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A new species of the aphid family Burmitaphididae (Hemiptera: Sternorrhyncha: Aphidomorpha) from Upper Cretaceous Burmese amber

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A new species of extinct aphids is reported based on a fossil specimen with a relatively complete body and broken wings from Upper Cretaceous Burmese amber. *Vasteantenatus reliquialaus* sp. nov. (Hemiptera: Aphidomorpha: Burmitaphididae) differs from other burmitaphidids in having antennae distinctly longer than the body. The diagnosis of Burmitaphididae is emended, and a key to all species of the family is provided

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Key words: Aphids, Antennae, Albian–Cenomanian, Myanmar.

BURMITAPHIDIDAE (infraorder Aphidomorpha: Tajmyraphidoidea), a family of extinct aphids from the late Mesozoic, has the most diverse specific morphological characters (Węgierek, Cai & Huang, 2018) in the superfamily Tajmyraphidoidea (Martin *et al.*, 2016) and is typified by species with greatly reduced hind wings (Węgierek, 2001, Poinar & Brown, 2005, 2006, Węgierek *et al.*, 2017, Węgierek *et al.*, 2018, Poinar, 2018). Stub-like hind wings in Burmitaphididae usually hook to the claval folds on the forewings, forming a wing-coupling system and only forewings are functional in flight (Ogawa & Yoshizawa, 2017). The diagnostic features of Burmitaphididae after Poinar & Brown (2005) include the following characters: stub-like reduced hind wings, 7-segmented short antennae, frons with tubercle, vein M with only one branch, rostrum and siphunculi absent. This family includes five described species in five genera, *Burmitaphis prolatum* Poinar & Brown, 2005, *Caulinus burmitis* Poinar & Brown, 2005, *Tanyaulus caudisetula* Poinar, 2018, *Echinoaphis penalverii* Węgierek *et al.*, 2018 and *Vasteantenatus hukawngi* Węgierek *et al.*, 2018. All were described from earliest Late Cretaceous Burmese

amber and did not survive to the Cenozoic (Heie & Węgierek, 2011).

Here we describe and illustrate a new species of Burmitaphididae, *Vasteantenatus reliquialaus* sp. nov. based on an alate female adult in an Upper Cretaceous amber inclusion also from Kachin Province in northern Myanmar. A large number of Cretaceous fossil groups have been discovered in this deposit (Rasnitsyn *et al.*, 2016), including 15 species of coccids, which are a sister group to aphids (Ross, 2018). The new species *Vasteantenatus reliquialaus* sp. nov. stands apart from other burmitaphidids based on its antennae, which are almost 1.5 times longer than the body and are of uniform width. The characters of the new species necessitate emendation of the diagnosis of *Vasteantenatus* and Burmitaphididae.

Materials and methods

The description of the new species is based on a specimen preserved in amber from the Hukawng Valley in northern Myanmar, which has been dated as Late Cretaceous (98.79 ± 0.62 Ma; earliest Cenomanian) based on U–Pb dating of zircons (Grimaldi *et al.*, 2002, Shi *et al.*, 2012). The specimen described in this paper is preserved in a relatively clear piece of amber

