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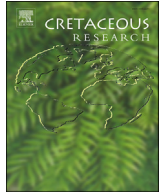
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Short communication

A new family Jubisentidae fam. nov. (Hemiptera: Fulgoromorpha: Fulgoroidea) from the mid-Cretaceous Burmese amber

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ABSTRACT

A new family of Fulgoroidea, Jubisentidae fam. nov. from the mid-Cretaceous Burmese amber is described, comprising two new monospecific genera, *Jubisentis hui* gen. et sp. nov. and *Furtivirete zhuoi* gen. et sp. nov. The probable relationships of this new family with other Fulgoroidea are briefly discussed. Peculiar features such as tegula and hind wing absent, foliaceous legs, tegmina subbrachypterous, body and tegmina covered with long bristles, seem to indicate a unique survival strategy of these cryptic insects.

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1. Introduction

Planthoppers is a group of diverse phytophagous insects, including more than 9000 described extant species (Urban and Cryan, 2007) and 301 fossil species worldwide. Currently, the superfamily Fulgoroidea contain eight extinct families and 21 recently recognized extant families (Szwedo, 2007, 2018). Extinct families comprise Jurassic Fulgoridiidae and Qiyangiricaniidae (Szwedo et al., 2011); Cretaceous Dorytocidae, Lalacidae, Mimarachnidae, Neazoniidae, Perforissidae (Hamilton, 1990; Szwedo, 2007; Shcherbakov, 2007a,b; Emeljanov and Shcherbakov, 2018); and Eocene family Weiwooidae (Lin et al., 2010). Extant families are Achilidae + Achilixiidae, Cixiidae, Caliscelidae, Delphacidae, Dictyopharidae, Derbidae, Eurybrachidae + Gengidae, Fulgoridae, Flatidae + Hypochthonellidae, Issidae + Acanaloniidae, Lophopidae, Meenoplidae + Kinnaridae, Nogodinidae, Ricianiidae, Tettigometridae and Tropiduchidae (Lin et al., 2010).

The mid-Cretaceous Burmese amber contains diverse fossil insects, hitherto, about 341 families, 499 genera and 603 species are known (Ross, 2018), but Auchenorrhyncha reported from Burmese amber are fairly rare, only seven families, nine genera and 10 species

have been described, and most of them belong to Fulgoroidea, such as achilids, perforissids, mimarachnids and dorytocids (Szwedo, 2004; Zhang et al., 2017; Shcherbakov, 2017; Emeljanov and Shcherbakov, 2018; Jiang et al., 2018); the others were placed in Cicadomorpha, including sinoalids, cicadellids and cicadids (Poinar and Kritsky, 2012; Poinar and Brown, 2017; Chen J. et al., 2018). Herein we describe two new planthopper species preserved in Burmese amber, with many particular morphological characters, e.g. tegula and hind wing absent, body and tegmina covered with long and dense setae, foliaceous legs, tegmina subbrachypterous. All of these peculiar characters apparently indicate a new taxon in Fulgoroidea.

2. Materials and methods

The type amber specimens described herein were contributed by Mr. Zhengkun Hu and De Zhuo, the material was collected from amber deposits Kachin (Hukawng Valley) of Northern Myanmar, age of Burmese amber (Zhang X. et al., 2018 Fig. 1) is attributed to the earliest Cenomanian (98.79 ± 0.62 Ma) (Shi et al., 2012). This deposit yielded many well-preserved insect fossils (Chen S. et al., 2018; Li et al., 2018; Lin et al., 2018; Liu et al., 2018; Zhang W.T. et al., 2018). The ambers studied in this paper are housed in the Key Lab of Insect Evolution and Environmental Changes, College of Life Sciences, Capital Normal University in Beijing, China (CNUB; Yunzhi Yao, Curator).

