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Cretaceous beetles of the Jinju Formation: *Cryptocoelus minimus* sp. nov. (Coleoptera: Elateridae) from the Early Cretaceous of South Korea

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Abstract

The Lower Cretaceous Jinju Formation of South Korea has recently emerged as an important Konservat-Lagerstätte for Mesozoic insects, yielding exceptionally preserved beetles. These discoveries provide new insights into the morphological evolution and biogeographic history of Mesozoic beetles. Here, we describe a new click beetle, *Cryptocoelus minimus* sp. nov., from the Jinju Formation, South Korea. *Cryptocoelus minimus* sp. nov. is characterized by a rounded anterior margin of the frons, a distinct antennal morphology compared to other species of *Cryptocoelus*, and different proportions of pronotum length to carina length and elytral length to width ratio. This find represents the third fossil species of Elateridae from the Jinju Formation and constitutes the youngest fossil record of the genus *Cryptocoelus*.

Key words: Republic of Korea, Early Cretaceous, Jinju Formation, Coleoptera, Elateridae

Introduction

Elateridae (or click beetles), a large family within Elateroidea (Cai *et al*. 2022, 2024), is distributed worldwide and currently comprises 709 extant genera with approximately 14,600 species, along with 105 extinct genera containing 269 species (Kundrata *et al*. 2020; Kundrata 2025). Recent studies indicate that extant Elateridae are classified into 17 subfamilies and 51 tribes (Motyka *et al*. 2025). Fossil records of Elateridae span from the Triassic to the Miocene (Kundrata *et al*. 2020), with the majority of described fossils originating from the Mesozoic, totaling 143 species. However, several Mesozoic taxa currently assigned to Elateridae may require taxonomic re-evaluation (Kundrata *et al*. 2020).

A key diagnostic feature of Elateridae is their jumping ability, produced by a rapid clicking mechanism in which the prosternal process snaps into the mesosternal cavity (Evans 1972, 1973; Sohn *et al*. 2019). Recent research suggests that this mechanism is ancestral, with multiple derived modifications, including non-clicking lineages, soft-bodied forms, and sexually dimorphic taxa with modified females (Motyka *et al*. 2025).

To date, two genera and two species of Elateridae have been reported from the Jinju Formation: *Megalithomerus magohalmii* and *Koreagrypnus jinju*. Notably, *Megalithomerus magohalmii* exhibits the largest body size known among fossil Elateridae (Sohn *et al*. 2019). Since these discoveries, no additional elaterid fossils have been described from the Lower Cretaceous Jinju Formation.

Here we report a new fossil record of *Cryptocoelus* within Elateridae from the Jinju Formation. This genus was originally placed in the subfamily Agrypninae (Dolin & Nel 2002), but Chang *et al*. (2007) later reassigned it as subfamily *incertae sedis* within Elateridae, due to the absence of deep grooves or impressions on the prosternal pleural sutures—features diagnostic of Agrypninae—and its possible affinity with Pyrophorinae.

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Material and methods

The fossil specimens examined in this study are deposited at Gongju National University of Education. Photographs were taken using a Sony α7R IV mirrorless camera fitted with a Canon MP-E 65 mm macro lens. Several specimens were recovered from Jeongchon-myeon, Jinju-si, Gyeongsangnam-do (35°07′63″N, 128°06′07″E), and an additional specimen was collected from Habin-myeon, Dalseong-gun, Daegu-gwangyeoksi (35°51′50″N, 128°25′23″E). The map figures (Figs. 1, 4) were drawn using Adobe Illustrator and Adobe Photoshop.

Geological setting

The Jinju Formation consists primarily of grey to black shale and sandstone, and its depositional environment is interpreted as a freshwater, perennial lacustrine system (Chough & Sohn 2010; Park *et al*. 2013; Paik *et al*. 2019; Paik *et al*. 2023; Lee *et al*. 2024a). Sedimentological analyses indicate a paleoclimatic transition within the formation, shifting from humid to arid conditions (Paik *et al*. 2023). Detrital zircon geochronology suggests that the youngest depositional age of the Jinju Formation is approximately 106 Ma (Lee *et al*. 2010; Park *et al*. 2013). More recent zircon dating constrains the lower boundary of the formation to 112.4 ± 1.3 Ma and the upper boundary to 108.7 ± 0.5 Ma (Lee *et al*. 2018; Lee *et al*. 2025).

The geological exposure at Jeongchon-myeon, Jinju-si has been largely destroyed due to construction activities, rendering the stratigraphic column unclear. In contrast, the stratigraphic succession at Habin-myeon, Dalseong-gun, Daegu-gwangyeoksi is well preserved. The geological section of the sediment is shown in Fig. 1B.

