

# New fossil elaterid (Coleoptera: Polyphaga: Elateridae) from Yixian Formation of western Liaoning, China<sup>\*</sup>

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**Abstract** A new species of the elaterid genus *Cryptoaelus* Dolin and Nel, 2002 from the Late Jurassic to Early Cretaceous Yixian Formation in the western Liaoning, China is described. Diagnosis of the genus is revised, and the systematic position of the genus is briefly discussed. Because the elaterids originated in the Early to Mid-Jurassic, this new material from the Late Jurassic-Early Cretaceous will enhance our understanding of the transition between ancient elaterids and extant ones, bridge the gap of cryptic relationships between the Mesozoic cupedids and elaterids, and expand our knowledge of their evolutionary history.

**Keywords:** Elateridae, new species, Yixian Formation, China

The Elateridae is a large family in the order Coleoptera. The family is composed of more than 10000 species, which are usually placed in 11 sub-families<sup>[1]</sup>. Among these, over 800 species have been recorded from China<sup>[2,3]</sup>. Elaterids are common and abundant in all parts of the world. Usually, they are easily recognized by their ability to jump into the air while making a clicking noise and by acute posterior pronotal angles, and possession of well-developed metacoxal plates. The latter feature has made it much easier to identify compressed fossil forms of the family<sup>[4]</sup>. Another intriguing biological feature of this family is having prolonged larval forms and short-lived adult forms occupying quite different niches. Adults are nocturnal living on vegetation, while larvae occur in a variety of habitats, including soil, litter, and rotten wood. Adult elaterids may be saprophagous, phytophagous, or predacious, but all appear to be liquid feeders practicing extraoral digestion<sup>[5]</sup>. Phytophagous soil-dwelling larvae are commonly known as wireworms, which have harmful economical importance to crops and forests<sup>[3]</sup>. By now, this family contains approximately 165 fossil species<sup>[6-25]</sup> and 25 amber species<sup>[26-28]</sup> that are attributed to some 72 genera reported from all over the world. Among these, 108 species in 32 genera are known from the Upper Jurassic strata of

Karatau<sup>[7-11]</sup> in Kazakhstan and 18 species in eight genera from China<sup>[11, 15, 16, 18, 21, 23-25]</sup>. Elaterids probably originated in the Early to Mid-Jurassic, flourished by the Late Jurassic, and many recent genera were established by the Early Palaeogene<sup>[4]</sup>. Late Jurassic-Early Cretaceous is just the transitional period between extant and extinct elaterids, and the new material from the Yixian Formation will enhance our understanding of the transition between ancient elaterids and extant ones, and expand our knowledge of their evolutionary history.

Up to date, fossils of one genus and three species have been collected from Yixian Formation, western Liaoning, China<sup>[11]</sup>. The Yixian Formation comprises mainly lacustrine sediments intercalated with volcanoclastics<sup>[29]</sup>. The exact age of this formation is still contentious. Three different opinions about the age (Late Jurassic, Late Jurassic-Early Cretaceous and Early Cretaceous) have been proposed based on both biostratigraphic and radiometric geochronology<sup>[30-34]</sup>. Recently, by comparing the Yixian biota with the Solnhofen biota in Germany, the Purbeck biota in England and Late Jurassic Terori-type and Ryoseki-type floras in Japan, Wang et al. considered that the age of the Yixian Formation should be from the Late Tithonian to the Berriasian<sup>[33, 34]</sup>.

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## 1 Material and methods

This study was the observation on a new elaterid, its part and counterpart, collected from the 2nd Bed of Yixian Formation in Huangbanjigou<sup>[35]</sup>, near Chaomidian Village, Shangyuan County, Beipiao City, Liaoning Province.

The specimen was examined using a Leica MZ12.5 dissecting microscope and illustrated with the aid of a drawing tube attachment. The terms of mesoventrite and metaventrite have been used in place of the misapplied terms of mesosternum and metasternum, following Lawrence<sup>[36]</sup>, Beutel and Hass<sup>[37]</sup> and Cleide Costa<sup>[38]</sup>.

