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A new caraboid larva from the Middle Jurassic of China (Insecta: Coleoptera)

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ABSTRACT

A new species of caraboid larva (Coleoptera, Adephaga), *Carabilarva gongi* sp. nov., is described based on a well-preserved specimen from the Middle Jurassic Daohugou deposits (in the upper part of Jiulongshan Formation) of Inner Mongolia, China. It is the fourth caraboid larva from the Mesozoic, and differs from the other three Mesozoic species mainly in having a longer body with shorter mandibles. Scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS) show that this Daohugou fossil is preserved as carbonaceous compressions that lost the micro-structure, such as macrochaetae.

1. Introduction

The Coleoptera (beetles), with more than 380,000 species, is the most diverse and species-rich insect order on earth, and the Adephaga, with more than 34,000 recorded species in about 10 families, is the second-largest suborder of the Coleoptera (Zhang SQ et al., 2018). Adephagans are mainly characterised by primarily predacious habits of the larvae and adults (Beutel et al., 2013). The phylogeny of adephagans is much disputed, and are usually divided into two main groups, Geadephaga (Caraboidea) and Hydradephaga. Caraboidea consists of two families, Trachypachidae (false ground beetles) and Carabidae (ground beetles and tiger beetles). The fossils of both families are abundant in Jurassic and Cretaceous deposits (Beutel et al., 2013). Mesozoic fossils of caraboid larvae are extremely rare, with only three records, *Carabilarva jurassica* Ponomarenko, 1985 from the Middle Jurassic Ichetuy Formation of Novospasskoye Village, Transbaikalia (Ponomarenko, 1985); *Carabilarva robusta* Makarov, 1995 from the Upper Jurassic Karabastau Formation of Karatau-Mikhailovka locality, Kazakhstan (Makarov, 1995); and *Carabilarva triassica* Makarov and Prokin, 2013 from the Upper Triassic Hassberge Formation of Lower Franconia, Germany (Prokin et al., 2013). Here, a new larva is described based on a well-preserved fossil from the Middle Jurassic Daohugou deposits of Inner Mongolia, China.

2. Material and methods

The specimen was collected from the Middle Jurassic Daohugou beds of Wuha Township, Ningcheng County, Chifeng City, Inner Mongolia (Fig.1). The Daohugou deposits are in the upper part of Jiulongshan Formation, consisting of grey tuff, tuffaceous siltstone and mudstone, are now considered to be one of the most important insect lagerstatten (Wang et al., 2013). The coleopteran assemblage is the most diverse in this fauna, and about 20 families have been described and more fossils (especially Polyphaga) await description (Wang et al., 2009a, 2012a; Jarzembowski et al., 2012). Most fossil insects from Daohugou are preserved as organic remains on the surface of grey tuffaceous siltstones (Wang et al., 2009b, 2013). The age of the fossil-bearing strata is still debatable. The radiometric dating of the overlying ignimbrite studied by different researchers yielded a similar radiometric age: 164–152 Ma

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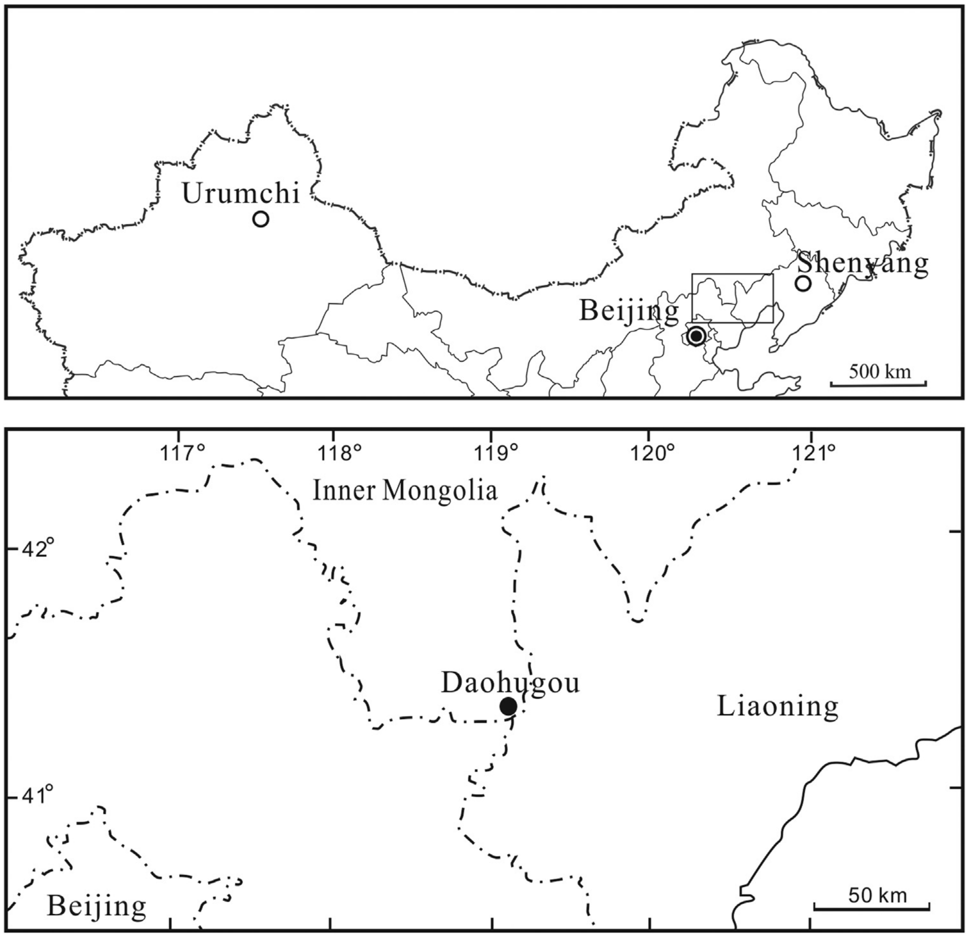

