New species of Miocene cytheracean Ostracoda from the Pohang Basin, SE Korea

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ABSTRACT – Seven new species of ostracods are described from the Miocene deposits of the Pohang Basin in southeastern area, Korea. *Baffinicythere paiki* is only the third record of the genus *Baffinicythere* in the world. In this study, the following new species are erected: *Callistocythere kyongjuensis, C. seojeongriensis, Baffinicythere paiki, Urocythereis pohangensis, Trachyleberis leei, T. praeniitsumai* and *Acanthocythereis koreana. J. Micropalacontol.* **16**(1): 31–40, May 1997.

INTRODUCTION

The Miocene sedimentary sequences in the Pohang Basin of SE Korea contain numerous macro- and microfossils which are employed in elucidating its sedimentary environments and tectonic history. With these aims, many palaeontological and sedimentological studies have been carried out during recent decades. Relatively abundant fossil groups such as Mollusca (Yoon, 1976a, b; Lee, 1992), plants (Chun, 1982), foraminifera (Kim, 1965; Yoo, 1969; Kim & Choi, 1977; Jung, 1993), diatoms (Lee, 1984 unpublished doctoral thesis, Seoul University), palynomorphs (Bong, 1985 unpublished doctoral thesis, Seoul University; Chung & Choi, 1993), silicoflagellates (Koh, 1986 unpublished doctoral thesis, Seoul University), nannofossils (You, 1983) and dinoflagellates (Yun, 1981) are reported. All these studies have improved our understanding of the origin and evolution of the Pohang Basin.

Recently, studies on the Ostracoda of the Pohang Basin have been undertaken by Huh (1991, 1994), Huh and Paik (1992a, b) and Huh *et al.* (1994). Most of these studies have been focused mainly on palaeoenvironmental investigations of the Pohang Basin. This is the first detailed taxonomic study on new ostracods of the Pohang Basin.

GEOLOGICAL SETTING

The Pohang Basin, the largest sedimentary basin along the eastern coast of the Korean Peninsula, includes fossiliferous Miocene sedimentary rocks which are up to 10 km thick (Chough, 1983). The Miocene sedimentary sequences of the Pohang Basin consist of the Yeonil Group which unconformably overlies Cretaceous and Eocene sedimentary and volcanic rocks, and consists largely of clastic sediments including conglomerate, sandstone and mudstone. The age of this group is generally considered to be Middle Miocene and probably early to mid-Middle Miocene. Conglomerates are abundant in the western part of the Pohang Basin and are intercalated with sandstone and mudstone, which are abundant in the centre of the basin. Most of the samples which vielded ostracods are from the middle part of the Yeonil Group, where the unconsolidated sandstones referred to in the taxonomic part are best developed.

The Yeonil Group comprises two units: a lower unit, mainly derived by mass flow deposits forming Gilbert-type fan delta, alluvial fan and steep-faced slope systems (Chough *et al.*, 1993), and an upper unit, composed of hemipelagic to pelagic sediments. The stratigraphical division of the sequence is conventionally divided into several formations, the boundaries and the exact age of which are still debatable (Um *et al.*, 1964; Kim, 1965; Yoon, 1975; Yun, 1986; Choe & Chough, 1988; Hwang, 1993 unpublished doctoral thesis, Seoul University).

MATERIAL AND METHODS

A total of nine sections from six areas containing fossil Ostracoda were collected and measured. The collected areas are given in detail with available palaeontological information and with the columnar sections in Huh (1991 unpublished doctoral thesis, Korea University) and Huh & Paik (1992a). The studied areas and sections are as follows: Daejeonri (section DJ), Seojeongri (sections SJ1, SJ2), Danguri (Section DG), Hakjeondong (section HJ), Mulcheonri (sections MC1, MC2) and Ododong (sections OD1, OD2). In these areas, 63 samples were collected and examined, but only 24 samples yielded ostracods (Fig. 1).