Numerous coleopteran fossils have previously been reported from the Jinju Formation. Park *et al*. (2013) first described the genus *Coptoclava* sp. from this unit. Subsequently, Sohn *et al*. (2019) described two genera of Elateridae, and Sohn & Nam (2021) established a new genus of carrion beetles (Coleoptera: Staphylinidae: Silphinae; Cai *et al*. 2022). Lee *et al*. (2022, 2023) reported the first Archostemata fossils from the Jinju Formation. More recently, Lee *et al*. (2024b) described Hydrophiloidea, and Lee *et al*. (2024c) documented Trachypachidae from the formation.

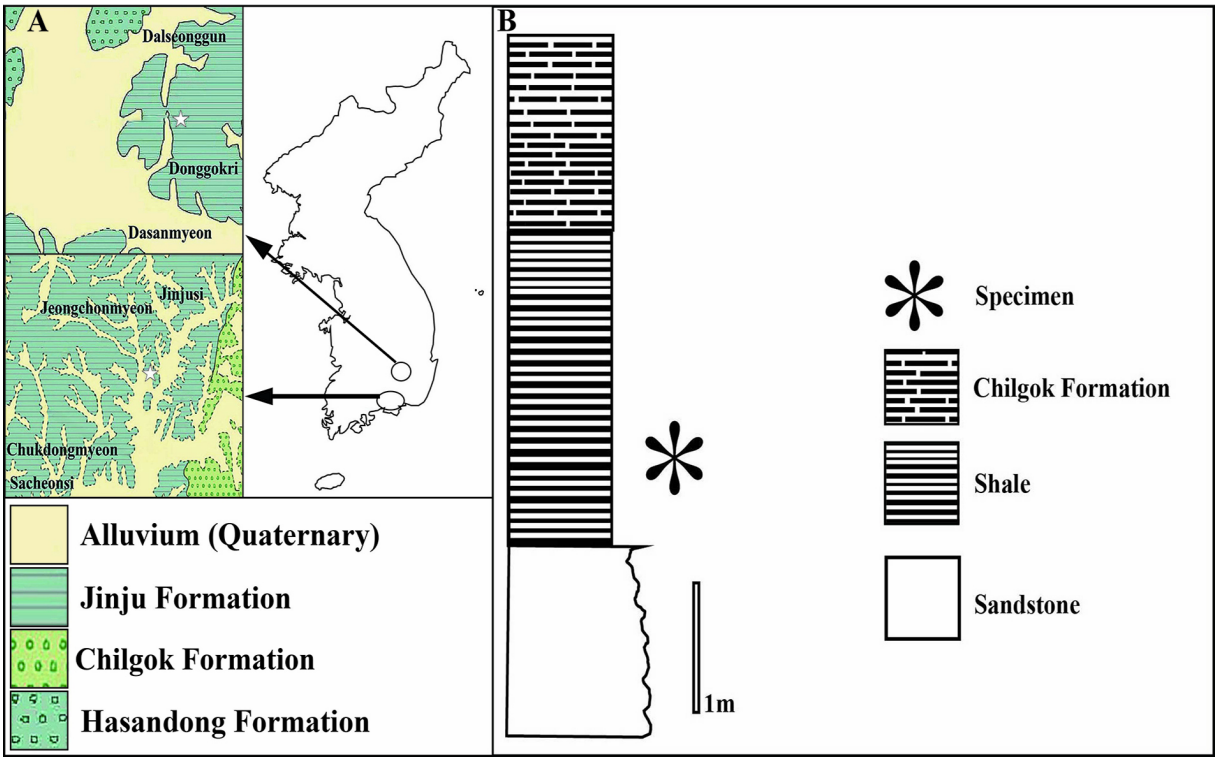

Figure 1. Map of the fossil localities and columnar section. **A,** Geological map of the locality (modified from Lee *et al*. 2024a); **B,** Columnar section of Habin-myeon, Dalseong-gun, Daegu-gwangyeoksi, Republic of Korea.

Systematic palaeontology

Order Coleoptera Linnaeus, 1758
Family Elateridae Leach, 1815
Genus *Cryptocoelus* Dolin & Nel, 2002

***Cryptocoelus minimus* sp. nov.**
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(Figs 2, 3)

Material. Holotype, GNUE217049A,B (part and counterpart); paratype, GNUE217048.

Etymology. The species name *minimus* is derived from Latin, meaning "smallest", refers to its comparatively shorter body length of holotype compared to other species.

Locality and horizon. Jeongchon-myeon, Jinju-si (GNUE217049A, B) and Habin-myeon, Dalseong-gun, Daegu-gwangyeoksi (GNUE217048), Republic of Korea; Jinju Formation, Lower Cretaceous (Albian).

Diagnosis. Anterior margin of frons rounded; 8th antennomere widest; 11th antennomere shortest in width.

