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Recent Ostracoda from the northeastern part of Osaka Bay, southwestern Japan

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Abstract

Ostracodes from Osaka Bay, southwestern Japan, were quantitatively studied in order to examine the relationships between environmental factors and species distribution. At least 109 species belonging to 43 genera were identified from 31 surface sediment samples. On the basis of Q-mode cluster analysis, four biotopes (A, B, C and D) are recognized. Characteristic species of each biotope are as follows: A (central bay at 17.2-37.2 m water depth), *Trachyleberis scabrocuneata, Cytheropteron miurense, Kobayashiina donghaiensis, Schizocythere kishinouyei and Krithe japonica*; B (inner part of the bay at 16.3-21.1 m water depth), *Bicornucythere bisanensis* (form A), *Bicornucythere bisanensis* (form M), *Cytheromorpha acupunctata, Loxoconcha viva* and *Nipponocythere bicarinata*; C (innermost part of the bay at 9.2-15.9 m water depth), B. *bisanensis* (form A), *Loxoconcha tosaensis* and *Spinileberis quadriaculeata*; D (inner part of the bay at 12.6 m water depth), *C. acupunctata*. These results suggest that species distribution is controlled by bathymetry. High abundance and high species diversities are found in the westernmost area. In contrast, low abundance and low species diversities are observed in the eastern area, where water masses with low dissolved oxygen content spread, especially in the summer. It is shown that the tidal current and the dissolved oxygen contents strongly influence abundance and species diversity of ostracodes in Osaka Bay.

Key words : Ostracoda, Osaka Bay, Japan, bathymetry, dissolved oxygen.

Introduction

Osaka Bay, located at the east end of the Seto Inland Sea, is of particular interest from the viewpoint of the ostracode fauna because of various environmental factors such as dissolved oxygen and residual currents which control bottom sediment. Ostracodes are known to be distributed in close association with various environmental factors such as substrates, water temperature, and water depth. In Japan, there have been many faunal studies of Recent ostracodes at various sites (Ishizaki, 1968, Uranouchi Bay; Ishizaki, 1969, Shinjiko and Nakanoumi; Ishizaki, 1971, Aomori Bay; Ikeya and Hanai, 1982, Lake Hamana; Frydl, 1982, Tateyama Bay; Bodergat and Ikeya, 1988, Ise and Mikawa Bays; Tabuki and Nohara, 1988, Off Sesoko Island; Ishizaki and Irizuki, 1990, Toyama Bay; Ikeya and Itoh, 1991, Sendai Bay; Ikeya and Suzuki, 1992, Off Shimane Peninsula; Ikeya et al., 1992, Otsuchi Bay; Zhou, 1995, Off southwest Japan; Yamane, 1998, Hiuchi-nada Bay; Tanaka et al., 1998, Miho Bay to Lake Shinji; Itoh, 1998, Lake Hamana). However, there has been no study of ostracodes from Osaka Bay.

Therefore, the aim of this study is to investigate the distribution of Recent ostracodes in the northeastern part of Osaka Bay and to discuss the relationship between the distribution of Recent ostracodes and environmental factors.

General features and environmental factors of Osaka Bay

Osaka Bay is located at the east end of the Seto Inland Sea (Fig. 1). The bay is elliptic in shape, with a longer axis of about 60 km and a shorter axis of

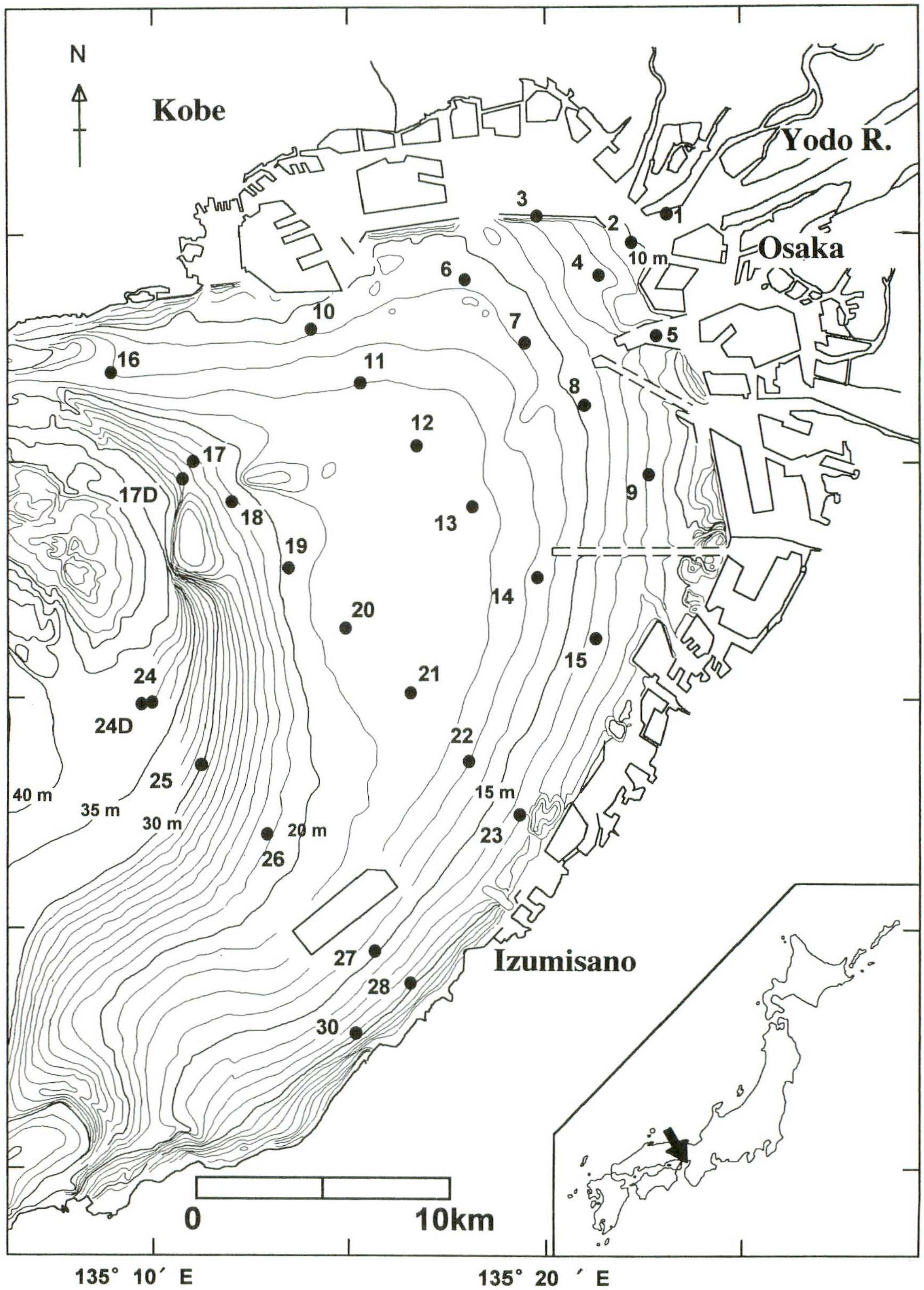

Fig. 1 Index map showing location of Osaka Bay and bathymetrical map of Osaka Bay showing location of the ostracode samples used in this study. Detailed data on stations are shown in Table 1.

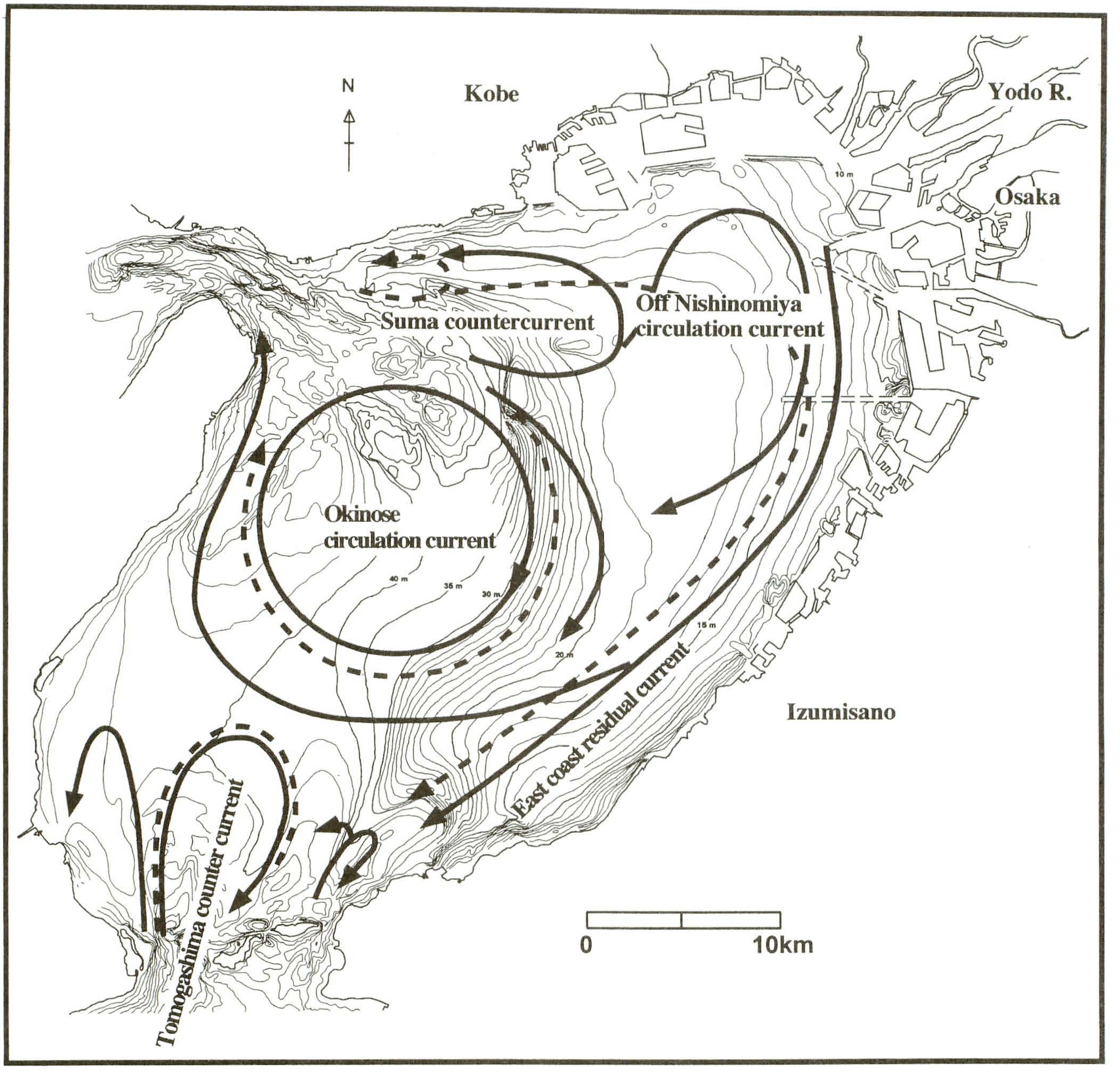

Fig. 2 Direction of residual currents (modified after Fujiwara et al., 1989).

about 32 km. The Akashi and Tomogashima Straits connect it with Harima-nada Bay and the open ocean, respectively. The area of the bay is 1530 km^2, and the mean water depth is about 20 m in the central basin or more than 50 m around the straits. There are two large rivers which flow into the bay, the Yodo River and Yamato River. Various industrial and domestic wastewaters have been emptied into the bay, mainly via these rivers.

In Osaka Bay, there are two large residual currents: the Okinose circulation current and East Coast residual current (Fig. 2). The former is a large clockwise current and controls the properties of the water and bottom sediment. The latter is a large current along the east coast of Osaka Bay.

The distribution of dissolved oxygen in the bottom water of Osaka Bay is shown in figure 3. Oxygen-deficient water in Osaka Bay is formed in a shallow region (<20 m in water depth) on the eastern side of the bay from May to September (Joh, 1989). The salinity is lower toward the inner part of the bay (Osaka Prefectural Fisheries Experimental Station, 1996 to 2000). The water temperature is higher in summer and lower in winter toward the inner part of

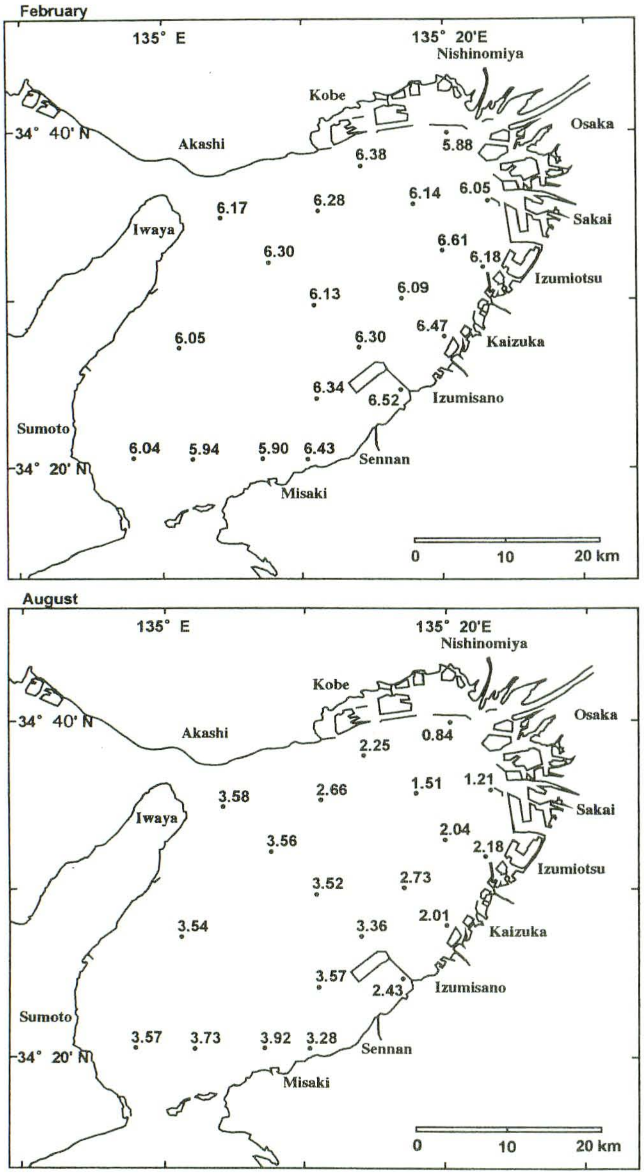

Fig. 3 Distribution of dissolved oxygen (ml/l) in the bottom water of Osaka Bay (the average observation from 1994 to 1998) (modified after Osaka Prefectural Fisheries Experimental Station, 1996 to 2000).

the bay (Osaka Prefectural Fisheries Experimental Station, 1996 to 2000).

The distribution of median grain size of the bottom sediment of Osaka Bay is shown in figure 4. The median grain size of the bottom sediment is smaller in the inner part of the bay and larger toward the straits. The sedimentation rate is higher around the central part of the bay and lower toward the inner part of the bay (Hoshika et al., 1994).

Samples and methods

The total of 31 samples used in this study was collected by the Marine Ecological Institute Co. in 26, 28 and 29 May 1999, using the Ekman-Birge Grab and Smith-McIntyre Grab samplers (Fig. 1; Table 1). Only the uppermost 1 cm of the sediment was used for this study. These sediment samples were fixed immediately with about 99% ethanol. In the laboratory, 100 cc of the sediment was washed with water through a 200 mesh sieve (75μm) and then dried. Samples containing abundant ostracode specimens were divided by a sample splitter into workable aliquot parts, of about 200 specimens. The ostracode individual number refers to the sum of larger numbers of the valves (left or right), picked from a fraction coarser than 125μm (115 mesh). In this study the living specimens of ostracodes were discriminated as carapaces with soft parts intact.