The body length was measured from the apex of

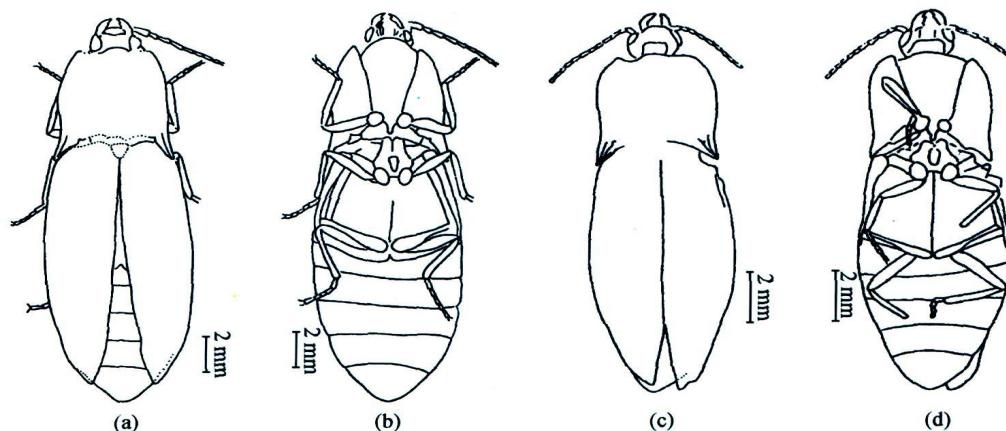


Fig. 1. *Cryptocoelus major* Dolin and Nel, 2002 ((a), (b)), and *Cryptocoelus buffoni* Dolin and Nel, 2002 ((c), (d)). (a) and (c) Dorsal view; (b) and (d) ventral view (Redrawing from Dolin and Nel<sup>[11]</sup>).

**Revised diagnosis:** The genus differs from all other closely related genera within the same family by the following features: body elongate, posterior angle of pronotum obviously prolonged backward, with distinct short carina; antennae short, not reaching posterior angle of pronotum, scape robust, pedicel much shorter than scape and antennomere 3, antennomeres 3 and 4 distinctly elongate; chin piece moderately or strongly arcuate; scutellum rounded, semi-oval, or subtriangular, never cordate; elytra with faintly longitudinal striae; mesocoxae open to mesepimeron; metacoxal plates obtusely long triangular, evenly narrowed laterally; tarsi with five tarsomeres, tarsomeres 1–4 succeeding shorter.

**Remarks:** The modified diagnosis of the genus is based on the type species (Fig. 1) and the new mate-

rial. the mandible to the apex of the abdomen. The body width was measured at the base of the elytra. Both length and width of pronotum were measured at the median line.

## 2 Systematic paleontology

**Order Coleoptera Linneus, 1758**

**Family Elateridae Leach, 1815**

**Genus *Cryptocoelus* Dolin and Nel, 2002**

Type species. *Cryptocoelus major* Dolin and Nel, 2002 (Fig. 1 (a), (b)), sampled near Chaomidian Village, Beipiao City, Liaoning Province, China.

rial.

***Cryptocoelus giganteus* sp. nov.**

**Etymology:** Name derived from Latin “*Giganteus*”, for its body is larger than any other fossil elaterids that have been previously reported.

**Holotype:** CNU-C-LB2006851-1, CNU-C-LB2006851-2, almost complete part and counterpart impression of elaterid, housed in Key Lab of Insect Evolution & Environment Change, Capital Normal University, Beijing, China.

**Horizon and locality:** Collected from a site near Chaomidian Village, Beipiao City, Liaoning Province, China; Upper Jurassic-Lower Cretaceous Yixian Formation (late Tithonian to Berriasian).

**Species diagnosis:** Differing from the other two species (Fig. 1) within the same genus by having a longer prosternal process, smaller procoxal cavity, different proportion of first three segments of antennae, and different proportion of the tarsomeres.

**Description** (Fig. 2 (a)): Body quite large, subcylindrical, smooth, elytra with faintly longitudinal striae, with short and pointed external ovipositor.

**Head:** oval; mandible robust (Fig. 2 (g)), in-

curved, without teeth on inner side; eyes small, oval; gular sutures parallel; frons flattened; labrum slightly transverse.

