

Taxonomy, biostratigraphic and paleoecological aspects of non-marine ostracod fauna from the Jinju Formation (Albian) of the Gyeongsang Basin, South Korea

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ABSTRACT

A total of seven species belonging to six genera of cypridoidean ostracods were recovered from three sections (Jeongchon, Hotan, and Tapri) of the Albian Jinju Formation from the Gyeongsang Basin, South Korea: *Scabriculocypris yanbianensis*, *Cypridea khandae* sp. nov., *Cypridea samesi*, *Mongolocypis kohi*, *Lycoperocypris?* cf. *celsa*, *Candona* sp., and *Djungarica* sp. Based on its morphology, *C. khandae* sp. nov. is considered to be the first record of the *Cypridea alta*-group in Korea. Although many species are endemic to the Jinju Formation, the occurrence of *Scabriculocypris yanbianensis* indicates that this fauna was linked with the contemporaneous fauna of the Tongfosi Formation of the Yanji Basin, northeast China. Based on previous studies and newly collected specimens, the taphonomic features of the sections indicate the presence of two distinct thanatocoenoses: a low-energy autochthonous thanatocoenosis (Jeongchon and Tapri sections) and a slightly higher energy thanatocoenosis (Hotan section). Finally, the absence of cytheroidean and darwinuloidean ostracods could be explained by the presence of unstable lake/temporal waterbodies and their low competitiveness.

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1. Introduction

Ostracods are microcrustaceans that have been regarded as one of the most important microfossils for paleoenvironmental reconstruction and biostratigraphic correlation (e.g., Anderson, 1985; Khand et al., 2000; Schudack and Schudack, 2012; Sames, 2011a, b; Sames and Horne, 2012; Wang et al., 2012, 2015, 2017a; Choi et al., 2020). In Korea, the first report of non-marine ostracods comes from the Uhangri Formation (Campanian) of the Haenam Basin, by Lee and Lee (1976); subsequently, non-marine ostracods have been reported from several different regions (e.g., Paik et al., 1988; Choi, 1990; Chun et al., 1993, 1995; Huh et al., 1998; Choi and Huh, 2016; Choi et al., 2017, 2018; Choi, 2019).

The first taxonomic study with ostracods in the Jinju Formation and their application for biostratigraphic correlation was developed in Paik et al. (1988). According to them, the ostracod fauna of the Jinju Formation consists of 18 species belonging to five genera. However, their results should be revised due to the poor preservation and lack of diagnostic characters of their ostracod specimens. Despite some questionable interpretations, this study was the pioneering detailed taxonomic investigation about the Cretaceous non-marine ostracod fauna in Korea. During 1990's, Choi (1990), Chun et al. (1990) and Seo (1996) reported the presence of cypridoidean ostracods in the country, including the new species *Cypridea (Pseudocypridina) jinuria* Choi, 1990, from the Jinju Formation. Recently, Choi and Huh (2016) and Choi et al. (2018) described two *Cypridea* species from the Jinju Formation, and discussed the ontogeny, sexual dimorphism and phylogenetic placement of *Mongolocypis kohi* Choi and Huh, 2016. However, many details of this fauna have not thus far been updated or are imperfectly known. Therefore, based on newly collected samples, the present paper not only revises the ostracod fauna from the Jinju

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Formation, but also discusses its application for biostratigraphic correlation and paleoenvironmental reconstruction.

2. Geological setting

Non-marine Cretaceous basins are distributed in the southern and central parts of South Korea (Fig. 1), which began to form during the Early Cretaceous (Hauterivian to Barremian, see Kang and Paik, 2013) due to the oblique subduction of the proto-pacific (Izanagi) plate (Watson et al., 1987; Chough et al., 2000; Chough and Sohn, 2010). Of these basins, the Gyeongsang Basin (Barremian to Campanian) is the largest non-marine sedimentary basin of the Korean Peninsula (e.g., Chang, 1975; Kang and Paik, 2013). Generally, the Gyeongsang Basin is divided into several sub-basins or blocks (Chang, 1977; Won et al., 1978; Chough and Sohn, 2010). The strata of this basin are divided into four lithographic units: The Sindong (non-volcanic strata), Hayang (partly volcanic strata) and Yucheon (dominantly volcanic strata) groups, and the Bulguksa Granites (Chang, 1975; Choi, 1986). In this study, we follow the lithostratigraphy of Chough and Sohn (2010) (Fig. 2).

The Jinju Formation (maximum 1800 m thick) is the uppermost unit of the Sindong Group in the Gyeongsang Supergroup, and consists of mainly dark gray to black shales, mudstones and sandstones (Chough and Sohn, 2010). The depositional environment of this formation has been interpreted as fluvial-lacustrine environment (Choi, 1986; Paik, 2005; Chough and Sohn, 2010).

Paik et al. (2019) stated that the lower part of the Jinju Formation was deposited in a mudflat to shallow lake as well as a channel environment. In addition, several dry periods were thought to exist during deposition of the upper part of the Jinju Formation based on the presence of palustrine carbonates, desiccation cracks, ooids, gypsum (Lee and Woo, 1996; Kim et al., 2005; Paik, 2005; Ha et al., 2015; Paik et al., 2019), carbon isotope records of plants (Hong et al., 2020), environmentally tolerant ichnocoenoses (Kim et al.,

2005), palynoflora (Yi et al., 1994) and microbial-caddisfly bioherms (Paik, 2005).

The age of the Jinju Formation was proposed a “Neocomian” (which includes all pre-Aptian stages in the Early Cretaceous, see Sames et al., 2010) based on palynomorphs (Choi, 1985; Choi and Park, 1987; Yi et al., 1994). However, detrital zircon dating (ca. 106 Ma) indicates an Albian age for this formation (Lee et al., 2010; Kim et al., 2011; Lee et al., 2018), which is corroborated by the occurrence of the pollen taxon *Corollina* sp. (Hong et al., 2020).

The Jinju Formation yields various fossils, such as dinosaurs, crocodylians, lizards, frogs, fishes, molluscs, spinicaudatans, isopods, spider, insects, ostracods, plants, and invertebrate trace fossils (e.g., Choi, 1990; Lee et al., 2001; Yabumoto et al., 2006; Park et al., 2012; Choi and Huh, 2016; Choi et al., 2018; Kim et al., 2018, 2019; Park et al., 2019; Lockley et al., 2020, and references therein). According to Park et al. (2013) and Nam and Kim (2016), the entomofauna of the Jinju Formation plays an important role in studying the evolution of the post-Jehol Biota. In addition, on the basis of its extraordinarily well-preserved and diverse vertebrate traces, Kim et al. (2018) regarded that the Jinju Formation is Konservat-Lagerstätte.

3. Material and methods

Ostracod samples were collected from the upper part of the Jinju Formation from three sections (Figs. 3 and 4): Seven samples (sample number JJ-1-1 to 1-3 and JJ-2-1 to JJ-2-4) from the Jeongchon section [JJ], Jinju City (GPS: N35°07'–35°08', E128°05'–128°06'); one sample (sample number JH-1) from the Hotan section [JH], Jinju City (GPS: N35°09'36", E128°07'26"); and one sample (sample number ST-1) from the Tapri section [ST], Sacheon City (GPS: N35°06'12", E128°03'58"). Ostracod specimens in rock samples (mainly black shales) were extracted using the method of Choi and Huh (2016).

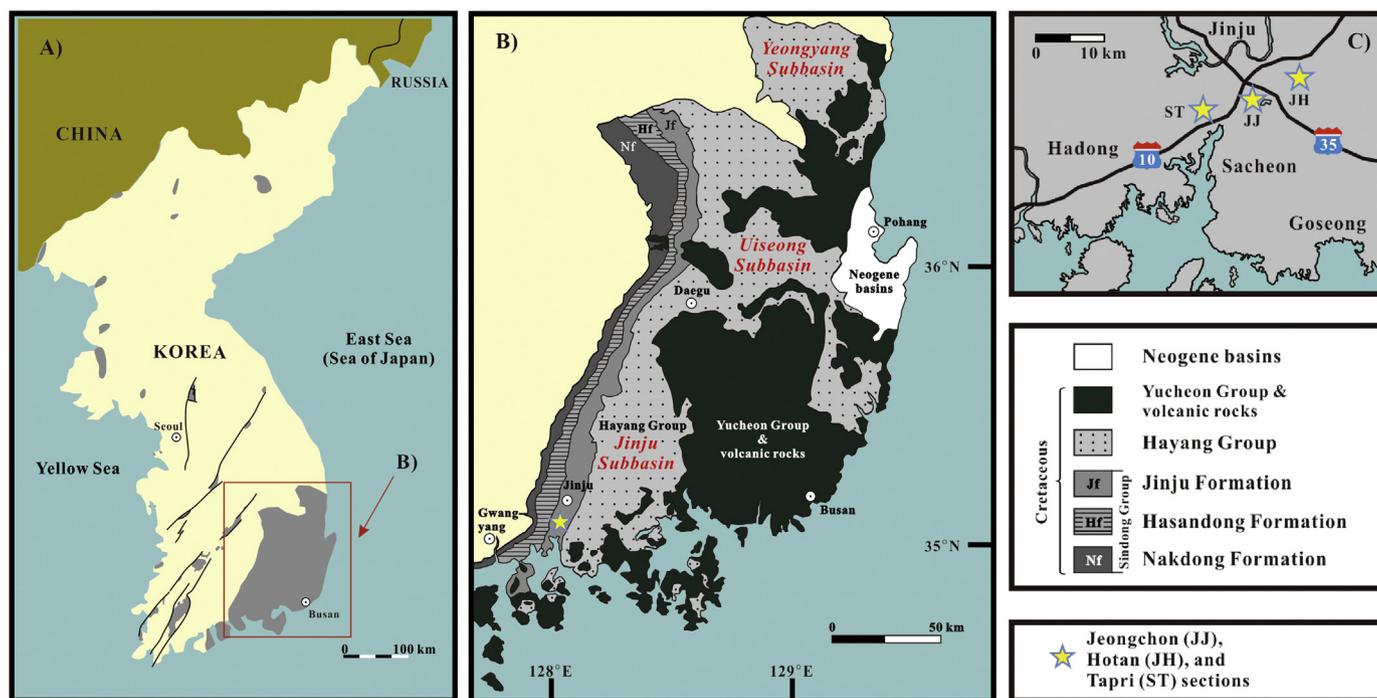


Fig. 1. Geological map of the Gyeongsang Basin and the studied sections of the Jinju Formation: (A) Distribution of the Cretaceous basins in the Korean Peninsula and location of the Gyeongsang Basin; (B) Geological map of the Gyeongsang Basin and the localities of the studied sections (modified from Lee et al., 2010); (C) Location of the Jeongchon (JJ) and Hotan (JH) sections in Jinju City, and the Tapri (ST) section in Sacheon City.

		Gyeongsang Basin				
		Jinju Subbasin	Uiseong Subbasin		Yeongyang Subbasin	
			Daegu area	Uiseong area		
Cretaceous	Upper	Maastrichtian				
		Campanian			Geumseongsan and Hwasun calderas	
			Goseong Fm.			
		Santonian			Sinyangdong Fm.	
		Coniacian	Jindong Fm.	Geoncheonri Fm. Chaeyaksan Bt. Songnaedong Fm. Banyaweol Fm.	Chunsan Fm.	Gisadong Fm.
		Turonian				Dogyedong Fm.
	Cenomanian					
	Lower	Albian	Gusandong Tuff		Sagok Fm. Jeongok Fm. Gugyedong Fm. Gumidong Fm. Iljik Fm.	Osipbong Fm.
			Haman Fm.			
			Silla Conglo.			
			Chilgok Fm.			
		Aptian	Jinju Fm.			Cheongryangsan Fm.
Hasandong Fm.			Gasandong Fm.			
Nakdong Fm.			Dongwhachi Fm. Ullyeonsan Fm.			
Barremian				Gyeongjeongdong Fm.		

Fig. 2. Stratigraphic chart of the Gyeongsang Basin (after Chough and Sohn, 2010; Kang and Paik, 2013; Lee et al., 2018). Abbreviations: Fm. = Formation; Bt. = Basalt.

Ostracod carapaces and valves were scanned with a Hitachi S-4700 Scanning Electronic Microscope in the Korea Basic Science Institute (Gwangju Center) of the Chonnam National University (Gwangju, South Korea). The figured specimens are deposited in the Korea Dinosaur Research Center of Chonnam National University, under the designated number KDRC-JJ-numbers for the specimens of the Jeongchon section, KDRC-JH-numbers for the specimens of the Hotan section, and KDRC-ST-numbers for the Tapri section.

4. Systematic paleontology

Terminology for ostracod morphology follows Sames (2011c), and size ranges follow Ayress and Whatley (2014): Very small: <0.40 mm, small: 0.40–0.50 mm, medium: 0.51–0.70 mm, large: 0.71–1.00 mm, very large: 1.01–2.00 mm, and gigantic: >2.0 mm. Abbreviations, L: length, H: height, W: width, LV: left valve, and RV: right valve.