Ostracode assemblages

At least 110 species belonging to 44 genera were identified from 31 samples (Table 2). Seven species were found to include living specimens. As the number of living specimens found in these samples was small, the result of this study is based on the total number of living and dead specimens.

1. Abundance

The number of individuals per 100 cc of wet sediments was calculated to give the density distribution of ostracodes (Fig. 5 and Table 3). In general, the density is lower toward the inner part of the bay. The areas showing especially high density, i.e., more than 1000 individuals, are concentrated in the middle part of the bay at a depth more than 20 m. The areas showing especially low density, i.e., less than 50 individuals, are distributed near the mouth of the Yodo River.

2. Diversity

The total number of species per station ranges from 1 to 58. The Shannon-Weaver function was used to obtain the diversity distribution of the ostracode assemblages. Samples containing more than 50 individuals were used in this function. The distribution of the diversity indices is shown in figure 6 and table 3. The distribution of diversity indices correlates with the abundance of ostracodes. In gen-

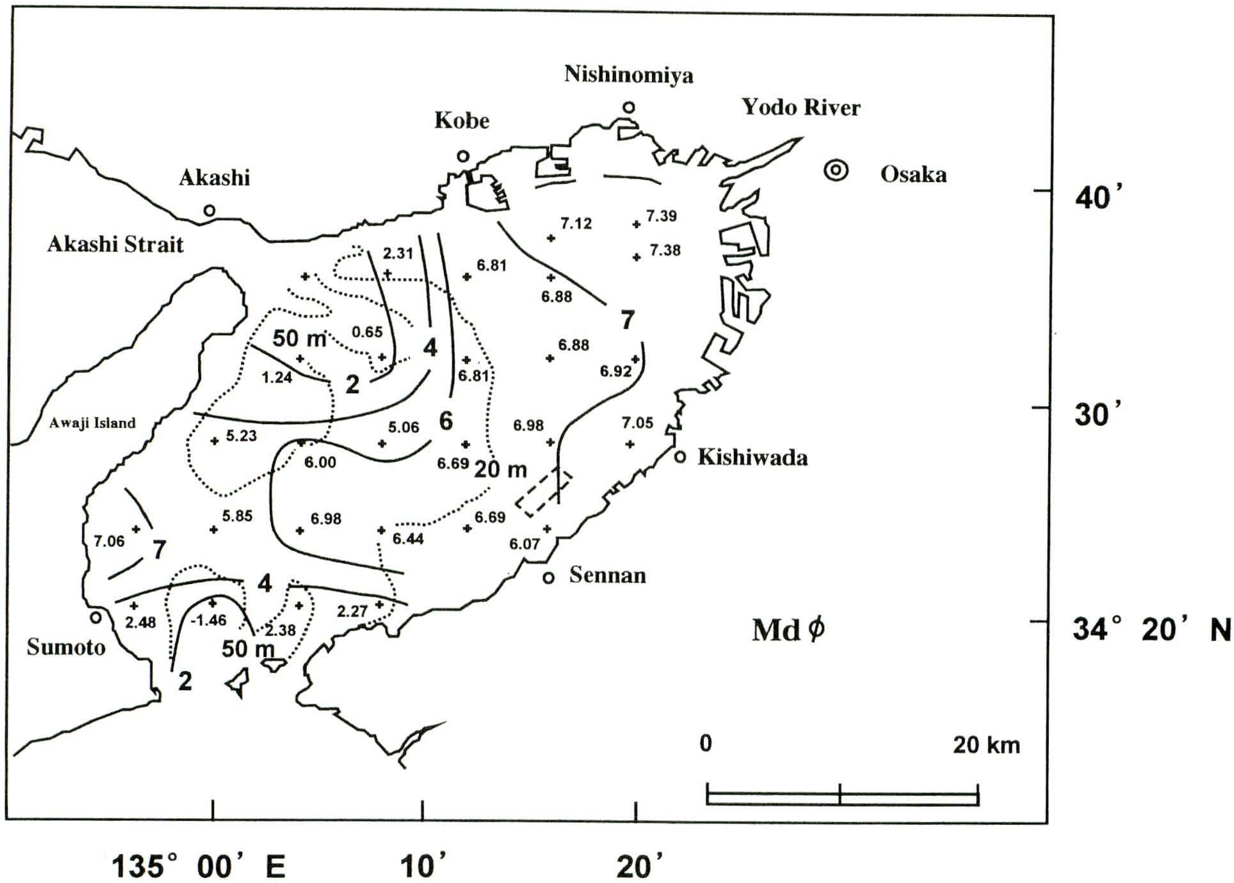

Fig. 4 Distribution of grain size (Mdϕ) of bottom sediment in Osaka Bay (modified after Hoshika et al., 1994).

eral, the diversity is lower toward the inner part of the bay. Stations with high diversity (more than 2.5) are restricted to the middle part of the bay at the depth of more than 20 m. Stations with low diversity (less than 2.0) are concentrated in the inner part of the bay.

3. Distribution of ostracode assemblages

Q-mode cluster analysis was used to recognize the biotopes of ostracodes and to examine the distribution of ostracode assemblages, which should be closely correlated with environmental factors. Taxa represented by three or more individuals in any one of the samples were used in this analysis (species of genus *Pontocythere* and family Paradoxostomatidae except for *Xiphichilus, Cytherois* and *Paracytherois* are expressed collectively in "spp."). These samples contain more than 50 individuals. The similarities used are Horn's overlap indices (Horn, 1966), and clustering was practised by the unweighted pair-group arithmetic average method. The results reveal four biotopes (A, B, C and D) (Fig. 7). The distribution of four biotopes is shown in figure 8, and briefly mentioned below.

Biotope A is composed of eight samples and distributed in the central bay at water depths of 17.2 to 37.2 m. The median grain size of the bottom sediment is 2.06 to 5.47 ϕ. The dominant species are *Bicornucythere bisanensis* (form A of Abe and Choe, 1988), *Bicornucythere bisanensis* (form M of Abe and Choe, 1988), *Cytheromorpha acupunctata, Loxoconcha viva, Nipponocythere bicarinata* and *Trachyleberis scabrocuneata*. This biotope is characterized by a high relative abundance of *T. scabrocuneata* and the occurrence of *Cytheropteron miurense, Kobayashiina donghaiensis, Schizocythere kishinouyei* (except for St.19) and *Krithe japonica* (except for St.24). *Loxoconcha epeterseni, Cythere nishinipponica, Pistocythereis* spp. and *Hemicytherura cuneata* are also common in this biotope. *Trachyleberis* sp. is present near the Akashi Strait (St. 16, 17D, 24 and 24D). *Aurila spinifera* s.l. (= *Aurila cymba* and *Aurila* cf. *Kiritsubo* of Yamane, 1998) is present in the deepest part of this biotope near the Akashi Strait (St. 24 and 24D).

Biotope B is composed of eight samples and

Table 1 List of sample data. E: Ekman-Birge Grab sampler. S: Smith-McIntyre Grab sampler.

St.	Water depth(m)	MD φ	Water temperature(℃)		Salinity(‰)		PH		DO (-0.5m)		DO (bottom+1m)		Sampler	Date	North latitude	East longitude
			(-0.5m)	(bottom+1m)	(-0.5m)	(bottom+1m)	(-0.5m)	(bottom+1m)	(mg / l)	(%)	(mg / l)	(%)				
1	8.8	5.23	20.70	17.80	2.90	30.83	7.92	8.18	5.78	78.0	7.44	93.1	E	990526	34° 40.45′	135° 23.30′
2	11.6	5.48	18.70	17.24	22.70	31.20	7.85	8.16	6.58	80.8	7.72	97.4	E	990526	34° 39.82′	135° 22.45′
3	13.9	5.65	21.17	15.60	9.33	31.45	8.08	7.98	7.07	84.6	5.77	70.1	E	990526	34° 40.35′	135° 19.90′
4	13.6	5.19	18.31	15.80	25.70	31.45	8.14	8.09	6.95	89.5	6.11	75.5	E	990526	34° 39.10′	135° 21.50′
5	15.9	5.33	18.23	15.60	23.50	31.55	7.95	7.93	7.59	95.6	5.06	62.0	E	990526	34° 37.78′	135° 22.98′
6	16.2	5.03	19.35	15.61	13.87	31.83	7.97	7.87	5.98	70.7	4.30	52.4	E	990528	34° 39.00′	135° 18.00′
7	17.3	5.33	18.99	15.26	27.97	22.50	8.26	8.06	8.56	110.4	6.35	73.2	E	990526	34° 37.62′	135° 19.60′
8	16.2	5.18	18.50	15.65	28.50	31.68	8.18	7.99	8.56	110.2	5.40	65.9	E	990526	34° 36.30′	135° 21.10′
9	12.6	5.32	18.45	17.31	29.50	31.30	8.19	8.20	8.56	110.2	7.73	97.7	E	990526	34° 34.81′	135° 22.80′
10	16.3	4.74	18.97	16.36	22.31	31.80	8.08	8.01	7.18	88.2	6.26	77.5	E	990528	34° 37.95′	135° 13.90′
11	18.4	5.22	18.66	16.56	21.47	31.85	8.01	8.01	7.18	87.3	7.05	87.7	E	990528	34° 36.80′	135° 15.20′
12	19.7	5.24	18.65	16.48	24.11	31.93	8.04	8.04	7.26	89.6	7.43	92.5	E	990528	34° 35.42′	135° 16.75′
13	19.1	5.07	18.39	16.42	26.77	31.87	7.99	7.98	7.33	92.2	7.27	90.2	E	990528	34° 34.12′	135° 18.20′
14	18.0	5.27	18.85	15.48	30.91	31.84	8.20	8.04	8.19	106.9	5.35	65.2	E	990526	34° 32.62′	135° 19.90′
15	13.5	4.79	15.00	15.44	30.84	31.68	7.92	7.96	7.54	97.3	4.13	48.4	E	990526	34° 31.30′	135° 21.40′
16	17.2	3.60	18.55	16.74	26.91	31.83	8.17	8.11	8.28	105.0	7.55	94.3	E	990528	34° 36.98′	135° 8.70′
17	22.2	5.29	18.50	16.81	29.38	32.06	8.16	8.09	7.10	98.8	7.42	93.1	E	990528	34° 35.28′	135° 11.37′
17D	26.9	5.30	18.36	16.82	29.99	32.08	8.14	8.09	7.56	96.2	7.08	88.7	S	990528	34° 34.80′	135° 10.50′
18	23.1	5.17	17.92	16.82	30.62	32.09	8.16	8.08	6.83	87.0	6.93	86.1	E	990528	34° 34.20′	135° 11.80′
19	20.2	5.47	17.25	16.81	31.92	32.06	8.09	8.07	6.86	87.1	5.95	75.1	E	990528	34° 32.80′	135° 13.28′
20	18.5	5.17	17.85	16.75	31.76	31.86	8.12	8.09	6.94	88.2	5.73	72.2	E	990528	34° 31.50′	135° 14.84′
21	18.7	5.52	17.92	16.78	30.31	31.82	8.00	8.03	7.00	87.7	6.43	80.2	E	990529	34° 30.08′	135° 16.52′
22	17.2	5.23	17.40	16.11	31.08	31.84	7.99	8.01	7.13	89.6	4.45	54.8	E	990529	34° 28.65′	135° 18.10′
23	13.6	4.78	17.19	16.76	31.63	31.97	7.93	7.91	7.03	88.1	5.75	71.7	E	990529	34° 27.53′	135° 19.40′
24	37.2	2.06	18.05	17.34	31.83	31.63	8.07	8.09	7.10	89.5	6.99	87.7	E	990529	34° 29.86′	135° 10.41′
24D		4.45											S	990529	≒St.24	≒St.24
25	30.1	5.36	18.52	18.10	31.40	32.02	8.11	8.09	7.41	94.0	7.02	88.1	S	990529	34° 28.57′	135° 11.00′
26	21.1	5.40	17.96	16.85	31.36	31.65	8.15	8.12	7.33	94.0	6.93	86.7	E	990529	34° 27.08′	135° 12.75′
27	14.1	5.07	18.52	17.07	31.49	31.93	8.16	8.16	7.44	95.7	6.60	83.0	E	990529	34° 24.60′	135° 15.58′
28	9.2	5.37	18.80	17.05	31.44	31.77	8.12	8.06	6.78	86.5	5.94	74.6	E	990529	34° 23.90′	135° 16.55′
30	9.9	5.13	19.06	17.88	31.83	32.12	8.04	8.07	5.52	71.3	6.26	79.9	E	990529	34° 22.80′	135° 15.05′

Table 2 List of ostracodes in Osaka Bay. (): number of living specimens.

Sp. \ St.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	17D	18	19	20	21	22	23	24	24D	25	26	27	28	30
Ambtonia obai					1					3	2	1				4	3		1	1			1				1			3	1
Amphileberis nipponica						1	1			1						1	1		1				1		4	9	2				
Anchistrocheles yamaguchii																		1							1						
Aurila corniculata																2									3		1				
Aurila cymba																									2	2	1			3	
Aurila disparata																									1	1					
Aurila munechikai																									2						
Aurila spinifera s.l.																									5	8					
Aurila sp. 1																1		1	2	1						2					1
Aurila sp. 2																2		1	1							1	2				
Aurila sp. 3																1	1		2											1	4
Aurila sp. 4																5	1	1									1			2	1
Aurila sp. 5																1															
Aurila sp. 6																															1
Aurila sp. 7																									1						
Bicornucythere bisanensis form A			2	4	48	3	9	10	9	26	22	22	9	7(1)	30	23	51	44(1)	51(1)	41(2)	22	82(8)	42(2)	82(1)	60	73	39(1)	47(4)	113(3)	65(1)	59
Bicornucythere bisanensis form M				3	25			6	8	21	21	15	2	2	11	16	84	29(1)	36	48	71	24(1)	18	18	16	17	32	53(3)	13	15	13
Bythoceratina subjaponica											1	1	1					2	3			1				3					1
Bythoceratina sp. 1																		2							1		1				4
Bythoceratina sp. 2																	1		1												
Callistocythere alata										5	2	1				6	1	2	1				1	1		1				3	
Callistocythere hayamensis																										1					
Callistocythere hotaru																		1													
Callistocythere reticulata																									2	2					1
Callistocythere undulatifacialis																1	1		1							1				3	5
Callistocythere sp.																1															
Cobanocythere ? sp.																		1												1	1
Coquimba ishizakii																1	2	1							2	1	2				
Cornucoquimba tosaensis																2		1							3	2	1				1
Cornucoquimba sp.																											1				
Cytheropteron miurense																17	5	4	9	3					9	12	13			1	
Cytheropteron uchioi																2															
Cytheropteron sp.																										1					
Cythere nishinipponica																14	4	6	3	1					17	22	10	1	2	2	9
Cythere omotenipponica																1	3								3	3	1				
Cytherois nakanoumiensis						1			4	1	2	1				3	5	1		2	3	3	1				2			3	4
Cytherois uranouchiensis					4	4	3	3	13	4	9	5	3	1	3(1)	3	9	9	9	6	5	3	4	3	1	7	2	3	1	1	5
Cytheromorpha acupunctata	1	1		4	47	2	5	11	77(7)	19(1)	54	27(1)	20	7	32(3)	10	25	30(2)	19	16	27(1)	29(5)	51	65(3)	13	14	14	24(2)	39(3)	25(1)	17(1)
Cytherura sp.																2	1			1					1	2	2				
Eucythere yugao																		2	1	1											
Finmarchinella uranipponica																1		1							1	1					
Hemicytherura cuneata																4	1	3	2	1					2	4	1				1
Hemicytherura tricarinata																1	1														
Kobayashiina donghaiensis																4	6	3	3	1					5	2	8	1			
Krithe japonica																9	15(2)	1	2	6	1		1			2	1				
Loxoconcha epeterseni																5	2	4	1	1						6	1				2
Loxoconcha harimensis																1		1	1						1						2
Loxoconcha japonica																										1					
Loxoconcha kattoi																										1					
Loxoconcha pulchra																											1				
Loxoconcha tosaensis			1	1	45		3	1	6						2	4							1	15		1			6	18	8
Loxoconcha uranouchiensis																4		3	2					1	2	2	1			3	2
Loxoconcha cf. *uranouchiensis*																									3						
Loxoconcha viva				2	18	2	5	2		24	42	26	27	4	11	34	39	12	18	24	24	55(1)	62	22(1)	4	6	11	53	39	11	20
Loxoconcha sp. 1	3															1	2	1									1			1	4