The stratigraphical relationships of the various samples to one another are depicted in the following outline:

Lower -	
North Section DJ	Sample DJ-1
Section SJ1	Sample SJ1-1
Section SJ2	Sample SJ2-1, SJ2-2, SJ2-3, SJ2-4, SJ2-5, SJ2-6
Section OD1	Sample OD1-1, OD1-2, OD1-3, OD1-4
Section OD2	Sample OD2-1
Section DG	Sample DG-1, DG-2, DG-3
Section HJ	Sample HJ-1, HJ-2, HJ-3
Section MC1	Sample MC-1, MC-2, MC-3, MC-4
South Section MC2	Sample MC2-1

Most ostracods occurred in the massive, fine to medium sandstone bed which also yields foraminifera, oysters and shell fragments. About 300 g portions of the dry samples were processed. Each dried sample was treated using the saturated sodium sulphate solution and naphtha method.

SYSTEMATIC DESCRIPTIONS

The following abbreviations are employed in the descriptions: J = juvenile, C = carapace, V = valve, RV = rightvalve, LV = left valve, L = length, H = height, W = width.

All the type specimens of the new taxa in this paper are deposited in the collections of the Palaeontology Laboratory of the Department of Geology, Chonnam National



Fig. 1. Location map showing the sampled localities of the Yeonil Group of the Pohang Basin.

University, Korea to which the catalogue numbers refer. Other specimens are deposited in the Micropalaeontology Museum at Aberystwyth.

> Class Ostracoda Latreille, 1806 Order Podocopida Müller, 1894 Suborder Podocopina Sars, 1866 Superfamily Cytheracea Baird, 1850 Family Leptocytheridae Hanai, 1957 Genus Callistocythere Ruggieri, 1953 Callistocythere kyongjuensis sp. nov. (Pl. 1, figs 1–6)

1992b Callistocythere sp. A; Huh & Paik, pl. 3, fig. 11.

1994 Callistocythere sp. A; Huh et al., pl. 1, figs. 5, 6.

Derivation of name. From Kyongju, the city where the type locality of the species is situated.

Diagnosis. A species of *Callistocythere* characterized by its four anterior and four posterior marginal ribs and centrally coarsely reticulate carapace. The species, although clearly *Callistocythere* resembles many *Leptocythere* species.

Holotype. Female LV (CNU-O-501).

Material. 17 adults.

Type locality and horizon. Sample horizon MC2-1, Mulcheonri area of Weolseong-gun, near Kyongju. Unconsolidated sediment with foraminifera and numerous shell fragments; massive fine to medium-grained sandstone. Miocene.

Description. Carapace small, oblong, highest at the anterior cardinal angle. Sexual dimorphism fairly strong: male slightly narrower in side view, and more compressed in dorsal view, especially posterocentrally. Anterior margin obliquely rounded, with some projections at termination of radial pore canals, especially along lower half of anterior margin; posterior margin truncated above, rounded below. Dorsal margin gently arched and inclined backward; ventral margin moderately sinuous near middle. Surface coarsely reticulate centrally. Eye spot prominent. Four anterior and four posterior marginal ribs distinct; the second anterior rib extends from the eye spot to the mid-anteroventral area; the third posterior rib short and distinct. Hingement pseudoentomodont and of the Callistocythere japonica type. Calcified inner lamella broad anteriorly, moderate posteriorly. Vestibulum present, but very narrow anteriorly. Radial pore canals moderately numerous, repeatedly bifurcate and polyfurcate. Snapknob present in right valve, corresponding snap-pit in left valve. Muscle scars located slightly below the centre. Four adductor scars in a vertical row; the dorsal subtriangular, the two median elongate, horizontal and the ventral subcircular. A slightly elongate, short frontal scar present. Fulcral point large and circular. Normal pores small, few, simple, scattered.

Dimensions (mm).

	L./	
Holotype, female LV (CNU-O-501)	0.56	0.30
Paratype, female LV (CNU-O-502)	0.56	0.30
Paratype, male RV (CNU-O-503)	0.56	0.28
Paratype, male LV (CNU-O-504)	0.56	0.29