Class Ostracoda Latreille, 1802
Order Podocopida Müller, 1894

Suborder Cypridocopina Jones, 1901
Superfamily Cypridoidea Baird, 1845
Family Alloiocypridae Ayress and Whatley, 2014

Genus *Scabriculocypris* Anderson, 1941
Type species: *Scabriculocypris trapezoides* Anderson, 1941

Scabriculocypris yanbianensis (Gou, 1983)
Fig. 5A–Q

1983 *Ilyocyprimorpha yanbianensis*, Gou, p. 49, pl. 1, figs. 8–11; pl. 2, fig. 27.

1988 Genus indet species, Paik, Kim and Huh, p. 107, pl. 3, figs. 10–11.

2020 *Scabriculocypris yanbianensis* (Gou), Choi et al., figs. 5G–L.

Material. About 100 carapaces and valves from samples JJ-1-2 and JJ-1-3 of the Jeongchon section.

Dimensions (adults). L: 0.80–0.93 mm, H: 0.48–0.55 mm, W: 0.38–0.40 mm.

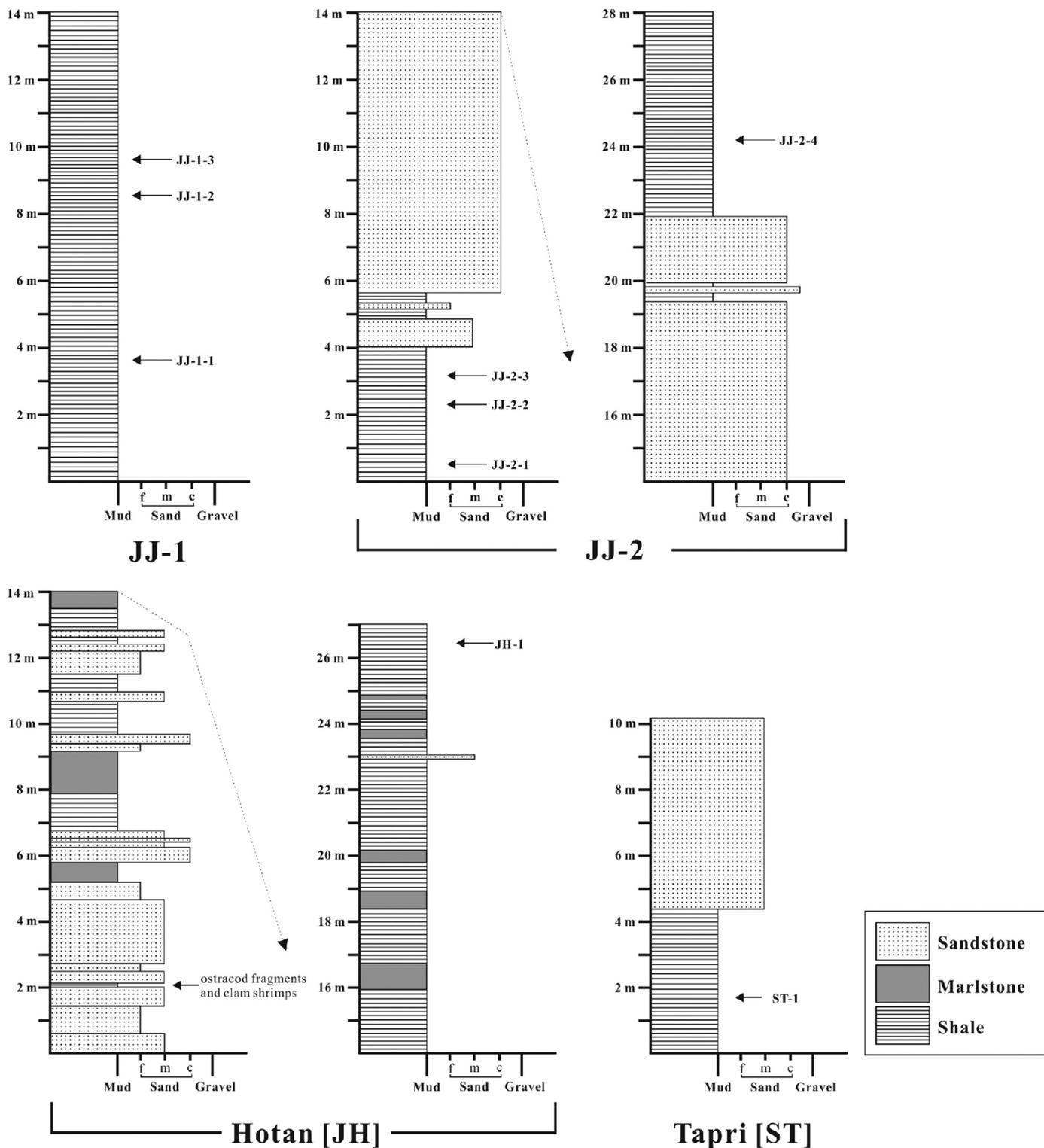


Fig. 3. Lithostratigraphy of the Jinju Formation from the Jeongchon (JJ-1 and JJ-2), Hotan (after Choi and Huh, 2016; Choi et al., 2018) and Tapri sections and occurrence of ostracods. Lithology of the Hotan section modified from Ha et al. (2015).

Description. Large carapace, elongated to rounded, subrectangular in lateral view. LV larger than RV; LV slightly overlapping RV along the margins. Maximum length at mid-height, maximum height at anterior cardinal angle (near 1/3 of length), and maximum width at mid-length. Anterior margin slightly infracurvate. Anterior cardinal angle somewhat rounded but distinct, especially in the RV, with a small

swelling developed below the anterior cardinal angle. Posterior margin nearly equicurvate or vertical; posterior cardinal angle nearly angular to somewhat rounded, and much more distinct than the anterior one. Dorsal margin almost straight and slightly inclined towards the posterior end. Moderately incised hinge margin forming a dorsal furrow. Ventral margin nearly straight but somewhat concave

	Gyeongsang Basin								
Subbasin	Jinju Subbasin								
Formation	Jinju Formation								
Section	Jeongchon							Hotan	Tapri
Sample Number	JJ-1-1	JJ-1-2	JJ-1-3	JJ-2-1	JJ-2-2	JJ-2-3	JJ-2-4	JH-1	ST-1
<i>Scabriculocypris yanbianensis</i>		—	—						
<i>Cypridea khandae</i> sp. nov.	—		—				—	—	—
<i>Cypridea samesi</i>		—						—	—
<i>Mongolocypsis kohi</i>	—	—	—	—		—			
<i>Lycpteroocypris?</i> cf. <i>celsa</i>	—						—		
<i>Candona</i> sp.	—						—	—	
<i>Djungarica</i> sp.							—		

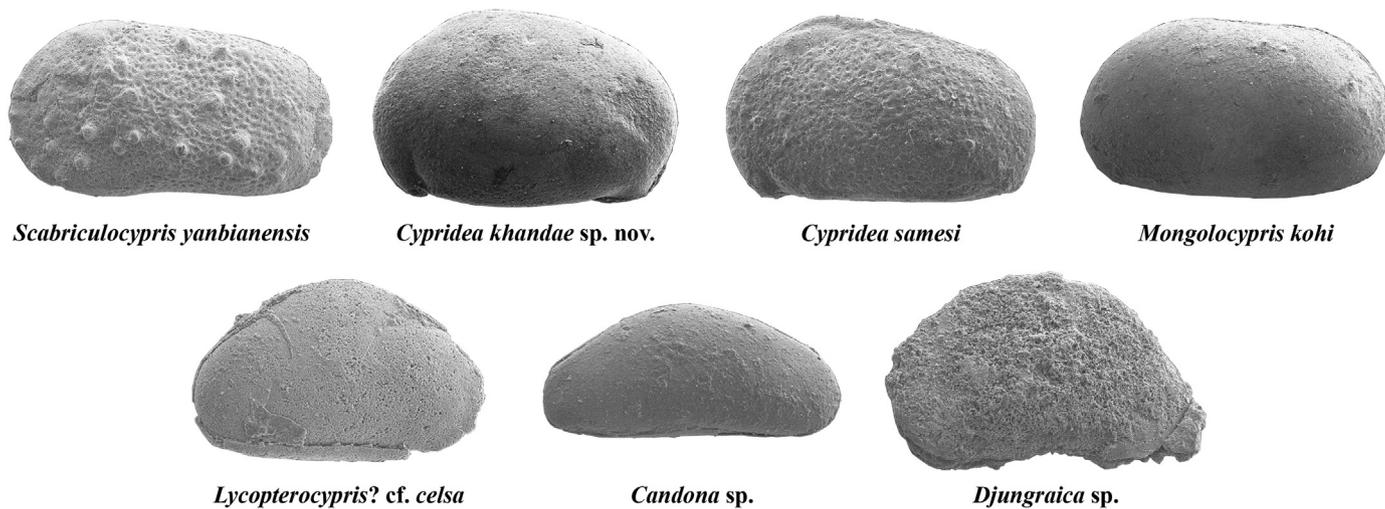


Fig. 4. Distribution and occurrence of ostracod species in the three sections of the Jinju Formation.

at the mid-length of both valves. Surface covered by puncta. Local ornamentation elements, when present, consist of rounded to conical tubercles distributed throughout the surface of the valves, and blunt spines distributed in the anterior marginal area.

Muscle scar pattern. Unknown.

Ontogenetic variation. Adult carapaces are more than 0.8 mm in length (maximum 0.93 mm). The size range of A-1 to A-2 instars is 0.59–0.7 mm. Generally, juvenile carapace outline is similar to the adult. However, some A-1? to A-2? instars show shorter carapace

shape (low L/H ratio) than the adults and much younger instar (A-3?). This morphological difference between specimens is most probably related to intraspecific variation rather than sexual dimorphism (because of the absence of sexual dimorphism record in the Genus *Scabriculocypris*). The youngest instar (A-3?, 0.45–0.47 mm in length) shows a somewhat more rounded and narrow posterior margin (see Fig. 5Q); the antero-dorsal swelling is indistinct or absent in juveniles. *Remarks.* *Scabriculocypris pingquanensis* Yang, 1985 from the Lower Cretaceous Xiguayuan, Yixian and Jiufotang formations of China is

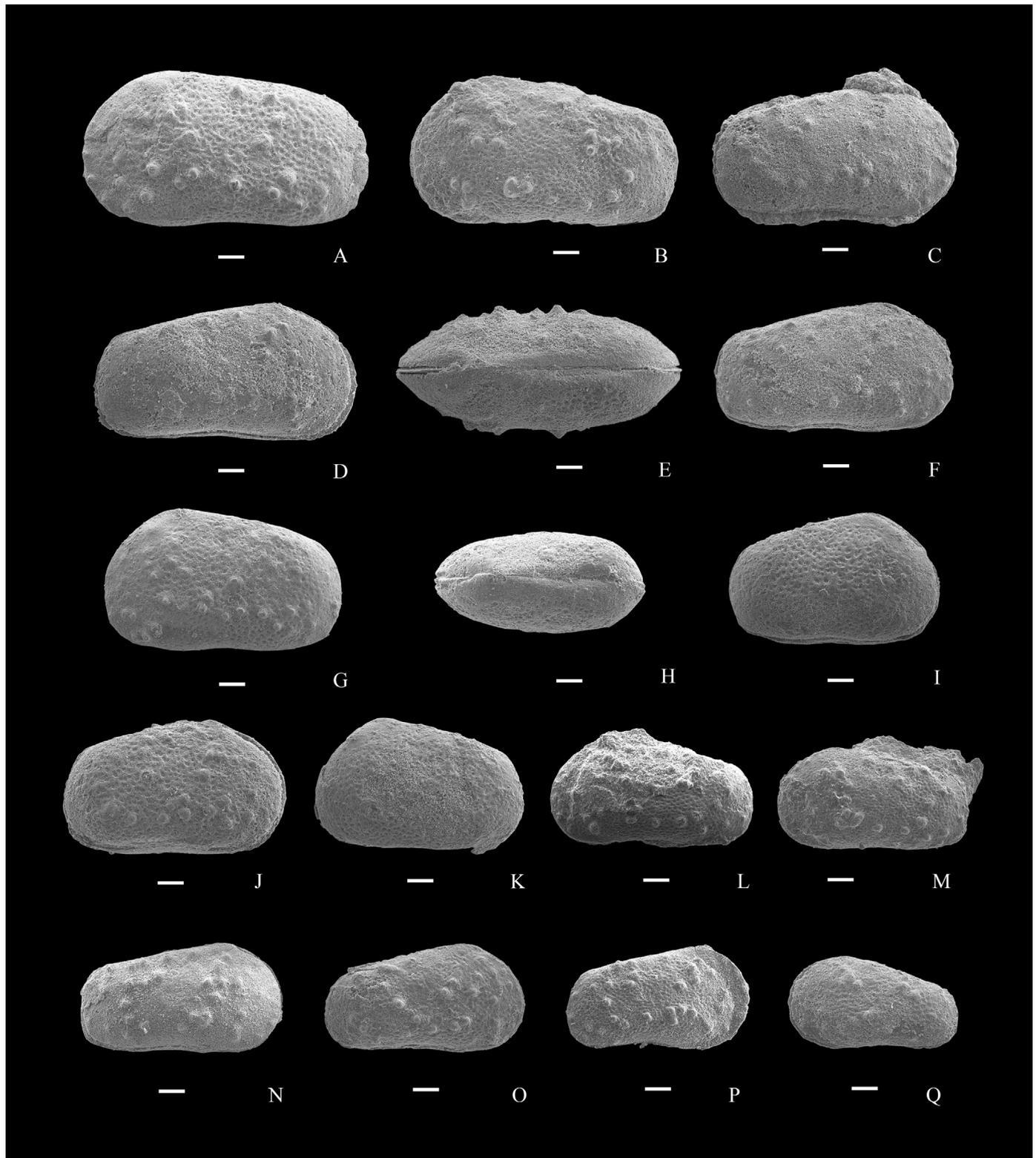


Fig. 5. *Scabriculocypris yanbianensis* (all specimens from sample JJ-1-3); A. Left view of adult carapace, KDRC-JJ-021; B. Left view of adult carapace, KDRC-JJ-022; C. Right view of A-1 instar carapace, KDRC-JJ-023; D. Right view of A-1 carapace, KDRC-JJ-024; E. Dorsal view of adult carapace, KDRC-JJ-025, anterior end to the left; F. Right view of A-1 instar carapace, KDRC-JJ-026; G. Left view of A-1? instar carapace, KDRC-JJ-027; H. Dorsal view of A-2 instar carapace (anterior end to the left), KDRC-JJ-028; I. Right view of A-2 instar carapace, KDRC-JJ-029; J. Right view of A-2? instar carapace, KDRC-JJ-030; K. Left view of A-2? instar carapace, KDRC-JJ-031; L. Left view of A-2 instar carapace, KDRC-JJ-032; M. Left view of A-2 instar carapace, KDRC-JJ-040; N. Right view of A-2 instar carapace, KDRC-JJ-041; O. Right view of A-2 instar carapace, KDRC-JJ-042; P. Right view of A-2 instar carapace, KDRC-JJ-043; Q. Left view of A-3? instar carapace, KDRC-JJ-044. Scale bars = 100 μ m.

