本州北部，津軽盆地の鮮新世－更新世貝形虫

PLIO-PLEISTOCENE OSTRACODA FROM THE TSUGARU BASIN, NORTH HONSHU, JAPAN

BY

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Abstract

This paper presents palaeoecological and systematic studies of ostracodes from the Plio-Pleistocene Daishaka Formation in the northeastern part of the Tsugaru Basin, North Honshu, Japan. Based on the analysis of molluscan fossils, most sediments of the Daishaka Formation are thought to be deposited in the sublittoral zone. Ostracodes from the Daishaka Formation are also mostly sublittoral sand inhabitants and are grouped into two assemblages -the upper and lower sublittoral sand assemblages. The ostracode species consist mainly of two different species groups as regards their geographical distribution. One group is composed of fossil and Recent species reported from Japan and its adjacent seas, and the other group includes species living in the cold, shallow-water area of the North Pacific, the North Atlantic and the Arctic Sea, associated with species related to these cold water forms. The ostracode fauna from the Daishaka Formation is peculiar in its richness of these circumpolar species when compared with other late Cenozoic faunas in Japan.

One hundred and fifty two species of ostracodes have been identified. Among them, twenty-two species are described as new; they are, *Pectocythere daishakaensis, Cluthia japonica, Paijenborchella hanaii, P. tsurugasakensis, Normanicythere japonica, Urocythereis? abei, U.? posterocostata, Ambostracon kitanipponica, Patagonacythere robusta, Finmarchinella (Finmarchinella) rectangulata, F. (Barentsovia) daishakaensis, Cornucoguimba alata, Acanthocythereis tsurugasakensis, Murrayina japonica, Buntonia hayamii, Robertsonites hanaii, R. tsugaruana, Semicytherura? daishakaensis, Cytheropteron yajimai, C. tsugaruense, Kangarina yamaguchii,* and *Loxoconcha (Loxoconcha) ozawai.* One species, *Robertsonites reticuliforma* (Ishizaki, 1966), is redescribed. The following seven genera are reported for the first time from Japan : *Cluthia* (Leptocytheridae), *Elofsonella, Normanicythere, Patagonacythere* (Hemicytheridae), *Murrayina, Celtia* (Trachyleberididae) and *Typholocythere* (Cytheruridae).

I Introduction

The Japanese Islands, situated in the middle latitudes, have been under the influence of oscillating warm and cold water currents throughout late Cenozoic time and especially since the Miocene. Consequently, two types of elements, northern or cold water elements and southern or warm water elements, can be recognized in the present-day Japanese marine ostracode fauna. In addition to these elements, there are also a few species which are descendants of the Paleogene forms or are indigeneous to the Japanese Islands. Recognition of these three types of elements is indispensable for understanding the genesis of the present-day Japanese marine ostracode fauna.

At present, however, knowledge of the Japanese late Cenozoic ostracode fauna has been limited to the warm water elements associated with the "Kakegawan molluscan fauna". Most of the cold water species occurring with the "Omma-Manganjian molluscan fauna" still await description. Thus this study of the Omma-Manganjian ostracodes provides not only a contribution to taxonomic knowledge, but also the fundamental information prerequisite to the identification of the cold water elements in Japanese present-day marine ostracodes.

Studies on Japanese Neogene ostracodes commenced with the descriptions of species by Hanai (1957a, 1957b, 1970 etc.) and included a few cold water species. Ishizaki (1966, 1971) described Miocene and Pliocene ostracodes from the Sendai Area of North Honshu and Recent ostracodes from Aomori Bay, also in North Honshu. Many of the species described by him are cold water forms. Okada (1979) listed species of Pleistocene cold water ostracodes from the Oga Peninsula, North Honshu.

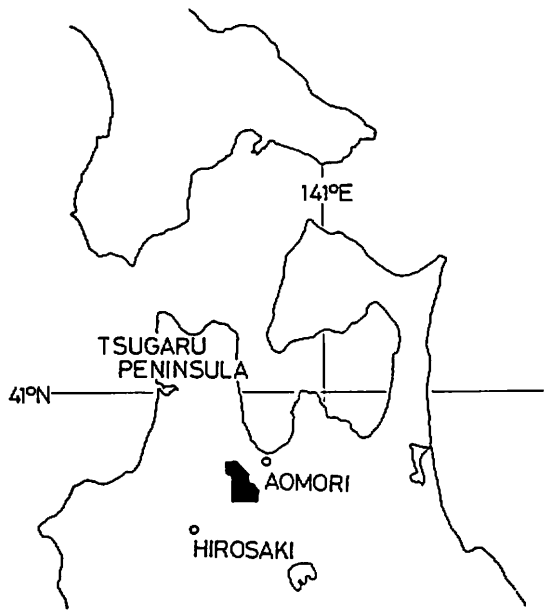
Ostracodes associated with the "Omma-Manganjian molluscan fauna" which spread southwards along the coast of Japan Sea during the Pliocene and Pleistocene are represented mostly by cold water dwellers which represent the subarctic cold water ostracode fauna that once existed in the Japanese area.

The present study deals with the palaeoecology of ostracodes from the Plio-Pleistocene Daishaka Formation in the Tsugaru Basin of North Honshu, with special reference to the reconstruction of the palaeoenvironment of that formation. It also gives the first comprehensive systematic descriptions of these cold water species.

For many years, the Plio-Pleistocene Daishaka Formation in the northeastern part of the Tsugaru Basin has been known to contain well-preserved marine fossil invertebrates. Plalaeontological studies have been carried out on molluscs (Nomura & Hatai (1935), Iwai (1962, 1965)), brachiopods (Kotoh (1957)) and bryozoa (Kataoka (1957)). Molluscan fossils from the Daishaka Formation are characterized by cold and shallow-water species, and are included by Otuka (1939) in the "Omma-Manganjian molluscan fauna". However, detailed studies of the Daishaka Formation have not been made until recently to clarify the stratigraphical and geographical distributions of fossil assemblages, and to allow us to understand the change of sedimentary environments in time and space. Tabuki (1983) succeeded in producing a bed by bed correlation of the formaiton, using some characteristic tuff and pumiceous layers as key beds, and described molluscan fossils from the formation in terms of their palaeoecology. On the basis of these stratigraphical and palaeontological studies it is at last possible to present a reasoned

reconstruction of the depositional environment of the Daishaka Formation.

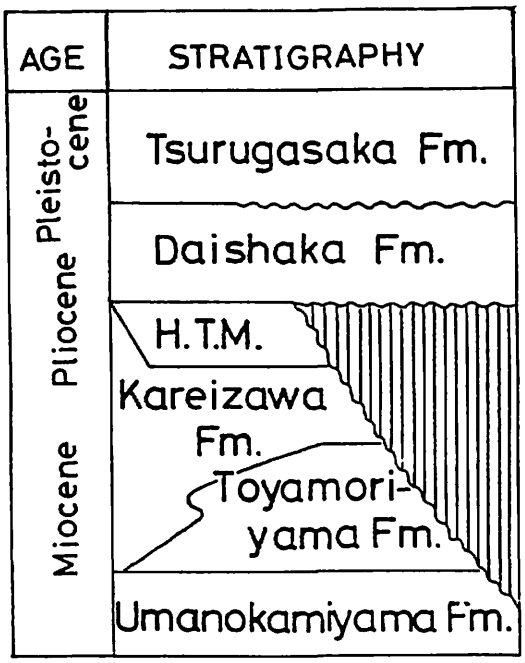
The ostracode fauna from the Daishaka Formation consists mostly of sublittoral species and the dominant ostracode species are common throughout the formation. However, Some subordinate species characterize particular types of sediments and based on their occurrence the fauna is subdivided into two assemblages, the upper and lower sublittoral sand assemblages. On the other hand, ostracode species from the Daishaka Formation also consist mainly of two species groups of different geographical distributions. One species group is composed of fossil and Recent species reported from Japan and its surrounding areas. The other group is characterized by cold and shallow-water species known from the North Pacific, the North Atlantic and the Arctic Sea, associated with species taxonomically related to these northern forms. Constituents of the former species group are characteristically found in the upper sublittoral sand assemblage, and those of the latter in the lower sublittoral sand assemblage.



Text-fig. 1. Index map

II Stratigraphy and depositional environment of the Daishaka Formation

Late Cenozoic deposits are extensively distributed in the northeastern part of the Tsugaru Basin. From bottom to top, they are divided into the Umanokamiyama (andesitic volcanic breccia, tuff and siliceous shale, more than 300 meters thick), Toyamoriyama (well-stratified hard siltstone, 380 meters thick), Kareizawa (massive siltstone, 500 meters thick), Daishaka (sandstone, siltstone and conglomerate 730 meters thick), Tsurugasaka (pumice tuff, 150 meters thick), Maedanome Formations (mud, sand, gravel and peat, 60 meters thick), Towada-Hakkoda volcanic ejecta and terrace deposits. The stratigraphical relations between the formations are shown in text-fig. 2. A detailed description of the stratigraphy and discussions on the palaeoenvironment of the Daishaka Formation have already been given by Tabuki (1983).



H.T.M.: Hitotsumori Tuff Member

Text-fig. 2. Stratigraphical units

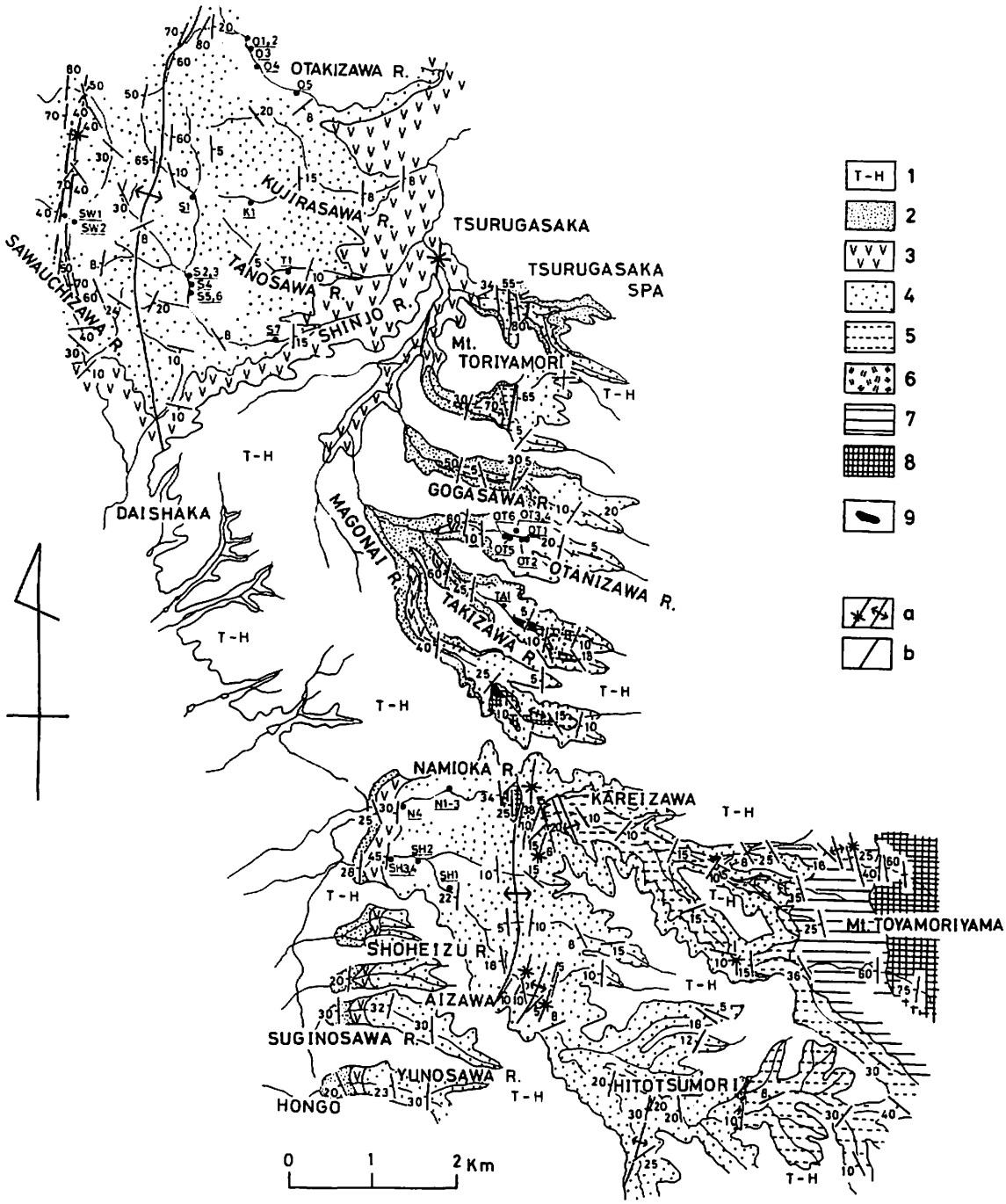
The distribution of the Daishaka Formation is separated into eastern and northern areas by the lowland in which the Tsurugasaka Formation is widely exposed (text-fig. 3). The Daishaka Formation consists of a lower and an upper stratigraphical unit. The boundary between these two units is drawn at the lower limit of the pyroclastic bed of DT-3 (text-fig. 4). The lower unit is dominated by sandstone which followed the deposition of the siltstone of the Kareizawa Formation, with probable shallowing of the sea. The upper unit is represented by cyclic sedimentation characterized by fine sediments (silt and fine- to medium-grained sand) in its lower transgressive stage and coarse sediments (medium- to coarse-grained sand and gravel) in its upper regressive stage. This general framework of sediments resulting from sea level change is obscured to a considerable extent by tectonic movements and local differences in the depositional environment. In fact, the upper unit shows remarkable lateral and vertical lithological changes. The Daishaka Formation is interbedded with many tuff layers, among which seven sets of pyroclastics (DT-1 to DT-7) are widely traceable over the study area and are useful for correlation. The description of these pyroclastic key beds appears in Tabuki (1983).

Abundant molluscan fossils occur in various types of sediments of the Daishaka Formation. The molluscan fossils from the fine sediments show various modes of occurrence but are thought to be autochthonous in a broad sense. On the contrary, in coarse sediments the molluscan shells usually suffer from destruction or abrasion suggesting that they are allochthonous, but some are apparently well preserved and can be regarded as autochthonous. Tabuki (1983) recognized seven molluscan assemblages which are thought to be composed of autochthonous constituents, four

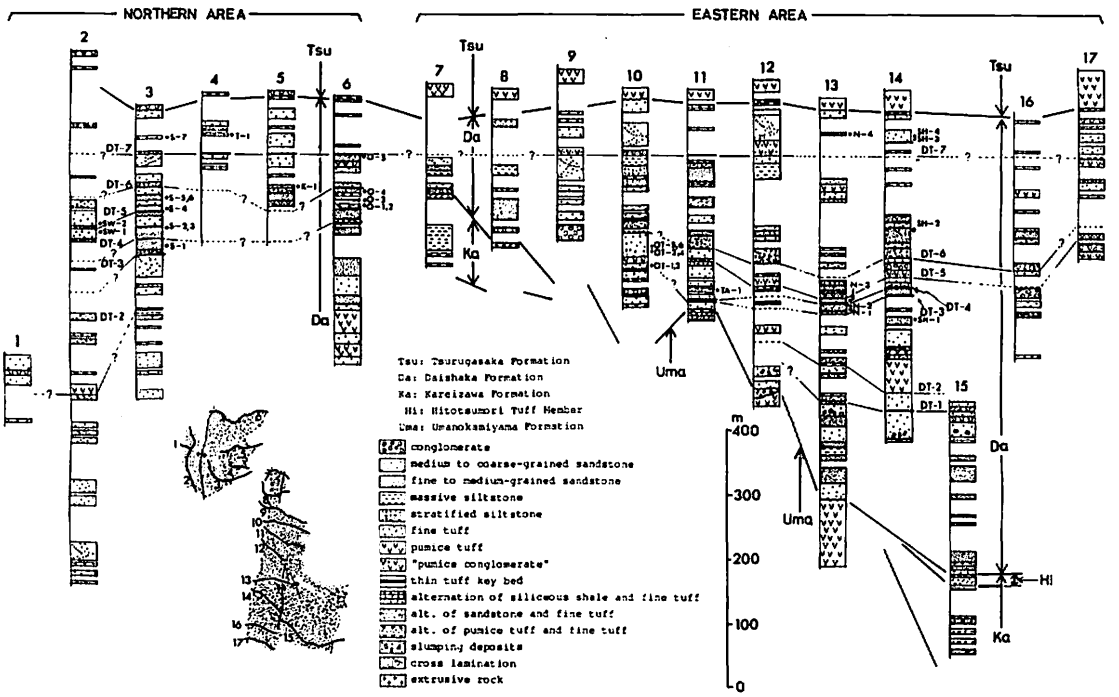
assemblages from fine sediments and three from coarse sediments. Their distributions are closely related to the nature of the sediments in which the molluscan fossils occur. The four assemblages are characterized by inhabitants of the muddy and sandy bottoms of the lower sublittoral zone, probably ranging from approximately 50 meters to more than 100 meters in depth. These assemblages are the *Acila nakazimai-Macoma calcarea* assemblage associated with sandy silt and silty, fine-grained sand, the *Portlandia japonica-Yoldia notabilis-Macoma calcarea* assemblage and the *Nuculana pernula sadoensis-Portlandia japonica-Limopsis tokaiensis* assemblage associated with silty fine-gained sand, and the *Astarte borealis-Venericardia ferruginea-Nuculana pernula sadoensis-Polynemamussium alaskense* assemblage found in gravelly ill-sorted fine- to medium-grained sand. The other three assemblages are dominated by the inhabitants of the sandy and gravelly bottoms of the upper sublittoral zone ranging from approximately 0 to 50 meters in depth. These assemblages are the *Acesta goliath-Ezocallista brevisiphonata-Astarte borealis* assemblage in gravelly, sandy silt or silty sand, the *Ezocallista brevisiphonata-Glycymeris yessoensis-Chlamys cosibensis* assemblage in gravelly, medium- to coarse-grained sand and the *Chlamys cosibensis-Chlamys swiftii* assemblage in gravel. Thus it may be said that fine sediments were deposited in the lower sublittoral zone, and coarse sediments in the upper sublittoral zone.

In most of the eastern area the Daishaka Formation lies unconformably on the underlying formations, indicating that the greater part of the area was subjected to subaerial erosion before its deposition. Only in the southeastern part was deposition of the Daishaka Formation continuous from the Kareizawa Formation onwards. Thereafter the depositional area extended northwards. The lower part of the lower unit in the eastern area is dominated by fine- to medium-grained sandstone which accumulated in the lower sublittoral zone, and the upper half of the lower unit is characterized by conglomeratic medium- to coarse-grained sandstone which was deposited in the upper sublittoral zone. In the lower part of the upper unit, fine sediments indicative of the lower sublittoral zone in the transgressive stage are sometimes found. They occur in the lower horizons of the lower part in the southeast and in the upper horizons in the northeast. These fine sediments pass laterally into coarser sediments which were deposited in the shallower upper sublittoral zone. The conglomeratic medium- to coarse-grained sandstone indicative of the upper sublittoral zone is predominant in the upper part of the upper unit, and contains allochthonous shells derived from various environments of the upper sublittoral zone. Peat and peaty mud are frequently found in the uppermost horizon. This may indicate a change of sedimentary environment from marine to brackish or freshwater conditions at the time.

In the northern area, the lower unit occupies the central part of an anticlinal dome, and consists of conglomeratic, medium- to coarse-grained sandstone similar in lithology to that in the upper part of the lower unit of the eastern area. The lower part of the upper unit is dominated by fine sediments characteristic of the lower sublittoral environment along the eastern flank of the dome. The fine sediments on the eastern flank of the dome, however, change laterally to coarse sediments on the western flank with allochthonous molluscan shells derived from the intertidal and subtidal zones. This suggests that the sea at that time became shallower from east to west in the northern area. In the upper part of the upper unit conglomeratic, medium- to coarse-grained sandstone with peaty mud in the uppermost horizon predominates over the northern area as in the eastern area.



Text-fig. 3. Geological map and sampling localities.
1 : Towada-Hakkoda volcanic ejecta, 2 : Maedanome Formation,
3 : Tsurugasaka Formation, 4 : Daishaka Formation,
5 : Kareizawa Formation, 6 : Hitotsumori Tuff Member
7 : Toyamoriyama Formation, 8 : Umanokamiyama Formation,
9 : extrusive rock (andesite). a : fold, b : fault.



Text-fig. 4. Columnar sections of the Daishaka Formation with the stratigraphical positions of sampling localities. 1－17 indicate the routes along which columnar sections are obtained, and which are shown in the map where the dotted area indicates the distribution of the Daishaka Formation.

1 : a tributary of Sawauchizawa River, 2 : Sawauchizawa River, 3 : Shinjo River, 4 : Tanosawa River, 5 : Kujirasawa River, 6 : Otakizawa River, 7 : the neighborhood of Tsurugasaka Spa, 8 : a tributary of Magonai River, 9 : Gogasawa River, 10 : Otanizawa River, 11 : Takizawa River, 12 : Magonai River, 13 : Namioka River, 14 : lower stream of Shoheizu River, 15 : upper stream of Shoheizu River, 16 : Suginosawa River, 17 : Yunosawa River.

Sampling localities of the Daishaka Formation :

The abbreviations of the names of the routes along which sampling was undertaken are as follows. SW : Sawauchizawa River. S : Shinjo River. T : Tanosawa River. K : Kujirasawa River. O : Otakizawa River. OT : Otanizawa River. TA : Takizawa River. N : Namioka River. SH : Shoheizu River.

(1) Sampling localities of the lower unit.

OT1 : an exposure along the Otanizawa River, 4.1 km S 17°E of Tsurugasaka station of Japanese National Railway (J. N. R.), Magonai, Aomori-shi (Lat. 40°45' 10"N, Long. 140°39' 08" E); thickness of exposed strata 14.1 m, sampling point 2 m stratigraphically above the lowest horizon at the exposure. Gravelly ill-sorted sand; allochthonous molluscan shells form shell beds. *Mizuhopecten yessoensis yokoyamae* and *Limopsis tokaiensis* are abundantly found.

OT2 : the same exposure as Loc. OT1, sampling point 4 m stratigraphically above the lowest horizon at the exposure. Gravelly silty sand; relatively well-preserved molluscs occur densely. *Astarte borealis, Ezocallista brevisiphonata* and *Acesta goliath* are particularly abundant (*Acesta goliath-Ezocallista brevisiphonata-Astarte borealis* assemblage of Tabuki (1983)).

SH1 : an exposure along riverbed of the Shoheizu River, 4.83 km N 83°E of Namioka station (J. N. R.), Kitanakanokaitaku, Namioka-cho (Lat. 40°42' 45" N, 140° 38' 30" E); thickness of exposed srata 13.1 m, sampling point 2 m stratigraphically below the topmost horizon at the exposure. Gray fine- to medium-grained sand with shell fragments; disarticulated but well-preserved bivalves as *Astarte borealis* and *Polynemamussium alaskense* occur relatively abundantly (*Astarte borealis-Venericardia ferruginea-Nuculana pernula sadoensis-Polynemamussium alaskense* ass.).

(2) Sampling localities of the upper unit

SW1 : a cliff along a branch stream of the Sawauchizawa River, 3.73 km N 9°W of Daishaka station (J. N. R.), Namioka-cho (Lat. 40°47' 15" N, Long. 140°35' 05" E); thickness of exposed strata 5 m, sampling point 2 m stratigraphically above the lowest horizon at the cliff. Gravelly medium- to coarse-grained sand; allochthonous intertidal and subtidal molluscs as *Pholadidea penita* and *Ezocallista brevisiphonata* are abundantly found.

SW2 : an exposure along the Sawauchizawa River, 3.6 km N 8°W of Daishaka station (J. N. R.), Namioka-cho (Lat. 40°47' 13" N, Long. 140°35' 14"E); thickness of exposed strata 25 m+, sampling point 17 m stratigraphically above the top surface of key tuff bed DT-5. Gray silty ill-sorted medium-grained sand; allochthonous molluscs as *Nuculana pernula sadoensis* and *Ezocallista brevisiphonata* and shell fragments are abundantly found.

S1 : an exposure along the road leading southward to Ushu-Kaido, 2.03 km N 20°W of eastern entrance of Shin-Daishaka tunnel, Aomori-shi (Lat. 40°47' 24"N, Long. 140°36' 15"E); thickness of exposed strata 5 m, sampling point 2 m stratigraphically above the lowest horizon at the exposure. Gray silty fine-grained sand; molluscan fossils occur sporadically or in small lenses. *Portlandia japonica* and *Macoma calcarea* are predominantly found (*Portlandia japonica-Yoldia notabilis-Macoma calcarea* ass.).

S2 : an exposure along the road leading southward to Ushu-Kaido, 1.18 km N 40°W of eastern entrance of Shin-Daishaka tunnel, Aomori-shi (Lat. 40°46'52"N, Long. 140°36'12"E); about 100 m in thickness, sampling point 11.2 m stratigraphically above the top surface of light brown fine-

grained tuff (2m) lying over DT-4. Gray silty fine-grained sand; molluscs are found sporadically (*Portlandia japonica-Yoldia notabilis-Macoma calcarea* ass.). Silt-walled and cone-shaped burrows with maximum diameter of 3 cm and maximum length of 40 cm exist densely.

S3 : the same exposure as Loc. S2, sampling point 3.5 m stratigraphically above the sampling point of Loc. S2, or 80 cm stratigraphically above the top surface of a set of light brown fine-grained tuff (70 cm) and overlying white fine-grained tuff (30 cm). Gray silty fine-grained sand with laminae of medium-grained sand; molluscan fossils are found sporadically, or relatively densely along laminae of medium-grained sand (*Portlandia japonica-Yoldia notabilis-Macoma calcarea* ass.). Silt-walled burrows are found.

S4 : the same exposure as Loc. S2, 1.05 km N 43°W of eastern entrance of Shin-Daishaka tunnel, Aomori-shi (Lat. 40°46'47"N, Long. 140°36'14"E); sampling point 4 m stratigraphically above the top surface of DT-5. Gray silty fine-grained sand with laminae of medium-grained sand; molluscan fossils occur sporadically, or relatively densely along laminae of medium-grained sand. *Portlandia japonica* predominates (*Portlandia japonica-Yoldia notabilis-Macoma calcarea* ass.). Silt-walled burrows are developed.

S5 : the same exposure as Loc. S2, 980 m N 47°W of eastern entrance of Shin-Daishaka tunnel, Aomori-shi (Lat. 40°46'44"N, Long. 140°36'15"E); sampling point 1 m stratigraphically above the top surface of medium-grained sand (5 m) lying over gray fine-grained sand including Loc. S4. Gray silty fine-grained sand with laminae of medium-grained sand; molluscs occur sporadically, or relatively densely along laminae of medium-grained sand (*Portlandia japonica-Yoldia notabilis-Macoma calcarea* ass.). Silt-walled burrows are found.

S6 : the same exposure as Loc. S5, sampling point 4 m stratigraphically above the sampling point of Loc. S5. Gray silty fine-grained sand; molluscan fossils occur sporadically. *Portlandia japonica* and *Solamen spectabilis* are dominantly found (*Nuculana pernula sadoensis-Portlandia japonica-Limopsis tokaiensis* ass.).

S7 : a small exposure along the Shinjo River, 280 m N 70°E of eastern entrance of Shin-Daishaka tunnel, Aomori-shi (Lat. 40°46'26"N, Long. 140°36'55"E); thickness of exposed strata 1. 5 m, sampling point 1 m stratigraphically above the lowest horizon at the exposure. Gravelly ill-sorted sand; allochthonous molluscan shells form shell beds. *Glycymeris yessoensis* and *Limopsis tokaiensis* are particularly abundant.

T1 : a small exposure along the Tanosawa River, 1.1 km N 27° E of eastern entrance of Shin-Daishaka tunnel, Aomori-shi (Lat. 40°46'54"N, Long. 140°37'05"E); thickness of exposed strata 2 m, sampling point 1.5 m stratigraphically above the lowest horizon at the exposure. Gravelly ill-sorted sand; allochthonous molluscan shells as *Chlamys cosibensis, Venericardia ferruginea* and *Glycymeris yessoensis* and shell fragments are abundantly found.

K1 : a small exposure along the Kujirasawa River, 1.85 km N 2°W of eastern entrance of Shin-Daishaka tunnel, Aomori-shi (Lat. 40°47'23"N, Long. 140°36'44"E); thickness of exposed strata 1. 8 m, sampling point 50 cm stratigraphically above the lowest horizon at the exposure.
Gravelly silty fine- to medium-grained sand; well-preserved molluscs are relatively densely found, but bivalves are disarticulated (*Astarte borealis-Venericardia ferruginea-Nuculana pernula sadoensis-Polynemamussium alaskense* ass.).

O1 : an exposure along the Otakizawa River, 3.15 km N 48°W of Tsurugasaka station (J. N.

R.), Aomori-shi (Lat. 40°48 28"N, Long. 140°36'40"E); thickness of exposed strata 4.5 m, sampling point 50 cm stratigraphically above the lowest horizon at the exposure. Gray silty fine-grained sand; molluscs occur sporadically or in small lenses. *Yoldia notabilis* and *Macoma calcarea* are dominantly found (*Portlandia japonica-Yoldia notabilis-Macoma calcarea* ass.). Silt-walled burrows are found.

O2 : the same exposure as Loc. O1, sampling point 50 cm stratigraphically below the topmost horizon at the exposure. Gray silty fine-grained sand; molluscs are found sporadically or in small lenses. *Portlandia japonica* and *Acila vigilia* are dominant species (*Portlandia japonica-Yoldia notabilis-Macoma calcarea* ass.). Silt-walled burrows are developed.

O3 : a small exposure along the riverbed of the Otakizawa River, 2.98 km N 49°W of Tsurugasaka station (J. N. R.), Aomori-shi (Lat. 40°48'22"N, Long. 140°36'42"E), thickness of exposed strata 50 cm, sampling point 30 cm stratigraphically above the lowest horizon at the exposure. Gravelly ill-sorted fine- to medium-grained sand; well-preserved molluscs occur densely to form shell beds. *Venericardia ferruginea* and *Polynemamussium alaskense* occur abundantly (*Astarte borealis-Venericardia ferruginea-Nuculana pernula sadoensis-Polynemamussium alaskense* ass.).

O4 : a small exposure along the Otakizawa River, 2.8 km N 51°W of Tsurugasaka station (J. N. R.), Aomori-shi (Lat. 40°48'17"N, Long. 140°36'46"E); thickness of exposed strata 1.7 m, sampling point 20 cm stratigraphically above the lowest horizon at the exposure. Ill-sorted fine- to medium-grained sand; well-preserved molluscs occur densely. *Venericardia ferruginea* and *Limopsis tokaiensis* are particularly abundant (*Astarte borealis-Venericardia ferruginea-Nuculana pernula sadoensis-Polynemamussium alaskense* ass.).

O5 : an exposure along the Otakizawa River, 2.28 km N 50°W of Tsurugasaka station (J. N. R.), Aomori-shi (Lat. 40°48'07"N, Long. 140°37'06"E); thickness of exposed strata 6.0 m, sampling point 2 m stratigraphically above the lowest horizon at the exposure. Gray silty fine-grained sand; molluscs are sporadically found. *Yoldia notabilis, Robaia robai* and *Macoma calcarea* are dominant species (*Portlandia japonica-Yoldia notabilis-Macoma calcarea* ass.). Burrows exist densely.

OT3 : an exposure along the Otanizawa River, 4.0 km S 16°E of Tsurugasaka station (J. N. R.), Magonai, Aomori-shi (Lat. 40°45'12"N, Long. 140°39'03"E), thickness of exposed strata 2.0 m, sampling point 50 cm stratigraphically above the lowest horizon at the exposure. Gravelly medium- to coarse-grained sand; all bivalves are disarticulated, but are relatively well-preserved. *Glycymeris yessoensis* and *Chlamys cosibensis* are dominantly found (*Ezocallista brevisiphonata-Glycymeris yessoensis-Chlamys cosibensis* ass.).

OT4 : the same exposure as Loc. OT3, sampling point 1.5 m stratigraphically above the lowest horizon at the exposure. Silty medium-grained sand; three articulated *Panomya arctica* occured at upright position along the sampling horizon.

OT5 : an exposure along the Otanizawa River, 4.03 km S 14°E of Tsurugasaka station (J. N. R.), Magonai, Aomori-shi (Lat. 40°45'10"N, Long. 140°39'00"E); thickness of exposed strata 7.4 m, sampling point 1 m stratigraphically above the lowest horizon at the exposure. Gravelly silty sand; well-preserved molluscan shells are lying parallel to the bedding plane and form a shell bed. *Monia macroschisma, Nuculana pernula sadoensis, Astarte borealis* and *Acesta goliath* are

dominantly found (*Acesta goliath-Ezocallista brevisiphonata-Astarte borealis* ass.).

OT6 : the same exposure as Loc. OT5, sampling point 3 m stratigraphically above the lowest horizon at the exposure. Gravelly medium- to coarse-grained sand; relatively well-preserved molluscan fossils occur abundantly. *Ezocallista brevisiphonata* and *Glycymeris yessoensis* are dominantly found (*Ezocallista brevisiphonata-Glycymeris yessoensis-Chlamys cosibensis* ass.).

TA1 : an exposure along the Takizawa River, 6.75 km N 53°E of Namioka station (J. N. R.), Namioka-cho (Lat. 40°44'39"N, Long. 140°38'57"E); thickness of exposed strata 3 m, sampling point 1 m stratigraphically above the lowest horizon of the exposure. Gravelly ill-sorted fine- to medium-grained sand; disarticulated but well-preserved molluscan shells occur abundantly. *Astarte borealis, A. alaskensis* and *Polynemamussium alaskense* are dominant species (*Astarte borealis-Venericardia ferruginea-Nuculana pernula sadoensis-Polynemamussium alaskense* ass.).

N1 : an exposure along the Namioka River, 5.13 km N 69°E of Namioka station (J. N. R.), Namioka-cho (Lat. 40°43'27"N, Long. 140°38'29"E); 58 m in thickness, sampling point 5.8 m stratigraphically below the base surface of DT-4. Gray silty fine-grained sand; well-preserved molluscs occur sporadically. *Nuculana pernula sadoensis* and *Portlandia japonica* are relatively abundant (*Nuculana pernula sadoensis-Portlandia japonica-Limopsis tokaiensis* ass.).

N2: the same exposure as Loc. N1, sampling point 40 cm stratigraphically below the base surface of DT-4. Gravelly fine- to medium-grained sand; well-preserved molluscan shells occur relatively densely. Bivalves are mostly disarticulated except *Nuculana pernula sadoensis* which is mostly articulated (*Astarte borealis- Venericardia ferruginea - Nuculana pernula sadoensis-Polynemamussium alaskense* ass.).