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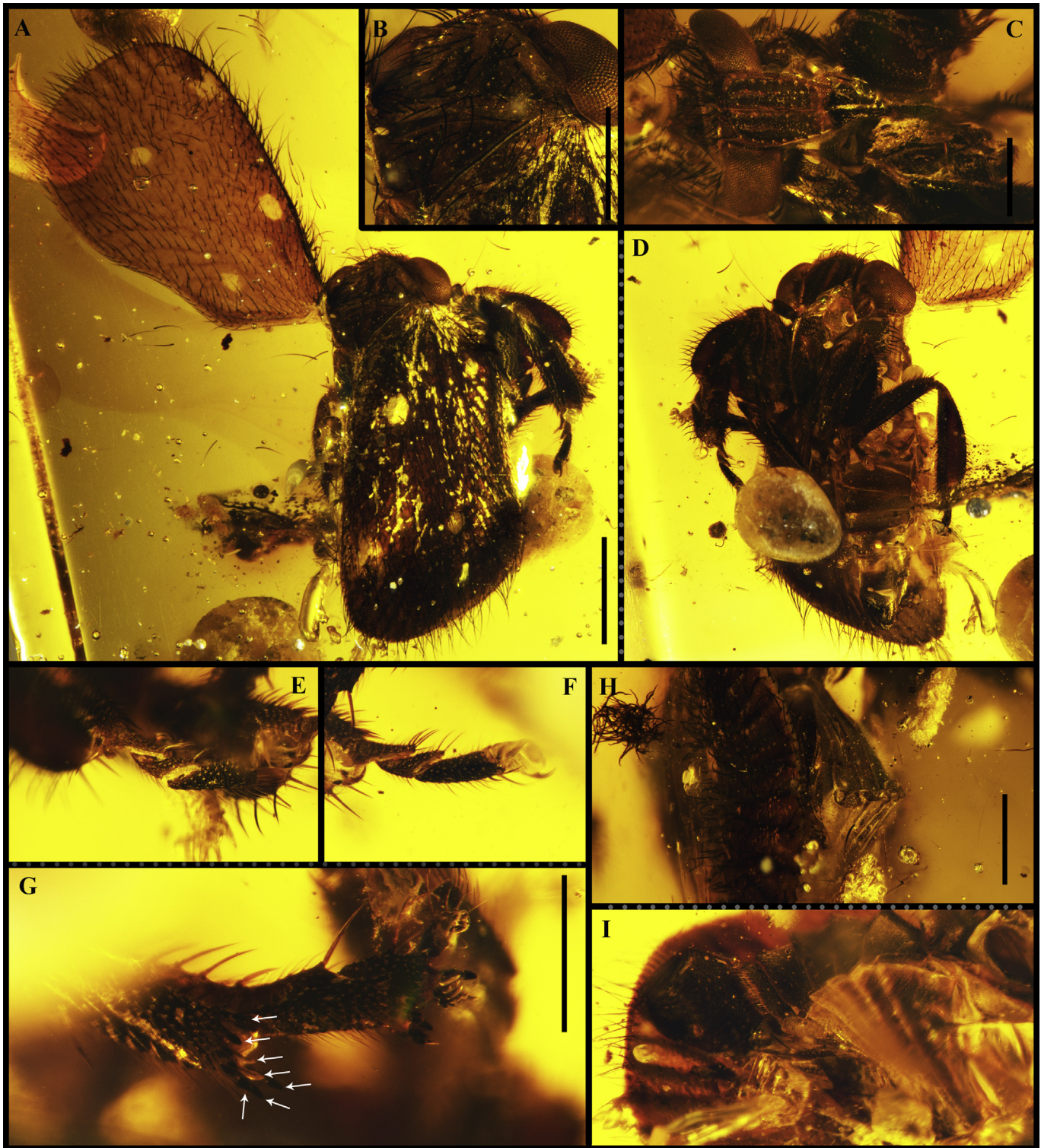


Fig. 1. Photographs of *Jubisentis hui* gen. et sp. nov. A, Habitus in dorsal view. B, head and thorax in dorsal view. C, Head in anteroventral view. D, Habitus in ventral view. E, Fore tarsus. F, Mid tarsus. G, Hind tarsus (the arrows are pointing to apical spines of hind tibia). H, Male genitalia in caudal view. I, Abdomen in lateral view. Scale bar for A, D = 1 mm; B–C, E–I = 0.5 mm. The scale bar of A is also valid for D; G is valid for E and F; H is valid for I.

The type specimens for study were examined and photographed using Nikon SMZ 25 microscope with a Nikon DS-Ri 2 digital camera system. The figures of line drawings were prepared by using Adobe Illustrator CS6 and Photoshop CS6 graphics software. The amber surfaces were polished, and all the measurements were showed in millimetres (mm).

3. Systematic palaeontology

Order Hemiptera [Linnaeus, 1758](#)
 Suborder Fulgoromorpha [Evans, 1946](#)
 Superfamily Fulgoroidea [Latreille, 1807](#)

Family Jubisentidae fam. nov.
Type genus: *Jubisentis* gen. nov.