Fig. 1. Map showing the location of the fossil locality (Daohugou Village).

(He et al., 2004; Liu et al., 2006), a Middle Jurassic or early Late Jurassic age. Further studies of the taxonomic composition of insect assemblages (e.g. beetles or bugs) are needed to gain more evidence to pinpoint the stratigraphical age of the Daohugou deposits. The palaeoclimate in Daohugou during mid-Jurassic times is thought to have been warm temperate (Rees et al., 2000; Wang et al., 2013).

The specimen was examined dry and under alcohol, photographs being taken using a ZEISS Stereo Discovery V16 microscope system. The micro-surface information (Fig.3) was obtained under the low vacuum mode (100 Pa in sample chamber) of the LEO1530VP SEM with the accelerating voltage 15–20 kV (Orr et al., 2009; Wang et al., 2012b). The elemental analyses of points and areas were examined by the INCA350 EDS (produced by the Oxford Instruments company) with the accelerating voltage 10–20 kV (Fig.3). The SEM and EDS analyses were performed in the State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (NIGPAS). Line drawings were adjusted with image editing software (CorelDraw X7). The specimen is deposited in the Nanjing Institute of Geology and Palaeontology (NIGP), Chinese Academy of Sciences.

3. Systematic palaeontology

Order Coleoptera Linnaeus, 1758
Suborder Adephaga Schellenberg, 1806
Superfamily Caraboidea Latreille, 1804
Genus *Carabilarva* Ponomarenko, 1985

Diagnosis. Head prognathous, labrum fused with clypeus, mandibles without mola. Abdomen with 9 sterna including pygopod, walking legs, and short urogomphi.

Remarks. *Carabilarva* is a collective group name. It is a collection of fossil beetle larvae that can be reasonably attributed to the superfamily Caraboidea but not to any of its particular subtaxa.

Species *Carabilarva gongi* sp. nov.

Holotype. NIGP169161, a beetle larva with head margin and right antennae damaged, legs incomplete.

Etymology. The specific epithet honours the fossil collector, Baode Gong.

Diagnosis. Body long, about 20 mm. Head somewhat wider than long. Mandible small, mandible/head length ratio about 0.38, and without incisor. Ecdysial line distinct, frontal suture slightly curved and narrow, coronal suture distinct and wide. Antenna shorter than head width; head longer than prothorax. The ratio of pronotum to mesonotum and metanotum is 1.63 and 1.68.

Description. Body length 19.70 mm, subparallel-sided, middle part of abdomen slightly widened; tergites sclerotized dorsally, with slightly conical pygopod; ecdysial line long and distinct; transverse swell extending over the full width of the terga (Figs. 2 A; 3 A).