**Antennae** (Fig. 3 (c)): short, fail to reach the posterior angle of pronotum, 11-segmented, serrate from antennomere 4; scape robust, pedicel much short than scape and antennomere 3; antennomere 3 to 5 distinctly elongate, 4 approximately 2.72 times as long as wide, antennomeres 4–10 successively narrower; antennomere 11 oblong.

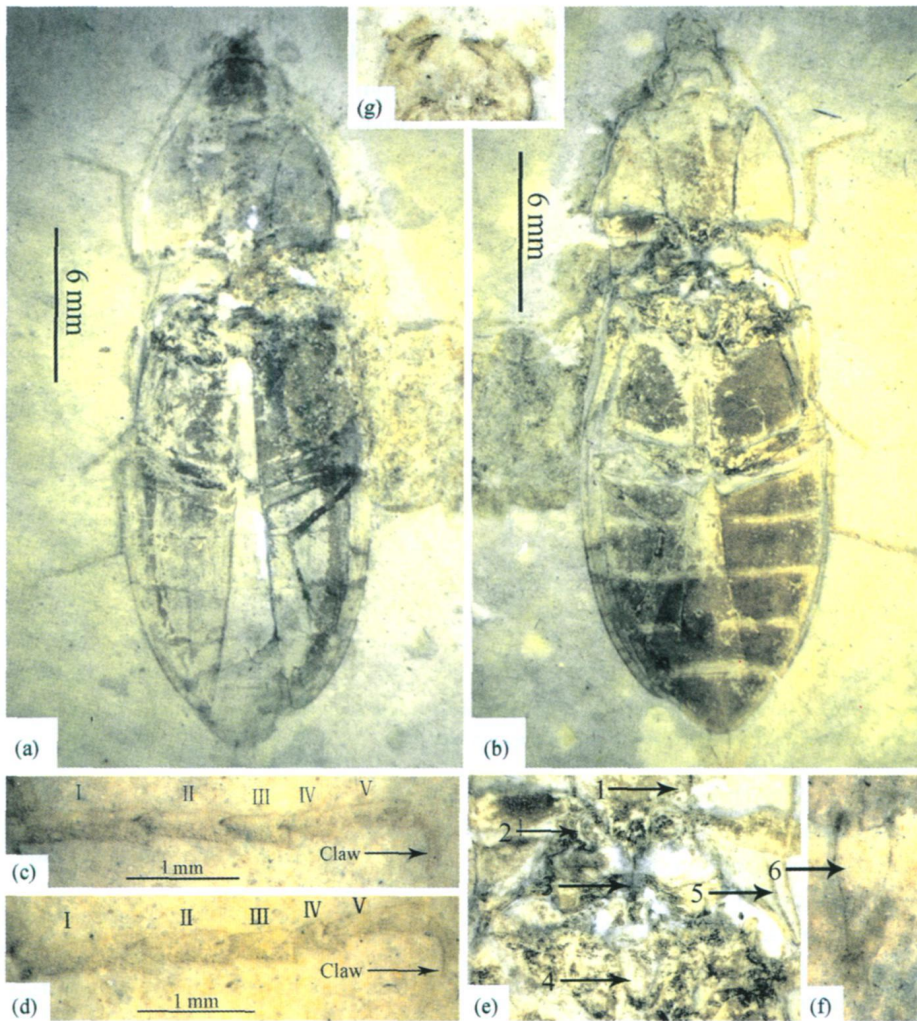


Fig. 2. *Cryptocaelus giganteus* sp. nov., holotype. (a) Dorsal view; (b) ventral view; (c) and (d) hindtibia dorsal view and ventral view. I – V, tarsomeres 1–5; (e) pro-mesothorax, 1 prosternal pleural suture; 2 procoxae; 3 prosternal process; 4 mesoventrite cavity; 5 carinae; (f) 6 ovipositor; (g) mandibles.