Figure 2. Photograph of *Cryptocoelus minimus* **sp. nov.**. **A,** holotype (GNUE217049A). **B,** Counterpart (GNUE217049B). Scale bar = 5 mm.

Description. Head length and width subequal. Anterior part of frons rounded. Eyes oval, occupying approximately one-third of head width. Antennae short, serrate from the fourth segment onward, not reaching the apex of the posterior pronotal angles, as in *C. buffoni*, *C. major*, and *C. gianteus* (Dolin & Nel 2002; Chang *et al*. 2007). Antenna with 11 antennomeres. First to third antennomeres nearly conical; fourth to ninth antennomeres cylindrical. Third antennomere three times longer than its apical width. Fourth antennomere triangular, slightly longer than the third, 2.2 times longer than wide at apex. Third and fourth antennomeres distinctly longer than the remaining antennomeres, with the fourth antennomere slightly longer than the third. Penultimate antennomeres nearly filiform. Fourth to seventh antennomeres

and eleventh antennomere twice as long as their distal width; ninth and tenth antennomeres 1.5 times longer than their distal width. Eighth antennomere widest. Pronotum (measured to the apex of the posterior angles) slightly longer than wide; measured at its median region, slightly wider than long. Anterior angles of pronotum sharp, anteriorly produced. Posterior angles of pronotum laterally projected, with apices curved and carinate. Sublateral carina distinct. Lateral margins of pronotum rounded and arcuately convex anteriorly, becoming posteriorly concave from the mid to posterior two-thirds. Prothoracic process slightly extending beyond procoxal cavities. Mesoepimeron slightly reaching mesocoxal cavities; mesoepisternum not reaching mesocoxal cavity. Mesosternal cavity teardrop-shaped. Metaventrite trapezoidal, broad posteriorly; lateral and posterior margins straight; median region inclined. Elytra 3.5 times longer than wide, with faint longitudinal striae lacking punctation. Medial and distal margins slightly thickened. Procoxae rounded and contiguous. Profemur nearly uniform in width. Protibia widening distally; mesotibia uniform. Mesocoxae rounded, separated, and open to mesepimeron. First and fifth mesotarsomeres slightly widened distally. Metacoxae rounded and contiguous; metacoxal plate narrowing laterally from midlength. Metafemur widest at midlength, slightly longer than metatibia; metatibia uniform. First and fifth tarsomeres equal in length and longer than the remaining segments. Abdomen with five visible ventrites; widest across the first ventrite and tapering posteriorly.

Figure 3. *Cryptocoelus minimus* **sp. nov.**, paratype (GNUE217048). Scale bar = 5 mm.

Measurements. The overall body length: 11 mm (GNUE217049A, B), 9 mm (GNUE217048); pronotum width: 3.3 mm (GNUE217049A, B), 2.5 mm (GNUE217048); pronotum length: 3.5 mm (GNUE217049A, B), 3 mm (GNUE217048); elytral length: 7mm (GNUE217048, GNUE217049A, B).

Discussion

The new specimens GNUE217049A, B, and GNUE217048 exhibit the following characters: (1) lateral margins of the pronotum arcuately convex in the anterior one-third and concave posteriorly; (2) posterior pronotal angles carinate and laterally produced; (3) procoxae and mesocoxae rounded; (4) mesocoxae open to the mesepimeron; (5) metacoxal plate narrowing laterally from the midpoint; (6) antenna short, not reaching the apex of the posterior pronotal angles, with the third and fourth antennomeres longer than the others, serrate from the fourth antennomere, penultimate antennomeres nearly filiform, and the terminal antennomere shorter than the penultimate ones; and (7) first and fifth tarsomeres longer than the remaining segments and equal in length. These features are consistent with the diagnostic *characters of* the genus *Cryptocoelus* (Dolin & Nel 2002; Chang *et al.* 2007; Alexeev 2011).

Cryptocoelus minimus **sp. nov.** differs from congeners from the Yixian Formation in the following respects: (1) head length and width are approximately equal, whereas the head is 1.25–1.3× wider in *C. buffoni* and 1.5× wider in *C. major*; (2) proportions of the pronotum length/carina length ratio and the elytron length/width ratio differ (see Table 1); (3) body size is markedly smaller, measuring 9–11 mm in *C. minimus* **sp. nov.**, compared with 14.3–17.2 mm in *C. buffoni*, 22.1 mm in *C. major*, and 27 mm in *C. gianteus*; and (4) anterior margin of the frons is rounded in *C. minimus* **sp. nov.**, compared with a straight anterior margin of the frons in *C. buffoni* and a barely concave margin in *C. major*. Previously, Sohn *et al*. (2019) described two genera and two species of Elateridae from the Jinju Formation: *Megalithomerus magohalmii* and *Koreagrypnus jinju*. *Cryptocoelus minimus* **sp. nov.** differs from these species in the following respects: (1) body length, measuring 9–11 mm in *C. minimus* **sp. nov.**, versus 47.8 mm in *M. magohalmii* and 23.1 mm in *K. jinju*; (2) elytral striae, which are faintly present in *C. minimus* **sp. nov.** but absent in both *M. magohalmii* and *K. jinju*; (3) absence of elytral punctation in *C. minimus* **sp. nov.**, whereas irregular punctation is present on the elytra of *M. magohalmii* and *K. jinju*; and (4) pronotal shape, with lateral margins arcuately convex in *C. minimus* **sp. nov.**, but not arcuately convex in *M. magohalmii* and *K. jinju*.

