of the Shimanto Supergroup (alternating beds of sandstone and siltstone), the Middle Miocene Kukinaga Group containing such tropical molluscan genera as *Vicarya* and *Terescopium*, and unconformably overlying Quaternary deposits (Hayasaka et al., 1983; Otsuka and Kuwayama, 2000). The Masuda Formation, which is the objective stratum in the present study, is the lowermost part of the Quaternary deposits. It is typically distributed from the middle to western part of the island and is composed of bay to shallow marine deposits. The Katanoyama Member of the Masuda Formation is distributed in the Katanoyama district, in the northern part of the island. It unconformably overlies the Kumage Group and is composed of sand, silt, and lignite beds containing fossils of fish, molluscs, crustaceans, amphibians, mammals, and plants. This assemblage is called the Katanoyama Fossil Assemblage (Otsuka and Kuwayama, 2000). Many fossil molluscs and brachiopods have been reported from the Masuda Formation in the Shimama to Kajikata districts in Nakatane Town, in southern Tanega-shima Island (Hayasaka, 1973; Hayasaka et al., 1983). Hatta (1988) reported fossil foraminifers from the same locality as that described in Hayasaka's studies (1973, 1983)

Hayasaka (1973) suggested, on the basis of fossil molluscs, that the depositional age of the Masuda Formation was early Pliocene. Hatta (1988) reported fossils indicative of the planktonic foraminiferal zone N.22 of Blow (1969), suggesting that the formation is Pleistocene in age. According to Otsuka and Kuwayama (2000), the lowest to middle part of the Masuda Formation in Nakatane Town has reversed polarity and the upper part has normal polarity. Moreover, the fission-track ages of the three intercalating tuff layers are 1.4 ± 0.2 Ma, 1.1 ± 0.2 Ma, and 1.0 ± 0.2 Ma. Therefore, the age of the Masuda Formation is early Pleistocene.

Materials

At the end of July 2002, I investigated the geology of the Katanoyama and Kajikata districts, throughout both of which the Masuda Formation is distributed. Many well-preserved fossil molluscs are found in the Kajikata district, whereas the deposits in the Katanoyama district are weathered. I collected samples of fossil ostracodes only from a cliff at a road cutting at Kajigata, Nakatane Town, southern Tanega-shima Island, where well-preserved fossil molluscs occurred (Fig. 1). This site corresponds to locality 1 of Hayasaka (1973) and Hatta (1988). The Masuda Formation exposed here is composed of sandstone more than 6 m thick. The lower half of the exposure consists of 3 m thick calcareous pebbly and muddy medium-grained sandstone intercalating with fossil-rich layers containing molluscs, brachiopods, bryozoans, and barnacles. Hayasaka (1973) reported such molluscan species as *Chlamys nipponica*, *Mizuhopecten tokyoensis hokurikuensis*, and *Notostrea musashiana*, and such brachiopod species as *Pictothyris* spp. and *Coptothyris* spp. The upper half of the exposure is weathered and composed of massive pebbly and muddy medium sandstone. Four samples (MD-1 to MD-4, in ascending order) were collected from the lower half of the exposure (Fig. 2). Sample MD-2 was collected from a fossil-rich layer.

Laboratory Procedures

Dried samples of about 100 g were weighed, boiled in a beaker for one hour on a hot plate, and washed with water on a 200-mesh sieve screen (opening, 75 μm). The samples were dried, then soaked in naphtha solution for about one hour. After the remaining naphtha was removed, the samples were boiled again for about two hours and washed on a 200-mesh sieve screen. As far as possible, 200 ostracode specimens were picked from each dried fraction on a 115-mesh sieve screen (125 μm) under a binocular microscope. The number of specimens (N in Table 1) was calculated by summing the valves and carapaces. Plates 1 to 3 show scanning electron micrographs, taken with a JEOL T-220A, of most species represented by more than three specimens in the four samples from the Masuda Formation.

Results and Discussion

About 200 specimens were picked from the four samples collected from the lower part of the Masuda Formation. The preservation of specimens is generally good but some specimens are badly preserved due to dissolution. Eighty-four species were identified in four samples (Table 1). Some species have not been previously described. Many of the species currently live along the coasts from central to southern Japan. The number of species in each sample was 47–56 (Table 1). The species diversity index, given by the Shannon-Wiener function ($H(S) = -\Sigma p_i \ln p_i$, where p_i = the proportion of specimens of the ith species) ranged from 3.31 to 3.44. The equitability index of Buzas and Gibson (1969) ($Eq. = e^{H(S)}/S$, where $H(S)$ = species diversity index, S = species number) ranged from 0.55 to 0.61. The high values for species diversity are dependent on species numbers because the equitability values are not high.

The most dominant species is *Neonesidea oligodentata*, numbering 95 individuals among 967 specimens. The subordinate species are *Aurila corniculata* and *Xestoleberis hanaii.* These three species live in *Zostera* beds or intertidal zones with many kinds of algae under the influence of the warm Kuroshio Current (e.g., Ishizaki, 1968; Hanai et al., 1977). Other dominant species are *Schizocythere kishinouyei* and *Cytheropteron miurense*, which are sand dwellers in shallow seas under the influence of open water, and are widely observed on Japanese coasts today (e.g., Hanai, 1957; Hanai et al., 1977). A few specimens of such upper to middle sublittoral species as *Cytheropteron uchioi*, *Argilloecia* spp., and *Cytherelloidea hanaii* (Ishizaki, 1981; Zhao and Wang, 1988; Zhou, 1995) also occurred in the samples. No enclosed muddy bay species were identified, except *Trachyleberis* sp. Thus, the ostracode assemblage from the Masuda Formation is characterized by mixed species including sand dwellers, phytal species, and middle sublittoral species. Therefore, the depositional environments of the formation are inferred to have been upper to middle sublittoral areas near rocky shores or *Zostera* beds under the influence of open-shore and near-shore currents.

