Recent ostracod assemblages from the northeastern coast of Vietnam and the biogeographical significance of the euryhaline species

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ABSTRACT: We report on Recent podocopid ostracods from the northern coast of Vietnam, describe two new ostracod species (*Loxoconcha vietnamensis* and *Caudites huyeni*), and describe the appendages of *Loxoconcha ocellata* Ho 1982. We identified 75 species from 15 Recent surface-sediment samples and recognized three biofacies (I, II, III) based on salinity ranges. Among these, biofacies II commonly occurs in marine to brackish waters over a wide range of salinity. The Recent ostracod assemblages of the northeastern coast of Vietnam shows a strong connection with the ostracod fauna of the coast of China.

INTRODUCTION

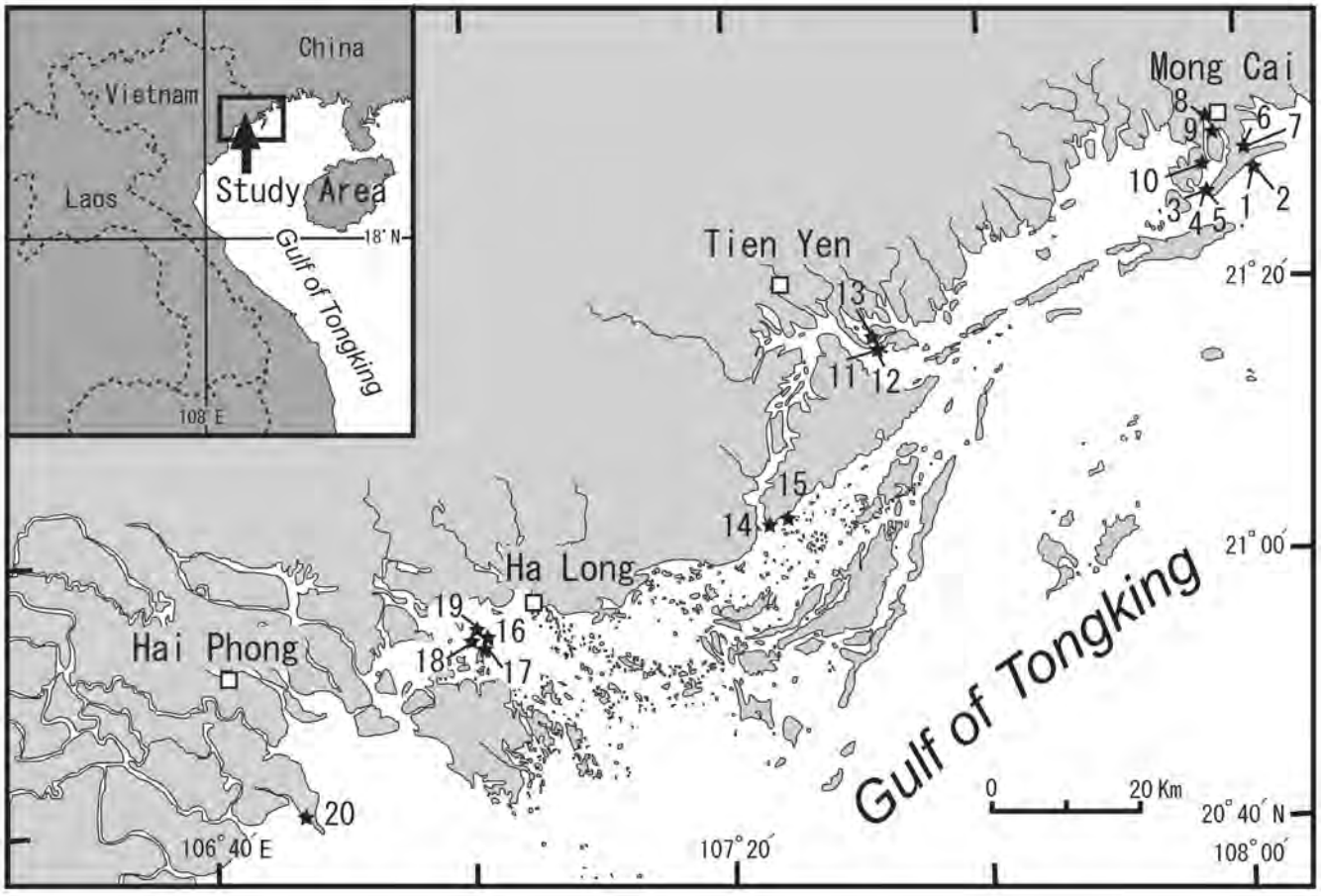
Since the publication of a checklist of Ostracoda from Southeast Asia (Hanai et al. 1980), our knowledge of the Recent benthic ostracod faunas of the region, including the East China Sea and Yellow Sea, has dramatically improved (Zhao et al. 1985; Whatley and Zhao 1987a, 1988; Whatley and Watson 1988; Zhao and Wang 1988; Zhao and Whatley 1989; Gou 1990; Mostafawi 1992; Mostafawi et al. 2005; Zhao 1984). The composition and biogeography of Recent ostracods along the eastern coast of Asia, including Southeast Asia, are particularly important in considering the dispersal and speciation of benthic marine animals in this region. However, information on Recent ostracod assemblages from the coast of the Indochinese Peninsula is completely lacking, although some Cenozoic fossil ostracods have been reported (Schneider 1971; Herrig 1976, 1977a, b, c, 1978). The purpose of our study was to characterize Recent ostracod assemblages along the northern coast of Vietnam and to examine the biogeographical significance of the relationship between these assemblages and those of adjacent areas.

STUDY AREA, MATERIAL AND METHODS

The coast of Vietnam comprises the eastern part of the Indochinese Peninsula and faces the South China Sea. The study area where we conducted sampling extended for 125 km along the northern coastline of Vietnam in the Gulf of Tonking (text-fig. 1). The coastline is complex, indented with the mouths of many large and small rivers, with hundreds of large and small islands making up coastal archipelagos. In the northern part of the study area, there are typical wave-dominated estuaries (barrier estuaries) with some barrier islands and coastal sand bars in the Mong Cai and Tien Yen areas. Ha Long Bay is situated in the central to southern parts of study area. Coastal areas in Hai Phong are characterized by rocky shores and beaches of gravel and sand.

In this study, we collected surface-sediment samples at 15 sampling sites (text-fig. 1, stars) by hand (at Stn.3) or by dragging a skimming net sampler (at Stns. 1-2 and 4-20). At Stns 1, 2, and 16-19, samples were collected by towing the sampler from a boat. Other samples were collected by dragging the sampler on shore at low tide. About15 cm^3 of surface sediment were sampled at each station. Usually there was only one sampling station per site, although samples were taken at two or three stations at some sites. In all, 20 stations were sampled (Table 1), although only one sample per site was analyzed in this study. Sediment samples were washed through a sieve of 45μm mesh size and dried in an oven at 60°C, and ostracod specimens were then picked out under a stereoscopic microscope (Nikon SMZ-U). The dried ostracod specimens were softened in a 10% sodium tripolyphosphate solution. Appendages were dissected from the ostracods in glycerine under a stereoscopic microscope (Nikon SMZ-U), mounted in Neo-Shigaral on glass slides, and covered with a cover slip. Removed valves were also immersed in glycerine on glass slides. Appendages and valves were drawn with the aid of a camera lucida mounted on a stereoscopic microscope (Olympus BX41). Other carapaces were mounted on stubs, coated with gold by using a JEOL ion sputter coater (JFC-1100), and viewed with a JEOL scanning electron microscope (JSM-6100). We interpreted ostracod specimens with appendages to mean that these specimen lived in the sample site (were autochthonous), and also interpreted the specimens consisting only of empty valves to mean that the specimens were dead and/or transported (were allochthonous) upon collection. Measurements (length and height) of specimens were made to the nearest 0.01 mm with an ocular micrometer.

To analyze biogeographic relationships, the Recent ostracod assemblages from northern Vietnam were compared with the ostracod faunas of adjacent areas. These areas and the studies from which information was extracted are as follows: Malacca Straits (Whatley and Zhao 1987a, 1988); Malay Peninsula, In-



TEXT-FIGURE 1
Map of the study area in the Gulf of Tonking, indicating sampling sites (stars); inset shows the location of the study area on the northern coast of Vietnam. Numbers indicating stations where samples were taken correspond to those in Table 1.

dian Ocean, and Indonesia (Zhao and Whatley 1989); Sunda Shelf (Mostafawi 1992); Hainan Island (Gou 1990); East China Sea and Yellow Sea (Zhao 1984; Whatley and Zhao 1987b; Wang, P. et al. 1988); off China (Zhao and Wang 1988); Southeast Asia (Hanai et al. 1980; Zhao and Whatley 1993); and Japan (Hanai et al. 1977). Of the 75 species found in this study, 32 (43%) were undescribed; the other 43 have been reported from neighboring regions. Among the 43 described species we found in Vietnam, *Callistocythere spectata*, *Coquimba gibboidea*, *Hemicytherura apta*, *Hemicytherura subcellulosiformis*, *Semicytherura* sp. 3, and *Wichmannella miaoliensis* were previously known only as fossils from Late Neogene deposits in Far Eastern Asia (Hu and Yang 1975; Hu 1976, 1982; Hou et al. 1982; Ruan and Hao 1988) and were excluded from the biogeographical analysis.

RESULTS

Ostracod assemblages and biofacies

Seventy-five species were identified in the analysis of 15 samples (one from each site) from the northern coast of Vietnam (Table 2). To investigate the geographic distribution of ostracod assemblages, we initially performed a Q-mode cluster analysis using the weighted pair-group arithmetic average based on Horn's overlap index (Horn 1966) on the 10 samples that contained more than 100 specimens each; however, we observed no obvious geographic patterns from this analysis. We then examined the relationship between the salinity measured at each station and the frequency of occurrence of living and/or dead specimens of 19 prominent species (Plate 1). We defined prominent species as those for which more than 10 total individuals were collected as living specimens. We recognized the following three biofacies (I, II, III) (text-fig. 2) based on the classification of habitat according to salinity range (35-30 psu, marine; <30 psu, brackish-water) as suggested by Wang et al. (1985).

Biofacies I: This biofacies is characterized by *Propontocypris clara*, *Copytus posterosulcus*, *Tanella gracilis* s.l., *Neocytheretta murilineata*, *Lococoncha vietnamensis*, *Tanella* sp, *Caudites* sp., and *Paracypris* sp. Living individuals of these species were restricted to the marine environment (35-31 psu).