Diagnosis. Small and compact planthoppers (3–5 mm), body and tegmina covered with long and dense setae, sensory pits absent at adult stage. Frons with median and lateral carinae, clypeus strongly raised, median carina of clypeus present, but lateral carinae absent, rostrum extending beyond hind coxae, apical segment longer than wide. Pronotum anterior margin exceeding middle level of eyes, posterior margin shallowly incised, each half of disc with a triangularly dark silhouette, median carina on pronotum only present in posterior area, mesonotum without carinae, tegula absent, tegmina subbrachypterous, veins indistinct or absent, claval suture and hind wing absent. Legs foliaceous, hind tibia without lateral teeth, hind midtarsomere with a row of apical teeth, all pectens of hind leg with subapical setae. Male pygofer elongate, female ovipositor ensiform and well developed.

Remarks. The new family belonging to the superfamily Fulgoroidea is based on these unique characters: antennae base situated below the eyes, pedicel broader than scape, with wart-like sensilla. But the new family Jubisentidae fam. nov. are characteristic of unique combination of features could clearly place it as a separate unit, such as tegula and hind wing absent, strongly modified venation, tegmina subbrachypterous, hind tibial pecten setigerous, foliaceous legs. And body covered with long and dense bristles are autapomorphic of this family.

In many characters the new erected family are similar to Cretaceous Perforissidae: body compact, primary median carina of frons present, clypeus carinate, pronotum much produced between eyes, covering vertex posteriorly, hind tibia without lateral teeth, hind tibial and tarsal pectens setigerous, female ovipositor ensiform and developed. But it is distinct in the absence of sensory pits and ocelli (Lack of ocelli is probably nymphal character retained in adults), posterior margin of pronotum shallowly incised, mesonotum without carina, claval suture reduced, tegmina most veins reduced or veins indistinct, and legs foliaceous. (In Perforissidae, sensory pits retained at adult stage, ocelli present, pronotum posterior margin deeply cleft, mesonotum with carinae, tegmina veins and claval suture normal, legs not foliaceous.) The monophyly of (Jubisentidae + Perforissidae) may be supported by two synapomorphies: hind tibial pecten setigerous, pronotum much produced between eyes, covering vertex posteriorly. Besides that, the features of sensory pits retained on head, thorax and abdomen at adult stage, sensory pits on face arranged in rows, pronotum posterior margin deeply cleft are synapomorphies of Perforissidae.

Genus *Jubisentis* gen. nov.

Etymology. The generic name is a combination of Latin 'jub-' meaning 'bristle' and 'sentis' meaning 'thorn', referring to the long setae. Gender masculine.

Type species. *Jubisentis hui* sp. nov.; by present designation.

Included species. Only type species.

Diagnosis. Lateral carinae on frons straight, only present toward top of head, junction between clypeus and frons slightly curved upward, apex of rostrum reaching middle of abdomen, shape of compound eyes transversely elongate in anteroventral view, posterior margin of pronotum exceeding eyes, size of pronotum larger than mesonotum, tegmina about two times as long as wide, with four light-colored spots, costal margin deeper concave proximad of midlength, most veins absent, only costal area with unclear veins, width of costal area/width of tegmen greater than 0.3, fore and mid femur and tibia, together with hind tibia foliaceous, hind tibia with a row of seven apical spines.

Jubisentis hui sp. nov. (Figs. 1–2)

Etymology. This specific name is dedicated to Mr. Zhengkun Hu for his contribution of this Burmese amber.

Type material. Holotype, CNU-HOM-MA2018001, adult male, well preserved, ventral view covered by large gas bubble.

Locality and horizon. Hukawng Valley, Kachin State, Northern Myanmar. Mid-Cretaceous, lowermost Cenomanian.

Diagnosis. Median carina of frons low, median carina of clypeus distinctly raised, mesonotum with two parallel dark bands, tegmina tectiform, only covering the abdomen, costal area with many parallel veins, hind femur carinate, hind tibia widened towards its apex, male gonostyles broad and concealing the aedeagus.

Description. A well-preserved specimen but right hind tarsus missing, adult male, total length of body about 3.61 mm.