The similarity index given by Horn's (1966) overlap index was calculated to discuss species differences among the samples (Table 2). If the two samples selected have the same species composition, the similarity value is 1.0. If they have no common species, then the value is 0. The similarity index between sample MD-1 and the other samples was relatively low (about 0.72), suggesting that the species composition of sample MD-1 was slightly different from that of the other samples. The similarity values between samples MD-2 and MD-3, and samples MD-3 and MD-4 were 0.86 and 0.87, respectively. The similarity value between samples MD-2 and MD-4 is 0.78. Therefore, species composition changes upwards through the formation. To clarify the ostracode faunal changes through the sequence, vertical changes in the relative frequency of

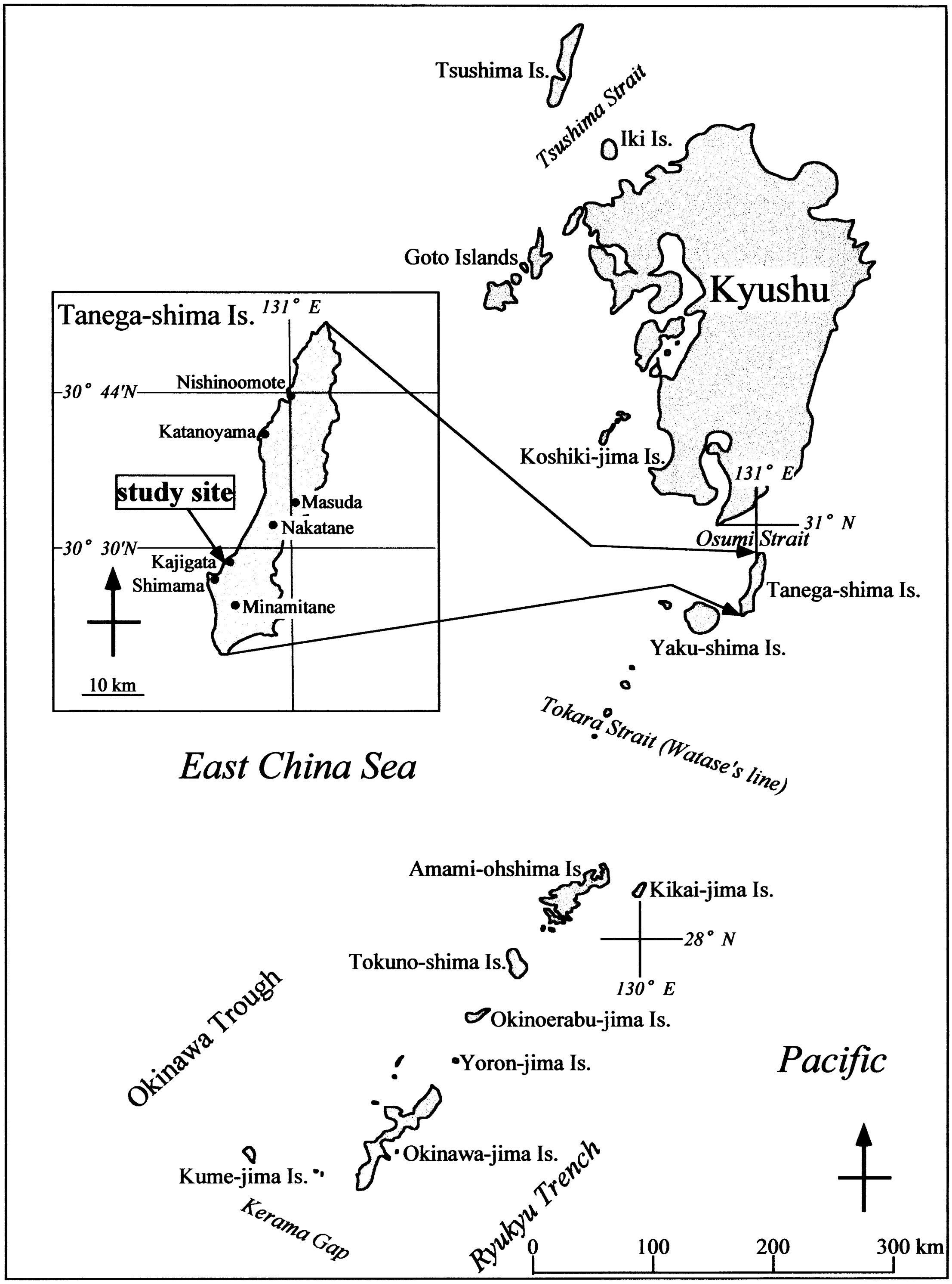

Fig. 1. Index map and location of the study site.

selected taxa were investigated. The most dominant species, *Neonesidea oligodentata*, increases upwards in the sequence from 3% to 14% (Fig. 3). A species that lives in shallow open sandy coasts, *Schizocythere kishinouyei*, also increases in number moving upwards in the formation. The relatively deep-water species, *Argilloecia* spp., is not included in the lowest sample. On the other hand, *Callistocythere undulatifacialis* and *Loxoconcha uranouchiensis*, which are dominant along coasts in bays, are dominant in sample MD-1 but rare in the upper samples (Fig. 3). Therefore, water depth became greater and the influence of the open sea became stronger moving upwards through the formation.

