



Short communication

The first notocupedin beetle in mid-Cretaceous amber of northern Myanmar (Insecta: Coleoptera: Archostemata)

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ABSTRACT

A rare ommatine beetle, *Notocupes ohmkuhnlei* sp. nov. (Insecta: Coleoptera: Archostemata), is described in Kachin amber from northern Myanmar. It is the first notocupedin in amber to be described from the fossil record belonging to an extinct, Mesozoic-Palaeocene group of archaic reticulated beetles which are better known as impressions in the sedimentary rocks of Eurasia and East Gondwana. The new species belongs to *Notocupes* sensu lato with its pronounced serration, short mesofemur, long pedicel and forward curved pronotum. Phylogenetic implications are discussed.

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1. Introduction

About two hundred species of fossil Cupedina (archostematan and myxophagan beetles) have been described from the Permian onwards, and archostematans (archaic beetles) are notable constituents of Mesozoic insect faunas, even occurring in regions from where they have now vanished (Kirejtshuk and Ponomarenko, 2015). Previously known from adpressions in Cretaceous non-marine sediments, some exceptionally well preserved as in north-eastern China (Zhang et al., 2015), these archaic beetles have been discovered in recent years as amber inclusions in northern Myanmar (Xia et al., 2015). Archostematans are, nevertheless, scarce in Burmese amber, which is surprising considering the modern association of these beetles with wood, and they are usually represented by smaller forms as might be expected. Here we describe a comparatively large form belonging to the extinct tribe