Biofacies II: This biofacies comprised nine characteristic species that ranged from marine to brackish-water environments. Among these species, *Hemicytheridea reticulata*, *Neomonoceratina delicata*, *Bicornucythere bisanensis* s.l., *Sinocytheridea impressa*, *Pontocythere miurensis*, *Loxoconcha ocellata* and *Propontocypris euryhalina* occurred commonly over a wide range of salinity (35-24 psu), as in other regions (Wang et al. 1985, Tanaka et al. 1998, Nakao and Tsukagoshi 2002). In the

TABLE 1
Location and habitat information for the 20 sampling stations in this study. Abbreviations for sediment type: c, coarse; f, fine; m, medium; mdy, muddy; sd, sand.

St.	Sediment	alinity (PSU	Latitude	Longitude	Coll. Date	Remarks
1	f-sd	33	21°28' 13"N,	108°01' 13"E	19, March, 2007	630m offshore (5m in depth) from Tra Co Beach, Mong Cai
2	f-sd	32	21°28' 26"N,	108°01' 10"E	19, March, 2007	360m offshore (4m in depth) from Tra Co Beach, Mong Cai
3	c-sd	29	21°26' 12"N,	107°57' 95"E	19, March, 2007	Tide pool (about 10-50cm in depth) in outer estuary, Mui Ngoc, Mong Cai
4	c-sd	28	21°26' 12"N,	107°57' 95"E	19, March, 2007	Shelly sand beach in outer estuary (about 1.5m in depth), Mui Ngoc
5	m-sd	28	21°26' 12"N,	107°57' 95"E	19, March, 2007	Tidal channel in outer estuary, 200m offshore from shelly sand beach (about 2.5m in depth) Mui Ngoc, Shell Beach
6	mdy f-sd	24	21°29' 33"N,	108°00' 70"E	19, March, 2007	Inter tidal flat with mangrove in bay (about 20-50cm in depth), Mong Cai
7	mdy f-sd	29	21°29' 33"N,	108°00' 70"E	20, March, 2007	Inter tidal flat with mangrove in bay (about 20-50cm in depth), Mong Cai
8	c-sd	3	21°31' 81"N,	107°57' 94"E	20, March, 2007	Inner estuary, Ka Long River (about 50cm in depth), Mong Cai
9	c-sd	16	21°30' 56"N,	107°58' 38"E	20, March, 2007	Inner estuary, Ka Long River (about 1m in depth), Mong Cai
10	m-sd	18	21°27' 45"N,	107°57' 38"E	20, March, 2007	30m offshore from tidal sand bar in central estuary (about 1.5m, Mong Cai)
11	m-sd	32	21°17' 14"N,	107°27' 18"E	20, March, 2007	Rocky coast and pocket sand beach in estuarine mouth (about 70cm in depth) Mui Chau, Tien Lang, Tien Yen
12	mdy f-sd	31	21°17' 14"N,	107°27' 18"E	20, March, 2007	Rocky coast and pocket sand beach in estuarine mouth (about 70cm in depth) Mui Chau, Tien Lang, Tien Yen
13	mud	31	21°17' 26"N	107°27' 12"E	20, March, 2007	Tide pool with mangrove in central estuary (ca. 20-50cm in depth), Mui Chau, Tien Lang, Tien Yen, Quang Ninh Province
14	m-sd	33	21°02' 48"N,	107°23' 08"E	20, March, 2007	Rocky coast-sand beach (about 50 cm in depth), Cai Bau Island, Van Don
15	mdy f-sd	32	21°03' 78"N,	107°25' 88"E	20, March, 2007	Muddy sand beach(about 50cm in depth), Cai Bau Island, Van Don
16	mdy f-sd	35	20°54' 48"N,	107°00' 72"E	21, March, 2007	Central bay, Ha Long Bay (3m in depth)
17	mdy f-sd	34	20°54' 00"N	107°00' 80"E	21, March, 2007	Central bay, Ha Long Bay (3.5m in depth)
18	mdy f-sd	34	20°54' 77"N,	107°01' 20"E	21, March, 2007	150m offshore (1.5m in depth) from Thien Cung Cave Island, Ha Long Bay
19	mdy f-sd	34	20°55' 77"N,	107°01' 53"E	21, March, 2007	Central bay (4.5m in depth), Ha Long Bay
20	f-sd	26	20°41' 71"N,	106°47' 21"E	21, March, 2007	Rocky coast and pocket sand beach (about 50cm in depth), Do Son

East China Sea, *P. euryhalina* has previously been reported over an extremely wide range of salinity, from 51.5 to 1.3 psu (Zhao 1984).

Biofacies III: This biofacies was represented by two species, *Propontocypris* sp. 1, and *Malaycythereis* sp., that were commonly found in brackish-water environments (29-24 psu).

Biogeographic relationships to adjacent areas

Text-fig. 3 indicates the distributions of the 37 species that had been previously described from Recent material; six species previously described only from fossil materials are excluded. Four species (*Atjehella semiplicata*, *Keijia demissa*, *Ruggieria darwini*, *Tanella gracilis* s.l.) are widespread from the Indian Ocean to the West Pacific (Indonesia, Malay Peninsula/Sunda Shelf, Vietnam, and China/Japan). Five species (*Copytus posterosulcus*, *Hemicytheridea reticulata*, *Hemikrithe orientalis*, *Javanella kendengensis*, *Loxoconcha sinensis*) occur in the West Pacific (Indonesia, Malay Peninsula/Sunda Shelf). The 24 species (*Alocopocythere profusa* and below in text-fig. 3) have ranges extending east and north of Vietnam, through the northern South China Sea to the East and Yellow Seas and Japanese coastal waters.

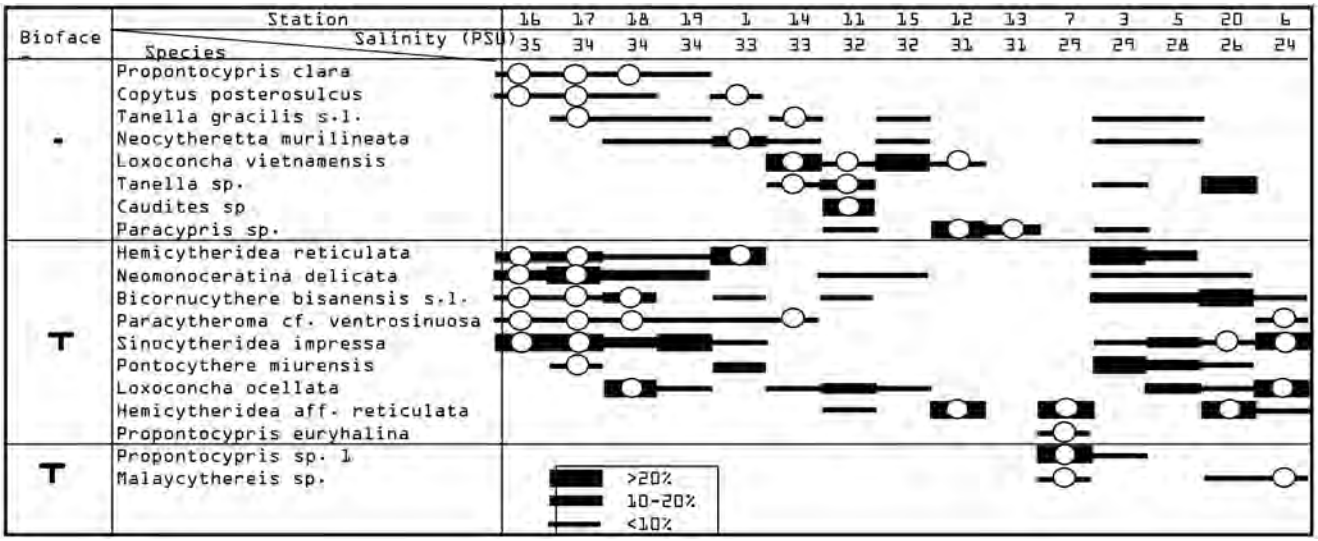
DISCUSSION

Text-figure 2 indicates that some of the ostracod species along the northern coast of Vietnam are adapted to a wide range of salinity. For example, although *Sinocytheridea impressa* inhabits coastal marine environments over a wide range of salinity along eastern Asia (this study and Wang and Zhao 1985), no living specimens of this species have been reported from Japan. However, fossil specimens of *S. impressa* have been sporadically reported from upper Pliocene to middle Pleistocene deposits in Japan (Ishizaki 1990; Ozawa 1996; Yamada et al. 2002; Irizuki et al. 2005), and these periods of occurrence coincide well with glacial periods. Euryhaline *S. impressa* could easily have expanded its range from the Asian coast to Japan when land bridges and/or shallow (brackish-water) seas appeared. Irizuki et al. (2005) proposed that the disappearance of *S. impressa* from Japan was related to the loss of the turbid, nutrient-rich bays this species inhabits. Along the northern coast of Vietnam, we found living specimens of *S. impressa* not only in turbid, nutrient-rich bays like Ha Long Bay (Stns.16, 17), but also in a mangrove swamp (Stn. 6) and in brackish conditions on bottoms of fine sand off a rocky coast (Stn. 20). Thus, *S. impressa* inhabits a wide range of estuarine environments with turbid, nutrient-rich conditions. The disappearance of extensive estuaries from around Japan may have caused the local extinction of *S. impressa* there.

Titterton and Whatley (1988) categorized Neogene and Recent ostracod assemblages from eastern Indochina, Indonesia, the Phillipines, and New Guinea as the East Indian Province, and noted that this province shows strong links with the Southern and Southwestern Pacific, Bengalian, Australian, and Khymerian (Taiwan, central Chinese coast) Provinces. Our study confirmed that the Recent ostracod fauna of the northern coast of Vietnam shows a strong connection with the Khymerian Province (particularly with the coast of China), as Titterton and Whatley (1988) had suggested. Future research will include the assessment of morphological changes in ostracod valves in detailed chronological order by studying drilling cores collected in Vietnam (Saito et al. 2004), and morphological studies on Recent ostracods from areas adjacent to Vietnam.

SYSTEMATIC DESCRIPTIONS

Following are descriptions of two new species and one species previously described only known from its valves. Morphological terms follow the usage of Scott (1961) and Athersuch et al. (1989). All ostracod taxa figured in this paper, other than those described below, are listed in alphabetical order in Appendix 1, along with the original name and remarks. All illustrated specimens are deposited in the Campus Museum of Shizuoka University (SUM).



TEXT-FIGURE 2
Diagram showing the 19 characteristic living species occurring in our study area, the biofacies (I-III) in which we have categorized them, and the range of salinity measured in the habitat of each species. White circles indicate samples containing specimens with appendages.