Hayasaka (1973) reported mixed molluscan assemblages

Table 1. List of fossil ostracodes from the Masuda Formation.

Masuda Formation	MD1	MD2	MD3	MD4	
Ambtonia sp.	2	1	1	1	5
Argilloecia lunata Frydl		2	2	1	5
Argilloecia sp. 1		2	2	4	8
Argilloecia sp. 2				1	1
Aurila corniculata Okubo	27	14	12	23	76
Aurila hataii Ishizaki	1				1
Aurila kiritsubo Yajima	2		1	2	5
Aurila tosaensis Ishizaki	1				1
Aurila uranouchiensis Ishizaki	3	2	2		7
Aurila sp. 1		4	3	4	11
Aurila sp. 2			1	1	2
Australimoosella tomokoae (Ishizaki)	2				2
Bythoceratina angulata Yajima		2	2		4
Bythoceratina hanaii Ishizaki	1	6	11	12	30
Bythoceratina sp.	1		1		2
Bythocythere maisakensis Ikeya & Hanai	1	1			2
Callistocythere japonica Hanai	2	1	1		4
Callistocythere cf. *reticulata* Hanai	1				1
Callistocythere undata Hanai	1				1
Callistocythere undulatifacialis Hanai	18	4	5	5	32
Coquimba cf. *subgibba* Hu	3		2	1	6
Cornucoquimba tosaensis (Ishizaki)	12	1	7	7	27
Cythere sp.	2				2
Cytherelloidea hanaii Nohara	3	3	3	4	13
Cytherelloidea munechikai Ishizaki		1			1
Cytheroma ? hanaii Yajima		1			1
Cytheropteron miurense Hanai	8	10	25	12	55
Cytheropteron uchioi Hanai			1		1
Cytheropteron sp.		4	3	3	10
Cytherura ? sp.		1	1		2
Hanaiborchella miurensis (Hanai)		1	3	3	7
Hanaiborchella triangularis (Hanai)	1			1	2
Hemicytherura cuneata Hanai	8	8	18	15	49
Hemicytherura kajiyamai Hanai	1		1		2
Hemicytherura sp.	4	1	2	4	11
Kangarina sp.		1			1
Krithe japonica Ishizaki			3		3
Loxoconcha epeterseni Ishizaki	1	1	9	6	17
Loxoconcha harimensis Okubo	4	2	6	2	14
Loxoconcha japonica Ishizaki		1			1
Loxoconcha optima Ishizaki		2			2
Loxoconcha uranouchiensis Ishizaki	11	1			12
Loxoconcha zamia Ishizaki	5	1	6	11	23
Loxoconcha sp.	1	2	1	1	5
Loxocorniculum mutsuense Ishizaki	11		2	3	16
Macrocypris sp.	1	5	3		9
Metacytheropteron sp.				1	1
Microcythere sp.		1			1
Munseyella japonica (Hanai)	7	4	3	7	21
Munseyella sp.				1	1
Neonesidea oligodentata (Kajiyama)	8	20	36	31	95
Neonesidea sp.			1	1	2
Pacambocythere japonica (Ishizaki)	1				1
Paracytheridea dialata Gou & Huang	3	1		1	5
Paracytheridea echinata Hu	3				3
Paradoxostoma sp.		1			1
Parakrithella pseudadonta (Hanai)	8	9	8	4	29
Pontocythere sp. 1	9		1	1	11
Pontocythere sp. 2			1		1
Propontocypris sp.			8	5	13
Pseudoaurila japonica (Ishizaki)	2			2	4
Pseudocythere cf. *flydli* Yajima		1	4		5
Pseudocythere sp.		1			1
Pseudopsammocythere tokyoensis Yajima		1			1
Robustaurila salebrosa (Brady)	1				1
Robustaurila sp.	13	3	7	3	26
Schizocythere kishinouyei (Kajiyama)	11	10	24	16	61
Sclerochilus sp.		2	3	2	7
Semicytherura miurensis Hanai		3	3	1	7
Semicytherura mukaishimensis Okubo	1	1	3		5
Semicytherura cf. *wakamurasaki* Yajima			1	1	2
Semicytherura yajimae Ikeya & Zhou	1	3	2	1	7
Semicytherura sp. 1	10	5	3	2	20
Semicytherura sp. 2			1		1
Semicytherura sp. 3			2		2
Sinoleberis tosaensis (Ishizaki)			1		1
Trachyleberis straba Frydl	1	1	4	5	11
Trachyleberis sp.	2	1		2	5
Xestoleberis hanaii Ishizaki	20	22	29	5	76
Xestoleberis sagamiensis Kajiyama	13	8	4	2	27
Xestoleberis sp. 1	2			2	4
Xestoleberis sp. 2		2	3		5
Xestoleberis sp. 3		1	1		2
Xestoleberis ? sp.	2	1	4	2	9
No. of specimens	257	188	297	225	967
No. of specimens/1g sample	19.36	17.65	40.08	16.29	21.42
Sample weight (g)	13.28	10.65	7.41	13.81	45.15
No. of species	50	53	56	47	84
Diversity (H(S))	3.418	3.435	3.419	3.313	3.637
Equitability(Eq)	0.61	0.586	0.545	0.585	0.452

Table 2. Matrix of Horn's overlap index between samples.