Table 2 (continued)

Loxoconcha sp. 2																															4
Microcythere sp. 1																		1													
Microcythere sp. 2																										2					
Microcythere sp. 3	1															1	1	1									4				
Miia uranouchiensis																											2				
Munseyella oborozukiyo																									1						
Munseyella sp.																2	1	1	1								1				
Neomonoceratina delicata																										1					
Neonesidea oligodentata																1		2	1						1	4	3			2	1
Neonesidea sp.																			1												
Nipponocythere bicarinata							1	1		14	38	15	13	1		15	37	46	31	28	29	25	4	3	6	10	14	24	3	1	5
Nipponocythere sp.																			1												
Paracytherois tosaensis					1											1				1						1	1				
Paradoxostomatidae spp.			1							1	2	1				2	4	6	5	2		1			1	8	2			2	2
Parakrithella pseudadonta																2		1	1						1	1	1			2	5
Parakrithella sp.													1																		
Pistocythereis bradyformis					3											6	11	11(1)	4	3	2				3	6	4	1	3	4	12
Pistocythereis bradyi	1				10	1		2	2	1	1		1		2	9	13		3	2		1		5	8	10	5	1	4	3	2
Pontocythere spp.																3	1	1							5	5	4				
Propontocypris attenuata											1		1																		8
Propontocypris sp. 1																	1	1	1							2	1			1	4
Propontocypris sp. 2																1		1	1	1								1	1	2	
Robustaurila ishizakii																3		2							2		1			1	1
Robustaurila kianohybridus																										1					
Rotundracythere ? sp.																1															
Schizocythere kishinouyei																13	2	5	3						9	16	3				4
Semicytherura henryhowei																															2
Semicytherura mukaishimensis																	1										1				
Semicytherura polygonoreticulata																3															
Semicytherura yajimae																2		1	1												
Semicytherura sp. 1																7	1	1		1					2	2	1				1
Semicytherura sp. 2																1		1													
Semicytherura sp. 3																		1													
Semicytherura sp. 4																			1												
Semicytherura sp. 5																															1
Semicytherura sp. 6																		1								1	1				
Spinileberis quadriaculeata					13	1	1	1	9	6	3	3	2		7	9	9	7	14	13	8	3	6	15	4	10	2	14	22	24	22
Sulcocytherura sp.																		1													
Trachyleberis scabrocuneata					1		1			3	2	1	1	1	1	14	32	26(2)	34(1)	17(3)	3	1		2	34	32	22	2	3	6	7
Trachyleberis cf. *scabrocuneata*																										1					
Trachyleberis sp.																2		3							6	10					
Xestoleberis hanaii																1	1	1		1					2	2	3			1	3
Xestoleberis opalescenta																		1													
Xestoleberis sp. 1																3	1		2												
Xestoleberis sp. 2																										1					
Xiphichilus sp.										1	1	4	3	1		2	2	8	3	9	5	5	2		7	6	5	2	1		
Gen. et sp. indet. 1						3																									
Gen. et sp. indet. 2									1																						
Gen. et sp. indet. 3																															1
Gen. et sp. indet. 4	1																														
Gen. et sp. indet. 5																			1												2
Gen. et sp. indet. 6																											1				
Gen. et sp. indet. 7																1		1													
Gen. et sp. indet. 8																	1									1					
Total number of specimens	7	1	4	14	216	18	29	37	129	130	203	123	84	24	99	292	383	300	279	232	200	233	195	232	257	344	235	227	250	210	254
Total number of species	5	1	3	5	12	9	9	9	9	15	16	14	13	8	9	59	41	54	42	27	12	13	14	12	43	55	49	14	14	30	43

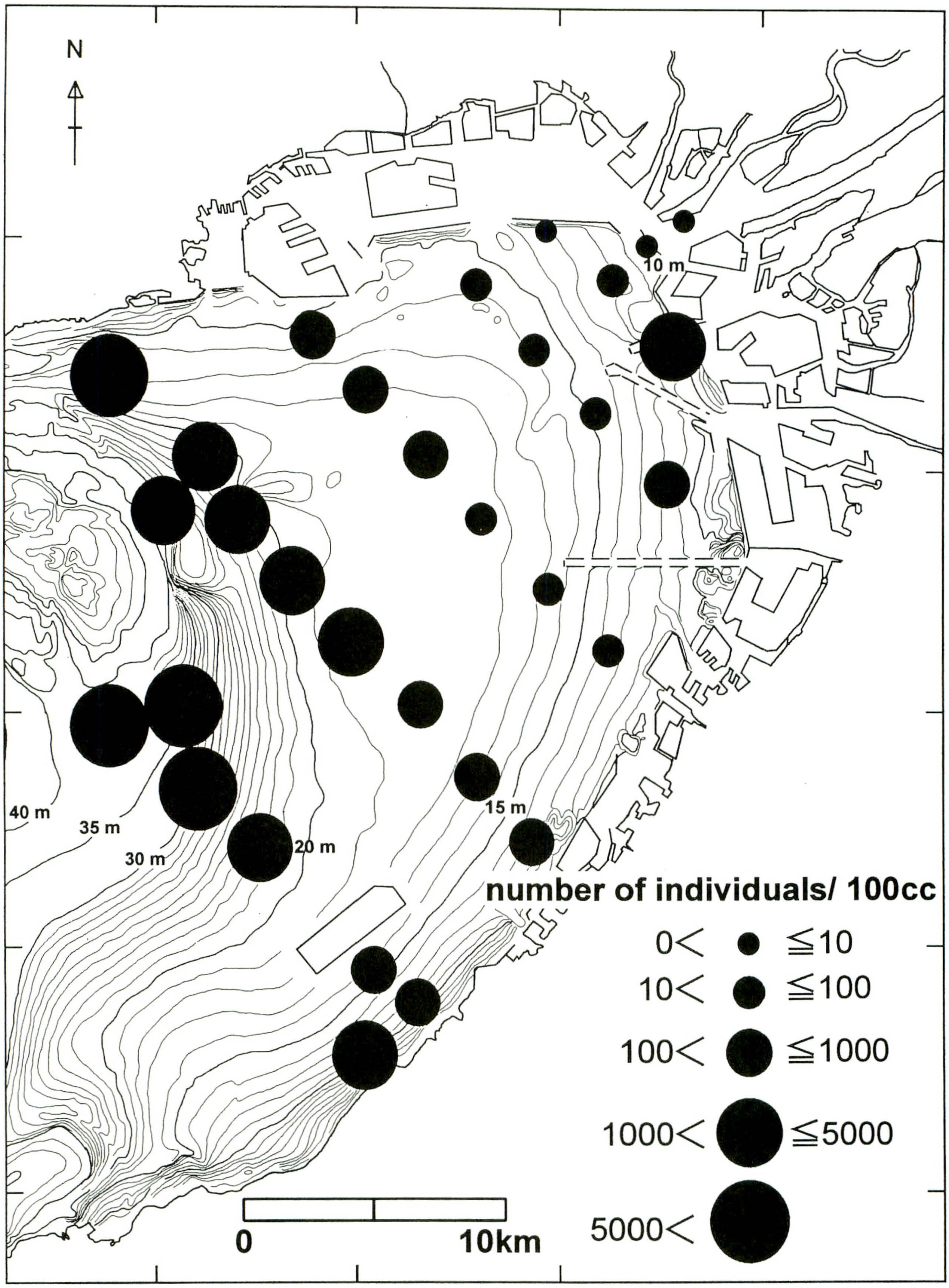

Fig. 5 Distribution of ostracode abundance in Osaka Bay (number of individuals / 100 cc wet sediment).

distributed in the inner part of the bay at water depths of 16.3 to 21.1 m. The median grain size of the bottom sediment is 4.74 to 5.52 ϕ. The dominant species are *B. bisanensis* (form A), *B. bisanensis* (form M), *C. acupunctata*, *L. viva* and *N. bicarinata*. *Cytherois uranouchiensis* and *Spinileberis quadriaculeata* are also common in this biotope.

Biotope C is composed of six samples and distributed in the innermost part of the bay and bay coast at water depths of 9.2 to 15.9 m. The median grain

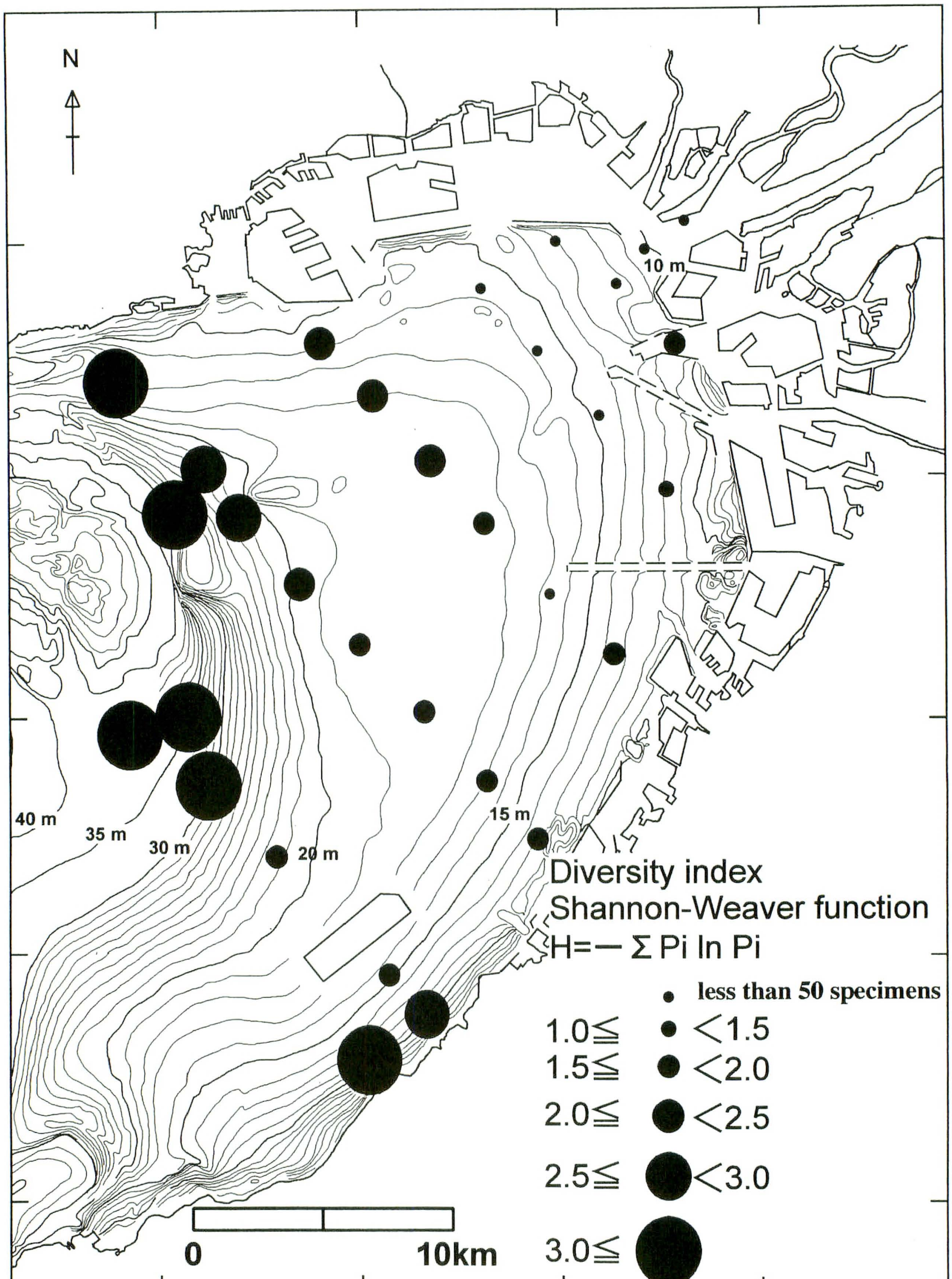

Fig. 6 Distribution of ostracode diversity indices in Osaka Bay.

size of the bottom sediment is 4.78 to 5.37 ϕ. The dominant species are *B. bisanensis* (form A), *B. bisanensis* (form M), *C. acupunctata, L. viva, Loxoconcha tosaensis* and *S. quadriaculeata*. This biotope is characterized by a high relative abundance of *S. quadriaculeata* and *B. bisanensis* (form A) and the occurrence of *L. tosaensis*.

Biotope D is composed of only one sample (St.9) and distributed in the inner part of the bay at water depths of 12.6 m. The median grain size of the bot-

Table 3 List of ostracode abundance and diversity indices in Osaka Bay

St.	Species diversity	Number of individuals/100cc
1		7.0
2		1.0
3		4.0
4		14.0
5	1.969	1152.0
6		18.0
7		29.0
8		37.0
9	1.436	129.0
10	2.185	129.0
11	2.000	203.0
12	2.049	123.0
13	1.914	84.0
14		24.0
15	1.712	99.0
16	3.524	9344.0
17	2.732	3064.0
17D	3.052	4800.0
18	2.828	4464.0
19	2.492	1856.0
20	1.927	1600.0
21	1.785	372.8
22	1.742	195.0
23	1.783	464.0
24	3.010	5482.7
24D	3.237	5504.0
25	3.118	6016.0
26	1.912	1816.0
27	1.726	500.0
28	2.515	560.0
30	3.092	1370.7

tom sediment is 5.32 ϕ. This biotope is characterized by the dominance of *C. acupunctata*.

Samples containing less than 50 individuals are distributed around the river mouth of the Yodo River. Relatively dominant species in each sample are *C. acupunctata* and *B. bisanensis* (form A).

The distribution of characteristic species in Osaka Bay is shown in figures 9a and 9b.