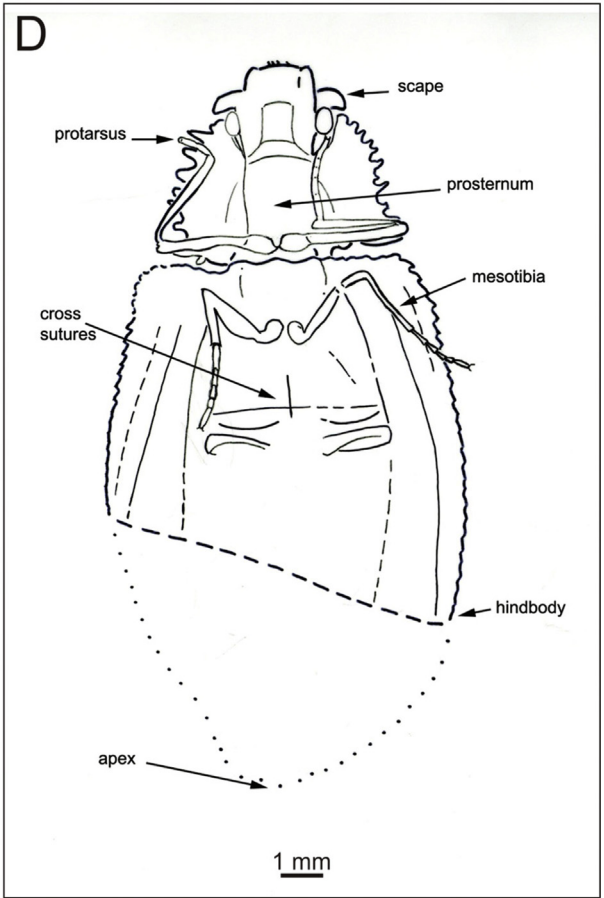
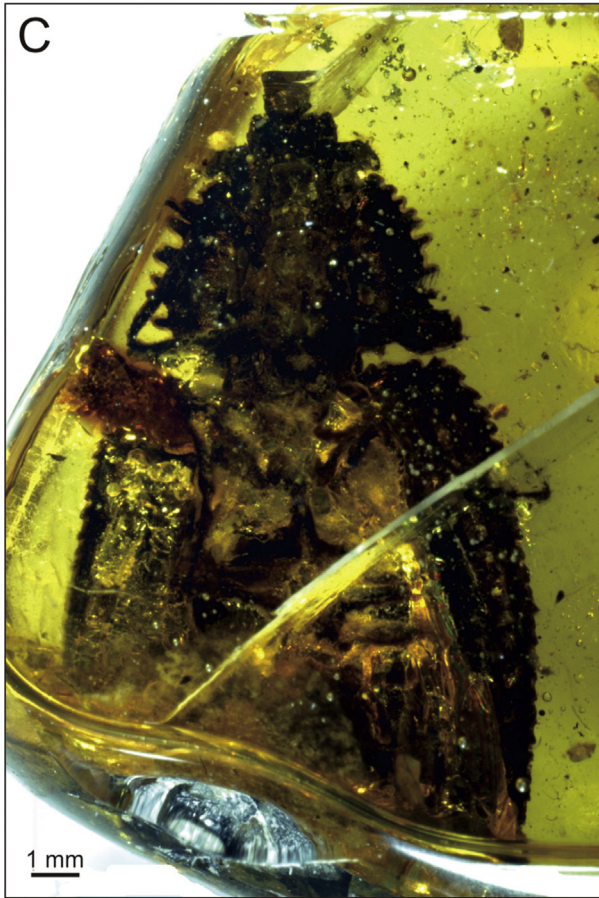
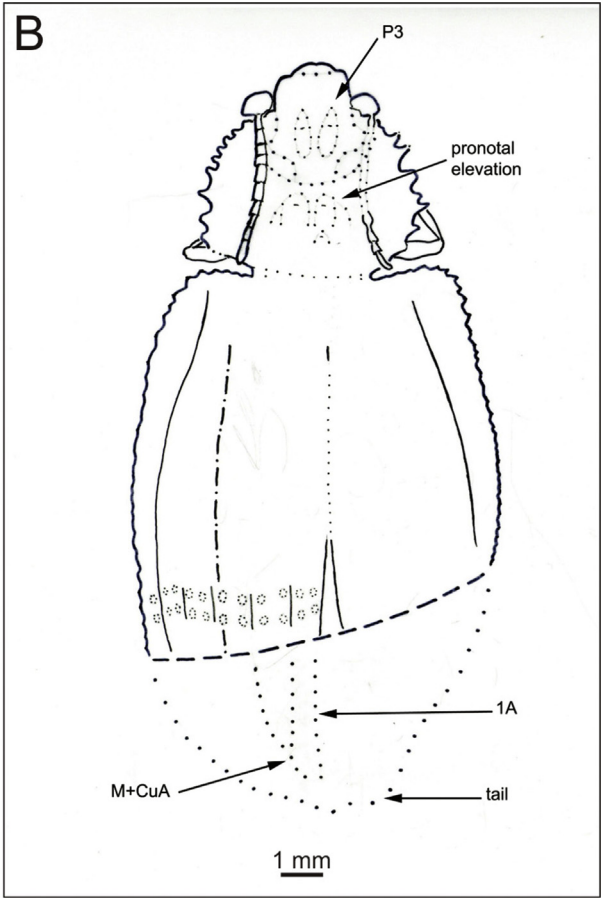
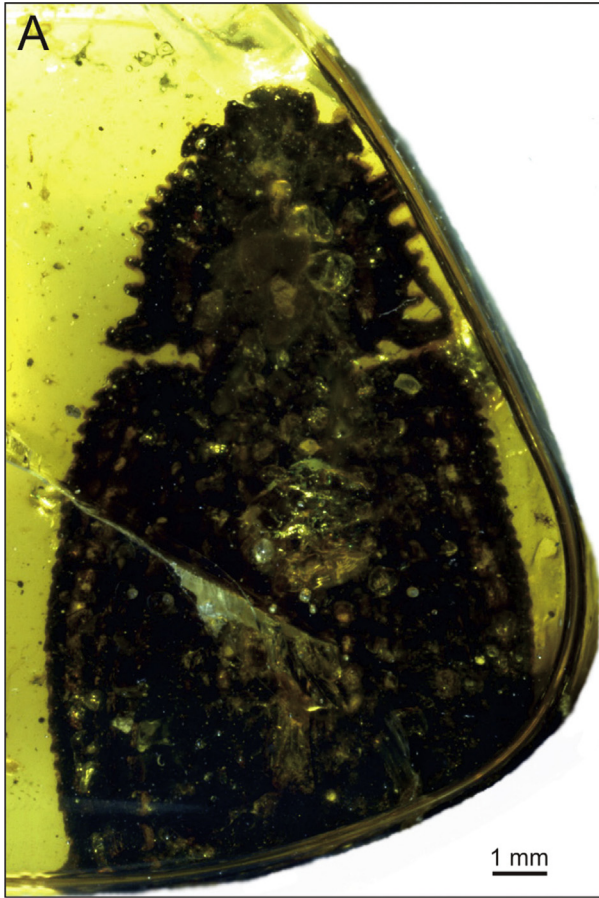
Notocupedini Ponomarenko, 1966, commonly placed in the extant subfamily Ommatinae Sharp and Muir, 1912, a group of 'living fossils' peculiar to the modern fauna of Australia and South America. Opinion is still divided as to whether ommatines are a subfamily of reticulated beetles/cupedids sensu lato (Kirejtshuk et al., 2016), or a separate family (Lawrence and Ślipiński, 2013). For consistency with Jarzembowski et al. (2015), we consider cupedids and ommatines in the broad sense, the latter including fossil notocupedins, the typical reticulated beetles of the Mesozoic with over 60 named species in at least four genera (Kirejtshuk and Ponomarenko, 2015). If the Triassic *Rhabdocupes* Ponomarenko, 1966 is excluded, that still leaves over 50 Mesozoic species of the common genus *Notocupes* Ponomarenko, 1964 sensu lato (comprising *Notocupes* sensu stricto plus *Amblomma* Tan, Ren & Liu, 2005 and the collective *Zygodenia* Handlirsch, 1906). The new, distinctive form in Kachin amber is referred to *Notocupes* sensu lato (see below).