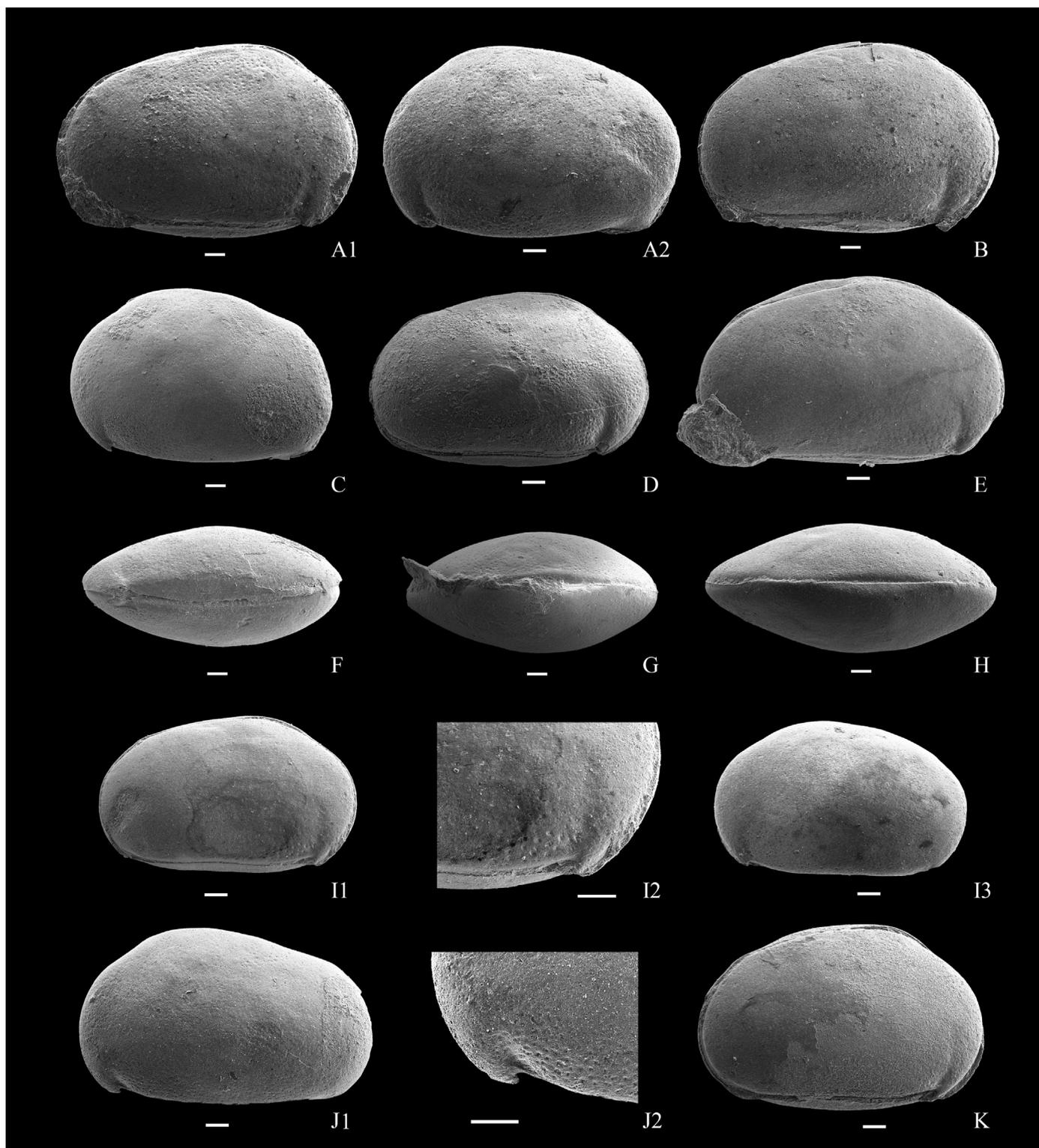


Fig. 6. *Cypridea khandae* sp. nov. (all specimens from sample ST-1); A1. Right lateral view of adult female carapace, KDRC-ST-001 (holotype); A2. Idem, left view of carapace; B. Right view of adult female carapace, KDRC-ST-002; C. Left view of A-1 instar female carapace, KDRC-ST-003; D. Right view of A-1 instar female carapace, KDRC-ST-004; E. Right view of adult male carapace, KDRC-ST-005; F. Ventral view (anterior end to the left) of A-1 instar female carapace, KDRC-ST-006; G. Dorsal view (anterior end to the left) of A-1 instar female carapace, KDRC-ST-007; H. Dorsal view (anterior end to the left) of adult male carapace, KDRC-ST-008; I1. Right view of A-1 instar male carapace, KDRC-ST-009; I2. Idem, detail of anteroventral area of the RV; I3. Idem, left view of carapace; J1. Left view of adult male carapace, KDRC-ST-010 (paratype); J2. Idem, detail of anteroventral area of the LV; K. Right view of adult female carapace, KDRC-ST-011. Scale bars = 100 μ m.

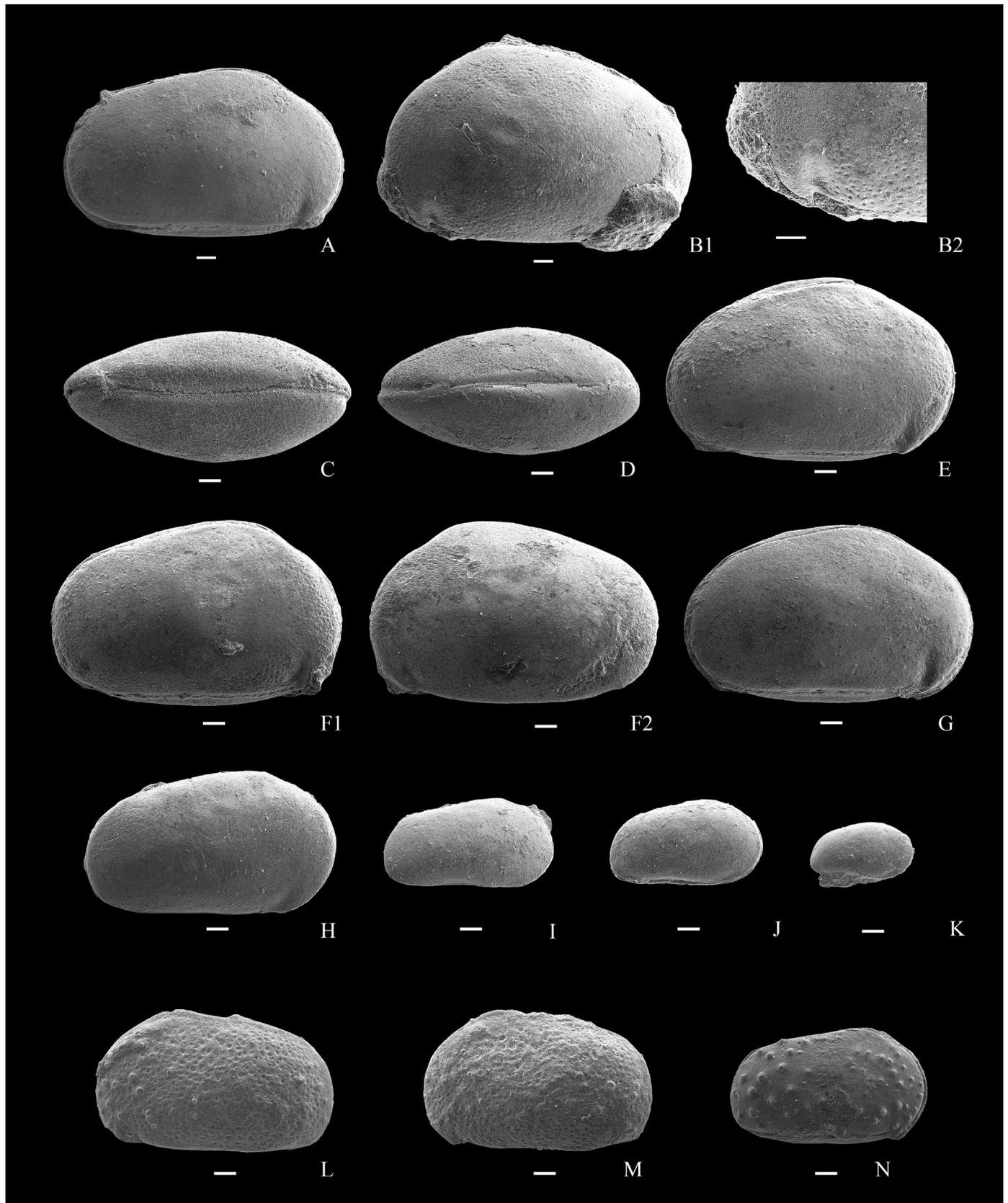


Fig. 7. A–K. *Cypridea khandae* sp. nov. (all specimens from sample ST-1); A. Right view of A-1? instar male carapace, KDRC-ST-012; B1. Left view of adult male valve, KDRC-ST-013; B2. Idem, detail of anteroventral area of the LV. C. Ventral view (anterior end to the left) of adult female carapace, KDRC-ST-014; D. Dorsal view (anterior end to the left) of A-1? instar female carapace, KDRC-ST-015; E. Right view of adult male carapace, KDRC-ST-016; F1. Right view of adult female carapace, KDRC-ST-017; F2. Idem, left view of carapace; G. Right view of adult male carapace, KDRC-ST-018; H. Right view of A-1? instar male valve, KDRC-ST-019; I. Right view of A-3 instar valve, KDRC-ST-020; J. Right view of A-3 instar

similar to *S. yanbianensis*. However, the former is larger and displays a stronger dorsal overlap.

The morphologic features of the studied specimens are very similar to *Scabricolocypis yanbianensis* (Gou, 1983) from the Albion Tongfosi Formation of the Yanji Basin, northeast China, such as the equicurvate/vertical posterior margin, size, development of an antero-dorsal swelling and surface punctation (Choi et al., 2020). Thus, the authors consider them to be the same taxon.

Family Cyprideidae Martin, 1940

Genus *Cypridea* Bosquet, 1852

Type species: *Cypris granulosa* Sowerby, 1836

Cypridea khandae sp. nov.

(urn: lsid:zoobank.org:pub: 1B7C8975-4971-4656-850E-DAE6E2127F47)

Figs. 6A–K, 7A–K

1988 *Cypridea* (*Cypridea*) sp. 3, Paik et al., p. 98, pl. 1, figs. 4–5.

1988 *Cypridea* (*Cypridea*) sp. 6, Paik et al., p. 101, pl. 1, figs. 10–11.

Etymology. Named for Mongolian ostracodologist Dr. Khand Yondon of her contribution to Mesozoic non-marine ostracod research, and for being a mentor to BDC and YQW since 2012.

Holotype. KDRC-ST-001 (Fig. 6A), complete female carapace, sample ST-1 from the Tapri section of the Jinju Formation, Length: 1.40 mm, Height: 0.80 mm, Width: 0.62 mm.

Paratype. KDRC-ST-010 (Fig. 6J), complete male carapace, sample ST-1 from the Tapri section of the Jinju Formation, Length: 1.43 mm, Height: 0.74 mm, Width: 0.58 mm.