N3 : the exposure, same as Loc. N1, sampling point 20 cm stratigraphically above the top surface of DT-4. Gravelly fine- to medium-grained sand; disarticulated bivalves are relatively densely found (*Astarte borealis-Venericardia ferruginea-Nuculana pernula sadoensis-Polynemamussium alaskense* ass.).

N4 : a small exposure, 4.53 km N 69°E of Namioka station (J. N. R.), Namioka-cho (Lat. 40° 43'19"N, Long. 140°38'05"E); thickness of exposed strata 1.5 m, sampling point 70 cm stratigraphically above the lowest horizon at the exposure. Silty ill-sorted sand with abundant fragments of bryozoa; allochthonous molluscs occur abundantly. *Arca boucardi* and *Pinctada* sp. predominate in this locality.

SH2 : an exposure along the Shoheizu River, 4.65 km N 77°E of Namioka station (J. N. R.), Namioka-cho (Lat. 40°42'59" N, Long. 140°38'13"E); thickness of exposed strata 4.6 m, sampling point 20 cm stratigraphically below the topmost horizon at the exposure. Gravelly sandy silt; abundant well-preserved molluscs are lying parallel to bedding plane (*Acesta goliath-Ezocallista brevisiphonata-Astarte borealis* ass.).

SH3 : an exposure along the Shoheizu River, 4.15 km N 76°E of Namioka station (J. N. R.), Namioka-cho (Lat. 40°42'59"N, Long. 140°37'58"E); 19 m in thickness, sampling point 1.4 m stratigrahically above the lowest horizon at the exposure. Gravelly silty ill-sorted sand; *Arca boucardi* occurs abundantly as disarticulated valves.

SH4 : the same exposure as Loc. SH3, sampling point 3.5 m stratigraphically above the lowest horizon at the exposure. Gravelly medium- to coarse-grained sand; relatively well-

Table 1. List of Plio-Pleistocene ostracodes from the Tsugaru Basin

species \ sampling number	SW1	SW2	S1	S2	S3	S4	S5	S6	S7	T1	K1	O1	O2	O3	O4	O5	OT1	OT2	OT3	OT4	OT5	OT6	TA1	N1	N2	N3	N4	SH1	SH2	SH3	SH4
Neonesidea mutsuensis (Ishizaki, 1971)	4								6	3								1				4				2				
Propontocypris (Propontocypris) attenuata (Brady, 1868)																	1								1	1				2
P. (P.) sp.												1										1								
P. (P.?) kanazawaensis (Ishizaki, 1963)																									1					
P. (P.?) sp. Hanai, Ishizaki and Ikeya, 1977																					2									
Argilloecia conoidea (Sars, 1866)																		4			4							1		
A. sp.										1										1	4									
Pontocythere miurensis (Hanai, 1959)	1			1								2		1	2	1		2	1		1	1		1			5	2		2	1
P. subjaponica (Hanai, 1959)	1																									1	1			1	
P. sp.										2																					
Neocytherideis? sp.					1																										
Krithe antisawanensis Ishizaki, 1966					2		1					1						2						1		1		1			
K. sp. Hanai and Ikeya, 1977																					2										
Parakrithella pseudadonta (Hanai, 1959)																													5	4	
Eucythere sp. 1													1									1									
E. sp. 2												1			1																
Pectocythere quadrangulata Hanai, 1957										1																					
P. pseudoamphidunta (Hanai, 1957)			1	1	2		3			1	6		2		3	1	1		2		1		2		1	3		1			
P. daishakaensis n. sp.	1		1	3	1		1				1				4		1	2	2	1		2	6	1	3	3		11			
Kotoracythere sp.																												3			
Munseyella hokkaidoana (Hanai,1957)	1			1			9				1		2		1	1							1					7			
M. japonica (Hanai, 1957)			1																					1					2		
M. hatatatensis (Ishizaki, 1966)									2		3	1	1		2	1	1	2	6	3	2		1			2					
M. sp.																2															
Callistocythere setanensis Hanai, 1957	1									5					1		10	2	3	2	7	1		3	3	5	3	15			
C. hayamensis Hanai, 1957	5			1					2	4			2														12	1		3	
C. alata Hanai, 1957																								1	2					2	
C. reticulata Hanai, 1957																					1						2				
C. rugosa Hanai, 1957																		1													
C.undulatifacialis Hanai, 1957	1		1												1			2	3						1					7	
C. japonica Hanai, 1957				1																							4				
C. subjaponica Hanai, 1957																										1				2	
C. sp.								1			1							1													
Cluthia japonica n. sp.				1	1								2					2	1						2						
Cythere lutea uranipponica Hanai, 1957	6	4	10	12		1		2	7	7	1	9	2		5	2	23	2	6		17	2		4		2		3	1	1	1
C. lutea omotenipponica Hanai, 1957																														2	1
C. golikovi Schornikov,1974																												3			
Loxocythere inflata Hanai, 1959			1	4						3	1				1	1	12	1	12	9	31	1			1	1	2			13	4
Schizocythere kishinouyei (Kajiyama, 1913)	17		3					1	2	6		1							1	1	1						2			1	
S. okhotskensis Hanai, 1970	2	7	19	11	34	7	2	5	12	8	43	12	30	22	24	2	9	58	29	19	17	17	30	12	42	9			37		37
S. sp.																			1	2											
Paijenborchella triangularis Hanai, 1970															1									2	3	1	1			1	1
P. miurensis Hanai, 1970																			1	1	2			5							
P. tsurugasakensis n. sp.												1				18															
P. hanaii n. sp.	2								2		2					3	1	4	6	1	1				1		1		2		1
Neomonoceratina japonica (Ishizaki, 1966)			7	12	8	9	1	6		1		2	8			1	2								14	8		30			
Paimenella limicola (Norman, 1865)			12		4		2	3	1		7	2	3	11	9	13	2	1	1		3			1	4	2		9			
Spinileberis quadriaculeata (Brady, 1880)																1															
Hemicythere yorokuensis Ishizaki, 1966	1	4				1		1		5	1			3	4				1			1					1			2	
H. orientalis Schornikov, 1974									1								2											1			
H. schotensis Schornikov, 1974	3		1							2																					
Bicostocella cancinna (Jones, 1857)			1		10					1	7		2	1	11	8				1	2	2	16	1		3		1	2		
Baffinicythere emarginata (Sars, 1866)	1	6	1	1	7			2	7	4	5	2	1	10	12		11	3	5		11	1	1						1	13	23
B. howei Hazel	8		1	3	2			4	4	24	5		1	2	8	3	1	12	13	6	5	9		5	7		1	2	1		
Ambostracon kitanipponica n. sp.			2						2			2	1																		
A. sp. 1										1																					
A. sp. 2								5			2				3				1			2									
Aurila cymba (Brady, 1869)	36		3					2		3							1	4	8	2	2	3		1	1		24			26	21
A. uranouchiensis Ishizaki, 1968	13	4			1	1	1		6	38	1	1		3	2			7	2	5		5					5	5		1	1
A. hataii Ishizaki, 1968			1																1												
Mutilus assimilis (Kajiyama, 1913)				1						1					1		2											1			
Finmarchinella (Finmarchinella) uranipponica Ishizaki, 1969								1		2							1			1				3		1	6			2	2
F. (F.) rectangulata n. sp.	1		1		9	2		2	3		5	1	2	11	10		1			2	1		1		6	8		1			
F. (Baruntsovia) angulata (Sars, 1866)		2		2				1	5	3	4	1	1	5	5		2	2	9	1	5	2		2	9	4		8	2		4
F. (B.) japonica (Ishizaki, 1966)	1	7		2	2				4	7	11	1	1	1	13	1	3	8	3		12		1	3	6	6			2		
F. (B.) nealei Okada, 1979		2	3	2	2				4	2	3	5	3		10	5	6		6	15	6	1				8		12			
F. (B.) hanaii Okada, 1979	26	1	10	9	6	5	4	10			5	19	3	10	8	1	2	2	3	2	1	1	3	3	4	1		2	1		
F. (B.) daishakaensis n. sp.	4	3	9	1	7	5	2	6	3	25	10		6	6	9	4	14	1	3	2	15	4				1		10		6	12
F. (B.) sp.	1																														
F.? sp.									1								1				6										
Urocythereis? gorokuensis Ishizaki, 1966		3	1		3		2	2	9	6	12	2			3	11	51	2	9	5	17	5	28	14	4	14		15		4	8
U.? abei n. sp.	2			2		1			2	17			1	1	3		12	1	9	12	18	3	10		1	4		2			5
U.? posturocostata n. sp.	2	2	2		1				3	23	2	2		1	2			3	3	1	5	2						2			2
U.? sp.									1	1		1																			
Normanicythere japonica n. sp.				2	1						2			1	2				1	2			4					8			
Patagonacythere robusta n. sp.	1			2	2	1		2		1	3	1	5	2	2	4	3	5	9	4	3	11	1		3	3		10	2		
Cornucoquimba saitoi (Ishizaki, 1963)	1	2	5	1	1		1		1	14	1		1	1	4		1		3	3	3	1		3	2	1	1	5		4	18
C. moniwensis (Ishizaki, 1966)	6	1		5			1	9		3	2	1			2			14	3	2	4	7		2	3				3	1	
C. tosaensis (Ishizaki, 1968)	8	1							4	10	1	2			1												14	3			
C. alata n. sp.	3				1					2	2			1	2	2															
Hurmanites? japonicus (Ishizaki, 1971)					1																										
Coquimba ishizakii Yajima, 1978	1		1						1	1		1															8			2	
Acanthocythereis dunelmensis (Norman, 1865)	1			3		4	5	3	1		4	2	1	3	3				2												
A. tsurugasakensis n. sp.				6			7									1								1							
A.? mutsuensis Ishizaki, 1971			1																						1						
A.? niitsumai (Ishizaki, 1971)																					2						1				
Actinocythereis sp. Ishizaki, 1968											2				1	4										1					
Murrayina japonica n. sp.		2																													
Celtia sp.		1							1	5								1								2			1		
Bicornucythere bisanensis (Okubo, 1975)																											1				
Buntonia hayamii n. sp.	1		3	1	3					1	4	1			1				2		1							4			
Ambocythere japonica Ishizaki, 1968																														1	
Robertsonites reticuliforma (ihsizaki, 1966)			23		6	12	6	6				6		1										2		4					
R. hanaii n. sp.			1		4						30		3			24															
R. tsugaruana n. sp.			11	5	9		1				4	1	2	1	10	3		2					4		8						
R. sp. 1																9															
R. sp. 2																6															
Bythoceratina hanaii Ishizaki, 1968									2																		2			2	
Cytherura? mainensis Hazel and Valentine, 1969			3		3	1			4	17	6		2	1	7		9	1	3	2	5	1	1		2	2		31			
Eucytherura neoalae (Ishizaki, 1966)	6		3	2	2		1	3	1	1	5	5		1				2	3	1	3		1		4	1		4	2		
Typholocythere japonica Ishizaki, 1981						1																					1				
Hemicytherura cuneata Hanai, 1957			1	3		6		4	1		1	5						2						1			84			3	
H. kajiyamai Hanai, 1957												2	2	1							1										
H. sp.																		1									5		8		
Howeina higashimeyaensis Ishizaki, 1971	4		7	1	3	1		1	1	20	2	2					9		1	1	3	2	3		1	3		5		51	32
H. leptocytheroidea (Hanai, 1957)	1					1				2						1															
H? sp.										1																					
Semicytherura henryhowei Hanai and Ikeya, 1977	7	2	16	9	20	19	4	16	4	4	9	18	16	16	21	3	7	10	4		23	1	3	4	3	3			1	3	4
S. subundata (Hanai, 1957)		7	2		2			5	9	2	9	8	3		6	1		1	1		2	1		2	7	1				1	3
S. skippa (Hanai, 1957)															1																
S. sp. 1																		1										1			
S. sp. 2																											1				
S. sp. 3																					1									1	
S. sp. 4																1															
S. sp. 5									1		3										2								1		
S. sp. 6															1																
S.? miurensis Hanai, 1957									2									1			1										
S.? daishakaensis n. sp.																											10		2		
Cytherurinae n. sp.																					1										
Cytheropteron miurense Hanai, 1957															1						5						5				
C. sawanense Hanai, 1957	18	2	16	17	15	8	8	22	6	6	19	13	6	15	29	16	3	57	53	6	32	31	5	32	17	11		13	10	6	8
C. sendaiense Ishizaki,1966	3						2		7		10			2	11				1	1	32		4		9	15		2				
C. yajimai n. sp.			2	8	6		2	5	1	4	9		3		4	8	4	21	3	5	12	17				2			5		
C. tsugaruense n. sp.											2				1						6		2								
C. sp. 1											1										2										
C. sp. 2																										1					
C. sp. 3			2	2			1					1	2		1			2	5			1		1				1			
Kangarina yamaguchii n. sp.	3			2		1		4			1		3	2				6				3							3	1	
Paracytheridea neolongicaudata Ishizaki, 1966								1				3																			
P. sp.?																	1		2					5			4				
Loxoconcha (Loxoconcha) subkotoraformа Ishizaki, 1966				2	1		1	4	1	1	5		1	1	2	3		40	9	3	6	6		1	4	2	24		1	1	1
L. (L.) lacta Ishizaki, 1968	1	1		1				1				1	1		1							2				3			3	5
L. (L.) viva Ishizaki, 1968									1								4				1										
L. (L.) kattoi Ishizaki, 1968																			1		1										
L. (L.) optima Ishizaki, 1968												1																		1	
L. (L.) hattorii Ishizaki, 1971	3								1	15							1										9		2	3	
L. (L.) kitanipponica Ishizaki, 1971																											2				
L. (L.) ozawai n. sp.										1	3						4	6			12	1	1		1	2		3			
L. (L.) sp.			1	1	1					1	1	3	1			2		2		1	2	1		3	1		8				
Cytheromorpha acupunctata (Brady, 1880)			1	1											1			2			1	1						1			
Loxocorniculum mutsuense Ishizaki, 1971										3		1					4												14	15	
Nipponocythere bicarinata (Brady, 1880)																											1				
N. sp.																		2			4										
Xestoleberis sp. Ishizaki, 1971								3	1						1		1	2					1								
X. sp. 1								1						1	1		1	1			6	1			1						
X. sp. 2																						3							1		
X. sp. 3																					5						2				
Paradoxostoma contendum Schornicov, 1974															1						2										
P. sp. 1																		1			1	2			1						
P. sp. 2					1																	2									
Sclerochilus sp. 1										1		1						4			6	2									
S. sp. 2											1											2									
total number of individuals	209	64	191	145	185	87	68	144	140	318	281	146	135	137	276	170	224	317	259	124	382	180	130	121	185	142	247	241	93	187	233
total number of species	42	21	41	40	38	20	24	34	44	50	53	43	40	30	55	38	39	51	50	33	60	48	24	31	39	38	35	36	24	36	33
weight of sample (gram)	40	40	80	10	40	80	20	10	10	40	10	10	10	20	5	15	40	5	40	80	5	20	20	10	15	20	5	20	80	80	15

preserved molluscs are abundantly found. *Mizuhopecten yessoensis yokoyamae* occurs mostly as articulated valves (*Ezocallista brevisiphonata-Glycymeris yessoensis-Chlamys cosibensis* ass.).

III Ostracode assemblages of the Daishaka Formation

Sampling of sediments for ostracodes was undertaken at the exposures in which undissolved molluscan shells occurred. Molluscs were sampled at the same time from the same point in the outcrop. Sediments from each locality were dried and 80 grams dry weight was washed through a Taylor's 200-mesh sieve. The risidue so obtained was split into unit samples containing about 200 ostracodes. All the individuals contained in the unit sample were picked and used for later analyses.

Ostracodes were obtained from 31 sediment samples and 152 species were idntified. Ostracodes occurred exclusively in sandy sediments of the formation, with the exception of the gravelly, sandy silt at locality SH2. Ostracodes were absent from the silty and gravelly sediments examined. The number of ostracode specimens per 80 grams was less than 1000 in 20 sediment samples which covered various types of sandy sediments. No definite relationship between ostracode abundance and nature of the sediment could be recognized. In five sand samples the number of ostracodes exceeded 2000 per 80 grams and two samples of gravelly, silty sand from localities OT2 and OT5 contained 5072 and 6112 individuals, respectively. The gravelly, silty sand contains molluscan assemblages characterized by *Acesta goliath, Ezocallista brevisiphonata* and *Astarte borealis.*

Ostracodes from the lower unit :

In the eastern area only three samples (OT1, OT2 and SH1) from the lower unit of the Daishaka Formation contained ostracodes. These three samples all lie in the uppermost part of the lower unit, although the exact stratigraphical positions of the first two are uncertain owing to lack of reliable key tuff beds in the area around the Otanizawa River. The sediments of the two localities OT1 and OT2 along the Otanizawa River are, respectively, gravelly, medium- to coarse-grained sand containing allochthonous molluscs derived from the upper sublittoral environments, and gravelly, silty sand characterized by the *Acesta goliath-Ezocallista brevisiphonata-Astarte borealis* molluscan assemblage. There coarse sediments are thought to have been deposited in the upper sublittoral zone.

In locality OT1, *Urocythereis? gorokuensis* dominates the assemblage. *Cyhtere lutea uranipponica, Finmarchinella daishakaensis, Loxocythere inflata* and *Urocythereis? abei* are the subordinate species. In locality OT2, stratigraphically 2 m above locality OT1, the dominant and subordinate species of locality OT1 are very few in number, and the three species, *Schizocythere okhotskensis, Cytheropteron sawanense* and *Loxoconcha subkotoraforma* predominate in almost the same abundance. The fine- to medium-grained sand of locality SH1 is considered to have accumulated in a deeper sea of the lower sublittoral zone than the coarse sediments of localities OT1 and OT2 and contains a characteristic association of ostracodes dominated by the two species, *Cytherura? mainensis* and *Neomonoceratina japonica* with *Callistocythere setanensis, Urocythereis? gorokuensis* and *Cytheropteron sawanense* as subordinate species.

Ostracodes from the lower part of the upper unit :

In the eastern area of the Daishaka Formation, fine sediments indicative of the lower sublittoral environment of the transgressive stage are developed at some horizons in the lower part of the upper unit. No ostracodes have been found in the fine sediments of the upper horizons in the northeastern part of the eastern area, probably due to subsequent dissolution of ostracode valves. Ostracodes were obtained in moderate numbers from the fine sediments in the lower horizons of the southeastern part. Ostracodes from the fine sediments of three localities along the Namioka River (fine-grained sand including the *Nuculana pernula sadoensis-Portlandia japonica-Limopsis tokaiensis* assemblage; locality N1, gravelly, fine- to medium-grained sand containing the *Astarte borealis-Venericardia ferruginea-Nuculana pernula sadoensis-Polynemamussium alaskense* assemblage; N2 and N3) are similar to one another in species composition and characterized by dominant occurrences of *Schizocythere okhotskensis* and *Cytheropteron sawanense.* The gravelly, fine- to medium-grained sand of locality TA1, a northern extension of the fine sediments in the lower horizons found around the Namioka River, contains an ostracode assemblage of similar species composition to those from the three localities along the Namioka River mentioned above except for the relatively rare occurrence of *Cytheropteron sawanense* and the common occurrence of *Elofsonella concinna.*

Fine sediments in the lower horizons change laterally northward into coarse sediments which were deposited in a shallower sea environment. Ostracodes were obtained from the coarse sediments of localities OT3 to OT6 along the Otanizawa River. The sediments are gravelly, medium-to coarse-grained sand with the *Ezocallista brevisiphonata-Glycymeris yessoensis-Chlamys cosibensis* assemblage in localities OT3 and OT6, silty, medium-grained sand with *Panomya arctica* standing upright in locality OT4, and gravelly, silty sand containing the *Acesta goliath-Ezocallista brevisiphonata-Astarte borealis* assemblage in locality OT5. In these sand samples *Schizocythere okhotskensis* and *Cytheropteron sawanense* are predominant, and *Loxocythere inflata, Baffinicythere howei, Urocythereis? gorokuensis, Urocythereis? abei* and *Cytheropteron yajimai* are commonly found. In locality OT5 *Cytheropteron sendaiense* occurs in almost the same abundance as the dominant *Cytheropteron sawanense.* Ostracodes from the gravelly, sandy silt of locality SH2, situated stratigraphically in the upper horizon of the lower part, show a similar species composition to that of ostracodes from the coarse sediments along the Otanizawa River noted above although they are relatively small in total number of individuals.

In the northern area the lithology of the lower part is rather different between the eastern and western flanks of the anticlinal dome; fine sediments alternating with coarse sediments are developed on the eastern flank, while coarse sediments predominate on the western flank. Ostracodes from fine sediments on the eastern flank were obtained from twelve localities; six localities along the Shinjo River (S1 to S6), one locality in the Kujirasawa River (K1), and five localities along the Otakizawa River (O1 to O5).

The fine sediments along the Shinjo River are composed of silty, fine-grained sand containing the *Portlandia japonica-Yoldia notabilis-Macoma calcarea* assemblage except for those in locality S6 where the *Nuculana pernula sadoensis-Portlandia japonica-Limopsis tokaiensis* assemblage is found. In these fine sediments, *Cytheropteron sawanense, Semicytherura henryhowei* and *Schizocythere okhotskensis* are dominant. *Neomonoceratina japonica, Robertsonites*

reticuliforma and *Finmarchinella hanaii* are subordinate, but the former two are dominant in some localities. *Palmenella limicola, Elofsonella concinna, Finmarchinella rectangulata, Robertsonites hanaii, R. tsugaruana, Acanthocythereis dunelmensis* and *Acanthocythereis tsurugasakensis* are characteristic in the fine sediments along the Shinjo River, though relatively small in individual numbers.

The fine sediments along the Kujirasawa and Otakizawa Rivers consist of gravelly, fine- to medium-grained sand in localities K1, O3 and O4. The sand contains the *Astarte borealis-Venericardia ferruginea-Nuculana pernula sadoensis-Polynemamussium alaskense* assemblage. The sediments of localities O1, O2 and O5 consist of silty, fine-grained sand containing the *Portlandia japonica-Yoldia notabilis-Macoma calcarea* assemblage. Ostracodes from these sediments are similar to those from sand samples along the Shinjo River and dominated by *Schizocythere okhotskensis, Semicytherura henryhowei* and *Cytheropteron sawanense* with associated *Palmenella limicola, Elofsonella concinna, Finmarchinella rectangulata* and *Finmarchinella hanaii* as subordinate species. *Robertsonites hanaii* is dominant in two localities K1 and O5, and in the northern area this species is known from the five localities, S1, S3, K1, O2 and O5. *Acanthocythereis dunelmensis* and *Robertsonites tsugaruana* characteristic of fine sediments are also found from the localities along the Kujirasawa and Otakizawa Rivers, though relatively small in numbers. In these localities, *Cythere lutea uranipponica, Baffinicythere emarginata* and *Finmarchinella japonica* occur commonly, although these species are common constituents also in coarse sediments.

Species composition of ostracodes from coarse sediments containing intertidal and upper sublittoral molluscs in the two localities SW1 and SW2 on the western flank is rather different from the eastern flank. The two localities also differ from each other. In locality SW1, *Aurila cymba, Finmarchinella hanaii, Cytheropteron sawanense* and *Schizocythere kishinouyei* are abundant and *Aurila uranouchiensis, Cornucoquimba tosaensis* and *Baffinicythere howei* occur commonly. However, in locality SW2, *Schizocythere okhotskensis, Baffinicythere emarginata, Finmarchinella japonica* and *Semicytherura subundata* are relatively abundant.

Ostracodes from the upper part of the upper unit :

In the upper part of the upper unit, coarse sediments are dominant in the area studied.

In the eastern area, ostracodes were obtained from three sediment samples at localities SH3, SH4 and N4. The lithology of SH3 is somewhat different from SH4. Locality SH3 consists of gravelly, silty, ill-sorted sand containing abundant allochthonous shells of *Arca boucardi* whilst locality SH4 is gravelly, medium- to coarse-grained sand characterized by the *Ezocallista brevisiphonata-Glycymeris yessoensis-Chlamys cosibensis* assemblage. Species composition of the ostracode assemblage from SH3 is, however, similar to that of SH4 in the abundance of *Howeina higashimeyaensis* and *Aurila cymba,* and in the common occurrence of *Loxocythere inflata, Baffinicythere emarginata, Finmarchinella daishakaensis, Cornucoquimba saitoi* and *Loxocorniculum mutsuense,* although *Schizocythere okhotskensis,* the dominant species in locality SH3, is absent. In silty, ill-sorted sand from locality N4, which contains allochthonous *Arca boucardi* and *Pinctada* sp., with fragments of bryozoa, *Hemicytherura cuneata* predominates and *Callistocythere hayamensis, Aurila cymba, Cornucoquimba tosaensis* and *Loxoconcha subkotoraforma* are sub-

ordinate.

In the northern area, localities S7 and T1 are represented by gravelly, ill-sorted sand containing allochthonous molluscs such as *Glycymeris yessoensis* and *Chlamys cosibensis*. *Schizocythere okhotskensis, Urocythereis? gorokuensis* and *Semicytherura subundata* are abundant in locality S7; *Aurila uranouchiensis, Finmarchinella daishakaensis, Baffinicythere howei,* and *Urocythereis? posterocostata* occur abundantly in locality T1.

General account of the ostracode fauna from the Daishaka Formation :

The molluscs from the sandy sediments of the Daishaka Formation are not strictly autochthonous as they do not maintain their position during life in the sediments and suffered postmortem transportation to some extent, though the degree of transportation differs from place to place. One can also suggest that some ostracodes obtained from the sandy sediments were transported a considerable distance from their normal habitats. The resulting admixture of ostracodes from various environments must have been extensive.

General high species diversity of ostracodes in sediment samples from the Daishaka Formation is ascribed to such an extensive mixing. It is thus difficult in this case to recognize definite ostracode assemblages related to particular sets of environmental factors. Consequently, discussions of the ostracodes from the Daishaka Formation must be confined to the general characteristics of the ostracode assemblages.

The relative abundance of some ostracode species in the Daishaka Formation is more relevant to the nature of sediments from which ostracodes were obtained than the stratigraphical positions or geographical situations of the sampling localities, and, at present, it is proper and fruitful to divide the sediment types into fine sediments and coarse sediments for discussion of the relationships between the ostracode assemblages and the nature of sediments. Two types of ostracode assemblages from the Daishaka Formation are recognized as given below. It is notable that species characteristic of the muddy bottom of inner bays such as *Trachyleberis scabrocuneata, Echinocythereis? bradyi, Bicornucythere bisanensis* and *Spinileberis quadriaculeata* are not found in the Daishaka Formation, except for a single adult specimen of *S. quadriaculeata* from locality O5 and one immature specimen of *B. bisanensis* from locality N4. This might suggest that the inner bay environment did not exist within the depositional area of the Daishaka Formation in the study area throughout the time of deposition.

Ostracodes from the Daishaka Formation are thought to be mostly sublittoral sand dwellers. *Schizocythere okhotskensis* and *Cytheropteron sawanense* are dominant, and *Cythere lutea uranipponica, Baffinicythere emarginata, Finmarchinella japonica, F. hanaii, F. daishakaensis, Urocythereis? gorokuensis, Cytherura? mainensis* and *Cytheropteron sendaiense* are common among most assemblages, irrespective of the sediment types.

The sublittoral sand assemblage from the Daishaka Formation is divided into two assemblages based mainly on the difference of subordinate species. The characteristic species combinations of these subordinate species can be correlated with particular sediment types namely coarse sediments and fine sediments.

(1) Upper sublittoral sand assemblage

This assemblage is contained in the coarse sediments. On the basis of the molluscan fauna

these coarse sediments are thought to have been accumulated in the upper sublittoral environment. This assemblage is characterized by rare to common occurrences of *Neonesidea mutsuensis, Loxocythere inflata, Schizocythere kishinouyei, Aurila cymba, A. uranouchiensis, Cornucoquimba tosaensis, Loxoconcha hattorii* and *Loxocorniculum mutsuense.* It is highly probable that most constituents of this assemblage are inhabitants of the upper sublittoral sand bottom under a relatively high energy environment. Some elements may have been derived from various environments of the upper sublittoral and intertidal zones.

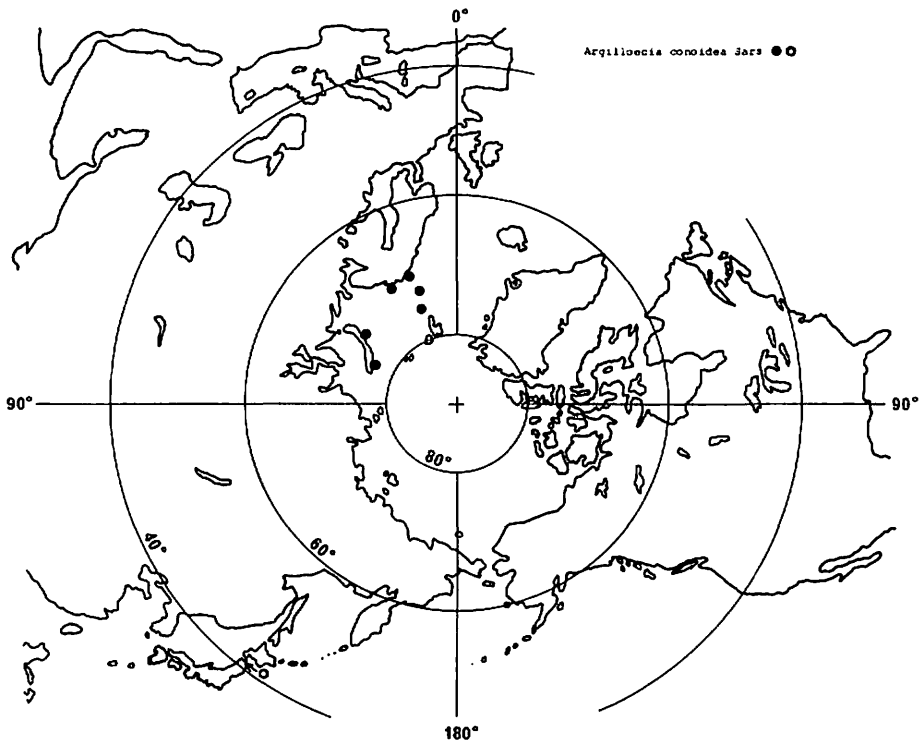
(2) Lower sublittoral sand assemblage

This assemblage is found in the fine sediments which are thought to have been deposited in the lower sublittoral zone. It is characterized by the dominant occurrence of *Semicytherura henryhowei* in addition to which there are rare to common occurrences of *Neomonoceratina japonica, Palmenella limicola, Elofsonella concinna, Finmarchinella rectangulata, Robertsonites reticuliforma, R. hanaii, R. tsugaruana* and *Acanthocythereis dunelmensis.* The major part of the assemblage consists of inhabitants probably of the lower sublittoral sand under a relatively low energy environment with some other elements derived mainly from the upper sublittoral environment.

Most ostracodes from the Daishaka Formation belong to two species groups in respect of their geographical distribution. One group consists of fossil and Recent species indigeneous to Japan and its surrounding areas. The other group consists of cold and shallow-water species belonging to genera with a circumpolar distribution, which consist of *Cluthia, Palmenella, Elofsonella, Baffinicythere, Finmarchinella, Normanicythere, Patagonacythere* and *Robertsonites.* Two species with a circumpolar distribution, *Argilloecia conoidea* and *Acanthocythereis dunelmensis,* are also included in this group. Geographical and stratigraphical distributions of the latter group have been widely known from the Recent seas of the North Pacific, the North Atlantic and the Arctic Sea, and the Pleistocene deposits peripheral to these seas by the faunal studies of Elofson (1941), Joy & Clark (1977), Hazel (1970), Neal & Howe (1975), Schornikov (1974), Swain (1963) and others. The geographical and stratigraphical distributions of these constituents are shown in text-figs. 5－15.

Among the species of the first indigenous geographical group, there is also a group of species regarded as peculiar to areas of cold climate. The geographical and stratigraphical distributions of these species are limited; they have been reported only from the late Cenozoic sediments of Northeast Japan and the Recent sediments of the North Pacific. This suggests that they are endemic. Examples of these species occurring in abundance in the Daishaka Formation are *Cytheropteron sawanense, Cythere lutea uranipponica, Semicytherura subundata, Schizocythere okhotskensis, Callistocythere setanensis* and *Munseyella hokkaidoana.* It is interesting to note that all the species mentioned above have closely related warm water species which have been reported from the late Cenozoic and Recent sediments of the Japanese area. At the same time, the first three species also have close relatives extending northwards into the Arctic Sea. The genera *Hemicythere,* so-called *Urocythereis?* and *Howeina* also characterize the cold water fauna of the Japanese area and they have not extended their distributions into the warm water area.