2. Geological setting

Kachin amber from northern Myanmar contains the most diverse biota in amber known from the Cretaceous: all the major

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divisions of extant insects (orders) are represented, beetles (Order Coleoptera Linnaeus, 1758) being one of the most diverse, but many species are still undescribed. Previously considered as reworked from the late Albian (Yu et al., 2019), the amber is now considered to be early Cenomanian (Smith and Ross, 2018) with U–Pb dating of zircons from the tuffaceous matrix giving an age of 98.8 ± 0.6 Ma (Shi et al., 2012).

Amber has been found in several localities in Myanmar, but the principal supply has been from Myitkyina District, Kachin State, in the Hukawng Valley; a major mining area is near Noije Bum Village in Tanaing or Tanai (Danai) Township (Kania et al., 2015: fig. 1(map); Jarzembowski et al., 2017a: fig. S1 (view)). The Kachin amber is prepared for the international jewellery trade and exported particularly to neighbouring China. In addition to over-preparation for display purposes, there is a degree of as yet unanalysed natural deformation and obscuration of the otherwise excellent amber inclusions, the latter affecting the material described below.

3. Material and method

The holotype is in a clear amber cabochon, brownish-yellow in colour, with a cockroach (Insecta: Blattodea) and other smaller inclusions. It is, however, partly obscured by impurities (on both surfaces), with a vertical fracture, and posterior third of the hind-body missing; the right protarsus is partly polished away. Observations were therefore augmented with photographs of three other specimens (see below). The holotype was examined under an Olympus SZX7 binocular microscope and Zeiss Stereo Discovery V16 microscope system with fibreoptics and top and bottom illumination. Photographs were taken with a Zeiss Axiocam 512 digital camera mounted on the microscope and operated with Zen 2.3 pro software. Only standard degreasing and local immersion in agave syrup (under a cover slip) to minimize surface interference were undertaken during examination.

Drawings were prepared from both photographs and specimen by hand (EAJ). Drawing conventions are: solid line, distinct margin; dashed, indistinct or damaged; dotted, extrapolated; dashed and dotted, folded. For morphology, we follow terminology used by Jarzembowski et al. (2019: figs S4, S6). The abbreviations used are NIGP, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (CAS).