Order PODOCOPIDA Sars 1866
Superfamily CYTHEROIDEA Baird 1850
Family LOXOCONCHIDAE Sars 1925
Genus *Loxoconcha* Sars 1866

Loxoconcha ocellata Ho 1982
Text-figure 4; Plate 1, fig. 15; Plate 2, figs 1-22

Loxoconcha ocellata HO 1982 (in HOU et al. 1982), p. 210, 211, figs 54a, b, pl. 78, figs 27-30. – WANG and ZHAO 1985, pl. 8, fig. 7. – ZHAO and WANG 1988, pl. 1, fig. 6. – WANG, Q. et al 1988, pl. 1, fig. 8. – HOU and GOU 2007, p. 402, 403, pl. 154, figs. 1, 2, pl. 156, figs. 2, 3.
Loxoconcha sp. A IWASAKI 1992, fig. 7.

Material: 173 specimens (Table 2).

Diagnosis: Carapace sub-rhomboidal in lateral outline, dorsal and ventral margins straight and almost parallel. Surface ornamented by primary and secondary reticulation. Sixth segment of antennule with one seta at distal end. Male copulatory organ has large, triangular distal process bearing trapezoidal process proximally; ductus ejaculatorius short, steeple-shaped, folded.

Description: Strong sexual dimorphism of valves (pl. 2, figs. 1-22); in lateral, dorsal, and ventral views, male more elongate; in anterior and posterior views, carapace of female triangular in shape. Eye tubercle present. Surface ornamented with primary and secondary reticulation. On interior, valves have 33 straight marginal pore canals (text-fig. 4A); duplicature well developed; hinge gongylodont; in right valve, anterior hinge element has single large tooth surrounded by depression, median element has numerous fine teeth, and posterior element large, elongate tooth; one Y-shaped frontal scar; four elliptical adductor scars in vertical row; one elliptical mandibular scar. Antennule (text-fig. 4B) with six articulated segments, with fourth and fifth segments fused; length ratio among distal segments 25:22:7:6:11:18; walls especially well developed on second to fifth segments; second segment with seta on posterior distal end and long setules on anterior proximal margin, and with short setules on anterior margin; third segment with seta on anterior distal end; fourth segment with seta on anterior distal end and with short seta on posterior distal end; fifth segment with one long and two shorter setae; sixth segment with one seta at distal end. Antenna (text-fig. 4C) with four articulated segments; length ratio among distal segments 25:12:32:4; walls well developed, especially broad in the third and fourth segments; second segment with long, two-segmented exopodite, several setules on outer lateral side, and one seta on posterior distal end of endopodite; anterior margin of third segment with two unequal plumose setae, posterior margin with one short seta at distal end and one seta in the middle; fourth segment with two stout, claw-like setae. Mandible (text-fig. 4D) five-segmented; length ratio among distal segments 53:7:6:4:2; basal segment (coxa, first segment of protopodite) with about six teeth and with one plumose seta on anterior distal margin; second segment of protopodite (basis) with exopodite consisting of five setae, with one plumose seta on distal margin; first segment of endopodite with two long and three plumose setae; second segment of endopodite with five plumose setae on posterior distal margin and two unequal setae on anterior distal end; third segment of endopodite with four simple setae and one stout seta. Maxillula (text-fig. 4E, F) an extremely thin branchial plate (exopodite) with at least 15 plumose setae; basal podomere bears palp and three masticatory processes, each process with six or seven stout setae. All three thoracic legs (text-fig. 4G-I) four-segmented, but differing somewhat in shape; length ratio among distal segments 70:60:25:33 for first thoracic leg, 78:64:26:37 for second thoracic leg, 49:40:14:23 for third thoracic leg; distal margin of each segment sometimes covered with many short setules; walls well developed on both margins of each segment; first segment with one seta on posterior proximal end and two plumose setae on anterior margin; first segment of first thoracic leg with two simple setae on anterior distal end; first segment of second and third thoracic legs with one plumose seta on anterior distal end; second segment of all legs bears plumose seta on anterior distal end; fourth segment of all three legs bears large terminal claw. Copulatory organ of male

TABLE 2
List of ostracod species detected in this study along the northern coast of Vietnam. Numbers in bold font included living specimens; numbers in italics included specimens with appendages.

species	st.1	st.3	st.5	st.6	st.7	st.11	st.12	st.13	st.14	st.15	st.16	st.17	st.18	st.19	st.20	total
Alocopocythere profusa Guan 1978 (in Guan et al. 1978)											5	2		7		14
Alocopocythere cf. profusa Guan 1978 (in Guan et al. 1978)														2		2
Atjehella semiplicata Kingma 1948											4	2				6
Aurila cymba (Brady 1869)		3	1								1					5
Aurila hataii Ishizaki 1968		1														1
Bicornucythere bisanensis s.l. (Okubo 1975)	2	12	2	3		1					21	12	13		3	69
Bythoceratina cf. callidictya Zhao 1988 (in Wang et al. 1988)						1										1
Callistocythere asiatica Zhao 1984									1							1
Callistocythere multirugosa Chen 1982 (in Hou et al	4			1							1					6
Callistocythere spectata Chen 1982 (in Hou et al. 1982)															6	6
Callistocythere sp. 1			1													1
Callistocythere sp. 2			1													1
Caudites sp.						33										33
Caudites huyeni sp. nov.		1							56							57
Copytus posterosulcus Wang 1985 (in Zhao et al	4										15	5	3			27
Coquimba gibboidea Hu 1982	6	3	2													11
Coquimna ishizakii Yajima 1978		1														1
Eucythere sp.						11					1					12
Hemicytheridea reticulata Kingma 1948	20	15	2								42	29	3	1		112
Hemicytheridea aff. reticulata Kingma 1948				3	76	1	52								63	195
Hemicythere sp.															1	1
Hemicytherura apta Hu 1976						1										1
Hemicytherura subcellulosiformis Ho et al. 1982 (in Hou et al. 1982)						2										2
Hemikrithe orientalis Van Den Bold 1950											1	1				2
Javanella kendengensis Kingma 1948										1						1
Keijella kloempritensis (Kingma 1948)											13	9	1	25		48
Keijella sp.													2			2
Keijia demissa (Brady 1868a)											1	2				3
Loxoconcha ocellata Ho 1982 (in Hou et al. 1982)			3	101		11			3	2			51	1	1	173
Loxoconcha sinensis Brady 1869						1					3		1			5
Loxoconcha taiwanensis Zhao 1988 (in Wang et al.	19	2														2
Loxoconcha uranouchiensis Ishizaki 1968	3	5	1			10			4	14	5	1	1			44
Loxoconcha vietnamensis sp. nov.						7	1		64	15						87
Loxoconcha sp.								6								6
Malaycythereis sp.				4	13										8	25
Munseyella cf. japonica (Hanai 1957)	4	2										2				8
Neocytheretta murilineata Zhao & Whatley 1989	7	1	1						1	1			1	1		13
Neomonoceratina delicata Ishizaki & Kato 1976		5	1			2				1	41	57	13	24	5	149
Neopellucistoma sp.		9														9
Neosinocythere elongata (Hu 1976)		2				1					1	1	1		2	8
Paracypris sp.		1				1	21	4								27
Paracytherois sp. (in Wang et al. 1988)									3							3
Paracytheroma cf. ventrosinuosa Zhao & Whatley	1			1					5		22	18	3	1		51
Paradoxostoma sp.											1					1
Pistocythereis bradyformis (Ishizaki 1968)												1	1	3		5
Pontocythere cf. kashiwarensis (Hanai 1959)		2														2
Pontocythere miurensis (Hanai 1959)	11	21	3									1			2	38
Pontocythere spatiosus Hou 1982 (in Hou et al. 1982		1														1
Pontocythere subjaponica (Hanai 1959)	1	1														2
Pontocythere triangulata (Hou 1982) (in Hou et al.		1														1
Pontocythere sp. 1		3														3
Pontocythere sp. 2	1	1														2
Pontocythere sp. 3		3														3
Pontocythere sp. 4		1														1
Propontocypris clara Zhao 1988 (in Wang et al. 1988)											14	12	8	4		38
Propontocypris euryhalina Zhao 1984					12											12
Propontocypris sp. 1		2			51											53
Propontocypris sp. 2												2	2	1		5
Ruggieria darwini (Brady 1868b)											8	3				11
Ruggieria sp.											7	1	5	5	1	19
Semicytherura sp. 1															1	1
Semicytherura sp. 2						3										3
Semicytherura sp. 3(S. sp. 2 of Ruan & Hao 198	2	1														3
Sinocythere dongtaiensis Chen 1982 (in Hou et al. 1982)															1	1
Sinocythere sinensis Hou 1982 (in Hou et al. 1982)		1				1									1	3
Sinocythere sp.		1				7				1						9
Sinocytheridea impressa (Brady 1869)	1	1	2	54							56	114	18	34	10	290
Spinileberis pulchra Chen 1982 (in Hou et al. 1982)					2											2
Stigmatocythere costa (Hu, 1977)	2	2									3	3	1	6		17
Tanella gracilis s.l. Kingma 1948		2	1						13	2		1	2	1		22
Tanella sp.		3				11			6						105	125
Venericythere aff. papuensis (Brady 1880)										1			7	26		34
Wichmannella miaoliensis (Hu & Yang 1975)											1	5				6
Xestoleberis sp.									2				1			3
Xiphichilus sinensis Yang & Ho 1982 (in Hou et al. 1982)						1										1
total	2	114	21	167	154	106	74	10	158	38	267	284	138	142	210	1948

