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Short communication

First Mesozoic brachypsectrid beetles in mid-Cretaceous amber from northern Myanmar (Coleoptera: Elateroidea: Brachypsectridae)

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ABSTRACT

With nine described species in two genera, Brachypsectridae is a small and widespread elateroid family. Fossil brachypsectrids have been confined to the Baltic and Dominican ambers, and very little is known about the early evolution of Brachypsectridae in the Mesozoic era. Here we describe and illustrate the first Mesozoic brachypsectrid, *Vetubrachypsectra burmitica* gen. et sp. nov., based on a male adult entombed in the mid-Cretaceous amber from northern Myanmar, approximately 99 million years ago. *Vetubrachypsectra* has a close affinity to the extant *Brachypsectra*, but primitively retains many plesiomorphic characters, including long antennae, tibial spurs 2-2-2 and male parameres without hook. Our discovery of a new Mesozoic brachypsectrid species pushes back the fossil record of Brachypsectridae by approximately 55 million years, which has great significance for further dating of phylogenetic trees of beetles.

1. Introduction

With nine formally named species in two genera, the elateroid family Brachypsectridae is small widespread family of beetles (Costa et al., 2006; Costa et al., 2010; Hájek, 2010; Kovalev and Kirejtshuk, 2016; Petrzelkova et al., 2016). The genus *Brachypsectra* LeConte comprises six described extant species: *B. fulva* LeConte from the southwestern United States and northern Mexico, *B. fuscula* Blair from Singapore, *B. jaechi* Petrzelkova, Makris and Kundrata from Turkey, *B. kadleci* Hájek from Iran, *B. lampyroides* Blair from southern India, and *B. vivafosile* Woodruff from the Dominican Republic. Additionally, an unnamed species known only as larvae is documented from northern Australia (Costa et al., 2006), and anther unnamed one as both female and larva is known from Cyprus (Petrzelkova et al., 2016). The other recently described extant brachypsectrid genus, *Asiopsectra* Kovalev and Kirejtshuk, contains only two species: *A. luculenta* Kovalev and Kirejtshuk from Iran and *A. mirifica* Kovalev and Kirejtshuk from Tajikistan. Adult males of *Brachypsectra* are usually attracted to lights at night, but are probably short-lived. *Brachypsectra* larvae are usually collected beneath loose bark, in cracks in rock, in leaf bases of monocolyledonous plants or under leaves or other debris on the ground (Costa et al., 2010). The *Brachypsectra* larvae appear to be non-specific ambush predators, preying on small animals such as spiders, ants, immature solpugids (Solifugae) and beetle larvae (Costa et al., 2006; Costa et al., 2010). The exact phylogenetic position of Brachypsectridae within the superfamily Elateroidea remains elusive. Based on both adult and larval characters, Brachypsectridae has been placed at or near the base of a clade containing Cerophytidae, Eucnemidae, Throscidae and Elateridae or a clade including these families plus the Cantharoidea (Lawrence, 1988). In a recent comprehensive phylogeny of Coleoptera based on both adult and larval characters, Brachypsectridae is supported as a sister group to (Throscidae (Cerophytidae, Eucnemidae)) (Lawrence et al., 2011). In a molecular-based phylogeny of beetles, Brachypsectridae is sister to a clade containing Cerophytidae, Eucnemidae (not monophyletic in the analysis) and Throscidae

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based on the Bayesian analysis, but not the maximum-likelihood one (McKenna et al., 2015). Unfortunately, probably due to its rarity, Brachypsectridae was not sampled in either the comprehensive phylogeny of Elateroidea by Kundrata et al. (2014) or the first phylogenomic study of beetles by Zhang et al. (2018). The adults of Brachypsectridae can be recognized based on the relatively flat body, large prominent eyes, antennae forming serrate to pectinate club, and free abdominal ventrites. Larval Brachypsectridae have a very distinctive body form, and they are easily distinguished from all other beetle larvae by a broad and flattened body with lateral branched processes, flexible tail spine, free labrum, and perforate mandibles (Costa et al., 2006; Costa et al., 2010).