All taxonomic acts established in the present work have been registered in ZooBank (see new taxonomic LSIDs below) together with the electronic publication LSID: zoobank.org:pub:DF47B6DA-50AE-41DA-810B-8DEF39ABD95B.

4. Systematic palaeontology

Class INSECTA Linnaeus, 1758

Order COLEOPTERA Linnaeus, 1758

Suborder ARCHOSTEMATA Kolbe, 1908

Family CUPEDIDAE Laporte, 1836 s. l.

Subfamily OMMATINAE Sharp & Muir, 1912

Tribe: NOTOCUPEDINI Ponomarenko, 1966

Genus *Notocupes* Ponomarenko, 1964

Type species. *Notocupes picturatus* Ponomarenko, 1964 (original designation); Upper Jurassic, Karatau, Kazakhstan.

Diagnosis. Head with longitudinal carinae and acute tubercles above eyes. Pronotum with flattened elevation (prominence)

divided by longitudinal and transverse furrows in middle of disc. Procoxae contiguous; metaventrite short. Abdominal ventrites tegular (overlapping), last ventrite more than twice as long as penultimate one. Elytron relatively broad, convex; four main veins present, usually well differentiated from intercalary veins, second (CuA) and third (M) veins joining before elytral apex, fused section joining first vein (1A). Two rows of cells present between veins with 20–30 cells in each row. Epipleural rim moderately wide, with or without row of cells. Elytral apex sometimes with tail. (After Ponomarenko, 2006.).

Remarks. The dorsal carinae and tubercles on the head (vertex) are variously called butterfly-like tubercles and posteromesal protuberances, etc; we simply refer to them as P3 below for consistency with other amber inclusions (Jarzembowski et al., 2017c). Some generic features are unfortunately not clearly visible or missing (ventrites) in the specimen described below. A pair of P3s plus anterior part of the pronotal elevation are, however, clearly visible in a photograph in Burmite-Miner (2019: fig. 7512); the elytral apices, veins and eleven rows of cells plus the head/thorax junction are also clearly visible in Jarzembowski et al. (2017b; fig. 1), the former also in Patrick Müller (illustrated pers. comm. 22/4/2017); these details are indicated in Fig. 1 herein (dotted lines).

Ponomarenko (2006) referred to *Notocupes* as *Zygadenia*, a name previously used interchangeably but now restricted to disarticulated elytra (Jarzembowski et al., 2015). Ponomarenko (in Jarzembowski et al., 2015) also considered that the procoxae may not be contiguous in some rock specimens and temporarily placed *Notocupes* in subfamily incerta (Kirejtshuk and Ponomarenko, 2015). The separation of the procoxae (by the prosternal process) is incomplete in the new amber specimen (see below) therefore the genus is restored to its tribe.

Notocupes ohmkuhnlei sp. nov.

urn:lsid:zoobank.org:act:ABD7B728-6A5F-4873-ACA1-DD338DA93B41 Fig. 1.

Fig. 1.

Derivation of name. After Dr Dr Christoph Öhm-Kühnle (Tübingen University), type donor.

Holotype. Adult specimen, registration number NIGP 171103, deposited in Nanjing Institute of Geology and Palaeontology; sex unknown.

Locality and horizon. Probably mine near Noije Bum Village, Tanaing Township, Myitkyina District, Kachin State, Myanmar, 26° 15' N., 96° 33' E.; unnamed horizon, Upper Cretaceous, lower Cenomanian.

Diagnosis. Large, circa two centimetres long, species of *Notocupes* s. l. with: pronounced serration along pronotum and elytron, especially anteriorly; pair of P3s on head; antennomeres (antennal segments) two and three of similar length; pronotal elevation with more than two lobes; anterior pronotal angles strongly curved forward; elytron with 20–25 window cells per longitudinal row, epipleural rim with row of cells and pair of rounded tails.