Species	Habitat	Indian Ocean	Indonesia	Malay Peninsula/Sunda Shelf	China/Japan	References
Atjehella semiplicata	-	*	*	*	*	9
Keijia demissa	-	*	*	*	*	9
Ruggieria darwini	-	*	*	*	*	9
Tanella gracilis s.l.	M	*	*	*	*	9,13
Copytus posterosulcus	M		*	*	*	9,13
Hemicytheridea reticulata	M-B		*	*	*	3,9,13
Hemikrithe orientalis	-		*	*	*	9
Javanella kendengensis	-		*	*	*	9
Loxoconcha sinensis	-		*		*	9
Keijella kloempritensis	-			*		7
Neocytheretta murilineata	M			*		9,13
Neomonoceratina delicata	M-B			*	*	3,9,13
Pontocythere subjaponica	-			*	*	4
Alocopocythere profusa	-				*	6
Aurila cymba	M-B				*	6
Aurila hataii	-				*	1
Bicornucythere bisanensis s.l.	M-B				*	8,11,13
Callistocythere multiruqosa	M-B				*	3
Callistocythere asiatica	M				*	2
Coquimna ishizakii	-				*	6
Loxoconcha ocellata	M-B				*	3,13
Loxoconcha taiwanensis	-				*	6
Loxoconcha uranouchiensis	M				*	5
Neosinocythere elongata	-				*	10
Paracytherois sp.(of Wang et al., 1988)	-				*	6
Pistocythereis bradyformis	M-B				*	6
Pontocythere miurensis	M-B				*	12,13
Pontocythere spatiosus	-				*	6,13
Pontocythere triangulata	-				*	6
Propontocypris clara	M				*	6,13
Propontocypris euryhalina	M-B				*	3,6,13
Sinocythere dongtaiensis	-				*	6
Sinocythere sinensis	M-B				*	8
Sinocytheridea impressa	M-B				*	3,13
Spinileberis pulchra	M-B				*	3
Stigmatocythere costa	-				*	6
Xiphichilus sinensis	M-B				*	3

TEXT-FIGURE 3
Biogeographical distribution of the 37 previously described species detected in this study along the northern coast of Vietnam. Asterisks indicate ranges extending from Vietnam also southward to the Indian Ocean, Indonesia, or the Malay Peninsula / Sunda Shelf, and northward to China and/or Japan. Habitat column: M, marine; B, brackish-water; M-B, euryhaline; -, no data. References: 1, Ishizaki (1968); 2, Zhao (1984); 3, Wang et al.(1985); 4, Whatley and Zhao (1987a); 5, Kamiya (1988); 6, Wang, P. et al. (1988); 7, Whatley and Zhao (1988); 8, Zhao and Wang (1988); 9, Zhao and Whatley (1989a); 10, Zhao and Whatley (1993); 11, Tanaka et al. (1998); 12, Nakao and Tsukagoshi (2002); 13, This study (habitat information).

(text-fig. 4J) has basal capsule subquadrangular, with three clasping apparatuses; wall well developed along the anterior margin; large, triangular distal process bears trapezoidal process proximally; ductus ejaculatorius short, steeple shaped, folded.

Individual dimensions: Length (L) and height (H), in millimeters, for right (RV) and left (LV) valves of individual specimens. Holotype (40933; from Hou et al. 1982), male, LV, L=0.60, H=0.32. SUM-CO-1504, male, RV, L= 0.59, H=0.32. SUM-CO-1514, male, LV, L=0.61, H=0.32; male RV, L=0.60, H=0.32. SUM-CO-1515, female, LV, L=0.52, H=0.34; RV, L=0.51, H=0.34.

Mean dimensions: Mean length (L) and mean height (H) followed by the range, all in millimeters, for right (RV) and left (LV) valves; sample size is also indicated. Male RV, L=0.59 (0.58–0.60), H=0.32 (0.31–0.32), n=4. Male LV, L=0.59 (0.56–0.61), H=0.32 (0.31–0.32), n=5. Female RV, L=0.49 (0.46–0.51), H=0.32 (0.30–0.34), n=7. Female LV, L=0.50 (0.48–0.54), H=0.34 (0.32–0.37), n=12. Adult minus 1 larva (A-1) RV, L=0.43 (0.42–0.45), H=0.27 (0.26–0.28), n=9. A-1 LV, L=0.44 (0.42–0.46), H= 0.28 (0.26–0.30), n=10. Adult minus 2 larva (A-2) RV, L=0.38 (0.35–0.40), H=0.25 (0.24–0.27), n=7. A-2 LV, L=0.38 (0.33–0.40), H=0.25 (0.21–0.27), n=7. Adult minus 3 larva (A-3) RV, L=0.32 (0.30–0.34), H=0.20 (0.19–0.22), n=8. A-3 LV, L=0.31 (0.29–0.33), H=0.20 (0.19–0.21), n=6. Adult minus 4 larva (A-4) RV, L=0.26 (0.25–0.27), H=0.17 (0.16–0.18), n=6. A-4 LV, L=0.25 (0.24–0.26), H=0.16 (0.16–0.17), n=5.

Occurrence: This species is widely distributed at depths of less than 50 m in the East China Sea (Wang and Zhao 1985; Wang P.et al. 1988) and along the northern coast of Vietnam (Stns. 5, 6, 11, 14, 15, 18–20).

Remarks: This species was originally described from a Holocene deposit north of Shanghai in Jiangsu Province, China (Hou et al. 1982). Recent specimens have been reported from the coast of China (Wang and Zhao 1985; Wang, Q. et al. 1988). This species resembles *Loxoconcha pulchra* described by Ishizaki (1968), for which living specimens have been found in euryhaline environments in Japan (Nakao and Tsukagoshi 2002). However, the outline of anterior margin and the pattern of surface ornamentation are different between the two species, and *L. ocellata* lacks ventral ridge.

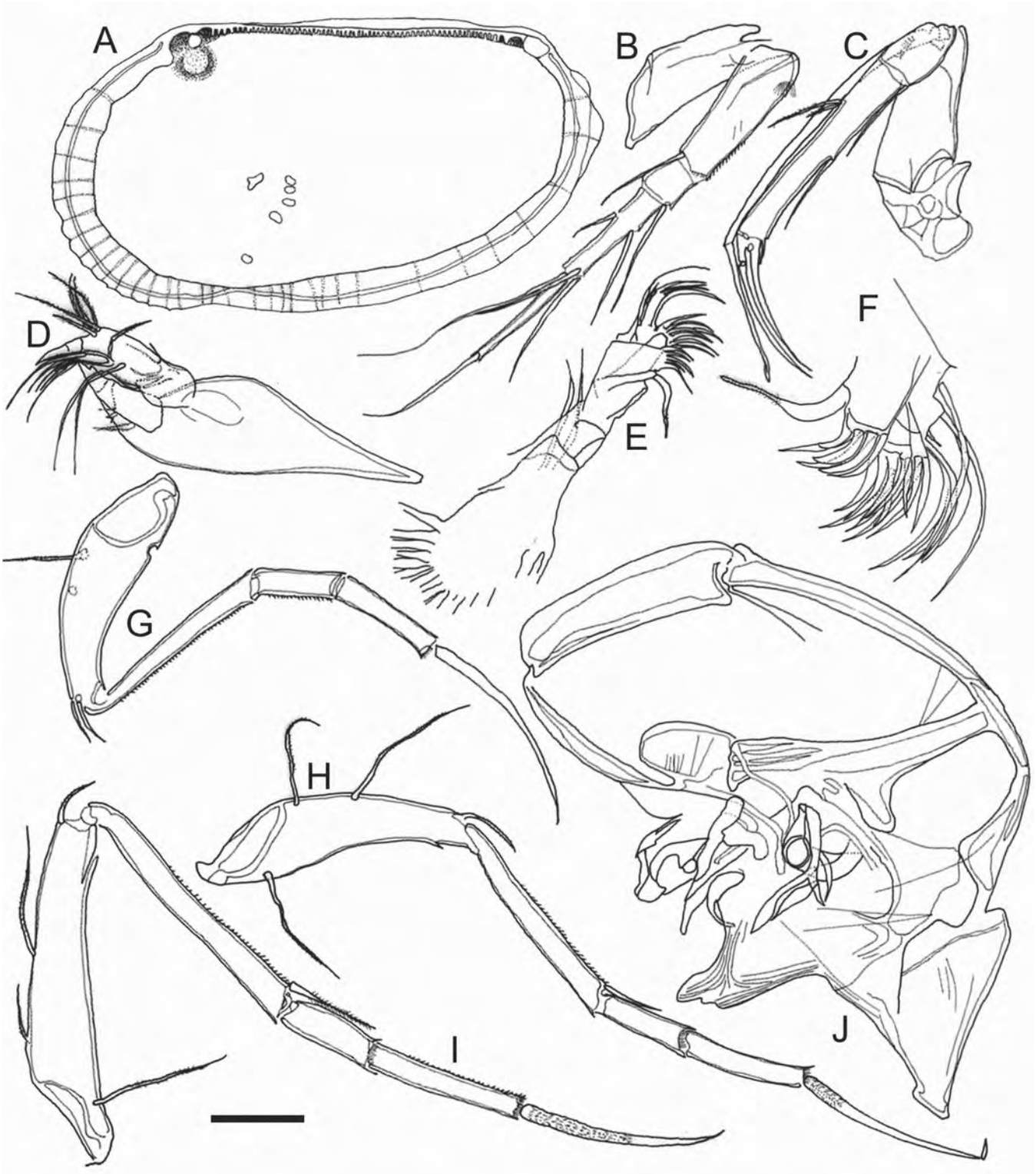
Loxoconcha vietnamensis Tanaka Komatsu and Phong, **n. sp.**
Text-figure 5; Plate 1, fig. 5; Plate 2, figs. 23–44

Etymology: The species is named for Vietnam, the country where the type locality is located.

Diagnosis: Carapace sub-rhomboidal in lateral outline, anterior margin evenly rounded, dorsal margin undulating. Surface ornamented with coarse primary reticulation. Ala well developed in posteroventral area. Third segment of antennule with simple seta on anterior distal end. Many setules present on anterior margin of segments 2–4 of thoracic legs. Ductus ejaculatorius of copulatory organ wormlike and tangled.

Holotype: Male with soft parts dissected in glycerine and sealed on a glass slide; valves stored in a micropalaeontological cavity slide (SUM-CO-1522). Stn. 14, surface sediments of rocky coast and sandy beach (muddy sand), ca. 30 km south of Tien Yen District, Quang Ninh Province; 21°02’48’’N, 107°23’08’’E; coll. 20 March 2007 by G. Tanaka, T. Komatsu, and N. Phong.

Allotype: Female carapace gold-coated for SEM observation (SUM-CO-1517). Same collection data as for holotype.



TEXT-FIGURE 4
Loxoconcha ocellata Ho 1982 (in Hou et al. 1982) from Stn. 6: (A-I) male SUM-CO-1520; (J) male SUM-CO-1521. Camera lucida drawings of **(A)** right valve; **(B)** antennule; **(C)** antenna; **(D)** mandible; **(E)** maxillula; **(F)** distal part of maxillula; **(G)** first thoracic leg; **(H)** second thoracic leg; **(I)** third thoracic leg; **(J)** copulatory organ. Scale: 100µm for (A); 50µm for (B-E), (G-J); 25µm for (F).

Paratypes: Male right valve (SUM-CO-1506), male carapace (SUM-CO-1516). Same collection data as for holotype.

Material: 87 specimens (Table 2).