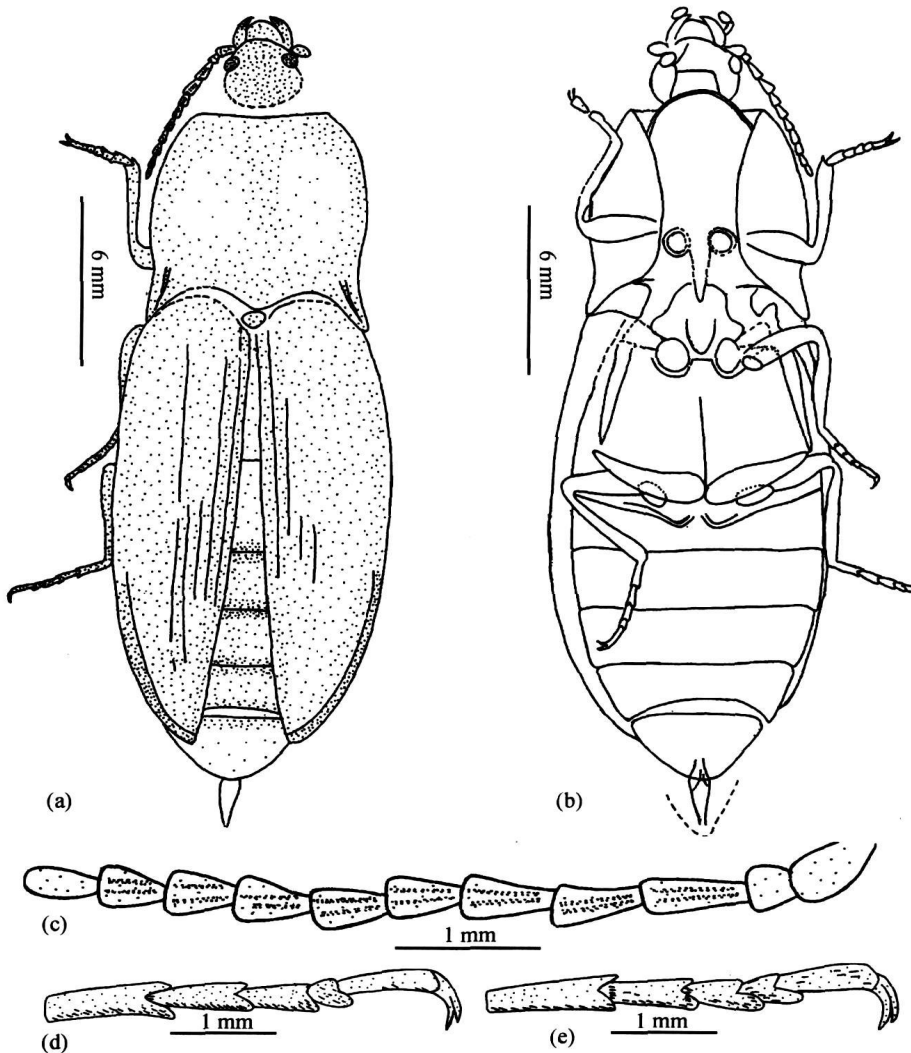


Fig. 3. *Cryptocaelus giganteus* sp. nov., holotype. (a) Dorsal view; (b) ventral view; (c) antennae dorsal view; (d) hindtibia ventral view; (e) hindtibia dorsal view.

**Pronotum:** smooth, subsquare, wider than head, anterior margin nearly straight, lateral sides arcuate in front of hind angles, basal margin moderately bisinuate, width equal to length if length measured at median line, 1.14 times as long as wide if length is measured from anterior angle to posterior angle disc slightly convex; hind angles acute, projecting backwardly, with distinct short carinae (Fig. 2 (e)).

**Scutellum:** small, subtriangular.

**Elytron:** approximately 1.14 times as wide as prothorax, 4 times as long as wide, lateral sides nearly parallel at middle, flattened on disc, with 5 faintly visible striae, intervals flat, epipleural rim narrow, with rounded humeral angle, apex of elytra slightly obtuse, not completely cover the last visible ventrite (Fig. 3 (a)).