Constituents of the indigeneous Japanese geographical group tend to be found in the upper sublittoral sand assemblage; examples are *Aurila cymba, Schizocythere kishinouyei* and *Cor-*

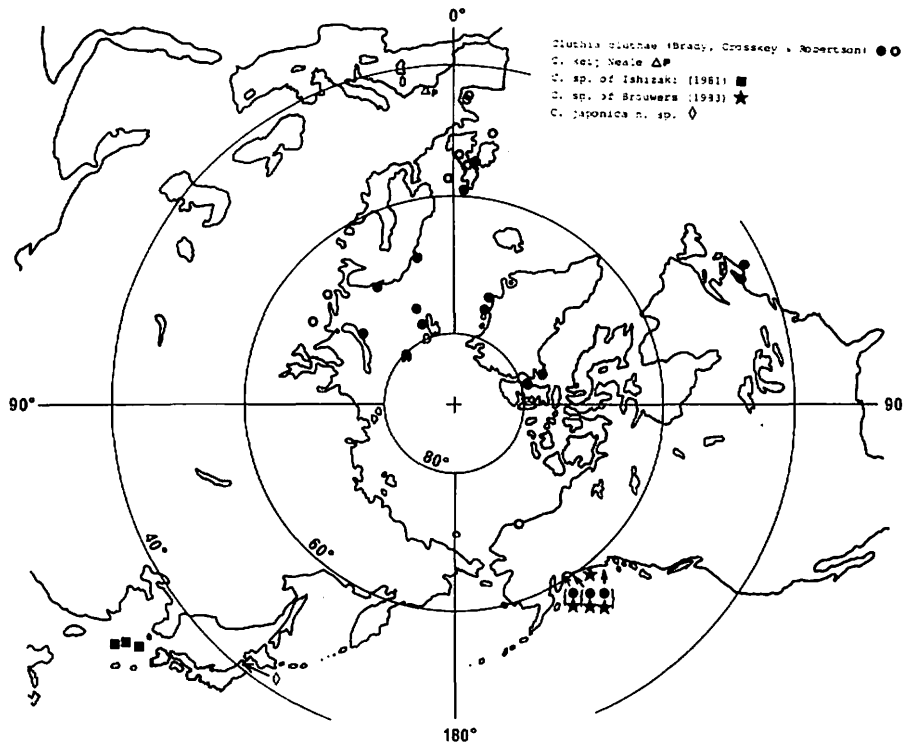


Text-fig. 5. Geographical and stratigraphical distribution of *Argilloecia conoidea.*

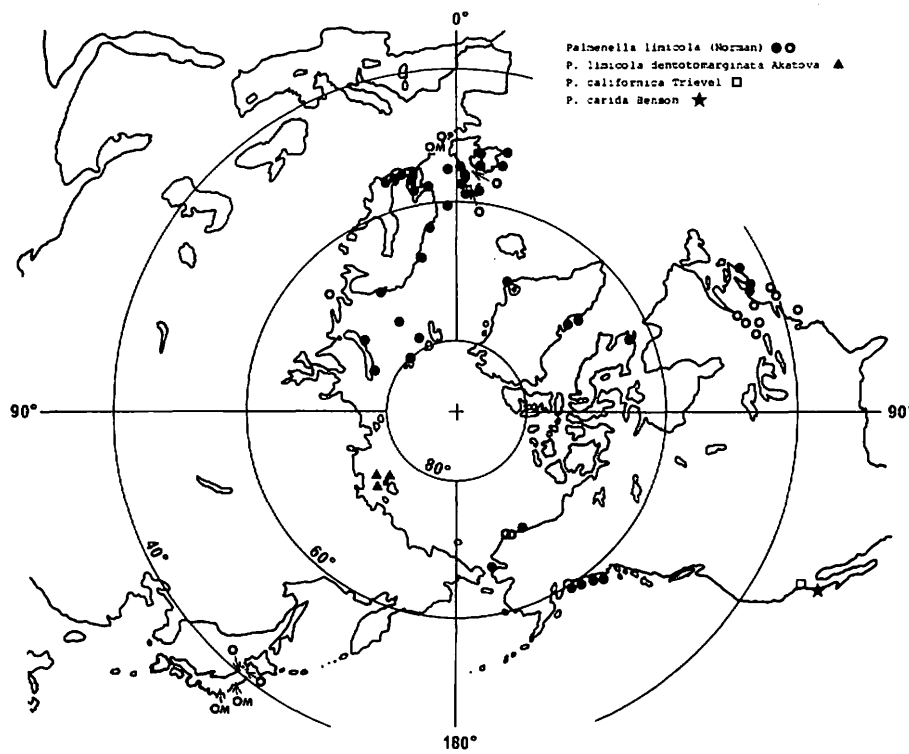
Text-figs. 5-15. Geographical and stratigraphical distributions of cold water species.

These figures are based on the data from the studies of Bassiouni (1965), Brouwers (1980, 1982a, 1982b, 1983), Carbonnel (1969), Carbonnel & Ballesio (1982), Cronin (1981), Diebel & Pietrzeniuk (1971), Elofson (1941), Hanai (1970), Hazel (1967, 1968, 1970), Hopkins, McDougall & Brouwers (1980), Ishizaki (1966, 1969, 1971, 1981), Neale (1973a, 1974a, 1974b), Neale & Schmidt (1967), Neale & Howe (1975), Okada (1979), Robinson (1978), Rosenfeld (1977), Schornikov (1974), Siddiqui & Grigg (1975), Swain (1963), Yajima (1982) and the present study.

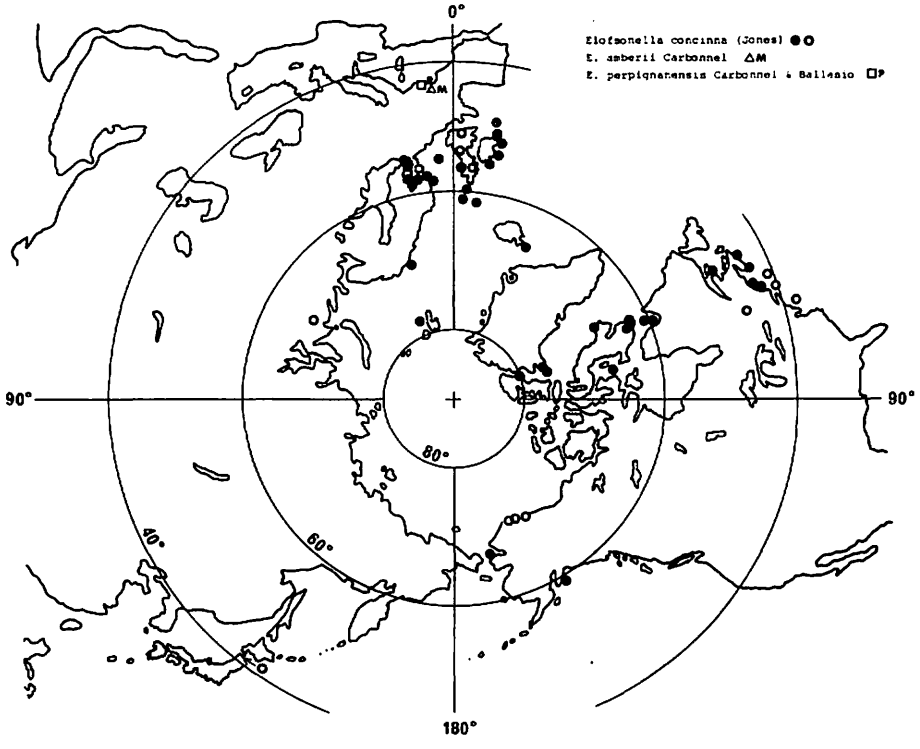
● ▲ ■ ★ ⧗ ----- Recent
○ △ □ ☆ ◇ ⋈ ⧖ Ⓐ ⊠ -- Pleistocene
△P □P ---------- Pliocene
△M □M ---------- Miocene



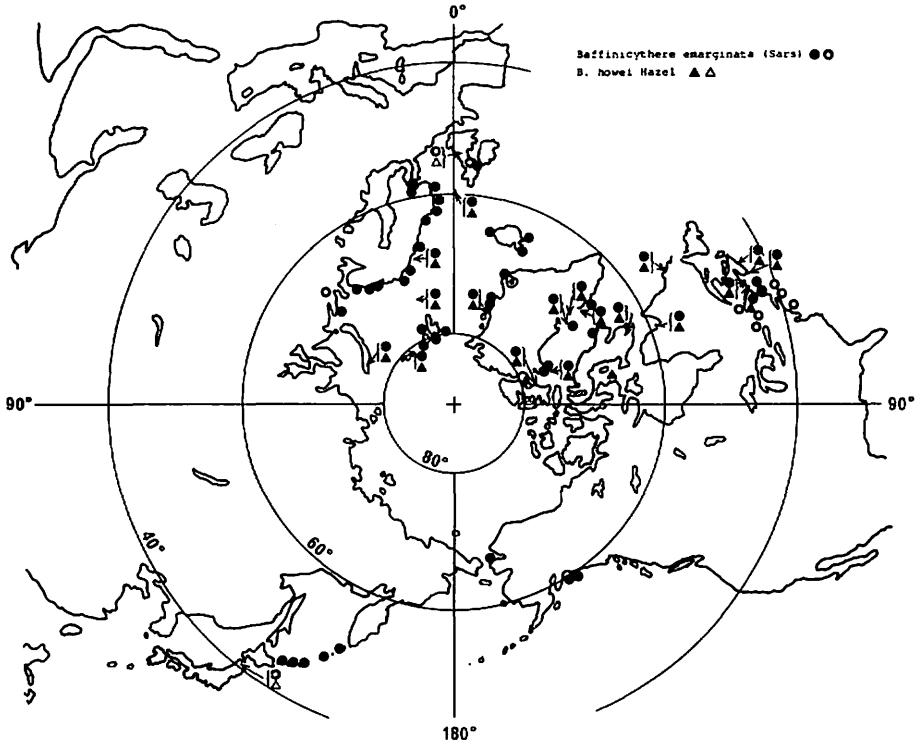
Text-fig. 6. Geographical and stratigraphical distribution of *Cluthia*.



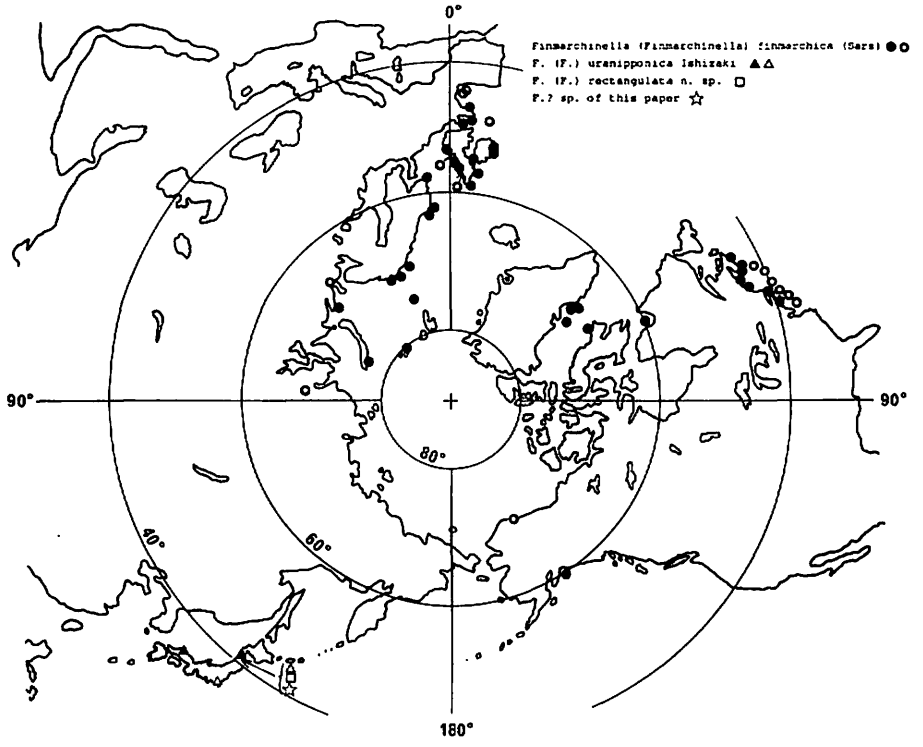
Text-fig. 7. Geographical and stratigraphical distribution of *Palmenella*.



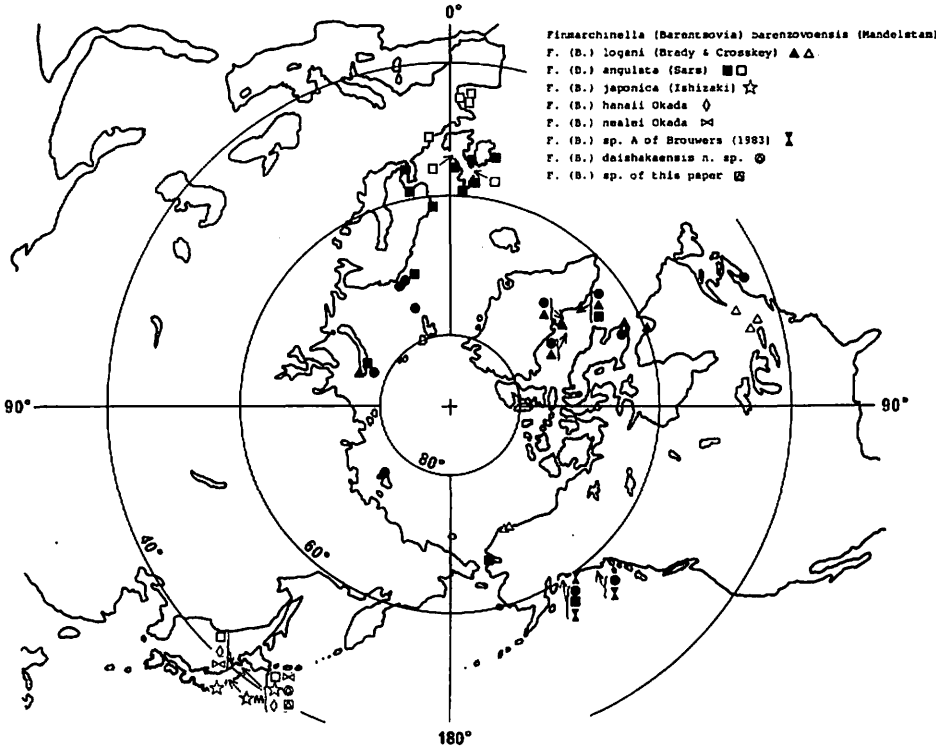
Text-fig. 8. Geographical and stratigraphical distribution of *Elofsonella*.



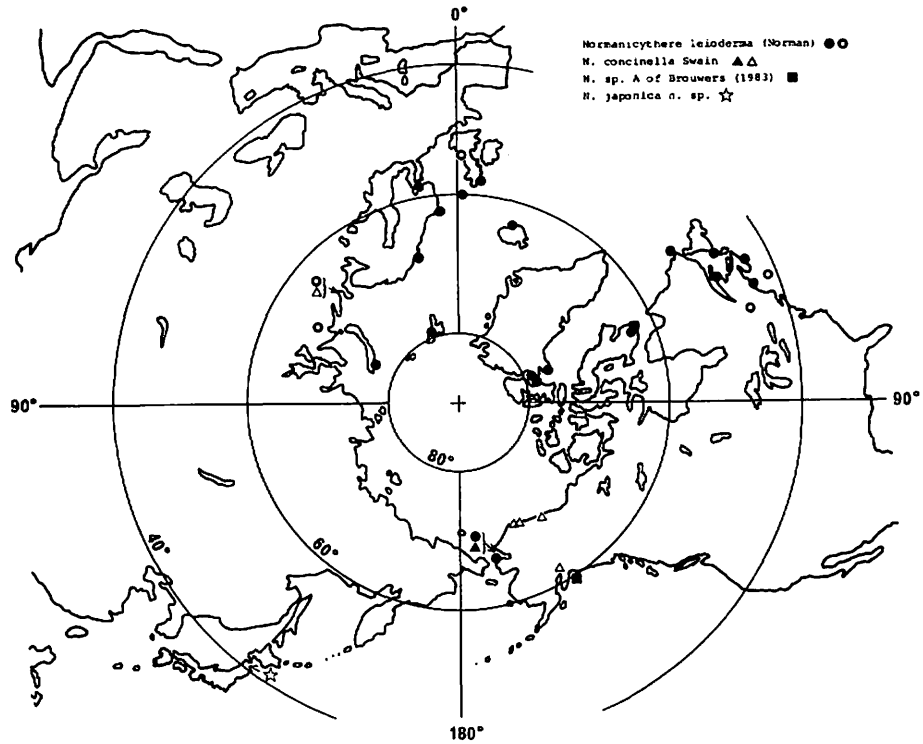
Text-fig. 9. Geographical and stratigraphical distribution of *Baffinicythere*.



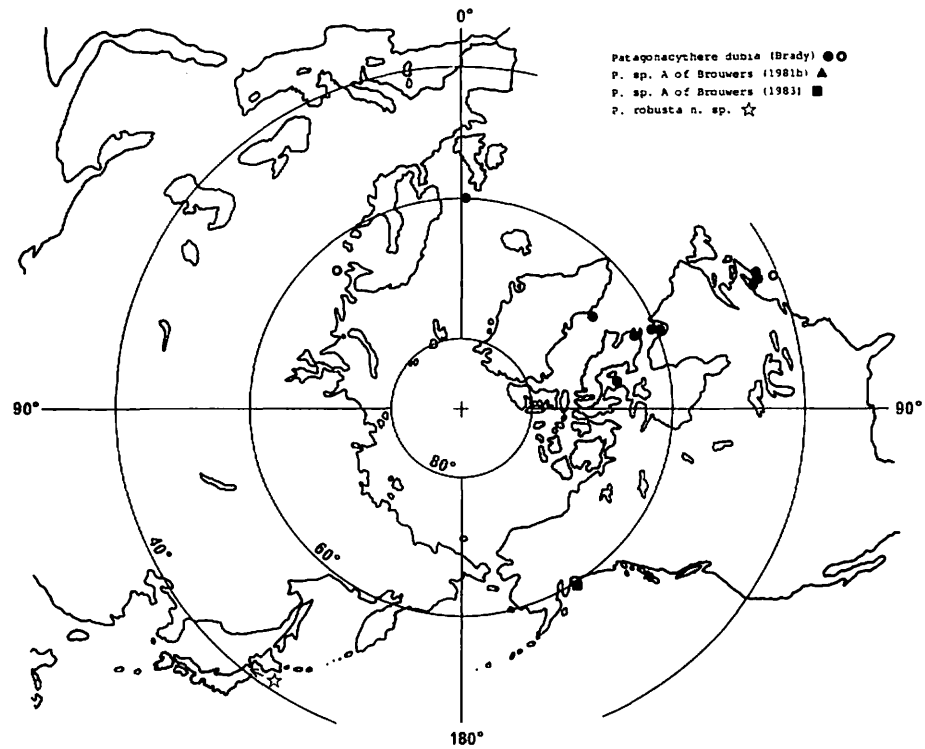
Text-fig. 10. Geographical and stratigraphical distribution of *Finmarchinella (Finmarchinella).*



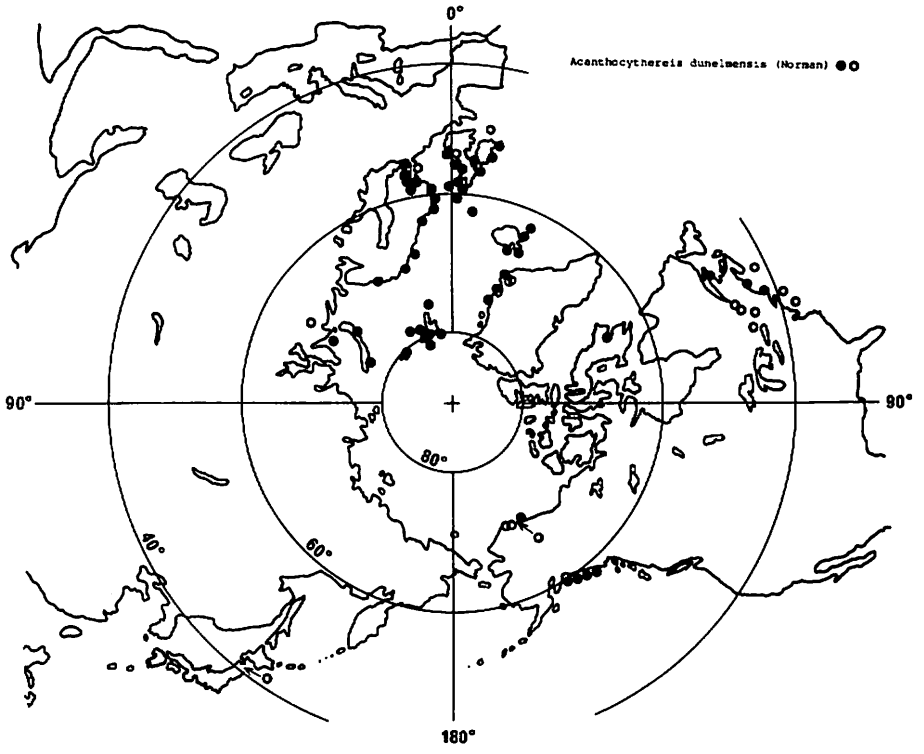
Text-fig. 11. Geographical and stratigraphical distribution of *Finmarchinella (Barentsovia).*



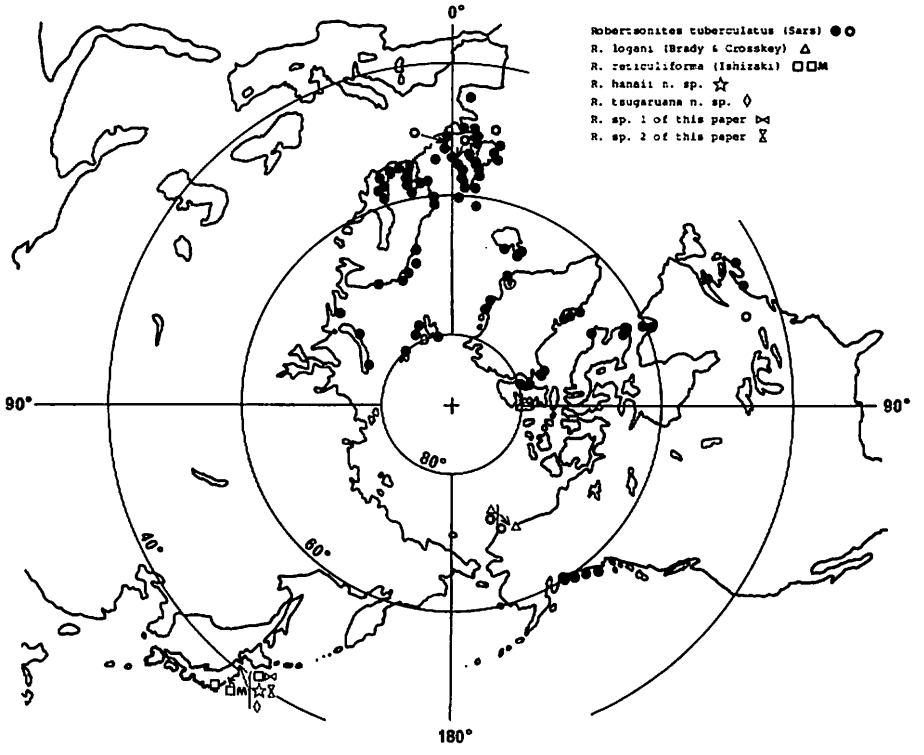
Text-fig. 12. Geographical and stratigraphical distribution of *Normanicythere*.



Text-fig. 13. Geographical and stratigraphical distribution of *Patagonacythere*.



Text-fig. 14. Geographicl and stratigraphical distribution of ***Acanthocythereis dunelmensis.***



Text-fig. 15. Geographical and stratigraphical distribution of *Robertsonites.*

nucoquimba tosaensis. Elements of the circumpolar geographical group, such as *Palmenella limicola, Elofsonella concinna* and *Acanthocythereis dunelmensis* are characteristically found in the lower sublittoral sand assemblage. This different relationship between the geographical species groups and the sediment types or sedimentary environments may be related to differences in water temperature probably connected with the characteristics of water mass structure in the area at that time, although differences in substrate formed by the sediments may control the local distributions of these species.

Comparison of the Daishaka fauna with other ostracode faunas from Northeast Japan :

Reports of late Cenozoic and Recent ostracode faunas from Northeast Japan are relatively few. There are faunal descriptions by Ishizaki of the Neogene ostracodes from the Sendai area (1966), and of the living fauna from Aomori Bay (1971). Okada (1979) discussed the ostracode fauna from the Pleistocene deposits of the Oga Peninsula. Hanai's serial works (1957a, 1957b, 1957c, 1959a, 1959b, 1970) include systematic descriptions of the species obtained from the Pliocene and Pleistocene sediments in some localities in Northeast Japan, and form the basis of ostracode studies in the region. Here the ostracode fauna from the Daishaka Formation is compared with other late Cenozoic faunas from Northeast Japan.

Ishizaki (1966) reported ostracodes from the Miocene Moniwa and Hatatate Formations and the Pliocene Tatsunokuchi Formation in the Sendai area. Almost all the genra reported from the two Miocene formations are found also in the Daishaka Formation. When viewed at species level, however, the Daishaka fauna is very different from the ostracodes of the two Miocene formations. Ostracodes from the Moniwa and Hatatate Formations are mostly composed of warm and temperate species living in the shallow sea area around Japan together with some fossil species. Ishizaki estimated that the main parts of these two formations had been deposited in warm and shallow water in a basin connected with the open sea. These species are mostly absent or represent a relatively small proportion of the Daishaka fauna. It is worth noting that five species, *Palmenella limicola, Robertsonites reticuliforma, Neomonoceratina japonica, Cythere lutea uranipponica* and *Cytheropteron sendaiense* which occur in the Hatatate Formation are also important constituent species of the ostracode fauna in the Daishaka Formation. In particular, the first three species are characteristic of the lower sublittoral sand assemblage found in the fine sediments of the Daishaka Formation. *Cythere lutea uranipponica* and *Cytheropteron sendaiense* are found throughout the formation irrespective of sediment type.

Ishizaki suggested that the ostracode fauna from the Pliocene Tatsunokuchi Formation had lived in a more or less enclosed bay environment in a cold water area. Dominant species in the Tatsunokuchi fauna are different from those of the Daishaka Formation. Exceptions are *Urocythereis? gorokuensis* and *Cythere lutea uranipponica*, both of which are relatively abundant in the two formations. The difference in dominant species might be partly ascribed to the different sedimentary environments of these two formations.

Okada (1979) discussed the compositional change of ostracode faunas from the Pleistocene Shibikawa and Anden Formations in the Oga Peninsula, Akita Prefecture. The sediments of these two formations consist of six cycles of sedimentation. Ostracodes are confined to the sediments of cycles II, III and V. The ostracodes from cycle II are very similar to those from the

Daishaka Formation in species composition as exemplified by the commonly dominant occurrence of *Schizocythere okhotskensis* with subordinate *Semicytherura henryhowei, Urocythereis? gorokuensis* and *Howeina higashimeyaensis.* The ostracodes from cycle II may be compared with those of the upper sublittoral sand assemblage of the Daishaka Formation, particularly in the fact that *Semicytherura henryhowei* occupies only a subordinate position, and that characteristic species of the lower sublittoral sand assemblage are absent or found only rarely. Ostracode faunas from cycles III and V differ from those of the Daishaka Formation; these faunas are characterized by the dominance of *Finmarchinella hanaii* which never reaches a dominant position in the Daishaka fauna. Okada explained the faunal difference between cycle II and cycles III and V as the increase or appearance of warm water elements.

Ishizaki (1971) published descriptions of Recent ostracodes from Aomori Bay. Ostracode samples used in his study were mostly obtained from offshore mud or muddy sand areas. Ostarcodes from this area are dominated by muddy bottom dwellers characteristic of inner bay environments such as *Howeina camptocyhteroidea, Bicornucythere bisanensis, Echinocytheis? bradyi* and *Spinileberis quadriaculeata.* These species are absent or extremely rare in the Daishaka fauna. Species common to the Daishaka fauna such as *Cythere lutea uranipponica* and *Howeina higashimeyaensis* are found in Aomori Bay in small numbers both as regards species and individuals. They are also not abundant in the Daishaka fauna although *Cythere lutea uranipponica* is found widely as a subordinate species.

Ostracodes of the Pliocene Sawane Formation and the Plio-Pleistocene Setana Formation, the molluscan faunas of which have been regarded as the typical Omma-Manganjian fauna, have not been fully described. Hanai (1957a, 1957b, 1957c, 1959a, 1959b, 1970) reported 17 new species from the Sawane and Setana Formations. It is thought that almost all the species from the Sawane and Setana Formations can be regarded as cryophilic species although their geographical distributions are confined to Japan and its adjacent areas. Seven species among ten species from the Sawane Formation and seven species among eight species from the Setana Formation are found in the Daishaka Formation. This fact indicates the general similarity of the Daishaka fauna to the faunas of the Sawane and Setana Formations.

Yajima (1982) described the ostracode fauna from the Upper Pleistocene Narita Group of the Boso Peninsula, Central Japan. The Narita Group is composed of a series of transgressive warm water sediments accumulated in the Paleo-Tokyo Bay during the interglacial periods. She reported cold water ostracode assemblages from the lower parts of each transgressive sand bed of the Narita Group. The cold water assemblages are characterized by *Robertsonites reticuliforma, Finmarchinella uranipponica, F. japonica, Howeina camptocytheroidea* and *H. higashimeyaensis.* Yajima mentioned that these cold water species may have been dominant in the Paleo-Tokyo Bay during the glacial periods and continued to live during the early transgressive phases of the following interglacial periods. *Finmarchinella japonica* and *Howeina-higashimeyaensis* occur commonly throughout the Daishaka Formation and *Robertsonites reticuliforma* is characteristic of the lower sublittoral sand assemblage. However, *Finmarchinella uranipponica* is rarely found, and *Howeina camptocytheroidea* is absent in the Daishaka Formation. There are many cold water species which are found in the Daishaka fauna, but are absent in the fauna of the Narita Group. This is probably due to the difference in the

geographical positions of the two areas.

IV Systematic description

Holotypes and illustrated specimens are deposited in the collection of the University Museum, University of Tokyo (UMUT). Specimen numbers are prefixed CA for Cenozoic Arthropoda. Synonyms after publication of Hanai *et al.* (1977) are listed in this systematic section. Refer to Hanai *et al.* (1977) for synonyms before 1977. Redescription was carried out only for the species thought to be given an insufficient original description. The following abbreviations are used in this section :

Sp : Specimen measured (L, R, C, F, M, A-1 for left valve, right valve, carapace, female, male, instar at adult-1 satge, respectively).
Me : Measurements (L, H, W for lenght, height, width).
N : Number of observations.
$\bar{X}$: Arithmetic mean (mm).
s : Standard deviation (mm).
V : Coefficient of variation.
OR : Observed range (mm).

Subclass OSTRACODA Latreille, 1806.
Order PODOCOPIDA Sars, 1866.
Superfamily CYPRIDACEA Baird, 1845.
Family PONTOCYPRIDIDAE G. W. Müller, 1894.
Genus *PROPONTOCYPRIS* Sylvester-Bradley, 1947.
Propontocypris sp.
Pl. 1, fig. 4

Illustrated specimen. A partly broken left valve, UMUT-CA 15741 (Pl. 1, fig. 4. L, 0.58; H, 0.29), Loc. OT6.

Remarks. This species is very similar to *Propontocypris* (*Propontocypris*) sp. of Yajima (1982) from the Pleistocene sediments of the Boso Peninsula, Central Honshu, in general shape. Slight differences are found in larger size, straight anterior half of dorsal margin and more distinct sinuation in ventral margin of the present species.

Occurrence. This species is found as one specimen at Loc. OI and OT6, respectively.

Genus *ARGILLOECIA* Sars, 1866
Argilloecia sp.
Pl. 1, figs. 1, 2.

Illustrated specimens. A right immature valve, UMUT-CA 15742 (Pl. 1, fig. 1. L, 0.59; H, 0.26), Loc. OT5; a left immature valve, UMUT-CA 15743 (Pl. 1, fig. 2. L, 0.57; H, 0.25), Loc. OT5.

Remarks. This species is characterized by nearly straight central part of dorsal margin which meets with anterior and posterior parts of dorsal margin making a blunt obtuse angle. This characteristic outline is of use in differentiating this species from other related species,

Argilloecia conoidea (Sars, 1866) reported from Russian Harbour, Novaya Zemlya by Neale & Howe (1975) and *A. lunata* Frydl, 1982 from the Holocene sediments of the southern part of the Boso Peninsula, Centarl Honshu, by Frydl (1982).

Occurrence. This species occurs rarely from three localities, Loc. OT4, OT5 and T1.

Superfamily CYTHERACEA Baird, 1850.
Family CYTHERIDEIDAE Sars, 1925.
Subfamily NEOCYTHERIDEIDINAE Puri, 1957.
Genus *NEOCYTHERIDEIS* Puri, 1952.
Neocytherideis? sp.
Pl. 1, fig. 3

Illustrated specimen. A right valve, UMUT-CA 15744 (Pl. 1, fig. 3. L, 0.47; H, 0.20), Loc. S3.

Remarks. Inner features and molt stage of this specimen are completely unknown due to its ill-preserved inner surface. This specimen is tentatively assigned to genus *Neocytherideis* based mainly on elongate oblong outline with straight dorsal margin.

Occurrence. This species is found as only one ill-preserved specimen mentioned above.

Genus *PONTOCYTHERE* Dubowsky, 1939.
Pontocythere sp.
Pl. 1, figs. 9－12; text-fig. 17－9.

Illustrated specimens. A right valve, UMUT-CA 15745 (Pl. 1, figs. 9, 12. L, 0.61; H, 0.26), Loc. T1; a left valve, UMUT-CA 15746 (Pl. 1, figs. 10, 11; text-fig. 17-9. L, 0.63; H, 0.25), Loc. T1.

Description. Valves elongate oblong in lateral view, highest at posterior one-forth of valve length in right valve and at anterior cardinal angle in left valve. Anterior margin broadly and obliquely rounded in left valve and narrowly rounded with its nearly straight upper one-third portion in right valve. Dorsal margin slightly arched in right valve and nearly straight in left valve. Ventral margin sinuate at about mid-length. Posterior margin broadly rounded, slightly extended below, meeting with dorsal margin at a blunt obtuse angle, and grading smoothly into ventral margin. Valves in dorsal view, smoothly arched on each side with greatest width at posterior one-third of valve length. Surface ornamented by punctations of normal pore openings and partly developed faint ridges running obliquely to ventral margin in ventral marginal area and running subparallel to anterior margin in anterior marginal area. Subcentral tubercle and eye tubercle absent.

Normal pore openings moderate in number, scattered and simple. Radial pore canals straight, simple, about 12 along anterior, about 11 along ventral and about 5 along posterior margins.

Marginal infold moderately wide along anterior margin and narrow along ventral and posterior margins. Vestibule deep along anterior and absent along ventral and posterior margins. Hinge desmodont of *Cushmanidea* type. Muscle scar field in anteroventral area. Muscle scars consisting of a trilobate frontal scar and an oblique row of four adductor scars. Two mandibular scars distinct just below muscle scar field.

Remarks. The present species is closely related to *Pontocythere* sp. 1 of Yajima (1982) in

general shape and ornamentation, but differs from the latter in having much larger valve size, unevenly rounded posterior margin, somewhat distinct anterior cardinal angle and faint ridges which are confined only to anterior and ventral marginal areas in distribution.

Occurrence. Only two adult valves of this species occur from Loc. T1.

Family EUCYTHERIDAE Puri, 1954.

Genus *EUCYTHERE* Brady, 1868.

Eucythere sp. 1

Pl. 1, figs. 5, 6; Pl. 20, fig. 1; text-fig. 17-10.

Illustrated specimen. A left valve, UMUT-CA 15747 (Pl. 1, figs. 5, 6; Pl. 20, fig. 1; text-fig. 17-10. L, 0.56; H, 0.31), Loc. OT6.

Description. Valve subtriangular in lateral view highest at anterior cardinal angle. Anterior margin broadly rounded, slightly extended below. Dorsal margin nearly straight in its anterior half and slightly convex in its posterior half. Ventral margin slightly sinuate at about anterior two-fifths of valve length. Posterior margin narrowly and obliquely rounded, grading smoothly into dorsal and ventral margins. Left valve in dorsal view gently convex with greatest width at about posterior two-fifths of valve lenght. Surface ornamented by punctations of normal pore openings and very faint reticulation covering over most of surface, arranged somewhat concentrically, particularly distinct in marginal area along free margin. Lateral compression lying in anteroventral and posteroventral marginal areas. Subcentral tubercle and eye tubercle absent.