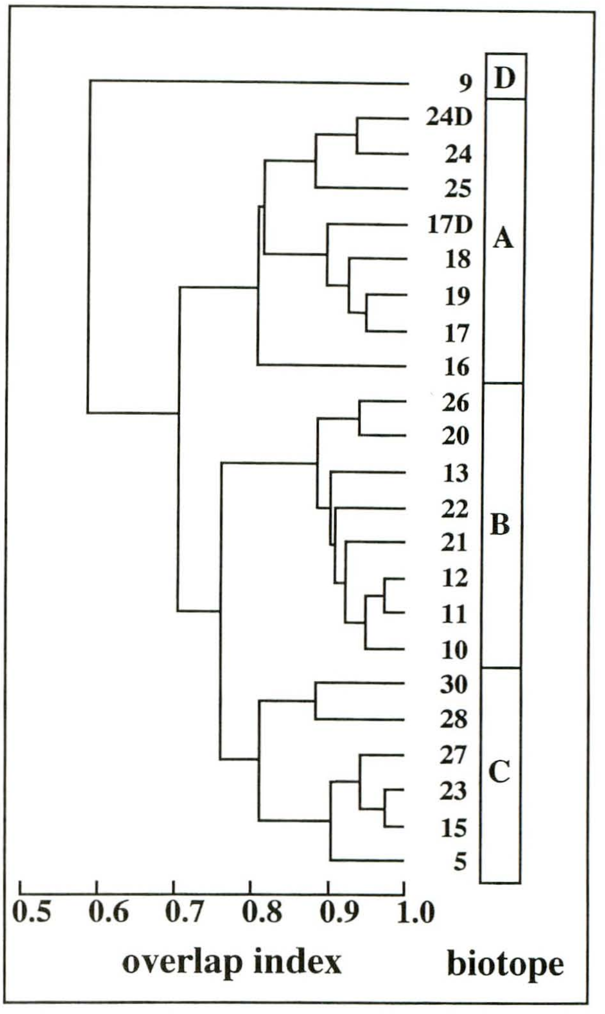

Fig. 7 Dendrogram of Q-mode cluster analysis. A, B, C and D refer to biotopes.

Discussion

Biotopes A, B and C range in water depth from 17.2 to 37.2 m, 16.3 to 21.1 m and 9.2 to 15.9 m, respectively. All stations of biotope A, except for St. 16, are at more than 20.2 m water depth. All stations of biotope B, except for St. 26, are at less than 19.7 m water depth. All stations of biotope C are at less than 15.9 m water depth. Therefore biotope A/B and B/C boundaries are at about 20 m and 16 m water depth, respectively. The distribution of biotopes is clearly correlated with water depth. However, in Osaka bay, the tidal current is fast on the west side, from the 20 m isobathymetic line of the central part of the bay (Fujiwara et. al. 1989). Thus, the biotope A/B boundary may be correlated with the tidal current.

The ostracode density and diversity are higher in the western part of the bay and lower toward the eastern part of the bay. Because of no living specimens and few juveniles with thin carapaces, the high density and diversity in the westernmost part of the bay represents ostracode valves that were transported by the tidal current and accumulated there. The oxygen deficiency in the shallow region (<20 m) in the eastern side of the bay during May and September (Joh, 1989) is expected to have serious effects on the benthos. Therefore, the ostracode density and diversity are lower toward the inner part of the bay, where the oxygen deficiency in the bottom water occurs in the summer.

Summary

1. At least 110 species belonging to 44 genera were identified from 31 samples. Living specimens of

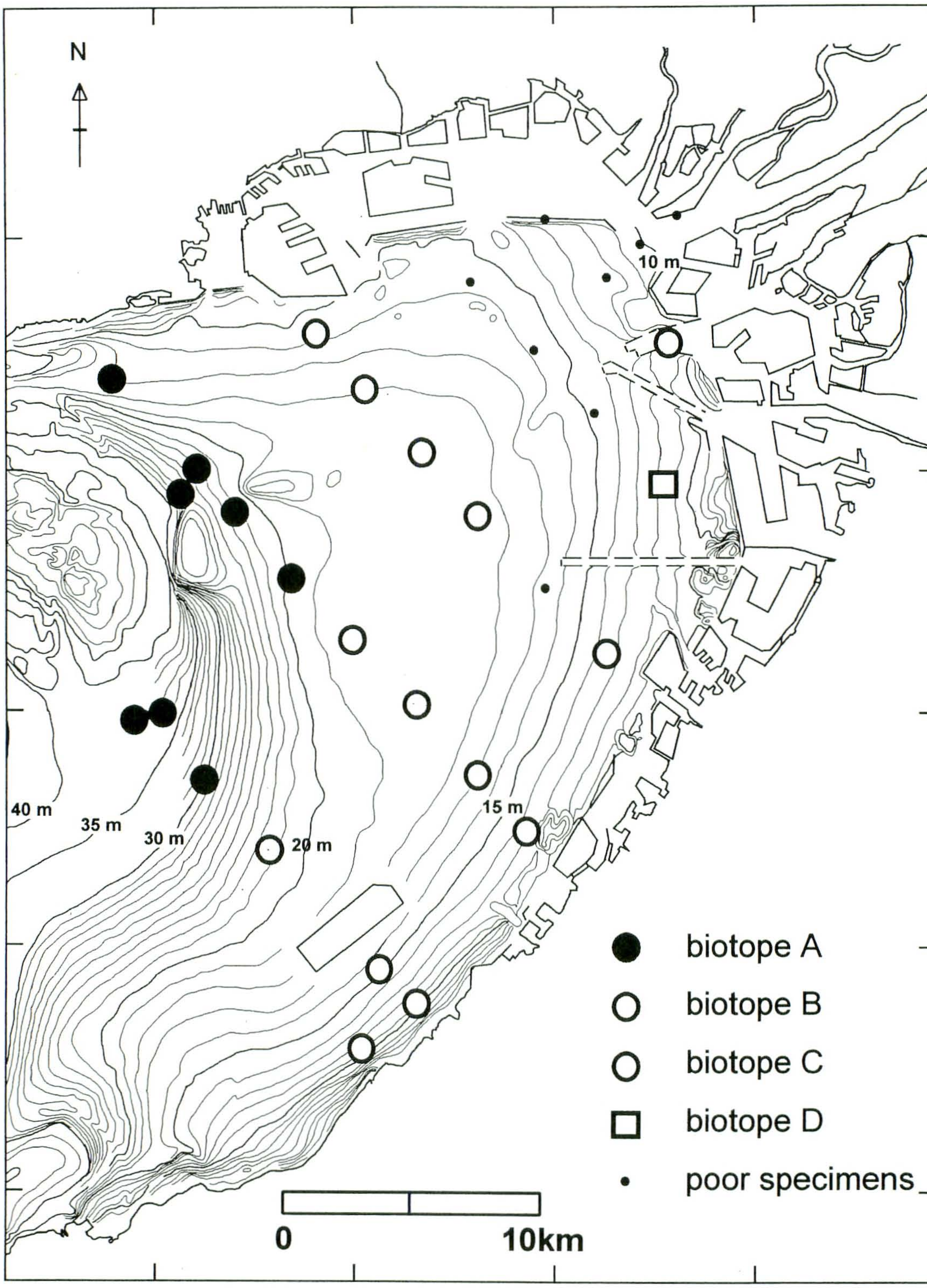

Fig. 8 Distribution of biotopes in Osaka Bay based on Q-mode cluster analysis.

seven species were found.

2. The result of Q-mode cluster analysis reveals four biotopes (A, B, C and D). Biotope A/B and B/C boundaries are at about 20 m and 16 m water depth, respectively.

3. The high density and diversity in the westernmost part of the bay represent the influence of the transportation and accumulation of ostracode valves by the tidal current.

4. Ostracode density and diversity are lower toward

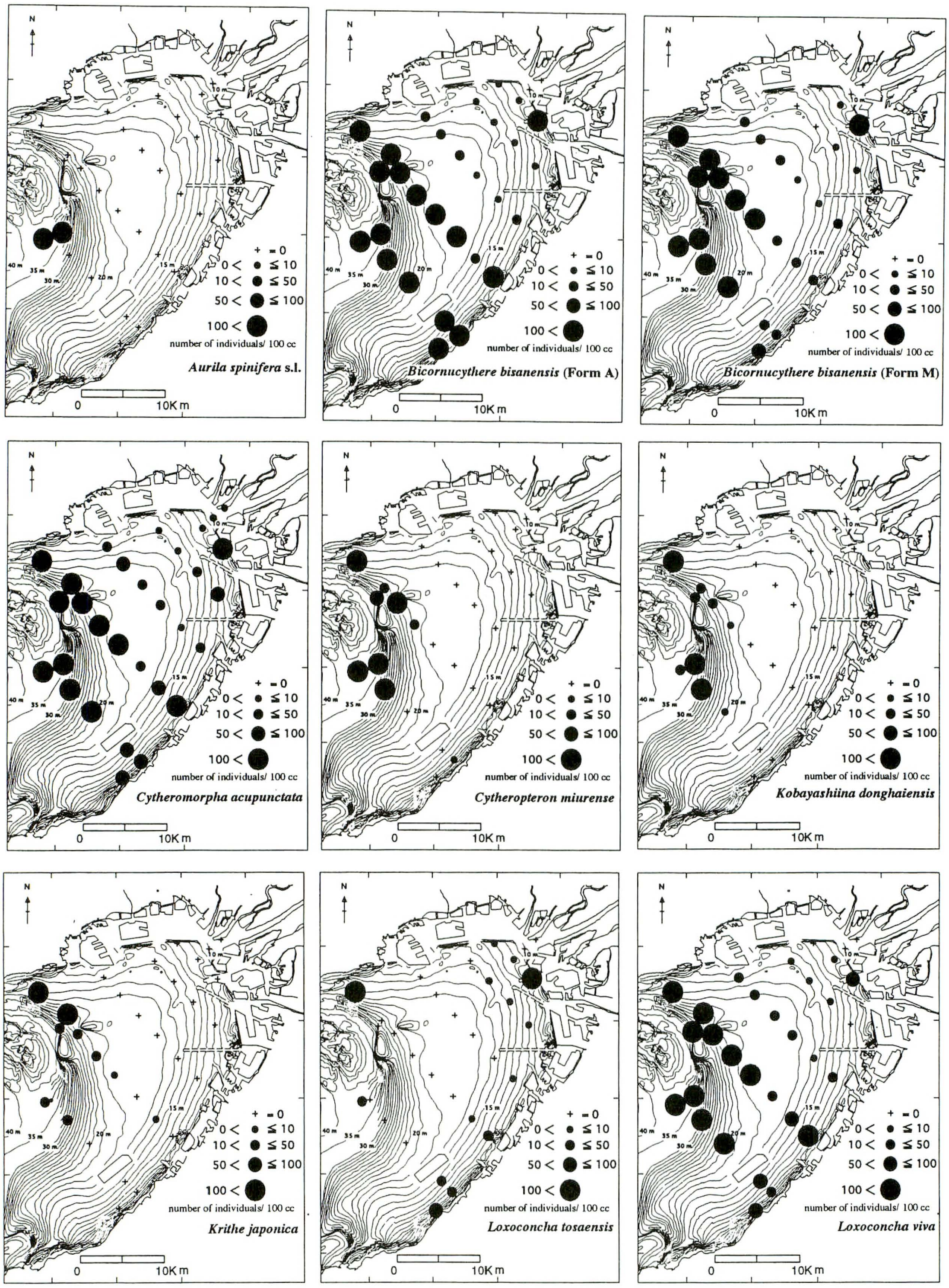

Fig. 9a Distribution of characteristic species in Osaka Bay (number of individuals / 100 cc wet sediment).

to the inner part of the bay because the oxygen deficiency in the bottom waters occurs there in the summer.

5. The distribution pattern and faunal structure of ostracodes in Osaka Bay are correlated with water depth, dissolved oxygen and tidal current.

Acknowledgement

We would like to thank Dr. Shusaku Yoshikawa

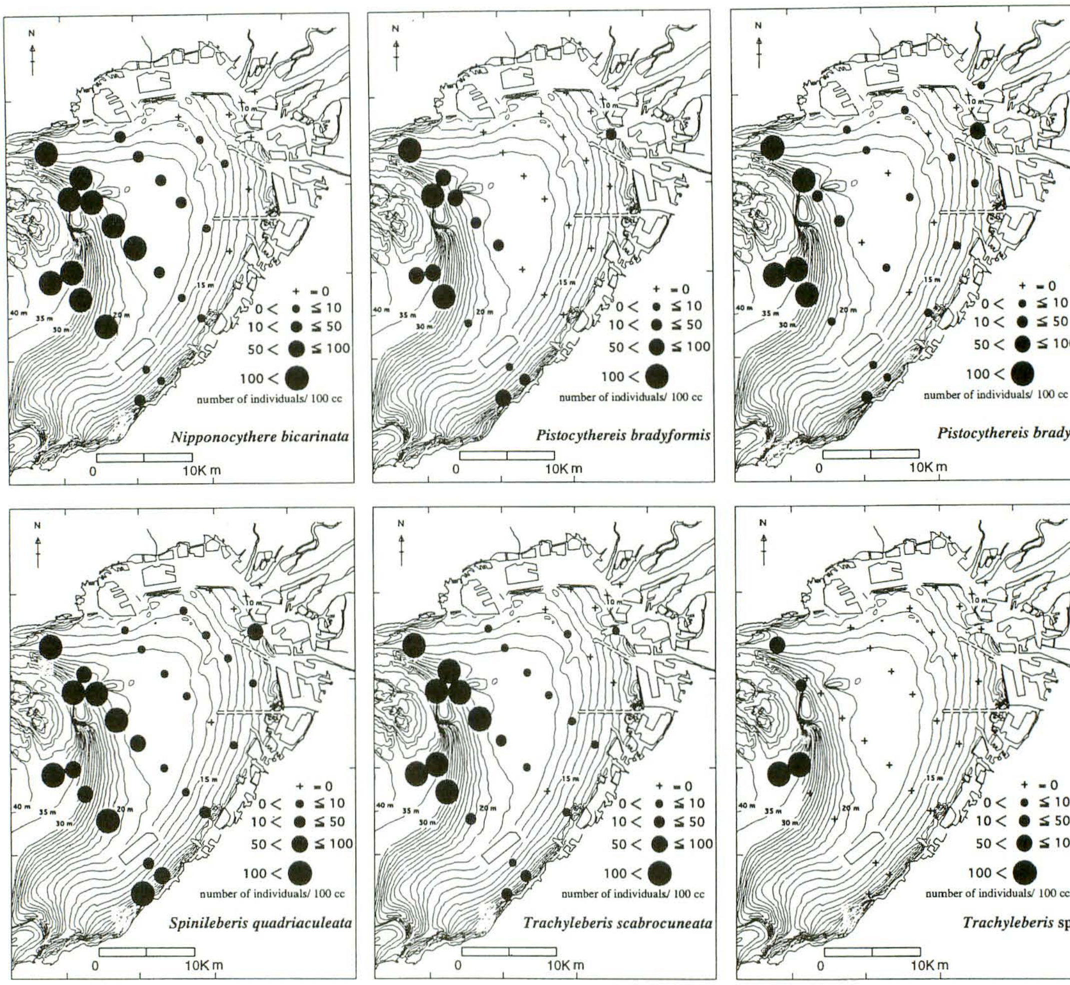

Fig. 9b Distribution of characteristic species in Osaka Bay (number of individuals / 100 cc wet sediment).

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Explanation of Plate 1

Scale bars = 100μm

Figs. 1-3 *Ambtonia obai* (Ishizaki, 1971)
1. Lateral view of right valve, juvenile, sample no. 16.
2. Lateral view of right valve, juvenile, sample no. 11.
3. Lateral view of left valve, juvenile, sample no. 11.

Figs. 4-7 *Amphileberis nipponica* (Yajima, 1978)
4. Lateral view of right valve, adult, sample no. 24D.
5. Lateral view of left valve, adult, sample no. 24D.
6. Lateral view of right valve, adult, sample no. 24D.
7. Lateral view of left valve, adult, sample no. 24.

Fig. 8 *Anchistrocheles yamaguchii* Yajima, 1987
Lateral view of left valve, adult, sample no. 24.

Fig. 9 *Aurila corniculata* (Okubo, 1980)
Lateral view of right valve, sample no. 25.