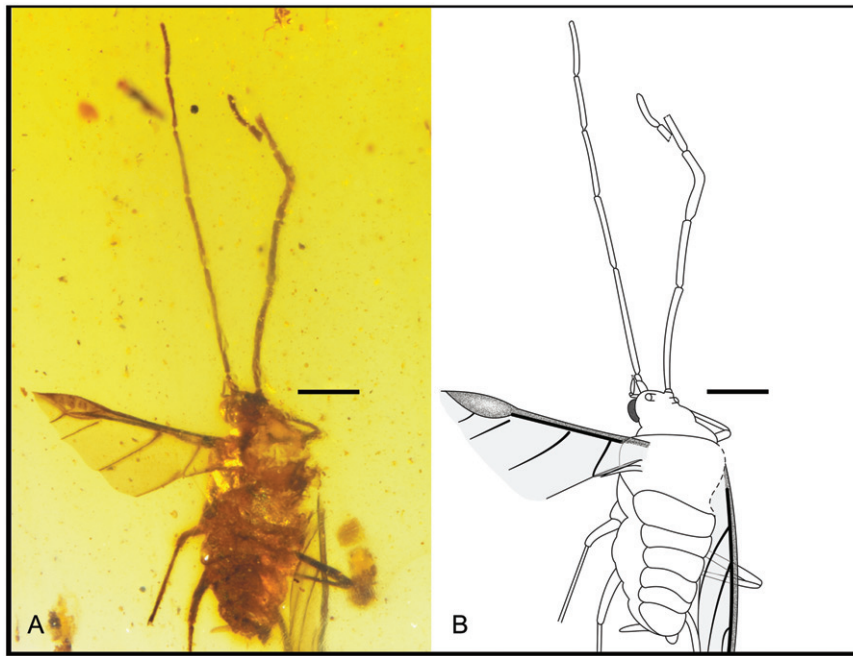


Fig. 1. Holotype of *Vasteantenus reliquialaus* sp. nov. CNU-APD-MA2018001. **A**, Photomicrographs of dorsal view. **B**, Line drawings of dorsal view. Scale bars = 0.5 mm.

and retains a complete body and broken forewings and legs. The holotype is deposited in the Key Lab of Insect Evolution and Environmental Changes, at the College of Life Sciences, Capital Normal University, in Beijing, China. The amber piece was carefully polished with emery paper and was examined and measured using a Nikon SMZ 18 dissecting microscope with a Leica DFC500 digital camera system. Line drawings were prepared by tracing the photographs using the software Adobe Photoshop CC2017 and Adobe illustrator CC2017. We follow the morphological nomenclature recommended by Węgierek (2002) and abbreviations proposed by Żyła *et al.* (2014).

Systematic palaeontology

Order HEMIPTERA Linnaeus, 1758

Suborder STERNORRHYNCHA Amyot & Serville, 1843

Infraorder APHIDOMORPHA Becker-Migdisova & Aizenberg, 1962

Superfamily TAJMYRAPHIDOIDEA Kononova, 1975

Family BURMITAPHIDIDAE Poinar & Brown, 2005

Emended diagnosis. Antennae seven-segmented; all flagellomeres with ellipsoidal secondary rhinaria in ring-like arrangement, distributed densely and equally. Three ocelli: one ocellus on front, two ocelli on back of head between two compound eyes. Forewings with one or two separated cubitus veins; vein M with a single-branch; claval folds distinct. Hind wings reduced, stub-shaped. Siphunculi absent.

Remarks. According to the diagnoses of the higher taxa of Aphidomorpha (Heie & Węgierek, 2009), the new specimen described herein can be assigned to the superfamily Tajmyraphidoidea based on the following characters: vein M originating from the base of the pterostigma, and not connected to the main vein; cubitus veins CuA_1 and CuA_2 branching off separately at the base from the main vein ($Sc + Rs + M$); CuA_1 leaving the main vein at an angle of 50° ($35\text{--}50^\circ$ in the diagnosis of Tajmyraphidoidea), CuA_2 short and forming an angle of 77° with the main vein ($75\text{--}90^\circ$ in the diagnosis of Tajmyraphidoidea); hind wings reduced; antennae with seven segments; last antennal segments lacking processus terminalis; siphunculi absent; ovipositor present. Furthermore, there are no other extant aphid families with greatly reduced stub-like hind wings, with the exception of the representatives of Burmitaphididae (Poinar & Brown, 2005) and Szelegiewucziidae (Węgierek *et al.*, 2017). Burmitaphididae can be clearly distinguished from Szelegiewucziidae by its weakly sclerotized abdomen (szelegiewucziids have a well-sclerotized abdomen with rows of conical glands) (Węgierek, 1989, Węgierek *et al.*, 2017). Consequently, *Vasteantenus reliquialaus* sp. nov., which also has reduced stub-like hind wings and a weakly sclerotized abdomen, is assigned to Burmitaphididae. In addition to these most critical features, the new specimen also has many similarities with other burmitaphidids, such as the last antennal segment remaining of uniform width; cubital veins with separate bases; vein M originating just after the base of the pterostigma; pterostigma narrow, three or four times longer than wide, and siphunculi absent.

