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Short communication

The first whirligig beetle larva from mid-Cretaceous Burmese amber (Coleoptera: Adephaga: Gyrinidae)

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ABSTRACT

The fossil record of Gyrinidae is not poor, with 19 species having been reported previously: here, however, we recognize the first whirligig beetle larva in mid-Cretaceous amber from Myanmar. *Cretogyrus beuteli* gen. et sp. nov. is described based on a well-preserved individual, differing from other gyrinid larvae by a combination of the following characters: mandibles large; neck region wide; two pairs of nasalean teeth present; cardo moderately elongated; series of small hooks on the lacinia absent; labial palpus 2-segmented; maxillary and labial palpomeres elongated and slender.

1. Introduction

Whirligig beetles (Gyrinidae) are a family of carnivorous aquatic beetles with an estimated 1000 living species distributed worldwide (Beutel, 1990; Beutel and Roughley, 1993; Beutel et al., 2008). Morphological data have supported a sister-group relationship of Gyrinidae with all other families in the suborder Adephaga, both aquatic and terrestrial (Beutel et al., 2013). Molecular data, however, have largely support a monophyletic origin of all aquatic Adephaga, with whirligigs sister to other aquatic families, in line with the stepping-stone hypothesis (Ribera et al., 2002; Hunt et al., 2007; McKenna et al., 2015). Relatively well known as model organisms for life on the water's surface (Blagodatski et al., 2014), whirligigs are highly adapted to the surface of still or running water (Beutel et al., 2018): the propulsive efficiency of the swimming legs is believed to be the highest measured for a thrust-generating apparatus within the animal kingdom (Voise and Casas, 2010). Larval whirligig beetles are predators under the water surface, where they seek out soft-bodied larvae of chironomids, tubificids, odonatan larvae, etc (Frederick, 1991). However, when compared to the immature stages of other water beetle families (Dytiscidae, Hydrophilidae, Aspidytidae, Noteridae, Meruidae, Coptoclavidae and Haliploidae), those of the family Gyrinidae are poorly known, and many genera have undescribed larvae (Archangelsky and Michat, 2007).

The fossil record of Gyrinidae is not sparse, 19 species in 11 genera being reported from the Jurassic to Recent, and almost all fossils are based on adults (Ponomarenko, 1973; Nel, 1989; Ponomarenko et al., 2005). Here, we describe the first fossil gyrinid larva from mid-Cretaceous Burmese amber, representing a new genus and species.

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2. Material and methods

The larva is completely preserved in an oblong-ovoid piece of light yellow amber from a mid-Cretaceous amber mine located near Noije Bum Village, Tanaing Town, Myanmar (Kania et al., 2015: fig. 1). The age given by U-Pb dating of zircons from the volcanoclastic matrix of the amber is early Cenomanian (98.8 ± 0.6 Ma) (Shi et al., 2012; Ross, 2015). The following abbreviations are used for morphological structures: A, antenna; MP, maxillary palp; LP, labial palp.

Photographs were taken using a Zeiss Stereo Discovery V16 microscope system. The figures were prepared with CorelDraw X7 and Adobe Photoshop CS6. The specimen is deposited in the Nanjing Institute of Geology and Palaeontology (NIGP), Chinese Academy of Sciences.

3. Systematic paleontology

Family Gyrinidae Latreille, 1810

Genus ***Cretogyrus*** gen. nov.
Type species: *Cretogyrinus beuteli* sp. nov.; by monotypy.

Etymology. The generic name combines the prefix 'creto-' (from latin for chalk), in reference to the Cretaceous geological period of the new genus, and '-*gyrus*' (from latin for circle), a traditional suffix of generic names in Gyrinidae based on the type genus.
Diagnosis. Body length about 11 mm. Mandible large, ratio of mandible:head length about 0.53:1; neck region wide, 0.48 mm across; two pairs of symmetrical nasalean teeth present; cardo moderately elongated, about 0.2 mm long; series of small hooks on lacinia absent; labial palpus 2-segmented and maxillary and labial palpomeres long and slender.

Cretogyrus beuteli sp. nov.
Figs. 1-2

Diagnosis. As for genus.
Etymology. The specific epithet '*beuteli*' is in honour of Prof. Rolf Beutel for his great contribution to studying beetles.
Holotype. NIGP169637; fore-, mid- and hindlegs partly covered by debris and bubbles; deposited in the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences.
Description. Body length 11.06 mm, sides subparallel, middle part of body slightly wider (Fig. 1A); head and tergite of pronotum sclerotized, rest of body soft; abdomen with 10 segments, with lateral gills on abdominal segments I–VIII; abdominal segment IX with four gills and segment X without gills but with four anal feet. More detailed measurements see Table 1.