Material. About 170 moderately to badly preserved carapaces and valves from sample ST-1 of the Tapri section, samples JJ-1-1, JJ-1-3 and JJ-2-4 of the Jeongchon section, and sample JH-1 of the Hotan section.

Dimensions (adults). L: 1.30–1.65 mm, H: 0.76–1.06 mm, W: 0.59–0.68 mm.

Diagnosis. Very large carapace, elongated-to inflated subovate in lateral view. LV larger than RV, valves somewhat asymmetrical due to the dorsal ridge and convex ventral margin of the LV. Rostrum short, but well-defined. Alveolus (notch, ridge and furrow) well-developed; alveolar furrow triangular and distinct in both valves, but somewhat longer in the RV. Rounded cyathus. Surface covered by fine puncta.

Description. Very large carapace, elongated subovate (male) to inflated subovate (female) in lateral view, elliptic shape in dorsal view. Maximum length at slightly below the mid-height, maximum height at the anterior cardinal angle near 1/3 of length, maximum width at mid-length. LV larger than RV; dorsal outline of LV somewhat prominent due to the dorsal ridge and the convex ventral margin of the LV. Anterior margin broadly rounded and weakly infracurvate; anterior cardinal angle rounded, protruding in the LV, ca. 150°. Rostrum short but well-defined, its point moderately bending backwards and not reaching the ventral margin. Alveolar notch short and moderately incised. Alveolar furrow distinct and separated by a well-developed alveolar ridge in both valves; its shape is triangular, moderately broad and incised, with the alveolar furrow in the RV being much broader and somewhat longer than the one in LV (reaching up to a maximum of nearly 1/3 of the height). Posterior margin weakly infracurvate to equicurvate; posterior cardinal angle somewhat angular in the LV and rounded in the RV, ca. 160°. Dorsal margin nearly straight to slightly rounded; dorsal outline of LV somewhat prominent by slightly to moderately developed dorsal ridge; both LV and RV dorsal margins

inclined towards to posterior end. In dorsal view, the slightly incised hinge margin forms a shallow dorsal furrow. Ventral margin nearly straight to convex in the LV with a moderately developed ventral ridge, but slightly concave in the RV; posteroventral region of the LV protruding with a rounded cyathus, but smoothly rounded in the RV. Carapace surface covered by very fine puncta, but local ornamentation elements are absent.

Muscle scar pattern. Unknown.

Dimorphism. Strong sexual dimorphism present. Males have elongated and somewhat slender carapaces shape in lateral and dorsal views; females show a more inflated carapace shape in lateral and dorsal views, with a low L/H ratio. The precocious sexual dimorphism occurs in the A-1 instar.

Ontogenetic variation. Adult carapaces are more than 1.30 mm in length. The sizes of A-1 juvenile carapaces/valves and A-2 to A-4? younger instars are around 0.5 mm–1.20 mm. The A-1 instar shows the same morphological features of the adult. A-3 and A-4? instars show a more tapered posterior margin than the A-1 instar and adults. The younger instars have faint rostrum, alveolus and cyathus, but more a visible alveolar furrow (see Fig. 7I–K).

Remarks. *Cypridea* sp. 3 and C. sp. 6 from the Jinju Formation of Paik et al. (1988) fit the diagnostic characters of *Cypridea khandae* sp. nov., such as carapace shape, area-wide ornamentation elements (fine puncta), and moderately to deeply incised alveolar notch and furrow. In addition, C. sp. 3 greatly resembles the male morph of *C. khandae* sp. nov., while C. sp. 6 has the same outline as the female morph. Thus, these two species are considered synonymous to *C. khandae* sp. nov.

One of the most important morphologic characters of *C. khandae* sp. nov. is an inverse-sized alveolar furrow (RV's furrow larger than LV's one). Generally, the alveolar furrow of representatives of the Genus *Cypridea* is much longer in the larger valve (which is usually the left one), whereas the one on the smaller valve is shorter and more triangular in shape (Sames, 2011c). Other 'inversed-sized alveolar furrow' species are *Cypridea* (*Morinina*) *tongfosiensis* Zhang, 1990 from the Dalazi Formation, Yanji Basin, China, and Krömmelbein (1965)'s South American collections, such as *Cypridea aff. opifera* (originally described in Krömmelbein, 1962), *C. tucanoensis* (probably a representative of the subgenus *Cyamo-cypris*; see Sames, 2011b), *C. maior* and *C. subtilis*. The functional and morphological significances of this feature are unclear.

Cypridea sp. 1 and C. sp. 2 (that should be combined a single taxon) of the Jinju Formation (Paik et al., 1988) show similar carapace/valve shape to *C. khandae* sp. nov., but the former two have well-rounded dorsal and ventral margins (thus maximum height at mid-length), as well as a distinct cyathus. *Cypridea prognata* Lübi-mova (in Zhang, 1985a) from the Jufotang Formation of Liaoning Province, northeast China is similar to the female morph of *C. khandae* sp. nov. with the same alveolus shape (except for the alveolar furrow) and cyathus, but *C. prognata* has a more inflated carapace in dorsal view, an indistinct dorsal ridge, and a lower L/H ratio with a strongly rounded ventral margin. *Cypridea anxiangensis* Guan (Zhang et al., 2006) considered this species to be synonymous of *C. profusa* has the same outline and alveolus shape (except alveolar furrow) of *C. khandae* sp. nov., but the former has rounder posterior cardinal angle and a strongly distinguished rostrum point. *Cypridea deplecta* Zhang, 1985a (see more details in Wang et al., 2013) from the Yixian Formation of northeast China is similar to *C. khandae* sp. nov., however, *C. deplecta* does not develop an alveolar ridge and shows a less developed alveolar furrow. *Cypridea latiovata* Hou, 1958 from the Gansu Province of China differs from *C. khandae* sp. nov. by the gigantic size, a broad rostrum, and a

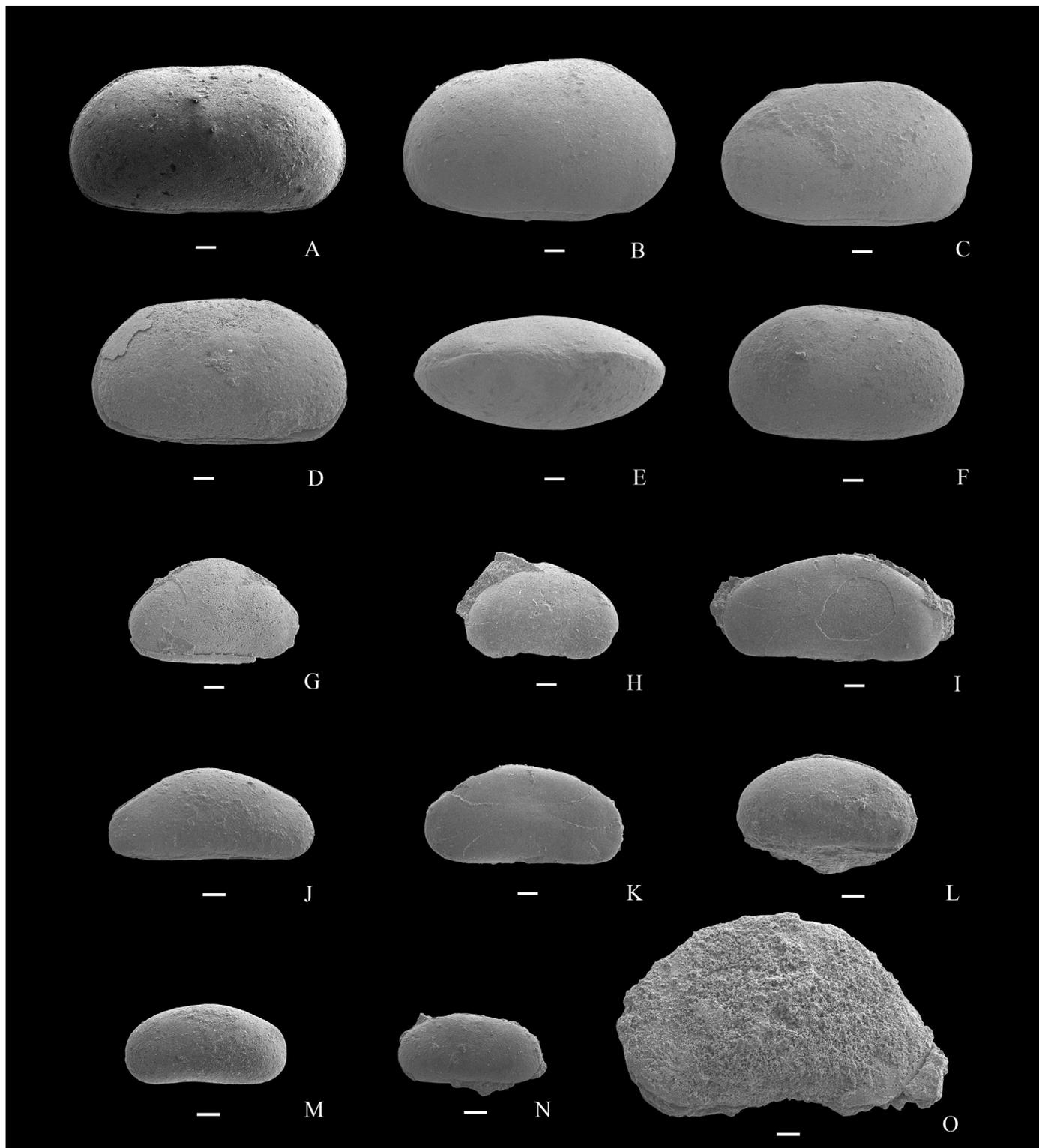


Fig. 8. A–F. *Mongolocypris kohi* Choi and Huh, 2016 (all specimens from sample JJ-1-3); A. Right view of adult male carapace, KDRC-JJ-045; B. Right view of adult female carapace, KDRC-JJ-046; C. Right view of A-1? female carapace, KDRC-JJ-047; D. Right view of A-1? female carapace, KDRC-JJ-048; E. Dorsal view (anterior end to the left) of adult female carapace, KDRC-JJ-049; F. Left view of A-1? female carapace, KDRC-JJ-050; G–H. *Lycopteroocypris?* cf. *celsa* Lúbimova, 1956 (all specimens from sample JJ-1-1); G. Right view of compressed carapace, KDRC-JJ-033; H. Right view of valve, KDRC-JJ-034; I–N. *Candona* sp.; I. Left view of adult valve, KDRC-JJ-036, sample number JJ-2-4; J. Right view of A-1 instar carapace, KDRC-JJ-035, sample number JJ-2-1; K. Right view of A-1 instar valve, KDRC-JJ-037, sample number JJ-2-4; L. Right view of A-1 instar carapace, KDRC-JJ-038, sample number JJ-1-3; M. Left view of A-2 instar carapace, KDRC-JH-016, sample number JH-1; N. Right view of A-3 instar valve, KDRC-JJ-39, sample number JJ-1-2. O. *Djungarica* sp., left view of dissolved carapace, KDRC-JJ-40, sample number JJ-2-4. Scale bars = 100 μ m.

distinct ventral ridge. The general outline of *Cypridea tosogensis* Lee (in Kim et al., 1992) from the Lower Cretaceous Sinuiju Formation of North Korea (near the western border of North Korea and China) is quite similar to the general shape of the present species, but its posterior margin is much narrower.

Cypridea ex gr. *alta* Wolburg, 1959 (in Sames, 2011b) from the Cedar Mountain Formation of United States of America resembles the general outline (except dorsal region), the rostrum/alveolus and cyathus in the LV of *C. khandae* sp. nov. However, the former has a strongly overreached dorsal ridge in the LV and shorter alveolar furrow in the RV. *Cypridea inaequalis* Wolburg, 1959 (also *Cypridea alta*-group) from Berriasian “German Wealden” is very similar to *C. khandae* sp. nov. However, the dorsal ridge of the former is very distinct, and the rostrum is more prominent than that of *C. khandae* sp. nov.

In addition, *C. khandae* sp. nov. is very similar to the representatives of the *Cypridea alta*-group Wolburg, 1959 (more details in Sames, 2011b, p. 404–405) due to its carapace shape, development of the cyathus, a relatively well developed dorsal ridge in the LV, ventral ridge, and short but well-developed rostrum with distinct alveolar furrow. Though, the dorsal ridge of *Cypridea khandae* sp. nov. is relatively weak and its L/H ratio is not always as low as other representatives of the *C. alta* group, it is not the only species in it with these characters; for instance, the subspecies *C. alta alta* Wolburg, 1959 from the Lower Cretaceous strata of Europe (Germany and England) also has a weakly developed dorsal ridge (see also subspecies list in Sames, 2011b, p. 404) and similar area-wide ornamentation. Thus, *Cypridea khandae* sp. nov. should be assigned to the *Cypridea alta* species group.

***Cypridea samesi* Choi, Wang and Huh, 2018**

Fig. 7L–N

1988 *Cypridea* (*Cypridea*) sp. 4, Paik et al., 98, 101, pl. 1, figs. 6–7.
 1988 *Cypridea* (*Cypridea*) sp. 7, Paik et al., 101–102, pl. 2, figs. 1, 3.
 1988 *Cypridea* (*Cypridea*) sp. 8, Paik et al., 102, pl. 2, figs. 2, 4.
 2018 *Cypridea samesi* n. sp. Choi et al., 386–389, figs. 3K–P, 4A–J.