Normal pore openings about 35 in number, scattered, consisting of sieve type pore with setal pore in its margin. Radial pore canals straight, simple, about 10 along anterior and about 4 along posterior margins.

Marginal infold rather broad along anterior margin and much narrower along ventral and posterior margins. Vestibule moderately deep anteriorly and narrow posteriorly. Hinge lophodont. Muscle scar field in ventrocentral area. Muscle scars consisting of a large V-shaped frontal scar with much longer posterior arm and an oblique row of four adductor scars; ventral one is much larger and lower three are rather elongate.

Remarks. Description is based on only one adult valve. This species is very close to *Eucythere yugao* Yajima, 1982 in its similar valve size, subtriangular outline and faintly reticulate valve surface. But, the present species differs from the latter in having more narrowly rounded posterior margin, less sinuate ventral margin and more widely distributed faint reticulation on surface.

Occurrence. This species is represented by only one adult left valve from Loc. OT6 and one left immature valve from Loc. O2.

Eucythere sp. 2

Pl. 1, figs. 7, 8; text-fig. 18-1

Illustrated specimen. A right valve, UMUT-CA 15748 (Pl. 1, figs. 7, 8; text-fig. 18-1. L, 0.66; H, 0.35), Loc. O4.

Description. Valve elongate subtrapezoidal in lateral view, highest at anterior cardinal

angle, situated at about mid-length. Anterior margin broadly and obliquely rounded. Dorsal margin slightly convex. Posterior margin obliquely truncate in its upper half, meeting with dorsal margin at a blunt obtuse angle, and obliquely arched in its lower half, grading into ventral margin. Ventral margin sinuate at about anterior one-third of valve length and slightly convex in its posterior two-thirds. In dorsal view, right valve showing smoothly arched outline with greatest width at about mid-length. Surface ornamented by punctations of normal pore openings and overall irregular undulation with distinct marks of internal muscle scars in ventrocentral area. Subcentral tubercle and eye tubercle absent.

Normal pore openings small in number, scattered, consisting of sieve type pores with setal pore opening. Radial pore canals straight, simple, about 10 along anterior and about 4 along posterior margins.

Marginal infold rather broad along anterior margin and narrow along ventral and posterior margins. Vestibule moderately deep anteriorly and shallow posteriorly. Hinge partly broken but lophodont. Muscle scar field in ventrocentral area. Muscle scars consisting of a large V-shaped frontal scar with an extremely short anterior arm and an oblique row of four adductor scars; all adductor scars are elongate and lower two scars are distinctly curved.

Remarks. Description is based on one right adult valve. The present species is close to *Eucythere yugao* Yajima, 1982 in general shape, but is distinguishable from the latter in having larger valve size, irregularly undulate surface and less prominent compression in anteroventral area.

Occurrence. One adult right valve of this species occurs from Loc. O4 and one immature right valve from Loc. O1.

Subfamily PECTOCYTHERINAE Hanai, 1957.

Genus *PECTOCYTHERE* Hanai, 1957.

Pectocythere daishakaensis n. sp.

Pl. 2, figs. 1－7; text-figs. 16-1, 2

Type. Holotype, a left female valve, UMUT-CA 15749 (Pl. 2, figs. 2, 5; text-fig. 16-1. L, 0.54; H, 0.31), Loc. TA1.

Illustrated specimens. A female carapace, UMUT-CA 15750 (Pl. 2, fig. 1, L, 0.55; H, 0.30; W, 0.29), Loc. SH1; a female carapace, UMUT-CA 15751 (Pl. 2, fig. 7. L, 0.54; H, 0.29; W, 0.27), Loc. SH1; a right male valve, UMUT-CA 15752 (Pl. 2, fig. 3, 6; text-fig. 16-2. L, 0.58; H, 0.29), Loc. SH1; a male carapace, UMUT-CA 15753 (Pl. 2, fig. 4. L, 0.58; H, 0.30; W, 0.27), Loc. SH1.

Diagnosis. Pectocythere characterized by punctate surface, distinct posterocentral swelling and posterodorsal bold ridges.

Description. Valves subrectangular, tapering posteriorly in lateral view, highest at anterior cardinal angle. Anterior margin broadly rounded, slightly extended below. Dorsal margin slightly arched. Ventral margin slightly concave. Posterior margin obliquely arched, meeting with dorsal margin in a blunt obtuse angle and grading into ventral margin. Left valve slightly larger than right. Valves elongate subelliptical in dorsal view with weak undulation. Surface ornamented by punctations of normal pore openings and some irregularly shaped low swellings. Low and somewhat elongate swelling in posterocentral area with very shallow surrounding

depression. Compressed marginal area lying in posterodorsal and posteroventral areas. Posterodorsal ridge short and bold, starting at posterior one-third of dorsal margin, curving almost parallel to posterior margin and becoming obscure at about lower one-fifth of valve height. A few marginal ridges running along anterior and ventral margins feeble, undulate and partly indistinct. Subcentral tubercle and eye tubercle not discernible.

Normal pore openings small in number, scattered, consisting of large sunken sieve type pores and small simple type pores. Radial pore canals slightly wavy, sometimes bifurcate, small in number, about 7 along anterior, 8 along ventral and 6 along posterior margins.

Marginal infold moderately broad along anteroventral margin. Vestibule present anteriorly and posteriorly, particularly deep along anteroventral margin. Hinge pentodont with an elongate anterior tooth, a subround posterior tooth and a finely crenulate median groove with widened and deepened sockets in its anterior and posterior terminations in right valve. Hinge of left valve complementary of that of right valve, with a finely crenulate median bar with terminal protruded teeth consisting of upper and lower elements being fused to each other. Muscle scar field in central to anterocentral area. Muscle scars consisting of one large V-shaped frontal scar and a vertical row of four adductor scars; median two scars are elongate.

Sexual dimorphism distinct. Males more slender than females.

Dimensions. Measurements of pooled specimens from Loc. SW1, S1, S2, K1, O4, OT1, OT2, OT3, TA1, N2, N3 and SH1 are as follows.

Sp	Me	N	$\bar{X}$	S	V	OR
L (F)	L	2				0.52−0.54
	H	2				0.30−0.31
R (F)	L	8	0.528	0.0128	2.42	0.51−0.54
	H	8	0.281	0.0083	2.95	0.27−0 29
L (M)	L	3	0.560			0.54−0.58
	H	3	0.290			0.28−0.30
R (M)	L	7	0.569	0.0168	2.95	0.54−0.59
	H	7	0.284	0.0151	5 32	0.26−0.30
C (F)	L	3	0.543			0.54−0.55
	H	3	0.297			0.29−0.30
	W	3	0.280			0.27−0.29
C (M)	L	1				0.58
	H	1				0.30
	W	1				0.27

Remarks. The present species is similar to *Pectocythere clavata* (Trievel, 1957) from the Holocene sediments from western North America, described by Valentine (1976) and *Pectocythere?* sp. cf. *P.? dentarticulata* (Smith, 1952) reported by Swain & Gilby (1974) from the Pacific coast in North America in having subrectangular lateral outline and punctated surface, but is apparently different from the latter in having concave ventral margin, distinct posterodorsal ridge and posterocentral swelling.

Occurrence. This species occurs commonly from 16 localities as listed in table 1.

Genus *KOTORACYTHERE* Ishizaki, 1966.

Kotoracythere sp.

Pl. 1, figs. 14－19.

Illustrated specimens. A right valve, UMUT-CA 15754 (Pl. 1, figs. 14, 17, 19. L, 0.58; H, 0.30), Loc. SH1; a left valve, UMUT-CA 15755 (Pl. 1, figs. 15, 16, 18. L, 0.61; H, 0.32), Loc. SH1.

Description. Valves subrhomboidal, slightly converging posteriorly in lateral view, highest at anterior cardinal angle and longest at mid-height. Anterior margin broadly and obliquely rounded. Dorsal margin nearly straight, slightly inclined downward in its posterior half. Ventral contact margin nearly straight with slight concavity at middle of valve length, but mostly hidden by protruded ventral marginal ridge forming a nearly straight ventral lateral outline. Posterior contact margin of left valve, vertically truncate in its upper half, meeting with dorsal margin at a distinct obtuse angle, and obliquely rounded in its lower half, partly obscured by the ventral marginal ridge, merging into ventral contact margin. In right valve, posterior margin truncate in its upper half, almost hidden by the ventral marginal ridge forming a rather sinuous outline with two distinct concavities. Valves elongate elliptical in dorsal view, with a distinct break of slope at posterior one-fourth of valve length. Surface ornamented by blunt and undulate ridges, and faint reticulation. Anterior marginal ridge short and blunt, starting from dorsal margin a little posterior to anterodorsal corner, running along anterior margin and becoming obscute at about lower one-third of valve length. The ventral marginal ridge arising from anteroventral area near anteroventral corner, rather weak in its anteriormost part, running posteriorly, obscuring most part of ventral contact margin, curving dorsally near posteroventral corner, running almost parallel to posterior margin leaving two concavities, particularly distinct in right valve, curving anterodorsally at about mid-height in right valve and at about lower one-third of valve height in left valve, and running obliquely to dorsal margin at posterior two-fifths of valve length, separating much compressed posterodorsal area from main part of carapace surface. An undulate and blunt longitudinal ridge starting at about anterior one-third of valve length in central area, running posteriorly, being slightly inclined ventrally at about posterior one-third of valve length, and running downward to terminate at about posterior one-sixth of valve length. Ventrolateral surface extending laterally with the increase of degree of extension toward posterior direction to form a node-like swelling at about posterior one-fourth of valve length. Subcentral tubercle and eye tubercle not discernible.

Normal pore openings relatively small in number, scattered. Radial pore canals simple, very few in number, at least 3 along anterior margin and 4 along posterior margin.

Marginal infold relatively broad along anterior margin and moderate to narrow along ventral and posterior margins. Vestibule present along free margin, except for middle one-third of ventral margin, particularly deep along anteroventral margin. Hinge pentodont.

Remarks. Specimens at hand are ill-preserved three adult valves in which details of carapace structure are not preserved. This species resembles *Kotoracythere abnorma* (Ishizaki, 1966) in general shape and surface ornamentation characterized by blunt and undulate ridges, but is different from the latter in having a much shorter anterior marginal ridge and only one distinct longitudinal ridge in central to posterior surface.

Occurrence. This species occurs rarely from Loc. SH1.

Genus *MUNSEYELLA* van den Bold, 1957.

Munseyella sp.

Pl. 1, fig. 13

Illustrated specimen. A right immature valve, UMUT-CA 15756 (Pl. 1, fig. 13. L, 0.52; H, 0.27), Loc. O5.

Remarks. This species is assignable to genus *Munseyella*, owing to its subrectangular outline, distinct two spines on posterior margin and pentodont hinge, and is characterized by simple surface ornamented only by punctations of normal pore openings.

Occurrence. Only two immature specimens of this species are found at Loc. O5.

Family LEPTOCYTHERIDAE Hanai, 1957

Genus *CALLISTOCYTHERE* Ruggieri, 1953

Callistocythere sp.

Pl. 2, figs. 8－11; text-fig. 18-2

Illustrated specimens. A right valve, UMUT-CA 15757 (Pl. 2, figs. 8, 11; text-fig. 18-2. L, 0.39; H, 0.20), Loc. OT3; a left valve, UMUT-CA 15758 (Pl. 2, figs. 9, 10. L, 0.38; H, 0.20), Loc. K1.

Description. Valves subrectangular in lateral view, highest at anterior cardinal angle. Anterior margin broadly rounded, slightly extended below in right valve. Dorsal margin nearly straight. Ventral contact margin sinuate at about mid-length, and mostly hidden by flattened ventral surface in lateral view giving straight ventral outline. In left valve, posterior margin slightly concave in its upper half, meeting with dorsal margin at a blunt obtuse angle, and obliquely and irregularly arched in its lower half, merging smoothly into ventral margin. In right valve, posterior margin broadly rounded in its upper half, merging smoothly into dorsal margin. Valves box-shaped with a protruded compressed anterior termination in dorsal view. Surface ornamented by punctations of normal pore openings. Submarginal ridge along free margin, and undulate and blunt short ridges in anteroventral area. Marginal rim present along valve margin, particularly bold along dorsal margin. Submarginal ridge starting from inner margin of compressed anterior marginal area at lower two-fifths of valve height, running subparallel to anterior margin and branching into two in area near ventral margin at about anterior one-fourth of valve length; one running on boundary between ventrolateral surface and ventral surface and terminating in its complicated undulation branching in posteroventral area, and the other offshoot extending into ventral surface, running posteriorly with some winding, curving dorsally near posteroventral corner making its appearance in lateral view, running around posterior margin and reaching to marginal rim near posterodorsal corner. Anterior marginal area extremely compressed. Shallow and relatively narrow depression extending subvertically in dorsomedian area.

Normal pore opening, simple type, small in number, scattered. Radial pore canals mostly bifurcate or rarely trifurcate, about 5 along anterior and a few along posterior margins.

Marginal infold moderately broad along anterior and posteroventral margins, and narrower in other area along free margin. Vestibule extremely shallow anteriorly and posteriorly. Hinge merodont with containant, alomost identical with that of *Callistocythere minor* Hanai, 1957. Snap knob of right valve distinct, but snap pit of left valve not observable due to poor preservation of

inner surface. Muscle scar field in central to anterocentral area. Muscle scars consisting of one large elongate frontal scar and a subvertical row of four adductor scars; median two scars are relatively elongate.

Remarks. Description is based on two adult valves, both of which are partly broken; right valve is lacking in posteroventral part and left valve lacking in anteroventral part. Preservation of inner surface of left valve is rather poor, and, therefore, observations of inner features are based mainly on right valve. This species is close to *Callistocythere minor* Hanai, 1957 in general shape, ornamentation and hinge, but is easily distinguishable from the latter in having a complicated submarginal ridge in posteroventral area instead of having projection of prominent ridge characteristic in *C. minor*. Posteroventral deep depression diagnostic in *C. minor* is lacking in this species.

Occurrence. The species is represented by only three adult valves, each one of them from Loc. OT3, S6 and K1, respectively.

Genus *CLUTHIA* Neale, 1973

Cluthia japonica n. sp.

Pl. 2, figs. 12－19; text-fig. 18-3

Type. Holotype, a left female valve, UMUT-CA 15759 (Pl. 2, figs. 13, 18. L, 0.39; H, 0.24), Loc. OT3.

Illustrated specimens. A right female valve, UMUT-CA 15760 (Pl. 2, figs. 12, 19. L, 0.40; H, 0.24), Loc. S3; a right male valve, UMUT-CA 15761 (Pl. 2, figs. 14, 17. L, 0.37; H, 0.21), Loc. OT2; a left male valve, UMUT-CA 15762 (Pl. 2, figs. 15, 16; text-fig. 18-3. L, 0.37; H, 0.21), Loc. OT2.

Diagnosis. Cluthia characterized by broad anterocentral swelling, and distinct posterodorsal and posteroventral tubercles.

Description. Valves small, elongate subpyriform in lateral view, highest at anterodorsal corner. Anterior margin broadly rounded, slightly extended below. Dorsal margin nearly straight. Ventral margin gently concave. Posterior margin broadly rounded, meeting with dorsal margin at a blunt obtuse angle and smoothly grading into ventral margin. Valves elongate hexagonal in dorsal view, laterally compressed in anteriormost, central and posteriormost areas. Surface ornamented by densely distributed small round pits. A broad and low swelling lying in anterocentral area. A distinct tubercle present in posterodorsal area a little anterior to posterodorsal corner. Ventral bold and low ridge running posteriorly from lower side of anterocentral swelling and ending as a tubercle at posterior one-fourth of valve length. Marginal rim bold and raised along anterior and posterior margins. Subcentral tubercle and eye tubercle absent.

Normal pore openings small in number, scattered, consisting of simple type pores situated on muri. Radial pore canals simple, about 20 along anterior margin and anterior one-fourth of ventral margin, and about 10 along posterior margin.

Marginal infold broad, particularly along anteroventral margin. Vestibule relatively deep anteriorly and narrow posteriorly. Hinge merodont with containant, the simplest hinge found in Leptocytherinae, with anterior and posterior crenulate elongate teeth and a finely crenulate median groove in right valve. Hinge of left valve complementary of right valve, with anterior

and posterior crenulate sockets and a finely crenulate median bar consisting of about 26 denticles, with a containant situated just above median bar, and connecting anterior socket with posterior socket. Anti-slip teeth present in front of anterior socket and behind posterior socket. Snab knob of right valve and snap pit of left valve distinct on ventral margin. Muscle scar field in central to anterocentral area. Muscle scars consisting of one large renifom frontal scar and a vertical row of four adductor scars.

Sexual dimorphism marked. Males more slender and longer than females.

Dimensions. Measurements of pooled specimens from Loc. S2, S3, O2, OT2, OT3 and N2 are as follows.

Sp	Me	N	$\bar{X}$	S	V	OR
L (F)	L	2				0.36−0.39
	H	2				0.23−0 24
R (F)	L	4	0.385	0.0173	4.49	0.36−0.40
	H	4	0.238	0.0126	5 29	0.22−0.25
L (M)	L	1				0 37
	H	1				0.21
R (M)	L	1				0.37
	H	1				0.21

Remarks. Hingement of this species is close to that of *Callistocythere minor* Hanai, 1957, from recent beach sand of Toura, Shizuoka Prefecture, but is distinguishable from the latter, through lack of shelves below anterior and posterior terminal parts of median bar. This species is closely related to *Cluthia cluthae* (Brady, Crosskey and Robertson, 1874), type species of genus *Cluthia*, reported by Neale (1973) from the North Atlantic, but differs from the latter in having only one broad swelling in anterocentral area, while distinct upper and lower swellings are observable in anterocentral area of *C. cluthae*. This species resembles to *Cluthia* sp. of Ishizaki (1981) from the East China Sea, but is different from the latter in having much larger valve size, more densely distributed pits on surface, distinct posterodorsal and posteroventral tubercles, a crenulate posterior tooth, and in lacking of posterodorsal oblique ridge characteristic of *C.* sp.

Occurrence. This species occurs rarely from 6 localities mentioned above.

Family CYTHERIDAE Baird, 1850

Subfamily SCHIZOCYTHERINAE Mandelstam, 1960

Tribe SCHIZOCYTHERINI Mandelstam, 1960

Genus *SCHIZOCYTHERE* Triebel, 1950

Schizocythere sp.

Pl. 3, figs. 1, 2; Pl. 20, fig. 2

Illustrated specimen. A right valve, UMUT-CA 15763 (Pl. 3, figs. 1, 2; Pl. 20, fig. 2. L, 0.71; H, 0.38), Loc. OT3.

Description. Valve subhexagonal in lateral view, highest at anterior cardinal angle. Anterior margin broadly rounded slightly extended below. Dorsal margin nearly straight, but slightly

concave in its central part. Ventral contact margin sinuate at about anterior two-fifths of valve length, and mostly hidden by flattened ventral surface making a nearly straight lateral outline of ventral margin. Posterior margin nearly triangular with somewhat winding sides. Valves relatively smooth, subelliptical in dorsal view, with greatest width at about posterior two-fifths of valve length. Surface ornamented by coarse reticulation with bold muri and ridges. Ventrolateral ridge arising from marginal rim near anteroventral corner, running posteriorly along boundary between ventrolateral and ventral surfaces, curving dorsally near posteroventral corner, running with some undulation toward posterior termination and becoming obscure near posterior termination. Short and oblique ridge starting from dorsal rim at about posterior one-fourth of valve length, running toward posterior termination and terminating in posterior caudal area to connect with short ridge bordering posterior margin. Eye tubercle distinct. Subcentral tubercle absent.

Normal pore openings moderate in number, scattered, consisting of large sieve type pores situated on muri or on margin of floor of fossa and small simple type pores on muri, though the latter type rather small in number. Radial pore canals not observable.

Marginal infold moderately broad along anterior margin, and narrower along ventral and posterior margins. No vestibule. Hinge Schizodont. Muscle scars not observable.

Remarks. Only two, left and right adult valves are available for study. Left valve is partly broken and its interior body cavity is packed with sediments. Therefore, description on interior surface of valve is based mainly on right valve. This species is closely related to *Schizocythere asagao* Yajima, 1982 in general shape and ornamentation, but is distinguishable from the latter in having larger valve size, different number and arrangement of reticules, particularly distinct in dorsal and posterodorsal marginal areas, and less prominent longitudinal ridges. It is notable that specimens at hand appear to be elongate in comparison with the other species of the genus.

Occurrence. This species is represented by two adult valves, right valve from Loc. OT3 and left valve from Loc. OT4.

Tribe PAIJENBORCHELLINI Deroo, 1966

Genus *PAIJENBORCHELLA* Kingma, 1948

Paijenborchella tsurugasakensis n. sp.

Pl. 3, figs. 11－18; Pl. 20, fig. 3; text-fig. 18-4.

Type. Holotype, a left female valve, UMUT-CA 15764 (Pl. 3; figs. 12, 15, 17; text-fig. 18-4. L, 0.57; H, 0.34), Loc. 05.

Illustrated specimens. A right female valve, UMUT-CA 15765 (Pl. 3, figs. 11, 16, 18; Pl. 20. fig. 3. L, 0.55; H, 0.31), Loc. O5; a right male valve, UMUT-CA 15766 (Pl. 3, fig. 13. L, 0.55; H, 0. 30), Loc. O5; a left male valve, UMUT-CA 15767 (Pl. 3, fig. 14. L, 0.56; H, 0.31), Loc. O5.

Diagnosis. Paijenborchella characterized by moderate valve size, vertically truncate upper half of posterior margin and fine reticulation.

Description. Valves elongate subovate in lateral view, highest at anterior cardinal angle, situated just above anterior end of median hinge element in left valve and just above anteromedian socket in right valve. Anterior margin broadly and evenly rounded. Dorsal margin slighly sinuate. Ventral contact margin sinuate at about anterior two-fifths of valve lenghth, and

mostly hidden by ventral crest extending ventrally forming arched lateral outline. Posterior margin subvertically truncate in its upper half, meeting with dorsal margin at a distinct obtuse angle in right valve and at a blunt obtuse angle in left valve, and obliquely arched in its lower half, grading into ventral margin. Anterior margin narrowly fringed by protrusion of flange. Dorsal view, actually given by dorsal view of central crests of both valves, elongate subelliptical with laterally compressed anterior and posterior marginal areas. Surface ornamented by fine reticulation with thick and bold muri, three longitudinal crests or ridges, and median sulcus. Marginal rim running along valve margin, particularly bold near posterodorsal corner in left valve to accomodate a large posterior socket internally, while, in right valve, apex of posterior tooth visible beyond posterodorsal corner of carapace in lateral view. Three longitudinal crests prominent. Central crest arising in anterocentral area, running longitudinally across median sulcus, curving ventrally near posterior termination and ending to form a weak and posteroventrally directed projection in area of junction of three crests. Ventrolateral crest starting at a little lower to starting point of central crest, curving gently almost parallel to ventral margin and terminating to connect with other crests. Ventral crest starting at lower side of distinct tubercle or swelling in anterodorsal marginal area, running along anterior margin, becoming obscure in its dorsal half, forming a gently curved ventral outline and ending to join with other crests in posteroventral corner. Median sulcus, deeply incised in its upper half, arising in area behind anterodorsal tubercle, extending posteroventrally in a short distance near dorsal margin, curving ventrally at about anterior one-fifth of valve length and running subvertically into ventrolateral crest across central crest. Subcentral tubercle and eye tubercle not discernible.

Normal pore openings moderate in number scattered, large sieve type with a setal pore in its margin. Other pore type not observed. Radial pore canals slightly wavy, simple, at least 11 along anterior margin.

Marginal infold moderately broad along anterior margin and narrower along ventral and posterior margins. Vestibule extremely shallow anteriorly and posteriorly. Hinge schizodont with a bifid subround anterior tooth, a crenulate curved posterior tooth and a finely crenulate median groove in right valve. Hinge of left valve complementary of right valve with a bifid subround anteromedian tooth. Muscle scar field in central to anterocentral area. Muscle scars consisting of a large subround frontal scar and a vertical row of relatively small four adductor scars; adductor scars are on median ridge.

Sexual dimorphism present. Males more slender than females.

Dimensions. Measurements of pooled specimens from Loc. O1 and O5 are given below.

Sp	Me	N	$\bar{X}$	S	V	OR
L (F)	L	6	0.558	0.0169	3.03	0.55−0.57
	H	6	0.332	0.0231	6.96	0.32−0.35
R (F)	L	3	0.573			0.55−0.62
	H	3	0.323			0.31−0.35
L (M)	L	1				0.56
	H	1				0.31
R (M)	L	1				0.55
	H	1				0.30

Remarks. All muscle scars of this species including dorsal scars and mandibular scars are the same as those of "Paijenborchella" sp. from Icebery Bap, Recent, San Juan Islands, Washington, in Hanai (1970) in their number and arrangement. The present species is similar to three species which belong to *Paijenborchella triangularis* group described by Hanai (1970) in general shape, but is larger than any species of this group. Among these three species, this species is close to *Paijenborchella miurensis,* Hanai, 1970 in having reticulate surface, but is distinguishable from the latter in having evenly rounded anterior margin, subvertically truncate upper half of posterior margin, sinuous dorsal margin and relatively fine reticulation in addition to its larger valve size.

Occurrence. This species occurs from two localities mentioned above, and is found abundantly at Loc. O5.

Paijenborchella hanaii n. sp.

Pl. 3, figs. 3－10; text-fig. 18-5

Type. Holotype, a right female valve, UMUT-CA 15768 (Pl. 3, figs. 3, 8, 10. L, 0.68; H, 0.42), Loc. OT1.

Illustrated specimens. A left female valve, UMUT-CA 15769 (Pl. 3, figs. 4, 7, 9. L, 0.68; H, 0.45), Loc. SH2; a right male valve, UMUT-CA 15770 (Pl. 3, fig. 5; text-fig. 18-5. L, 0.70; H, 0.37), Loc. SH2; a left immature valve, UMUT-CA 15771 (Pl. 3, fig. 6. L, 0.55; H, 0.33), Loc. OT3.

Diagnosis. Paijenborchella characterized by relatively large valve size, reticulate surface consisting of reticules variable in size and three steeply rising longitudinal crests with distinct struts.

Description. Valves elongate subovate in lateral view, highest at anterior cardinal angle, situated just above posterior end of anterior socket in left valve and just above anteromedian socket in right valve. Anterior margin broadly rounded, slightly extended below. Dorsal margin nearly straight in right valve and slightly arched in left valve. Ventral contact margin sinuate at about anterior two-fifths of valve length, and mostly hidden by ventral crest extending ventrally and making a gently arched lateral outline. Posterior margin obliquely truncate in its upper half, meeting with dorsal margin at a distinct obtuse angle in right valve and at a blunt obtuse angle in left valve, slightly convex in its lower half and grading into ventral margin. Protrusion of flange fringing narrowly almost all free margin. Valves in dorsal view subelliptical with protrusions of anterior and posterior terminal laterally compressed areas. Surface ornamented by reticulation, pits, three longitudinal crests or ridges and median sulcus. Reticulation covering most of surface, but variable in size of reticule. Posterior area prevailed by coarse reticulation and rest of area covered by relatively fine reticulation or pits; pitted surface developed particularly in anterior and posterior marginal areas. Three longitudinal crests with distinct struts steeply rising and undulating. Central crest arising in anterocentral area, running longitudinally across median sulcus and terminating in posterocentral area at mid-height. Ventrolateral crest starting in area a little below starting point of central crest, running nearly parallel to ventral margin, making arch ventrally and terminating in area near ventral margin at about posterior one-fourth of valve length. Ventral crest starting from the same starting point as ventrolateral crest, running posteriorly, making a curved ventral outline and terminating

near posterior end. Median sulcus arising in area a little posterior to anterodorsal corner, and extending downward to ventrolateral crest across interuption of central crest. Subcentral tubercle and eye tubercle not discernible.

Nature of normal pore openings same as that of *Paijenborchella tsurugasakensis*. Radial pore canals slighrly wavy, simple, about 10 along anterior and about 3 along posterior margins. Characters observable in inside view of carapace, including marginal infold, hingement and muscle scars, as well as tendency of sexual dimorphism being similar to those described for *P. tsurugasakensis*.

Dimensions. Measurements of pooled specimens from Loc. SW1, OT1, OT3 and SH2 are as follows.

Sp	Me	N	OR
L (F)	L	1	0.68
	H	1	0.45
R (F)	L	2	0.68−0.69
	H	2	0.41−0.42
R (M)	L	2	0.70−0.74
	H	2	0.37−0 38
L (A-1)	L	1	0.55
	H	1	0.33

Remarks. The present species is similar to *P. tsurugasakensis* n. sp. in general shape and reticulate surface, but is easily ditinguished from the latter in having morphological characteristics described in diagnosis and more protruded posterior margin.

Occurrence. This species occurs rarely from 12 localities as listed in table 1.

Family HEMICYTHERIDAE Puri, 1953
Subfamily HEMICYTHERINAE Puri, 1953
Tribe HEMICYTHERINI Puri, 1953
Genus *ELOFSONELLA* Pokorny, 1955
Elofsonella concinna (Jones, 1856)
Pl. 4, figs. 1, 2.

Illustrated specimens. A right female valve, UMUT-CA 15772 (Pl. 4, fig. 1. L, 0.88; H, 0.53), Loc. K1; a left female valve, UMUT-CA 15773 (Pl. 4, fig. 2. L, 0.88; H, 0.53), Loc. K1.

Remarks. Bassiouni (1965) recognized two forms in this species based on surface ornamentation; pitted form characterized by pitted surface with a indication of reticulation in its posterior half, and reticulate form having reticulate surface, and he gave these two forms chronological subspecific names, *Elofsonella concinna concinna* (Jones, 1856) for Pleistocene pitted form and *E. concinna neoconcinna* Bassiouni, 1965 for recent reticulate form. Later, Hazel (1967) pointed out that both pitted and reticulate forms are living off the coast of northeastern North America and that gradational series from one form to the other is observable in one sample in which both forms occur in some abundance. These facts led him to conclude that this

morphological variation is of the infrasubspecific level. All specimens from the Daishaka Formation are referable to reticulate form characterized by coarse reticulation over entire surface, being accompanied with the second-ordered reticulation. It seems likely that such variation of ornamentation is infrasubspecific in nature. At present, however, we can not decide whether such variation is genetical or ecological in nature.

Occurrence. This species occurs rarely to commonly from 16 localities.

Genus *NORMANICYTHERE* Neale, 1957

Normanicythere japonica n. sp.

Pl. 8, figs. 11－14; Pl. 9, figs. 1. 3.

Type. Holotype, a right female valve, UMUT-CA 15774 (Pl. 8, figs. 11, 13; Pl. 9, fig. 3. L, 1. 12; H, 0.57), Loc. SH1.

Illustrated specimens. A right male valve, UMUT-CA 15775 (Pl. 8, figs. 12, 14. L, 1.11; H, 0. 53), Loc. OT3; a right immature valve, UMUT-CA 15776 (Pl. 9, fig. 1. L, 0.74; H, 0.44), Loc. SH1; a left immature valve, UMUT-CA 15777 (Pl. 9, fig. 2. L, 0.73; H, 0.40), Loc. SH1.

Diagnosis. Normanicythere characterized by widely distributed weak reticulation and laterally compressed valves.

Description. Valve large, elongate subtrapezoidal, slightly tapering posteriorly in lateral view, highest at anterodorsal corner. Anterior margin broadly rounded, slightly extended below. Dorsal margin slightly arched in female and its anterior half nearly straight in male. Ventral margin nearly straight, slightly sinuate at anterior one-third of valve length in female. Posterior margin slightly concave in its upper half, meeting with dorsal margin at a obtuse angle, and forming a caudal area in its lower half, merging smoothly into ventral margin. Valve subtrapezoidal in dorsal view. Surface ornamented by punctations of normal pore openings, small pits, and weak reticulation of shallow fossae. Degree of development of ornamentation different between female and male. Surface of female form prevailed by punctations of normal pore openings, and partly ornamented by reticulation of shallow fossae mainly distributed in area along anterior margin. Surface of male form covered mostly by reticulation of shallow fossae, particularly distinct and forming a posteriorly and radially extending reticulation in posterior area. Three weak marginal ridges present. One, situated most distally, starting from anterior side of eye tubercle, running almost parallel to free margin and becoming indistinct near posterodorsal corner. The other weaker and partly obscure two ridges arising from area near anterodorsal corner, running along anterior and ventral margins and terminating near posteroventral corner. Subcentral tubercle and eye tubercle indistinct.

Normal pore openings moderate in number, scattered. Detailed nature of pore type not observable owing to ill-preservation. Radial pore canals simple, nearly straight, numerous in number, particularly along anteroventral margin.

Marginal infold moderately broad along anterior margin and narrow along ventral and posterior margins. Vestibule extremely shallow particularly along anteroventral margin. Hinge holamphidont with a stepped anterior tooth, a gently curved posterior tooth and a finely crenulate median groove in right valve. Muscle scar field in subcentral tubercle. Muscle scars consisting of three frontal scars and a vertical row of four adductor scars; upper three adductor

scars are distinctly divided.

Dimensions. Measurements of pooled specimens from Loc. S2, O4, OT4 and SH1 are as follows.

Sp	Me	N	$\bar{X}$	OR
R (F)	L	1		1.12
	H	1		0.57
R (M)	L	1		1.11
	H	1		0.53
R (A-1)	L	2		0.87−0.96
	H	2		0.46−0.52
R (A-2)	L	2		0.73−0.74
	H	2		0.40−0.44
L (A-2)	L	3	0.710	0.71−0.73
	H	3	0.400	0.39−0.41

Remarks. Only two adult right valves are available for study from Daishaka Formation; more elongate one is thought to be male, and the other one female. Immature valves are partly covered with faint reticulation and have two broad and weak swellings situated in posterodorsal and posteroventral areas, respectively. These swellings, however, become rather obscure or are lacking in adult valves. Dorsal adductor scar which is distinctly divided in adult valves is sometimes undivided in immature valves. Neale & Schmidt (1967) examined the variation of general shape and of the number of pitting on surface of the two species of genus Normanicythere reported before, *N. leioderma* (Norman, 1869) and *N. concinella* Swain, 1963. Finally, they concluded that these species differ from each other in the details of general shape, the number and arrangement of pittings or reticules, and geographical distribution, and that, therefore, for the time being, they might be regarded as separate species occupying particular geographical areas. The present species is more closely related to *N. concinella* in general shape and ornamentation, but is distinguishable from *N. concinella* in having laterally compressed valves and stronger pittings or reticules on surface. It seems likely that there is a tendency that the number of pittings and reticules of male form decreases from *N. japonica* n. sp. through *N. concinella* to *N. leioderma,* accompanying with more or less gradational lateral inflation of valves. This tendency of morphologic variation in male is also recognizable in female, but is not so conspicuous as in male. It is still a pending question whether the gradational morphologic change ranging over three species is actually intraspecific or interspecific variation in nature. The species also resembles *Urocythereis? gorokuensis* Ishizaki, 1966 from the Pliocene sediments of the Sendai area, described by Ishizaki (1966), in general shape, but is easily distinguishable from the latter in having more elongate shape, less developed reticulation and different muscle scar pattern.