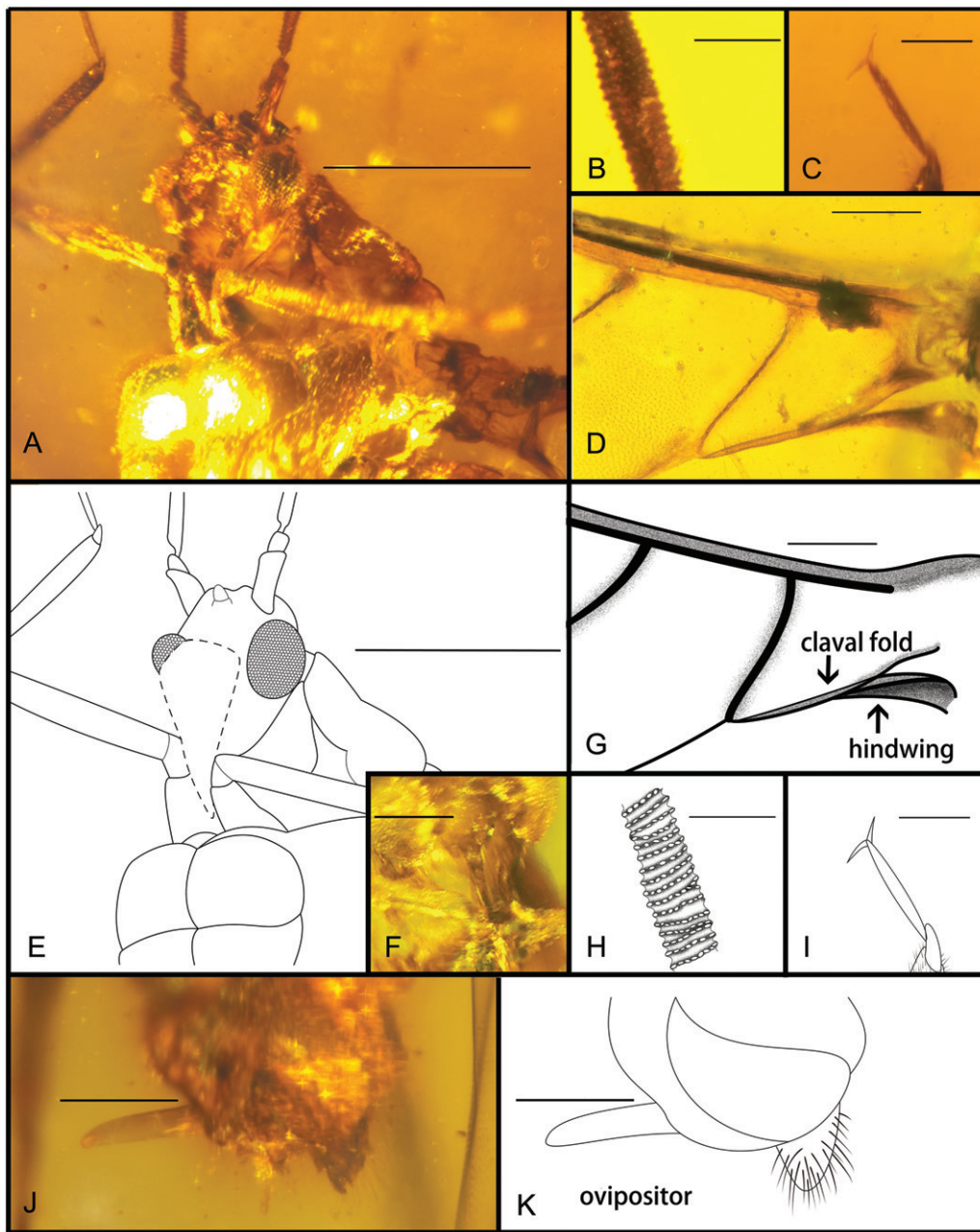


Fig. 2. Detail photographs and line drawings of *Vasteantenus reliquialaus* sp. nov. holotype, CNU-APD-MA2018001. Photomicrographs: **A**, Ventral view of rostrum; **B**, Secondary rhinaria on antennal segment; **C**, Developed tarsal claws on tarsus 2; **D**, Hind wing and claval fold on forewing; **E**, Ventral view of head; **F**, Ventral view of rostrum. Line drawings; **G**, Hind wing and claval fold on forewing; **H**, Secondary rhinaria on antennal segment; **I**, Developed tarsal claws on tarsus 2; **J**, Photomicrographs of ovipositor; **K**, Line drawings of ovipositor. Scale bars for **A**, **E** = 0.5 mm; **B**, **C**, **H**, **I** = 0.1 mm; **D**, **F**, **G**, **J**, **K** = 0.2 mm.