Head. Head including compound eyes nearly 1.18 mm wide, wider than pronotum, vertex and frons covered with many long setae, lateral margins of vertex carinate, parallel, median carina of vertex absent. Frons slightly longer than broad, lateral margin with a marked keel, median carina complete, lateral carinae incomplete, marginal carinae not extending to clypeus, postclypeus covered with short setae, median carina of clypeus present and distinctly raised, compound eyes developed. Antennal scape short, pedicel covered with short setae, subcylindrical, with wart-like sensilla, flagellum about 0.80 mm long, whip-like.

Thorax. Pronotum covered with many long setae, size larger than mesonotum, extending forward up to level anterior to compound eyes, covering vertex posteriorly, anterior margin of pronotum arcuately convex, lateral carinae on pronotum absent. Mesonotum wider than long, covered with many long setae, apex pointed, anterior margin of mesonotum nearly straight, its disc with two parallel dark bands.

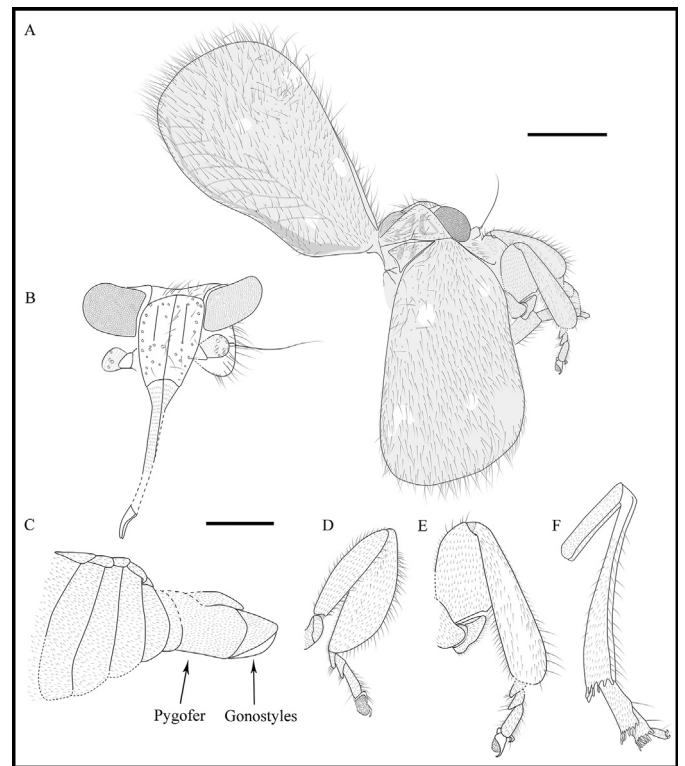


Fig. 2. Line drawings of *Jubisentis hui* gen. et sp. nov. A, Habitus in dorsal view. B, Head. C, Abdomen in ventral view. D, Fore leg. E, Mid leg. F, Hind leg. Scale bar for A = 1 mm; B–F = 0.5 mm.

Wings. Tegmina tectiform, only covering the abdomen, broad in apical portion, bearing long setae in tubercles, 3.25 mm long, 1.72 mm wide, about two times as long as wide, with four irregular light-colored spots, costal margin angulate at base, then slightly arcuate, apical margin mildly curved, posterior margin almost straight, wing-coupling fore fold absent, costal area developed, very broad, with many parallel and branched veins.

Legs. Fore leg 3.52 mm long, covered with densely short setae, coxa elongate, fore femur dilated and foliaceous, slightly shorter than fore tibia, inner margin provided with interlaced long setae, lateral surface bearing a row of long setae, fore tibia dilated and foliaceous, outer margin provided with interlaced long setae, lateral surface bearing a row of long setae, basitarsomere and midtarsomere of similar length, common length slightly longer than apical tarsomere, fore tarsomeres length: I 0.16 mm, II 0.19 mm, III 0.31 mm, arolium developed, tarsal claws large. Mid leg 3.65 mm long, covered with densely short setae, coxa elongate, mid femur dilated and foliaceous, much shorter than mid tibia, mid tibia dilated and foliaceous, long setae of mid femur and tibia as in fore leg, basitarsomere and midtarsomere short, common length longer than apical tarsomere, mid tarsomeres length: I 0.19 mm, II 0.22 mm, III 0.29 mm, arolium and tarsal claws similar to fore leg. Hind leg 3.06 mm long, covered with densely short setae, hind femur about 0.79 mm long, approximately half of hind tibia, carinate, hind tibia about 1.47 mm long, carinate, widened towards its apex, margins with long setae, basitarsomere the longest, 0.42 mm long, at least with nine apical spines, midtarsomere 0.24 mm long, at least with nine apical spines, apical margin almost straight, apical tarsomere small, 0.14 mm long, tarsal claws apparently smaller than fore and mid claws.