	MD-1	MD-2	MD-3	MD-4
MD-1		0.724	0.7119	0.7279
MD-2			0.8617	0.7778
MD-3				0.8695
MD-4				

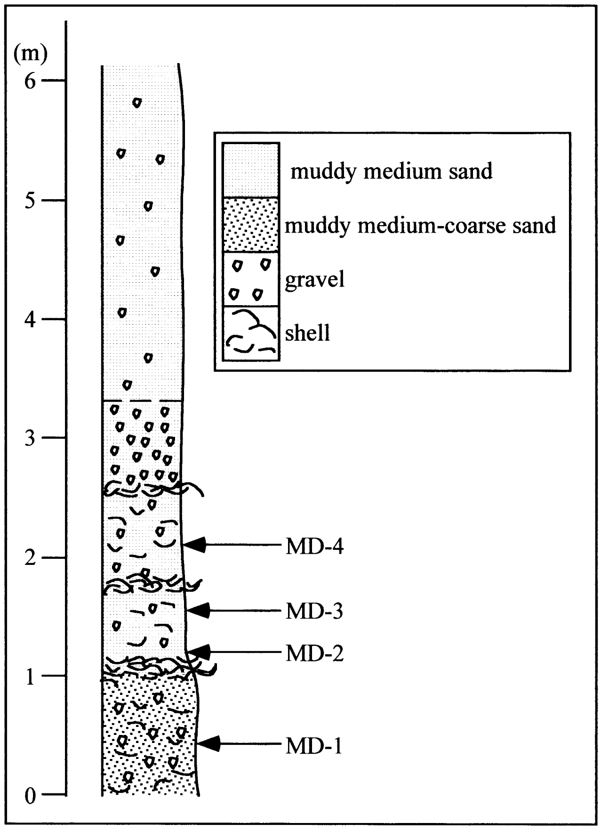

Fig. 2. Columnar section with sampling horizons in the study site.

composed of swimming, burrowing, or infaunal, epifaunal, and sessile species from the same locality (locality 1 of Hayasaka, 1973). They are mostly extant species, and only three species and one subspecies of these 32 species of molluscs and brachiopods are extinct. Hayasaka (1973) inferred that the depositional environment of the Masuda Formation was characterized by clear sea water of normal salinity and shallow depth in near-shore zones, with a bottom consisting largely of sand with local muddy areas and probably with a rocky bottom exposed here and there. Moreover, paleowater temperature was inferred to have been warm to moderate. According to Hatta (1988), 39% of the fossil foraminifers observed here are planktonic species. Hatta (1988) also reported such fossil benthic foraminifers as *Cibicides refulgens* and *Elphidium crispum*, which live in sandy shallow seas around Japan, and the *Eggerella-Textularia* assemblages and *Elphidium-Pseudononion* assemblages, characteristic of bays. He inferred on the basis of these fossil foraminifers that the depositional environments were shallow seas under the influence of open water. The results of the present study based on fossil ostracodes are consistent with those of previous studies and suggest that water depth increased and water turbulence became stronger upwards in the formation.

The ostracode faunas from the Masuda Formation were compared with those from the Pleistocene Nakoshi Sand and Chinen Sand from the Ryukyu Islands (Nohara, 1987), which are situated to the south of Tanega-shima Island and are now in a tropical marine climatic zone (Ogasawara, 1994). The depositional environments of these strata are thought to be similar to that of the Masuda Formation. According to Nohara (1987), 237 species and 36 species are included in the Chinen and Nakoshi Sands, respectively. The 10 highest-ranking species in the present study are also dominant in these formations but *Cornucoquimba shimajiriensis*, *Hermanites nodulosa*, *Paijenborchella spinosa*, and *Schizocythere taiwanensis*, which characterize those formations, are not found in the Masuda Formation. *Bradleya pitalia*, *Morkhovenia inconspicua*, *Neobuntonia* sp., and *Trieberina sertata*, which live only in tropical to subtropical shallow water (Zhou, 1995), are also not found in the Masuda Formation. Thus, the fossil ostracode faunas from Tanega-shima Island are somewhat different from the Pleistocene to Recent faunas of the Ryukyu Islands and are more similar to those living along the Pacific coasts from the Honshu to Shikoku Islands (e.g., Ishizaki, 1968; Frydl, 1982; Zhou, 1995), a warm temperate marine climatic zone (Ogasawara, 1994).