However, the variation within burmitaphidids is quite large (see Key to species of Burmitaphididae). To date, six genera of the aphid family Burmitaphididae have been described—all from the Upper Cretaceous deposits of northern Myanmar. *Burmitaphis* is characterized by a triangular head, forewings lacking CuA_2 and a short abdomen, which are not present in the other genera. *Tanyaulus* and *Echinoaphis* are distinguished by a long rostrum, abdomen with setal clusters and vein M_1 with an arched base. They can be distinguished from each other by the ratio of wing length to

body length, and the position of vein M . *Vasteantenus* is characterized by a large body (about 2 mm long) and extremely long antennae (Węgierek *et al.*, 2018).

Within *Vasteantenus*, *V. reliquialaus* and *V. hukawngi* can be distinguished from each other by the gross body shape (fusiform in *V. reliquialaus* vs ellipsoid in *V. hukawngi*), the original point of vein R_s (vein R_s leaving the midpoint of the pterostigma in *V. reliquialaus* vs vein R_s leaving the pterostigma in the distal quarter in *V. hukawngi*), the width of the antennae

(*V. reliquialaus* with the uniform antennal width from segment III to segment VII vs *V. hukawngi* with the gradually tapered antennal width from segment III to segment VII), and the ratio of antennae length to body length (the antennae length is approximately 1.5 times the body length in *V. reliquialaus* vs approximately equal to the body length in *V. hukawngi*). The morphological characteristics of burmitaphidids are clearly very diverse, therefore, we have emended the diagnosis of Burmitaphididae to account for this spectrum of characters.

Vasteantenatus Wegierek, Cai & Huang, 2018

Type species. Vasteantenatus hukawngi Węgierek *et al.*, 2018.

Emended diagnosis. Body length approximately 2 mm. Antennae long, measuring at least longer than body length. Rostrum short, extending to fore coxae. Forewing: CuA₂ clear and straight; vein M with two straight branches; pterostigma long and narrow, with a sharp tip.

Vasteantenatus reliquialaus sp. nov.

Type material. Holotype, CNU-APD-MA2018001, an alate female adult, relatively well preserved with incomplete forewings. Accessible dorsal and ventral views (Figs 1, 2).

Locality and stratigraphic level. Hukawng Valley, northern Myanmar; lower Upper Cretaceous (lowermost Cenomanian), unit un-named.

Etymology. The species epithet *reliquialaus* is a combination of the Latin word ‘reliquiae’ meaning ‘remains’ and the Latin noun ‘ala’ meaning ‘wing’), referring to the incomplete wings.

Diagnosis. Head wider than long, with its anterior margin nearly straight. Antennae slender, measuring 1.5 times the body length, with straight apex. Antennae of uniform width from segment III to segment VII. Vein Rs arising at the midpoint of pterostigma; pterostigma measuring three times longer than wide, with a sharp tip. Tarsi 2 four times as long as tarsi 1, with two developed tarsal claws. Abdomen gradually narrowing to the end of the body.

Description. Alate female. Body elongate and fusiform, 2.03 mm long.

Head (Fig. 1) is heavily sclerotized, transversely oval, wider than long; its anterior margin nearly straight. Compound eyes hemispherical, bulging laterally, with their length slightly shorter than length of head. Ocelli three: two situated on the back of head between two compound eyes, one situated on top of head. Rostrum short, extending to fore coxae. Antennae with seven segments, *ca* 2.99 mm long, far longer than

body length, and longer than tibiae of all legs; antennal segment III 0.87 mm long, 23 times as long as wide; segments IV–V of the similar length, respectively 0.58 mm and 0.54 mm; segments VI–VII of similar length, respectively, 0.41 mm and 0.43 mm; last segment with straight apex, lacking processus terminalis. All flagellomeres bearing secondary rhinaria (Fig. 2C, D); secondary rhinaria slender, more or less ellipsoidal, arranged in transverse rows distributed densely and equally; antennal segment III with more than 60 rows of secondary rhinaria.