Abdomen. Part abdomen covered by large gas bubble, abdominal sternites III–VIII visible, medioventral pygofer process absent (ventral margin of pygofer is straight), lateral margins of pygofer expanded, anal tube truncate apically, anal styles invisible.

Genus **Furtivirete** gen. nov.

Etymology. The generic name is a combination of Latin 'furtiv-' meaning 'stolen' and 'rete' meaning 'net', referring to its indistinct meshwork veins. Gender neutrum.

Type species. *Furtivirete zhuoi* sp. nov.; by present designation.

Included species. Only type species.

Diagnosis. Lateral carinae on frons curved laterally, nearly present throughout, junction between clypeus and frons slightly curved upward, shape of compound eyes nearly semicircle in anteroventral view, posterior margin of pronotum not exceeding eyes, size of pronotum approximately the same as mesonotum, tegmina about 1.5 times as long as wide, costal margin almost straight, with untraceable and irregular meshwork veins, width of costal area/width of tegmen less than 0.3, fore and mid femur and tibia, together with hind tibia foliaceous, hind tibia with a row of eight apical spines.

Furtivirete zhuoi sp. nov. (Figs. 3–4)

Etymology. This specific name is dedicated to Mr. De Zhuo for his contribution of this Burmese amber.

Type material. Holotype, CNU-HOM-MA2018002, adult female, well preserved, but part rostrum and fore leg missing.

Locality and horizon. Hukawng Valley, Kachin State, Northern Myanmar. Mid-Cretaceous, lowermost Cenomanian.

Diagnosis. Median carina of frons low, median carina of clypeus raised, anterior margin of mesonotum almost straight, tegmina tectiform, only covering the abdomen, with many cells, hind femur shorter than hind tibia, hind tibia widened towards its apex, female ovipositor elongate, strong teeth on the external margin of gonopods absent.

Description. A well-preserved holotype, but fore tibia and tarsus missing, adult female, total length of body about 4.59 mm.

Head. Head including compound eyes about 1.55 mm wide, wider than pronotum, vertex and frons covered with long setae, vertex median carina absent, lateral margins carinate and parallel. Frons longer than broad, lateral margin with a marked keel, median carina complete, lateral carinae slightly incomplete, marginal carinae not extending to clypeus, median carina of clypeus present and distinctly raised, postclypeus covered with short setae, compound eyes developed. Antennal scape short, pedicel subcylindrical, covered with short setae, with many wart-like sensilla, flagellum about 0.77 mm long, whip-like.

Thorax. Pronotum covered with many long setae, size similar to mesonotum, extending forward up to level anterior to compound eyes, covering posterior vertex, anterior margin of pronotum arcuately convex, lateral carinae on pronotum absent. Mesonotum nearly as long as wide, covered with many long setae, apex pointed, anterior margin of mesonotum almost straight.

Wings. Tegmina tectiform, slightly broad in apical portion, only covering the abdomen, bearing many long setae in tubercles, 4.22 mm long, 2.87 mm wide, about 1.5 times as long as wide, costal margin angulate at base, then slightly arcuate, apical margin mildly round, posterior margin almost straight, wing-coupling fore fold absent, costal area developed, very broad, tegmina with illegible reticulate venation.

Legs. Fore leg covered with densely short setae, coxa elongate, fore femur dilated and foliaceous, inner margin provided with interlaced long setae, lateral surface bearing a row of long setae, fore tibia partly preserved, dilated and foliaceous. Mid leg 5.18 mm long, covered with densely short setae, coxa elongate, mid femur dilated and foliaceous, much shorter than mid tibia, inner margin provided with interlaced long setae, lateral surface bearing a row of long setae, mid tibia dilated and foliaceous, outer margin provided with interlaced long setae, lateral surface bearing a row of long setae, basitarsomere and midtarsomere of similar length, common length longer than apical tarsomere, mid tarsomeres length: I 0.25 mm, II 0.15 mm, III 0.34 mm, arolium developed, tarsal claws large. Hind leg 3.04 mm long, covered with densely short setae, hind femur about 0.88 mm long, apparently shorter than hind tibia, hind tibia about 1.48 mm long, widened towards its apex, margins with long setae, basitarsomere longest, 0.29 mm long, at least with eight apical spines, midtarsomere 0.20 mm long, at least with nine apical spines, apical margin almost straight, apical tarsomere thin, 0.19 mm long, tarsal claws apparently smaller than mid claws.