Head. (Figs. 2B, C; 3B, C) Head length 2.50 mm; head width 2.55 mm, the

ratio of head length to width about 0.98, the back edge slightly concave. Ecdysial line distinct, frontal suture slightly curved and narrow, coronal suture distinct and wide. Antennae 4-segmented, filiform, located on the side of head, the junction protruding; scape length 0.49 mm, flagellomere I length 0.44 mm, flagellomere II

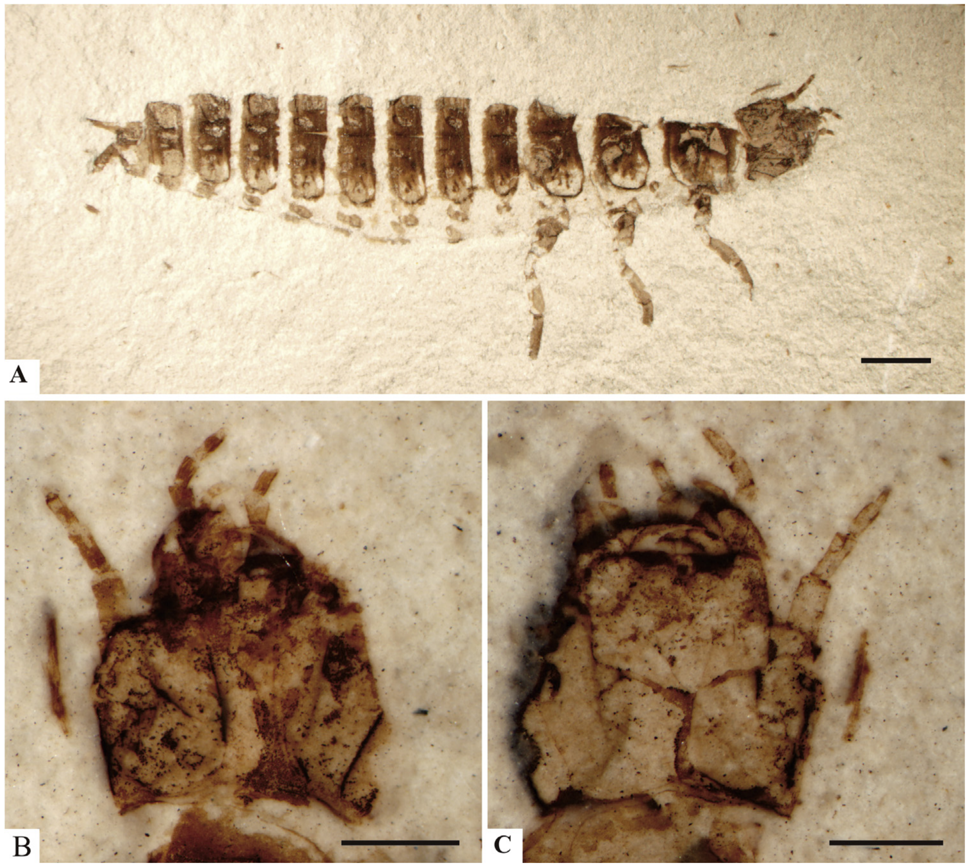

Fig. 2. *Carabilarva gongi* sp. nov. A, body; B, head (ventral aspect); C, head (dorsal visual); Scale bar represents 2 mm in A, 1 mm in B and C.

length 0.36 mm, flagellomere III length 0.17 mm. Mandible stout, mandible length 0.95 mm;

maxillary palp 3-segmented, the relative lengths being 3 > 1 > 2 (MP2 = 0.26 mm, MP3 = 0.37 mm); labial palp 2-segmented (LP1 = 0.27 mm, LP2 = 0.34 mm), the end of first segment bulging, the second segment rod-shaped.

Thorax. Pronotum, mesonotum, metanotum well sclerotized dorsally. Pronotum length 2.13 mm, width 3.54 mm, with maximum width near anterior margin; mesonotum length 1.31 mm, width 3.81 mm; metanotum length 1.27 mm, width 3.79 mm. Ecdysial line distinct on terga.

Legs. Legs 6-segmented including 2 equal claws, relative size of segment of fore-, mid-, and hind-leg similar; coxae large, the base distinctly wide; trochanter slightly curved; femur and trochanter rod-shaped; the relative lengths being: femur > coxa > trochanter.

Abdomen. Terga narrow, I-VIII tergite width approximately equal, pygidium narrow; the eighth tergite narrowest and fourth widest, median ecdysial line of terga distinct; abdominal tergite I length 1.02 mm, width 3.44 mm; II length 1.03 mm, width 3.84 mm, III length 1.04 mm, width 3.86 mm; IV length 1.07 mm, width 3.93 mm; V length 1.07 mm, width 3.85 mm; VI length 1.11 mm, width 3.62 mm; VII length 1.15 mm, width 3.26 mm; VIII length 1.02 mm, width 2.90 mm; IX length 0.96 mm, width 0.99 mm. Pygopod undeveloped, urogomphi 1.00 mm long. Spiraculae distinct under the terga and differ in size.