Description: Valves (pl. 2, figs.1-10, 12-21) sub-rhomboidal in lateral view; anterior margin evenly rounded; dorsal margin undulating; posterior margin truncate; ventral margin straight. Lateral outline fusiform in dorsal and ventral views; carapace quadranglar in anterior and posterior views. Strong sexual dimorphism; male is more elongate in lateral view and is strongly inflated posterodorsally; carapace of female inflated laterally in dorsal view. Eye tubercle present. Surface ornamented with strong primary reticulation. Ala well developed in posteroventral area. Interior of valve (text-fig. 5A) has 33 straight marginal pore canals; duplicature present; hinge gongylodont; in right valve, anterior element has single large tooth surrounded by depression, median element has numerous fine teeth, and posterior element has elongated large tooth; one semilunar-shaped frontal scar; four elliptical adductor scars in vertical row; one circular mandibular scar. Antennule (text-fig. 5B) has six articulated segments, with the fourth and fifth segments fused; length ratio among distal segments 30:29:8:8:15:25; walls especially well developed on second to sixth segments; second segment with setules on anterior margin; third segment with simple seta on anterior distal end; fourth segment with claw-like seta with serration on anterior distal end and with simple seta on distal end; fifth segment with three simple setae; sixth segment with four long simple setae at distal end. Antenna (text-fig. 5C) with four articulated segments; length ratio among distal segments 32:12:46:5; walls well developed; second segment with long, three-segmented exopodite, numerous setules on outer lateral side, and one long simple seta on posterior distal end of endopodite; third segment with one simple seta along anterior margin; posterior margin of third segment with one short seta at the distal end and two simple setae in the middle; fourth segment with two stout claw-like setae. Mandible (text-figs 5D, E) five-segmented; length ratio among distal segments 73:14:8:8:3; basal segment (coxa, first segment of protopodite) with about six teeth; second segment of protopodite (basis) with one long seta on posterior margin; first segment of endopodite with two long and two short setae on distal end; second segment of endopodite with four plumose setae on lateral margin, and one stout simple seta and two simple setae on distal end; third segment of endopodite with three stout simple setae. Maxillula (text-fig. 5F) extremely thin; branchial plate (exopodite) with at least 15 plumose setae; basal podomere bears palp and three masticatory processes, each process with several setae, palp with three simple setae on distal end. All three thoracic legs (text-figs 5G-I) four-segmented, but differing somewhat in shape. Length ratio among distal segments 39:31:16:19 for first thoracic leg, 49:44:17:22 for second thoracic leg, and 60:54:20:29 for third thoracic leg; anterior margin on second to fourth segments with many setules; distal margin of segments covered with many short setules; walls well developed on both margins of each segment; first segment with one plumose seta on posterior proximal end and two plumose setae on anterior margin; first segment of first thoracic leg with two plumose setae at anterior distal end; first segment of second and third thoracic legs with plumose seta at anterior distal end; second segment of all legs bears seta at anterior distal end; fourth segment of all legs bears large terminal claw. Copulatory organ of male (text-fig. 5J) has sub-quadrangular basal capsule bearing a large triangular distal process proximally; ductus ejaculatorius wormlike and tangled.

Individual dimensions: Length (L) and height (H), in millimeters, for right (RV) and left (LV) valves of individual specimens. Holotype (SUM-CO-1522), male, RV, L=0.48, H=0.27. Allotype (SUM-CO-1517), female, LV, L= 0.43, H=0.28; RV, L=0.43, H=0.28. Paratype (SUM-CO-1516), male, RV, L=0.48, H=0.25; LV, L=0.48, R=0.26. Paratype (SUM-CO-1506), male, RV, L=0.46, H=0.26.

Mean dimensions: Mean length (L) and mean height (H) followed by the range, all in millimeters, for right (RV) and left (LV) valves; sample size is also indicated. Male RV,

L=0.48 (0.46–0.51), H=0.25 (0.23–0.27), n=6. Male LV, L= 0.47 (0.46–0.51), H=0.25 (0.24–0.27), n=12. Female RV, L=0.41 (0.40–0.43), H=0.26 (0.24–0.28), n=8. Female LV, L=0.41 (0.39–0.43), H=0.26 (0.25–0.28), n=10. A-1 RV, L=0.36 (0.34–0.39), H=0.21 (0.20–0.22), n=10. A-1 LV, L=0.36 (0.33–0.38), H=0.22 (0.21–0.23), n=10. A-2 RV, L= 0.29 (0.29–0.31), H=0.18 (0.17–0.19), n=5. A-2 LV, L= 0.30 (0.29–0.30), H=0.18 (0.18), n=3. A-3 LV, L=0.28 (0.28, 0.28), H=0.17 (0.16, 0.17), n=2.

Occurrence: Around the coast of Tien Yen District, Quang Ninh Province, northeastern Vietnam (Stns. 11, 12, 14, 15).

Remarks: *Loxoconcha vietnamensis* sp. nov. differs from *L. zhejiangensis*, reported from Recent sediments from the intertidal zone of the East China Sea and Yellow Sea (Zhao 1984), in lacking transverse ridges dorsally and posteriorly. *Loxoconcha vietnamensis* resembles *L. uranouchiensis* described by Ishizaki (1968); however, the outlines of the anterior, dorsal, and posterior margins and the pattern of surface ornamentation are very different between the two, and *L. vietnamensis* has a prominent posteroventral ala. *Loxoconcha vietnamensis* differs from *L. ventispina* Zheng 1987 in having a dorsally protruding posterior outline and lacking a ventral spine.

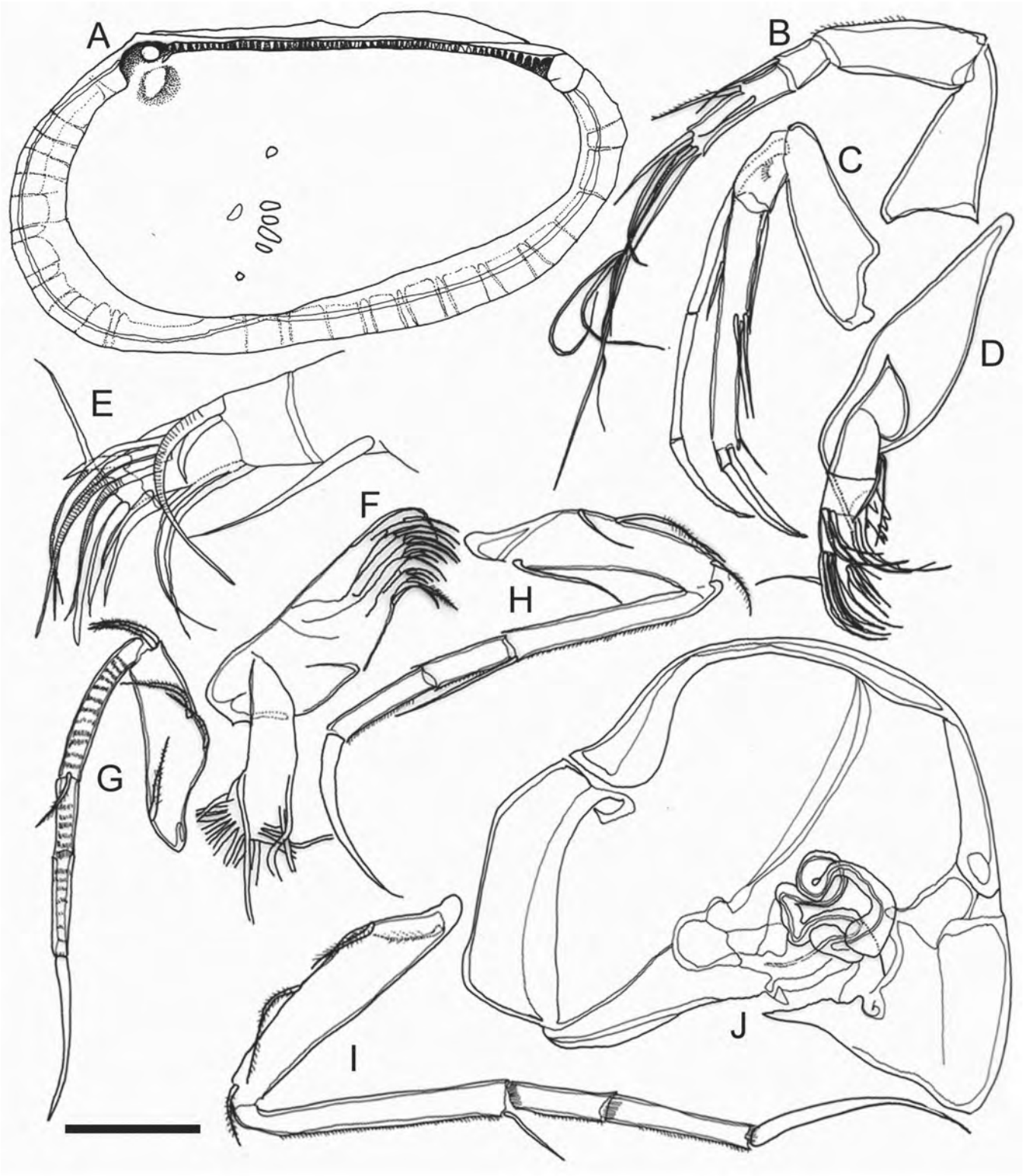
Family HEMICYTHERIDAE Puri 1953
Genus *Caudites* Coryell and Fields 1937

Caudites huyeni Tanaka, Komatsu and Phong, **sp. nov.**
Text-figure 6; Plate 1, fig. 4; Plate 3, figs. 1–22

Etymology: The species epithet is based on the first name of a Vietnamese paleontologist, Professor Dang Tran Huyen, Department of Paleontology and Stratigraphy, Vietnam Institute of Geosciences and Mineral Resources (VIGMR), Hanoi, Vietnam.

Diagnosis: Carapace sub-trapezoidal in lateral outline; anterior margin evenly rounded and curved ventrally; posterior margin tapering, more rounded. A transverse vertical ridge runs from posterodorsal area to posteroventral area. Marginal denticles present. Male copulatory organ with a triangular distal process bearing two quadrangular processes proximally. Ductus ejaculatorius short, tongue-shaped.

Holotype: Male with soft parts dissected in glycerin and sealed on a glass slide; valves stored in a micropalaeontological cavity slide (SUM-CO-1523). Stn. 14, surface sediment from rocky coast and sand beach (muddy sand), ca. 30 km south of Tien Yen District, Quang Ninh Province, Vietnam; 21°02’48’’N, 107°23’08’’E; collected 20 March 2007 by G. Tanaka, T. Komatsu, and N. Phong.