Description. Body: black and flattened dorsoventrally, length as preserved, holotype: 16.5 mm (estimated complete length, 21 mm), maximum width (across folded elytra), 9.5 mm; other specimens 17–18 mm long. Cuticle tuberculate and serrated (markedly along outer edge of pronotum and anterior part of elytra) and setose or thinly scaled (including white clumps on elytra).

Head: broad, prognathous (but mandibles (jaws) obscured); gula rectangular, elongate; eyes rounded (not enlarged), temples not protruding and shorter than eyes; antennae inserted

anterolaterally on head and moniliform, reaching posterior end of prothorax; first antennomere (scape) large, second (pedicel) similar length to third antennomere.

Prothorax: shorter than broad and wider than head but narrower than hindbody (wings folded). Pronotum transverse, anterior angles strongly curved forward, posterior angles rounded, outer edge curved and strongly serrated and thickened. Pronotal elevation semicircular in front with separate pair of central lobes and two smaller, outer lobes; small lobe present behind central lobe. Distinct belt of translucent cuticle between elevation and serrated edge. Prosternum rectangular, elongate and downcurved with short prosternal process. Notopleural suture present. Foreleg (proleg) inserted posteromesally; procoxae adjacent, incompletely separated anteriorly (three quarters) by prosternal process; profemur thickened, extending slightly beyond edge of prothorax, protibia thinner and a little shorter, protarsus (left, retracted) with elongate first and fifth protarsomeres (segments), second to fourth protarsomeres progressively shorter.

Hindbody: middle (meso-) leg: mesofemur thick, extending beyond edge of abdomen (but not elytra), meso-tibia and tarsus thinner, latter like protarsus with first mesotarsomere elongate, then segments getting shorter except fifth. Metaventrite short and broad; cross sutures (discrimen, katapisternal) visible. Metatrochantin transverse, curved. Metacoxa large and also transverse. Elytra: moderately wide with rounded tails overlapping broad, flat, somewhat elongate abdomen; anterior (outer) margin of elytron curved, slightly incurved apically, humerus (shoulder) rounded; elytron convex in cross (transverse) section with discal fold set in from margin and with elytral disc comparatively flat; ten longitudinal rows of well-developed window cells (between 20 and 25 cells per row), especially on disc, separated by four strong veins (with intercalaries); veins two and three (CuA and M) fused and curved towards first vein (1A) subapically; epipleural rim moderately wide, broadening anteriorly, with single row of cells lined with translucent/transparent cuticle; additional outer row of seven cell-like patches of translucent cuticle anterolaterally.

Comparison. A distinctly serrated pronotum and elytral edge are also found in *Notocupes viridis* Soriano & Delclòs, 2006 from the Lower Cretaceous of Spain which also has short temples, projecting pronotal angles, broad meso- and metaventrites, and elytral tails. This species differs, however, in possessing: distinct tubercles behind the eyes, a short prosternum, less rounded posterior pronotal angles, elevation apparently bilobed, an acellular rim, shorter protarsus and longer mesofemur, plus much smaller body (8 mm long).

Notocupes cyclodonta Tan, Ren, Shih & Ge, 2006 also has a pair of P3s on the head and an elongate prosternum, but has serrulate rather than serrate pronotal and elytral margins, the third antennomere is relatively longer, the pronotal elevation is bilobed, the metaventrite displays just a metakatepisternal (transverse) suture, and has a smaller body size (half of *Notocupes ohmkuhnlei* sp. nov.). A single row of rim cells and a four-lobed elevation with smaller posterior lobes are seen in the smooth-margined *Notocupes nigrimonticola* Ponomarenko, 1968 from the Upper Jurassic of Kazakhstan, which is also of comparable size (22 mm long). The four lobes are, however, reversed in this species in that the larger ones are on the outside (and not central).

A short, anterolateral cell-like row is possibly present on the elytron of *Notocupes mongolicus* Ponomarenko, 1994 from the Lower Cretaceous of Mongolia.