4. Discussion

This larva can be attributed to the Caraboidea by the following characters: head prognathous, labrum fused with clypeus, mandibles without mola, walking legs, and short urogomphi (Alarie et al., 2004; Beutel et al., 2013). The larval differences between Carabidae and Trachypachidae are based on inner structures and chaetotaxy which are not preserved in our fossils (Arndt and Beutel, 1995; Alarie et al., 2011). Therefore, the new fossil cannot be attributed to any family, like the other three Mesozoic caraboid larvae. *Carabilarva gongi* can be obviously distinguished from these three taxa in having a longer body (about 20 mm in *C. gongi*, but 9.1 mm in *C. jurassica*, 10.5 mm in *C. robusta*, and 9.2 mm in *C. triassica*; Fig. 2A) and shorter mandibles (mandible/head length ratio 0.38 in *C. gongi*, but 0.58 in *C. jurassica*, 0.74 in *C. robusta*, and 0.87 in *C. triassica*; Fig. 2B, C).

Fossil insects from Daohugou are famous for their excellent macroscopic preservation, and most Daohugou fossils are compression fossils comprising biopolymers (Wang et al., 2009b). However, further investigation shows that Daohugou fossils usually do not preserve microscopic details, such as structures of wing scales (Zhang QQ et al., 2018). Our EDS analyses reveal that a much higher concentration of elemental carbon is present in the specimen NIGP169161, suggesting the cuticle is preserved as a carbonaceous compressions (Fig. 4D). Furthermore, our SEM analyses show that this Daohugou fossil is preserved as discrete compressions and distinctly lost the micro-structure, such as macrochaetae (Fig. 4). Our result is consistent with the previous result that Daohugou fossils do not preserve microscopic details evidently due to diagenetic alteration (Zhang QQ et al., 2018).

5. Conclusions

A new species of caraboid larva, *Carabilarva gongi* sp. nov., is described from the Middle Jurassic Daohugou deposits. The fossil is the fourth caraboid larva from the Mesozoic and described as a formal species. *C. gongi* can be obviously distinguished from the other three Mesozoic caraboid larva by a longer body and shorter

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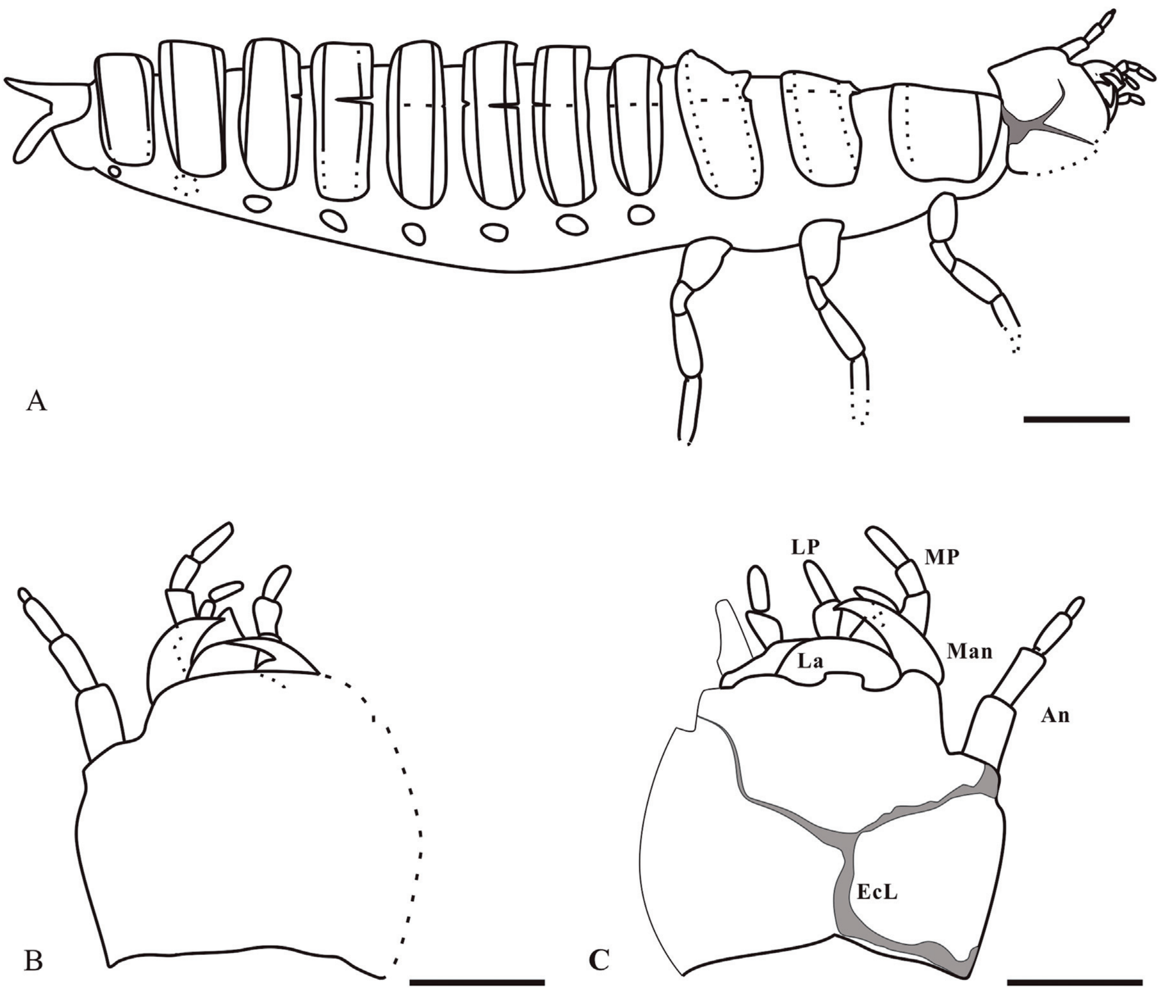