**Ventral surface** (Fig. 3 (b)): chin piece normally arcuate; prosternal sutures single; procoxal cavity open behind, rounded; prosternal process extending far behind coxae; mesoventral cavity apparently open anteriorly, V-shaped; metaventrite small, without transverse sutures; mesocoxae open to mesepimeron; mesoventrite and metaventrite separated by distinct suture; metaventrite with longitudinal suture; metepisternum narrow; metacoxal plates obtusely long triangular, evenly narrowed laterally; abdomen with 5 visible ventrites, superimposed each others, narrowed from the base of fifth visible ventrite, first visible ventrite much longer than others, 1.23 times as long as the previous one; ovipositor coniform (Fig. 2 (f)).

**Legs:** tibia and tarsi setosed; procoxa rounded; protibiae more or less straight, slightly swollen api-

cally, with one short spur at tip; mesocoxa rounded, bigger than procoxa, mesotrochanter oval; metacoxa transverse, metatrochanter oval, metatarsi with 5 tarsomeres, tarsomere 1 much longer than others, tarsomeres 1–4 succeeding shorter, the fourth one is the shortest, subcordate; claws simple, falciform (Fig. 3 (d), (e)).

**Measurement** (mm): body length 27; body width 8; elytron length 16.

### 3 Discussion and conclusions

(1) The genitalia of beetles is largely internal in both sexes, and the ovipositor is highly reduced as a result. This feature is probably related to the general body structure of beetles because the delicate genitalia can be protected internally when the beetles wedge into tight space or in soil<sup>[4]</sup>. But the new species and *Cryptocaelus buffoni* Dolin and Nel, 2002 obviously preserved with short, pointed, external ovipositor, so we may deduce that their ovipositor may be more or less sclerotized, and during their lifetime they should lay their eggs into the soil just like the extant species do, for the larvae of most extant species live underground<sup>[2,3]</sup>.

(2) One distinct feature of the new species is its possession of robust mandibles, different from extant elaterids, but similar to the beetles of the Jehol entomofauna, cupedids<sup>[39]</sup>. Nowadays, cupedids are relict beetles, with cryptic habits, but they are one group of primitive beetles. From the Triassic to the Early Cretaceous, cupedids were quite diverse, but in the Mid to Late Cretaceous the diversity of the group decreased. Some authors deduced that the extinction of some Cupedomorpha might have been caused by competition with modern wood-eating forms, such as Elateridae or Buprestidae<sup>[40,41]</sup>, especially elaterids, for they have obvious advantage in escaping their natural enemy's hunting. The new elaterid from the Liaoning beds may further attest to this deduction.

(3) We do not support Dolin and Nel's assignment of *Cryptocaelus* to the extant subfamily Agrypninae<sup>[1]</sup> for two reasons: firstly, we cannot find any deep grooves or impressions on prosternal pleural sutures both on this newly collected specimen and the previously reported ones, for having such grooves or impressions is regarded as an important diagnostic feature of the Agrypninae or Agrypnini<sup>[1,42]</sup>. Second-

ly, in a widely accepted taxonomic framework of the Elateridae by Stibick, the subfamily Agrypninae is degraded to a tribe status—Agrypnini, subordinate to Pyrophorinae<sup>[1]</sup>. According to this system, the genus in question has a closer relationship with the Pyrophorinae as indicated by the following characteristics: chin piece normally arcuate; prosternal process normally elongate; mesocoxae open to mesepimeron; scutellum never cordate.

(4) We also do not support Dolin and Nel's assignment of *Cryptocaelus* to the fossil tribe Cryptocardiini<sup>[10,11]</sup>. Although this genus has high resemblance to *Cryptocardius* (another genus of Cryptocardiini known from Karatau<sup>[10,11]</sup>), as the scutellum of *Cryptocaelus* never cordate, this feature contradicts the tribe diagnostic feature of Cryptocardiini Dolin, 1980; thus, it seems inconsequent to attribute this genus to Cryptocardiini as suggested by Dolin and Nel<sup>[1]</sup>.

(5) We still cannot assign this genus to any other known subfamily or tribe due to the absence of the characteristics currently used to diagnose the family<sup>[1]</sup>, for example, the position of the mouthparts and whether with basal setae on claws or not. It is still inadvisable to set a new subfamily or tribe just by one single genus, so we temporarily make its subfamily and tribe status uncertain, and look forward to more exquisite-preserved fossil elaterids of this genus to be collected and studied in the future.

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