TEXT-FIGURE 5
Loxoconcha vietnamensis sp. nov., holotype, male, SUM-CO-1522, Stn. 14. Camera lucida drawings of **(A)** right valve; **(B)** antennule; **(C)** antenna; **(D)** mandible; **(E)** distal part of mandible; **(F)** maxillula; **(G)** first thoracic leg; **(H)** second thoracic leg; **(I)** third thoracic leg; **(J)** copulatory organ. Scale: 100ìm for (A); 50ìm for (B-D), (F-J); 25ìm for (E).

Allotype: Female carapace gold-coated for SEM observation (SUM-CO-1519). Same collection data as for holotype.

Paratypes: Male carapace (SUM-CO-1518). Same collection data as for holotype.

Material: 57 specimens (Table 2). Same collection data as for holotype.

Description: Carapace (text-fig. 6; pl. 1, fig. 4; pl. 3, figs 1-22) valves sub-trapezoidal in lateral view; anterior margin evenly rounded and curved ventrally; dorsal margin straight, sloping toward posterior; posterior margin truncate and caudate ventrally; ventral margin nearly straight, concave in anterior part; surface ornamented with primary reticulation; marginal denticles present; eye tubercle and subcentral tubercle present; a cardinal ridge runs from basal part of eye tubercle nearly parallel to anterior margin and ends at anteroventral margin; three cardinal ridges run from the posterodorsal/posteroventral area to anterodorsal/anteroventral area; a transverse vertical ridge runs from posterodorsal area to posteroventral area; in dorsal and ventral views, lateral outline undulating, posterior end more pointed than anterior; in anterior and posterior views, carapace polygonal in outline, broadest at point near mid-height. Strong sexual dimorphism; in lateral, dorsal and ventral views, male more elongate; in anterior, posterior, dorsal and ventral views, carapace of female inflated laterally. Interior of valve (text-fig. 6A) has 83 straight marginal pore canals; duplicature well developed; hinge holamphidont; in right valve, anterior element has single large tooth, anteromedian element is a socket, median element has numerous fine teeth, posteromedian element consists of several teeth, and posterior element is a large, rounded tooth; three frontal scars (middle one is small); four circular/elliptical adductor scars, the two in the middle subdivided; a deep anteromedian depression lies between the frontal and adductor scars, corresponding to the external subcentral tubercle. Antennule (text-fig. 6B) has six articulated segments, with fourth and fifth segments fused; length ratio among distal segments 36:33:12:10:8:11; walls well developed in each segment; first segment with many setules on lateral side; second segment with plumose seta at posterior distal end and long setules on anterior margin, and with several setules on posterior margin; third segment with a stout seta at anterior distal end; fourth and fifth segments with one stout seta and two simple setae at anterior distal end; sixth segment with one stout seta and two simple setae at distal end. Antenna (text-fig. 6C) with four articulated segments; length ratio among distal segments 51:19:45:6; walls well developed, especially broad in the third segment; first segment with many setules on lateral side; second segment with long, three-segmented exopodite, two setules on anterior marginal side of endopodite, and one plumose seta at posterior distal margin; along anterior margin, third segment has two unequal simple setae and two setules; along posterior margin of third segment, one short plumose seta and one comb-like seta at the distal end and two plumose setae in the middle; fourth segment with three stout claw-like setae. Mandible (text-fig. 6D) five-segmented; length ratio among distal segments 53:17:11:11:9; basal segment (coxa, first segment of protopodite) with about 10 teeth, and with one seta on anterior distal margin; second segment of protopodite (basis) with exopodite consisting of five setae, with one plumose seta on distal margin; first segment of endopodite with two long plumose setae and one short simple seta on anterior distal margin and one seta on posterior distal margin; second segment of endopodite with four long and two short simple setae on posterior distal margin, and one stout comb-like seta on anterior distal end; third segment of endopodite bearing three simple setae and one plumose seta. Maxillula (text-fig. 6E) extremely thin; branchial plate (exopodite) with 15 plumose setae; basal podomere bearing palp and three masticatory processes, each process with several setae; palp with four simple setae at distal end. All three thoracic legs (text-fig. 6F–H) four-segmented but differing somewhat in shape; length ratio among distal segments 41:26:21:19 for first thoracic leg, 44:29:24:23 for second thoracic leg, 50:38:25:24 for third thoracic leg; walls well developed on both margins of each segment; first segment has one seta at posterior proximal end and two plumose setae on anterior margin; first segment of first thoracic leg with two plumose setae on anterior distal end; second and third thoracic legs with long plumose seta and one stout seta on anterior margin and one plumose seta at posterior proximal end; second segment of second and third legs with a simple seta at anterior distal end, the setae different in length between the two; all three legs have fourth segment bearing large terminal claw. Copulatory organ of male (text-fig. 6I) has basal capsule subquadrangular, with two stout plumose setae; wall well developed along anterior margin; triangular distal process bearing two quadrangular processes proximally; ductus ejaculatorius short, tongue shaped.

Individual dimensions: Length (L) and height (H), in millimeters, for right (RV) and left (LV) valves of individual specimens. Holotype (SUM-CO-1523), male, RV, L=0.55, H=0.28. Allotype (SUM-CO-1519), female, LV, L=0.56, H=0.31; RV, L=0.58, H=0.31. Paratype (SUM-CO-1518), male, RV, L=0.55, H=0.28; LV, L=0.55, H=0.28. Paratype SUM-CO-1499), male RV, L=0.55, H=0.28

Mean dimensions: Mean length (L) and mean height (H) followed by the range, all in millimeters, for right (RV) and left (LV) valves; sample size is also indicated. Male RV, L= 0.55, H=0.28 (0.28, 0.29), n=4. Male LV, L=0.56 (0.55–0.57), H=0.27 (0.26–0.28), n=6. Female RV, L=0.58 (0.57–0.60), H=0.32 (0.30–0.33), n=6. Female LV, L=0.58 (0.56–0.60), H=0.31 (0.30–0.33), n=16. A-1 RV, L=0.47 (0.46–0.48), H=0.26 (0.25–0.27), n=5. A-1 LV, L=0.47 (0.45–0.49), H=0.25 (0.24–0.26), n=8. A-2 RV, L=0.38 (0.37–0.39), H=0.21 (0.20–0.22), n=3.

Occurrence: This species is known from only two localities in northeastern Vietnam (Stn. 3, Stn. 14, this study).

Remarks: This species differs from *Caudites scopulicolus jasonensis* Zhao & Whatley 1989, reported from Recent sediments in Jason Bay, Malay Peninsula, in having a tapering but more rounded posterior margin; a transverse vertical ridge from the posterodorsal area to the posteroventral area; a different pattern of reticulation in the ventromedian area; and fewer anterior radial pore canals.

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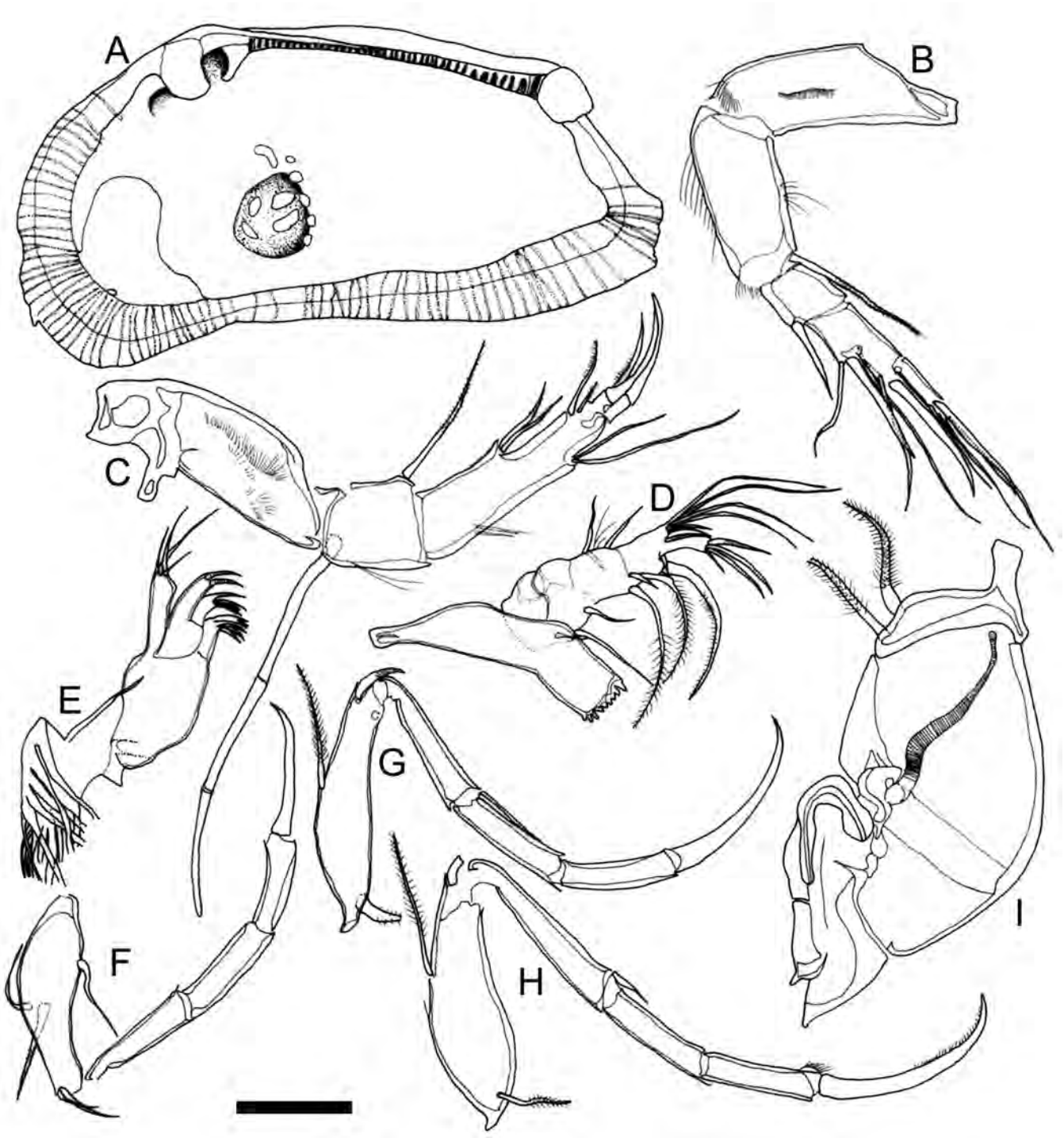

TEXT-FIGURE 6
Caudites huyeni sp. nov., holotype, male, SUM-CO-1523, Stn. 14. Camera-lucida drawings of **(A)** male right valve; **(B)** antennule; **(C)** Antenna; **(D)** Mandible; **(E)** Maxillula; **(F)** First thoracic leg; **(G)** Second thoracic leg; **(H)** Third thoracic leg; **(I)** Copulatory organ. Scale: 100µm for (A); 50µm for (B–I).