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Explanation of Plate 1

Figs 1–6. *Callistocythere kyongjuensis* sp. nov. All specimens are from sample horizon MC2-1: figs 1–2. Holotype, female LV (CNU-O-501), 1) external lateral view (×82), 2) internal view (×80); fig. 3. Paratype, female LV (CNU-O-502), external lateral view (×80); figs 4–5. Paratype, male RV (CNU-O-503), 4) external lateral view (×82), 5) internal view (×80); fig. 6. Paratype, male LV (CNU-O-504), external lateral view (×80). **Figs 7–10**. *Callistocythere seojeongriensis* sp. nov. All specimens ×77: fig. 7. Holotype, female RV (CNU-O-505), external lateral view, sample SJ2-3; fig. 8. Paratype, female RV (CNU-O-506), internal view, sample SJ2-3; fig. 9. Paratype, female LV (CNU-O-507), external lateral view, sample SJ2-3; fig. 10. Paratype, male LV (CNU-O-508), external lateral view, sample SJ2-1. **Figs 11–15**. *Baffinicythere paiki* sp. nov. All specimens ×69: fig. 11. Holotype, female RV (CNU-O-509), external lateral view, sample SJ2-3, fig. 12. Paratype, female LV (CNU-O-510), external lateral view, sample SJ2-3, fig. 13. Paratype, male RV (CNU-O-511), external lateral view, sample SJ2-3, fig. 14. Paratype, male LV (CNU-O-512), external lateral view, sample MC2-1, fig. 15. Paratype, male RV (CNU-O-513), internal view, sample MC2-1.



Plate 1

Remarks. This species somewhat resembles *Callistocythere reticulata* Hanai, 1957 in carapace outline and surface ornamentation, but differs in the finer details of ornamentation and the pattern of anterior and posterior ribs.

Distribution. Abundant at sample horizon MC2-1, to which it is confined.

Callistocythere seojeongriensis sp. nov. (Pl. 1, figs 7-10)

Derivation of name. From Seojeongri village, the type locality of the species.

Diagnosis. A species of *Callistocythere* characterized by its finely reticulate surface ornament and numerous, various ribs, especially strong posterior marginal ribs.

Holotype. Female RV (CNU-O-505).

Material. 11 carapace, 45 adults.

Type locality and horizon. Sample horizon SJ2-3, Seojeongri area of Yeongil-gun, near Pohang. Unconsolidated sediment with foraminifera and numerous shell fragments; massive fine-grained sandstone.

Description. Carapace small, subrectangular, highest at the anterior cardinal angle. Sexual dimorphism strong; female broader than male in posterocentral area, male slightly narrower than female in lateral outline. Anterior margin obliquely rounded; posterior margin truncated in upper half, gently rounded in lower half. Posterior cardinal angle distinct. Dorsal margin broadly arched; ventral margin broadly concave. Surface ornament with finely reticulation over most of the central part of the carapace. Two anterior marginal ribs prominent; outer rib weakly, very short, nearly vertical; inner rib narrow, distinct, broadly rounded, extending from lower terminal to upper terminal of anterior margin. Two posterior marginal ribs strongly prominent; outer rib subcircular, extending from the posterior fifth of dorsal margin to the ventral sinuosity; inner rib subrounded, distinct, starting from the posterior fourth of dorsal margin and terminates at mid-length. Numerous small ribs occur, and a sinuous posteroventral rib is especially distinct. Eye spot distinct. Hingement pseudoentomodont and of the Callistocythere japonica type. Calcified inner lamella broad anteriorly; moderate posteriorly. Anterior vestibulum narrow. Snap-knob and snap-pit distinct. Four adductor muscle scars in a vertical row and a frontal muscle scar in a row. Normal pore small, few, simple.

Dimensions (mm).

n	
59 0.32	2
59 0.34	1
59 0.33	3
59 0.31	l
	59 0.32 59 0.34 59 0.33 59 0.33

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Remarks. This species resembles *Callistocythere subsetanensis* Ishizaki, 1966 from the Miocene and Pliocene of the Sendai area of Japan, in shape and ornamentation, but the present species differs in its more finely reticulate surface ornament, presence of eye spot, more prominent marginal ribs and presence of numerous ribs. This species also resembles *Callistocythere* sp. (Yajima, 1988) from the Miocene of Japan in general appearance, but differs in details of the surface ornament.

Distribution. Abundant at sample horizon SJ2-3 and rare at SJ2-1, SJ2-2, SJ2-4, HJ-2, OD1-2, OD1-3 and OD1-4.

Family Hemicytheridae Puri, 1953
Subfamily Aurilinae Puri, 1953
Genus Baffinicythere Hazel, 1967
Baffinicythere paiki sp. nov.
(Pl. 1, figs 11–15; Pl. 2, figs 1–2)

1992a *Baffinicythere* sp.: Huh & Paik, pl. 1, figs 14, 15. 1992b *Baffinicythere* sp.: Huh & Paik, pl. 1, figs 14, 15. 1994 *Baffinicythere* sp.: Huh *et al.*, pl. 2, figs 1, 2.