Material. More than 500 carapaces and valves, including juveniles from sample JJ-1-2 of the Jeongchon section, sample JH-1 of the Hotan section, and sample ST-1 of the Tapri section.

Dimensions (adults). L: 0.91–1.08 mm, H: 0.46–0.64 mm, W: 0.33–0.46 mm.

Remarks. *Cypridea samesi* shows two anterodorsal swellings on the both valves, but indistinct in the RV. The details of this species were described by Choi et al. (2018). The poorly preserved younger juveniles of this species had rarely been discovered in the Hotan section (see Choi et al., 2018, fig. 4b therein). However, some complete younger juveniles (A-2?, 0.75 mm in length) are identified for the first time in this study (Fig. 7O). The sexual dimorphism is not identified in this species.

Genus ***Mongolocypris* Szczechura, 1978**

Type species: *Cypridea distributa* Stankevitch (in Stankevitch and Sochava, 1974)

***Mongolocypris kohi* Choi and Huh, 2016**

Fig. 8A–F

1988 *Cypridea* (*Pseudocypridina*) sp. 1 Paik, Kim and Huh, pp. 103, 104, pl. 2, figs. 6, 7.
 1988 *Cypridea* (*Pseudocypridina*) sp. 2 Paik, Kim and Huh, p. 104, pl. 2, figs. 5, 8.
 1988 *Cypridea* (*Pseudocypridina*) sp. 3 Paik, Kim and Huh, p. 104, pl. 2, figs. 9, 10.
 1996 *Cypridea* cf. *curtorostrata* Hao – Seo, pp. 24, 25, pl. 1, figs. 1–4.
 2016 *Mongolocypris kohi* sp. nov. Choi and Huh, 242–246, figs. 4–5.

Material. About 1000 carapaces and valves, including males/females and juveniles from samples JJ-1-1, JJ-1-2, JJ-1-3, JJ-2-1 and JJ-2-3 of the Jeongchon section.

Dimensions (adults). L: 1.30–1.47 mm, H: 0.65–0.79 mm, W: 0.48–0.62.

Remarks. *Mongolocypris kohi* is considered an ‘early form’ of the Genus by the presence of the faint rostrum and the alveolar furrow (see more details in Choi and Huh, 2016). In this species, strong sexual dimorphism is identified; males have elongated and larger carapace, and females have inflated and low L/H ratio than males. Generally, the adults have more than 1.30 mm in length. And, the size range of juveniles (A1 to A4?) is 1.28 to 0.5 mm in length.

Family Cyprididae Baird, 1845

Genus ***Lycoperocypris* Mandelstam (in Lüvimova, 1956)**

Type species: *Cypris faba* Egger, 1910.

***Lycoperocypris? cf. celsa* Lüvimova, 1956**

Fig. 8G–H

Material. Two carapace and valve from samples JJ-1-1 and JJ-2-4 of the Jeongchon section.

Dimensions. L: 0.78–0.81 mm, H: 0.47–0.51 mm, W: Unknown (due to the compression).

Description. Large carapace, rounded and subtriangular in lateral view. Maximum length at slightly below the mid-height, maximum height at mid-length. LV larger than RV. Both anterior and posterior margins equally rounded and strongly infracurvate, with nearly faint cardinal angles. Dorsal margin strongly arched and strongly inclined towards both the anterior and posterior ends. Ventral margin almost straight, but moderately concave at the mid-length of the RV. Surface ornamentation unknown due to the dissolved carapace.

Muscle scar pattern. Unknown.

Ontogenetic variation. Unknown.

Remarks. The general outline of *Lycoperocypris? celsa* is different from other *Lycoperocypris* species by its more triangular shape with relatively low length/height ratio in lateral view. Another triangular-shaped taxon is *L. helongensis* Zhang, 1990 from the Dalazi Formation, Yanji Basin, China, which has a much more elongated carapace (higher length/height ratio) and convex ventral margin in both valves. *Lycoperocypris? cf. celsa* resembles the representatives of the Genera *Triangulicypris* and *Advenocypris* from the Cretaceous strata of China. However, some species of *Triangulicypris* and *Advenocypris* have large nodes, puncta or a distinct dorsal ridge (see figures of Zhang et al., 2014). These characters have not been reported in representatives of the Genus *Lycoperocypris*. As *L. celsa* shows a very long temporal range (Hauterivian to Maastrichtian, e.g., Ye, 1994; Neustrueva et al., 2005) and the recovered specimens had very poor preservation, the authors decided to only tentatively classify the recovered specimens as *Lycoperocypris? cf. celsa*.

Family Candonidae Kaufmann, 1900

Genus ***Candona* Baird, 1845**

Type species: *Cypris candida* Müller, 1776

***Candona* sp.**

Fig. 8I–N

1988 *Candona* sp. 1 Paik, Kim and Huh, p. 104, pl. 3, fig. 1.
 1988 *Candona* sp. 3 Paik, Kim and Huh, p. 105, pl. 3, fig. 4.
 1988 *Candona* sp. 4 Paik, Kim and Huh, p. 105, pl. 3, figs. 5 and 6.

Material. 30 badly to moderately preserved specimens, including juveniles from samples JJ-1-1, JJ-1-2, JJ-1-3, JJ-2-1 and JJ-2-4 of the Jeongchon section, and sample JH-1 of the Hotan section.

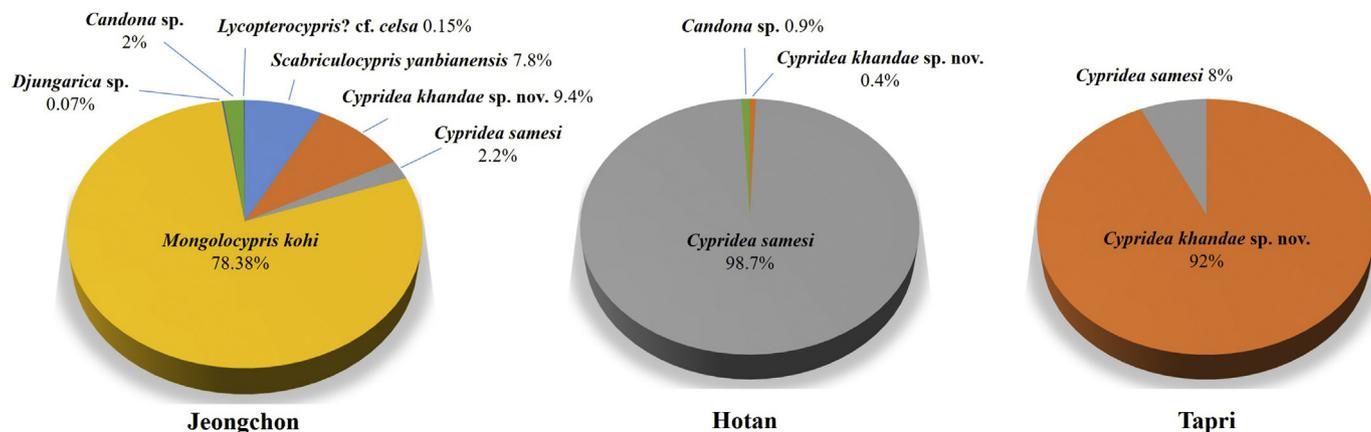


Fig. 9. Comparison between the relative abundance of ostracod species from the three sections (Jeongchon, Hotan, and Tapri) of the Jinju Formation.

Dimensions (adults). L: 0.90–1.00 mm, H: 0.40–0.48 mm.
Description. Medium to large carapace, elongated and ovate in lateral view. Maximum length at slightly below the mid-height, maximum height and width slightly behind mid-length. LV larger than RV; LV overlapping RV along all margins except at the hinge. Anterior margin narrow and slightly infracurvate; anterior cardinal angle broad and slightly curved, ca. 150°. Posterior margin nearly equicurvate to slightly infracurvate and almost vertical; posterior cardinal angle angular in the RV, somewhat rounded in the LV, ca. 140°. Dorsal margin somewhat rounded with indistinct dorsal hump; anterodorsal margin long, straight to slightly rounded, but posterodorsal margin relatively short, nearly straight and strongly declined to posterior end. Ventral margin nearly straight in the LV, but somewhat concave in mid-length of the RV. Surface smooth.
Muscle scar pattern. Unknown.
Ontogenetic variation: Adult carapaces are more than 0.9 mm in length. The size range of A-1 to A-3 instars is 0.50–0.83 mm.
Remarks. All three species (*Candona* sp. 1, *C.* sp. 3 and *C.* sp. 4) from Paik et al. (1988) are considered to be the same taxon due to their similar carapace shape. In addition, the specimens from Paik et al. (1988) were collected from the same sample. *Candona* sp. in this

study also fit the morphologic characters of the *Candona* specimens from Paik et al. (1988). Therefore, all *Candona* species in Paik et al. (1988) are merged with *Candona* sp. from this study. Some characters of *C.* sp. are identified, such as the slender carapace shape with very angular posterior cardinal angle in the RV and nearly straight dorsal margin that can be seen in lateral view. However, many specimens are crushed, which makes it hard to assigned them to a species.

Family Djungaridae Gou and Hou (in Hou et al., 2002)

Genus *Djungarica* Galeeva (in Ye et al., 1977)

Type species: *Djungarica saidovi* Galeeva (in Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, 1963)

Djungarica sp.

Fig. 80

Material. Only one dissolved carapace from sample JJ-2-4 of the Jeongchon section.

Dimensions. L: 1.48 mm, H: 0.88 mm, W: not available.

Description. Very large subtriangular carapace in lateral view. Maximum length at near 1/3 of height, maximum height at mid-

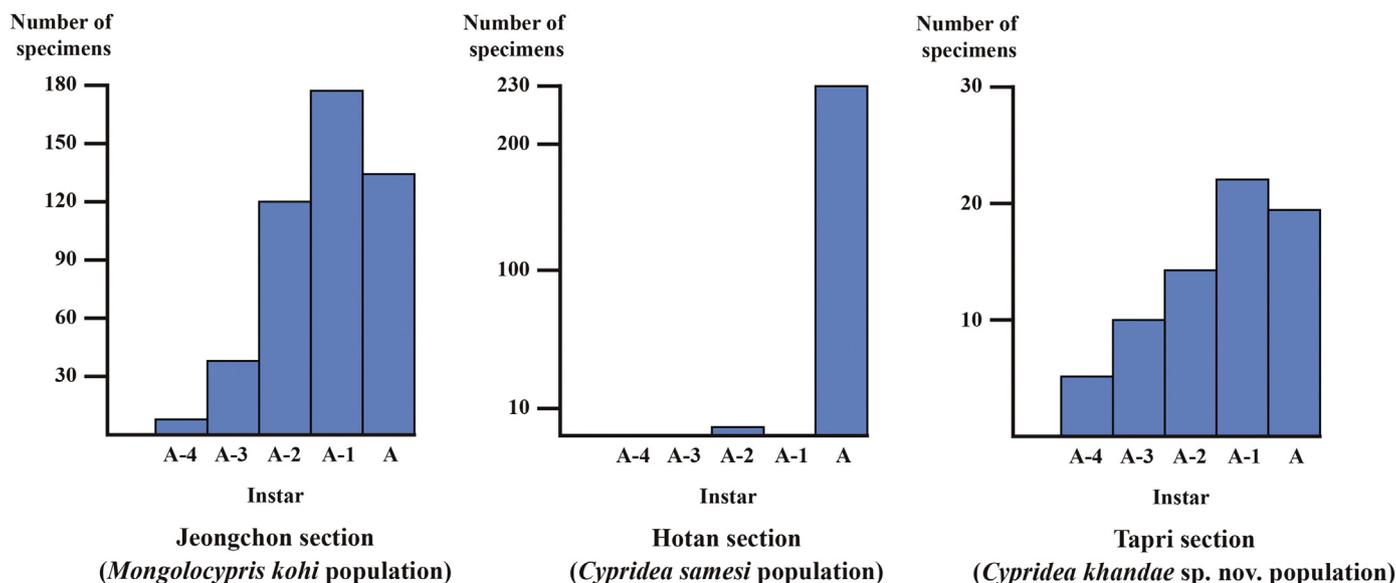


Fig. 10. Population structures of the selected ostracod species and specimens in the studied sections (Jeongchon, Hotan, and Tapri) of the Jinju Formation.

length, maximum width unknown. Valve overlapping type unknown. Anterior margin nearly supracurvate, anterodorsal margin almost straight to slightly rounded, anterior cardinal angle rounded, ca. 155°. Posterodorsal margin strongly declined towards to posterior end, with a straight posteroventral margin forming a posterior protrusion slightly below mid-height; posterior cardinal angle rounded and somewhat narrower than anterior one, ca. 150°. Dorsal margin rounded and strongly declined to both anterior and posterior ends. Ventral margin strongly concave in near mid-length. Surface ornamentation unknown due to the dissolved carapace.

Muscle scar pattern. Unknown.

Ontogenetic variation. Unknown.