5. Discussion

Like some other archostematans, *Notocupes* may be a recognisable fossil beetle but is harder to define phylogenetically. Ponomarenko and Ren (2010) considered five key characters as diagnostic which, however, appear as family group (tribal) characters in a twenty-seven character analysis (Bremer-supported parsimony) by Tan et al., 2012. Serration or even serrulation is not included, although the notocupedin taxa used in the cladistics analysis include a serrate species of *Notocupes* (*N. viridis*, see above) and two serrulate species (amblommans: the most distinctive of these, *N. cyclodonta* (see above), is not included). Nevertheless notocupedins emerged as a monophyletic group, although neither the tribe nor type genus are considered monophyletic (Yamamoto, 2017) on the phylistic system of Kirejtshuk et al. (2010). Although distinctive, serration could well be homoplastic (convergent) as not only seen in other archostematans (*Paraodontomma* Yamamoto, 2017), but also in non-archostematans from the same deposit, e.g. the clown beetle *Cretonthophilus tuberculatus* Caterino, Wolf-Schwenninger & Bechly, 2015 where it has a more digitate form. The function could be disruptive rather than lacerating defence (Jarzembowski et al., 2018: NIGP 169926 nec 130418).

Another character proposed earlier to distinguish *Notocupes* is an unshortened pedicel (second antennomere) in relation to the third antennomere (Tan and Ren, 2009), as in the amber fossil above. This corresponded to one of the key characters, long pedicellum, of Ponomarenko and Ren (2010). Used unsupported by other characters (such as from head and pronotum) this feature was, however, considered unreliable (Kirejtshuk et al., 2010). Unfortunately, the subsequent head and pronotal character analysis in Tan et al., 2012 is not helpful, although earlier, Ponomarenko (1966) suggested that the shape of the pronotum (such as the anteriorly pointed angles) was useful in distinguishing congeners, especially *Rhabdocupes* Ponomarenko, 1966.

A third character which emerged was the length of the mesofemur (Jarzembowski et al., 2015), considered long in *Notocupes* sensu stricto and reaching the margin of the body (wings folded), as opposed to just the margin of the abdomen, as in the amber fossil. *N. ohmkuhnlei* sp. nov. differs in this respect from the serrate Spanish species (*N. viridis*), which has a long mesofemur, and resembles the serrulate Chinese species (amblommans) with short legs. If we combine leg and pedicel length with pronotal shape in the amber fossil as suggested above, then it belongs to *Notocupes* sensu lato (Jarzembowski et al., 2015). Fossil notocupedins can often be keyed out on size (Dr Alexandr G. Ponomarenko pers. comm., 29/5/2012) and coupled with morphology, in this case including the distinct ornamentation, a new species is proposed in this widespread and common genus.

6. Conclusion

The ommatines are arguably the 'most ancestral' living beetles and a fossil group, the monophyletic Notocupedini (with Cretaceous *Notocupes/Zygadenia* and Triassic *Rhabdocupes*), was only distinguished by a single homoplastic character by Tan et al. (2012; vein fusion: 1A + (M + CuA) see above). This venational feature is accompanied in the new amber fossil by short antennae, an incomplete prosternal process, unreduced pronotal sutures, simple tarsi, and absence of antennal protuberances, all associated with ommatines, plus lack of size reduction found in other (crown-group) archostematans. By contrast, the cupedine-like abdominal regulation (overlapping segments) in notocupedins is an interesting anomaly unfortunately not observable in the inclusion: more material is needed. In the meantime, this first notocupedin record in fossil resin can be referred to the type genus sensu lato as

Notocupes ohmkuhnlei sp. nov. based on a combination of characters. Readily recognised on account of its relative size and distinctive ornament, it adds to the growing family group diversity of beetles in mid-Cretaceous Myanmar. This large beetle was probably endemic to the ancient forest as notocupedins are known from the earlier Mesozoic of Australia as well as China (Jarzembowski et al., 2015) and could have colonised the West Burma Block. Belonging to a diverse group, it is likely that additional species will be found.

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