Table 1. Comparison among the described species of the extinct genus *Cryptocoelus*.

Species	Pronotum length/ carina length ratio	Elytron length/ width ratio	Body length	Reference
Cryptocoelus minimus **sp. nov.**	1:5.5~6.5	1: 2.8	9 ~ 11 mm	This study
C. baissensis	1:6	1:3.4-4	13 mm	Alexeev, 2011
C. buffoni	1:3.8~4.3	1:3.9~4	14.3 ~ 17.2 mm	Dolin & Nel, 2002; Alexeev, 2011
C. ?*buffoni*	1:5	1:3.4	16 mm	Dolin & Nel, 2002; Alexeev, 2011
C. dolini	1:5.7	1:4.2	12.1 mm	Alexeev, 2011
C. gianteus	1:4	1:3.8	27 mm	Chang *et al*. 2007: Alexeev, 2011
C. lukashevichae	1:4.5	1:3.6	15 mm	Alexeev, 2011
C. major	1:4.5	1:4.1	22.1 mm	Dolin & Nel, 2002: Alexeev, 2011
C. shcherbakovi	1:2.8	1:4.4	12 mm	Alexeev, 2011
C. sinitshenkovae	1:5	1:3.6-3.7	13 mm	Alexeev, 2011

The genus *Cryptocoelus* was initially documented from China and Russia, comprising eight species (Dolin & Nel 2002; Chang *et al*. 2007; Alexeev 2011). Our study presents the first fossil record of the genus *Cryptocoelus* from the Korean Peninsula and extends the known geographic distribution of the genus (Fig. 4). Two notable aspects emerge from our research. First, the age of *C. minimus* **sp. nov.** is significantly younger than that of other *Cryptocoelus* species. The Jinju Formation, from which *C. minimus* **sp. nov.** was recovered, is dated to the Albian based on several analysis

(Lee *et al*. 2010; Kang & Paik 2013; Lee *et al*. 2018; Paik *et al*. 2019). In contrast, the Yixian Formation, where *C. buffoni*, *C. major*, and *C. giganteus* were discovered, has been dated to between 125.755 ± 0.061 Ma and 124.122 ± 0.048 Ma, corresponding to the Barremian, based on U–Pb chemical abrasion–isotope dilution–isotope ratio mass spectrometry (CA-ID-IRMS) dating technique (Zhong *et al*. 2021). Additionally, the Zaza Formation, which yielded *C. baissensis*, *C. lukashevichae*, *C. scherbakovi*, *C. dolini*, and *C. sinitshenkovae*, has been estimated as Aptian or older based on floral and faunal evidence (Zherikhin *et al*. 1999). Therefore, *C. minimus* **sp. nov.** represents the youngest fossil record of the genus *Cryptocoelus* currently known.

Cryptocoelus minimus **sp. nov.** also shows the smallest body length compared to other species (Table 1). This might represent that the genus *Cryptocoelus* may tended to evolved into small body. Further study requires to resolve this.

Conclusion

Cryptocoelus has previously been documented from the Yixian Formation in China and the Zaza Formation in Russia (Dolin & Nel 2002; Chang *et al*. 2007; Alexeev 2011; Telnov *et al*. 2024; Yin *et al*. 2024). Both formations are dated to the Early Cretaceous, ranging from the Barremian to the Aptian (Zherikhin *et al*. 1999; Zhong *et al*. 2021; Zhang *et al*. 2023). Given that the Jinju Formation is dated to the Albian (Lee *et al*. 2010; Kang & Paik 2013; Lee *et al*. 2018; Paik *et al*. 2019), *C. minimus* **sp. nov.** represents the youngest fossil record of the extinct genus *Cryptocoelus* currently known. Moreover, based on body size, *C. minimus* **sp. nov.** is the smallest species described to date within the genus. The new material provides valuable insight into the morphological variability and potential ecological breadth of *Cryptocoelus*.

Figure 4. Distribution of the genus *Cryptocoelus*. Background map: © Hellerick, licensed under CC BY-SA 4.0.

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