Derivation of name. In honour of Professor Kwang Ho Paik of Korea University, Seoul in recognition of his important contribution to our knowledge of the Miocene deposits of the Korea Peninsula.

Diagnosis. A species of *Baffinicythere* characterized by its relatively small carapace, coarsely but regularly reticulate ornament conforming to a somewhat radiate pattern about the valve centre, two frontal muscle scars and sexual dimorphism with males shorter than females.

Holotype. Female RV (CNU-O-509).

Material. 9 carapaces, 48 valves, 3 juveniles.

Type locality and horizon. Sample horizon SJ2-3, Seojeongri area of Yeongil-gun, near Pohang. Unconsolidated sediment with foraminifera and numerous shell fragments: massive fine-grained sandstone.

Description. Carapace medium, elongate, subrectangular (male) to subtrapezoidal or auriform (female) in lateral view. Maximum height at the anterior cardinal angle. Anterior margin well rounded without distinct cardinal angles; posterior margin rather narrowly terminated; upper half broady arched, lower half convex. Dorsal margin virtually straight and inclined towards the posterior, or broadly convex; ventral margin more or less sinuous, anterior third slightly concave, behind midlength slightly convex. Surface coarsely, regularly reticulate with distinct ribs forming triangle in postero-lateral area but slightly less prominent than that of *Baffinicythere howei*. Less prominent submarginal curved rib extending from in front of eye tubercle, converging with anteroventral margin, and bending

Explanation of Plate 2

Figs 1–2. *Baffinicythere paiki* sp. nov. All specimens ×69: fig. 1. Paratype, female LV (CNU-O-514), internal view, sample SJ2-3; fig. 2. Paratype, female RV (CNU-O-515), internal view, sample SJ2-4. **Figs 3–9**. *Urocythereis pohangensis* sp. nov. All specimens ×47, sample horizon SJ2-3: fig. 3. Paratype, female LV (CNU-O-517), external lateral view; fig. 4. Paratype, female RV (CNU-O-518), external lateral view; fig. 5. Paratype, male RV (CNU-O-519), external lateral view; fig. 6. Holotype, male LV (CNU-O-516), external lateral view; fig. 7. Paratype, female LV (CNU-O-520), internal view; fig. 8. Paratype, female RV (CNU-O-521), internal view; fig. 9. Paratype, juv. RV (CNU-O-522), external lateral view; fig. 10–15. *Trachyleberis leei* sp. nov. All specimens ×60: fig. 10. Paratype, female RV (CNU-O-524), external lateral view; sample SJ2-4; fig. 11. Paratype, female LV (CNU-O-525), internal view, sample SJ2-4; fig. 12. Holotype, female LV (CNU-O-526), external lateral view, sample SJ2-4; fig. 13. Paratype, female RV (CNU-O-526), external lateral view, sample SJ2-4; fig. 14. Paratype, female RV (CNU-O-526), internal view, sample SJ2-4; fig. 14. Paratype, female RV (CNU-O-527), internal view, sample SJ2-4; fig. 15. Paratype, male RV (CNU-O-528), external lateral view, sample SJ2-3; fig. 14. Paratype, female RV (CNU-O-527), internal view, sample SJ2-3; fig. 15. Paratype, male LV (CNU-O-528), external lateral view, sample SJ2-3; fig. 15. Paratype, male LV (CNU-O-528), external lateral view, sample SJ2-3; fig. 15. Paratype, male LV (CNU-O-528), external lateral view, sample SJ2-3; fig. 15. Paratype, male LV (CNU-O-528), external lateral view, sample SJ2-3; fig. 15. Paratype, male LV (CNU-O-528), external lateral view, sample SJ2-3; fig. 15. Paratype, male LV (CNU-O-528), external lateral view, sample SJ2-3; fig. 15. Paratype, male LV (CNU-O-528), external lateral view, sample SJ2-3; fig. 15. Paratype, male LV (CNU-O-528), external lateral view, sample SJ2-3; fig. 15. Paratype, male LV (CNU-O-528), external late



Plate 2

upwards posteriorly to meet anterior corner of posteroventral triangle of ribs. Slightly prominent posterodorsal and posteroventral node, extending to nearly vertical ribs. Subcentral tubercle present but not prominent. Eye tubercle small, prominent. Marginal pore canals numerous, swollen at mid-length. Small anterior and posterior vestibulae. Hinge robustly holamphidont, with posterior tooth of the right valve reniform. Ocular sinus conspicuous. Normal pore canals scattered, sieve type. Adductor muscle scars; a single subrounded dorsal scar, two rounded dorso-median scars, an elongate ventro-median scar (in some cases, the right half is absent) and an elongate ventral scar. Two rounded frontal scars. Strongly sexual dimorphism; male more slender and shorter than female.