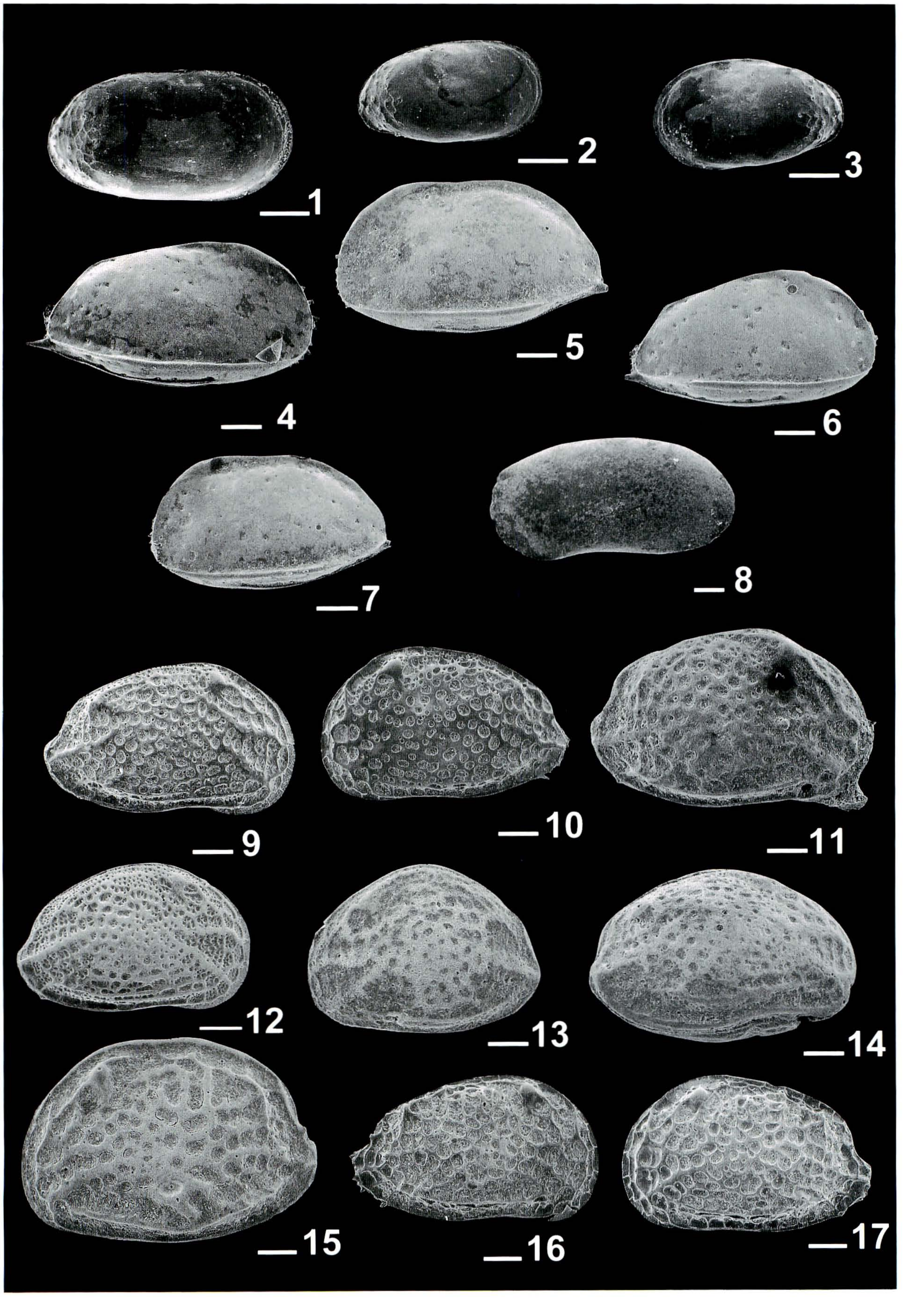
Figs. 10, 11 *Aurila cymba* (Brady, 1869)
10. Lateral view of left valve, A-1 instar, sample no. 24D.
11. Lateral view of right valve, adult, female, sample no. 24.

Fig. 12 *Aulira disparata* (Okubo, 1980)
Lateral view of right valve, juvenile, sample no. 24D.

Figs. 13, 14 *Aurila munechikai* Ishizaki, 1968
13. Lateral view of left valve, adult, sample no. 24.
14. Right lateral view of carapace, adult, sample no. 24.

Figs. 15-17 *Aurila spinifera* s.l. Schornikov and Tsareva, 1995
15. Lateral view of left valve, adult, sample no. 24D.
16. Lateral view of right valve, A-1 instar, sample no. 24.
17. Lateral view of left valve, A-1 instar, sample no. 24.

Plate 1



Explanztion of Plate 2

Scale bars = 100μm

Figs. 1, 2 *Aurila* sp. 1
1. Lateral view of left valve, sample no. 24D.
2. Lateral view of right valve, sample no. 24D.

Fig. 3 *Aurila* sp. 2
Lateral view of right valve, juvenile, sample no. 16.

Figs. 4, 5 *Aurila* sp. 3
4. Lateral view of left valve, juvenile, sample no. 30.
5. Lateral view of left valve, juvenile, sample no. 30.

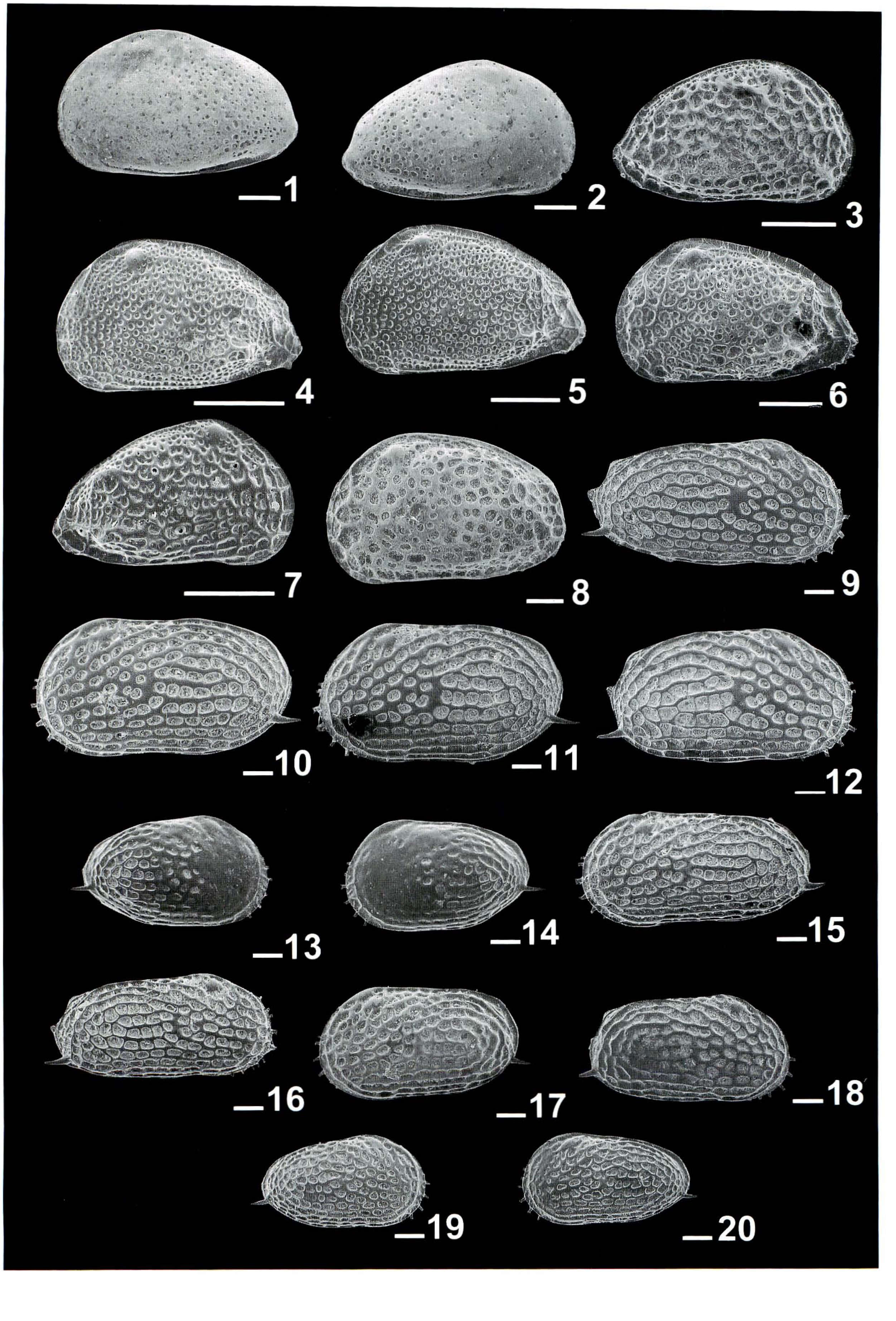
Figs. 6, 7 *Aurila* sp. 4
6. Lateral view of left valve, juvenile, sample no. 17.
7. Lateral view of right valve, juvenile, sample no. 16.

Fig. 8 *Aurila* sp. 6
Lateral view of left valve, sample no. 30.

Figs. 9-14 *Bicornucythere bisanensis* (Okubo, 1975) (form A)
9. Lateral view of right valve, adult, male, sample no. 23.
10. Lateral view of left valve, adult, male, sample no. 23.
11. Lateral view of left valve, adult, female, sample no. 27.
12. Lateral view of right valve, adult, female, sample no. 27.
13. Lateral view of right valve, A-1 instar, sample no. 28.
14. Lateral view of left valve, A-1 instar, sample no. 28.

Figs. 15-20 *Bicornucythere bisanensis* (Okubo, 1975) (form M)
15. Lateral view of left valve, adult, male, sample no. 18.
16. Lateral view of right valve, adult, male, sample no. 18.
17. Lateral view of left valve, adult, female, sample no. 17.
18. Lateral view of right valve, adult, female, sample no. 17.
19. Lateral view of right valve, A-1 instar, sample no. 17.
20. Lateral view of left valve, A-1 instar, sample no. 17.

Plate 2



Explanation of Plate 3

Scale bars = 100μm

Figs. 1-4 *Bythoceratina subjaponica* Zhou, 1995
1. Lateral view of right valve, juvenile, sample no. 18.
2. Lateral view of left valve, juvenile, sample no. 17D.
3. Lateral view of right valve, adult, sample no. 12.
4. Lateral view of left valve, adult, sample no. 13.

Figs. 5, 6 *Bythoceratina* sp. 1
5. Lateral view of left valve, juvenile, sample no. 30.
6. Lateral view of left valve, juvenile, sample no. 30.

Figs. 7, 8 *Bythoceratina* sp. 2
7. Lateral view of left valve, juvenile, sample no. 18.
8. Lateral view of right valve, juvenile, sample no. 17.

Figs. 9-13 *Callistocythere alata* Hanai, 1957
9. Lateral view of left valve, adult, sample no. 28.
10. Lateral view of right valve, adult, sample no. 11.
11. Lateral view of left valve, adult, sample no. 28.
12. Lateral view of right valve, adult, sample no. 10.
13. Lateral view of right valve, juvenile, sample no. 16.

Figs. 14 *Callistocythere hayamensis* Hanai, 1957
Right lateral view of carapace, adult, sample no. 24D.

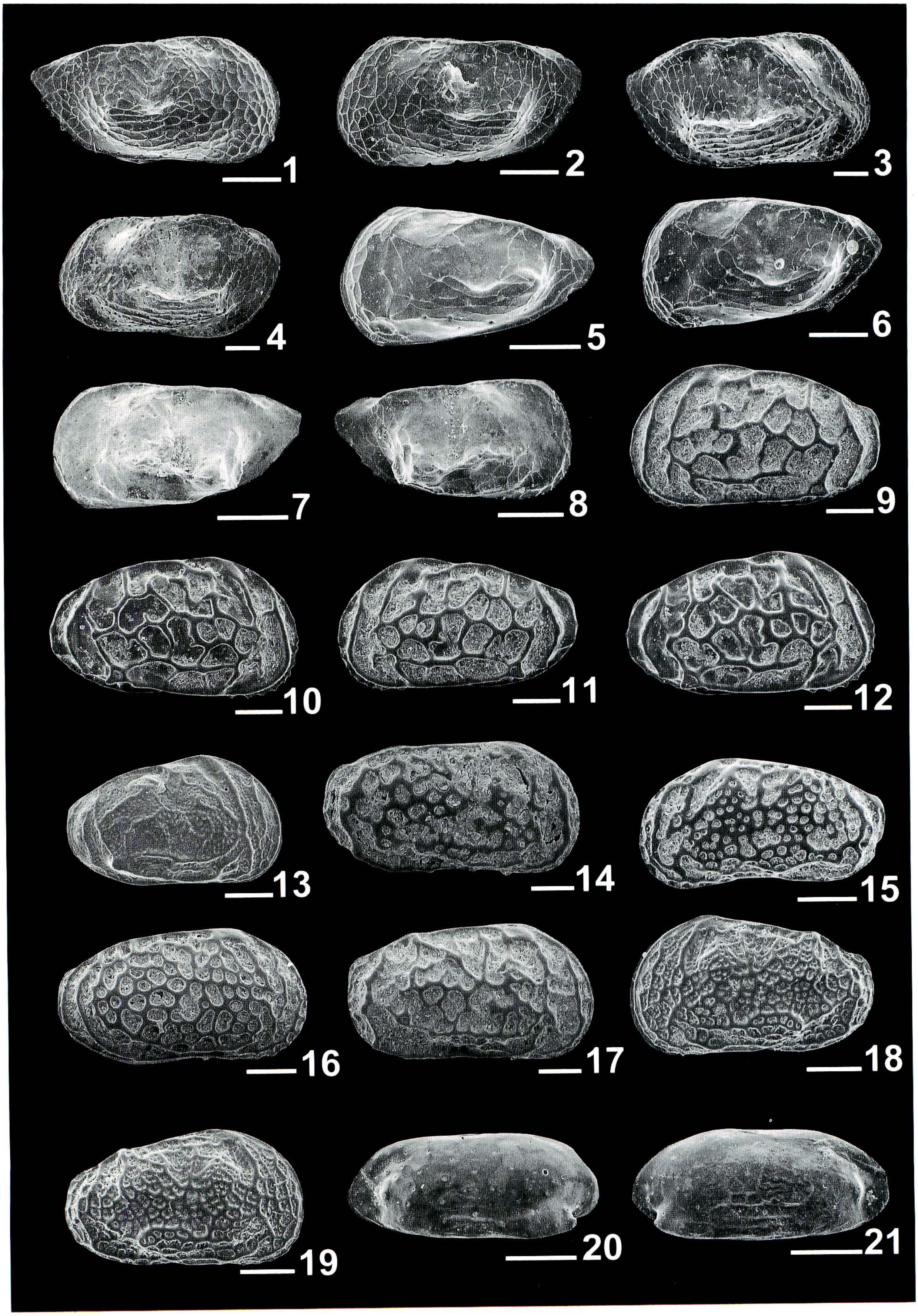
Fig. 15 *Callistocythere hotaru* Yajima, 1982
Lateral view of left valve, adult, sample no. 17D.

Fig. 16 *Callistocythere reticulata* Hanai, 1957
Right lateral view of carapace, adult, sample no. 24.

Figs. 17-19 *Callistocythere undulatifacialis* Hanai, 1957
17. Right lateral view of carapace, adult, sample no. 30.
18. Lateral view of left valve, juvenile, sample no. 28.
19. Lateral view of right valve, juvenile, sample no. 28.

Figs. 20, 21 *Cobanocythere* ? sp.
20. Lateral view of left valve, adult, sample no. 17D.
21. Lateral view of right valve, adult, sample no. 30.