Fossil brachypsectrids are sparse. To date, only two species belonging to the extant *Brachypsectra*, *B. moronei* Branham and *B. vivafosile* Woodruff, have been described from the Miocene Dominican amber (ca. 18–20 Ma) (Wu et al., 1996; Woodruff, 2004; Costa et al., 2006). In addition, an undescribed species of *Brachypsectra* is also known from the Eocene Baltic amber (Klausnitzer, 2009). Fossil evidence of Brachypsectridae from the Mesozoic, being of great significance for understanding the origin and early diversification of the family, is lacking. Here we describe and figure the first Mesozoic and earliest known fossil brachypsectrids from the mid-Cretaceous Burmese amber.

2. Material and methods

The sole fossil specimen was found by screening more than 23,000 pieces of fossiliferous Burmese amber that were derived from the Hukawng Valley in Tanai Township, Myitkyina District of Kachin State, northern Myanmar (Yin et al., 2018: Fig. 1A). The fossil resin is dated stratigraphically as late Albian to early Cenomanian (Ross et al., 2010). Recent U-Pb dating of zircons from the tuffaceous matrix produced a maximum age of 98.8 ± 0.6 million years (Shi et al., 2012), but new evidence of reworking (pholadid bivalve boring of the amber pebbles) (Smith and Ross, 2018; Mao et al., 2018) indicates that this is actually a minimum age. The studied specimen (NIGP170326) is deposited in the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, China.

The amber piece was trimmed with a small table saw, ground with emery papers of different grain sizes, and finally polished with polishing powder. Observations and photographs were taken using a Zeiss Discovery V20 stereo microscope and a Zeiss Axio Imager 2 light microscope with a digital camera attached. Photomicrographs with a green background were taken using fluorescence as light source attached to a Zeiss Axio Imager 2 light microscope. Focus stacking software (Helicon Focus 3.10) was used to increase depth

Fig. 1. Microphotographs of holotype (NIGP170326) of *Vetubrachypsectra burmitica* gen. et sp. nov. from mid-Cretaceous Burmese amber, under normal reflected light. A. dorsal view; B. ventral view. Scale bars: 1 mm.

of field. The nomenclatural acts established herein are registered under ZooBank LSID urn:lsid:zoobank.org:pub:5EF612A-85DA-40F3-829A-D8FC3BDD4EA4.

3. Systematic palaeontology

Order: Coleoptera Linnaeus, 1758
Superfamily: Elateroidea Leach, 1815
Family: Brachypsectridae Horn, 1881

Genus: ***Vetubrachypsectra*** gen. nov., Qu and Cai.
Type species. *Vetubrachypsectra burmitica* gen. et sp. nov.

Etymology. The genus-group name is a combination of Latin *vetus*, meaning 'old', and the genus *Brachypsectra*; it is feminine in gender. The genus is registered under LSID urn:lsid:zoobank.org:act:2853F3D5-13B4-4D8D-BA85-16AF3B7E1170.

Diagnosis. Small (ca. 4.8 mm long), habitus elaterid-like. Antenna long; antennomeres 4–10 expanded apically, but not forming a compact club; pedicel distinctly shorter than scape, subapically attached to the latter. Maxillary palp long; palpomere 3 distinctly longer than wide; palpomere 4 oblique apically. Pronotum about 0.76 times as long as wide. Prosternum very long, about 3.2 times as long as mid length of coxa. Elytra without row of punctures or striae. Tibial spurs 2-2-2. Male parameres simple, without hooks.

Description. Length about 4.8 mm. Body elongate, about 2.8 times as long as wide (in male), finely pubescent.

Head (Figs. 2A, B and 3A) twice as wide as long, slightly declined, deeply inserted into prothorax. Occipital region without carina. Eyes (Figs. 2A, B and 3A) large, more or less globular, strongly protruding and finely facetted, without interfacetal hairs. Frontoclypeal region strongly declined anteriorly, so that mouthparts directed ventrally. Antennal insertions concealed from above, placed within saucer-like fossae which are separated by flat area about two-thirds the width of one fossa; each continuing ventrally and laterally to form a short, oblique subantennal groove. Frontoclypeal suture absent. Labrum small. Antennae (Fig. 2E) elongate, 11-segmented, with antennomeres 4 to 10 expanded apically on one side; scape distinctly longer than wide and distinctly longer than pedicel, which is attached subapically; pedicel reduced, broadened apically; antennomere 3 elongate; antennomeres 4–10 elongate. Mandible small, subtriangular. Maxillary palpi elongate; palpomere 1 small; palpomeres 2–4 distinctly longer than wide.