Remarks. Although the representatives of the Genus *Djungarica* have been commonly reported from the Lower Cretaceous deposits of China (e.g., Hou et al., 2002; Wang et al., 2015, 2016; Qin et al., 2018), this is the first description of the Genus in South Korea. *Djungarica* sp. from the Jinju Formation is similar in shape to *D. camarata* Zhang, 1985b from the Dadianzi and Yixian formations (see Wang et al., 2016, p. 413), but it is much smaller, its posterior protrusion is located slightly lower in the posterior margin, and belongs to a relatively younger stratigraphic age than the latter (Hauterivian to Barremian).

5. Discussion

5.1. Biostratigraphy

The ostracod biostratigraphy of the Jinju Formation has been discussed by several authors (Paik et al., 1988; Hayashi, 2006). Paik et al. (1988) stated that the ostracod fauna from the Jinju Formation can be correlated with the Upper Cretaceous to Paleogene *Cypridea-Cypridea-Candona* zone of the Yantze Han River plain in Hou et al. (1978), as they share the same *Candona* species. Hayashi (2006) established the “3-Diverse *Cypridea* assemblage” for the Jinju Formation (incorrectly designated as the Dongmyeong Formation therein), which can be correlated with the Upper Shouchang, Lower Fengjiashan and Puchanghe formations of China, the Upper Wakamiya Formation of Japan, and an unknown deposit in the Shaaazantin Gobi of Mongolia. However, many ostracod species of Paik et al. (1988) and Hayashi (2006) have been revised in recent years (Choi and Huh, 2016; Choi et al., 2018; this study) based on a large quantity of newly collected specimens. Therefore, the ostracod biostratigraphy of the Jinju Formation needs to be revised, based on this new data.

In this study, seven species belonging to six genera were recovered from three sections of the Jinju Formation (Fig. 9): *Scabriculocypris yanbianensis*, *Cypridea khandae* sp. nov., *C. samesi*, *Mongolocypsis kohi*, *Lycoperocypris?* cf. *celsa*, *Candona* sp., and *Djungarica* sp. Among them, *C. khandae* sp. nov., *C. samesi*, and *M. kohi* are presumed endemic to the Jinju Formation. *Scabriculocypris yanbianensis* was reported from the Albian Tongfosi Formation of the Yanji Basin in northeast China (Gou, 1983; Choi et al., 2020). *Lycoperocypris?* cf. *celsa* was found in the Sainshand Formation (Albian to Cenomanian) (Lübimova, 1956; Khand et al., 2000) and the Shinekhudag Formation (Hauterivian to Barremian) of Mongolia (Neustrueva et al., 2005). Representatives of the Genus *Cypridea* abundantly occurred in worldwide non-marine Upper Jurassic to Cretaceous strata (except for Antarctica and Australia, Sames, 2011b). Representatives of the Genus *Mongolocypsis* are commonly reported from the Aptian to Maastrichtian (possibly up to Danian, see Ye, 1994) strata of East Asia (see species list in Cao, 1996; Hou et al., 2002; Neustrueva et al., 2005; Hayashi et al., 2010; Wang et al., 2015; Choi and Huh, 2016) and Alaska (Brouwers and De Deckker, 1993), but their major radiation started

during the Albian (e.g., Wang et al., 2015; Choi et al., 2020). Finally, representatives of the Genus *Djungarica* are recovered from the Upper Jurassic to Aptian strata in China (Wang et al., 2015; Qin et al., 2018 and references therein). Consequently, the ostracod fauna in this study may indicate an Albian age for the Jinju Formation.

Although the ostracod assemblage from the Jinju Formation consist of well-known genera from worldwide (*Scabriculocypris*, *Cypridea* and *Candona*) and Asian regions (*Mongolocypsis*, *Lycoperocypris* and *Djungarica*), its endemicity at the species level makes it difficult to be correlated with other assemblages in a supra-continental scale.

5.2. Paleoenvironment

According to Whatley (1983, 1988) and Boomer et al. (2003), ostracod population structure and preservation are important indicators for the reconstruction of paleoenvironment. The taphonomic features (population and preservation) of each section and their subsequent interpretations are as follows (see also Figs. 9 and 10).

- 1) Jeongchon section: Sample JJ-1-1 contains almost exclusively compressed carapaces and valves but displays a relatively high species diversity (four species), with various size ranges. Many specimens are articulated, such as *Mongolocypsis kohi* and the badly preserved *Cypridea khandae* sp. nov. (with strong sexual dimorphism). *Lycoperocypris?* cf. *celsa* and *Candona* sp. were rare in this sample. Samples JJ-1-2 and JJ-1-3 show the most abundant populations, with high diversity (four species) and almost all complete carapaces of juveniles and adults. *Mongolocypsis kohi* is the most abundant taxon in the samples, and *Scabriculocypris yanbianensis* were only recovered from them. The preservation and population of these ostracods point towards low energy autochthonous assemblages. Samples JJ-2-1 and JJ-2-3 show low diversity (one or two species), but juvenile and male/female adult carapaces of *Mongolocypsis kohi* are common, and valves are rarely identified, which are indicative of a low energy environment. Although sample JJ-2-4 contains four species with articulated carapaces, very few specimens were recovered, with the majority being dissolved and, thus, making it difficult to obtain more details from the sample. *Mongolocypsis kohi* is absent in this sample. In summary, a total of seven cypridoidean species were recovered from the Jeongchon section (Fig. 9), and the general features of the ostracod population/preservation (Fig. 10) show a low-energy autochthonous thanatocoenosis (*in situ* assemblage, see Boomer et al., 2003; Cabral et al., 2008) with limited transportation. The presence of invertebrate fossils such as aquatic insects, spiders and clam shrimps also supports our interpretation (Park et al., 2013; Nam and Kim, 2016; Park et al., 2019).
- 2) Hotan section: The JH-1 sample is characterized by moderate diversity (three species) and very abundant adult carapaces of *Cypridea samesi* (about 99% of occurred specimens, see Fig. 9). *Cypridea khandae* sp. nov. and *Candona* sp. are rarely recovered in this section. A low valve/carapace ratio with a majority of adult specimens (Fig. 10) implies that this assemblage is a slightly higher energy thanatocoenosis, with the juveniles having been removed by current post-mortem (Boomer et al., 2003; Nye et al., 2008).
- 3) Tapri section: The sample ST-1 shows low diversity (two species, see also Fig. 9), but juvenile and adult male/female carapaces of *Cypridea khandae* sp. nov. are very common with rare occurrences of *Cypridea samesi*. A-1 instar is most abundant, and valves or carapaces of much younger juveniles (A-3 to A-4?) are also common (Fig. 10). It matches very well with the population age structure illustration of Boomer et al. (2003; fig. 2 therein).

Thus, this assemblage was considered to be a low-energy autochthonous thanatocoenosis.

In summary, the taphonomic features of the sections show two types of thanatocoenosis: a low-energy autochthonous thanatocoenosis (Jeongchon and Tapri sections), and a slightly higher energy thanatocoenosis (Hotan section). These assemblages are good paleoenvironmental indicators, with most of the population structures (e.g., ontogenetic stages and articulated carapaces) being indicative of shallow waterbodies (e.g., shallow lake and/or pond). Additionally, two ostracod species from the Jeongchon and Tapri sections may choose their sexual reproduction mode (i.e. *C. khandae* sp. nov. and *M. kohi*), although a mixed reproduction is proposed for them (Sames, 2011b; Sames and Horne, 2012). The sexual reproduction mode may indicate more variable and unstable environmental conditions (Schmit et al., 2013; Wang et al., 2017b).

The ostracod assemblage of the Jinju Formation consists only of representatives of the Superfamily Cypridoidea. Recent cypridoideans are abundant and diverse in almost all non-marine realms (Karanovic, 2012). These taxa possess desiccation resistant-resting eggs, which enable them to survive long dry periods, adapt in temporary waterbodies, and allow them to be transported through passive means such as winds or large animals (Horne and Martens, 1998). Genera *Cypridea* and *Mongolocypis* are the representatives of the extinct Family Cypridoidea of the Superfamily Cypridoidea (Horne and Colin, 2005; Sames, 2011b; Choi and Huh, 2016). According to Horne (2002), some species of *Cypridea* tolerated and inhabited saline lakes (see also Sames, 2011b, p. 373), but most species dwelled in freshwater environments (Horne, 2002; Sames, 2011b). *Mongolocypis* may have been able to tolerate a wide range of paleoenvironments, because the representatives of this genus are well-documented from many upper Lower and Upper Cretaceous strata in China (e.g., Hou et al., 2002; Van Itterbeeck et al., 2004, 2005; Wang et al., 2017a; Choi et al., 2020), Mongolia (e.g., Szczechura, 1978; Neustrueva et al., 2005), Korea (e.g., Choi and Huh, 2016; Choi et al., 2017; Choi, 2019), and Japan (e.g., Cao, 1996; Hayashi et al., 2010). Genera *Scabriculocypris*, *Candona*, *Lycoprocypris* and *Djungarica* all belong to the Superfamily Cypridoidea, which inhabit both ephemeral and permanent waterbodies (e.g., Meisch, 2000; Horne, 2002; Wang et al., 2016).

Interestingly, the ostracod assemblage of the Jinju Formation lacks elements from the subfamily Timiriaseviinae of the Superfamily Cytheroidea and the Superfamily Darwinuloidea, which possess brood care and probably lived in permanent waterbodies (Horne and Martens, 1998; Horne, 2002; Sames 2011a; Sames and Horne, 2012). This absence might be influenced by the presence of unstable lakes/temporal waterbodies in the regions (e.g., seasonal pools or small lakes around large lake), due to the increasing of aridity (see above “Geological Setting”), and/or their low competitiveness (alongside their tolerance limits, see also Sames, 2011a). An increase in the diversity of *Mongolocypis* species in China and Korea occurs during moments of decreased presence (Albian–Cenomanian) of Timiriaseviinae and Darwinuloidea (see Wang et al., 2015; Choi and Huh, 2016; Choi et al., 2020 and unpublished data of YQW) during that period in East Asia (except Mongolia, see Khand, 2000). However, this hypothesis is uncertain yet, and needs further investigation.

6. Conclusion

Seven non-marine ostracod species were recovered from three sections (Jeongchon, Hotan, and Tapri) of the Jinju Formation of the Gyeongsang Basin, South Korea. This fauna is endemic to South Korea, and consists of the following representatives of the Superfamily Cypridoidea (especially extinct Family Cypridoidea):

Scabriculocypris yanbianensis, *Cypridea khandae* sp. nov., *C. samesi*, *Mongolocypis kohi*, *Lycoprocypris?* cf. *celsa*, *Candona* sp., and *Djungarica* sp. Combined with the previous published ostracod species, the ostracod fauna indicates an Albian age for the Jinju Formation.

The taphonomic features of the Jinju Formation allowed for the interpretation of two thanatocoenoses: A low-energy autochthonous thanatocoenosis in the Jeongchon and Tapri sections, and a slightly higher energy thanatocoenosis in the Hotan section. Based on the ostracod composition of the fauna, which consisted only cypridoideans, the paleoenvironment of the studied sections of the Jinju Formation is interpreted as having been composed of an unstable lake/temporal waterbodies. In addition, the absence of cytheroideans and darwinuloideans may also potentially be indicative of their low competitiveness against cypridoideans.

This investigation is the first detailed study on the ostracod fauna of the Gyeongsang Basin. Therefore, the data herein will provide a better understanding about the non-marine ostracods for the Cretaceous basins of Korea.

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References

- Anderson, F.W., 1941. Ostracoda from the Portland and Purbeck beds at Swindon. *Proceedings of Geologists' Association* 51, 373–384.
- Anderson, F.W., 1985. Ostracod faunas in the Purbeck and Wealden of England. *Journal of Micropalaeontology* 4 (2), 1–68.
- Ayress, A.M., Whatley, R.C., 2014. Early Cretaceous non-marine ostracoda from the North Falkland Basin, South Atlantic. *Palaeontology* 57, 1143–1175.
- Baird, W., 1845. Arrangement of the British Entomostraca, with a list of species, particularly noticing those which have as yet been discovered within the bounds of the club. *Transactions of the Berwickshire Naturalist's Club* 2 (13), 145–158.
- Boomer, I., Horne, D.J., Slipper, I.J., 2003. The use of ostracods in palaeoenvironmental studies, or what can you do with an ostracod shell?. In: Park, L.E., Smith, A.J. (Eds.), *Bridging the Gap: Trends in the Ostracode Biological and Geological Sciences*, vol. 9. Paleontological Society Papers, Ithaca, New York, pp. 153–179.
- Bosquet, J., 1852. Description des Entomostracés Fossiles des Terrains Tertiaires de la France et de la Belgique. *Mémoires Couronnés et Mémoires des Savants Étrangers* 24, 1–142 (in French).
- Brouwers, E.M., De Deckker, P., 1993. Late Maastrichtian and Danian ostracode faunas from northern Alaska: Reconstructions of environment and paleogeography. *PALAIOS* 8, 140–154.
- Cabral, M.C., Colin, J.-P., Azerêdo, A.C., 2008. Taxonomy and palaeoecology of new brackish ostracod species from the Middle Cenomanian of Lousa, Lisbon region, Portugal. *Palaeogeography, Palaeoclimatology, Palaeoecology* 264, 250–262.
- Cao, M., 1996. Nonmarine Cretaceous Ostracods from Inner Zone of SW Japan. *Bulletin of the Kitakyushu Museum of Natural History* 15, 13–30.
- Chang, K.H., 1975. Cretaceous stratigraphy of southeast Korea. *Journal of the Geological Society of Korea* 11, 1–23.