Dimensions (mm).

. ,	L	Н
Holotype, female RV (CNU-O-509)	0.67	0.39
Paratype, female LV (CNU-O-510)	0.65	0.39
Paratype, male RV (CNU-O-511)	0.63	0.35
Paratype, male LV (CNU-O-512)	0.61	0.36
Paratype, male RV (CNU-O-513)	0.63	0.35
Paratype, female LV (CNU-O-514)	0.63	0.36
Paratype, female RV (CNU-O-515)	0.65	0.40

Remarks. This species is superficially similar in general appearance to *Baffinicythere emarginata* (Sars, 1866) (Hazel, 1967), but differs in details of ornament, carapace outline, carapace size and frontal muscle scar pattern. This species is distinguished from Baffinicythere howei Hazel, 1967 (Hazel, 1967; Horne & Whittaker, 1983) in its different muscle scar pattern, size, sexual dimorphism and the distribution pattern of its ribs. Also, this species is distinguished from Meridionalicythere discophora (Skogsberg, 1928) from the S. W. Atlantic (Whatley et al., 1987) by its adductor muscle scar pattern and the nature of its surface ornament. This species seems to belong to Baffinicythere by virtue of its undivided ventro-median adductor muscle scar, strong sexual dimorphism and the triangle formed by ribs in the postero-lateral area. This species is also closely allied to the genus Hemicythere in having two frontal scars, but Hazel (1967) observed that the lower frontal muscle scar tends to be easily overlooked.

Distribution. Abundant at sample horizon SJ2-3 and rare at SJ2-2, SJ2-4, HJ-2 and MC2-1.

Genus Urocythereis Ruggieri, 1950 Urocythereis pohangensis sp. nov. (Pl. 2, figs 3-9)

1992a Urocythereis sp.; Huh & Paik, pl. 1, figs 17, 18. 1992b Urocythereis sp.; Huh & Paik, pl. 1, figs 17, 18. 1994 Urocythereis sp.; Huh et al., pl. 2, fig. 7.

Derivation of name. From Pohang, the Tertiary sedimentary basin in Korea where the type locality of the species is situated.

Diagnosis. An inflated, elongate species of Urocythereis characterized by its coarsely reticulate surface ornament with numerous intramural spines, two subparallel ventrolateral ribs and prominent subcentral tubercle.

Holotype. Male LV (CNU-O-516).

Material. 3 carapaces, 84 valves, 22 juveniles.

Type locality and horizon. Sample horizon SJ2-3, Seojeongri area of Yeongil-gun, near Pohang. Unconsolidated sediment with foraminifera and shell fragments rich; massive fine-grained sandstone.

Description. Carapace large, inflated, elongate and subrectangular in lateral view. Maximum height at anterior cardinal angle. Anterior margin well rounded; posterior margin dorsally and ventrally convex and centrally compressed. Posteroventral margin more or less prominent, projecting posteriorly. Dorsal margin nearly straight, slightly inclined posteriorly; ventral margin with oval incurvatine at mid-length. Surface coarsely reticulate with numerous intramural spines. Two subparallel ribs extend across the ventro-lateral surface. Slightly depressed postero-lateral area. Prominent subcentral tubercle. Eye tubercle ovate with post-ocular sulcus. Normal pore canals scattered, sieve type. Marginal pore canals numerous and straight. Calcified inner lamellar of median width. Anterior vestibulum moderately deep. Hinge holamphidont, with reniform posterior tooth in right valve which exhibits a wide auriline notch. Adductor muscle scar vertical row of four, of which the two middle scars are distinctly divided. Three frontal scars, of which the middle is distinctly smaller. Strongly sexual dimorphism, male more elongate and slender than female.

Dimensions (mm).