Abdomen. Abdomen with genital segment about 2.33 mm long, covered with densely short setae, pregenital segments gradually contracted, ovipositor up curved, basal part of gonapophysis VIII visible, gonopods elongate, strong teeth on the external margin absent, anal tube with a lobe, anal styles visible and elongate.

4. Discussion

This new family Jubisentidae are characteristic of a particular set of characters, sometimes are shared with other planthoppers, such as lack of tegulae and hind wing also appear in Delphacidae, Cixiidae, Dictyopharidae and Caliscelidae; foliaceous legs are present among various families of planthoppers, e.g. Issidae, Caliscelidae, Eurybrachidae, Lophopidae, Delphacidae, Dictyopharidae; untraceable, reduced or strongly modified venation pattern is present in some Dictyopharidae, Tropicuchidae, Issidae and Lophopidae; tegmina subbrachypterous resembles Issidae related group. But the new erected family differ from Delphacidae by the absence of a movable apical spur of hind tibia; distinct from

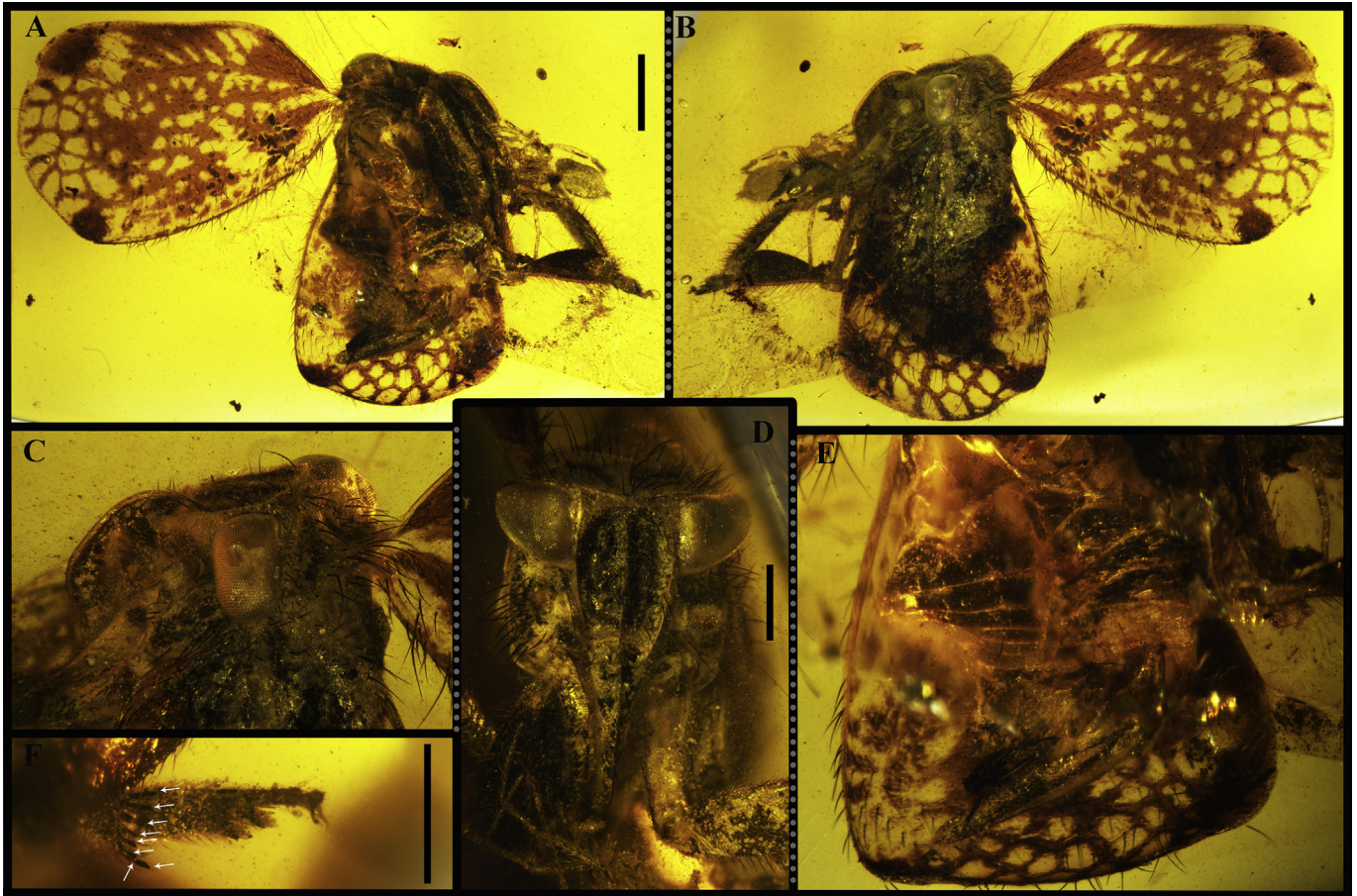


Fig. 3. Photographs of *Furtivirete zhuoi* gen. et sp. nov. A, Habitus in right lateral view. B, Habitus in left lateral view. C, Head and thorax in lateral view. D, Head in anteroventral view. E, Abdomen in lateral view. F, Hind tarsus (the arrows are pointing to apical spines of hind tibia). Scale bar for A–B = 1 mm; C–F = 0.5 mm. The scale bar of A is also valid for B; D is valid for C and E.

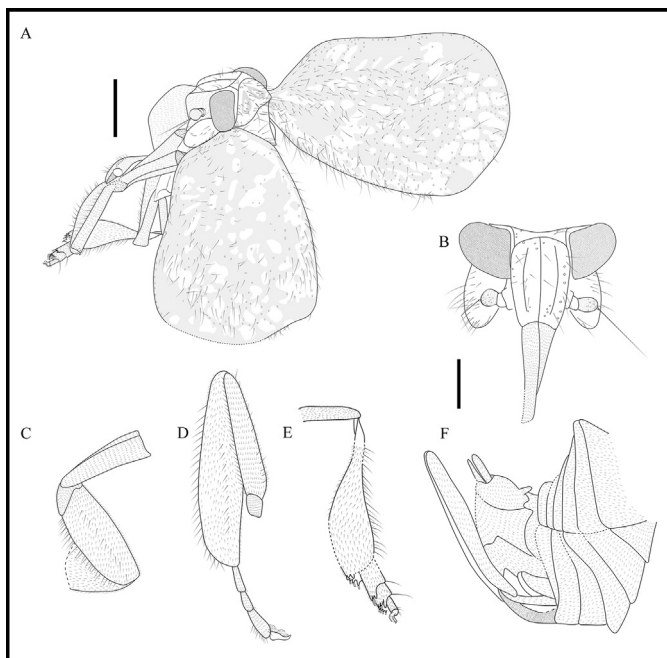