Plate 3



Explanation of Plate 4

Scale bars = 100μm

Figs. 1, 2 — *Coquimba ishizakii* Yajima, 1978
1. Lateral view of right valve, adult, sample no. 24D.
2. Lateral view of right valve, juvenile, sample no. 24.

Figs. 3, 4 — *Cornucoquimba tosaensis* (Ishizaki, 1968)
3. Left lateral view of carapace, adult, sample no. 24.
4. Lateral view of left valve, juvenile, sample no. 24.

Fig. 5 — *Cornucoquimba* sp.
Lateral view of left valve, sample no. 25.

Figs. 6-9 — *Cytheropteron miurense* Hanai, 1957
6. Lateral view of left valve, juvenile, sample no. 24.
7. Lateral view of right valve, juvenile, sample no. 24.
8. Lateral view of left valve, adult, sample no. 24D.
9. Lateral view of right valve, adult, sample no. 24.

Fig. 10 — *Cytheropteron* sp.
Lateral view of left valve, sample no. 24D.

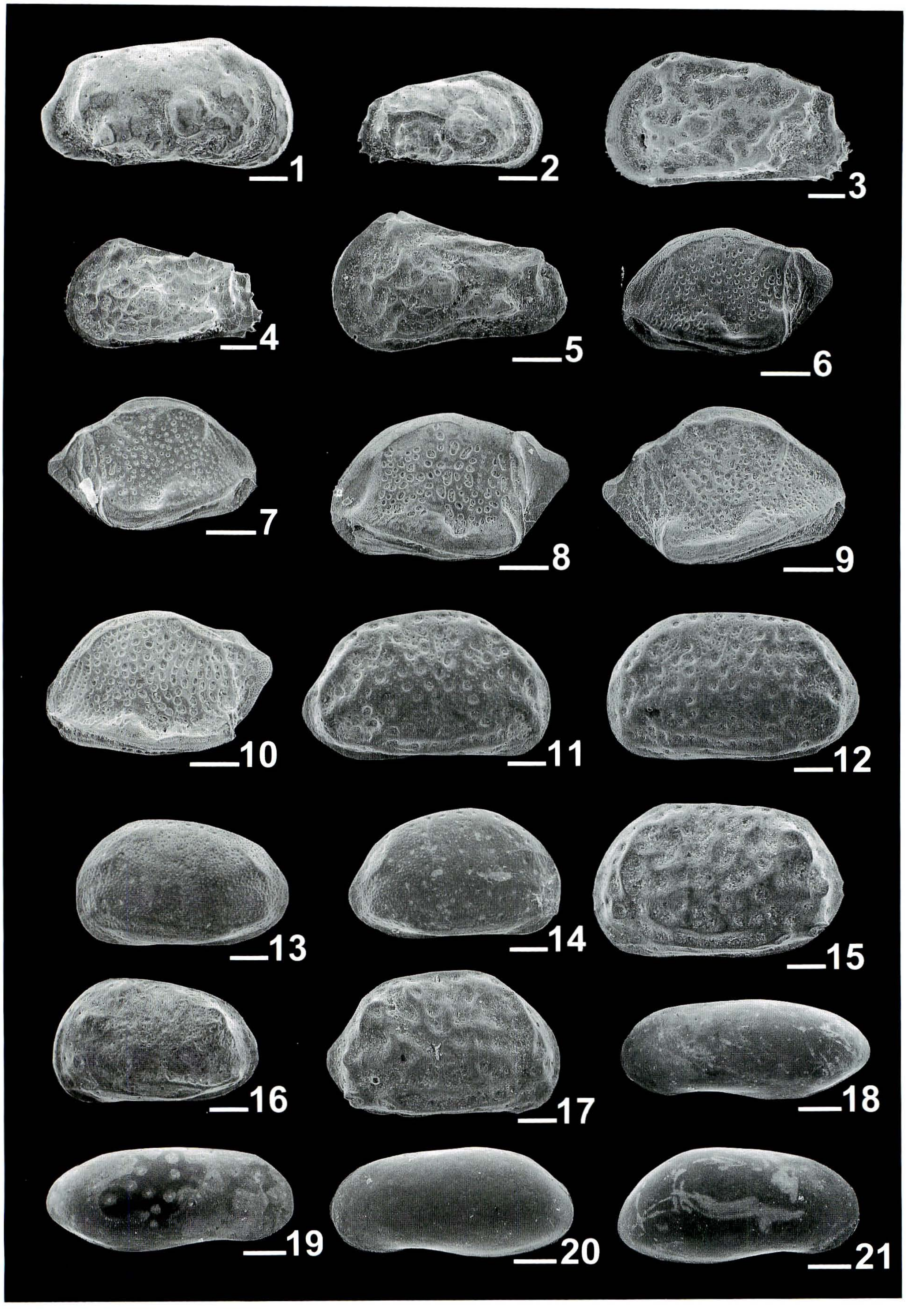
Figs. 11-14 — *Cythere nishinipponica* Okubo, 1976
11. Lateral view of right valve, adult, sample no. 24.
12. Lateral view of left valve, adult, sample no. 24.
13. Lateral view of left valve, juvenile, sample no. 24D.
14. Lateral view of right valve, juvenile, sample no. 24D.

Figs. 15-17 — *Cythere omotenipponica* Hanai, 1959
15. Lateral view of left valve, adult, sample no. 24.
16. Lateral view of left valve, juvenile, sample no. 24.
17. Lateral view of right valve, adult, sample no. 24D.

Figs. 18, 19 — *Cytherois nakanoumiensis* Ishizaki, 1969
18. Lateral view of left valve, adult, sample no. 9.
19. Lateral view of right valve, adult, sample no. 9.

Figs. 20, 21 — *Cytherois uranouchiensis* Ishizaki, 1968
20. Lateral view of left valve, adult, sample no. 9.
21. Lateral view of right valve, adult, sample no. 9.

Plate 4



Explanation of Plate 5

Scale bars = 100μm

Figs. 1-4 *Cytheromorpha acupunctata* (Brady, 1880)
1. Lateral view of right valve, adult, female, sample no. 9.
2. Lateral view of left valve, adult, female, sample no. 9.
3. Lateral view of left valve, adult, male, sample no. 27.
4. Lateral view of right valve, adult, male, sample no. 23.

Fig. 5 *Cytherura* sp.
Lateral view of right valve, juvenile, sample no. 25.

Figs. 6, 7 *Eucythere yugao* Yajima, 1982
6. Lateral view of right valve, juvenile, sample no. 18.
7. Lateral view of right valve, adult, sample no. 17D.

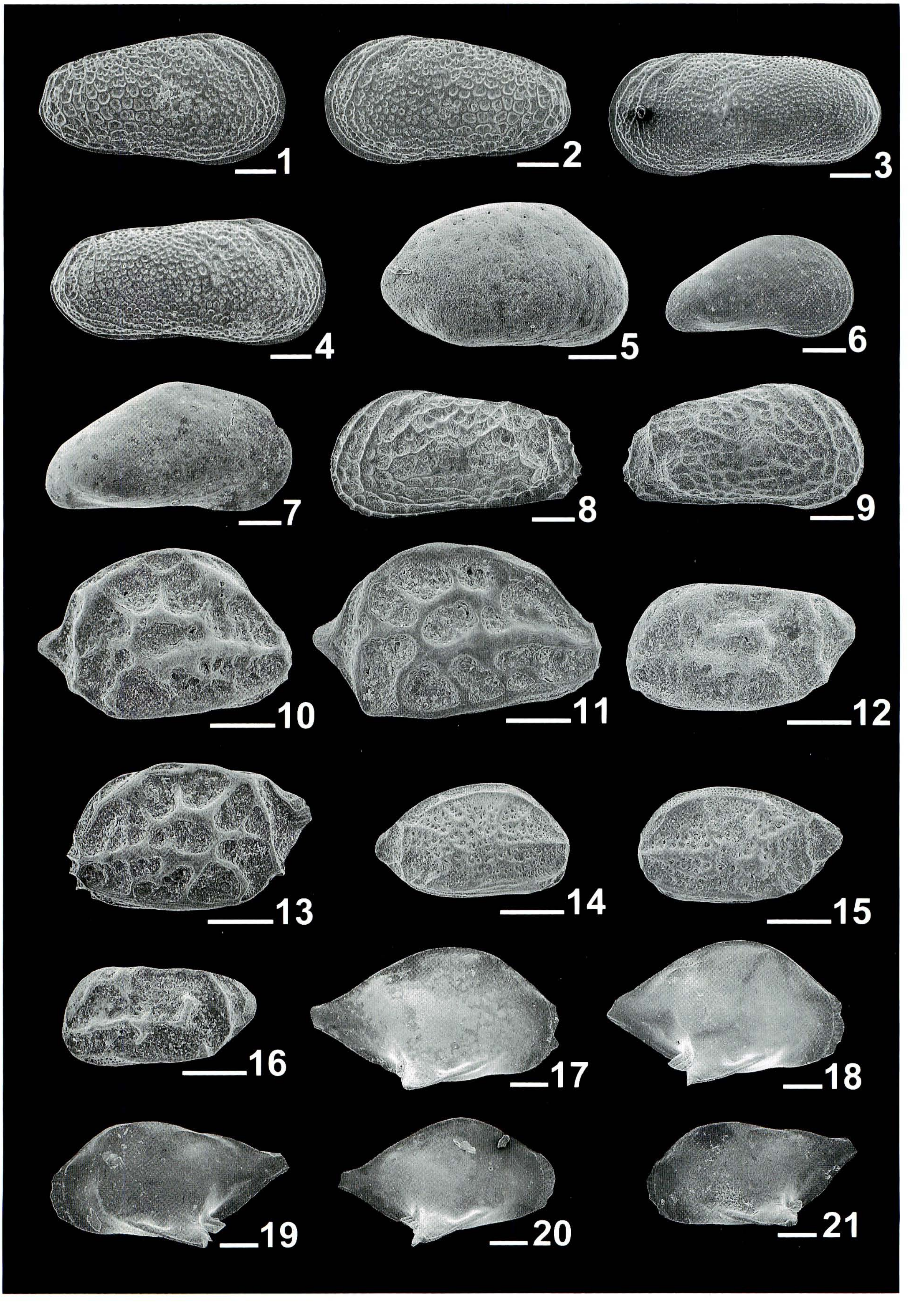
Figs. 8, 9 *Finmarchinella uranipponica* Ishizaki, 1969
8. Lateral view of left valve, juvenile, sample no. 24.
9. Lateral view of right valve, juvenile, sample no. 24D.

Figs. 10-15 *Hemicytherura cuneata* Hanai, 1957
10. Lateral view of right valve, adult, sample no. 24D.
11. Lateral view of right valve, adult, sample no. 24.
12. Lateral view of left valve, adult, sample no. 16.
13. Lateral view of left valve, adult, sample no. 17D.
14. Lateral view of right valve, juvenile, sample no. 16.
15. Lateral view of left valve, juvenile, sample no. 16.

Fig. 16 *Hemicytherura tricarinata* Hanai, 1957
Lateral view of left valve, sample no. 17.

Figs. 17-21 *Kobayashiina donghaiensis* Zhao, 1988
17. Lateral view of right valve, adult, sample no. 25.
18. Lateral view of right valve, adult, sample no. 16.
19. Lateral view of left valve, adult, sample no. 24.
20. Lateral view of right valve, juvenile, sample no. 16.
21. Lateral view of left valve, juvenile, sample no. 25.

Plate 5

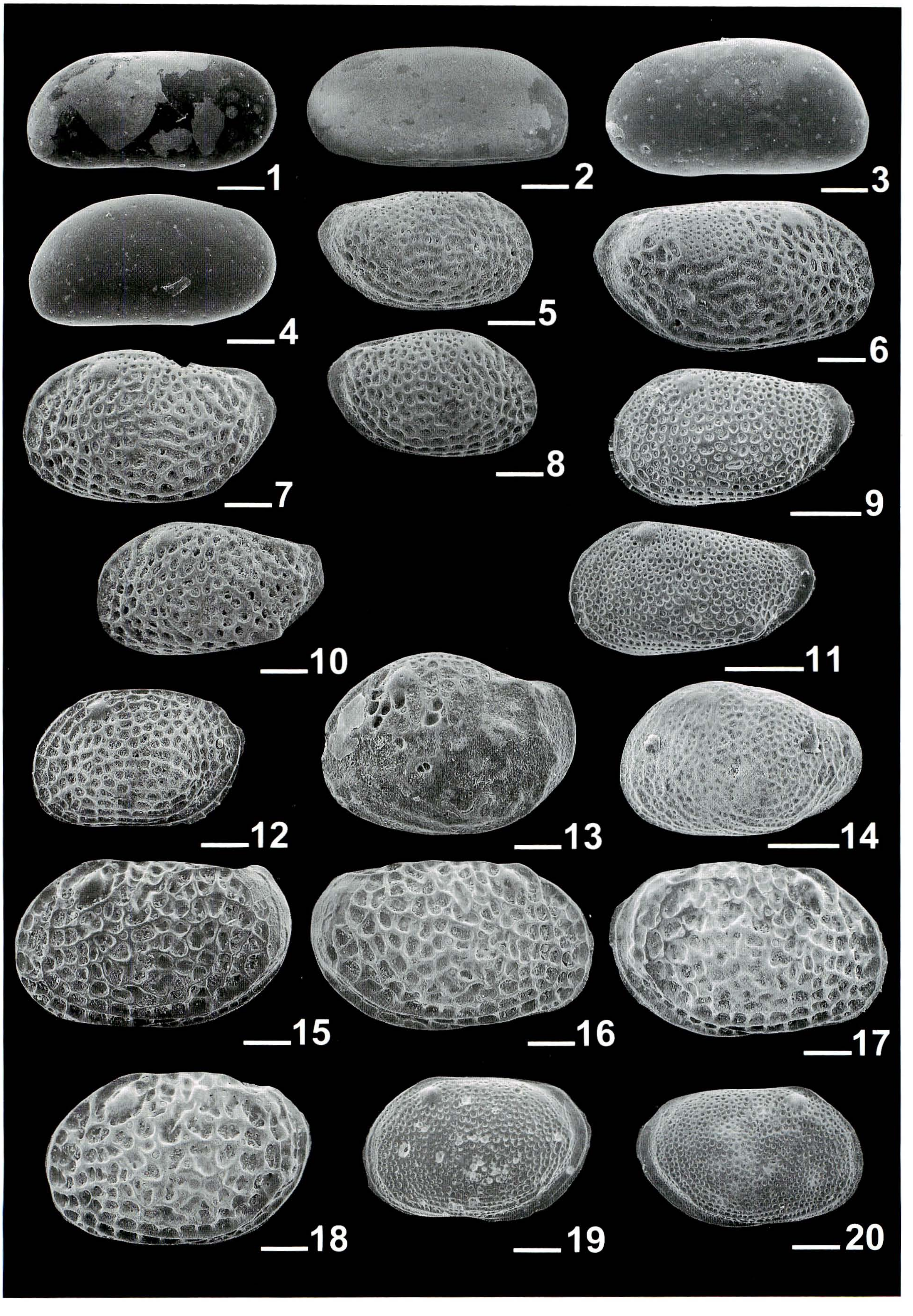


Explanation of Plate 6

Scale bars = 100 μm

Figs. 1-4	*Krithe japonica* Ishizaki, 1971 1. Lateral view of right valve, adult, male, sample no. 17. 2. Left lateral view of carapace, adult, male, sample no. 17. 3. Lateral view of left valve, adult, female, sample no. 17. 4. Lateral view of right valve, adult, female, sample no. 16.
Figs. 5-9	*Loxoconcha epeterseni* Ishizaki, 1981 5. Lateral view of right valve, male, sample no. 25. 6. Lateral view of right valve, adult, male, sample no. 24D. 7. Lateral view of left valve, adult, female, sample no. 24D. 8. Lateral view of right valve, female, sample no. 24D. 9. Lateral view of left valve, juvenile, sample no. 16.
Figs. 10, 11	*Loxoconcha harimensis* Okubo, 1980 10. Lateral view of left valve, adult, female, sample no. 17D. 11. Lateral view of left valve, juvenile, sample no. 30.
Fig. 12	*Loxoconcha japonica* Ishizaki, 1968 Lateral view of left valve, juvenile, sample no. 24D.
Fig. 13	*Loxoconcha kattoi* Ishizaki, 1968 Lateral view of left valve, adult, sample no. 24D.
Fig. 14	*Loxoconcha pulchra* Ishizaki, 1968 Lateral view of left valve, juvenile, sample no. 25.
Figs. 15-20	*Loxoconcha tosaensis* Ishizaki, 1968 15. Lateral view of left valve, adult, male, sample no. 5. 16. Lateral view of right valve, adult, male, sample no. 5. 17. Lateral view of right valve, adult, female, sample no. 5. 18. Lateral view of left valve, adult, female, sample no. 5. 19. Lateral view of left valve, juvenile, sample no. 5. 20. Lateral view of right valve, juvenile, sample no. 5.