Table 1
Measurements of larval morphology. The unit of length is the millimetre.

Structure	Measurement
Total length	11.03
Head length	1.04
Head width	0.85
HL/HW	1.22
Eye length	0.35
Eye width	0.18
Abdomen I length	0.78
Abdomen II length	0.78
Abdomen III length	0.77
Abdomen IV length	0.88
Abdomen V length	0.76
Abdomen VI length	0.75
Abdomen VII length	0.58
Abdomen VIII length	0.92
Abdomen VIII width	1.09
Mandible length	0.55
MadL/HL	0.53
Lacineal length	0.12
Maxillary palp I	0.16
Maxillary palp II	0.13
Maxillary palp III	0.18
Maxillary palp IV	0.17
Labial width	0.21
Labial palp I	0.19
Labial palp II	0.29
Labial palp III	0.22
Prothoracic length	1.38
Mesothoracic length	0.81
Metathoracic length	0.94
Gill length I	1.43
Gill length II	2.33
Forecoxal length	0.65
Foretrochanteral length	0.20
Forefemoral length	0.47
Foretibial length	0.29
Foretarsal length	0.17
Midcoxal length	0.78
Midtrochanteral length	0.15
Midfemoral length	0.53
Midtibial length	0.33
Hindcoxal length	0.76
Hindtrochanteral length	0.27

Abbreviations: HL, head length; HW, head width; MadL, mandible length.

Head (Fig. 2). Head length (without mandible) 1.04 mm, width 0.85 mm, the ratio of head length to width about 1.22:1, posterior margin straight. Compound eyes large, 0.35 mm long and 0.18 mm wide. Coronal suture and frontal suture indistinct. Head capsule rough, two setae on lateral edge distinct (Fig. 2D), anterior seta about 0.13 mm and posterior about 0.24 mm long. Nasale with four teeth, lateral short. Antenna filiform, 4-segmented, relative lengths AII>AIII>AIV>AI. Mandibles large, about 0.55 mm long; curved and pointed, slightly narrowed, without any teeth. Maxilla about 0.29 mm long, lacinea sharp, about 0.12 mm long; cardo large, with length greater than width, stipes shorter; maxillary palpus 4-segmented, MPIII>MPIV>MPI>MPII. Labium wide, 0.21 mm long, trapezoidal; labial palpus 2-segmented, prementum divided completely, thick and slightly curved, LPII>LPI. Distinct Y-shaped suture present on ventral side of head, forks notably short.
Thorax. Prothorax large (Fig. 1B), with length greater than width, 1-segmented, anterior with strongly sclerotized tergite subdivided by a groove, posterior narrow and membranous. Meso- and metathorax unsclerotized and wide. Legs with coxae widest and femora longest; swimming hairs absent.
Abdomen. Segments I–VII similar in shape and size, wide, with a pair of slender lateral plumose gills; segment VIII trapezoidal and longest, with two gills at lateral edge; segment IX narrow, with two pairs of gills; segment X narrowest and shortest, with four straight and short anal feet (Fig. 1C). Plumose gills longer than abdomen, with the first pair shortest and the third pair longest.

4. Discussion

The new species can be attributed to Gyrinidae based on the following characters: prementum completely divided, ten abdominal segments present, lateral gills present on abdominal segments