Occurrence. This species is rarely found at 9 localities as listed in table 1.

Tribe UROCYTHEREIDINI Hartmann and Puri, 1974

Genus *UROCYTHEREIS* Ruggieri, 1950

Urocythereis? gorokuensis Ishizaki, 1966

Pl. 6, figs. 2－17.

Not *Urocythereis gorokuensis* : Ishizaki, 1971, p. 83, 84, Pl. 3, figs. 4, 5.

Urocythereis? gorokuensis : Hanai et al., 1977, p. 46; Yajima, 1982, p. 213, 214, Pl. 13, fig. 14.

Illustrated specimens. A right female valve, UMUT-CA 15778 (Pl. 6, fig. 2. L, 1.01; H, 0.57), Loc. S3; a right male valve, UMUT-CA 15779 (Pl. 6, fig. 3. L, 0.92; H, 0.49), Loc. OT3; a left male valve, UMUT-CA 15780 (Pl. 6, fig. 4. L, 0.97; H, 0.51), Loc. SH4; a right immature valve at A-1 stage, UMUT-CA 15781 (Pl. 6, fig. 5, L, 0.80; H, 0.46), Loc. S7; a left immature valve at A-1 stage, UMUT-CA 15782 (Pl. 6, fig. 6, L, 0.81; H, 0.47), OT3; a right immature valve at A-2 stage, UMUT-CA 15783 (Pl. 6, fig. 7. L, 0.60; H, 0.35), Loc. S7; a left immature valve at A-2 stage UMUT-CA 15784 (Pl. 6, fig. 8. L, 0.60; H, 0.35), Loc. OT3; a right immature valve, UMUT-CA 15785 (Pl. 6, fig. 9, L, 0.70; H, 0.38), Loc. OT2; a right valve, UMUT-CA 15786 (Pl. 6, figs. 10, 17. L, 0.98; H, 0.51), Loc. S7; a left valve, UMUT-CA 15787 (Pl. 6, figs. 11, 16. L, 0.91; H, 0.48), Loc. K1; a right immature valve at A-1 stage, UMUT-CA 15788 (Pl. 6, fig. 12. L, 0.79; H, 0.44), Loc. K1; a left immature valve at A-1 stage, UMUT-CA 15789 (Pl. 6, fig. 13. L, 0.79; H, 0.45), Loc. K1; a right immature valve at A-2 stage, UMUT-CA 15790 (Pl. 6, fig. 14. L, 0.61; H, 0.36), Loc. K1; a left immature valve at A-2 stage, UMUT-CA 15791 (Pl. 6, fig. 15. L, 0.61; H, 0.36), Loc. S7.

Remarks. This species was first described from the Pliocene Tatsunokuchi Formation of North Honshu, Japan, with one adult right valve designated as holotype and one immature left valve as paratype by Ishizaki (1966), Thereafter, Yajima (1982) reported immature specimens of the species which hold many characters in common with paratype of *U. ? gorokuensis* from the Pleistocene Yabu and Kamiiwahashi Formations of the northern part of the Boso Peninsula, Central Japan. Specimens from the Daishaka Formation can be grouped into two groups of specimens; specimens of one group are close to holotype of Ishizaki (1966) and specimens of the other close to paratype specimen. Both groups of specimens, however, consist of both immature and adult valves, and a group close to paratype contains two adult valves which are almost the same as male valves of holotype in the height-length ratio, muscle scar pattern and hingement type, but are generally distinguishable from the latter in having more slender outline and smaller fossae distsibuted relatively sparsely on surface. In general, however, wide variations of outline and ornamentation are observable in both groups and, further, there are a few immature specimens not assighnable to either group. Therefore, it may be proper to interprete at present, that the two groups of variation are taxonomically intraspecific rather than of interspecific variation.

Occurrence. This species occurs commonly from 24 localities as listed in table 1.

Urocythereis? abei n. sp.

Pl. 7, figs. 1—11; Pl. 20, fig. 5; text-fig. 18-6

Type. Holotype. a left female valve, UMUT-CA 15792 (Pl. 7, fig. 2; Pl. 20, fig. 5. L, 1.11; H, 0.64), Loc. OT3.

Illustrated specimens. A right female valve, UMUT-CA 15793 (Pl. 7, fig. 1. L, 1. 10; H, 0.61). Loc. OT3; a right female valve, UMUT-CA 15794 (Pl. 7, fig. 9. L, 1. 13; H, 0.64), Loc. OT3; a right

female valve, UMUT-CA 15795 (Pl. 7, fig. 11; text-fig. 18-6. L, 1.05; H, 0.57), Loc. T1; a left female valve, UMUT-CA 15796 (Pl. 7, fig. 8. L, 1.14; H, 0.63), Loc. OT3; a left female valve, UMUT-CA 15797 (Pl. 7. fig. 10. L, 1.13; H, 0.64), Loc. OT4; a righ male valve, UMUT-CA 15798 (Pl. 7, fig. 3. L, 1.18; H, 0.61), Loc. OT4; a right immature valve at A-1 stage, UMUT-CA 15799 (Pl. 7, fig. 4. L, 0.89; H, 0.51), Loc. T1; a left immature valve at A-1 stage, UMUT-CA 15800 (Pl. 7, fig. 5. L, 0.87; H, 0.48), Loc. T1; a right immature valve at A-2 stage, UMUT-CA 15801 (Pl. 7, fig. 6. L, 0. 69; H, 0.40), Loc. T1; a left immature valve at A-2 stage, UMUT-CA 15802 (Pl. 7, fig. 7. L, 0.66; H, 0.40), Loc. T1.

Diagnosis. Species close to *Urocythereis? gorokuensis,* but different in having large valve size, inflated valves and radiating ridges in posterior area.

Description. Valves large, subtrapezoidal, slightly tapering posteriorly, highest at anterior cardinal angle. Anterior margin broadly rounded, slightly extended below. Dorsal and ventral margins gently arched. Posterior margin slightly concave in its upper half and convex in its lower half, grading smoothly into dorsal and ventral margins. Valves subelliptical in dorsal view. Viewed anteriorly, carapace appearing nearly bell-shaped with more or less flattened ventral surface. Surface ornamented by overall coarse reticulation. Ridges radiating from area of subcentral tubercle. Areas between radiating ridges filling with reticulation, except for anterodorsal area. A weak marginal ridge starting from anterodorsal area, a little anterior to eye tubercle, running along anterior margin, extending into ventral surface, running almost parallel to valve margin, and terminating at about posterior one-third of valve length. Subcentral tubercle and eye tubercle rather obscure.

Normal pore openings numerous, scattered, mostly located on margin of floor of fossa and some on muri, including large sunken sieve type pores and small simple type pores. Radial pore canals, simple, nearly straight, numerous in particular along anteroventral margin.

Marginal infold moderately broad along anterior margin and narrow along ventral and posterior margins. Vestibule extremely narrow along ventral and posterior margins. Hinge holamphidont with an anterior tooth, an auxiliary socket opening ventrally, a finely crenulate median groove, and a gently arched posterior tooth in right valve. Complementary hinge elements in left valve. Muscle scar field in subcentral tubercle. Muscle scars consisting of two frontal scars and a row of four adductor scars; median two scars are distinctly divided.

Sexual dimorphism marked. Males more elongate than females.

Dimensions. Measurements of pooled specimens from Loc. S7, T1, OT1, OT3, OT4, OT6 and SH4 are as follows.

Sp	Me	N	$\bar{X}$	S	V	OR
L (F)	L	6	1.118	0.0232	2.08	1.08−1.14
	H	6	0.640	0.0141	2.20	0.62−0.66
R (F)	L	11	1.085	0.0380	3.50	1.03−1.13
	H	11	0.606	0.0242	3.99	0.57−0.64
R (M)	L	2				1.12−1.18
	H	2				0.56−0.61

Remarks. This species is closely related to *Urocythereis? gorokuensis* Ishizaki, 1966 in having similar outline and reticulate surface, but is easily discriminated from the latter in having larger valve size, arched ventral margin and radiating ridges in posterior area. The species also resembles *Urocythereis*? sp. of this paper in having similar outline and some radiating ridges in posterior area, but is different from the latter in having larger valve size and much inflated valves.

Occurrence. The species is commonly found at 19 localities as listed in table 1, without any preference for particular sediment type.

Urocythereis? posterocostata n. sp.

Pl. 8, figs. 1–10; text-fig. 18-7.

Type. Holotype, a left valve, UMUT-CA 15803 (Pl. 8, figs. 2, 5. L, 1.11; H, 0.62), Loc. T1.

Illustrated specimens. A right valve, UMUT-CA 15804 (Pl. 8, figs. 1, 6. L, 1.08; H, 0.61), Loc. T1; a right valve, UMUT-CA 15805 (Pl. 8, fig. 10; text-fig. 18-7. L, 1.14; H, 0.62), Loc. T1; a left valve, UMUT-CA 15806 (Pl. 8, fig, 9, L, 1.11; H, 0.64), Loc. T1; a right immature valve at A-1 stage, UMUT-CA 15807 (Pl. 8, fig. 3. L, 0.88; H, 0.49), Loc. T1; a left immature valve at A-1 stage, UMUT-CA 15808 (Pl. 8, fig. 4. L, 0.84; H, 0.49); Loc; T1; a right immature valve at A-2 stage, UMUT-CA 15809 (Pl. 8, fig. 7, L, 0.66; H, 0.38), Loc. OT5, a left immature valve at A-2 stage, UMUT-CA 15810 (Pl. 8, fig. 8. L, 0.66; H, 0.41), Loc. T1.

Diagnosis. Species close to *Urocythereis? gorokuensis* but different in having large valve size and posterodorsal hook-shaped ridge.

Description. Viewed laterally, dorsally and anteriorly, carapace outline and surface ornamentation appear to be similar to those of *Urocythereis? abei* except for the followings: In addition to a weak marginal ridge along valve margin, distinct anterior ridge, situated a little more proximal than marginal ridge, starting at anterodorsal corner of valve margin, and running almost parallel to anterior margin to connect with the marginal ridge near anteroventral corner. Ventral ridge, relatively strong and undulate in its posterior half, starting from anteroventral area, a little posterior to terminal of anterior ridge, running along boundary between ventrolateral surface and ventral surface, and connecting with marginal ridge at lower one-fourth of valve height near tip of posterior projected area. Posterodorsal hook-shaped ridge prominent, arising from posterior one-third of valve length near dorsal margin, a little inside of terminal of the marginal ridge, running almost parallel to dorsal margin, curving ventrally at about posterior one-fifth of valve length and running subvertically to connect with one of the radiating ridges at upper one-third of valve height.

Nature of subcentral tubercle, eye tubercle, normal pore openings, radial pore canals, marginal infold and hingement similar to those of *Urocythereis? abei.* Posterior tooth of right valve sharply curved. Muscle scars consisting of two frontal scars and a row of four adductor scars; dorsomedian one is distinctly divided and ventromedian one is extremely elongate but not divided.

Dimensions. Measurements of specimens from Loc. T1 are given below.

Sp	Me	N	$\bar{X}$	OR
L	L	3	1.103	1.09−1.11
	H	3	0.633	0.62−0.64
R	L	3	1.110	1.08−1.14
	H	3	0.617	0.61−0.62

Remarks. This species is close to *Urocythereis? abei* n. sp. in large valve size, subtrapezoidal outline and reticulate surface, but is different from the latter in having a posterodorsal hook-shaped ridge, distinct anterior and ventral ridges, and an elongate and undivided ventromedian adductor scar.

Occurrence. This species occurs commonly from 13 localities as listed in table 1.

Urocythereis? sp.

Pl. 6. fig. 1.

Urocythereis gorokuensis Ishizaki, 1966, Ishizaki, 1971, p. 83, 84, Pl. 3, figs. 4,5.

Illustrated specimen. A right immature valve, UMUT-CA 15811 (Pl. 6, fig. 1. L, 0.79; H, 0.42), Loc. T1.

Remarks. Three immature specimens corresponding to Recent specimens of *U.? gorokuensis* Ishizaki, 1966 from Aomori Bay, North Honshu, Japan, reported by Ishizaki (1971) also occur from the Daishaka Formation. These specimens are similar to immature specimens of *U.? gorokuensis* described originally by Ishizaki (1966) from Goroku in general outline and reticulate surface, but are distinctly discernible from the latter in having much less inflated valves and reticulation which fills the area between ridges radiating from subcentral tubercle in posterior area. Recent specimens of *U.? gorokuensis* from Aomori Bay will be given a new specific status in the future.

Occurrence. Three immature valves are found, each one of them from Loc. S7, T1 and O1, respectively.

Genus *AMBOSTRACON* Hazel, 1962

Ambostracon kitanipponica n. sp.

Pl. 10, figs. 1−8; text-fig. 18-8

Type. Holotype, a left female valve, UMUT-CA 15812 (Pl. 10, figs. 2, 5, 7. L, 0.78; H, 0.45), Loc. S1.

Illustrated specimens. A right female valve, UMUT-CA 15813 (Pl. 10, fig. 1, 6, 8. L, 0.75; H, 0.45), Loc. S1; a right male valve, UMUT-CA 15814 (Pl. 10, fig. 3. L, 0.77; H, 0.45), Loc. O1; a left male valve, UMUT-CA 15815 (Pl. 10, fig. 4; text-fig. 18-8. L, 0.75; H, 0.44), Loc. S7.

Diagnosis. Ambostracon characterized by details of strong and bold submarginal ridge starting at eye tubercle, running along anterior margin and on boudary between lateral and ventral surfaces, and limited distribution of reticulation only in central area of valves.

Description. Valves subtrapezoidal, tapering posteriorly in lateral view, highest at anterior cardinal angle. Anterior margin broadly rounded, slightly extended below. Dorsal margin gently

arched, partly sinuate owing to irregular marginal ridge. Ventral contact margin sinuate at about anterior two-fifths of valve length, mostly hidden by marginal ridge. Marginal ridge giving a straight or slightly arched lateral outline of ventral margin. Posterior margin slightly concave in its upper half with a distinct small projection of "hinge ear" near its upper end, meeting with dorsal margin at a obtuse angle, and protruding into a weak caudal projection with irregular outline in its lower half, grading into ventral margin. Valves irregularly subhexagonal in dorsal view. Surface ornamented by strong ridges and reticulation. Reticulation distributed only in central area. Marginal ridge running around entire valve margin and coinciding with marginal rim along dorsal and posterior margins. Strong and bold submarginal ridge starting at lower side of eye tubercle, running along anterior margin, laying about six short ridges radially toward marginal ridge, continuing to run along boundary between ventrolateral surface and somewhat flattened ventral surface with a distinct sinuation at posterior two-fifths of valve lengh and branching into two ridges near posteroventral corner; one running longitudinally to tip of caudal area, and the other turning sharply upward and joining with marginal rim near posterodorsal corner. An undulate posterodorsal ridge starting from posterior portion of submarginal ridge at about upper one-third of valve height, running obliquely toward subcentral tubercle and merging into muri of reticulation. Subcentral tubercle obscure and eye tubercle distinct.

Normal pore openings moderate in number, scattered, but pore type being not clear owing to relatively ill-preserved outer surface. Radial pore canals, nearly straight, medially bulbous, without branching, numerous in number in particular along anteroventral margin.

Marginal infold moderately broad. Vestibule extremely shallow anteriorly and posteriorly. Hinge holamphidont with a round anterior tooth, a large round posterior tooth and a finely crenulate median bar in right valve and complementary elements in left valve. Muscle scar field in subcentral tubercle. Muscle scars consisting of two frontal scars and a vertical row of four adductor scars; dorsomedian one is distinctly divided and ventromedian one is elongate but not divided.

Sexual dimorphism marked. Males more slender than females.

Dimensions. Measurements of pooled specimens from Loc. S1, S7, O1 and O2 are given as follows.

Sp	Me	N	$\bar{X}$	OR
L (F)	L	2		0.75−0.78
	H	2		0.45
R (F)	L	3	0.760	0.75−0.78
	H	3	0.447	0.44−0.45
L (M)	L	1		0.75
	H	1		0.44
R (M)	L	1		0.77
	H	1		0.45

Remarks. This species is closely related to *Ambostracon costatum* Hazel, 1962 from the Holocene shelf samples from off the western North America, reported by Valentine (1976), in

general shape and surface ornamentation, but is distinguishable from the latter in having a much weaker posterodorsal obligue ridge and distinct reticulation confined to central area in distribution, and in lacking in an undulate and oblique posterodorsal ridge.

Occurrence. This species occurs rarely from four locailities mentioned above.

Ambostracon sp. 1

Pl. 10, fig. 9.

Illustrated specimen. A right valve, UMUT-CA 15816 (Pl. 10, fig. 9. L, 1.10; H, 0.63), Loc. T1.

Description. Shape of carapace similar to that of *Ambostracon kitanipponica* n. sp. Dorsal margin smoothly arched. Ventral margin slightly sinuate at about anterior one-third of valve length. Posterior margin forming a caudal projected area, obliquely truncate in its upper half. Lower half of posterior margin narrowly rounded and merging smoothly into ventral margin. Anterior margin and lower half of posterior margin denticulate. Viewed dorsally, ventrolateral ridge gradually expanding laterally as traced toward posterior direction and culminating in greatest width at posteroventral node-like projection. Posterojacent terminal area compressed. Surface ornamented by overall reticulation and ridges. Nature of marginal and prominent submarginal ridges similar to those of *A. kitanipponica,* except for some details of submarginal ridge; starting area of submarginal ridge being a little anterior to eye tubercle, and branching way of submarginal ridge in posteroventral area; one branch continuing to run longitudinally toward posterior end, bifurcating near posterior end and connecting with marginal ridge, and the other branch weak and undulate, turning upward, making an acute angle, joining with posterodorsal oblique ridge, changing its direction toward posterodorsal corner and connecting with marginal ridge near posterodorsal corner. Posterodorsal ridge starting from turning point of the latter branch of submarginal ridge, running toward subcentral tubercle and merging into muri of reticulation at about posterior two-fifths of valve length. Anterior short ridge prominent, running vertically from lower side of eye tubercle and merging into muri at about upper two-fifths of valve height. Shallow depression lying below dorsal margin, extending into area behind eye tubercle and anterior short vertical ridge.

Normal pore openings moderate in number, scattered, consisting of sunken sieve type pores situated on muri or on margin of floor of fossa. Other pore type not discernible. Nature of radial pore canals uncertain.

Marginal infold moderately broad. Hinge holamphidont. Other inner features not observable owing to poor preservation of inner surface.

Remarks. The present species resembles *Ambostracon* sp. E of Valentine (1976) in general shape and reticulation pattern, but is easily distinguished from the latter in having much larger valve size, presence of anterior portion of submarginal ridge and lack or less development of ridges radiating from subcentral tubercle.

Occurrence. A single adult right valve has been found so far at Loc. T1.

Ambostracon sp. 2

Pl. 10, fig. 10.

Illustrated specimen. A right immature valve, UMUT-CA 15817 (Pl. 10, fig. 10. L, 0.79; H, 0.

44), Loc. O4

Remarks. Illustrated specimen is the largest among specimens from the Daishaka Formation which are represented only by immature form. The species is characterized by its subquadrate lateral outline, irregular lateral outline of lower half of posterior margin, reticulate surface, distinct anterior longitudinal and ventrolateral ridges, and prominent posterodorsal and posteroventral projections.

Occurrence. This species is found rarely at Loc. S6, K1, O4, OT3 and OT6.

Genus *PATAGONACYTHERE* Hartmann, 1962

Patagonacythere robusta n. sp.

Pl. 9, figs. 4－12; text-fig. 20-1

Type. Holotype, a right female valve, UMUT-CA 15818 (Pl. 9, fig. 4. L, 1.01; H, 0.57), Loc. SH1.

Illustrated specimen. A left female valve, UMUT-CA 15819 (Pl. 9, figs. 5, 10. L, 0.99; H, 0.57), Loc. SH1; a right male valve, UMUT-CA 15820 (Pl. 9, figs. 6, 11; text-fig. 20-1. L, 1.01; H, 0.55), Loc. OT1; a left male valve, UMUT-CA 15821 (Pl. 9, fig. 7. L, 1.05; H, 0.56), Loc. SH1; a male carapace, UMUT-CA 15822 (Pl. 9, fig. 12. L, 1.03; H, 0.52; W, 0.50), Loc. SH1; a right immature valve, UMUT-CA 15823 (Pl. 9, fig. 8. L, 0.69; H, 0.41), Loc. O4; a left immature valve, UMUT-CA 15824 (Pl. 9, fig. 9. L, 0.69; H, 0.41), Loc. OT3.

Diagnosis. Patagonacythere characterized by well-developed bold ridges and divided uppermost adductor scar.

Description. Valves large, subrectangular in lateral view, highest at anterior cardinal angle. Anterior margin broadly and obliquely rounded, and fringed by denticles in its lower two-thirds. Dorsal margin slightly arched, partly sinuous, with distinct anterodorsal and posterodorsal "hinge ears" in left valve. Ventral margin nearly straight. Posterior margin consisting of slightly concave upper half and slightly caudate lower half with two spines, meeting with dorsal and ventral margins at a relatively distinct obtuse angle. Viewed dorsally, carapace appearing extremely irregularly shaped owing to bold anterior submarginal ridge, well-developed subcentral tubercle and posteroventral and posterodorsal projections. Surface ornamented by reticulation, bold ridges, tubercles and projections. Anterior marginal rim starting from area just above eye tubercle in left valve and from anterior side of eye tubercle in right valve, and running around free margin to terminate near posterodorsal corner. Anterior submarginal ridge located a little more proximally than anterior marginal rim, rather bold and ornamented with small pits, and running around anterior margin from lower side of eye tubercle to terminate near anteroventral corner. Ventrolateral ridge starting at a little posterior to terminal of anterior submarginal ridge, running posteriorly along boundary between ventrolateral surface and flattened ventral surface, and terminating with node-like projection at posterior one-fourth of valve length. Characteristic posterodorsal hook-shaped ridge with its apex forming a prominent projection, originating at a little posterior to eye tubercle, running along dorsal margin, curving anteroventrally at about posterior one-sixth of valve length, running almost horizontally, thereafter being inclined anteroventrally at about posterior one-third of valve length, and continuing to run into subcentral tubercle. Subcentral tubercle and eye tubercle rather

prominent.

Normal pore openings moderate in number, scattered. Radial pore canals nearly straight and bulbous medially, numerous in number in particular along anterior and anteroventral margins.

Marginal infold moderately broad along anterior margin and narrow along ventral and posterior margins. Vestibule present along all free margin, though extremely shallow along ventral and posterior margins. Hinge holamphidont with a stepped anterior tooth, a gently curved posterior tooth with an auxiliary socket opening ventrally and a finely crenulate median groove in right valve, and complementary elements in left valve. Muscle scar field in subcentral tubercle. Muscle scars consisting of three frontal scars and a vertical row of four adductor scars; upper three adductor scars are distinctly divided.

Sexual dimorphism distinct, males more slender than females.

Dimensions. Measurements of pooled specimens from Loc. SW1, OT1, OT6, and SH1 are given below.

Sp	Me	N	OR
R (F)	L	1	1.01
	H	1	0.57
L (F)	L	1	0.99
	H	1	0.57
R (M)	L	1	1.01
	H	1	0.55
L (M)	L	2	1.05
	H	2	0.55−0.56
C (M)	L	2	1.03−1.08
	H	2	0.52−0.57
	W	2	0.52−0.55

Remaks. The species is close to *Patagonacythere dubia* (Brady, 1868) from off northeastern North America of Hazel (1967) in general outline and similar arrangement of reticulation and ridges. But, the species is distinguishable from the latter in having a bolder and more protruded anterior submarginal ridge, well-developed ventrolateral and posterodorsal ridges and a distinctly divided uppermost adductor scar. Prominent rugged surface of this species are shown in dorsal view.

Occurrence. The species occurs commonly from 22 localities as listed in table 1 without regard to particular sediment type in abundance.

FINMARCHINELLA group

Genus *FINMARCHINELLA* Swain, 1963

Subgenus *FINMARCHINELLA* Swain, 1963

Finmarchinella (Finmarchinella) rectangulata n. sp.

Pl. 4, figs. 3−15; text-figs. 16-3, 4

Type. Holotype, a left female valve, UMUT-CA 15825 (Pl. 4, fig. 4. L, 0.61; H, 0.30), Loc. O4.

Illustrated specimens. A right female valve, UMUT-CA 15826 (Pl. 4, fig. 3. L, 0.56; H, 0.27), Loc. O4; a right female valve, UMUT-CA 15827 (Pl. 4, fig. 10. L, 0.63; H, 0.31), Loc. OT5; a right female valve, UMUT-CA 15828 (Pl. 4, fig. 13; text-fig. 16-4. L, 0.58; H, 0.27), Loc. N2; a right female valve, UMUT-CA 15829 (Pl. 4, figs. 14, 15. L, 0.60; H, 0.29), Loc. O4; a left female valve, UMUT-CA 15830 (Pl. 4, fig. 9. L, 0.60; H. 0.29), Loc. O3; a left female valve, UMUT-CA 15831 (Pl. 4, fig. 11. L, 0.58; H, 0.28), Loc. S3; a left female valve, UMUT-CA 15832 (Pl. 4, fig. 12; text-fig. 16-3. L, 0.63; H, 0.32), Loc. O4; a right male valve, UMUT-CA 15833 (Pl. 4, fig. 5. L, 0.52; H, 0.23), Loc. O1; a left male valve, UMUT-CA 15834 (Pl.4, fig. 6. L, 0.56; H, 0.25), Loc. O3; a right immature valve, UMUT-CA 15835 (Pl. 4, fig. 7. L, 0.47; H, 0.23), Loc. N2; a left immature valve, UMUT-CA 15836 (Pl. 4, fig. 8. L, 0.46; H, 0.23), Loc. S3.

Diagnosis. *Finmarchinella* characterized by subrectangular lateral outline with straight dorsal margin. Muscle scars consisting of two frontal scars and four adductor scars; dorstmedian adductor scar being divided.

Description. Valves subrectangular in lateral view. Anterior margin broadly and evenly rounded. Dorsal margin straight. Ventral contact margin sinuate at anterior one-fourth of valve length in right valve and at about mid-length in left valve. Ventrolateral surface overhanging ventrally to hide a part of ventral contact margin in its posterior half, and meeting with roughly flattened ventral surface at a acute angle. Posterior margin concave in its upper half, meeting with dorsal margin at a obtuse angle, protruding into a caudal process with irregular outline in its lower half, and grading into ventral margin. In dorsal view, valves elliptical to subhexagonal. Individual variation of surface ornamentation strong, varying from specimen with distinct reticulation and undulate ridges to that characterized by prevalence of punctation and obscureness of reticulation and ridges. Three low but prominent ridges radially extending from area a little anterior to subcentral tubercle, and terminating at anterior marginal ridge. Anterior marginal ridge, starting from upper side of eye tubercle, running parallel to anterior margin, and extending into ventral surface to join with one of four longitudinal ridges on ventral surface at middle of one longitudinal ridge. Velate ridge, starting from anteroventral area just behind anterior marginal ridge, running roughly along boundary between ventrolateral surface and ventral surface, curving upward at about posterior one-sixth of valve length and branching into two ridges at about lower one-third of valve height; one branch, short, running horizontally to terminate at tip of caudal process, and the other running upward parallel to posterior margin and terminating in area near posterodorsal corner. Characteristic vertical ridge, undulate and rather weak in its lower two-thirds, starting at the terminal of offshoot of velate ridge in area a little anterior to posterior cardinal angle, and running vertically to join with velate ridge in posteroventral area. Subcentral tubercle and eye tubercle prominent in specimens well ornamented with ridges and reticulation, and obscure in punctate, rather smooth specimens.

Normal pore openings moderate in number, scattered, including large sunken sieve type pores and small simple type pores. Radial pore canals, nearly straight without branching, numerous in number in particular along anteroventral margin.

Marginal infold moderately broad along anterior margin and narrow along ventral and posterior margins. Line of concrescence coincident with inner margin. No vestibule. Hinge antimerodont; anterior and posterior terminal elements, with 5-6 teeth, respectively, and a finely

crenulate median groove, in right valve. Hingement of left valve complementary of that of right valve. Muscle scar field in subcentral tubercle. Muscle scars consisting of two frontal scars and a row of four adductor scars; dorsomedian one is distinctly divided and ventromedian one is elongate but not divided.

Sexual dimorphism marked. Males more slender and lower than females.

Dimensions. Measurements of pooled specimens from Loc. D1, S3, S4, S6, S7, O1, O2, O3, O4, OT1, OT5, N2, N3 and SH1 are as follows.

Sp	Me	N	$\bar{X}$	S	V	OR
L (F)	L	9	0.593	0.0250	4.22	0.56−0.63
	H	9	0.290	0.0150	5.17	0.27−0.32
R (F)	L	12	0.592	0.0291	4.92	0.55−0.63
	H	12	0.288	0.0171	5.94	0.26−0.31
L (M)	L	6	0.560	0.0178	3.18	0.53−0.58
	H	6	0.255	0.0105	4.12	0.24−0.27
R (M)	L	5	0.532	0.0110	2.07	0.52−0.54
	H	5	0.238	0.0084	3.53	0.23−0.25

Remarks. This species is easily differentiated from other species of genus *Finmarchinella* reported before, in having smaller size, more rectangular lateral outline, delicate surface ornamentation and muscle scar pattern being characterized by two frontal scars and undivided ventromedian adductor scar.

Occurrence. The species is found at 17 localities, though relatively small in abundance.

Subgenus *BARENTSOVIA* Neale, 1974

Finmarchinella (Barentsovia) daishakaensis n. sp.

Pl. 5, figs. 1−9; text-figs. 16-5, 6.

Type. Holotype, a left female valve, UMUT-CA 15837 (Pl. 5, fig. 2, L, 0.73; H, 0.38), Loc. K1.

Illustrated specimens. A right female valve, UMUT-CA 15838 (Pl. 5, fig, 1. L, 0.74; H, 0.38), Loc. SH4; a right female valve, UMUT-CA 15839 (Pl. 5, fig. 8; text-fig. 16-6. L, 0.70; H, 0.35), Loc. SH4; a left female valve, UMUT-CA 15840 (Pl. 5, fig. 7. L, 0.72; H, 0.36), Loc. OT5; a left female valve, UMUT-CA 15841 (Text-fig. 16-5. L, 0.70; H, 0.36), Loc. SH3; a female carapace, UMUT-CA 15842 (Pl. 5, fig. 9. L, 0.74; H, 0.38; W, 0.38), Loc. SH3; a right male valve, UMUT-CA 15843 (Pl. 5, fig. 3. L, 0.66; H, 0.30), Loc. SH4; a left male valve UMUT-CA 15844 (Pl. 5, fig. 4, L, 0.68; H, 0.31), Loc. OT4; a right immature valve, UMUT-CA 15845 (Pl. 5, fig. 5, L, 0.57; H, 0.32), Loc. K1; a left immature valve, UMUT-CA 15846 (Pl. 5, fig. 6. L, 0.59; H, 0.32), Loc. K1.

Diagnosis. *Finmarchinella* characterized by well-developed posterodorsal U-shaped ridge, falling down side long, opening anteriorly and being angular in posterodorsal corner.

Description. Valves subtrapezoidal in lateral view, highest at anterior cardinal angle. Anterior margin broadly and obliguely rounded, fringed by a series of weak and small denticles in its lower two-thirds. Dorsal margin gently arching in female and straight in male. Ventral contact margin sinuate at anterior one-fourth of valve length in right valve and at about mid-

length in left valve, partly hidden by overhanging ventrolateral surface in its posterior half. Posterior margin concave in its upper half meeting with dorsal margin in a blunt obtuse angle, protruding into a caudal process with weak notches in its lower half, and merging more or less smoothly into ventral margin. In dorsal view, carapace subhexagonal. Surface ornamented by reticulation of thick muri. U-shaped ridge in posterodorsal area distinct, as described in diagnosis; consisting of strong hook-shaped posterodorsal ridge, weak short oblique ridge and strong horizontal ridge. Hook-shaped ridge running posteriorly from just below eye tubercle, increasing the degree of intensity in its posterior half, and being bent sharply downward at posterior one-fourth of valve length, running vertically to join with the short oblique ridge at about upper one-fourth of valve height. Short oblique ridge weak, running obliquely to connect hook-shaped ridge with horizontal ridge at middle of valve height. The horizontal ridge slightly undulate, running toward upper part of subcentral tubercle. Marginal ridge running around parallel to nearly all contact margin, very weak in posterior and dorsal areas being coincident with marginal rim. Velate ridge starting from anteroventral area just behind anterior marginal ridge, running toward posterolateral direction forming a blunt wing-like projection, curving obliguely upward at posterior one-fourth of valve length, and terminating at tip of caudal process. A ridge extending anteriorly from subcentral tubercle, slightly inclined downward. The other ridges radiating posteroventrally from subcentral tubercle prominent below the horizontal ridge. Subcentral tubercle and eye tubercle conspicuous.

Nature of normal pore openings, radial pore canals, marginal infold, line of concrescence, vestibule, hingement and sexual dimorphism similar to those of *Finmarchinella* (*F.*) *rectangulata*. Muscle scar field in subcentral tubercle. Muscle scars consisting of three frontal scars and a vertical row of four adductor scars; median two scars are distinctly divided.

Dimensions. Measurements of pooled specimens from Loc. S1, S7, T1, K1, OT1, OT3, OT5, SH3, and SH4 are given below.

Sp	Me	N	$\bar{X}$	S	V	OR
L (F)	L	8	0.713	0.0183	2.57	0.69−0.74
	H	8	0.360	0.0106	2.94	0.35−0.38
R (F)	L	9	0.714	0.0180	2.52	0.69−0.74
	H	9	0.359	0.0162	4.51	0.34−0.38
C (F)	L	1				0.74
	H	1				0.38
	W	1				0.38
L (M)	L	3	0.657			0.63−0.68
	H	3	0.297			0.28−0.31
R (M)	L	2	0.655			0.65−0.66
	H	2	0.295			0.29−0.30

Remarks. This species is closely related to *F.* (*B.*) *angulata* (Sars, 1866) of Neale (1974), but is differentiated from *F.* (*B.*) *angulata* in having a distinct horizontal ridge, and hook-shaped posterodorsal ridge which does not obscure dorsal contact margin. In dorsal view, the valves of

the species are more vaulted than those of *F.* (*B.*) *angulata,* in particular, in the anterior area.

Occurrence. This species occurs commonly from 25 localities. However, it is not able to specify the sediment types from which the species occurs abundantly.