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PLATE 1

Scanning electron photomicrographs of the 19 characteristic living species shown in text-fig. 2. scale bar is 100μm.

1 *Propontocypris clara* Zhao 1988 (in Wang, P. et al. 1988). Right external lateral view of carapace, Stn. 16 (SUM-CO-1495).

2 *Copytus posterosulcus* Wang 1985 (in Zhao et al. 1985). Right external lateral view of carapace, Stn. 16 (SUM-CO-1496).

3 *Tanella gracilis* s.l. Kingma 1948. Right external lateral view of carapace, Stn. 14 (SUM-CO-1497).

4 *Neocytheretta murilineata* Zhao and Whatley 1989. Right external lateral view of carapace, Stn. 1 (SUM-CO-1498).

5 *Loxoconcha vietnamensis* sp. nov. Right valve, Stn. 14 (SUM-CO-1506).

6 *Tanella* sp. Right valve, Stn. 20 (SUM-CO-1499).

7 *Caudites* sp. Right valve, Stn. 11 (SUM-CO-1500).

8 *Paracypris* sp. Right external lateral view of carapace, Stn. 12 (SUM-CO-1501).

9 *Hemicytheridea reticulata* Kingma 1948. Right valve, Stn. 7 (SUM-CO-1502).

10 *Neomonoceratina delicata* Ishizaki and Kato 1976. Right valve, Stn. 17 (SUM-CO-1503).

11 *Bicornucythere bisanensis* s. l. (Okubo 1975). Right valve, Stn. 18 (SUM-CO-1505).

12 *Paracytheroma* cf. *ventrosinuosa* Zhao and Whatley 1989. Right valve, Stn. 16 (SUM-CO-1507).

13 *Sinocytheridea impressa* (Brady 1869). Right valve, Stn. 16 (SUM-CO-1508).

14 *Pontocythere miurensis* (Hanai 1959). Right valve, Stn. 3 (SUM-CO-1509).

15 *Loxoconcha ocellata* Ho 1982 (in Hou et al. 1982). Right valve, Stn. 6 (SUM-CO-1504).

16 *Hemicytheridea* aff. *reticulata* Kingma 1948. Right valve, Stn. 17 (SUM-CO-1510).

17 *Propontocypris euryhalina* Zhao 1984. Right valve, Stn. 7 (SUM-CO-1511).

18 *Propontocypris* sp. 1. Right valve, Stn. 7 (SUM-CO-1512).

19 *Malaycythereis* sp. Right valve, Stn. 7 (SUM-CO-1513).

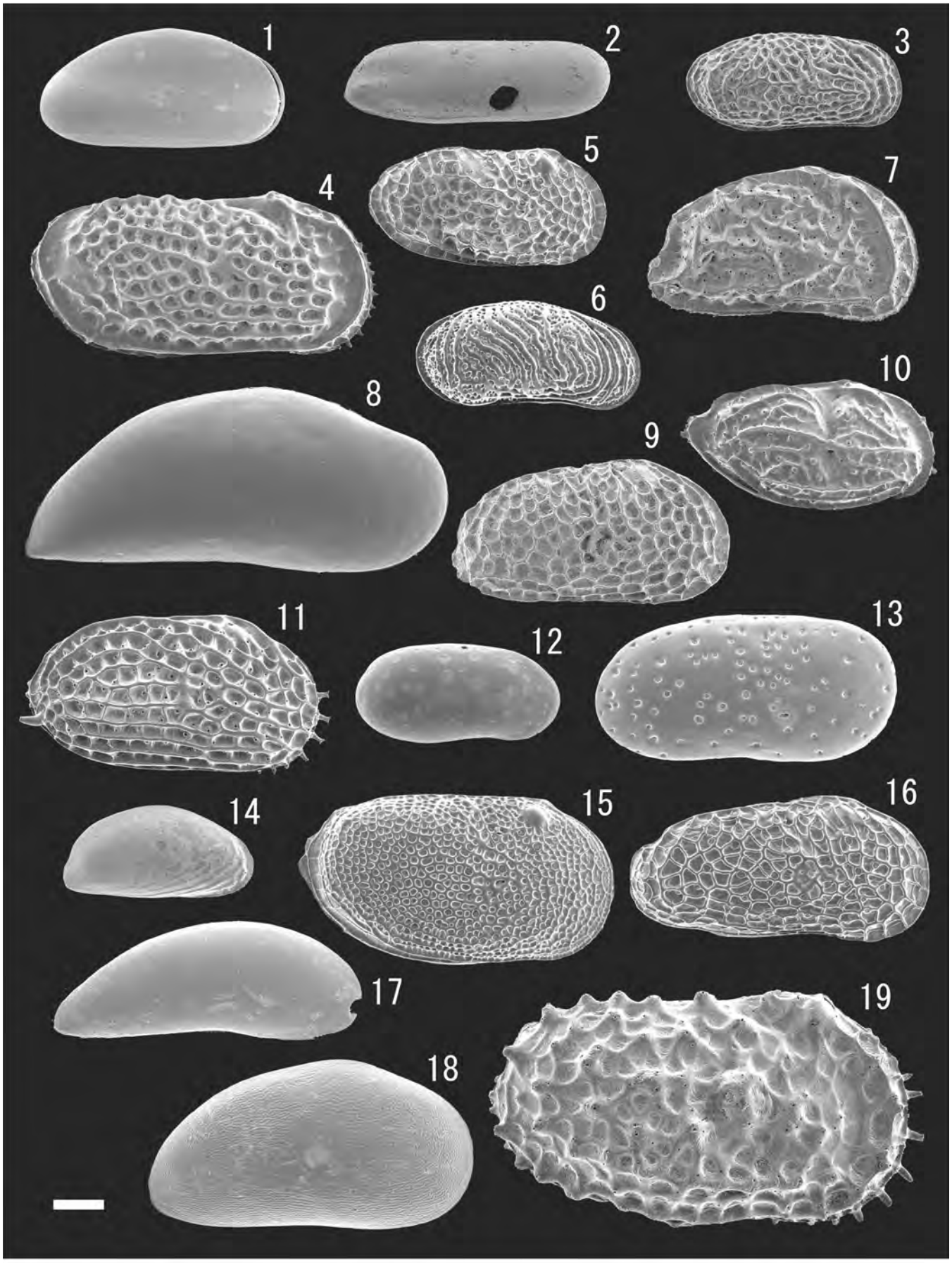
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PLATE 2

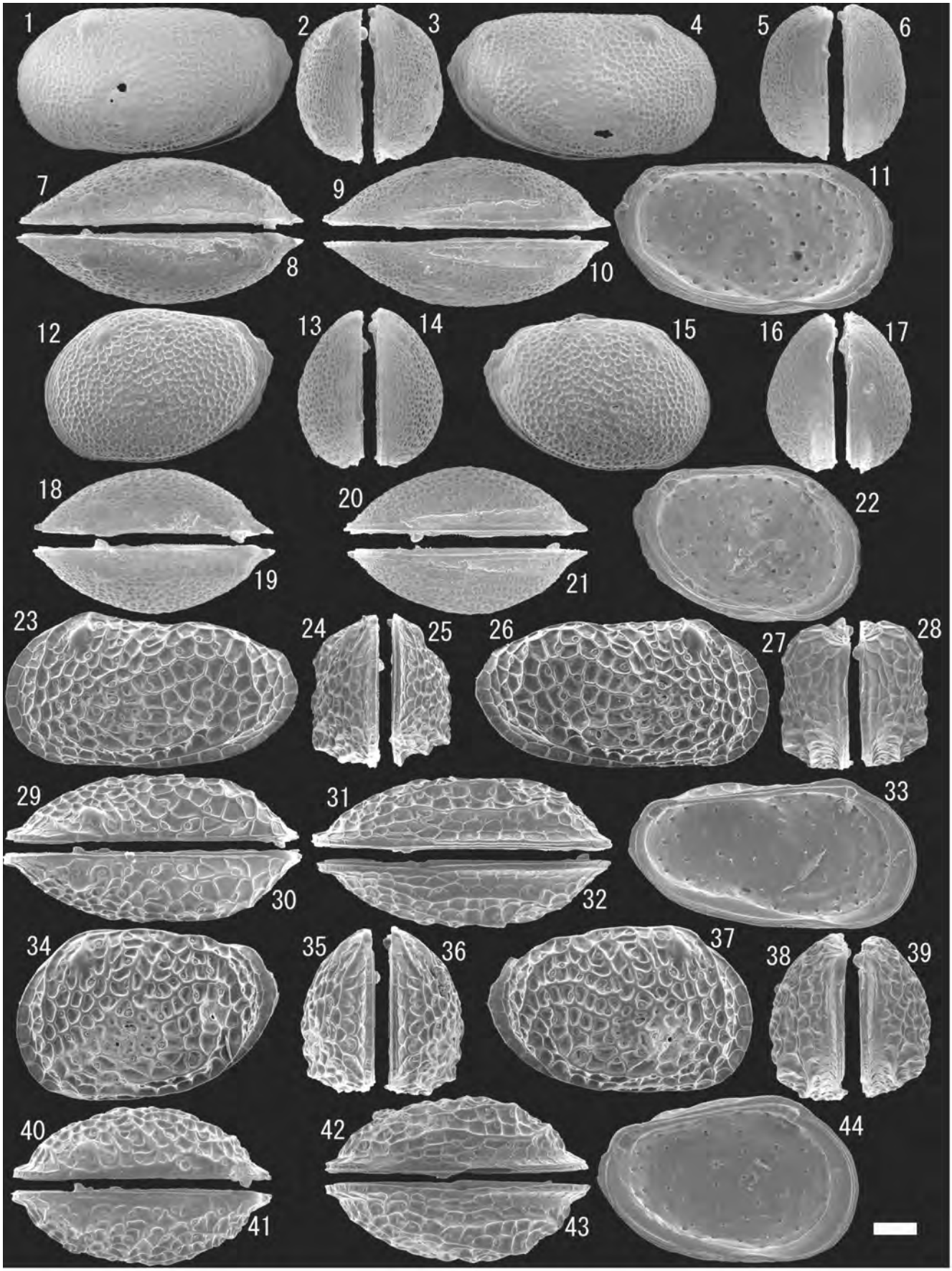
Scanning electron photomicrographs of loxoconchid ostracods from the northern coast of Vietnam.
Outer view of left valve (1, 12, 23, 34); anterior view of right valve (2, 13, 24, 35); anterior view of left valve (3, 14, 25, 36); outer view of right valve (4, 15, 26, 37); posterior view of left valve (5, 16, 27, 38); posterior view of right valve (6, 17, 28, 39); dorsal view of right valve (7, 18, 29, 40); dorsal view of left valve (8, 19, 30, 41); ventral view of left valve (9, 20, 31, 42); ventral view of right valve (10, 21, 32, 43); inner view of left valve (11, 22, 33, 44). Scale bar: 100μm; A for 1–22, B for 23–44.