Pronotum comparatively long, about 0.76 times as long as wide; widest posteriorly, with distinct lateral carinae; anterior angles oblique, not produced forward; posterior angles acute, produced laterally and posteriorly, embracing elytral bases, bearing carinae which extend anteriorly and end at posterior third of disc (Fig. 2C), which is slightly convex; posterior edge trisinuate. Prosternum in front of coxae about 4.2 times as long as shortest diameter of procoxal cavity, slightly convex, with short chin piece. Prosternal process narrow, apex extending posteriorly to fit into mesoventral cavity. Procoxae with well-developed articulating area and slender trochantin concealed by expansion of prosternal cowling. Procoxal cavities strongly transverse, externally broadly open. Scutellar shield elevated, with slightly rounded lateral edges and rounded apex.

Elytra about 1.7 times as long as greatest combined width and 2.6 times as long as pronotum; sides widest at middle; apices conjointly, broadly rounded; disc coarsely punctate, without impressed striae (Figs. 2D and 3C); sutural stria deeply impressed; scutellary striole absent; humeri moderately developed; epipleura gradually narrowed posteriorly. Mesoventrite very short; discrimen not visible. Mesocoxae transverse, not projecting, with exposed trochantins. Mesocoxal cavities narrowly separated. Metaventrite long and flat; discrimen well developed, vaguely indicated anteriorly; transverse (katepisternal) suture absent; visible portion of metanepisternum wide, parallel-sided; metepimeron concealed beneath elytra. Metacoxae strongly transverse, extending laterally to meet elytra; metacoxal plates complete, narrow. Hind wings well-developed, partly exposed.

Legs slender and simple; trochanters moderately elongate; trochanterofemoral joints on fore and mid legs slightly oblique; tibial spurs 2-2-2, well developed. Tarsal formula 5-5-5 (Fig. 2F, G); tarsomeres 1–4 combined more than twice as long as 5; tarsomere 4 shortest, without ventral lobe; pretarsal claws simple; empodium visible, bisetose.

Abdomen (Fig. 3B) with five ventrites. Ventrite 1 as long as ventrite 2, without postcoxal lines; intercoxal process acute. Ventrites 3–4 distantly shorter than ventrite 2; ventrite 5 broadly rounded at apex. Sternite IX broadly rounded anteriorly. Aedeagus (Fig. 3D, E) of typical trilobate type, symmetrical; parameres simple, without apical or laterally hooks; penis undivided.

Female unknown.

Vetubrachypsectra burmitica sp. nov., Qu and Cai
(Figs. 1–3)

Etymology. The specific epithet refers to the occurrence of the fossil in Burmite (Burmese amber). The species is registered under LSID urn:lsid:zoobank.org:act:7280BDE2-C0AF-4A4C-A49E-7E8488DD7B0E.

Holotype. Male, NIGP170326, completely preserved adult; mid-Cretaceous, Hukawng Valley, Kachin State, northern Myanmar; deposited in the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, China.

Diagnosis. As for the genus (*vide supra*).

Description. Body comparatively small, about 4.83 mm long (from anterior margin of head to apex of genitalia). Body oblong to somewhat elongate, about 2.8 times as long as wide, finely pubescent. Head widest across eyes, 0.47 mm wide. Eyes large, protruding laterally. Antennae about 2.21 mm long, length of antennomeres 1–11: 0.15 mm, 0.13 mm, 0.21 mm, 0.21 mm, 0.21 mm, 0.22 mm, 0.21 mm, 0.20 mm, 0.20 mm, 0.17 mm, 0.31 mm; antennomeres 4–10 expanded apically, but not forming a distinct club with antennomere 11. Maxillary palpi elongate; palpomere 3 slightly wider than palpomere 2; palpomere 4 about 1.7 times as long as palpomere 3, apex oblique; palpomere 4 slightly widened apically. Pronotum comparatively long, 1.08 mm long (along midline) and 1.43 mm wide. Elytra 2.94 mm long, each about 0.83 mm wide. Aedeagus symmetrical, with partly exposed wide parameres; inner edge of paramere nearly straight, outer edge with obtuse angle (ca. 115°), sharp at apex; penis finely pubescent, short.