Finmarchinella (*Barentsovia*) sp.

Pl. 5, fig. 10.

Illustrated specimen. A right valve, UMUT-CA 15847 (Pl. 5, fig. 10. L, 0.84; H, 0.45), Loc. SW1.

Description. Right valve large, subtrapezoidal in lateral view, tapering posteriorly, highest at anterior cardinal angle. Anterior margin broadly and obliquely rounded. Dorsal margin gently arching. Ventral contact margin sinuate at anterior one-fourth of valve length, partly obscured by overhanging of ventrolateral surface in its posterior half. Posterior margin slightly concave in its upper half meeting with dorsal margin at a blunt obtuse angle and forming a large caudal process with its narrowly rounded lower half. Viewed dorsally, valve nearly trapezoidal with greatest width at posterior one-fourth of valve length, where ventrolateral surface swells. Posterior caudal area compressed. Surface ornamented by large reticules with shallow floor and blunt ridges. Anterior marginal ridge distinct, beginning at anterior cardinal angle, running along anterior margin to connect with ventral marginal rim at a little posterior to anteroventral corner. Five ridges extending radially from subcentral tubercle; anterior two bold and prominent, bold and short one running toward eye tubercle, and rather thick and irregular one running toward anterior marginal ridge. Posterodorsal ridge beginning at mid-length near dorsal margin, running posteriorly and branching off into two at a little anterior to posterior cardinal angle; one prominent, running vertically to ventrolateral swelling, and the other running obliquely toward middle of ventral margin to connect with strongly arched ridge extending radially from subcentral tubercle. Subcentral and eye tubercles prominent.

Normal and radial pore canals, marginal infold and hingement similar to those described for Finmarchinella (*F.*) *rectangulata.*

Remarks. Description is based on only one poorly preserved adult right valve which does not permit us to make detailed observation, in particular, on inner surface including radial pore canals and muscle scar pattern. General outline of valve and general pattern of surface ornamentation characterized by bold ridges and shallow floor of reticulation of this species indicate that the species is closely related to *F.* (*B.*) *hanaii* Okada, 1979 from the Pleistocene sediments of the Oga Peninsula, described by Okada (1979). However, this species is different from *F.* (*B.*) *hanaii* in its distinctly larger valve size and details of surface ornamentation, in particular, the presence of anterior bold ridges, distinct posterior vertical ridge and well-developed ventrolateral swelling.

Occurrence. Only one valve is found at Loc. SW1.

Finmarchinella? sp.

Pl. 5, figs. 11－14; text-fig. 18-9.

Illustrated specimens. A right valve, UMUT-CA 15848 (Pl. 5, figs. 11, 13; text-fig. 18-9. L, 0.43; H, 0.22), Loc. OT2; a right immature valve, UMUT-CA 15849 (Pl. 5, fig. 12. L, 0.40; H, 0.20),

Loc. OT5; a left immature valve, UMUT-CA 15850 (Pl. 5, fig. 14. L, 0.34; H, 0.18), Loc. S7.

Description. Valves thin, small, elongate, subrectangular in lateral view, highest at anterior cardinal angle. Anterior margin broadly and obliquely rounded. Dorsal margin gently arching in right valve, nearly straight in left valve. Ventral margin nearly straight, slightly sinuate at anterior one-fourth of valve length in right valve. Posterior margin nearly straight in its upper half and broadly rounded in its lower half, grading smoothly into dorsal and ventral margins. Viewed dorsally, valves elliptical, slightly compressed in posterior one-fifth of valve length. Surface ornamentation being characterized by fine punctation. Fine reticulation confined to compressed posterior one-fifth area of surface. Ventrolateral surface extending laterally to form alae-like projection and somewhat flattened ventral surface. Subcentral tubercle and eye tubercle obscure in exterior view, but distinct in interior view appearing as inside depression.

Normal pore openings of simple type pores, relatively small in number, scattered. Radial pore canals straight, simple, densely spaced, especially dense along anteroventral margin, 25 along anterior and 13 along posterior margins.

Marginal infold broad along anterior margin, narrower along posterior margin. Line of concrescence coincident with inner margin. No vestibule. Hinge antimerodont with elongate anterior and posterior projections and a finely denticulate median groove in righ valve. Muscle scars located in subcentral depression, consisting of two frontal scars and a vertical row of four adductor scars two of which are distinctly divided.

Remarks. Only one adult valve and four juvenile valves are available for study. General shape, hingement type, muscle scar pattern and radial pore canals of this species coincide with those diagnostic of genus *Finmarchinella.* The species is, however, dissimilar to other species of genus *Finmarchinella* in having rather small and thin valves without distinct caudal process, and lacking any costation and distinct reticulation on surface. The assignment of the species to genus *Finmarchinella* is doubtful at present.

Occurrence. The species occurs rarely from only three localities, Loc. OT2, OT5 and S7.

Subfamily THAEROCYTHERINAE Hazel, 1967
Tribe THAEROCYTHERINI Hazel, 1967
Genus *CORNUCOQUIMBA* Ohmert,1968
Cornucoquimba alata n. sp.

Pl. 10, figs. 11－15; Pl.11, fig. 1; text-fig. 18-10.

Type. Holotype, a right male valve, UMUT-CA 15851 (Pl. 10, fig. 11; Pl. 11, fig. 1; text-fig. 18-10. L, 1.04; H, 0.55), Loc. SW1.

Illustrated specimens. A female carapace, UMUT-CA 15852 (Pl.10, figs. 12, 15. L, 0.95; H, 0.55; W, 0.53), Loc. SW1; a right immature valve, UMUT-CA 15853 (Pl. 10, fig.13. L, 0.76; H, 0. 44), Loc. T1; a left immature valve, UMUT-CA 15854 (Pl. 10, fig. 14. L, 0.78; H, 0.45), Loc. O4.

Diagnosis. Cornucoquimba characterized by sparsely distributed round fossae and alae-like ventrolateral extension of ridge.

Description. Valves subtrapezoidal, tapering posteriorly in lateral view, highest at anterior cardinal angle. Anterior margin broadly rounded, slightly extended below. Dorsal margin gently arched. Ventral margin slightly concave. Posterior margin slightly concave in its upper half,

meeting with dorsal margin in a blunt obtuse angle, and obliquely arched in its lower half with three spines, smoothly grading into ventral margin. Valves subtriangular with posterior terminal protrusion in dorsal view, widest at about posterior one-third of valve length. Surface ornamented by rather sparsely distributed round fossae of variable size, and marginal rim and furrow. Bold marginal rim fringing entire valve margin. Marginal furrow running just inside of entire marginal rim and interrupted in area below eye tubercle and in area just above anteroventral corner. Ventrolateral surface expanding posterolaterally to form alae-like ridge leaving a node-like projection in its posterior extremity near posteroventral corner. Ventral surface flattened.

Normal pore openings moderate in number, scattered, but pore type uncertain owing to poorly preserved outer surface. Radial pore canals straight, medially bulbous, without branching, numerous in number in particular along anteroventral margin.

Marginal infold moderately broad, in particular, along anteroventral margin. Vestibule extremely shallow anteriorly and posteriorly. Hinge holamphidont; an anterior tooth round, and a posterior tooth large and curved in right valve. Muscle scar field in subcentral tubercle. Muscle scars consisting of two frontal scars and a vertical row of four adductor scars; median two scars are distinctly divided.

Sexual dimorphism distinct. Males more elongate than females.

Dimensions. Measurements of pooled specimens from Loc. SW1, T1, O4 and O5 are given below.

Sp	Me	N	OR
R (M)	L	1	1.04
	H	1	0.55
C (F)	L	2	0.91—0.95
	H	2	0.49—0.55
	W	2	0.47—0.53
L (A-1)	L	1	0.78
	H	1	0.45
R (A-1)	L	2	0.74—0.76
	H	2	0.44

Remarks. This species resembles *Cornucoguimba moniwensis* (Ishizaki, 1966) from the Miocene deposits of the Sendai area, described by Ishizaki (1966), in general outline and poorly developed reticulation, but is different from the latter in having more narrowly rounded anterior margin, arched dorsal margin and more inflated valves.

Occurrence. This species occurs rarely from seven localities listing in table 1.

Family TRACHYLEBERIDIDAE Sylvester-Bradley, 1948
Subfamily TRACHYLEBERIDINAE Sylvester-Bradley, 1948
Tribe TRACHYLEBERIDINI Sylvester-Bradley, 1948
Genus *ACANTHOCYTHEREIS* R. C. Howe, 1963

Acanthocythereis tsurugasakensis n. sp.

Pl. 11, figs. 2－10; text-fig. 20-2.

Type. Holotype, a right female valve, UMUT-CA 15855 (Pl. 11, figs. 2, 10. L, 0.91; H, 0.60), Loc. S5.

Illustrated specimens. A right male valve, UMUT-CA 15856 (Pl. 11, figs. 3, 8. L, 0.98; H, 0.58), Loc. S5; a left male valve, UMUT-CA 15857 (Pl. 11, figs. 4, 7, 9; text-fig. 20-2.L, 0.95; H, 0.59), Loc. S5; a right immature valve, UMUT-CA 15858 (Pl. 11, fig. 5. L, 0.77; H, 0.50), Loc. S2; a left immature valve, UMUT-CA 15859 (Pl. 11, fig. 6. L, 0.81; H, 0.57), Loc. S2.

Diagnosis. *Acanthocythereis* characterized by rapid tapering off of lateral outline and less spinose surface with faintly reticulate or smooth anterior and posterior marginal areas.

Description. Valves large, subpyriform, tapering posteriorly in lateral view, highest at anterior cardinal angle. Anterior margin broadly rounded, slightly extended below. Dorsal margin nearly straight, partly irregular due to spinose dorsolateral surface. Ventral contact margin sinuate at mid-length, mostly hidden by ventral ridge. Ventral margin gently arched in female, and with a distinct sinuation at about posterior two-fifths of valve length in male. Posterior margin vertically truncate in its upper half in female right valve and obliquely truncate in male right valve, meeting with dorsal margin at a blunt obtuse angle. Lower half of posterior margin merging smoothly into ventral margin. Anterior and posterior margins fringed by spines. Viewed dorsally, valves rather compressed laterally, especially in anterior area, and central and posterior outlines irregular due to spinose surface. Surface ornamented by feeble reticulation with spine-like projections, except for faintly reticulate or smooth anterior and posterior marginal areas. Anterior marginal ridge starting in area a little anterior to eye tubercle, running along anterior margin for a short distance, passing at about upper one-fifth of valve height into a row of tubercles lying parallel to anterior margin, changing into ventral ridge near anteroventral corner, running nearly parallel to ventral margin and terminating at about mid-length. Another row of weak tubercles lying between anterior fringing spines and above-mentioned row of tubercles, continuing into peripheral ridge near anteroventral corner. The peripheral ridge extending into area near posteroventral corner and passing into tubercles aligned parallel to posteroventral margin. Subcentral tubercle and eye tubercle obscure.

Normal pore openings moderate in number, scattered, consisting of sunken sieve type pores situated on muri, or on margin of floor of fossa and cone-like projection. Radial pore canals not observable.

Marginal infold moderately wide along anterior margin and narrower along ventral and posterior margins. No vestibule. Hinge holamphidont with a stepped anterior tooth, a gently curved posterior tooth and a finely crenulate median groove in right valve, and complementary elements in left valve. Muscle scar field in subcentral tubercle. Muscle scars consisting of one J-shaped frontal scar and a row of four adductor scars; median two scars are relatively elongate.

Sexual dimorphism distinct. Males more slender and longer than females.

Dimensions. Measurements of pooled specimens from Loc. 2 and S5 are as follows.

Sp	Me	N	OR
R (F)	L	2	0.91−0.92
	H	2	0.60
R (M)	L	1	0.98
	H	1	0.58
L (M)	L	1	0.95
	H	1	0.59
R (A-1)	L	1	0.77
	H	1	0.50
L (A-1)	L	2	0.79−0.81
	H	2	0.53−0.57

Remarks. This species is similar to *Acanthocythereis niitsumai* (Ishizaki, 1971) from Aomori Bay, North Honshu in general ornamentation, but it differs from the latter in its rapid tapering off of lateral outline. The species is characterized also by its less spinose surface and very faint reticulate or smooth anterior and posterior marginal areas.

Occurrence. This species occurs rarely from Loc. S2, O5 and N1 and abundantly from Loc. S5.

Genus *MURRAYINA* Puri, 1954

Murrayina japonica n. sp.

Pl. 12, figs. 3−8; text-fig. 19-1.

Type. Holotype, a right valve, UMUT-CA 15860 (Pl. 12, figs. 3, 6, 8; text-fig. 19-1. L, 1.02; H, 0.53), Loc. SW2.

Illustrated specimen. A left valve, UMUT-CA 15861 (Pl. 12, figs. 4, 5, 7. L, 0.99; H. 0.54), Loc. SW2.

Diagnosis. Murrayina characterized by large valve size and reticulation over all surface, consisting of round fossae variable in size and disposed in more or less concentrical pattern.

Description. Valves subrectangular in lateral view, highest at anterior cardinal angle. Anterior margin broadly and evenly rounded. Dorsal margin nearly straight. Ventral margin slightly concave. Posterior margin broadly rounded with irregular outline owing to protrusion of muri. Lower two-thirds of anterior margin denticulate. Viewed dorsally, right valve more compressed particularly in its anterior terminal part than left. Surface ornamented by reticulation consisting of moderately thick muri and round fossae, arranged concentrically near valve margin. Fossae variable in size, relatively large in areas along anterior and posterior margins and smaller in other areas. Anterior marginal ridge distinct in right valve, starting from anterior side of eye tubercle, running around anterior margin and merging into muri near anteroventral corner. Ventral marginal area rather compressed, particularly in posteroventral area. Subcentral tubercle obscure and eye tubercle distinct.

Normal pore openings moderate in number, scattered, consisting of sunken sieve type pores situated on muri or on margin of floor of fossa. Radial pore canals slightly winding, sometimes

bifurcate, moderate in number.

Marginal infold moderately broad along anterior margin and narrower along ventral and posterior margins. Vestibule shallow along all free margin, but relatively deep along anteroventral and posteroventral margins. Hinge holamphidont with an elongate anterior tooth, a curved elongate posterior tooth and a finely crenulate median groove in right valve and complementary elements in left vale. Muscle scar field in subcentral tubercle. Muscle scars consisting of one U-shaped frontal scar and a vertical row of four adductor scars; dorsomedian one is extremely elongate.

Dimensions. Measurements of pooled specimens from Loc. SW2 are as follows.

Sp	Me	N	OR
L	L	1	0.99
	H	1	0.54
R	L	1	1.02
	H	1	0.53

Remarks. Only two adult valves of this species were obtained from the Daishaka Formation. Right valve is smaller than left in the height-length ratio. Slight difference is also found between two valves in arrangement of reticules, particularly in anterior marginal area. It may be proper at present to place these two specimens in the same species on the basis of general shape and ornamentation, despite of above mentioned slight difference of ornamentation. It is probable that more elongate right valve is male, and left valve female. This species is close to *Murrayina martini* (Ulrich & Bassler, 1904) from the lower to middle Miocene Calvert and Choptank Formations, North America, reported by Forester (1980) in its similar lateral outline and round fossae, but differs, from the latter in having much larger valve size and entire coverage of reticulation over surface, without leaving any smooth area along anterior and posterior margins. This species is also similar to *M. howei* Puri, 1954 from the lower to middle Miocene Calvert Formation, remarked by Forester (1980) in its similar outline and similar valve size, but is distinguished from the latter in having round fossae and in its lack of smooth anterior and posterior marginal areas.

Occurrence. This species occurs as only two adult valves from only one locality, Loc. SW2.

Genus *CELTIA* Neale, 1973

Celtia sp.

Pl. 11, figs. 11－14; Pl. 12, figs. 1, 2; text-fig. 20-3.

Illustrated specimens. A right valve, UMUT-CA 15862 (Pl. 11, figs. 11, 14; Pl. 12, fig. 2; text-fig. 20-3. L, 0.94; H, 0.52), Loc. Tl; a left valve, UMUT-CA 15863 (Pl. 11, figs. 12, 13; Pl. 12, fig. 1. L, 0.96; H, 0.54), Loc. T1.

Description. Valves large, subelliptical slightly tapering posteriorly in lateral view, highest at anterior cardinal angle. Anterior margin broadly rounded, extended below. Dorsal margin slightly arched. Ventral margin slightly sinuate at about anterior two-fifths of valve length. Posterior margin slightly convex in its upper half, obliquely arched in its lower half, and merging

into dorsal and vertical margins. Lower half of anterior margin and of posterior margin denticulate. Viewed dorsally, valves relatively smooth and subelliptical with slight concavities at about anterior one-fourth of valve length and at about mid-length. Greatest width at about posterior one-fourth of valve length. Surface ornamented entirely with reticulation consisting of round fossae and relatively thick muri. Reticulation arranged more or less concentrically, particularly in area along valve margin. Posteroventral marginal area laterally compressed. Subcentral tubercle and eye tubercle obscure.

Normal pore openings moderate in number, scattered. Pore type unknown due to poor preservation of outer surface. Radial pore canals not observable.

Marginal infold moderately broad along anterior margin and narrower along ventral and posterior margins. Vestibule extremely shallow anteriorly and posteriorly. Hinge holamphidont, an anterior tooth stepped, a posterior tooth gently curved and a median groove finely crenulate in right valve. Hinge of left valve not observable. Muscle scar field in subcentral tubercle. Muscle scars consisting of one U-shaped frontal scar and a subvertical row of four adductor scars; dorsomedian one is extremely elongate.

Remarks This species is closely similar to *Celtia quadridentata* (Baird, 1850) from the North Sea reported by Neale (1973) in general shape and entire coverage of surface reticulation, but is easily distinguishable from the latter in having larger valve size, less elongate and more rounded lateral outline, less protruded posterior margin, relatively smooth dorsal outline and round fossae, while elongate fossae are prevailing in central to ventral area in *C. quadridentata.* The present species also resembles *Celtia japonica* Ishizaki, 1982 from the East China Sea in general shape and ornamentation, but differs from the latter in having much larger valve size, more elongate outline and less protruded posterior margin.

Occurrence. This species occurs rarely from Loc. SW2, T1, OT2, N3 and SH3.

Subfamily BUNTONIINAE Apostolescu, 1961

Genus *BUNTONIA* H. V. Howe, 1935

Buntonia hayamii n. sp.

Pl. 12, figs. 9–15; text-figs. 16-7, 8.

Type. Holotype, a right female valve, UMUT-CA 15864 (Pl. 12, figs. 9, 14; text-fig. 16-8. L, 0.64; H, 0.39), Loc. O1.

Illustrated specimens. A left female valve, UMUT-CA 15865 (Pl. 12, fig. 10. L, 0.67; H, 0.40), Loc. OT5; a right male valve, UMUT-CA 15866 (Pl. 12, fig. 11. L. 0.68; H, 0.34), Loc. OT3; a left male valve, UMUT-CA 15867 (Pl. 12, figs, 12, 13; text-fig. 16-7. L, 0.67; H, 0.39), Loc. SH2; a male carapace, UMUT-CA 15868 (Pl. 12, fig. 15. L, 0.71; H, 0.38; W, 0.29), Loc. SH2.

Diagnosis. Buntonia, characterized by moderate valve size, and weak and undulate marginal ridges in posterior half of surface.

Description. Valves subelliptical in lateral view, highest at about posterior two-fifths of valve length in right valve and at anterior cardinal angle in left valve. Anterior margin broadly and evenly rounded. Dorsal margin gently arched. Ventral margin arched in right valve and nearly straight in left valve. Posterior margin obliquely truncate in its upper half with distinct posterodorsal projection to internally accomodate posterior socket, making a blunt obtuse angle

with dorsal margin in left valve, and merging smoothly into dorsal margin in right valve. Lower half of posterior margin obliquely arched, merging into ventral margin. Lower half of posterior margin weakly denticulated. Valves elongate subelliptical in dorsal view, steeply sloping in posterior terminal. Surface ornamented by faint ridges in its posterior half and punctations of normal pore openings. Marginal rim lying around entire valve margin, particularly raised along anterior margin with posterojacent narrow and compressed marginal area. A few weak and undulate marginal ridges lying along posterior and ventral margins, particularly distinct in posterior terminal area. Trace of a few longitudinal ridges in posterior half of valve surface. Subcentral tubercle and eye tubercle absent.

Normal pore openings moderate in number, scattered, consisting of large sunken sieve type pores and small simple type pores. Radial pore canals slightly wavy, bulbous medially, simple, numerous in number, particularly along anteroventral margin.

Marginal infold moderately broad along anterior margin and narrower along ventral and posterior margins. Vestibule relatively deep anteriorly and extremely shallow ventrally and posteriorly. Hinge holamphidont; an anterior tooth relatively small and round, a posterior tooth elongate and large, and a median groove finely crenulate in right valve, and complementary elements in left valve. Muscle scar field in anterocentral area. Muscle scars consisting of one J-shaped frontal scar and a subvertical row of four adductor scars; median two scars are relatively elongate.

Sexual dimorphism marked. Males more slender than females.

Dimensions. Measurements of pooled specimens from Loc. SW1, S1, S3, O1, O5, OT3 and SH2 are as follows.

Sp	Me	N	$\bar{X}$	S	V	OR
L (F)	L	2				0.62−0.67
	H	2				0.38−0.40
R (F)	L	6	0.660	1.00	1.52	0.64−0.67
	H	6	0.405	1.71	4.22	0.39−0.44
L (M)	L	2				0.67
	H	2				0.39
R (M)	L	5	0.666	2.42	3.63	0.63−0.70
	H	5	0.362	1.60	4.42	0.34−0.39
C (M)	L	2				0.63−0.71
	H	2				0.36−0.38
	W	2				0.29−0.30

Remarks. The present species is closely related to *Buntonia hanaii* Yajima, 1978 from the Pleistocene sediments of the Kisarazu area near Tokyo, in general outline and ornamentation, but is distinguishable from the latter in its larger valve size, slight protrusion of posterior margin toward posterior direction, and presence of less prominent marginal ridges in posterior half of valve surface.

Occurrences. The present species occurs rarely from 11 localities as listed in table 1.

Genus *ROBERTSONITES* Swain, 1963

Robertsonites hanaii n. sp.

Pl. 13, figs. 1−12; text-figs. 16-9, 10.

Type. Holotype, a right female valve, UMUT-CA 15869 (Pl. 13, figs. 1, 6. 12; text-fig. 16-10. L, 1.08; H, 0.67), Loc. K1.

Illustrated specimens. A left female valve, UMUT-CA 15870 (Pl. 13, figs. 2, 5, 11; text-fig. 16-9. L, 1.06; H, 0.70), Loc. K1; a right male valve, UMUT-CA 15871 (Pl. 13, fig. 3. L, 0.99; H, 0. 56), Loc. K1; a left male valve, UMUT-CA 15872 (Pl. 13, fig. 4, L, 1.06; H, 0.60), Loc. K1; a right immature valve at A-1 stage, UMUT-CA 15873 (Pl. 13, fig. 7. L, 0.79; H, 0.54), Loc. K1; a left immature valve at A-1 stage, UMUT-CA 15874 (Pl. 13, fig. 8. L, 0.81; H. 0.58), Loc. K1; a right immature valve at A-3 stage, UMUT-CA 15875 (Pl. 13, fig. 9. L, 0.52; H, 0.35), Loc. K1; a right immature valve at A-5 stage, UMUT-CA 15876 (Pl. 13, fig. 10. L, 0.35; H, 0.24), Loc. K1.

Diagnosis. *Robertsonites* characterized by relatively large valve size, subelliptical lateral outline and coarsely reticulate surface.

Description. Valves large, subelliptical, tapering posteriorly in lateral view, highest at anterodorsal corner. Anterior margin broadly rounded, slightly extended below. Dorsal margin nearly straight, somewhat sinuous due to irregularly projected dorsolateral surface. Ventral margin gently arched. Posterior margin nearly straight in its upper half, meeting with dorsal margin in a blunt obtuse angle. Lower half of posterior margin, obliquely arched, grading smoothly into ventral margin. Anterior and lower half of posterior margins denticulate. Valves subelliptical in dorsal view, though considerably irregular owing to well-developed ridges and tubercles. Surface ornamented by coarse reticulation and ridges. Anterior ridge prominent, running obliquely downward from lower side of eye tubercle to terminate at abovt lower one-seventh of valve height. Ventral marginal ridge located most interiorly and most prominent among three ventral ridges, running parallel to ventral margin from ventral termination of anterior ridge to area near posteroventral corner. Subvertical short ridge starting at posterior one-fourth of dorsal margin, running downward to a little upper to mid-height. A rather weak and elongate swelling located in anteroventral area near anteroventral corner and a node-like projection situated at mid-height near posterior termination prominent. A shallow and elongate depression present at a little posterior to eye tubercle, extending subvertically from dorsal margin at anterior two-fifths of valve length to about upper one-third of valve height. Subcentral tubercle and eye tubercle moderately developed.

Normal pore openings, moderate in number, scattered, consisting of large sunken sieve type pores located on muri or on margin of floor of fossa. Small simple type pores, though small in number, distributed in area near valve margin. Radial pore canals slightly winding, sometimes bifurcate, moderate in number.

Marginal infold moderately broad along anterior margin and narrow along ventral and posterior margins. Vestibule present along almost all free margin, although rather shallow. Hingement holamphidont with a stepped anterior tooth, a deep socket, a finely crenulate median groove and a strongly curved posterior tooth in right valve, and complementary elements in left valve. Muscle scar field in subcentral tubercle. Muscle scars consisting of one heart-shaped frontal scar and a vertical row of four adductor scars; median two scars are relatively elongate.

Sexual dimorphism prominent. Males more slender than females.

Dimensions. Measurements of pooled specimens from Loc. K1 and Loc. O2 are given as follows.

Sp	Me	N	$\bar{X}$	S	V	OR
L (F)	L	2				0.97－1.06
	H	2				0.64－0.70
R (F)	L	5	1.05	0.0265	2.52	1.0 －1.08
	H	5	0.652	0.0148	2.27	0.63－0.67
L (M)	L	2				1.06－1.09
	H	2				0.60－0.62
R (M)	L	5	1.006	0.0305	3.03	0.97－1.05
	H	5	0.576	0.0134	2.33	0.56－0.59

Remarks. General outline and ornamentation of this species vary considerably in the observed case of ontogenetic series from A-5 to adult stage. Ornamentation at later molt stage is generally coarser and bolder than that of the earlier. However, the tempo or degree of development of ornamentation is different from stage to stage in its details; the anteroventral weak swelling appears and the node-like projection near posterior termination abruptly becomes conspicuous at adult stage. On the other hand, the prominent ventral marginal ridge and the posterodorsal subvertical short ridge are less prominent at later molt stage. This species is closely similar to *R. tuberculatus* (Sars, 1865) in general outline and ornamentation. Hazel (1967) pointed out the wide variation of *R. tuberculatus* in outline and ornamentation. Recently, Horne (1983) figured and remarked on specimens of *R. tuberculatus* from Greenland, Norway and Alaskan Shelf. Japanese species is close to a form of *R. tuberculatus* from Alaskan Shelf. Horne mentioned that the Alaskan specimens are less elongate and have more prominent nodes than those from Greenland and Norway. This species is, however, different from *R. tuberculatus* from Alaskan Shelf in having much less elongate and more rounded outline and distinct anterior subvertical ridge, and in lacking in anterior ridge. The anterior ridge which is characteristic of *R. tuberculatus* is generally undulate and strong in its upper one-fourth and lower one-fourth, and runs downward subvertically from a little anterior to eye tubercle to connect with one of the ventral marginal ridges near anteroventral corner.

Occurrence. This species occurs from five localities, Loc. S1, S3, K1, O2 and O5, and is abundant at two localities, Loc. K1 and O5.

Robertsonites reticuliforma (Ishizaki, 1966)

Pl. 14, figs. 1－12; text-figs. 17-1, 2.

Buntonia? reticuliforma : Hanai et al., 1977, p. 53

Buntonia? japonica : Yajima, 1978, p. 387, Table 5.

Robertsonites? reticuliforma : Yajima, 1982, p. 205, Pl. 12, fig. 13.

Illustrated specimens. A right female valve, UMUT-CA 15877 (Pl. 14, figs. 1, 6. L, 0.87; H, 0.54), Loc. O2; a right female valve, UMUT-CA 15878 (Pl. 14, fig. 12; text-fig. 17-2, L, 0.84; H, 0.

51). Loc. O2; a left female valve, UMUT-CA 15879 (Pl. 14, figs. 2, 5. L, 0.83; H, 0.54), Loc. S1; a left female valve, UMUT-CA 15880 (Pl. 14, fig. 11; text-fig. 17-1. L, 0.87; H, 0.56), Loc. O2; a right male valve, UMUT-CA 15881 (Pl. 14, fig. 3. L, 0.85; H, 0.48), Loc. O2; a left male valve, UMUT-CA 15882 (Pl. 14, fig. 4. L, 0.81; H, 0.47), Loc. S6; a right immature valve at A-1 stage, UMUT-CA 15883 (Pl. 14, fig. 7. L, 0.70; H, 0.44), Loc. O2; a left immature valve at A-1 stage, UMUT-CA 15884 (Pl. 14, fig. 8. L, 0.68; H, 0.45), Loc. S4; a right immature valve at A-3 stage, UMUT-CA 15885 (Pl. 14, fig. 9. L, 0.48; H, 0.33), Loc. O2; a partly broken immature carapace at A-5 stage, UMUT-CA 15886 (Pl. 14, fig. 10. L, 0.32; H, 0.22), Loc. O2.

Diagnosis. *Robertsonites* characterized by relatively small valve size, subpyriform lateral outline, details of surface ornamentation and shape of frontal scar.

Description. Valves subpyriform in lateral view. Details explaining lateral and dorsal outlines similar to those described for *Robertsonites hanaii.* Surface ornamentation overall similar to that of *R. hanaii,* but different in minute details. Anterior ridge distinct, slightly curved, running downward from lower side of eye tubercle, and terminating at about lower one-seventh of valve height. One ventral marginal ridge prominent, starting at terminal of anterior ridge, running parallel to ventral margin, once being weakened near posteroventral corner, and reaching to node-like projection situated at about lower one-third of vale height. Posterodorsal subvertical ridge short but prominent, slightly curved, starting at about posterior one-fifth of valve length near dorsal margin, and running downward to about mid-height. An elongate swelling with about four small fossae in anteroventral area. A very shallow and subvertically elongate depression lying at a little posterior to eye tubercle. Subcentral tubercle and eye tubercle not conspicuous.

Nature of pore canals, marginal infold, vestibule, hingement as well as nature of sexual dimorphism similar to those of *R. hanaii.* Shape and distribution pattern of muscle scars also similar to that of *R. hanaii*, except for shape of frontal scar being J-shaped.

Dimensions. Measurements of pooled specimens from Loc. S1, S4, S5, S6 and O2 are given as follows.

Sp	Me	N	$\bar{X}$	S	V	OR
L (F)	L	6	0.838	0.0293	3.50	0.80−0.87
	H	6	0.553	0.0197	3.56	0.53−0.58
R (F)	L	7	0.850	0.0231	2.72	0.81−0.88
	H	7	0.531	0.0241	4.54	0.49−0.56
L (M)	L	3	0.800			0.73−0.86
	H	3	0.467			0.42−0.51
R (M)	L	1				0.85
	H	1				0.48

Remarks. This species was originally described by Ishizaki (1966), from the Miocene Hatatate Formation of the Sendai area, Northeast Honshu. This species shows a remarkable similarity with *R. hanaii* n. sp. in general morphology including ontogenetic developpment of ornamentation. In particular, the pattern of reticulation and ridges at adult stage of the species

is extremely close to that of *R. hanaii*. The species is, however, distinguishable from *R. hanaii* in its smaller size, more tapered outline toward posterior direction and J-shaped frontal scar, as well as in details of ornamentation; a prominent ventral marginal ridge reaching to posterior node-like projection, well-developed anteroventral elongate swelling which appears in earlier molt stage, and poorly developed subcentral tubercle and eye tubercle.

Occurrence. The species occurs commonly and extrusively from fine sediments of 9 localities as listed in table 1.

Robertsonites tsugaruana n. sp.

Pl. 15, figs. 1－12; Pl. 20, fig. 6.

Type. Holotype, a left female valve, UMUT-CA 15887 (Pl. 15, figs. 2, 5, 11. L, 0.96; H, 0.61), Loc. K1.

Illustrated specimens. A right female valve, UMUT-CA 15888 (Pl. 15, fig. 1; Pl. 20, fig. 6. L, 0.90; H, 0.55), Loc. K1; a right female valve, UMUT-CA 15889 (Pl. 15, figs. 6, 12. L, 0.91; H, 0.56), Loc. K1; a right male valve, UMUT-CA 15890 (Pl. 15, fig. 3. L, 0.87; H, 0.47), Loc. TA1; a left male valve, UMUT-CA 15891 (Pl. 15, fig. 4. L, 0.87; H, 0.51), Loc. K1; a right immature valve at A-1 stage, UMUT-CA 15892 (Pl. 15, fig. 7. L, 0.73; H, 0.45), Loc. O4; a left immature valve at A-1 stage, UMUT-CA 15893 (Pl. 15, fig. 8. L, 0.73; H, 0.48), Loc. O2; a right immature valve at A-3 stage, UMUT-CA 15894 (Pl. 15, fig. 9. L, 0.52; H, 0.34), Loc. S2; a right immature valve at A-5 stage, UMUT-CA 15895 (Pl. 15, fig. 10. L, 0.33; H, 0.23), Loc. OT2.

Diagnosis. Robertsonites characterized by finely reticulate anterior surface and coarsely reticulate posterior surface without prominent tubercles and nodes and by four marginal ridges distinct around free margin.

Description. Valves large, subelliptical and similar to *R. hanaii* in lateral view, but dentation along anterior and posteroventral margins weak and dorsal outline rather smooth in this species. Surface characterized by relatively fine reticulation in its anterior area and coarser reticulation in its posterior area, and about four marginal ridges running along nearly entire free margin; most prominent marginal ridge located in relatively inner area of lateral surface and projected in posteroventral area. A very weak and broad swelling lying a little posterior to lower half of anterior margin. Subcentral tubercle and eye tubercle rather obscure.

Nature of pore canals, marginal infold, vestibule, hingement, muscle scar pattern, as well as nature of sexual dimorphism as explained for *R. hanaii*. Frontal scar J-shaped, similar to that of *R. reticuliforma*.

Dimensions. Measurements of pooled specimens from Loc. TA1 and N2 are given as follows.