1-11 *Loxoconcha ocellata* Ho 1982 (in Hou et al. 1982); valves of a male individual from Stn. 6 (SUM-CO-1514).

12-22 *Loxoconcha ocellata* Ho 1982 (in Hou et al. 1982); valves of a female individual from Stn. 6 (SUM-CO-1515).

23-33 *Loxoconcha vietnamensis* sp. nov., paratype; valves of a male individual (SUM-CO-1516) from Stn. 14.

34-44 *Loxoconcha vietnamensis* sp. nov., allotype; valves of a female individual (SUM-CO-1517) from Stn. 14.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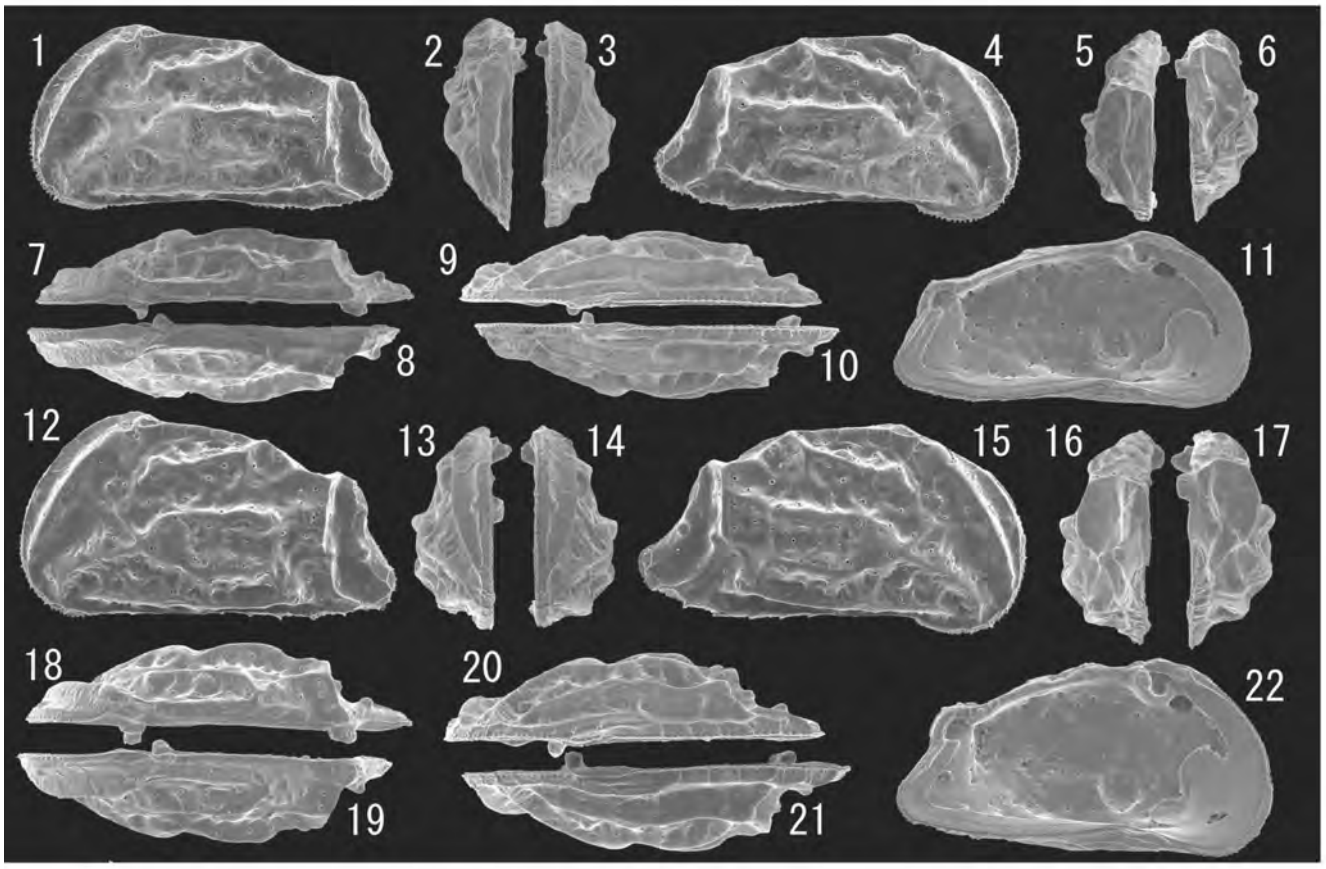

PLATE 3

Scanning electron photomicrographs of *Caudites huyeni* sp. nov., a hemicytherid ostracod from the northern coast of Vietnam. Outer view of left valve (1, 12); anterior view of right valve (2, 13); anterior view of left valve (3, 14); outer view of right valve (4, 15); posterior view of left valve (5, 16); posterior view of right valve (6, 17); dorsal view of right valve (7, 18); dorsal view of left valve (8, 19); ventral view of left valve (9, 20); ventral view of right valve (10, 21); inner view of left valve (11, 22). Scale bar is 100μm.

1-11 *Caudites huyeni* sp. nov., male, paratype (SUM-CO-1518), Stn. 14.

12-22 *Caudites huyeni* sp. nov., female, allotype (SUM-CO-1519), Stn. 14.

APPENDIX 1

Bicornucythere bisanensis (Okubo 1975) s. l. Hanai et al. 1980 *Leguminocythereis bisanensis* Okubo 1975 (Pl. 1, fig. 11). Abe (1988) reported that this species contains four different forms (A, G, P, and M) based on carapace morphology. The shell morphology found in northern Vietnam is comparable to form G, which is distributed from the coast of the Korean Peninsula to China (Abe 1988).

Caudites sp. (Pl. 1, fig. 7). Based on the carapace outline and surface ornamentation, this appears to be an undescribed species.

Copytus posterosulcus Wang 1985 (in Zhao et al. 1985) (Pl. 1, fig. 2). This species has been reported from the South China Sea at depths of 20-50 m (Zhao et al. 1985).

Hemicytheridea reticulata Kingma 1948 (Pl. 1, fig. 9). The shell outline and reticulation pattern of the specimen figured accord well with the original illustration (pl. 7, fig. 7c of Kingma 1948).

Hemicytheridea aff. *reticulata* Kingma 1948 (Pl. 1, fig. 16). Our specimen differs from *H. reticulata* Kingma 1948 in the dorsal reticulation pattern, but has a similar pattern to that illustrated in SEM photomicrographs by Zhao and Whatley (1989) (their pl. 4, fig. 15) for *H. reticulata* Kingma 1948.

Neocytheretta murilineata Zhao and Whatley 1989 (Pl. 1, fig. 4). Zhao and Whatley (1989) described this species from the Sedili River, southern Malay Peninsula, where they found living specimens format depths of 6-20 m.

Neomonoceratina delicata Ishizaki and Kato 1976 (Pl. 1, fig. 10). This species resembles *Neomonoceratina crispata* described by Hu (1976) from the Pliocene Cholan Formation, Taiwan. However, photographs Hu's (1976) photographs of the type specimen are not very clear. Hou and Gou (2007) treated *N. crispata* as a synonym of *N. delicata*, and we accept their opinion here.

Paracypris sp. (Pl. 1, fig. 8). Based on the carapace outline, this appears to be an undescribed species.

Paracytheroma cf. *ventrosinuosa* Zhao and Whatley 1989 (in Zhao and Whatley 1989) (Pl. 1, fig. 12). The female specimens figured resemble *P. ventrosinuosa* (pl. 2, fig. 13 of Zhao and Whatley 1989). However, the specimens from northern Vietnam have a more rounded outline than *P. ventrosinuosa*.

Pontocythere miurensis (Hanai 1959) Hanai et al. 1977 *Cushmanidea miurensis* Hanai 1959 (Pl. 1, fig. 14). In Japan, this species has been reported to live in a wide range of salinity (6 to ca. 25 psu) (Nakao and Tsukagoshi 2002); it also occurs in the marine environment (G. Tanaka personal observation).

Propontocypris clara Zhao 1988 (in Wang, P. et al. 1988) (Pl. 1, fig. 1). This species was originally described on the basis of specimens from Recent bottom sediments (40–320 m depth) from the East China Sea.

Propontocypris euryhalina Zhao 1984 (Pl. 1, fig. 17). Zhao (1984) originally described this species from the coast of the East China Sea and Yellow Seas, and reported it to be euryhaline, living at salinities of 1.3-51.5 psu in the supratidal zone.

Propontocypris sp. 1 (Pl. 1, fig. 18). Based on the carapace outline and surface ornamentation, this appears to be an undescribed species.

Sinocytheridea impressa (Brady 1869) Whatley and Zhao 1987b *Cytheridea impressa* Brady 1869 (Pl. 1, fig. 13). Whatley and Zhao (1987b) considered many morphologically similar species (*Cyprideis yehi, Eucytheridea sinobesani*, *Sinocytheridea sinensis, S. latiovata, S. longa*) reported from East Asia to be synonyms of *S. impressa*. We follow their opinion.

Malaycythereis sp. (Pl. 1, fig. 19). With its conical spines, this species differs from *Malaycythereis trachodes* described from Jason Bay, Malay Peninsula (Zhao and Whatley 1989).

Tanella gracilis s. l. Kingma 1948 (Pl. 1, fig. 3). Kingma (1948) originally described this species from an Upper Pliocene deposit on Java.

Tanella sp. (Pl. 1, fig. 6). Many morphologically different species have been reported from the West Pacific as *T. gracilis* (e.g., Hartmann 1978; Mostfawi 1992). Our material is morphologically similar to *T. gracilis* reported by Hartmann (1978: pl. 4, figs. 4-13) from the western Australian coast, but differs from the latter in having coarse ornamentation and strong, sinuate ridges running obliquely across the middle to posterior part of the valves.