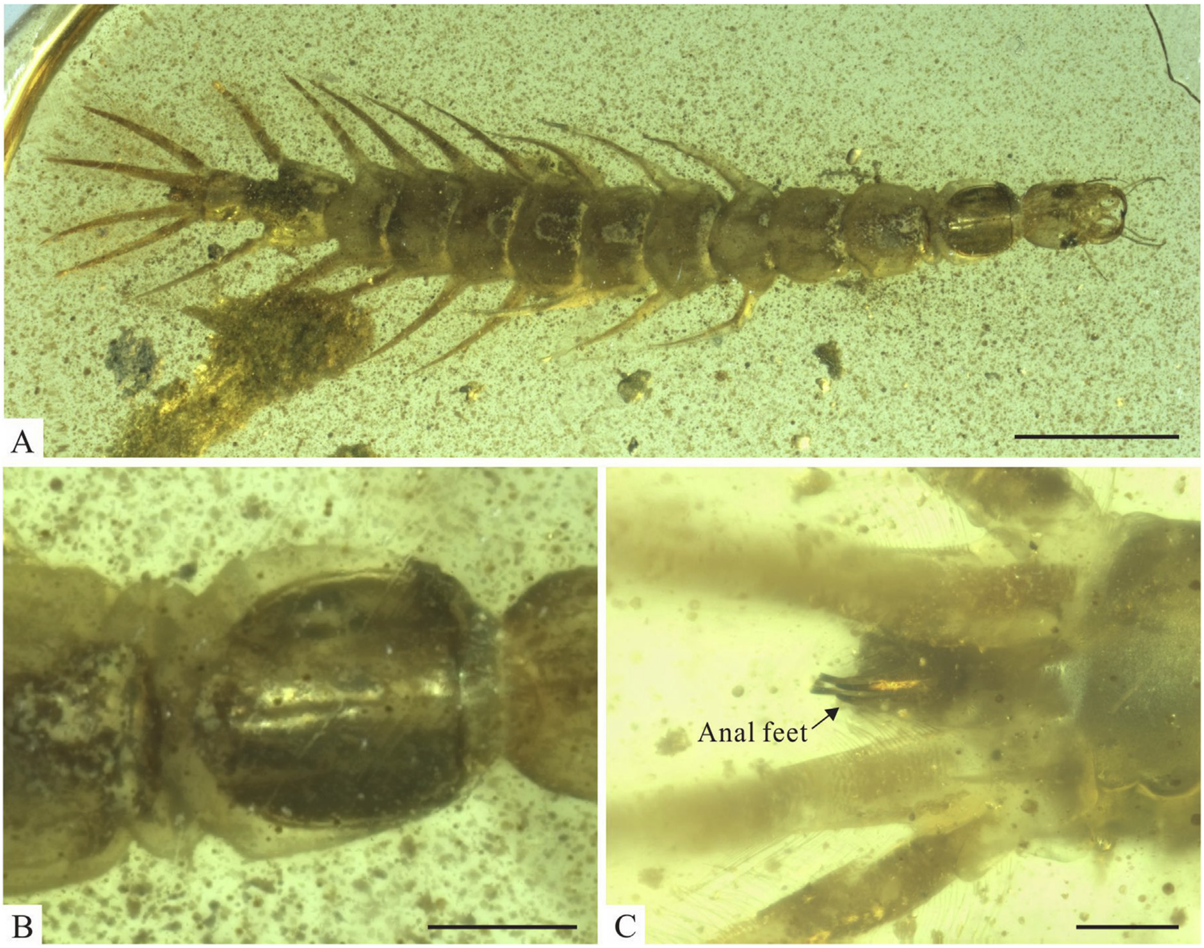

Fig. 1. *Cretogyrus beuteli* gen et sp. nov., holotype, NIGP169637. A, habitus in dorsal view; B, prothorax; C, abdominal segment X. Scale bars represent 2 mm in A, 0.5 mm in B, and 0.2 mm in C.

I–IX, and four terminal abdominal hooks on segment X (Frederick, 1991; Beutel et al., 2018). It distinctly differs from other known genera: from *Enhydrus* Castelnau, *Dineutus* Macleay and *Andogyrus* Ochs in having the wide neck region; from *Orectochilus* Dejean, *Orectogyrus* Régimbart and *Gyretes* Brullé in having two pairs of symmetrical nasalean teeth; from *Dineutus* Macleay, *Andogyrus* Ochs and *Macrogyrus* Straneo in having a moderately elongated cardo; from *Gyrinus* Geoffroy and *Aulonogyrus* Motschulsky in lacking a series of small hooks on the lacinia, with a 2-segmented labial palpus, and elongated and slender maxillary and labial palpomeres.

Aquatic beetles have a rich fossil record due to their strongly sclerotized bodies and predilection for habitats such as lakes and marshes that enhances preservation (Smith, 2000), but they are very rare in Burmese amber although there are at least 64 species of beetles preserved in Burmese amber (11 Archostemata; 40 Staphylinidae; 5 Curculionidae; 2 Psephenidae; one each of Hydrophilidae, Hydraenidae, Scirtidae, Elmidae, Ptilodactylidae and Curculionidae) (Ross, 2018). For Gyrinidae, our specimen represents the first record from Burmese amber. The occurrence of aquatic beetles is unusual due to their watery habitat. As Bao et al. (2017) suggested, an exposed lifestyle, abundant resin, and rapid embedding acting together have led to the near-perfect preservation of fossil inclusions in this amber. The discovery of a gyrinid larva points to the presence of fresh water and emergent vegetation or land nearby (for pupation). Therefore, aquatic beetle fossils in Burmese amber can provide insights into the environment as well as morphological date and critical information for time-calibration of phylogenies. The search for and discovery of fossil inclusions supports the use of aquatic beetles as models in evolutionary biology.