4. Discussion

Vetubrachypsectra gen. nov. can be firmly placed in the extant family Brachypsectridae based on the slightly flattened body, transverse procoxae, presence of metacoxal plates, acute posterior pronotal angles, simple pretarsal claws, and distinctly pectinate antennae in males (Costa et al., 2006; Costa et al., 2010). *Vetubrachypsectra* is readily separated from the recently discovered genus *Asiopsectra* (from Iran and Tajikistan) by the presence of 11-semgented and pectinate antennae (antennae 12-segmented and

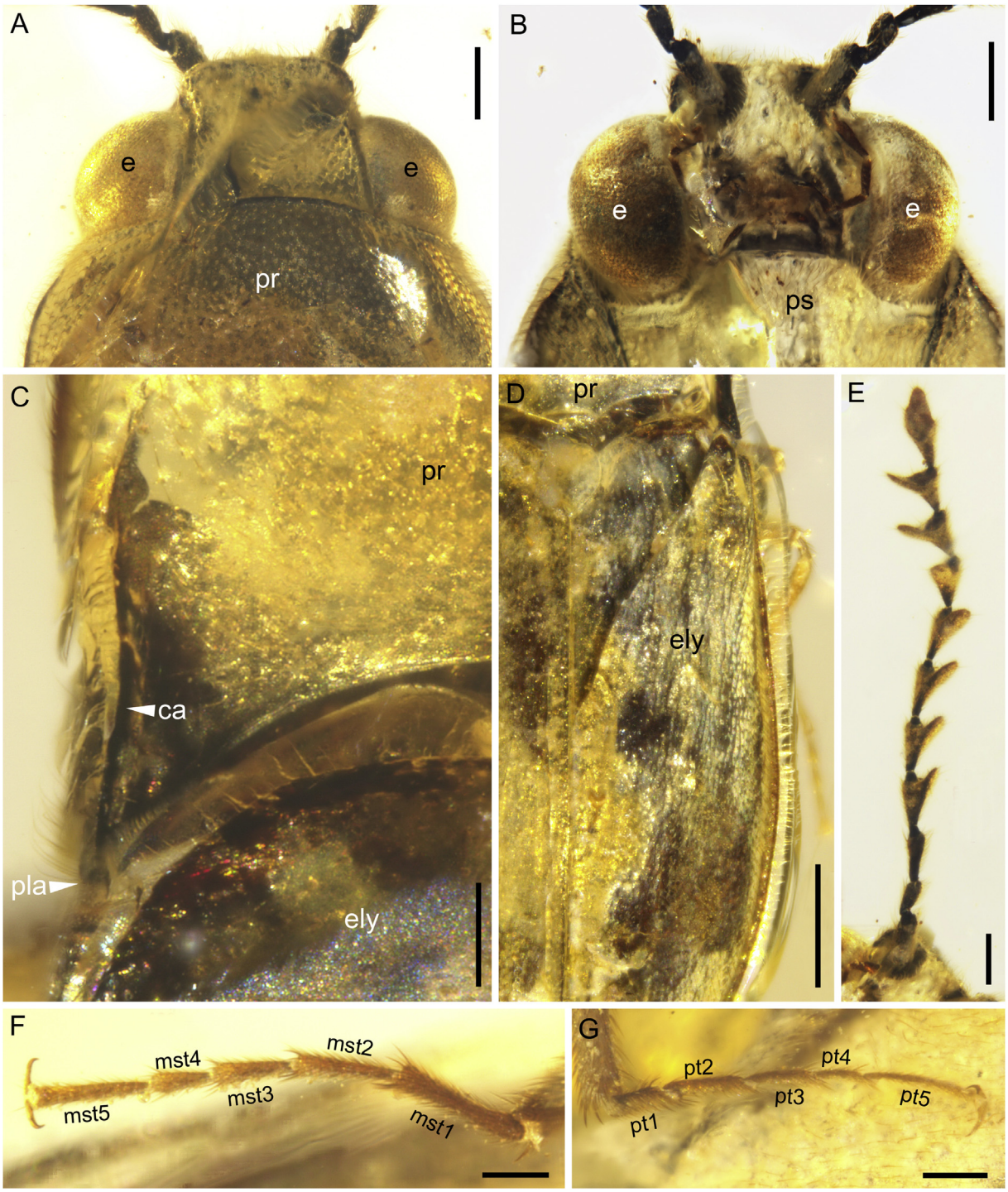

Fig. 2. Details of *Vetubrachypsectra burmitica* gen. et sp. nov. from mid-Cretaceous Burmese amber, holotype (NIGP170326), under normal reflected light. A. head, dorsal view; B. head, ventral view; C. left posterior pronotal angle and carina on pronotal disc; D. anterior part of right elytron; E. right antenna, ventral view; F. right mesotarsus; G. left protarsus. Abbreviations: ca, carina; e, eyes; ely, elytron; mst1–5, mesotarsomeres 1–5; pla, posterolateral angle; pr, pronotum; ps, prosternum; pt1–5, protarsomeres 1–5. Abbreviation: pc, procoxa. Scale bars: 200 μm in A, B and E; 100 μm in C, E–G; 500 μm in D.

bilamellate in *Asiopsectra*) and carinae (keels) along the posterior pronotal angles (absent in *Asiopsectra*), and the absence of "window" punctures on the elytra (Kovalev and Kirejtshuk, 2016). *Vetubrachypsectra* has a very close affinity to the other extant brachypsectrid genus *Brachypsectra*. They share similar large eyes, antennal morphology, and the presence of carinae along the posterior pronotal angles. However, *Vetubrachypsectra* appears to retain several ancestral characters, including comparatively long antennae, unreduced maxillary palpomere 3, tibial spurs 2-2-2, and male parameres simple (without hook). It is noteworthy that the fossil genus has a comparatively longer pronotum and non-striate elytra, distinctly differing from those in *Brachypsectra*. In addition, *Vetubrachypsectra* has another peculiar character unknown in all extant representatives of Brachypsectridae, i.e. the pedicel