	L	Н
Holotype, male LV (CNU-O-516)	0.93	0.50
Paratype, female LV (CNU-O-517)	0.88	0.51
Paratype, female RV (CNU-O-518)	0.86	0.49
Paratype, male RV (CNU-O-519)	0.96	0.49
Paratype, female LV (CNU-O-520)	0.87	0.52
Paratype, female RV (CNU-O-521)	0.90	0.52
Paratype, juv. RV (CNU-O-522)	0.62	0.37

Remarks. This species is closely similar to Yezocythere havashii Hanai & Ikeya, 1991 from the Omma-Manganji Ostracoda fauna of Japan in the general lateral outline, distribution pattern of muscle scars and hinge structure. However, this species is distinguished from the latter by its reticulate ornament pattern with numerous intramural spines and prominent subcentral tubercle. The present authors regard Yezocythere Hanai & Ikeya, 1991 as a junior synonym of Urocythereis. This species resembles Elofsonella concinna (Jones, 1857) from the Tomikawa Formation in Omma-Manganji Area of Japan (Cronin & Ikeya, 1987) in lateral outline and general surface ornament, but differs in its less conspicuous anterior marginal rim, reticulate ornament and absence of secondary reticulation. This species is also distinguished from Baffinicythere ishizakii (Irizuki, 1996) in lacking a denticulate posterior margin and in its larger size. (Irizuki's specimens measure Holotype L = 1.219, H = 0.569 and the paratypes range from 1.268 to 1.336 long, and 0.630 to 0.740 high). The present species is distinguished from other Urocythereis species by its surface ornament with intramural spines.

Distribution. Abundant at sample horizons SJ2-3, SJ2-4, HJ-2 and rare at SJ2-2, SJ2-5 and MC2-1.

Family **Trachyleberididae** Sylvester-Bradley, 1948 Subfamily **Trachyleberidinae** Sylvester-Bradley, 1948 Genus *Trachyleberis* Brady, 1889 *Trachyleberis leei* sp. nov. (Pl. 2, figs 10–15)

1992a Acanthocythereis sp.; Huh & Paik, pl. 2, fig. 10.

1992b Acanthocythereis sp.; Huh & Paik, pl. 2, fig. 10.

Derivation of name. In honour of Dr. Eui Hyeong Lee of Korea University, Korea, in recognition of his important contribution to our knowledge of Korean Miocene Ostracoda.

Diagnosis. A species of *Trachyleberis* characterized by its regularly, well-reticulated surface ornament, numerous conjunctive spines, and ocular rib which connects midanteriorly with a rib which parallels the anterior and ventral margins.

Holotype. Female LV (CNU-O-523).

Material. 21 carapace, 61 valves, 6 juveniles.

Type locality and horizon. Sample horizon SJ2-3, Seojeongri area of Yeongil-gun, near Pohang. Unconsolidated sediment with foraminifera and rich in shell fragments: massive fine sandstone.

Description. Carapace large, subrectangular, tapering posteriorly. Left valve is slightly larger than right valve. Strongly sexually dimorphic; male is longer and narrower than female in lateral view. Greatest length near mid-height, greatest height at anterior cardinal angle. Anterior margin broadly and obliquely rounded with tiny spines; posterior margin protruded posteriorly, posterodorsal margin slightly concave or straight, posteroventral margin broadly and obliquely rounded with small spines. Dorsal margin straight;, with anterior hinge ear; ventral margin with more pronounced oral incurvature in male than in female. Surface reticulate ornament with conjunctive spines on intersections of lattice. Eye tubercle distinct, prolonged with ocular rib which extends to the mid anterior margin, from where it parallels the anterior and ventral margins. Anterior region compressed Posterior lateral surface almost smooth with some small spines. Marginal denticles spinose numerous, small, along anterior and posteroventral margins. Internal features typical of genus with distinct snap-knob orally in RV.

Dimensions (mm).