Plate 6



Explanation of Plate 7

Scale bars = 100μm

Figs. 1, 2 *Loxoconcha uranouchiensis* Ishizak, 1968
1. Lateral view of right valve, juvenile, sample no. 16.
2. Lateral view of left valve, adult, male, sample no. 28.

Figs. 3-5 *Loxoconcha cf. uranouchiensis* Ishizak, 1968
3. Lateral view of left valve, adult, sample no. 24.
4. Lateral view of right valve, adult, sample no. 24.
5. Lateral view of right valve, adult, sample no. 24.

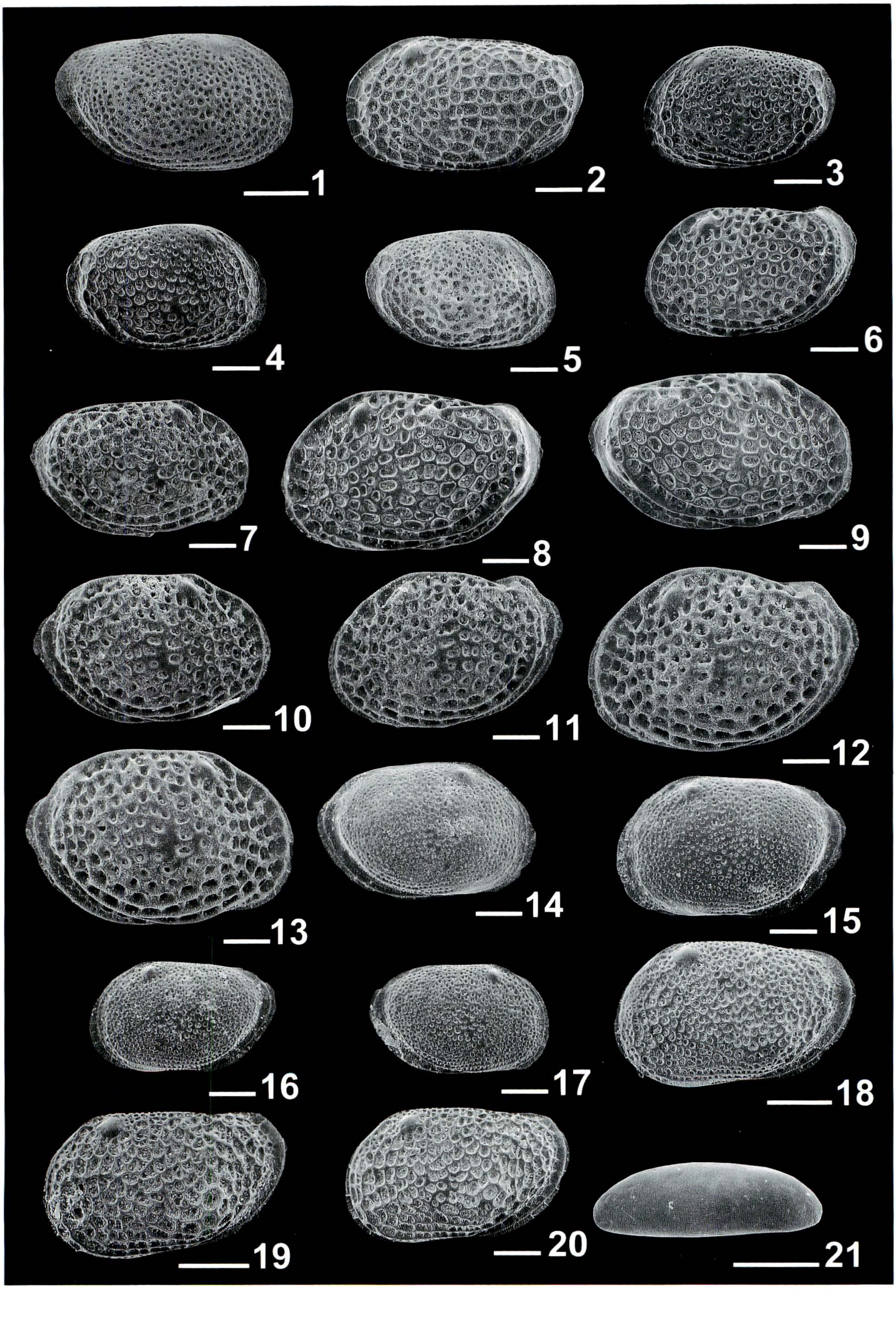
Figs. 6-17 *Loxoconcha viva* Ishizak, 1968
6. Lateral view of left valve, adult, male, sample no. 22.
7. Lateral view of right valve, adult, male, sample no. 22.
8. Lateral view of left valve, adult, male, sample no. 22.
9. Lateral view of right valve, adult, male, sample no. 22.
10. Lateral view of right valve, adult, female, sample no. 22.
11. Lateral view of left valve, adult, female, sample no. 22.
12. Lateral view of left valve, adult, female, sample no. 22.
13. Lateral view of right valve, adult, female, sample no. 22.
14. Lateral view of right valve, juvenile, sample no. 22.
15. Lateral view of left valve, juvenile, sample no. 22.
16. Lateral view of left valve, juvenile, sample no. 22.
17. Lateral view of right valve, juvenile, sample no. 22.

Fig. 18 *Loxoconcha* sp. 1
Lateral view of left valve, juvenile, sample no. 30.

Figs. 19, 20 *Loxoconcha* sp. 2
19. Lateral view of left valve, juvenile, sample no. 30.
20. Lateral view of left valve, juvenile, sample no. 30.

Fig. 21 *Microcythere* sp. 1
Lateral view of left valve, juvenile, sample no. 17D.

Plate 7

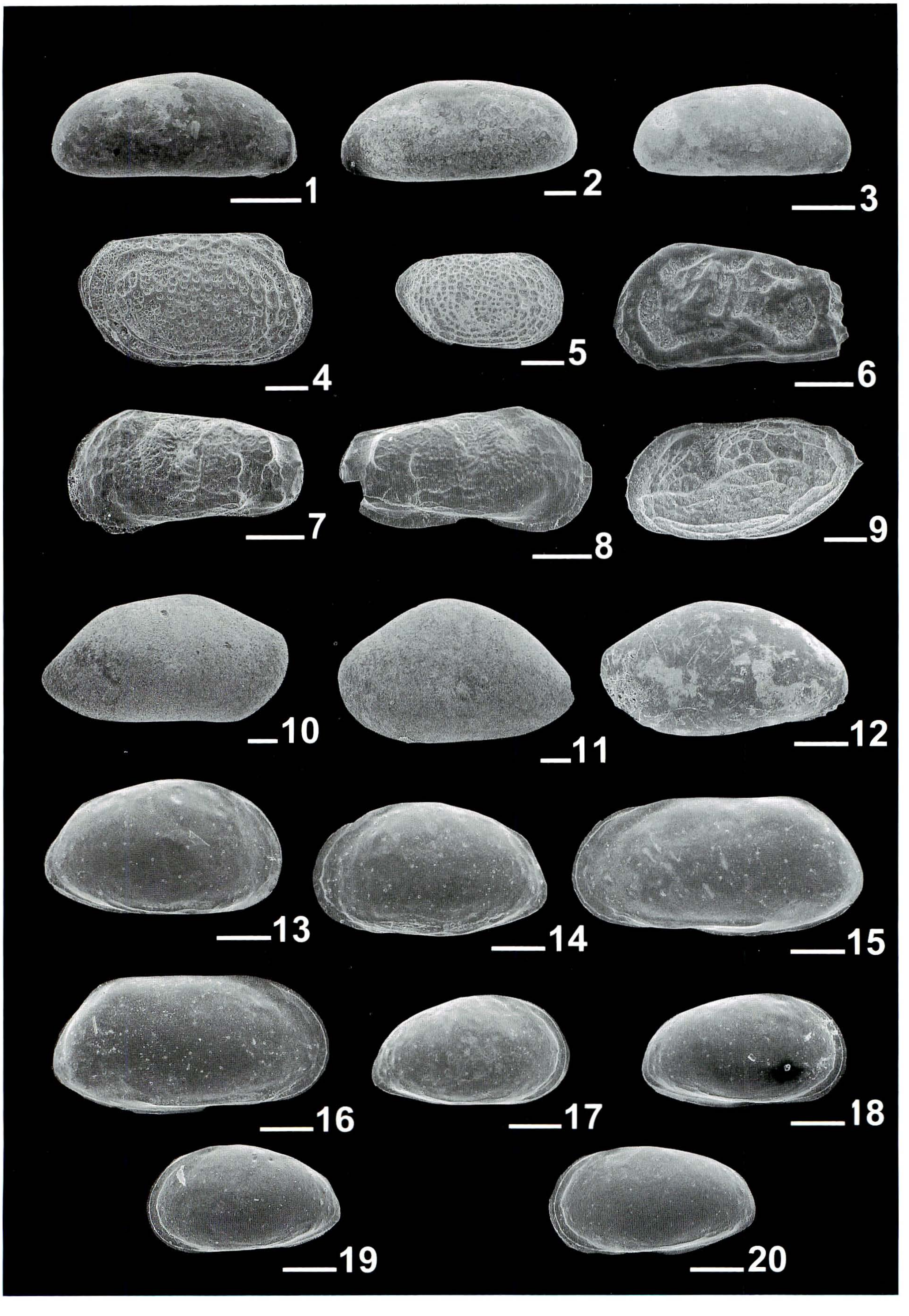


Explanation of Plate 8

Scale bars = 100μm

Fig. 1	*Microcythere* sp. 2 Lateral view of left valve, sample no. 24D.
Figs. 2, 3	*Microcythere* sp. 3 2. Lateral view of right valve, adult, sample no. 25. 3. Lateral view of left valve, juvenile, sample no. 25.
Figs. 4, 5	*Miia uranouchiensis* Ishizaki, 1968 4. Lateral view of right valve, adult, sample no. 25. 5. Lateral view of right valve, juvenile, sample no. 25.
Fig. 6	*Munseyella oborozukiyo* Yajima, 1982 Left lateral view of carapace, adult, sample no. 24.
Figs. 7, 8	*Munseyella* sp. 7. Lateral view of left valve, juvenile, sample no. 16. 8. Lateral view of right valve, juvenile, sample no. 18.
Fig. 9	*Neomonoceratina delicata* Ishizaki and Kato, 1976 Left lateral view of carapace, adult, sample no. 24D.
Figs. 10, 11	*Neonesidea oligodentata* (Kajiyama, 1913) 10. Lateral view of right valve, adult, sample no. 24D. 11. Lateral view of left valve, adult, sample no. 24D.
Fig. 12	*Neonesidea* sp. Lateral view of left valve, sample no. 18.
Figs. 13-20	*Nipponocythere bicarinata* (Brady, 1880) 13. Lateral view of right valve, adult, female, sample no. 20. 14. Lateral view of left valve, adult, female, sample no. 11. 15. Lateral view of left valve, adult, male, sample no. 11. 16. Lateral view of right valve, adult, male, sample no. 11. 17. Lateral view of right valve, juvenile, female?, sample no. 11. 18. Lateral view of right valve, juvenile, male?, sample no. 11. 19. Lateral view of left valve, juvenile, female?, sample no. 11. 20. Lateral view of left valve, juvenile, male?, sample no. 11.

Plate 8



Explanation of Plate 9

Scale bars = 100μm

Fig. 1 *Paracytherois tosaensis* Ishizaki, 1968
Lateral view of left valve, sample no. 5.

Figs. 2-4 *Parakrithella pseudadonta* (Hanai, 1959)
2. Lateral view of left valve, adult, sample no. 24.
3. Lateral view of right valve, adult ?, sample no. 24D.
4. Lateral view of right valve, juvenile, sample no. 30.

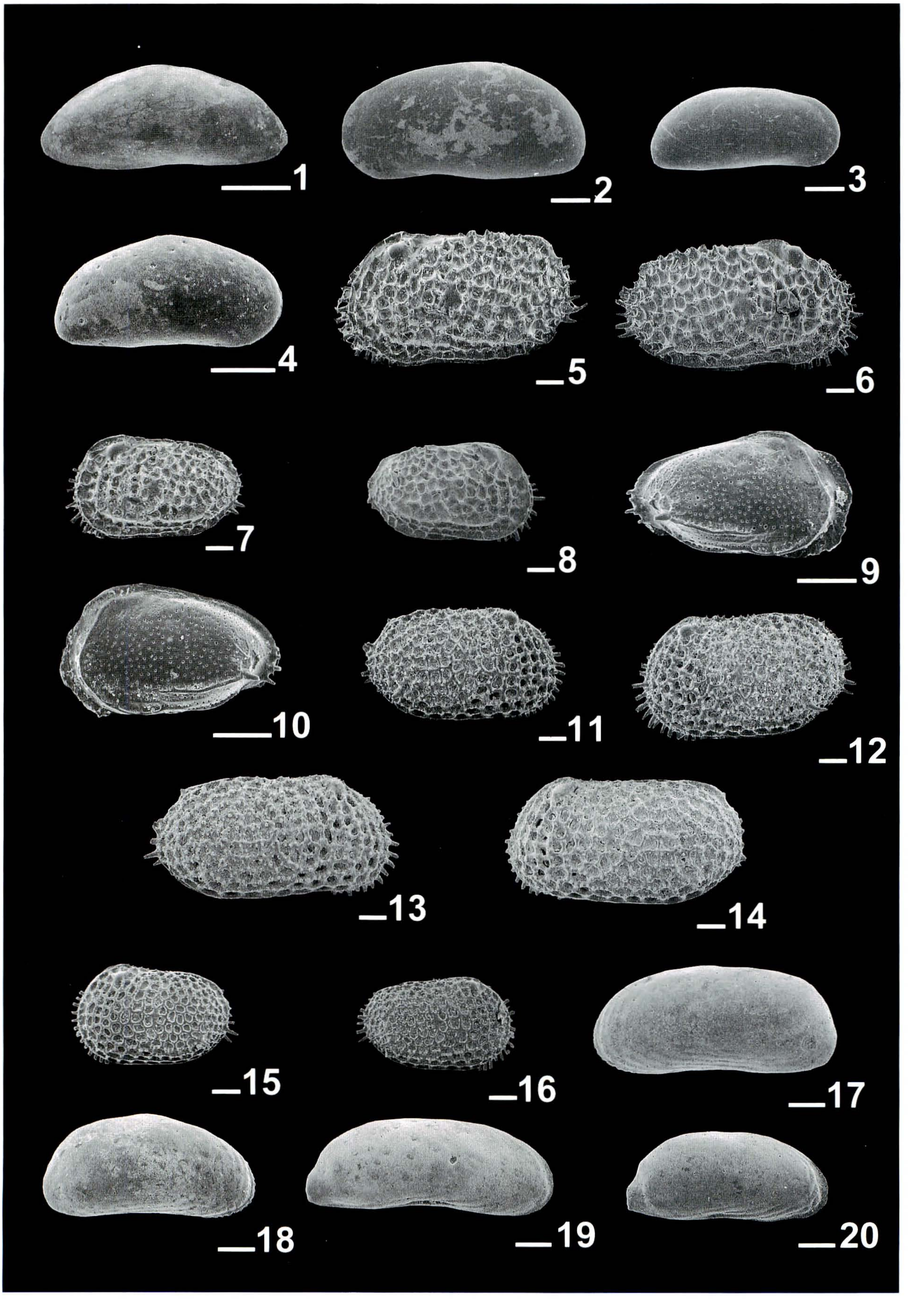
Figs. 5-10 *Pistocythereis bradyformis* (Ishizaki, 1968)
5. Lateral view of left valve, adult, sample no. 17.
6. Lateral view of right valve, adult, sample no. 17D.
7. Lateral view of left valve, juvenile, sample no. 17D.
8. Lateral view of right valve, juvenile, sample no. 24D.
9. Lateral view of right valve, juvenile, sample no. 17.
10. Lateral view of left valve, juvenile, sample no. 17.