Fig. 3. *Carabilarva gongi* sp. nov., line drawings; A, body; B, head (ventral visual); C, head (dorsal visual); Scale bars represent 2 mm in A, and 1 mm in B and C. An, Antenna; EcL, ecdysial line; La, labium; LP, labial palp; Man, mandible; MP, maxillary palp.

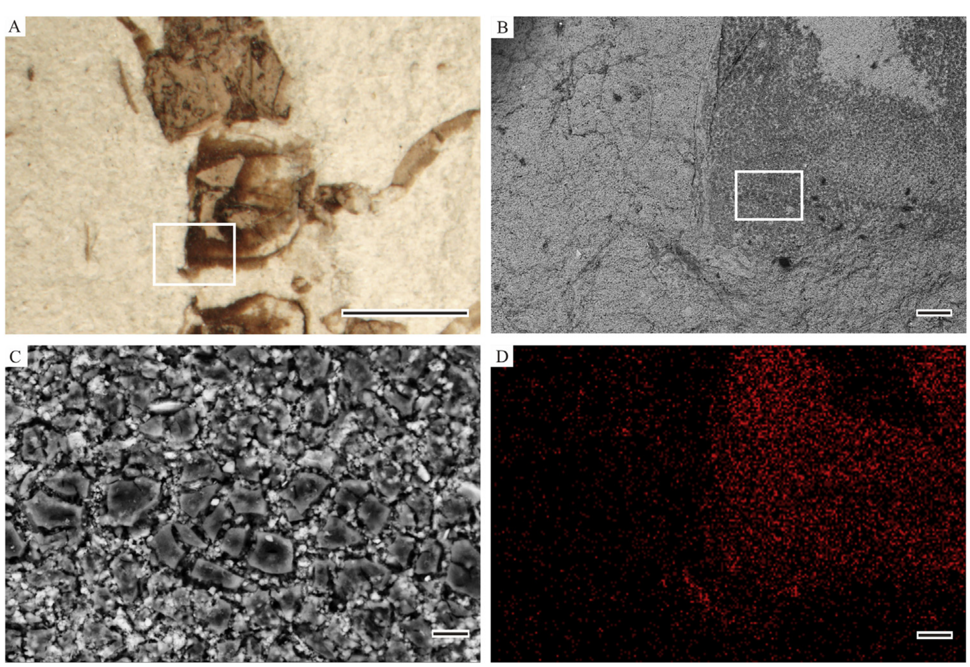

Fig. 4. *Carabilarva gongi* sp. nov. A, light photomicrograph; B, C, SEM magnifications of area shown by white squares in A, B respectively; D, EDS image, carbon elemental map of B. Scale bars represent 2 mm in A, 100 μm in B and D, and 10 μm in C.

mandibles. Our analyses support the previous result that Daohugou fossils do not preserve microscopic details. Our find augments the diversity of known Mesozoic caraboid larvae, and enhances our understanding of their morphology.

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