Thorax: mesosternum heavily sclerotized (Fig. 2A, B), with distinct median suture, clear transverse suture. Forewing partly preserved, with distinct claval folds (Fig. 2E, F). Wing veins with extended pigmented areas. Pterostigma long (0.58 mm) and narrow, three times longer than wide, with a sharp tip (Fig. 1). Cubital veins separated from main vein (Sc + Rs + M) without common stem; vein CuA₁ manifestly longer than CuA₂, length of CuA₂ 0.29 mm; vein M originating after base of pterostigma, almost but not connected to the main vein; vein Rs slightly curved, departing at almost the midpoint of pterostigma. Hind wings reduced to stubs, 0.30 mm long, with only one longitudinal vein (Fig. 2E, F). Femur thick; length of hind femur 0.59 mm. Tarsi distinctly slender, with two segments; tarsi 2 four times as long as tarsi 1, with two developed tarsal claws (Fig. 2G, H).

Abdomen: thick and gradually narrowing to the end of the body, six segments visible dorsally, last segment with its posterior edge almost straight. Siphunculi absent. Ovipositor slender, length of visible portion, 0.21 mm. Cauda conical, with setae.

Key to species of Burmitaphididae

1. Vein M₁ clearly curved, extending to the margin of the forewing; Vein M₂ almost straight, remote from margin of the forewing; pterostigma approximately triangular, almost twice as long as wide; abdomen deformed, with dense hair or fluff... .. 2
- 2
- Both veins M₁ and M₂ almost straight, extending to the margin of the forewing; pterostigma nearly fusiform, three or four times longer than wide; abdomen normal, generally smooth 3
2. Head nearly trilateral; rostrum long, not longer than body length; length of antennae longer than half of body length; forewings longer than body length; vein M originating after base of pterostigma, close to but not connected to the main vein; ovipositor present

Tanyaulus caudisetula Poinar, 2018

Head nearly square; rostrum long, far longer than body length; length of antennae distinctly shorter than half of body length; forewings shorter than body length; vein M originating at base of pterostigma, distinctly not connected to the main

vein; ovipositor absent

Echinoaphis penalverii Węgierek *et al.*, 2018

3. Compound eyes with lengths distinctly shorter than length of head; length of antennae distinctly shorter than half of body length; antennal segment III longer than half of subsequent segments; antennal segments IV–VI of the similar or same length; vein M almost equal to common stem of vein M 4
Compound eyes with lengths approximately equal to or slightly shorter than length of head; length of antennae far longer than body length; antennal segment III shorter than half of subsequent segments; antennal segments IV–VI various lengths; vein M shorter than common stem of vein M 5

4. Body thick; head nearly trilateral; ocellus absent or invisible; only one cubital vein visible; Vein M₁ almost equal to common stem of vein M; cauda knob-shaped

Burmitaphis prolatum Poinar & Brown, 2005

Body slender; head wider than long; with three ocelli; cubital veins not connected by common stem; Vein M₁ longer than common stem of vein M; cauda rod-shaped

Caulinus burmitis Poinar & Brown, 2005

5. Fusiform body; rostrum short, distinctly shorter than body length; antennae with its length approximately 1.5 times the body length, with uniform antennal width from segment III to segment VII; vein Rs leaving the midpoint of the pterostigma; abdomen gradually narrowing to the end of the body, with nearly straight end

Vasteantenatus reliquialaus sp. nov.

Ellipsoid body; rostrum invisible; antennae nearly equal in length to the body, with gradually tapered antennal width from segment III to segment VII, vein Rs emerging from the distal quarter of the pterostigma; abdomen of uniform width, with rounded end

Vasteantenatus hukawngi Węgierek *et al.*, 2018

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