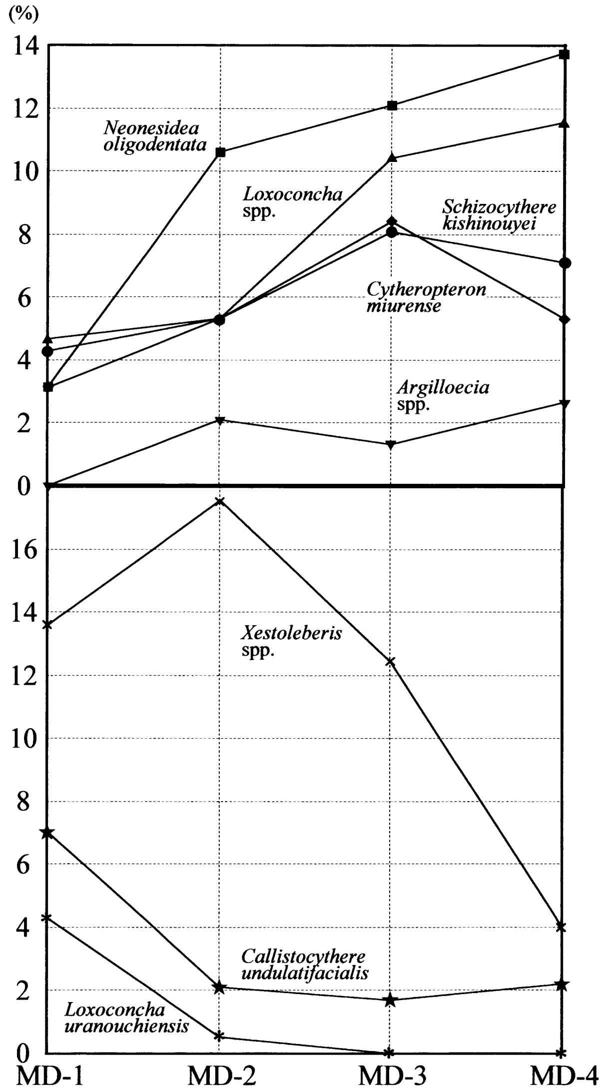

Fig. 3. Diagram showing vertical changes of relative frequency (%) of some selected taxa. Vertical and horizontal axes show relative frequency (%) and samples, respectively.

Conclusions

1. Eighty-four ostracode species occur in the lower Pleistocene Masuda Formation in Kajikata, Nakatane Town, Tanega-shima Island, southern Japan.
2. Fossil ostracode assemblages from the Masuda Formation are characterized by mixed species living in near-shore sand, upper to middle sublittoral seas, *Zostera* beds, and intertidal rocky shorefaces, under the influence of open water. They are more similar to Recent warm temperate water assemblages found from the Honshu to Shikoku Islands than to tropical water assemblages in the Pleistocene to Holocene deposits of the Ryukyu Islands.

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（要　旨）

入月俊明，2004，種子島下部更新統増田層から産出した貝形虫化石．島根大学地球資源環境学研究報告，23，65-77

84種の貝形虫化石が種子島に分布する下部更新統増田層（約1.4-1.0 Ma）から採取した4試料より初めて報告された．優占種は *Neonesidea oligodentata*，*Aurila corniculata*，*Xestoleberis hanaii*，*Schizocythere kishinouyei*，および *Cytheropteron miurense* で，これらは現在外洋水の影響が強い沿岸砂底や藻場に生息している種である．上～中部亜沿岸帯に生息する *Argilloecia* spp.，*Cytheropteron uchioi*，および *Cytherelloidea hanaii* も産出した．このように，増田層の堆積環境は開放的な沿岸流の影響が強い上部から中部亜沿岸帯と推定される．増田層の貝形虫化石群集は琉球列島の更新～完新世の堆積物中にみられる熱帯性群集よりも本州や四国で認められる暖温帯性群集により類似している．

Plate 1. Selected ostracode species from the lower Pleistocene Masuda Formation (Part 1). All figures were taken by scanning electron microscope (SEM). All specimens are stored in the Department of Geoscience, Interdisciplinary Faculty of Science and Engineering, Shimane University (DGSU). Scale bars indicate 0.1 mm (a for 2, b for 1, 8, 14-17 and 19, c for 3-6, 10-12 and 18, d for 7, 9 and 13). LV: left valve, RV: right valve.

1: *Cytherelloidea hanaii* Nohara, 1976, adult RV, sample MD-4, DGSU no. CO 0106.
2: *Neonesidea oligodentata* (Kajiyama, 1913), adult RV, sample MD-4, DGSU no. CO 0107.
3: *Macrocypris* sp., juvenile LV of carapace, sample MD-2, DGSU no. CO 0108.
4: *Argilloecia lunata* Frydl, 1982, adult LV, sample MD-2, DGSU no. CO 0109.
5: *Argilloecia* sp., adult LV of carapace, sample MD-2, DGSU no. CO 0110.
6: *Pontocythere* sp. 1, female RV of carapace, sample MD-1, DGSU no. CO 0111.
7: *Krithe japonica* Ishizaki, 1971, juvenile RV, sample MD-3, DGSU no. CO 0112.
8: *Parakrithella pseudadonta* (Hanai, 1959), female LV, sample MD-4, DGSU no. CO 0113.
9: *Munseyella japonica* (Hanai, 1957), female LV, sample MD-1, DGSU no. CO 0114.
10: *Callistocythere japonica* Hanai, 1957, adult LV, sample MD-3, DGSU no. CO 0115.
11: *Callistocythere undulatifacialis* Hanai, 1957, adult LV, sample MD-1, DGSU no. CO 0116.
12: *Schizocythere kishinouyei* (Kajiyama, 1913), adult LV, sample MD-4, DGSU no. CO 0117.
13: *Hanaiborchella miurensis* (Hanai, 1957), adult LV, sample MD-4, DGSU no. CO 0118.
14: *Aurila corniculata* Okubo, 1980, female RV, sample MD-3, DGSU no. CO 0119.
15: *Aurila kiritsubo* Yajima, 1982, adult LV of carapace, sample MD-4, DGSU no. CO 0120.
16: *Aurila uranouchiensis* Ishizaki, 1968, adult LV of carapace, sample MD-2, DGSU no. CO 0121.
17: *Aurila* sp., adult RV of carapace, sample MD-2, DGSU no. CO 0122.
18: *Robustaurila* sp., adult LV of carapace, sample MD-1, DGSU no. CO 0123.
19: *Pseudoaurila japonica* (Ishizaki, 1968), juvenile RV, sample MD-1, DGSU no. CO 0124.