- Chang, K.H., 1977. Late Mesozoic stratigraphy, sedimentation and tectonics of southeastern Korea. *Journal of the Geological Society of Korea* 13, 76–90 (in Korean, with English abstract).
- Choi, D.K., 1985. Spores and pollen from the Gyeongsang Supergroup, southeastern Korea and their chronologic and paleoecologic implications. *Journal of the Paleontological Society of Korea* 1, 33–50.
- Choi, H.L., 1986. Fluvial plain/lacustrine facies transition in the Cretaceous Sindong Group, South coast of Korea. *Sedimentary Geology* 48, 295–320.
- Choi, S.J., 1990. Some nonmarine fossils from the central part of Gyeongsang Basin, S. Korea. *Journal of the Paleontological Society of Korea* 6, 165–179.
- Choi, B.-D., 2019. Cretaceous non-marine ostracods from Korea (Unpubl. PhD thesis). Chonnam National University, p. 219.
- Choi, D.K., Park, J.B., 1987. Palynology of the Jinju Formation (Lower Cretaceous), Waegwan-Daegu and Jinju areas, Korea. *Journal of the Paleontological Society of Korea* 3, 28–43.
- Choi, B.-D., Huh, M., 2016. *Mongolocypris kohi* sp. nov.: A new Early Cretaceous non-marine ostracod species from the Jinju Formation, South Korea. *Cretaceous Research* 57, 239–247.
- Choi, B.-D., Jugdernamjil, M., Huh, M., Khand, Y., 2017. Cretaceous non-marine ostracods from the Hampyeong Basin, southwestern Korean Peninsula. *Journal of the Geological Society of Korea* 53 (5), 631–643 (in Korean, with English abstract).
- Choi, B.-D., Wang, Y.-Q., Huh, M., 2018. *Cypridea* species (Crustacea, Ostracoda) from the Lower Cretaceous Jinju Formation of the Gyeongsang Basin, South Korea. *Palaeoworld* 27, 382–391.
- Choi, B.-D., Wang, Y., Hu, L., Huh, M., 2020. Ostracod faunas from the Dalazi and Tongfosi formations (Yanji Basin, Northeast China): biostratigraphic, palaeogeographic and palaeoecological implications. *Cretaceous Research* 105, 104018.
- Chough, S.K., Sohn, Y.K., 2010. Tectonic and sedimentary evolution of a Cretaceous continental arc-backarc system in the Korean peninsula: New view. *Earth-Science Reviews* 101, 225–249.
- Chough, S.K., Kwon, S.T., Ree, J.H., Choi, D.K., 2000. Tectonic and sedimentary evolution of the Korean peninsula: a review and new view. *Earth-Science Reviews* 52, 175–235.
- Chun, H.Y., Kim, D.H., Um, S.H., Bong, P.Y., Lee, H.Y., Choi, S.J., Kim, B.C., Kwon, Y.I., Lee, D.Y., Park, Y.S., Choi, Y.S., 1990. The study on the organic remains of the separated sedimentary basins in Korea (II). Korea Institute of Energy and Resources, p. 288 (in Korean, with English abstract).
- Chun, H.Y., Um, S.H., Choi, S.J., Kim, Y.B., Kim, B.C., Choi, Y.S., 1993. Fossil floral and faunal assemblages and paleoenvironmental modelling study on the Cretaceous sedimentary basins scattered in/near the Ogcheon Belt (I). Korea Institute of Energy and Resources, p. 122 (in Korean, with English abstract).
- Chun, H.Y., Choi, Y.S., Choi, S.J., Kim, Y.B., Kim, B.C., Lee, B.S., 1995. Stratigraphy and Paleontology of the Cretaceous strata in the Jeongok-Cheolwon Area. Korea Institute of Geology, Mining and Materials, p. 69 (in Korean, with English abstract).
- Egger, J.R., 1910. Ostracoden und Foraminiferen des Eybrunner Kreidemergelsin der Umgebung von Regensburg. *Berichte des Naturwissenschaftlichen Verein Regensburg* 12, 86–126 (in German).
- Gou, Y.S., 1983. Cretaceous ostracods from the Yanbian area, Jilin Province. *Acta Palaeontologica Sinica* 22 (1), 42–57.
- Ha, S., Chae, Y.-U., Jeong, G.Y., Son, M., Yang, K., Paik, I.S., Lim, H.S., 2015. A preliminary study of calcite beef found in the Cretaceous Jinju Formation, Gyeongsang Basin, Korea. *Journal of the Geological Society of Korea* 51 (6), 597–604.
- Hayashi, K., 2006. Nonmarine ostracode zonation and long-distance correlation based on analysis of regional ostracode successions in China, Korea, Japan, and Mongolia. *Cretaceous Research* 27, 168–188.
- Hayashi, K., Matsukawa, M., Ohira, H., Chen, P., Zhen, J., Ito, M., Koarai, K., Obata, I., 2010. Revised age of the Sasayama Group, southwest Japan, based on ostracode and conchostracan biostratigraphy and zircon fission-track dating. *Journal of the Geological Society of Japan* 116, 283–286.
- Hong, S.K., Yi, S., Shinn, Y.J., 2020. Middle Albian climate fluctuation recorded in the carbon isotope composition of terrestrial plant matter. *Journal of Asian Earth Sciences* 196, 104363.
- Horne, D.J., 2002. Ostracod biostratigraphy and palaeoecology of the Purbeck Limestone Group in southern England. *Special Papers in Palaeontology* 68, 1–18.
- Horne, D., Martens, K., 1998. An assessment of the importance of resting eggs for the evolutionary success of Mesozoic non-marine cypridoidean Ostracoda (Crustacea). *Archiv für Hydrobiologie* 52, 549–561. Special Issue, *Advances in Limnology*.
- Horne, D.J., Colin, J.-P., 2005. The affinities of the ostracod genus *Cypridea* Bosquet, 1852, and its allies, with consideration of implications for the phylogeny of nonmarine cypridoidean ostracods. *Revue de Micropaléontologie* 48, 25–34.
- Hou, Y.T., 1958. Jurassic and Cretaceous nonmarine ostracods of the subfamily Cypridaeinae from north-western and north-eastern regions of China. In: *Memoirs of the Institute of Paleontology, Academia Sinica* 1, pp. 33–113.
- Hou, Y.-T., Ho, J.-D., Ye, C.-H., 1978. The Cretaceous-Tertiary Ostracods from the Marginal region of the Yangtze-Han River plain in Central Hubei. In: *Memoirs of Nanjing Institute of Geology and Palaeontology, Academia Sinica* 9, pp. 129–206 (in Chinese).
- Hou, Y.-T., Gou, Y., Chen, D.-Q., 2002. Fossil Ostracoda of China, Vol. 1—Superfamilies Cypridae and Darwinulididae. Science Press, Beijing, p. 1090 (in Chinese).
- Huh, M., Lee, Y.N., Lim, S.K., Hwang, K.G., 1998. Research Report on the Haenam Dinosaur Site, Korea. Chonnam National University Museum, p. 215.
- Jones, T.R., 1901. On some Carboniferous shale from Siberia. *Geological Magazine* 4 (8), 433–436.
- Kang, H.C., Paik, I.S., 2013. Review on the geological ages of the formations in the Gyeongsang Basin, Korea. *Journal of the Geological Society of Korea* 49 (1), 17–29 (in Korean with English abstract).
- Karanovic, I., 2012. *Recent Freshwater Ostracods of the World*. Springer, p. 608.
- Kaufmann, A., 1900. Cypriden und Darwinuliden der Schweiz. *Revue Suisse de Zoologie. Annales de la Société Zoologique de Suisse* 8, 209–423 (in German).
- Khand, Y., 2000. The origins of modern nonmarine ostracod faunas: evidence from the Late Cretaceous and Early Palaeogene of Mongolia. *Hydrobiologia* 419, 119–124.
- Khand, Y., Badamgarav, D., Ariunchimeg, Y., Barsbold, R., 2000. Cretaceous system in Mongolia and its depositional environments. In: Okada, H., Mateer, N.J. (Eds.), *Cretaceous Environments of Asia. Developments in Palaeontology and Stratigraphy*, vol. 17, pp. 49–79.
- Kim, S., Han, N., Yun, H., Jeon, B., Park, J., Lim, K., Park, I., Lee, J., Choi, J., 1992. Fossils of Korea II. Science and Technology Press, p. 112.
- Kim, J.Y., Keighley, D.G., Pickerill, R.K., Hwang, W., Kim, K.-S., 2005. Trace fossils from marginal lacustrine deposits of the Cretaceous Jinju Formation, southern coast of Korea. *Palaeogeography, Palaeoclimatology, Palaeoecology* 218, 105–124.
- Kim, J.-S., Cho, H., Son, M., Sohn, Y.K., 2011. Geochronology of the Gyeongsang Supergroup. In: *Abstract of the Annual Conference of the Geological Societies in Korea*, p. 20. Jeju, South Korea.
- Kim, K.S., Lim, J.D., Lockley, M.G., Xing, L., Kim, D.H., Piñuela, L., Romilio, A., Yoo, J.S., Kim, J.H., Ahn, J., 2018. Smallest known raptor tracks suggest microraptorine activity in lakeshore setting. *Scientific Reports* 8 (1). <https://doi.org/10.1038/s41598-018-35289-4>.
- Kim, K.S., Lockley, M.G., Lim, J.D., Kim, D.H., 2019. The oldest known anuran (frog) tracks from the Jinju Formation, Lower Cretaceous, Korea. *Cretaceous Research* 96, 142–148.
- Krömmelbein, K., 1962. Zur Taxonomie und Biochronologie stratigraphisch wichtiger Ostracoden-Arten aus der oberjurassisch? – unterkretazischen Bahia–Serie (Wealden–Fazies) NE–Brasilien. *Senckenbergiana Lethaea* 43, 437–528.
- Krömmelbein, K., 1965. Neue, für Vergleiche mit West–Afrika wichtige Ostracoden–Arten der brasilianischen Bahia–Serie (Ober–Jura?/Unter– Kreide in Wealden–Fazies). *Senckenbergiana Lethaea* 46a, 177–213 (Weiler Festschrift).
- Latreille, P.A., 1802. *Genera Crustaceorum et Insectorum*, Tomus Primus. Koenig, Paris, p. 302 (in French).
- Lee, D.S., Lee, H.Y., 1976. Geologic and geochemical study on the rock sequences containing oily materials in Southwestern coast area of Korea. *Economic and Environmental Geology* 9 (1), 45–74.
- Lee, K.C., Woo, K.S., 1996. Lacustrine stromatolites and diagenetic history of carbonate rocks of Chinju Formation in Kunwi area, Kyongsangbukdo, Korea. *Journal of the Geological Society of Korea* 32, 351–365.
- Lee, Y.-N., Yu, K.-M., Wood, C.B., 2001. A review of vertebrate faunas from the Gyeongsang Supergroup (Cretaceous) in South Korea. *Palaeogeography, Palaeoclimatology, Palaeoecology* 165 (3–4), 357–373.
- Lee, Y.I., Choi, T., Lim, H.S., Orihashi, Y., 2010. Detrital zircon geochronology of the Cretaceous Sindong Group, Southeast Korea: implications for depositional age and Early Cretaceous igneous activity. *Island Arc* 19, 647–658.
- Lee, T.-H., Park, K.-H., Yi, K., 2018. Nature and evolution of the Cretaceous basins in the eastern margin of Eurasia: A case study of the Gyeongsang Basin, SE Korea. *Journal of Asian Earth Sciences* 166, 19–31.
- Lockley, M.G., Lim, J.D., Park, H.D., Romilio, A., Yoo, J.S., Choi, J.W., Kim, K.S., Choi, Y., Kang, S.-H., Kim, D.H., Kim, T.H., 2020. First reports of *Crocodylopus* from East Asia: implications for the paleoecology of the Lower Cretaceous. *Cretaceous Research* 111, 1–13.
- Lübbimova, P.S., 1956. Ostracody Melovykh Otlozheniy Vostochnoy Chasti Mongolskoy Narodnoy Respubliki i ikh Znachenie dlya Stratigrafii (Ostracoda from Cretaceous deposits of the eastern part of the People's Republic of Mongolia and their significance for stratigraphy). *Trudy Vsesoyuznogo Neftyanogo Nauchno-Issledovatel'skogo Geologo–Razvedochnogo Instituta (VNIIGRI), Novaya Seriya* 93, 1–174 (in Russian).
- Martin, G.P.R., 1940. Ostracoden des norddeutschen Purbeck und Wealden. *Senckenbergiana* 22, 275–361 (in German).
- Meisch, C., 2000. *Freshwater Ostracoda of Western and Central Europe*. Spektrum Akademischer Verlag, Heidelberg, p. 522.
- Müller, O.F., 1776. *Zoologiae Danice Prodromus, Seu Animalium Daniae et Norvegiae Indigenarum Characteres, Nomina et Synonyma Imprimis Popularium*. Lipsiae et Havniae, Copenhagen, p. 282.
- Müller, G.W., 1894. Die Ostracoden des Golfes von Neapel und der Angrenzenden Meeresabschnitte. *Fauna und Flora Golfes von Neapel. Monograph* 21, 1–404 (in German).
- Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, 1963. *Index Fossil Handbook of Northwest China*. Science Press, Beijing, p. 163 (in Chinese).
- Nam, K.-S., Kim, J.-H., 2016. Reconstruction and paleoecological implications of dragonfly *Hemeriscopus baissicus* Pritykina, 1977 (Hemeriscopidae) from the Lower Cretaceous Jinju Formation in the Jinju Area, Korea. *Journal of the Geological Society of Korea* 52, 105–112 (in Korean, with English abstract).
- Neustrueva, I.Y., Sinitsa, S.M., Khand, Y., Melnikova, L.M., 2005. Paleontologia Mongolii. *Posdnemesosoijskye i Paleogenovyje Ostrakody* (Paleontology of Mongolia: Late Mesozoic and Paleogene ostracods). Nauka, Moskva, p. 166 (in Russian).