	L	Н
Holotype, female LV (CNU-O-523)	0.74	0.42
Paratype, female RV (CNU-O-524)	0.73	0.39
Paratype, female LV (CNU-O-525)	0.75	0.42
Paratype, female RV (CNU-O-526)	0.74	0.40
Paratype, female RV (CNU-O-527	0.73	0.40
Paratype, male LV (CNU-O-528)	0.75	0.38

Remarks. The present species resembles *Trachyleberis mizunamiensis* Yajima, 1992 from Mizunami in central Japan in shape and surface ornamentation, but the present species differs from the latter in its weak, shorter ocular rib, the nature of its anterior ornament and its v-shaped

frontal muscle scar. This species differs from most other species of *Trachyleberis* because of its enhanced reticulate ornament. However, it clearly belongs in *Trachyleberis* because of its anterodorsal rib, subrectangular lateral outline, spinose ornament and oblique ocular rib. The type species, *Trachyleberis scabrocuneata* (Brady), is more elongate, is pustulate rather than spinose and has a very strong, sharp, ocular rib.

Distribution. Abundant at sample horizon SJ2-3 and rare at SJ2-1, SJ2-2, SJ2-4, SJ2-5, HJ-1, HJ-2, OD1-2, OD1-3, OD1-4 and MC1-3.

Trachyleberis praeniitsumai sp. nov. (Pl. 3, figs 1–5)

1992a Trachyleberis niitsumai Ishizaki; Huh & Paik, pl. 2, figs 6, 7.

1992b Trachyleberis niitsumai Ishizaki; Huh & Paik, pl. 2, figs 6, 7.

1994 Trachyleberis niitsumai Ishizaki; Huh et al., pl. 2, fig. 11.

Derivation of name. Latin, with reference to the probable ancestral relationship of the species to *Trachyleberis niitsumai* Ishizaki.

Diagnosis. A species of *Trachyleberis* characterized by its irregular surface ornament with blunt tubercles and well-developed anteroventral marginal rib.

Holotype. Female LV (CNU-O-529).

Material. 59 carapaces, 83 valves, 46 juveniles.

Type locality and horizon. Sample horizon SJ2-3, Seojeongri area of Yeongil-gun, near Pohang. Unconsolidated foraminifera and shell fragments rich; massive fine sandstone.

Description. Carapace large, subrectangular, tapering posteriorly. Left valve is slightly larger than right valve. Strong sexual dimorphism; carapace of male is longer and narrower than that of female. Anterior margin broadly rounded with tiny spines; posterior margin narrowly protruded posteriorly, just below mid-height. Dorsal margin nearly straight in left valve, but broadly rounded in right valve; ventral margin slightly sinuous. Surface covered with weak irregular reticulae and moderately prominent, blunt tubercles. Subcentral tubercle prominent. Eve tubercle distinct, prolonged with anterodosal oblique rib. Anterior marginal rib distinct, divided; upper part nearly straight inclined from anterior cardinal angle to mid-height; lower part broadly rounded prolonged to mid-length along the ventral margin. Caudal region smooth with some small spines. Internal features as for genus. Snap knob occurs orally in RV. Dimensions (mm).

	L	
Holotype, female LV (CNU-O-529)	0.76	0.44
Paratype, female RV (CNU-O-530)	0.76	0.41
Paratype, female LV (CNU-O-530)	0.77	0.44
Paratype, female LV (CNU-O-531)	0.80	0.44
Paratype, female RV (CNU-O-532)	0.79	0.42

Remarks. This species has a close affinity to *Trachyleberis niitsumai* Ishizaki, 1971 from Aomori Bay of Japan in general appearance. However, this species differs from the

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latter in its well-developed anteroventral marginal rib, less prominent spines and carapace shape. This species also resembles *Trachyleberis scabroculeata* (Brady, 1880) from the Recent of Japan, the type species of *Trachyleberis*, in shape and inner features, especially in the presence of the well-developed anterodorsal rib, but this species is clearly different to the latter in surface ornamentation. This species somewhat resembles *Trachyleberis* sp. Yajima, 1988 from the Japanese Miocene, but differs in details of surface ornament.

Distribution. Abundant at sample horizon SJ2-1, SJ2-2, SJ2-3, OD1-3, OD1-4, and rare at SJ2-2, OD1-1 and OD1-2.

Genus Acanthocythereis Howe, 1963 Acanthocythereis koreana sp. nov. (Pl. 3, figs 6–12)

1992a Acanthocythereis mutsuensis Ishizaki; Huh & Paik, pl. 2, figs 8, 9.

1992b Acanthocythereis mutsuensis Ishizaki; Huh & Paik, pl. 2, figs 8, 9.

1994 Acanthocythereis mutsuensis Ishizaki; Huh et al., pl. 2, fig. 12.

Derivation of name. From Korea, referring to the first occurrence of the species in the Korean peninsula.