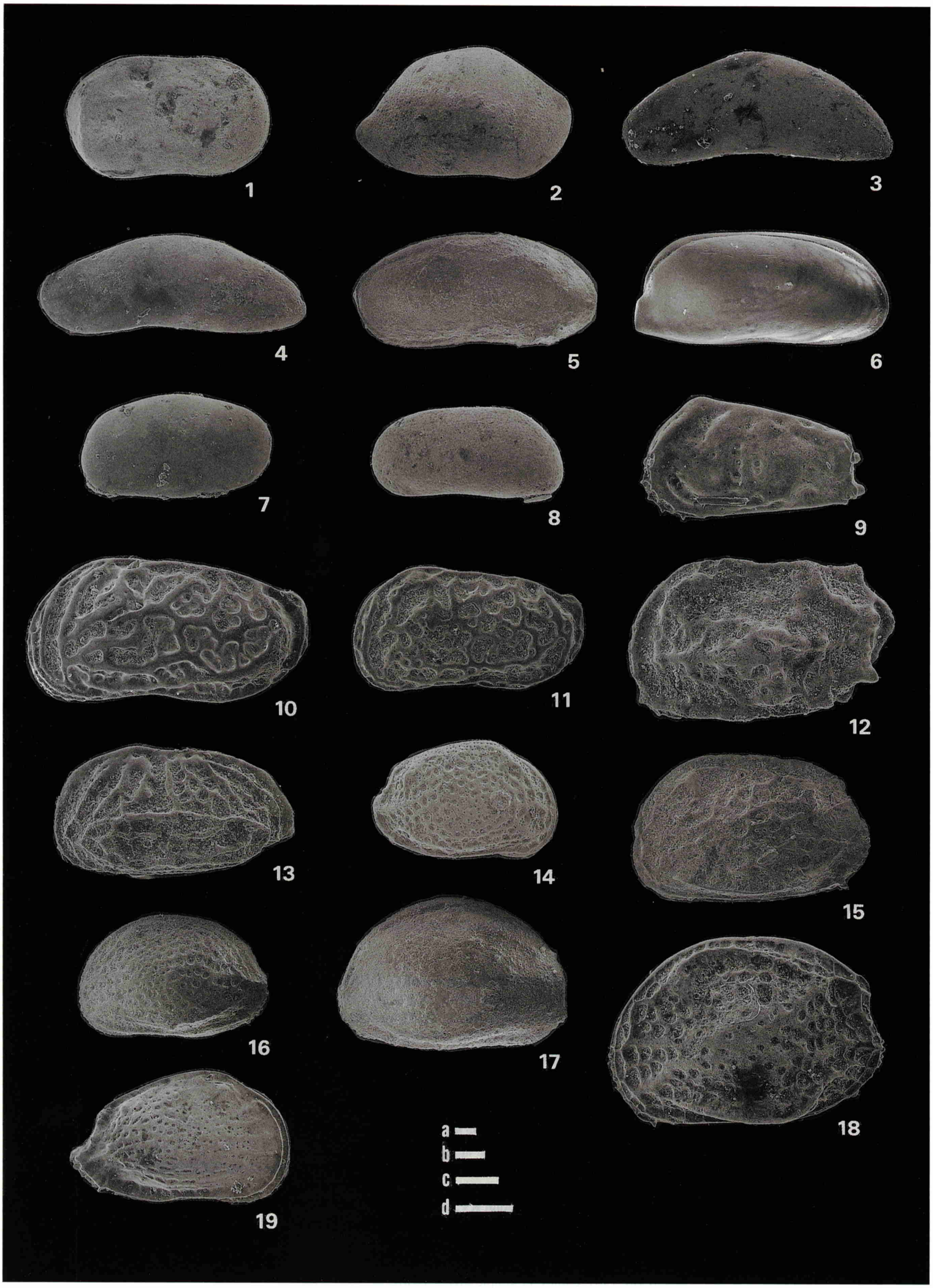
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Plate 2. Selected ostracode species from the lower Pleistocene Masuda Formation (Part 2). All figures were taken by scanning electron microscope (SEM). All specimens are stored in the Department of Geoscience, Interdisciplinary Faculty of Science and Engineering, Shimane University (DGSU). Scale bars indicate 0.1 mm (a for 3; b for 1, 4-7, 15-18; c for 2, 8-14). LV: left valve, RV: right valve.