Sp	Me	N	$\bar{X}$	OR
L (F)	L	1		0.96
	H	1		0.61
R (F)	L	3	0.903	0.90−0.91
	H	3	0.550	0.54−0.56
L (M)	L	1		0.87
	H	1		0.51
R (M)	L	2		0.87−0.88
	H	2		0.47−0.48

Remarks. This species is closely related to *Robertsonites hanaii* n. sp. and *R. reticuliforma* (Ishizaki, 1966) in having subelliptical or subpyriform outline and reticulate surface, but is different from other species of genus *Robertsonites* in characters enumerated in diagnosis of this species. Presence of prominent tubercles and nodes have been considered as diagnostic in the generic level by Swain (1963). The specimens at earlier molt stage of this species have more protruded posterodorsal ridge and ventral marginal ridge. In fact, specimens of A-5 stage have well-preserved posterodorsal and posteroventral ridges or nodes, and are closely similar to the specimens at the corresponding stage of *R. hanaii* and *R. reticuliforma* in general shape and surface ornamentation, though they are characterized by its more densely distributed punctations on surface. The species resembles *Buntonia? japonica* (Ishizaki, 1966) from the Pliocene Tatsunokuchi Formation of the Sendai area in its similar outline, reticulate surface and distinct marginal ridges around free margin, and lack of prominent tubercles and nodes, but is easily distinguishable from the latter in having larger valve size, less elongate outline, finely reticulate anterior surface, laterally much more inflated valves, and a distinct projection of marginal ridge in posteroventral area.

Occurrence. The species is commonly found at 13 localities as listed in table 1. The occurrence of the species is confined to fine sediments with one exception where the species occurs from coarse sediments at Loc. OT2.

Robertsonites sp. 1

Pl. 16, figs 1−6; text-fig. 20-4.

Illustrated specimens. A right valve, UMUT-CA 15896 (Pl. 16, figs. 1, 4, 6; text-fig. 20-4. L, 0.79 H, 0.48), Loc. O5; a left valve, UMUT-CA 15897 (Pl. 16, figs. 2, 3, 5. L, 0.80; H, 0.45), Loc. O5.

Description. Valves subpyriform in lateral view, highest at anterodorsal corner. Anterior margin broadly rounded, slightly extended below. Dorsal margin gently arched. Ventral margin gently arched. Posterior margin nearly straight in its upper half and obliquely arched in its lower half, making a blunt obtuse angle with dorsal margin and merging into ventral margin. Anterior margin and lower half of posterior margin denticulate. Valves rather smooth and subelliptical in dorsal view. Surface ornamented by reticulation, being obscured in anteriormost and posteriormost areas. About three distinct marginal ridges running along nearly entire free margin. One marginal ridge located most interiorly somewhat protruded in posteroventral area.

Subcentral tubercle and eye tubercle not prominent.

Nature of pore canals, marginal infold, vestibule, hingement, J-shaped frontal scar similar as described for *R. reticuliforma*.

Remarks. Only two adult valves are available for study; left valve is more elongate and more inflated than the right. Poor preservation of inner surface obscures the details of radial pore canals. The species is closely related to *Robertsonites tsugaruana* n. sp. in having similar outline, reticulate surface and distinct marginal ridges, but is distinguishable from *R. tsugaruana* in having smaller valve size, partial obscureness of reticulation and more tapering outline toward the posterior, and lack of anteroventral swelling. Posterodorsal ridge and one marginal ridge tend to be more prominent at earlier molt stage; the tendency is recognizable in the three species of genus *Robertsonites* described above, though they are less developed in this species than the three species. The species resembles *Buntonia? japonica* (Ishizaki, 1966) from the Pliocene Tatsunokuchi Formation of the Sendai area, but is discernible from the latter in having less elongate outline, partial obscureness of reticulation and more inflated valves.

Occurrence. The species is common at single locality, Loc. O5.

Robertsonites sp. 2

Pl. 16, fig. 7.

Illustrated specimen. A left immature valve, UMUT-CA 15898 (Pl. 16, fig. 7. L, 0.78; H, 0. 49), Loc. O5.

Remarks. Only juvenile valves were obtained. The largest two left valves are almost the same in valve size as left immature valve at A-1 stage of *Robertsonites hanaii* n. sp., but are different from that of *R. hanaii* in slender outline and in details of ornamentation, including presence of two node-like projections near anterior margin; one situated at upper one-third of valve height and the other near anteroventral corner, and further, relatively prominent posterodorsal and posteroventral node-like projections. These characteristics of outline and ornamentation of the species are strongly reminiscent of *R. tuberculatus* (Sars, 1865), in particular, from Alaskan Shelf reported by Horne (1983).

Occurrence. The species occurs from only two localities, Loc. K1 and O5.

Family CYTHERURIDAE G. W. Müller, 1894

Subfamily CYTHERURINAE G. W. Müller, 1894

Genus *HEMICYTHERURA* Elofson, 1941

Hemicytherura sp.

Pl. 17, figs. 7, 8.

Illustrated specimens. A right immature valve, UMUT-CA 15899 (Pl. 17, fig. 7. L, 0.34; H, 0.19), Loc. SH2; a left immature valve, UMUT-CA 15900 (Pl. 17, fig. 8. L, 0.34; H, 0.20), Loc. SH2.

Remarks. This species is characterized by finely reticulate central area and punctate marginal area, and distinct three ridges radiating from central area toward valve margin.

Occurrence. This species occurs from Loc. OT2, N4 and SH2 rarely to commonly.

Genus *HOWEINA* Hanai, 1957

Howeina? sp.

Pl. 16, figs. 13, 14.

Illustrated specimen. A left valve, UMUT-CA 15901 (Pl. 16, figs. 13, 14. L, 0.42; H, 0.25), Loc. T1.

Remarks. Poorly preserved specimen does not warrant its generic and specific identification. This species seems to be characterized by subquadrate outline and almost smooth surface. S-shaped inner margin in posterior area of inner surface suggests that it belongs to either genus *Semicytherura* or genus *Howeina.*

Occurrence. Only one specimen is found at Loc. T1.

Genus *SEMICYTHERURA* Wagner, 1957

Semicytherura sp. 1

Pl. 16, figs. 9－12; text-fig. 19-2.

Illustrated specimens. A right valve, UMUT-CA 15902 (Pl. 16, figs. 9, 12; text-fig. 19-2. L, 0.36; H, 0.21), Loc. OT2; a left valve, UMUT-CA 15903 (Pl. 16, figs. 10, 11. L, 0.34; H, 0.20), Loc. SH2.

Description. Valves small, subelliptical in lateral view, highest at mid-length in right valve and at about anterior one-third of valve length in left. Anterior margin broadly rounded with its nearly straight upper portion in right valve. Dorsal margin gently arched. Ventral margin nearly straight. Posterior margin narrowly rounded in its middle, forming a caudal process. Viewed dorsally, valves subhexagonal with greatest width at about posterior one-fourth of valve length. Surface ornamented by weak and partly obscure ridges. Marginal ridges lying nearly parallel to ventral and dorsal margins. A few faint longitudinal costae arising in anterocentral area, running posteriorly, forming area of fusuline shape, and again converging in posterocentral area.

Normal pore openings small in number, scattered, consisting of simple type pores. Radial pore canals wavy, rarely bifurcate, small in number, about 11 along anterior and about 6 along posterior margins. Marginal infold wide anteriorly and posteriorly. Vestibule not discernible. Hinge Cytherurinae type lophodont. Muscle scar field in anterocentral area. Muscle scars consisting of one frontal scar and a nearly vertical row of four adductor scars.

Remarks. This species is very similar to *Semicytherura? miurensis* (Hanai, 1957) in lateral outline, but is easily distinguishable from the latter in having more blunt caudal process and poor development of S-shaped posterior inner margin, and in lacking in cobweb-like reticulation and also in its lack of flattened ventral surface. The present species is also close to *Cytherura* cf. *corensis* Grossman, 1967 reported by Swain & Kraft (1975) from northern North America in ornamentation, but differs from the latter in having posteriorly converging lateral outline and location of caudal process being situated in lower half of carapace height.

Occurrence. Only two specimens mentioned above are found at Loc. OT2 and SH2.

Semicytherura sp. 2

Pl. 16, figs. 18, 19.

Illustrated specimen. A right valve, UMUT-CA 15904 (Pl. 16, figs. 18, 19. L, 0.36; H, 0.20), Loc. N4.

Description. Right valve small, subovate in lateral view, highest at mid-length. Anterior

margin obliquely rounded. Dorsal margin strongly arched. Ventral contact margin sinuate at about anterior one-third of valve length, mostly hidden by ventrolateral surface in lateral view. Ventrolateral surface extending ventrally and forming a gently arched ventral margin of lateral outline. Posterior margin protruding into a distinct caudal process in its mid-height. Right valve smoothly arched with compressed posterior terminal part of caudal process in dorsal view. Surface ornamented by longitudinal ridges and fine pits in interspaces between ridges. Several longitudinal ridges arising from lower half of anterior marginal area, running posteriorly, covering over all surface, and converging in area a little anterior to caudal process.

Normal pore openings small in number, scattered. Pore type and radial pore canals not observable.

Marginal infold moderately broad anteriorly and narrower ventrally and posteriorly. No vestibule. Hinge Cytherurinae type lophodont. Muscle scar field in anterocentral area. Muscle scar not observable due to poor preservation except for an oblique row of four adductor scars.

Remarks. This species resembles *Semicytherura wakamurasaki,* Yajima, 1982 from the Pleistocene sediments of the Boso Peninsula, in general shape and ornamentation, but differs from the latter in having less elongate outline and arched ventral margin.

Occurrence. One right valve from Loc. N4 is only a specimen available for study.

Semicytherura sp. 3

Pl. 16, fig. 8.

Illustrated specimen. A right immature valve, UMUT-CA 15905 (Pl. 16, fig. 8. L, 0.40; H, 0.19), Loc. SH4.

Remarks. This species is similar to *Semicytherura wakamurasaki* Yajima, 1982 in general shape and ornamentation, but larger valve size, lower position of caudal process and lack of distinct longitudial ridges of this species differentiate this species from *S. wakamurasaki.*

Occurrence. Two specimens are found at Loc. OT5 and SH4.

Semicytherura sp. 4

Pl. 16, fig. 17

Illustrated specimen. A partly broken left immature valve, UMUT-CA 15906 (Pl. 16, fig. 17. L, 0.37; H, 0.20), Loc. O5.

Remarks. This species is characterized by two groups of oblique ridges in anterior surface, starting from anterior terminal area; one group running toward posterodorsal direction and the other toward posteroventral direction. Another diagnostic character includes posterior faintly reticulate and pitted surface and flattened ventral surface.

Occurrence. Only one left valve from Loc. O5 is available for study.

Semicytherura sp. 5

Pl. 16, fig. 20

Illustrated specimen. A right valve, UMUT-CA 15907 (Pl. 16, fig. 20. L, 0.47; H, 0.26), Loc. OT5.

Remaks. This species is similar to *Semicytherura? miurensis* (Hanai, 1957) in shape and

general pattern of ornamentation, but is different from the latter in having more narrowly rounded anterior margin, more posterior location of greatest height, and ornamentation characterized by longitudinal ridges with faint vertical ridges which fill interspaces.

Occurrence. This species occurs rarely from Loc. S7, T1, OT5 and SH3.

Semicytherura sp. 6

Pl. 17, figs. 9, 10

Illustrated specimen. A right valve, UMUT-CA 15908 (Pl. 17, figs.9, 10. L, 0.32; H, 0.16), Loc. O4.

Remarks. The species is represented only by a poorly preserved left adult valve, whose posterior caudal process is broken off. *Semicytherura paradoxa* (Müller, 1894) from the Gulf of Naples figured by Puri, Bonaduce & Malloy (1965) is similar to this Japanese species in general outline and arrangement of main ridges.

Occurrence. Only one specimen occurs from Loc. O4.

Semicytherura? daishakaensis n. sp.

Pl. 17, figs. 1–6; text-fig. 19-3

Type. Holotype, a right valve, UMUT-CA 15909 (Pl. 17, figs. 1, 4, 6. L, 0.52; H, 0.32), Loc. N4.

Illustrated specimen. A left valve, UMUT-CA 15910 (Pl. 17, figs. 2, 3, 5; text-fig. 19-3. L, 0.52; H, 0.32), Loc. SH3.

Diagnosis. A species characterized by trapezoidal outline, surface reticulation with thin undulate muri, Cytherurinae-type lophodont hingement and narrow marginal infold with inner margin running nearly parallel to outer margin.

Description. Valves subtrapezoidal in lateral view, highest at anterior cardinal angle. Anterior margin broadly and obliquely rounded. Dorsal margin gently arched. Ventral margin nearly straight. Posterior margin forming a caudal process, slightly concave in its upper half in right valve, somewhat convex in left valve. Lower half of posterior margin grading smoothly into ventral margin. Valves relatively smooth, relatively inflated and subelliptical in dorsal view. Surface covered by reticulation with thin undulate muri of irregular thickness. Weak vertical sulcus lying medially. Ventrolateral surface extending laterally to form flattened ventral surface.

Normal pore openings moderate in number, scattered, consisting of simple type pores. Radial pore canals straight, simple, small in number, about 8 along anterior and about 7 along posterior margins.

Marginal infold relatively narrow along all free margio. No vestibule. Hinge Cytherurinae type lophodont with terminal teeth being connected with selvage. Median hinge element smooth. Muscle scar field in ventrocentral area. Muscle scars consisting of one J-shaped frontal scar and a subvertical row of four adductor scars; four adductor scars are on central ridge.

Dimensions. Measurements of pooled specimens from Loc. N4 and SH3 are as follows.

Sp	Me	N	$\bar{X}$	S	V	OR
L	L	8	0.531	0.927	1.75	0.52－0.55
	H	8	0.328	1.09	3.32	0.31－0.34
R	L	2				0.52
	H	2				0.32－0.34

Remarks. The present species resembles *Howeina camptocytheroidea* Hanai, 1957 in general outline, but differs from the latter in having more or less evenly reticulate surface and much narrower marginal infold.

Occurrence. This species occurs occasionally from two localities, Loc. N4 and SH3.

CYTHERURINAE genus uncertain

Cytherurinae gen. and sp. indet.

Pl. 16, figs. 15, 16

Illustrated specimen. A carapace, UMUT-CA 15911 (Pl. 16, figs. 15,16. L, 0.38; H, 0.20; W, 0.12), Loc. OT5.

Remarks. This species is characterized by smooth surface and its box-shaped carapace with a short handle-like caudal process. Viewed dorsally, elongate quadrangular with compressed posterior terminal projection of caudal process.

Occurrence. Only one carapce is found at Loc. OT5.

Subfamily CYTHEROPTERINAE Hanai, 1957

Genus *CYTHEROPTERON* Sars, 1866

Cytheropteron yajimai n. sp.

Pl. 17, figs. 13－18; Pl. 20, fig. 7; text-figs. 17-3, 4

Type. Holotype, a right valve, UMUT-CA 15912 (Pl.17, figs.13, 16, 18; text-fig. 17-4. L, 0.62; H, 0.38), Loc. N3.

Illustrated specimen. A left valve, UMUT-CA 15913 (Pl. 17, figs. 14, 15, 17; Pl. 20, fig. 7; text-fig. 17-3. L, 0.57; H, 0.35), Loc. OT2.

Diagnosis. Cytheropteron chararterized by moderate valve size and surface ornamentation of vertical ridges with large and round holes and punctations filling interspaces between the ridges.

Description. Valves subrhomboidal in lateral view, highest at about mid-length. Anterior margin obliquely rounded. Dorsal margin arched. Ventral contact margin sinuate at about anterior two-fifths of valve length, obscured by alae-like ventrolateral expansion forming a gently arched ventral outline. Posterior margin protruding posteriorly, narrowly rounded near mid-height, and merging into dorsal and ventral margins. Valves smoothly elliptical with compressed and pointed anterior and posterior terminals in dorsal view. Roughness of surface ornamentation variable individually from well-ornamented uneven surface covered with prominent ridges and small round holes arranged vertically between ridges to relatively smooth surface prevailed by sparsely distributed punctations and undulate weak ridges. Prominent alate

ridge arising in anterocentral area, running posteriorly, bordering along boundary between ventrolateral surface and ventral flattened surface and merging into one of weak ridges in posteroventral area. Short longitudinal ridge starting at anterior margin a little higher than anteroventral corner, running posteriorly to join to ventrolateral ridge. Dorsal marginal ridge running from anterior margin a little lower than anterodorsal corner, running parallel to dorsal margin and merging into one of less prominent ridges in posterior marginal area. An elongate depression lying in anterior area of alae-like ventrolateral surface.

Normal pore openings moderate in number, scattered, consisting of simple type pores. Radial pore canals simple, small in number, sparsely distributed along anterior and posterior margins.

Marginal infold moderately broad. Vestibule relatively deep anteriorly and narrow ventrally and posteriorly. Hinge Cytheropterinae type merodont. Muscle scar field in anteroventral area. Muscle scars consisting of one elongate frontal scar and an oblique row of four adductor scars.

Dimensions. Measurements of pooled specimens from Loc. O5, OT1, OT2, N3 and SH2 are as follows.

Sp	Me	N	$\bar{X}$	S	V	OR
L	L	6	0.587	3.35	5.71	0.56−0.60
	H	6	0.348	1.67	4.80	0.33−0.37
R	L	4	0.613	1.92	1.63	0.58−0.63
	H	4	0.395	0.866	2.19	0.38−0.40

Remarks. This species is closely related to *Cytheropteron sawanense* Hanai, 1957 in general shape and surface ornamentation, but is distinguishable from the latter in having less developed ridges and node-like projections near anterodorsal and posterodorsal corners.

Occurrence. The present species occurs rarely to commonly from 19 localities as listed in table 1.

Cytheropteron tsugaruense n. sp.

Pl. 18, figs. 1−6; Pl. 20, fig. 8; text-figs. 17-5, 6.

Type. Holotype, a left valve, UMUT-CA 15914 (Pl. 18, figs. 2, 3, 5; text-fig. 17-5. L, 0.48; H, 0.30), Loc. O4.

Illustrated specimen. A right valve, UMUT-CA 15915 (Pl. 18, figs. 1, 4, 6; Pl. 20, fig. 8; text-fig. 17-6. L, 0.49; H, 0.31), Loc. OT5.

Diagnosis. Cytheropteron characterized by rather slender main body of valves with two prominent node-like projections on alae-like lateral extension.

Description Valves subrhomboidal in lateral view, highest at mid-length in right valve, at anterior one-third in left valve. Anterior margin obliquely rounded. Dorsal margin strongly arched in right valve, gently arched with a large projection in posterodorsal corner in left valve. Ventral margin gently arched. Posterior margin obliquely rounded. Viewed dorsally, main body of valves appearing relatively slender with prominent alae-like extension of ventrolateral surface. Surface ornamented by reticulation, ridges and node-like projections. Two prominent node-like

projections lying anteriorly and posteriorly on ventrolateral alae-like extension with a distinct depression between these two projections. Dorsal marginal ridge arising near anterodorsal corner, running along dorsal margin and merging into one of less prominent ridges in posterior marginal area. Vertical ridges prominent over all lateral surface and round reticules of variable size aligned in interspaces between vertical ridges.

Features of inner surface including normal and radial pore canals, hingement and muscle scar pattern of this species similar to those described for *C. yajimai*.

Dimensions. Measurements of pooled specimens from Loc. K1, O4, OT5 and TA1 are as follows.

Sp	Me	N	$\bar{X}$	S	V	OR
L	L	2				0.48－0.53
	H	2				0.30－0.32
R	L	4	0.513	1.79	3.49	0.49－0.54
	H	4	0.335	2.18	6.51	0.31－0.37

Remarks. This species is closely related to *Cytheropteron sawanense* Hanai, 1957 in general outline and ornamentation, but differs from the latter in characters enumerated in diagnosis.

Occurrence. The present species occurs rarely from Loc. K1, O4, OT5 and TA1.

Cytheropteron sp. 1

Pl. 18, figs. 7,8; text-fig. 19-4.

Illustrated specimens. A left valve, UMUT-CA 15916 (Pl.18, figs. 7,8; text-fig. 19-4. L, 0.49; H, 0.32), Loc. K1.

Remarks. The species is represented so far only by left valves. Left valve is quite similar to that of *Cytheropteron tsugaruense* n. sp. in lateral outline and ornamentation. However, anterior part of dorsal margin is strongly arched in this species. Further, ventral ridge forming the alae-like extension of ventrolateral surface is not so strongly developed as is observed in *C. tsugaruense*.

Occurrence. The present species occurs rarely; two left valves from Loc. K1 and one left valve from Loc. OT5.

Cytheropteron sp. 2

Pl. 18, figs 9, 10.

Illustrated specimen. A right valve, UMUT-CA 15917 (Pl. 18, figs. 9,10. L, 0.50; H, 0.26), Loc. N3.

Remarks. This species is close to *Cytheropteron rarum* Hanai, 1957 in its elongate subrhomboidal outline, but this sepcies is different from the latter in having thin and undulate vertical ridges and punctations over entire surface.

Occurrence. Only one specimen is found at Loc. N3.

Cytheropteron sp. 3

Pl. 17, figs. 11, 12.

Illustrated specimen. A right immature valve, UMUT-CA 15918 (Pl. 17, fig. 11. L, 0.44; H, 0.28), Loc. S1; a left immature valve, UMUT-CA 15919 (Pl. 17, fig. 12. L, 0.53; H, 0.34), Loc. OT3.

Remarks. This species is characterized by subtriangular lateral outline and densely distributed punctations over all surface. Adult form is so far unknown.

Occurrence. This species is found rarely at 11 localities as listed in table 1.

Genus *KANGARINA* Coryell and Fields, 1937

Kangarina yamaguchii n. sp.

Pl. 18, figs. 11－16; text-figs. 17-7, 8

Type. Holotype, a left valve, UMUT-CA 15920 (Pl. 18, figs. 12, 15. L, 0.39; H, 0.24), Loc. OT2.

Illustrated specimens. A right valve, UMUT-CA 15921 (Pl. 18, figs. 11, 14, 16; text-fig. 17-8. L, 0.40; H, 0.25), Loc. OT2; a left valve, UMUT-CA 15922 (Pl. 18, fig. 13; text-fig. 17-7. L, 0.38; H, 0.24), Loc. O3.

Diagnosis. Kangarina characterized by strong resupinate mid-rib with struts, well-developed nearly straight dorsal marginal ridge and irregular rows of small pits surrounding mid-rib.

Description. Valves subrhomboidal in lateral view, highest at about two-fifths of valve length. Anterior margin obliguely rounded. Dorsal margin nearly straight owing to straight dorsal ridge in right valve, and slightly arched because of arched dorsal ridge in left valve. Ventral contact margin sinuate at about anterior one-fifth of valve length, mostly hidden by well-developed ventrolateral ridge. Posterior margin protruding into a caudal process, just above mid-height, meeting with dorsal margin at a blunt obtuse angle and merging smoothly into ventral contact margin. Valves compressed laterally and subrhombic in dorsal view with greatest width at mid-length. Surface ornamented by strong ridges and faint reticulation. Prominent resupinate mid-rib running from posterodorsal corner toward anteroventral direction, turning to longitudinal direction in central area, and terminating in anterior marginal area. Dorsal marginal ridge strong, arising in anterior marginal area, running along anterior and dorsal margins, turning its direction ventrally near posterodorsal corner, and running downward to join with ventrolateral ridge near posteroventral corner. Ventrolateral ridge arising in anteroventral area, running posteriorly, culminating in greatest lateral extension at mid-length and terminating near posteroventral corner with distinct spine. Caudal process rather compressed laterally.

Normal pore openings small in number, scattered, consisting of simple type pores. Radial pore canals straight, moderate in number, densely spaced anteriorly.

Marginal infold moderately broad. Vestibule shallow anteriorly and posteriorly. Hinge Cytheropterinae type merodont. Muscle scar field in anterocentral area. Muscle scars consisting of one U-shaped frontal scar and a subvertical row of four adductor scars; median two scars are longitudinally elongate.

Dimensions. Measurements of pooled specimens from Loc. SW1, S2, S6, O2, O3, OT2, OT6 and SH4 are given below.

Sp	Me	N	$\bar{X}$	S	V	OR
L	L	9	0.373	1.33	3.57	0.35－0.39
	H	9	0.236	0.956	4.05	0.22－0.25
R	L	11	0.374	1.43	3.82	0.35－0.40
	H	11	0.240	1.48	6.17	0.22－0.26

Remarks. This species is very close to *Kangarina septentrionalis* Neale, 1972 from offshore of North Norway in general shape and general pattern of ornamentation, but in detail, Norwegian species has distinct three rows of reticules in posteroventral surface and arched dorsal ridge in right valve.

Occurrence. This species occurs rarely from 11 localities as listed in table 1.

Family PARACYTHERIDEIDAE Puri, 1957

Genus *PARACYTHERIDEA* G. W. Müller, 1894

Paracytheridea sp.

Pl. 19, fig. 1.

Illustrated specimen. A partly broken left immature valve, UMUT-CA 15923 (Pl. 19, fig. 1. L, 0.85; H, 0.40), Loc. OT3.

Remarks. This species is similar to *Paracytheridea bosoensis* Yajima, 1978 from the Pleistocene sediments of the Kisarazu area near Tokyo, but differs in having larger valve size and distinct projection at anterior terminal of alae-like ventrolateral expansion.

Occurrence. The present species occurs rarely from Loc. OT1, OT3, N1 and SH1.

Family LOXOCONCHIDAE Sars, 1925

Genus *LOXOCONCHA* Sars, 1866

Loxoconcha ozawai n. sp.

Pl. 18, figs. 17－22; text-fig. 19-5.

Type. Holotype, a right female valve, UMUT-CA 15924 (Pl. 18, figs. 17, 20, 22; text-fig. 19-5. L, 0.50; H, 0.30), Loc. OT5.

Illustrated specimen. A left male valve, UMUT-CA 15925 (Pl. 18, figs. 18, 19, 21. L, 0.51; H, 0.27), Loc. OT2.

Diagnosis. Loxoconcha characterized by subrhomboidal outline, finely reticulate anterior and posterior surfaces, coarsely reticulate dorsal and ventral surfaces, and alae-like ventrolateral projection.

Description. Valves subrhomboidal in lateral view, highest at anterior cardinal angle. Anterior margin broadly rounded, slightly extended below. Dorsal margin nearly straight with posterior terminal projection to accomodate posterior socket internally in left valve. Ventral margin slightly arched. Posterior margin broadly and obliquely rounded, meeting with dorsal margin at a blunt obtuse angle. Valves in dorsal view subelliptical with greatest width at about posterior one-third of valve length. Surface covered entirely by fine reticulation, but sparse in adductor muscle field. Reticule size variable, relatively large in dorsal and ventral areas and

rather small in anterior and posterior areas. Ventrolateral surface forming an alae-like projection. Ventral surface falttened. Ventrolateral ridge arising in area near anteroventral corner, fringing edge of alae-like ventrolateral projection and terminating near posteroventral corner. Subcentral tubercle obscure and eye tubercle distinct.

Normal pore openings sieve type, moderate in number, scattered. Radial pore canals straight, simple, sparsely distributed anteriorly and posteriorly.

Marginal infold moderately broad along free margin. Vestibule present along anterior and posterior margins, relatively deep along anteroventral margin. Hinge Loxoconchinae type gongylodont with a round anterior tooth surrounded by horse-shoe-shaped socket, a posterior horse-shoe-shaped fused denticle with large socket opening ventrally, and a finely crenulate median groove in right valve. Hinge of left valve complementary. Muscle scar field in subcentral tubercle. Muscle scars consisting of one U-shaped frontal scar and an oblique row of four adductor scars; median two are longitudinally elongate.

Sexual dimorphism distinct. Males more slender than females.

Dimensions. Measurements of pooled specimens from Loc. K1, OT2 and OT5 are as follows.

Sp	Me	N	O
L (M)	L	2	0.49−0.51
	H	2	0.26−0.27
R (F)	L	1	0.50
	H	1	0.30
R (M)	L	2	0.50−0.51
	H	2	0.26−0.27

Remarks. General shape and ornamentation of *Loxoconcha* sp. of Frydl (1982) from the Holocene deposits of the Boso Peninsula is close to those of this species. Elongate outline and alae-like ventrolateral projection of this species, however, easily differentiate this species from *Loxoconcha* sp. of Frydl (1982).

Occurrence. This species occurs rarely from 10 localities as listed in table 1.

Loxoconcha sp.

Pl. 19, figs. 2,3.

Illustrated specimens. A right immature valve, UMUT-CA 15926 (Pl. 19, fig. 2. L, 0.48; H, 0.30), Loc. OT3; a left immature valve, UMUT-CA 15927 (Pl. 19, fig. 3. L, 0.49; H, 0.31), Loc. OT5.

Remarks. Frydl (1982) illustrated a species of *Loxoconcha* from the Holocene of the Boso Peninsula characterized by punctuated surface quite similar to that of this species. Less converged lateral outline of this species, however, easily differentiates this species from the species from the Boso Peninsula.

Occurrence. This species occurs occasionally from 14 localities as listed in table 1.

Genus *NIPPONOCYTHERE* Ishizaki, 1971

Nipponocythere sp.

Pl. 19, figs. 4－7; text-fig. 19-6.

Illustrated specimens. A right female valve, UMUT-CA 15928 (Pl. 19, figs. 4,5; text-fig. 19-6. L, 0.46; H, 0.22), Loc. OT5; a right male valve, UMUT-CA 15929 (Pl. 19, figs. 6,7; L, 0.43; H, 0.19), Loc. OT2.

Description. Right valve elongate subpyriform in lateral view, highest at anterior cardinal angle. Anterior margin broadly and evenly rounded. Dorsal margin nearly straight. Ventral margin slightly arched. Posterior margin concave in its upper half meeting with dorsal margin at a blunt obtuse angle, protruding into a caudal process in its lower half, and grading into ventral margin. Valve width thin in dorsal view. Lateral surface ornamented by fine punctations in its anterior half and by reticulation in its posterior half. Very faint striations lying longitudinally in ventral surface. Anterior and ventral marginal areas laterally compressed.

Normal pore canals, simple type with lips, small in number, scattered. Radial pore canals about 8 along anterior margin and about 2 along posterior margin, simple, except for trifurcate one along posterior margin.

Marginal infold rather broad along free margin. Vestibule relatively deep anteriorly and narrow posteriorly. Hinge modified gongylont with a posterior element subdivided into 5-6 teeth. Median groove smooth in right valve. Muscle scar field in anterocentral area. Muscle scars consisting of one large heart-shaped frontal scar and an oblique row of four adductor scars; dorsomedian one is longitudinally elongate.

Sexual dimorphism present. Males more slender than females.

Remarks. This species is closely related to *Cytheropteron? nealei* Joy and Clark, 1977 from the central Arctic Sea in general shape and ornamentation. The species differs from *C.? nealei* in its larger valve size and less elongate lateral outline with a blunt caudal process. The present species also resembles *Nipponocythere hastata* Frydl, 1982, but is distinguishable from the latter in having a slender outline with more distinct caudal process and strongly compressed ventral marginal area.

Occurrence. This species occurs from two localities; two specimens from Loc. OT2 and four from Loc. OT5. Pooled specimens consist of two adult right valves and four immature forms.

Family XESTOLEEBERIDIDAE Sars, 1928

Genus *XESTOLEBERIS* Sars, 1866

Xestoleberis sp. 1

Pl. 19, figs. 14, 15; text-fig. 19-7.

Illustrated specimen. A right valve, UMUT-CA 15930 (Pl. 19, figs. 14, 15; text-fig. 19-7. L, 0.57; H, 0.30), Loc. OT1.

Description. Right valve subtriangular in lateral view, highest at about mid-length. Anterior margin narrowly rounded. Dorsal margin strongly arched. Ventral margin nearly straight. Posterior margin obliquely truncate in its upper half. Posterior end pointed, and narrowly rounded in its tip. Viewed dorsally, side smoothly arched, with greatest width at about posterior two-fifths of valve length. Surface smooth and expanding ventrolaterally to form flattened

ventral surface.

Normal pore openings, sieve type with central small pore, moderate in number, and scattered. Radial pore canals simple, short, about 7 along anterior margin. Marginal infold moderately broad along anterior and posterior margins. Vestibule relatively deep anteroventrally and narrow posteriorly. Hinge *Xestoleberis* type merodont. Muscle scar field in central to anterocentral area. Muscle scars consisting of one large round frontal scar and an oblique row of four adductor scars.

Remarks. This species is close to *Xestoleberis* sp. reported by Ishizaki (1983) from the Pliocene Ananai Formation, Kochi Prefecture, Shikoku, in general shape, but is distinguishable from the latter in its anteriorly situated greatest height.

Occurrence. This species occurs rarely from 8 localities as listed in table 1.

Xestoleberis sp. 2

Pl. 19, fig. 16.

Illustrated specimen. A left immature valve, UMUT-CA 15931 (Pl. 19, fig. 16. L, 0.36; H, 0.22), Loc. OT6.

Remarks. Less elongate and less pointed outline and lack of flattened ventral surface are the characters which discriminate this species from *X.* sp. 1. of this paper.

Occurrence. This species is rarely found at Loc. OT6 and SH3.

Xestoleberis sp. 3

Pl. 19, fig. 17.

Illustrated specimen. A left immature valve, UMUT-CA 15932 (Pl. 19, fig. 17. L, 0.39; H, 0.25), Loc. OT5.

Remarks. This species resembles *Xestoleberis dentata* Schornikov, 1975 from the intertidal zone in Shirahama, Kii Peninsula, Southwestern Honshu, in general outline, but the difference can be found in the more broadly rounded anterior margin and less distinct sinuation of ventral margin of the present species.

Occurrence. This species occurs occasionally from Loc. OT5 and N4.

Family PARADOXOSTOMATIDAE Brady and Norman, 1899

Genus *PARADOXOSTOMA* Fischer, 1855

Paradoxostoma sp. 1

Pl. 19, fig. 12.

Illustrated specimen. A right immature valve, UMUT-CA 15933 (Pl. 19, fig. 12. L, 0.52; H, 0.31), Loc. OT5.

Remarks. Specimens are poorly preserved, but are assignable to genus *Paradoxostoma* in general outline and hinge type.

Occurrence. This species occurs rarely from Loc. OT2, OT5, OT6 and N2.

Paradoxostoma sp. 2

Pl. 19, fig. 13.

Illustrated specimen. A right immature valve, UMUT-CA 15934 (Pl. 19, fig. 13. L, 0.56; H, 0.30), Loc. S3.

Remarks. This species is similar to *Paradoxostoma nigromaculatum* Schornikov, 1974 from the Kuril Islands in general outline, but poor preservation does not warrant proper specific identification.

Occurrence. Only one specimen from Loc. S3 is available for study.

Genus *SCLEROCHILUS* Sars, 1866

Sclerochilus sp. 1

Pl. 19, figs. 8, 9; text-fig. 19-8.

Illustrated specimen. A right valve, UMUT-CA 15935 (Pl. 19, figs. 8,9; text-fig. 19-8. L, 0.61; H, 0.29), Loc. OT6.