5. Concluding remarks

A new genus and species of Gyrinidae, *Cretogyrus beuteli* gen. et sp. nov., is described from mid-Cretaceous Burmese amber. The new find represents the first whirligig beetle to be preserved in Burmite amber and supports the uniqueness of the West Burma Block entomofauna. The disparate morphological information and detailed measurement provided by the well-preserved and rare specimen enhance our understanding of the morphology and diversity of the Gyrinidae in the late age of the dinosaurs.

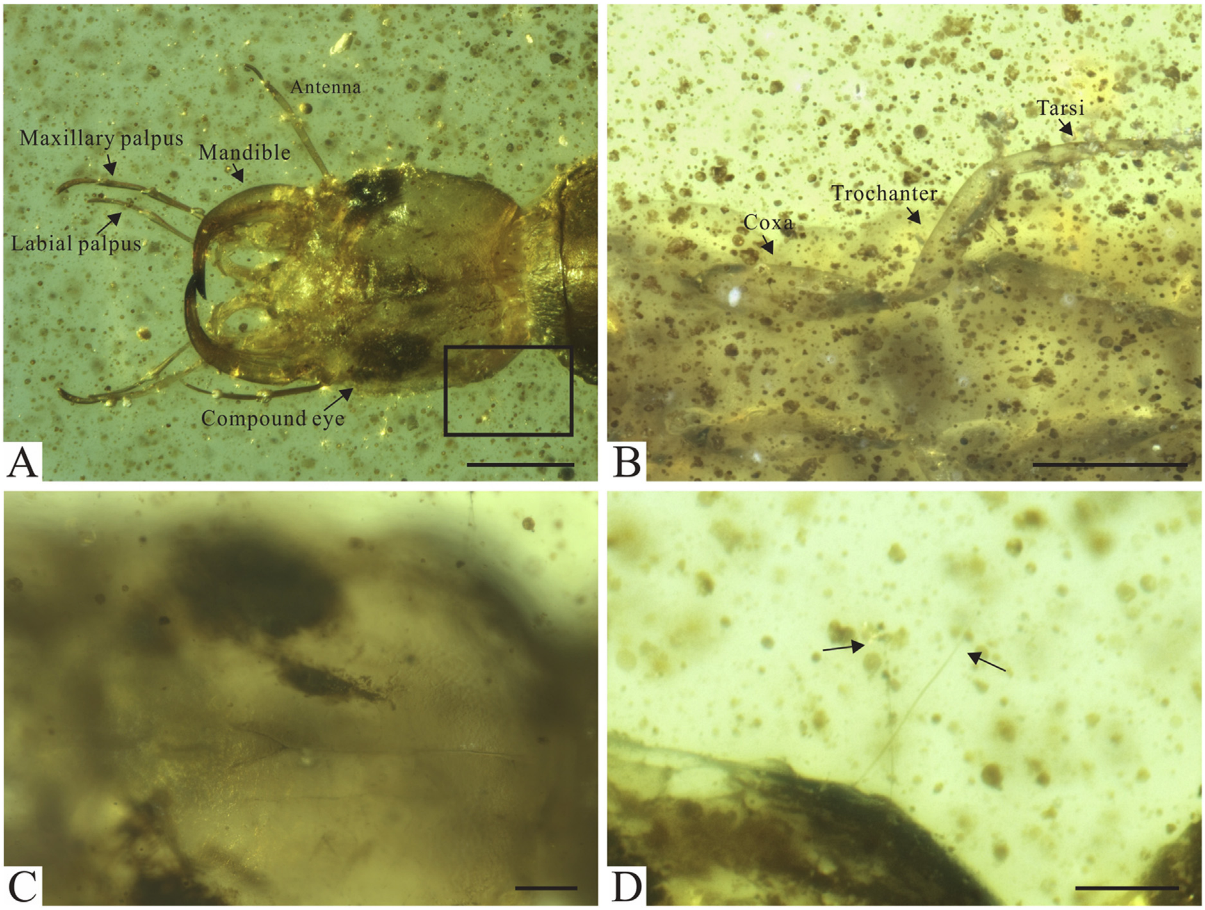

Fig. 2. *Cretogyrus beuteli* gen. et sp. nov., holotype, NIGP169637. A, head in dorsal view; B, left foreleg. C, Y-shaped suture on the venter of the head; D, two setae on lateral side of head, magnification of black square of A. Scale bars represent 0.4 mm in A, 0.5 mm in B, 0.1 mm in C, and 0.2 mm in D.

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