1: *Cornucoquimba tosaensis* (Ishizaki, 1968), adult RV, sample MD-3, DGSU no. CO 0125.
2: *Coquimba* cf. *subgibba* Hu, 1982, adult RV, sample MD-3, DGSU no. CO 0126.
3: *Trachyleberis straba* Frydl, 1982, male RV, sample MD-3, DGSU no. CO 0127.
4: *Trachyleberis* sp., juvenile LV, sample MD-2, DGSU no. CO 0128.
5, 6: *Ambtonia* sp.; 5: female LV, sample MD-1, DGSU no. CO 0129; 6: male RV, sample MD-1, DGSU no. CO 0130.
7: *Bythoceratina hanaii* Ishizaki, 1968, adult LV, sample MD-3, DGSU no. CO 0131.
8: *Pseudocythere* cf. *flydli* Yajima, 1982, juvenile LV, sample MD-3, DGSU no. CO 0132.
9: *Hemicytherura* sp., adult LV, sample MD-3, DGSU no. CO 0133.
10: *Hemicytherura cuneata* Hanai, 1957, adult LV, sample MD-3, DGSU no. CO 0134.
11: *Semicytherura* sp. 1, adult LV, sample MD-1, DGSU no. CO 0135.
12, 14: *Semicytherura mukaishimensis* Okubo, 1980; 12: adult RV, sample MD-2, DGSU no. CO 0136; 14: adult LV, sample MD-3, DGSU no. CO 0137.
13: *Semicytherura yajimae* Ikeya and Zhou, 1992, adult RV, sample MD-3, DGSU no. CO 0138.
15: *Cytheropteron miurense* Hanai, 1957, adult LV, sample MD-3, DGSU no. CO 0139.
16: *Cytheropteron* sp., adult LV, sample MD-3, DGSU no. CO 0140.
17: *Paracytheridea dialata* Gou and Huang, 1983, female RV, sample MD-4, DGSU no. CO 0141.
18: *Paracytheridea echinata* Hu, 1981, adult LV, sample MD-1, DGSU no. CO 0142.

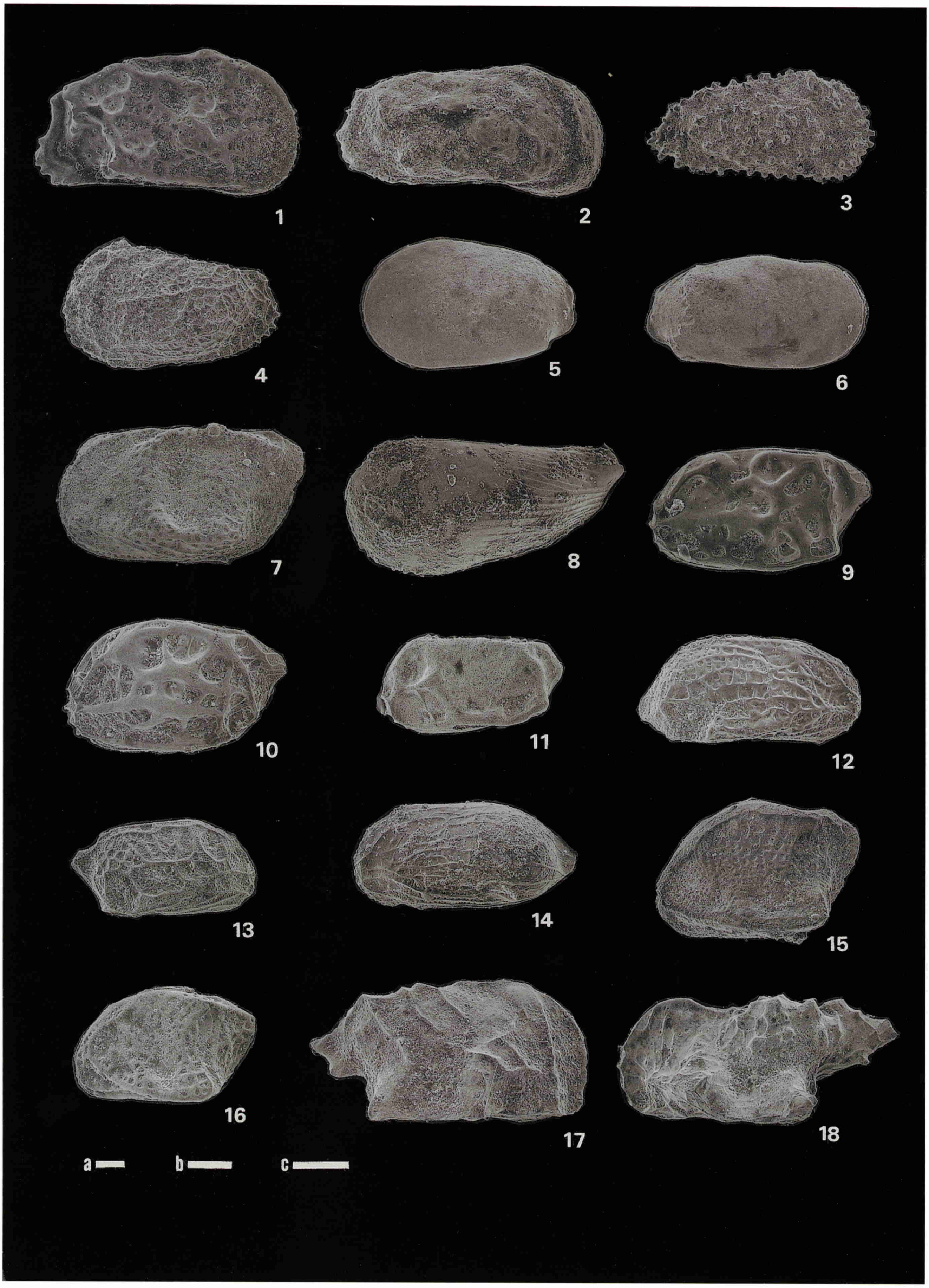
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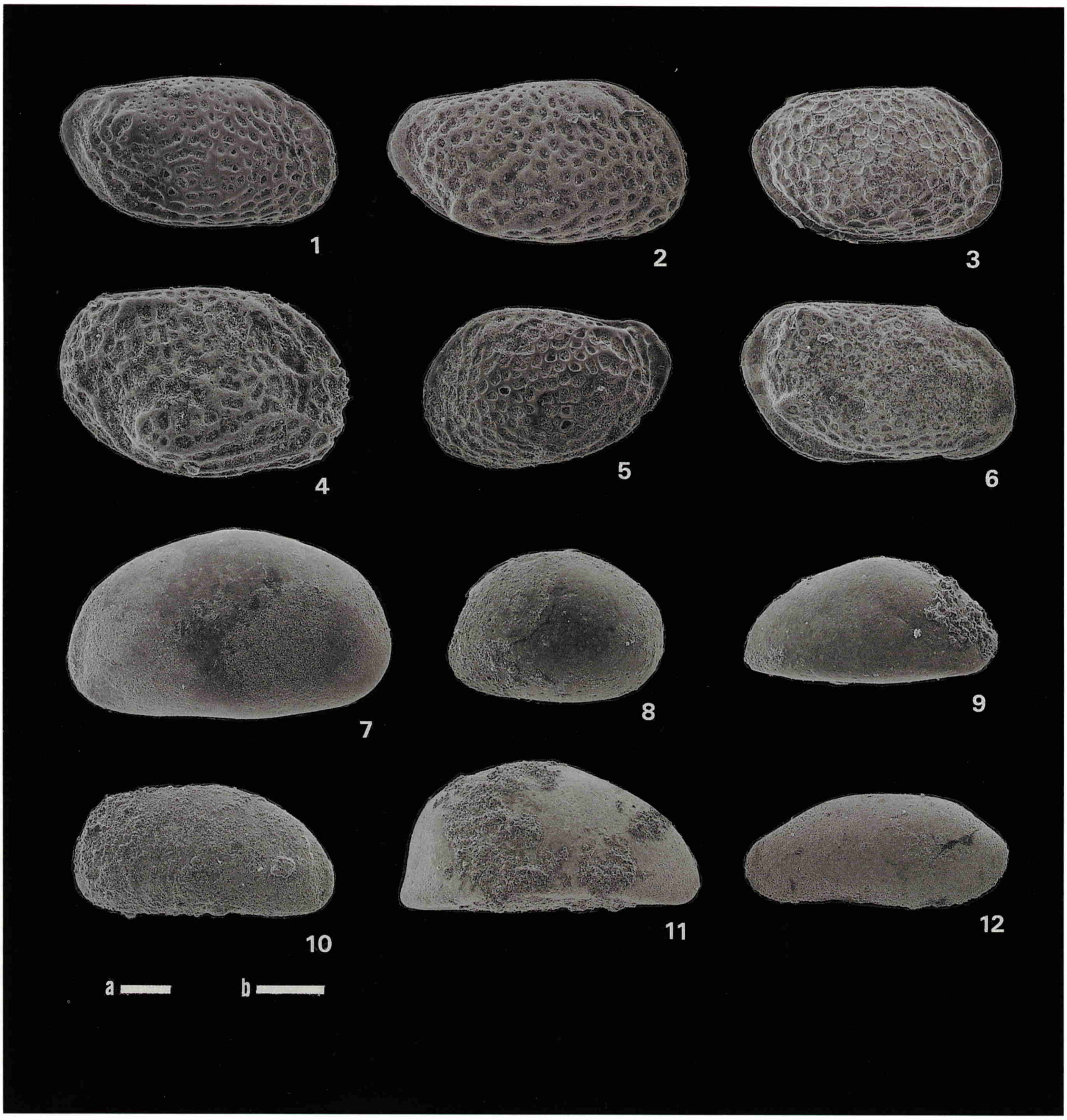
Plate 3. Selected ostracode species from the lower Pleistocene Masuda Formation (Part 3). All figures were taken by scanning electron microscope (SEM). All specimens are stored in the Department of Geoscience, Interdisciplinary Faculty of Science and Engineering, Shimane University (DGSU). Scale bars indicate 0.1 mm (a for 5-7, 10-12, b for 1-4, 8 and 9). LV: left valve, RV: right valve.