Description. Right valve elongate subpyriform in lateral view, highest at about posterior one-fourth of valve length. Anterior margin narrowly rounded. Dorsal margin gently arched. Ventral margin distinctly sinuate at about anterior one-third of valve length. Posterior margin broadly rounded. Viewed dorsally, valve smoothly curved and compressed.

Normal pore openings simple type, small in number and scattered. Radial pore canals polyfurcate, relatively dense along anteroventral margin.

Marginal infold rather broad along free margin. Vestibule deep along anteroventral and posteroventral margins. Hinge Paradoxostomatinae type lophodont. Muscle scar field in subcentral area. Muscle scars consisting of an oblique row of five adductor scars.

Remarks. This species resembles *Sclerochilus* sp. reported by Ishizaki (1981) from the East China Sea in general outline, but differs from the latter in having less elongate outline with round posterior margin.

Occurrence. This species occurs rarely from Loc. T1, O1, OT2, OT5 and OT6.

Sclerochilus sp. 2

Pl. 19, figs. 10, 11.

Illustrated specimens. A right valve, UMUT-CA 15936 (Pl. 19, figs. 10,11. L, 0.78; H, 0.40), Loc. T1.

Remarks. Inner features, especially muscle scar pattern of the specimens are not well observable due to poor preservation of inner surface. This species is different from *Sclerochilus* sp. 1 in subtle change of curvature in its lateral outline, especially along dorsal and posteroventral margins as well as in its larger valve size.

Occurrence. This species occurs rarely from Loc. K1 and OT6.

Text-fig. 16. Internal views.

Figs. 1,2. *Pectocythere daishakaensis* n. sp.

1. a left female valve (holotype, UMUT-CA 15749, Loc. TA1). ×128.
2. a right male valve (UMUT-CA 15752, Loc. SH1). ×128.

Figs. 3,4. *Finmarchinella rectangulata* n. sp.

3. a left female valve (UMUT-CA 15832, Loc. O4). ×116.
4. a right female valve (UMUT-CA 15828, Loc. N2). ×122.

Figs. 5,6. *Finmarchinella daishakaensis* n. sp.

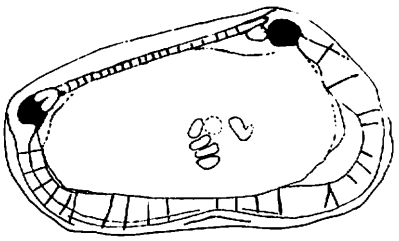
5. a left female valve (UMUT-CA 15841, Loc. SH3). ×103.
6. a right female valve (UMUT-CA 15839, Loc. SH4). ×104.

Figs. 7,8. *Buntonia hayamii* n. sp.

7. a left male valve (UMUT-CA 15867, Loc. SH2). ×104.
8. a right female valve (holotype, UMUT-CA 15864, Loc. O1). ×108.

Figs. 9,10. *Robertsonites hanaii* n. sp.

9. a left female valve (UMUT-CA 15870, Loc. K1). ×66.
10. a right female valve (holotype, UMUT-CA 15869, Loc. K1). ×65.



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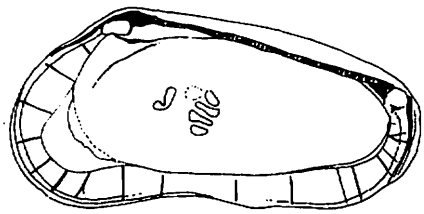

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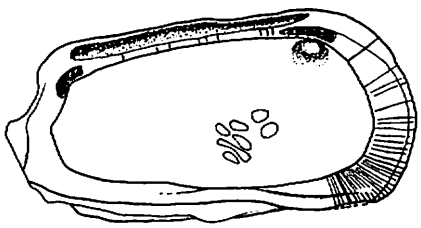

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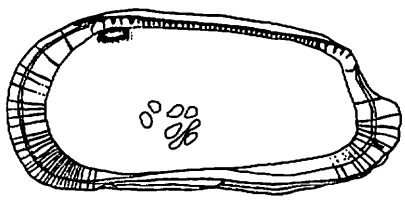

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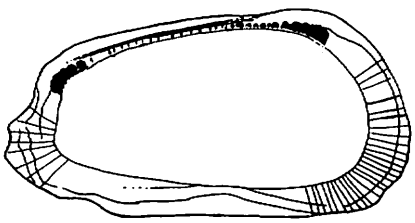

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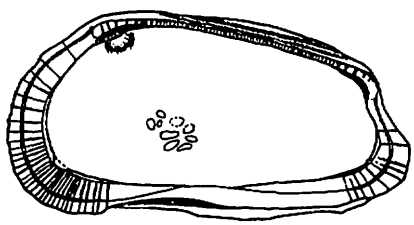

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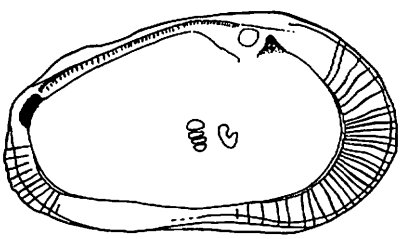

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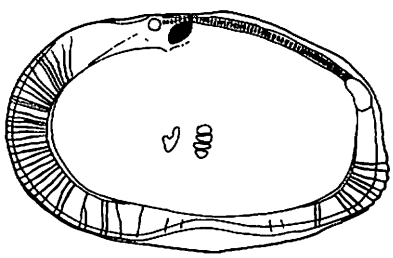

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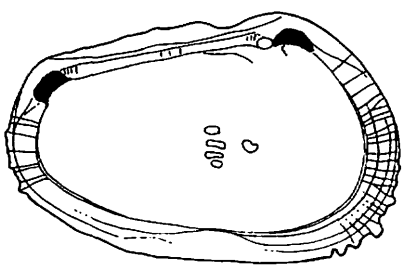

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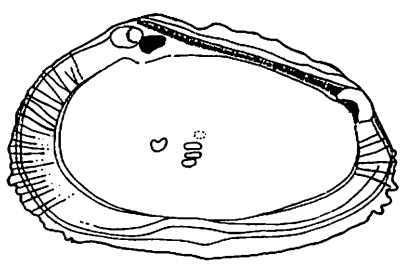

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Text-fig. 17. Internal views.

Figs. 1,2. *Robertsonites reticuliforma* (Ishizaki, 1966)

1. a left female valve (UMUT-CA 15880, Loc. O2). ×80.
2. a right female valve (UMUT-CA 15878, Loc. O2). ×83.

Figs. 3,4. *Cytheropteron yajimai* n. sp.

3. a left valve (UMUT-CA 15913, Loc OT2). ×118.
4. a right valve (holotype, UMUT-CA 15912, Loc. N3). ×116.

Figs. 5,6. *Cytheropteron tsugaruense* n. sp.

5. a left valve (holotype, UMUT-CA 15914, Loc. O4). ×146.
6. a right valve (UMUT-CA 15915, Loc. OT5). ×133.

Figs. 7,8. *Kangarina yamaguchii* n. sp.

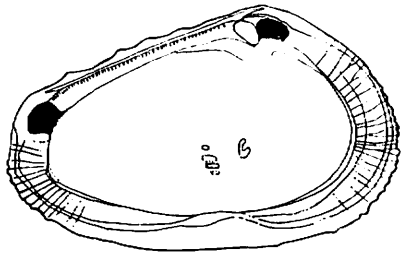
7. a left valve (UMUT-CA 15922, Loc. O3). ×184.
8. a right valve (UMUT-CA 15921, Loc. OT2). ×183.

Fig. 9. *Pontocythere* sp.

a left valve (UMUT-CA 15745, Loc. T1). ×110.

Fig. 10. *Eucythere* sp. 1

a left valve (UMUT-CA 15747, Loc. OT6). ×120.



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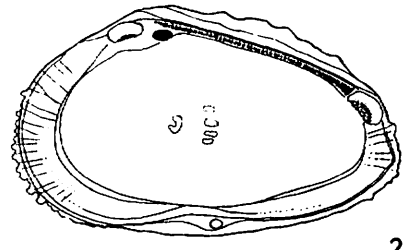

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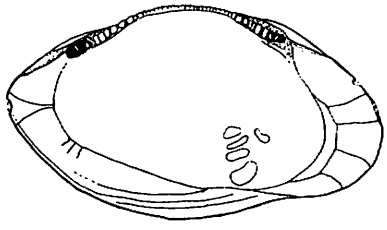

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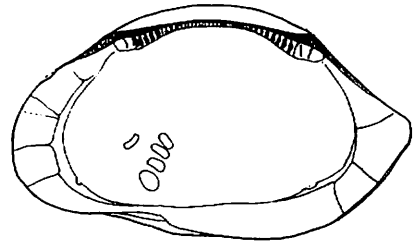

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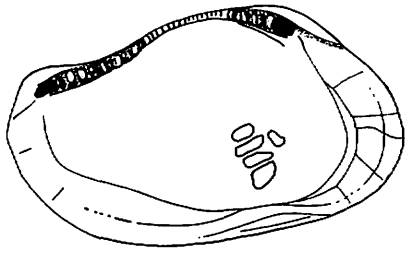

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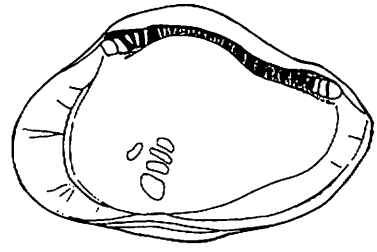

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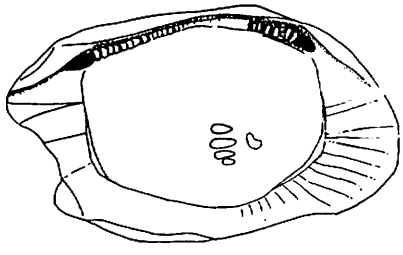

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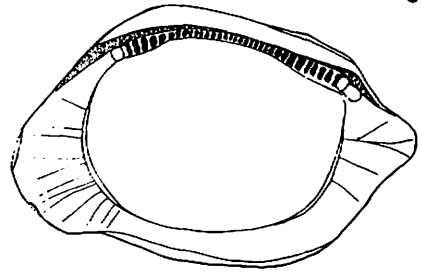

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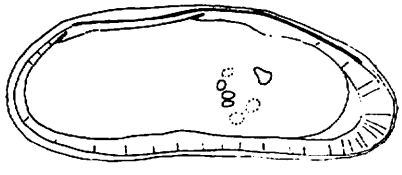

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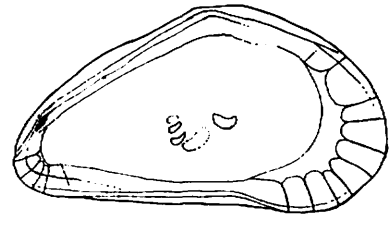

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Text-fig. 18. Internal views.

fig. 1. *Eucythere* sp. 2
a right valve (UMUT-CA 15748, Loc. O4). ×103.

Fig. 2. *Callistocythere* sp.
a right valve (UMUT-CA 15757, Loc. OT3). ×179.

Fig. 3. *Cluthia japonica* n. sp.
a left male valve (UMUT-CA 15762, Loc. OT2). ×189.

Fig. 4. *Paijenborchella tsurugasakensis* n. sp.
a left female valve (holotype, UMUT-CA 15764, Loc. O5). ×126.

Fig. 5. *Paijenborchella hanaii* n. sp.
a right male valve (UMUT-CA 15770, Loc. SH2). ×101.

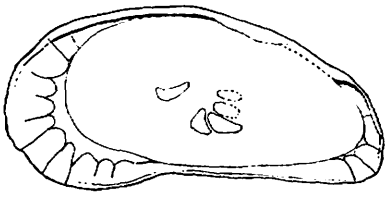
Fig. 6. *Urocythereis? abei* n. sp.
a right female valve (UMUT-CA 15795, Loc. T1). ×70.

Fig. 7. *Urocythereis? posterocostata* n. sp.
a right valve (UMUT-CA 15805. Loc. T1). ×61.

Fig. 8. *Ambostracon kitanipponica* n. sp.
a left male valve (UMUT-CA 15815, Loc. S7). ×91.

Fig. 9. *Finmarchinella?* sp.
a right valve (UMUT-CA 15848, Loc. OT2). ×156.

Fig. 10. *Cornucoquimba alata* n. sp.
a right male valve (holotype, UMUT-CA 15851, Loc. SW1). ×69.



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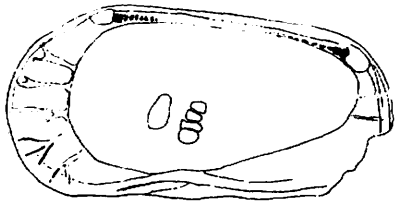

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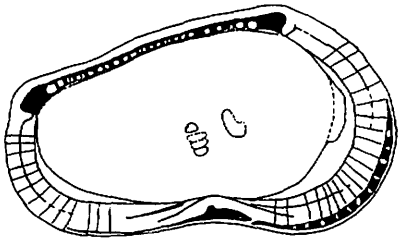

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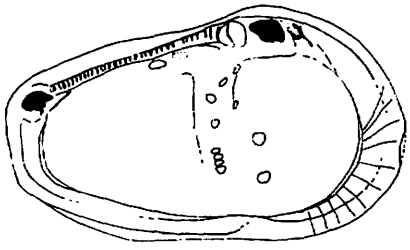

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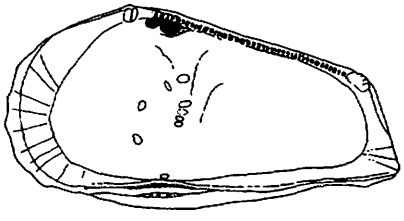

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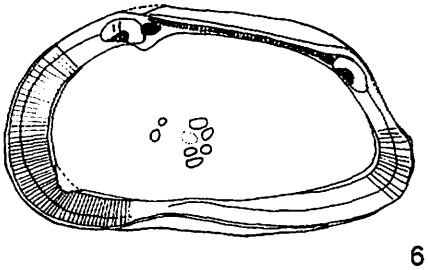

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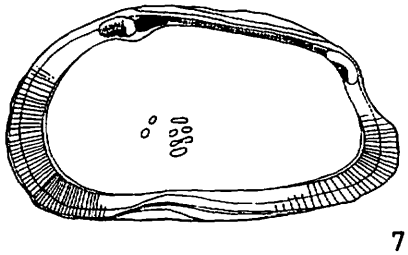

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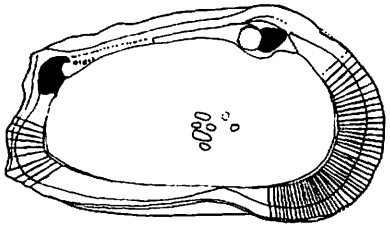

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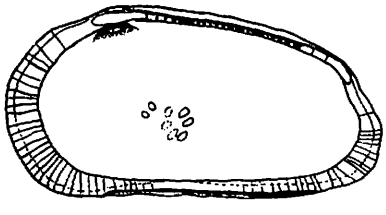

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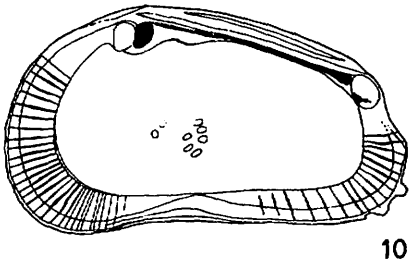

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Text-fig. 19. Internal views.

Fig. 1. *Murrayina japonica* n. sp.
a right valve (holotype, UMUT-CA 15860, Loc. SW2). ×68.

Fig. 2. *Semicytherura* sp. 1
a right valve (UMUT-CA 15902, Loc. OT2). ×200.

Fig. 3. *Semicytherura? daishakaensis* n. sp.
a left valve (UMUT-CA 15910, Loc. SH3). ×137.

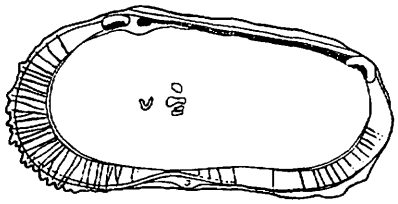
Fig. 4. *Cytheropteron* sp. 1
a left valve (UMUT-CA 15916, Loc. K1). ×143.

Fig. 5. *Loxoconcha ozawai* n. sp.
a right valve (UMUT-CA 15924, Loc. OT5). ×136.

Fig. 6. *Nipponocythere* sp.
a right valve (UMUT-CA 15928, Loc. OT5). ×152.

Fig. 7. *Xestoleberis* sp. 1
a right valve (UMUT-CA 15930, Loc. OT1). ×123.

Fig. 8. *Sclerochilus* sp. 1
a right valve (UMUT-CA 15935, Loc. OT6). ×108.



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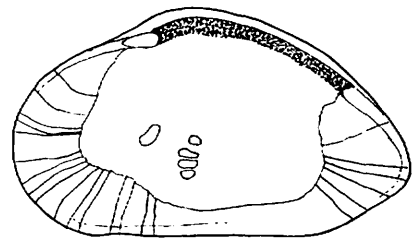

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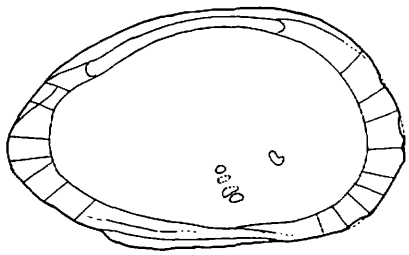

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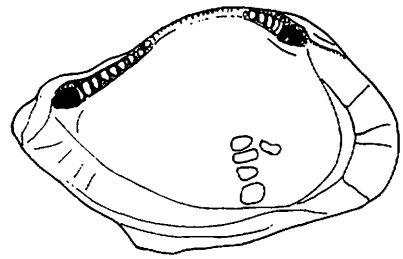

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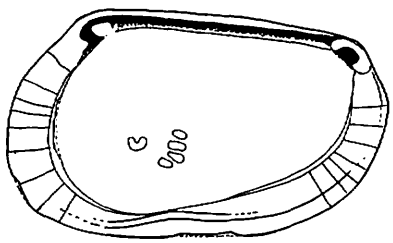

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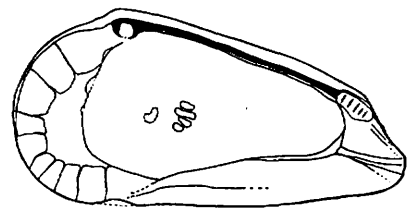

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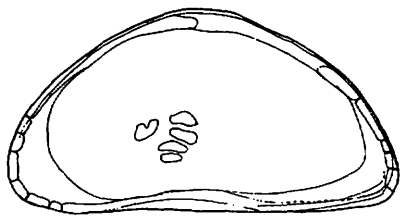

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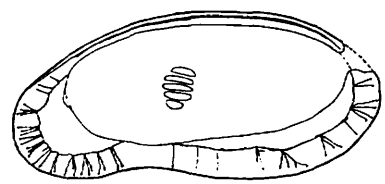

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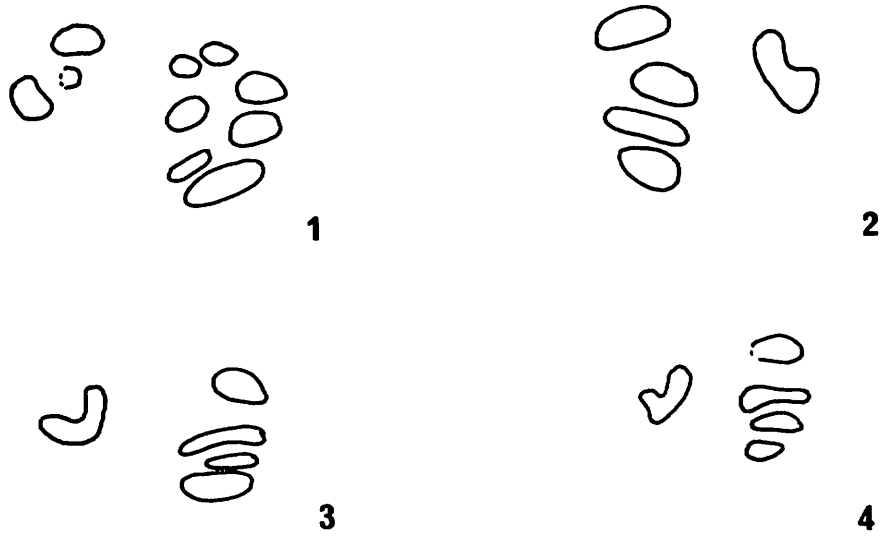

Text-fig. 20. Muscle scar patterns

Fig. 1. *Patagonacythere robusta* n. sp.

a right male valve (UMUT-CA 15820, Loc. OT1). ×260.

Fig. 2. *Acanthocythereis tsurugasakensis* n. sp.

a left male valve (UMUT-CA 15857, Loc. S5). ×270.

Fig. 3. *Celtia* sp.

a right valve (UMUT-CA 25862, Loc. T1). ×210.

Fig. 4. *Robertsonites* sp. 1

a right valve (UMUT-CA 15896, Loc. O5). ×200.

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References cited

Bassiouni, M. A. A. 1965. Über einige Ostarcoden aus dem Interglazial von Esbjerg. *Medd. fra Dansk Geol. Forening*, v. 15, no. 4, p. 507－518, 2 pl.

Brouwers, E. M. 1980. Ostracodes from 1977 Offshore Boreholes in the Beaufort Sea. Environmental Assesment of the Alaskan Continental Shelf. Annual Reports of Principal Investigators for the year ending March 1980. v. 14, p. 221－229, 4 tex-fig.

_____. 1982a. Analysis of Inner Neritic Ostracode Assemblages from the Beaufort Sea, Northern Alaska : Implications for interpreting Analogous Ouaternary Sediments [abs.] . Eleventh Annual Arctic Workshop. Institute of Arctic and Alpine Research, Boulder, University of Colorado. p. 5－7.

_____. 1982b. Reevaluation of Cytheracean Ostarcode Species Identified by Painter (1965) from Localities in the Northeastern Pacific Ocean and Chukchi Sea. *U. S. geol. Surv., Open-File Report* 82－736, 35 p. 4 text-fig.

_____. 1983. Occurrence and Distribution Chart of Ostracodes from the Northeastern Gulf of Alaska. *U. S. geol. Surv., Miscellaneous Field Studies, Map MF*-1518, 2 sheets and pamphlet.

Carbonnel, G. 1969. Variations Phenotypiques chez Une Espece Tortonienne du Genre *Elofsonella* Pokorny. *In* J. W. Neale [ed.] The taxonomy, morphology and ecology of Recent Ostracoda. p. 85－92, 1 pl., 1 text-fig., Edinburgh, Oliver Boyd.

_____. and R. Ballesio. 1982. Les Ostracodes Pliocenes du Sud-Est de la France. *Doc. Lab. Geol. Lyon*, no. 85, p. 1－113, 6 pl., 11 text-fig.

Cronin, T. M. 1981. Paleoclimatic implications of Late Pleistocene marine ostracodes from the St. Lawrence Lowlands. *Micropaleontology*, v. 27, no. 4, p. 384－418, 11 pl., 3 text-fig.

Diebel, K. and E. Pietrzeniuk. 1971. Holozäne Ostracoden der Doggerbank, Nordsee. *In* H. J. Oertli [ed.] Paleoecologie des Ostracodes, Pau, 1970. *Bull. Centre Rech. Pau-SNPA*, v. 5, supl., p. 377－390, 3 text-fig.

Elofson, O. 1941. Zur Kenntnis der marinen Ostracoden Schwedens, mit besonderer Berucksichtigung des Skageraks. *Zool. Bidr. Uppsala*, v. 19, p. 215－534, 52 text-fig., 42 maps..

Forester, R. M. 1980. A Systematic Revision of the Ostracode Species Described by Ulrich and Bassler and by Mulkin from the Chesapeake Group in Maryland and Virginia. *U. S. geol. Surv., Prof. Paper* 1128, 25 p., 7 pl.

Frydl, P. M. 1982. Holocene ostracods in the southern Boso Peninsula. *In* T. Hanai [ed.] Studies on Japanese Ostracoda, *Univ. Mus., Univ. Tokyo, Bull.* no. 20, p. 61－140, pl. 8,9.

Hanai, T. 1957a. Studies on the Ostracoda from Japan, I. Subfamily Leptocytherinae, n. subfam. *J. Fac. Sci. Univ. Tokyo*, sec 2, v. 10, pt. 3, p. 431－468, pl. 7－10, 2 text-fig.

_____. 1957b. Studies on the Ostracoda from Japan, II. Subfamily Pectocytherinae n. subfam. ibid., sec 2, v. 10, pt. 3, p. 469－482, pl. 11, 6 text-fig.

_____. 1957c. Studies on the Ostracoda from Japan, III. Subfamilies Cytherurinae G. W. Müller (emend. G. O. Sars, 1925) and Cytheropterinae n. subfam. ibid., sec. 2, v. 11, pt. 1, p. 11－36, pl. 2－4, 9 text-fig.

_____. 1959a. Studies on the Ostracoda from Japan, IV. Family Cytherideidae Sars, 1925. ibid., sec. 2, v. 11, pt. 3, p. 291－308, pl. 16－18, 4 text-fig.

_____. 1959b. Studies on the Ostracoda from Japan, V. Subfamily Cytherinae Dana, 1852 (emend.). ibid., sec. 2, v. 11, pt. 4, p. 409－418, pl. 28, 1 text-fig.

_____. 1970. Studies on the ostracod subfamily Schizocytherinae Mandelstam. *J. Paleontol.*, v. 44, no. 4, p. 693－729, pl. 107, 108, 19 text-fig., 5 tables.

_____, N. Ikeya, K. Ishizaki, Y. Sekiguchi and M. Yajima. 1977. Checklist of Ostracoda from Japan and its

adjacent seas. *Univ. Mus., Univ. Tokyo, Bull.*, no. 12, 120 p., 4 pl., 2 text-fig.

Hazel, J. E. 1967. Classification and distribution of the Recent Hemicytheridae and Trachyleberididae (Ostracoda) off northeastern North America. *U. S. geol. Surv., Prof. Paper* 564, 49 p., 11 pl., 2 text-fig.

_____. 1968. Pleistocene ostracode zoogeography in Atlantic Coast submarine canyons. *J. Paleontol.*, v. 42, no. 5, p. 1264－1271, 3 text-fig.

_____. 1970. Atlantic continental shelf and slope of the United States, ostracode zoogeography in the southern Nova Scotian and northern Virginian faunal Provinces. *U. S. geol. Surv., Prof. Paper* 529-E, p. i-v, E1-E21, 69 pl., 11 fig., 3 tables.

Hopkins, D. M., K. McDougall and E. M. Brouwers. 1980. Microfossil Studies of Pelukian and Flaxman Deposits, Alaskan Coast of the Beaufort Sea. Environmental Assesment of the Alaskan Continental Shelf. Annual Reports of Principal Investigators for the year ending March 1980. v. 14, p. 230－239, 1 text-fig.

Horne, D. J. 1983. on *Robertsonites tuberculatus* (Sars). *Stereo-atlas of Ostracod shells*. v. 10, pt. 8, p. 39－52.

Ishizaki, k. 1966. Miocene and Pliocene ostracodes from the Sendai area, Japan. *Tohoku Univ., Sci. Rep.*, 2nd ser. (Geo l.), v. 37, no. 2, p. 131－163, pl. 16－19, 1 text-fig.

_____. 1969. Ostracodes from Shinjiko and Nakanoumi, Shimane Prefecture, western Honshu, Japan. ibid., v. 41, no. 2, p. 197－224, pl. 24－26, 16 text-fig.

_____. 1971. Ostracodes from Aomori Bay, Aomori Prefecture, northeast Honshu, Japan. ibid., v. 43, no. 1, p. 59－97, pl. 1－7, 8 text-fig.

_____. 1981. Ostracoda from the East China Sea. ibid., v. 51, nos. 1,2, p. 37－65, pl. 8－15, 1 text-fig.

_____. 1983. Ostracoda from the Pliocene Ananai Formation, Shikoku, Japan. *Trans. Proc. palaeontol. Soc. Japan*, n. s., no. 131, p. 135－158, pl. 28－35, 1 text-fig.

Iwai, T. 1962. The Pliocene deposits and molluscan fossils from the northeast margin of the Tsugaru Basin, Aomori Prefecture, Japan. *Saito Ho-on Kai Mus. Res. Bull.*, no. 31, p. 35－46.

_____. 1965. The geological and paleontological studies in the marginal area of the Tsugaru Basin, Aomori Prefecture, Japan. *Bull. Educ. Fac., Hirosaki Univ.*, no. 15, p. 1－68, pl. 12－20.

Joy, J. A. and D. L. Clark. 1977. The distribution, ecology and systematics of the benthic Ostracoda of the central Arctic Ocean. *Micropaleontology*, v. 23, no. 2, p. 129－154, pl. 1－3.

Kataoka, J. 1957. Bryozoa from the Daishaka Formation (Pliocene), Minami-Tsugaru-Gun, Aomori Prefecture. *Trans. Proc. palaeontol. Soc. Japan*, n. s., no. 28, p. 143－153, pl. 22.

Koto, J. 1957. Brachiopoda from the Daishaka and Tsurugasaka fossil zones, Minami-Tsugaru-Gun, Aomori Prefecture. ibid., n. s., no. 25, p. 7－10.

Neale, J. W. 1972. *Kangarina septentrionalis* and *Paracytheridea norvegica* n. spp. from Offshore North Norway. *Astarte*, v. 5, nos. 1,2, p. 33－37, pl. 1.

_____. 1973a. *Cluthia* (Crustacea, Ostracoda) a new Pleistocene and Recent leptocytherid genus. *J. Paleontol.*, v. 47, no. 4, p. 683－688, 1 pl., 2 text-fig.

_____. 1973b. *Celtia* gen. nov., a new genus of marine Ostracoda (Crustacea) from the Celtic province and Neogene deposits. *Rev. Espanola. Micropaleontol.*, v. 5, no. 3, p. 435－445, 1 pl., 3 text-fig.

_____. 1974a. The genus *Finmarchinella* Swain 1963 (Crustacea : Ostracoda) and its species. *Bull. Br. Mus. nat. Hist.* (*Zool.*), v. 27, no. 2, p. 83－93, pl. 1,2, 2 text-fig.

_____. 1974b. Ostracod faunas from the Celtic Sea. *Geoscience and man*, v. 6, p. 81－98, 10 text-fig., 3 tables.

_____ and R. A. M. Schmidt. 1967. On *Normanicythere leioderma* (Norman) and *Normanicythere concinella* Swain. *Micropaleontology*, v. 13, no. 3, p. 345－350, 6 text-fig.

_____. and H. V. Howe. 1975. The marine Ostracoda of Russian Harbour, Novaya Zemlya and other high latitude faunas. In F. M. Swain [ed.] Biology and paleobiology of Ostracoda. *Bull. Am. Paleontol.*, v. 65, no. 282, p. 381－431, 7 pl., 10 text-fig.

Nomura, S and K. Hatai. 1935. Pliocene Mollusca from the Daishaka shell-beds in the vicinity of Daishaka, Aomori-ken, Northeast Honshu, Japan. *Saito Ho-on Kai Mus., Res. Bull.*, no. 6, p. 83－142, pl. 9－13.

Okada, Y. 1979. Stratigraphy and Ostracoda from the Late Cenozoic strata of the Oga Peninsula, Akita Prefecture. *Trans. Proc. palaeontol. Soc. Japan*, n. s., no. 115, p. 143－173, pl. 21－23.

Otuka, Y. 1939. Mollusca from the Cainozoic System of eastern Aomori Prefecture, Japan. *J. geol. Soc. Japan*, v. 46, no. 545, p. 23－31, pl. 2.

Puri, H. S., G. Bonaduce and J. Malloy. 1965 [1964]. Ecology of the Gulf of Naples. *Publ. Stn. Zool. Napoli*, v. 33, supl., p. 87－199, 67 text-fig.

Robinson, J. E. 1978. The Pleistocene. In R. H. Bate and J. E. Robinson [ed.] A stratigraphical index of British Ostracoda. *Geol. J., Spec. Iss.*, 8, p. 451－472, 6 pl.

Rosenfeld, A. 1977. Die rezenten Ostracoden-Arten in der Ostsee. *Meyniana* 29, p. 11－49, 10 pl., 45 text-fig., 1 table.

Schornikov, E. I. 1974. On the study of Ostracoda (Crustacea) from the intertidal zone of the Kuril Islands. *Trans. Acad. Sci. USSR, Far East Sci. Center, Inst. Mar. Biol.*, no. 1, p. 137－214, pl. 1－4, 43 text-fig. (In Russian).

_____. 1975. Ostracod fauna of the intertidal zone in the vicinity of the Seto Marine Biological Laboratory. *Publ. Seto Mar. biol. Lab.*, v. 22, no. 1, p. 1－30, 15 text-fig.

Siddiqui, Q. A and U. M. Grigg. 1975. A preliminary survey of the ostracodes of Halifax Inlet. *In* F. M. Swain [ed.] Biology and paleobiology of Ostracoda. *Bull. Am. Paleontol.*, v. 65, no. 282, p. 369－379, 2 pl., 2 text-fig.

Swain, F. M. 1963. Pleistocene Ostracoda from the Gubik Formation, Arctic coastal plain, Alaska. *J. Paleontol.*, v. 37, no. 4, p. 798－834, 5 pl., 13 text-fig.

_____ and J. M. Gilby. 1974. Marine Holocene Ostracoda from the Pacific coast of North and Central America. *Micropaleontology*, v. 20, no. 3, p. 257－352, pl. 1－7.

_____ and J. C. Kraft. 1975. Biofacies and microstructure of Holocene Ostracoda from tidal bays of Delaware. *In* F. M. Swain [ed.] Biology and paleobiology of Ostracoda. *Bull. Am. Paleontol.*, v. 65, no. 282, p. 601－622, 5 pl., 2 text-fig.

Tabuki, R. 1983. Paleoenvironment of the Plio-Pleistocene Daishaka Formation, Tsugaru Basin, Northeast Japan. *Trans. Proc. palaeontol. Soc. Japan*, n. s., no. 130, p. 61－78, 5 text-fig.

Valentine, P. C. 1976. Zoogeography of Holocene Ostracoda off western North America and paleoclimatic implications. *U. S. geol. Surv., Prof. Paper* 916, 47 p., 14 pl., 19 text-fig.

Yajima, M. 1978. Quaternary Ostracoda from Kisarazu near Tokyo. *Trans. Proc. palaeontol. Soc. Japan*, n. s., no. 112, p. 371－409, pl. 49, 50.

_____. 1982. Late Pleistocene Ostracoda from the Boso Peninsula, Central Japan. *In* T. Hanai [ed.] Studies on Japanese Ostracoda. *Univ. Mus., Univ. Tokyo, Bull.*, no. 20, p. 141－227, pl. 10－15.