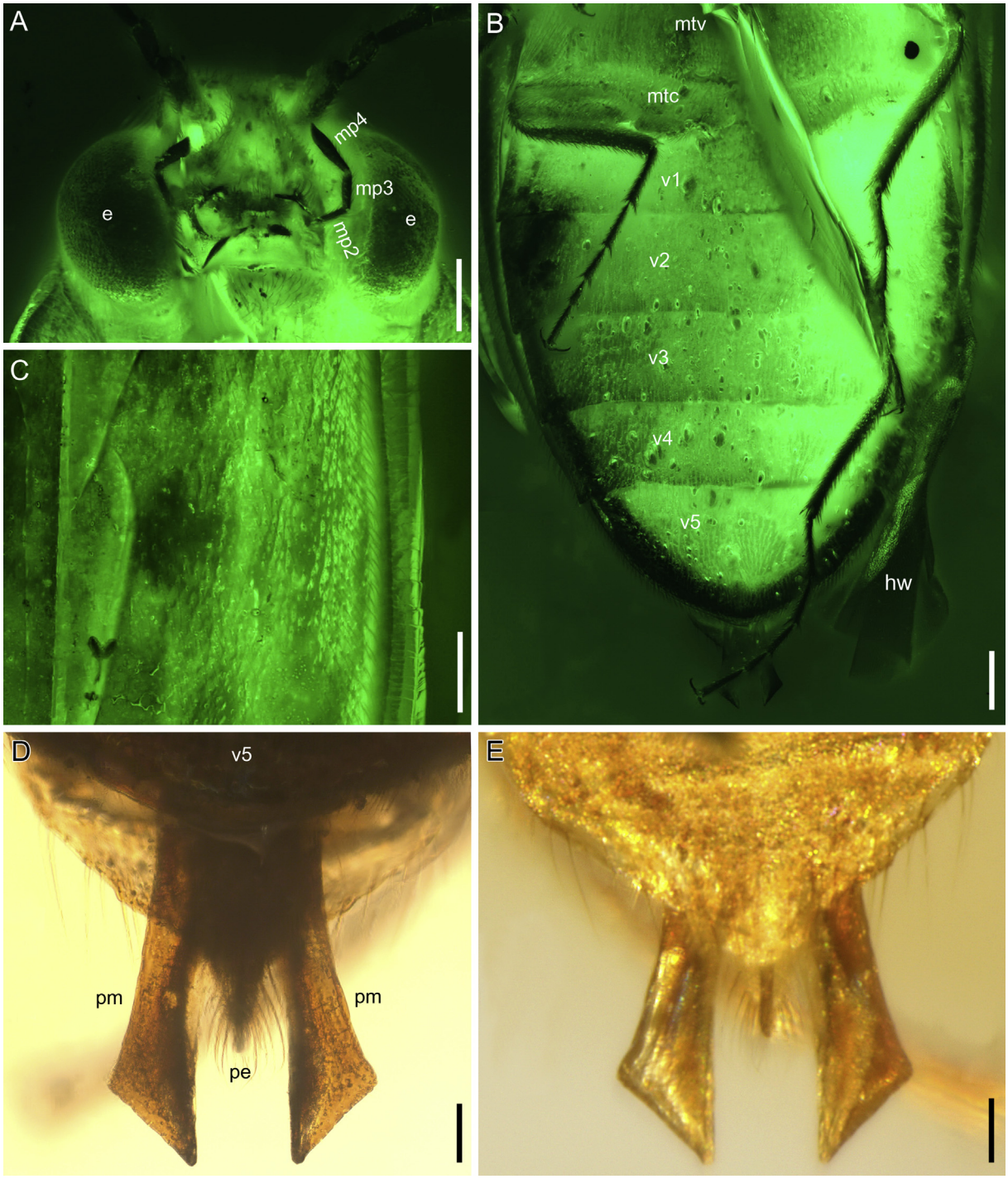

Fig. 3. Details of *Vetubrachypsectra burmitica* gen. et sp. nov. from mid-Cretaceous Burmese amber, holotype (NIGP170326), A–C under green epifluorescence, D and E under normal reflected light. A. head, ventral view; B. metathorax and abdomen, ventral view; C. enlargement of right elytron; D. male genitalia, ventral view; E. same as D, dorsal view. Abbreviations: e, eye; hw, hind wing; mp2–4, maxillary palpomeres 2–4; mtc, metacoxa; mtv, metaventrite; pe, penis; pm, paremere; v1–5, abdominal ventrite 1–5. Scale bars: 200 μm in A–C; 50 μm in D and E.

subapically attached to the scape. Such a feature, to our knowledge, has only been documented in the closely related elateroid families such as Cerophytidae and Eucnemidae. The presence of this morphological character in fossil brachypsectrids suggests the hypothesis that Brachypsectridae is sister to a clade comprising Cerophytidae and Eucnemidae, as indicated by both phylogenies based on morphological and molecular data (Lawrence et al., 2011; McKenna et al., 2015).

The holotype of *Vetubrachypsectra burmitica* sp. nov. is exceptionally well-preserved, with the genitalia exposed and clearly visible. The genitalic structures such as a penis and parameres confirms its identity as a male specimen. The clearly pectinate antennae and elongate body shape are also suggestive of a male. All extant species of *Brachypsectra* are obviously sexually dimorphic: males have a more elongate body form and more pectinate antennae, whereas females bear a more oval body and less

pectinate antennae (Costa et al., 2006; Costa et al., 2010). As such, it will be not unexpected to discover oval female brachypsectrids with less modified antennae, as found in the extant forms, from the Mesozoic in the future.