- Nye, E., Feist-Burkhardt, S., Horne, D.J., Ross, A.J., Whittaker, J.E., 2008. The palaeoenvironment associated with a partial *Iguanodon* skeleton from the Upper Weald Clay (Barremian, Early Cretaceous) at Smokejacks Brickworks (Ockley, Surrey, UK), based on palynomorphs and ostracods. *Cretaceous Research* 29, 417–444.
- Paik, I.S., 2005. The oldest record of microbial-caddisfly bioherms from the Early Cretaceous Jinju Formation, Korea: occurrence and palaeoenvironmental implications. *Palaeogeography, Palaeoclimatology, Palaeoecology* 218, 301–315.
- Paik, K.-H., Kim, Y.-K., Huh, M., 1988. Ostracodes from the Chinju Formation (Cretaceous, Non-marine) in Kyongsang Basin, Korea. *Journal of the Paleontological Society of Korea* 4, 94–109.
- Paik, I.S., Kim, H.J., Kim, S., Lee, J.E., So, Y.H., Lee, H., 2019. Fossil-bearing deposits in the Jinju Formation at Jinju: Occurrences, paleoenvironments and stratigraphic implications. *Journal of the Geological Society of Korea* 5 (5(5)), 513–530.
- Park, T.-Y., Wilson, G.D.F., Lee, D.-C., Choi, D.K., 2012. Occurrence of the isopod *Archaeoniscus coreaensis* new species from the Lower Cretaceous Jinju Formation, Korea. *Journal of Paleontology* 86 (4), 626–640.
- Park, T.-Y.S., Kim, Y.-H., Nam, K.-S., 2013. Preliminary research on the aquatic coleopteran, *Coptoclava* from the Early Cretaceous Jinju Formation. *Journal of the Geological Society of Korea* 49 (6), 617–624 (in Korean with English abstract).
- Park, T.-Y.S., Nam, K.-S., Selden, P.A., 2019. A diverse new spider (Araneae) fauna from the Jinju Formation, Cretaceous (Albian) of Korea. *Journal of Systematic Palaeontology* 17 (15), 1271–1297.
- Qin, Z., Xi, D., Sames, B., Do Carmo, D.A., Wang, X., Xu, Y., Yu, Z., Wei, F., Leite, A.M., Wan, X., 2018. Ostracods of the non-marine Lower Cretaceous Dabeigou Formation at Yushuxia (Luanping basin, North China): Implications for the early Jehol Biota age. *Cretaceous Research* 86, 199–218.
- Sames, B., 2011a. Early Cretaceous *Theriosynoecum* Branson 1936 in North America and Europe. In: Sames, B. (Ed.), *Taxonomic Studies in Early Cretaceous Non-marine Ostracoda of North America*, vol. 57, pp. 291–344. *Micropaleontology*.
- Sames, B., 2011b. Early Cretaceous *Cypridea* Bosquet 1852 in North America and Europe. In: Sames, B. (Ed.), *Taxonomic studies in Early Cretaceous nonmarine Ostracoda of North America*, vol. 57, pp. 345–431. *Micropaleontology*.
- Sames, B., 2011c. Glossary of morphologic terms of late Mesozoic nonmarine Ostracoda, relevant to *Theriosynoecum* Branson 1936 and *Cypridea* Bosquet 1852. In: Sames, B. (Ed.), *Taxonomic studies in Early Cretaceous nonmarine Ostracoda of North America*, vol. 57, pp. 433–454. *Micropaleontology*.
- Sames, B., Horne, D.J., 2012. Latest Jurassic to Cretaceous non-marine ostracod biostratigraphy: Unde venis, quo vadis? *Journal of Stratigraphy* 36, 267–289.
- Sames, B., Cifelli, R.L., Schudack, M.E., 2010. The nonmarine Lower Cretaceous of the North American Western Interior foreland basin: New biostratigraphic results from ostracod correlations and early mammals, and their implications for paleontology and geology of the basin—An overview. *Earth-Science Reviews* 101, 207–224.
- Schmit, O., Adolfsson, S., Vandekerckhove, J., Rueda, J., Bode, S.N.S., Rossetti, G., Michalakis, Y., Jokela, J., Martens, K., Mesquita-Joanes, F., 2013. The distribution of sexual reproduction of the geographic parthenogen *Eucypris virens* (Crustacea: Ostracoda) matches environmental gradients in a temporary lake. *Canadian Journal of Zoology* 91 (9), 660–671.
- Schudack, U., Schudack, M., 2012. Non-Cypridean Ostracoda from the Lower Cretaceous of the Iberian Chain (Spain). *Neues Jahrbuch für Geologie und Paläontologie - Abhandlungen* 266 (3), 251–271.
- Seo, S.J., 1996. Lower Cretaceous Ostracodes Fossil from Chinju Formation, Chinju Korea. *Research in Science Education* 22, 23–27 (in Korean with English abstract).
- Sowerby, J.D.C., 1836. Descriptive notes respecting the shells figured in plates XI to XXI. In: Fitton, W.H. (Ed.), *Observation on some of the strata between the Chalk and the Oxford Oolithe*. The Geological Society, London, pp. 344–345.
- Stankevitch, E.S., Sochava, A.V., 1974. Ostrakody senona Mongolii. In: Kramarenko, N.N. (Ed.), *Fauna i biostratigrafija mezozoja i kainozoja Mongolii (Mesozoic and Cenozoic faunas and biostratigraphy of Mongolia)*, vol. 1. *Sovmestnaya Sovetsko-Mongolskaya Paleontologicheskaya Ekspeditsiya (The Joint Soviet-Mongolian Paleontological Expedition)*, Moskva, pp. 268–286 (in Russian).
- Szczuchura, J., 1978. Fresh-water ostracodes from the Nemegt Formation (Upper Cretaceous) of Mongolia. *Palaeontologica Polonica* 38, 65–121.
- Van Itterbeeck, J., Markevich, V.S., Horne, D., 2004. The age of the dinosaur-bearing Cretaceous sediments at Dashuiguo, Inner Mongolia, P.R. China based on charophytes, ostracods and palynomorphs. *Cretaceous Research* 25, 391–409.
- Van Itterbeeck, J., Horne, D.J., Bultynck, P., Vandenberghe, N., 2005. Stratigraphy and palaeoenvironment of the dinosaur-bearing Upper Cretaceous Iren Dabasu Formation, Inner Mongolia, People's Republic of China. *Cretaceous Research* 26, 699–725.
- Wang, Y.Q., Sha, J.G., Pan, Y.H., Zhang, X.L., Rao, X., 2012. Non-marine Cretaceous ostracod assemblages in China: A preliminary review. *Journal of Stratigraphy* 36 (2), 289–299.
- Wang, Y.Q., Sha, J.G., Pan, Y.H., 2013. Revision of *Cypridea* (non-marine Ostracoda) from the Early Cretaceous Yixian Formation of the Beipiao-Yixian Basin in western Liaoning, northeast China. *Cretaceous Research* 40, 102–109.
- Wang, Y.Q., Sha, J.G., Pan, Y.H., Zhang, X.L., 2015. Early Cretaceous nonmarine ostracod biostratigraphy of western Liaoning area, NE China. *Micropaleontology* 61 (2), 135–145.
- Wang, Y.Q., Sha, J.G., Pan, Y.H., Zuo, Q.M., 2016. The Early Cretaceous non-Cypridea Ostracoda from Yixian and Jiufotang formations of western Liaoning (China). *Palaeoworld* 25, 406–424.
- Wang, Y.Q., Sames, B., Liao, H.Y., Xi, D., Pan, Y.H., 2017a. Late Cretaceous ostracod fauna from the Shenjiatun section (Songliao Basin, Northeast China): Biostratigraphic and palaeoecological implications. *Cretaceous Research* 78, 174–190.
- Wang, Y.Q., Yang, W.G., Pan, Y.H., Liao, H.Y., 2017b. Species of the genus *Cypridea* Bosquet, 1852 (Ostracoda) from the Lower Cretaceous Yixian and Jiufotang formations of western Liaoning, China. *Palaeoworld* 26, 339–351.
- Watson, M.P., Hayward, A.B., Parkinson, D.N., Zhang, Z.M., 1987. Plate tectonic history, basin development and petroleum source rock deposition onshore China. *Marine and Petroleum Geology* 4, 205–225.
- Whatley, R.C., 1983. The application of Ostracoda to paleoenvironmental analysis. In: Maddocks, R.F. (Ed.), *Applications of Ostracoda*. Proceedings of the Eighth International Symposium on Ostracoda. Department of Geosciences, University of Houston, pp. 51–77.
- Whatley, R.C., 1988. Population structure of ostracods: some general principles for the recognition of palaeoenvironments. In: De Decker, Colin, J.-P., Peypouquet, J.-P. (Eds.), *Ostracoda in the Earth Sciences*. Elsevier, pp. 103–124.
- Wolburg, J., 1959. Die Cyprideen des NW-deutschen Wealden. *Senckenbergiana Lethaea* 40, 223–315.
- Won, C.K., Kang, P.C., Lee, S.H., 1978. Study on the tectonic interpretation and igneous pluton in the Gyeongsang Basin. *Journal of the Geological Society of Korea* 14, 79–92 (in Korean, with English abstract).
- Yabumoto, Y., Yang, S.-Y., Kim, T.-W., 2006. Early Cretaceous freshwater fishes from Japan and Korea. *Journal of the Paleontological Society of Korea* 22 (1), 119–132.
- Yang, R.Q., 1985. The Jurassic–Cretaceous nonmarine ostracod fauna from north Hebei. *Professional Papers of Stratigraphy and Palaeontology* 12, 197–232 (in Chinese, with English abstract).
- Ye, C.-H., 1994. Succession of Cypridacea (Ostracoda) and nonmarine Cretaceous stratigraphy of China. *Cretaceous Research* 15, 285–303.
- Ye, C.H., Gou, Y.X., Hou, Y.T., Cao, M.Z., 1977. Mesozoic–Cenozoic ostracode fauna from Yunnan. In: Nanjing institute of Geology and Palaeontology, Chinese Academy of Science (Ed.), *Divisions and Correlations of the Mesozoic Volcano-Sedimentary Formations in Zhejiang and Aihui Provinces, Part II*. Science Press, Beijing, pp. 153–330 (in Chinese).
- Yi, M.-S., Cho, B.-H., Chi, J.-M., 1994. Palynomorphs from the Jinju Formation in the Euseong area, Korea. *Journal of the Paleontological Society of Korea* 10, 41–56.
- Zhang, L.-J., 1985a. The freshwater ostracodes from the Lower Cretaceous Jiufotang and Shahai formations in the Western Liaoning. In: *Selected Paper on Micropalaeontology of China*. Science Press, Beijing, pp. 137–149 (in Chinese with English abstract).
- Zhang, L.-J., 1985b. Ostracods. In: Zhang, L.J., Wu, R.P., Wu, H.Z. (Eds.), *Mesozoic Stratigraphy and Palaeontology of Western Liaoning*. Geological Publishing House, Beijing, pp. 1–120 (in Chinese).
- Zhang, L., 1990. New species of Early Cretaceous non-marine ostracods from NE China, vol. 22. *Bulletin of the Shenyang Institute of Geology and Mineral Resources, Chinese Academy of Geological Sciences*, pp. 90–107.
- Zhang, X.-Q., Li, G., Li, H.-M., 2006. Late Cretaceous ostracods from the Nanxiong Group in the Nanxiong Basin of Guangdong Province. *Acta Micropalaeontologica Sinica* 23 (2), 115–153.
- Zhang, Z.-L., Cai, X.-Y., Zhang, M., Li, J.-C., Zhang, Y., 2014. An analysis of the relationship between types of ostracoda shell ornaments and shell shapes and the environment from Late Cretaceous Qingshankou Formation to 1st Member of Nenjiang Formation in Songliao Basin. *Geology in China* 41 (1), 135–147.