1: *Loxoconcha epeterseni* Ishizaki, 1981, male RV, sample MD-2, DGSU no. CO 0143.
2: *Loxoconcha harimensis* Okubo, 1980, male RV, sample MD-4, DGSU no. CO 0144.
3: *Loxoconcha uranouchiensis* Ishizaki, 1968, female RV, sample MD-1, DGSU no. CO 0145.
4: *Loxoconcha zamia* Ishizaki, 1968, female RV, sample MD-4, DGSU no. CO 0146.
5: *Loxoconcha* sp., adult LV, sample MD-2, DGSU no. CO 0147.
6: *Loxocorniculum mutsuense* Ishizaki, 1971, adult RV, sample MD-1, DGSU no. CO 0148.
7: *Xestoleberis hanaii* Ishizaki, 1968, adult LV, sample MD-2, DGSU no. CO 0149.
8: *Xestoleberis sagamiensis* Kajiyama, 1913, juvenile LV, sample MD-3, DGSU no. CO 0150.
9: *Xestoleberis* sp. 1, juvenile LV, sample MD-1, DGSU no. CO 0151.
10: *Xestoleberis* sp. 2, adult? RV, sample MD-2, DGSU no. CO 0152.
11: *Xestoleberis*? sp., adult RV, sample MD-4, DGSU no. CO 0153.
12: *Sclerochilus* sp., adult LV, sample MD-4, DGSU no. CO 0154.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