Brachypsectridae is usually considered a rare lineage of Coleoptera with only a scarce representation in museum collections (Costa et al., 2006), which may be caused by the cryptic life of the immature stages and short life span of adults (Costa et al., 2010). Considering the world distribution pattern of *Brachypsectra* and the recent discovery of a second genus *Asiopsectra* by Kovalev and Kirejtshuk (2016), it is possible to discovery more populations/species and even genera in different zoogeographical regions in the future (Petrzelkova et al., 2016). Our discovery of a new genus from the Mesozoic highlights the antiquity of Brachypsectridae, consistent with the molecular clock estimate which indicated a late Jurassic origin of the family (McKenna et al., 2015).

5. Conclusions

Our discovery of a male specimen of *Vetubrachypsectra burmitica* gen. et sp. nov. in the mid-Cretaceous amber from northern Myanmar (ca. 99 Ma) represents the earliest record for the elateroid family Brachypsectridae. *Vetubrachypsectra* is closely related to *Brachypsectra*, but it primitively retains many plesiomorphic traits such as long antennae, tibial spurs 2-2-2 and parameres without hook in males. Prior to our discovery, the earliest known record, although not formally named, was reported from the Eocene Baltic amber (Klausnitzer, 2009). Therefore, our find pushes back the fossil record of Brachypsectridae by approximately 55 million years. The first Brachypsectridae from the Mesozoic is of great significance for further dating of phylogenetic trees of Coleoptera.

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