Diagnosis. A rather large, thick-shelled species of *Acanthocythereis* distinguished by its surface ornament with numerous small spines and tubercles superimposed on coarse web-like reticulation and lack of short vertical posterodorsal rib.

Holotype. Female, RV (CNU-O-533).

Material. 27 carapaces, 159 valves, 2 juveniles.

Type locality and horizon. Sample horizon DJ-1, Daejonri area of Yeongil-gun, near Pohang. Unconsolidated foraminifera and shell fragment rich; massive mudstone.

Description. Carapace rather large, thick-shelled, subtrapezoidal. In lateral view, carapace tapering slightly toward the posterior end. Sexual dimorphism distinct; male carapace is longer and narrower than female carapace. Maximum height at anterior cardinal angle. Anterior margin broadly rounded and nearly symmetrical with numerous marginal spines; posterior margin nearly vertical and obliquely rounded with small spines. Dorsal margin straight with numerous spines; ventral margin nearly straight in female, but slightly sinuous in male. Surface ornament with numerous, irregularly small spines superimposed on feeble web-like reticulation. Anterior marginal spines arranged concentrically about subcentral tubercle. Subcentral tubercle prominent. Eye tubercle distinct, just below anterior end of dorsal margin, and somewhat obliquely elongated. Calcified inner lamella moderately wide. Line of concrescence and inner margin coincide throughout the margin. Marginal pore canals numerous, simple, nearly straight, and numerous at anterior and posterior margins, and slightly inflated near the middle ventral margin. Hinge holamphidont, with slightly crenulate posterior tooth in right valve. Muscle scars consist of a v-shaped frontal scar and a vertical row of four adductor scars; dorso-median adductor scar elongate anteroventrally. Normal pores simple. **Dimensions (mm).**

	L	Н
Holotype, female RV (CNU-O-533)	0.97	0.61
Paratype, female LV (CNU-O-534)	0.91	0.60
Paratype, female RV (CNU-O-535)	0.99	0.63
Paratype, female LV (CNU-O-536)	0.96	0.61
Paratype, male RV (CNU-O-537)	1.09	0.56
Paratype, male LV (CNU-O-538)	1.01	0.54
Paratype, male LV (CNU-O-539)	1.12	0.63

Remarks. This species resembles *Acanthocythereis mut*suensis Ishizaki 1971 from the Aomori bay of Japan in general appearance, but differs in the developmental degree of spines, the reticulation on the surface, lack of a short vertical posterodorsal rib consisting of small spines and larger carapace size. This species differs from *Acanthocythereis dunelmensis* (Norman, 1865) from Quaternary of the Gulf of Alaska (Brouwers, 1993) in its less developed reticulate ornament, and numerous, irregularly small spines, and lack of a short vertical posterodorsal rib.

Distribution. Common at sample horizon DJ-1, SJ1-1, SJ2-5, SJ2-6, MC1-3, HJ-2, HJ-3, OD1-2, OD1-3, OD2-1 and rare at SJ2-4, OD1-1.

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Explanation of Plate 3

Figs 1–5. *Trachyleberis praeniitsumai* sp. nov. All specimens ×54: figs 1–2. Paratype, female C (CNU-O-530), 1) right lateral view, 2) left lateral view, sample SJ2-3; fig. 3. Holotype, female LV (CNU-O-529), external lateral view, sample SJ2-1; fig. 4. Paratype, female LV(CNU-O-531), internal view, sample SJ2-3; fig. 5. Paratype, female RV(CNU-O-532), internal view, sample SJ2-3; Figs 6–12. *Acanthocythereis koreana* sp. nov.: fig. 6. Paratype, female LV (CNU-O-534), external lateral view (×48), sample SJ2-6; fig. 7. Holotype, female RV (CNU-O-533), external lateral view (×48), sample DJ-1; fig. 9. Paratype, female LV (CNU-O-538), external lateral view (×48), sample DJ-1; fig. 9. Paratype, female LV (CNU-O-538), external view (×47) sample DJ-1; fig. 11. Paratype, male LV (CNU-O-538), external lateral view (×47), sample DJ-1; fig. 12. Paratype, male LV (CNU-O-538), external lateral view (×47), sample HJ-3; fig. 12. Paratype, male LV (CNU-O-539), internal view (×47), sample DJ-1.

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