Figs. 11-16 *Pistocythereis bradyi* (Ishizaki, 1968)
11. Lateral view of right valve, adult, female, sample no. 8.
12. Lateral view of left valve, adult, female, sample no. 17.
13. Lateral view of right valve, adult, male, sample no. 24.
14. Lateral view of left valve, adult, male, sample no. 24.
15. Lateral view of left valve, juvenile, sample no. 9.
16. Lateral view of right valve, juvenile, sample no. 27.

Figs. 17, 18 *Pontocythere miurensis* (Hanai, 1959)
17. Lateral view of left valve, adult, sample no. 24.
18. Lateral view of right valve, adult, sample no. 24.

Figs. 19, 20 *Pontocythere* cf. *subjaponica* (Hanai, 1959)
19. Lateral view of right valve, adult, sample no. 24.
20. Lateral view of right valve, adult, sample no. 24D.

Plate 9

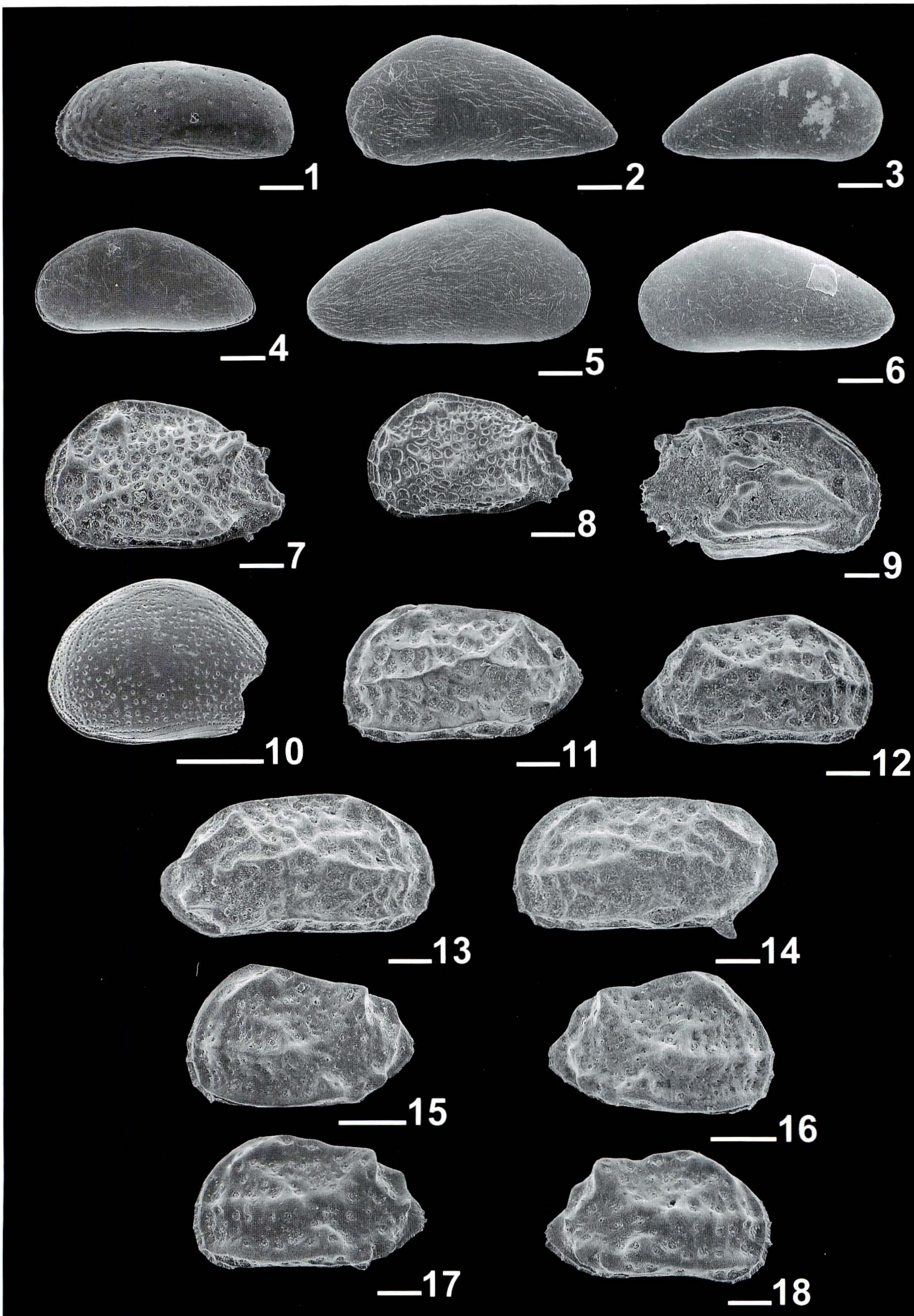


Explanation of Plate 10

Scale bars = 100μm

Fig. 1	*Pontocythere* sp. Lateral view of left valve, sample no. 24D.
Figs. 2, 3	*Propontocypris attenuata* (Brady, 1868) 2. Lateral view of left valve, adult, sample no. 30. 3. Lateral view of right valve, adult, sample no. 30.
Fig. 4	*Propontocypris* sp. 1 Left lateral view of carapace, sample no. 24D.
Figs. 5, 6	*Propontocypris* sp. 2 5. Lateral view of right valve, sample no. 28. 6. Lateral view of left valve, sample no. 28.
Figs. 7, 8	*Robustaurila ishizakii* (Okubo, 1980) 7. Lateral view of left valve, juvenile, sample no. 24. 8. Lateral view of left valve, juvenile, sample no. 17D.
Fig. 9	*Robustaurila kianohybridus* (Hu, 1982) Right lateral view of carapace, adult, sample no. 24D.
Fig. 10	*Rotundracythere* ? sp. Lateral view of right valve, sample no. 16.
Figs. 11-18	*Schizocythere kishinouyei* (Kajiyama, 1913) 11. Lateral view of left valve, adult, female, sample no. 24. 12. Lateral view of right valve, adult, female, sample no. 24. 13. Lateral view of right valve, adult, male, sample no. 24. 14. Lateral view of left valve, adult, male, sample no. 24D. 15. Lateral view of left valve, juvenile, sample no. 16. 16. Lateral view of right valve, juvenile, sample no. 16. 17. Lateral view of left valve, juvenile, sample no. 24. 18. Lateral view of right valve, juvenile, sample no. 24.

Plate 10

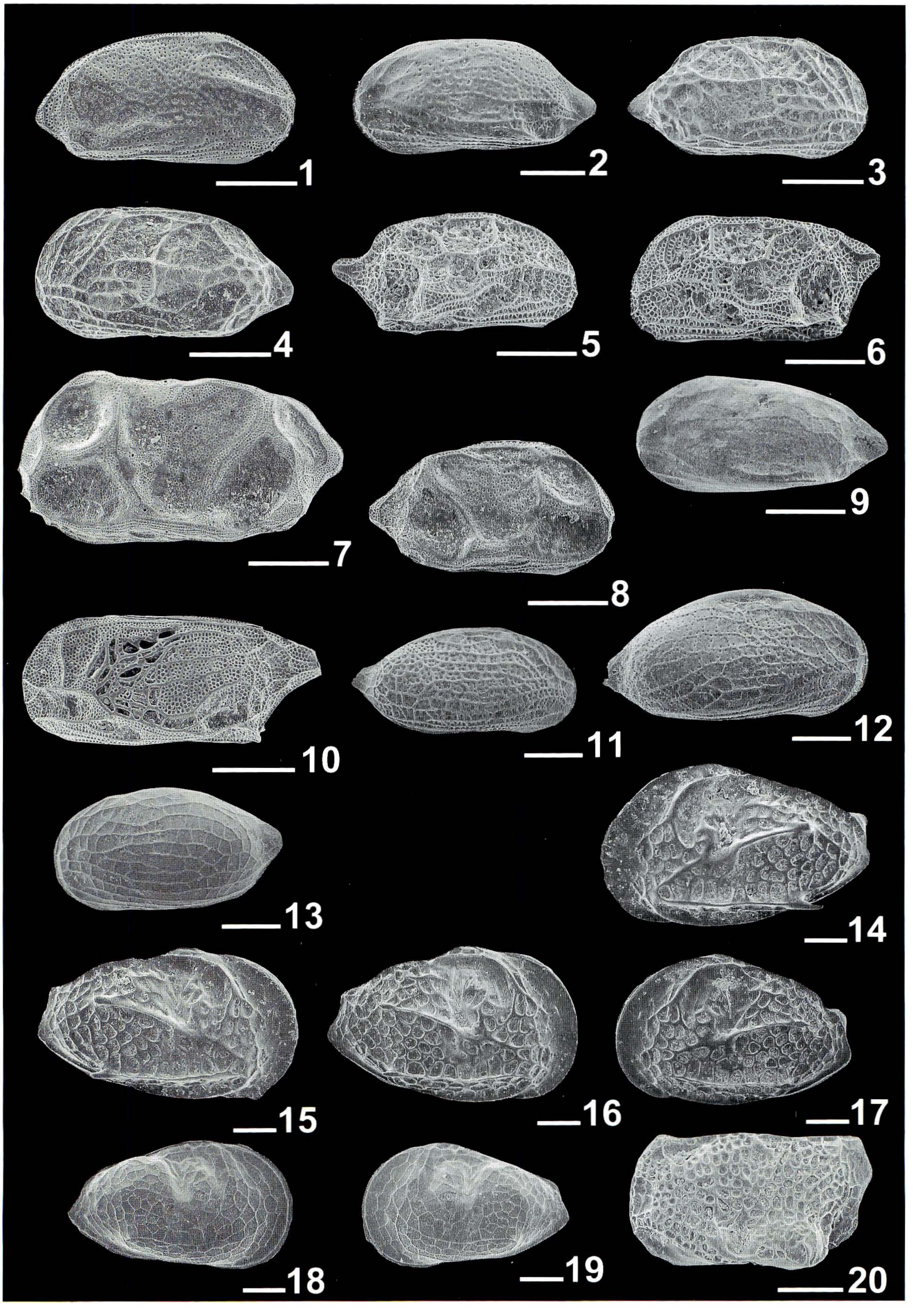


Explanation of Plate 11

Scale bars = 100μm

Fig. 1	*Semicytherura henryhowei* Hanai and Ikeya, 1977 Lateral view of right valve, juvenile, sample no. 30.
Fig. 2	*Semicytherura mukaishimensis* Okubo, 1980 Lateral view of left valve, adult, sample no. 17.
Figs. 3, 4	*Semicytherura polygonoreticulata* Ishizaki and Kato, 1976 3. Lateral view of right valve, adult, sample no. 16. 4. Left lateral view of carapace, adult, sample no. 16.
Figs. 5, 6	*Semicytherura yajimae* Ikeya and Zhou, 1992 5. Lateral view of right valve, adult, sample no. 16. 6. Lateral view of left valve, adult, sample no. 18.
Figs. 7, 8	*Semicytherura* sp. 1 7. Lateral view of left valve, adult, sample no. 24. 8. Lateral view of right valve, juvenile, sample no. 16.
Fig. 9	*Semicytherura* sp. 2 Lateral view of left valve, juvenile, sample no. 16.
Fig. 10	*Semicytherura* sp. 4 Left lateral view of carapace, adult, sample no. 18.
Fig. 11	*Semicytherura* sp. 5 Lateral view of right valve, sample no. 30.
Figs. 12, 13	*Semicytherura* sp. 6 11. Lateral view of right valve, sample no. 24D. 12. Lateral view of left valve, sample no. 24D.
Figs. 14-19	*Spinileberis quadriaculeata* (Brady, 1880) 14. Lateral view of left valve, adult, male, sample no. 5. 15. Lateral view of right valve, adult, male, sample no. 5. 16. Lateral view of right valve, adult, female, sample no. 5. 17. Lateral view of left valve, adult, female, sample no. 28. 18. Lateral view of right valve, juvenile, sample no. 28. 19. Lateral view of left valve, juvenile, sample no. 27.
Fig. 20	*Sulcocytherura* sp. Lateral view of left valve, sample no. 17D.

Plate 11



Explanation of Plate 12

Scale bars = 100μm

Figs. 1–6 *Trachyleberis scabrocuneata* (Brady, 1880)
1. Lateral view of right valve, juvenile, sample no. 17D.
2. Lateral view of left valve, juvenile, sample no. 17D.
3. Lateral view of right valve, adult, male, sample no. 17D.
4. Lateral view of left valve, adult, male, sample no. 19.
5, 6. Lateral views of left and right valves from same individual, adult, female, sample no. 19.

Figs. 7, 8 *Trachyleberis* cf. *scabrocuneata* (Brady, 1880)
7. Lateral view of right valve, juvenile, sample no. 24D.
8. Lateral view of left valve, juvenile, sample no. 24D.

Figs. 9–13 *Trachyleberis* sp.
9. Lateral view of left valve, adult, female, sample no. 24.
10. Lateral view of right valve, adult, female, sample no. 24.
11. Lateral view of left valve, adult, male, sample no. 24D.
12. Lateral view of left valve, juvenile, sample no. 17D.
13. Lateral view of right valve, juvenile, sample no. 24D.

Fig. 14 *Xestoleberis hanaii* Ishizaki, 1968
Lateral view of right valve, juvenile, sample no. 17.

Figs. 15, 16 *Xestoleberis* sp. 2
15. Lateral view of left valve, sample no. 18.
16. Lateral view of left valve, sample no. 18.

Fig. 17 *Xestoleberis* sp. 3
Lateral view of left valve, adult, sample no. 24D.

Figs. 18, 19 *Xiphichilus* sp.
18. Lateral view of left valve, sample no. 18.
19. Lateral view of right valve, sample no. 24D.

Fig. 20 Gen. et sp. indet. 5
Lateral view of left valve, sample no. 30.

Fig. 21 Gen. et sp. indet. 6
Lateral view of left valve, sample no. 25.

Plate 12