Fig. 4. Line drawings of *Furtivirete zhuoi* gen. et sp. nov. A, Habitus in left lateral view. B, Head. C, Fore leg. D, Mid leg. E, Hind leg. F, Abdomen in lateral view. Scale bar for A = 1 mm; B–F = 0.5 mm.

Cixiidae and Dictyopharidae in hind tibial pecten setigerous, pronotum much produced between eyes, covering vertex posteriorly; differ from Issidae related group and some other higher planthoppers in hind midtarsomere with a row of apical teeth, all pectens of hind leg with subapical setae. In addition, Jubisentidae are also similar to Perforissidae in many characters, such as the unique shape of their body and pronotum, the pattern of frons and clypeus carinae, setigerous pectens of hind legs, and the structure of ovipositor. In summary, this new family Jubisentidae with unique combination of features, e.g. tegulae and hind wing absent, foliaceous legs, strongly modified venation, tegmina subbrachypterous. Although many of these characters can be traced in other unrelated planthopper groups, the new taxa apparently can't be attributed to any known family in Fulgoroidea, so that they are placed in a new family, and body covered with long and dense setae are autapomorphic of the new family. These new taxa seem to be closely related to Perforissidae from their common morphological features, they constitute a group of neotenous planthoppers in the Cretaceous (ocelli absence is probably nymphal character retained in adult Jubisentidae; sensory pits retained at adult Perforissidae).

Jubisentidae present hind tibial pecten setigerous, this character was believed to be a plesiomorphic condition (Emeljanov, 1987). Based on the characters of hind tibial pecten setigerous and at least in part sensory pits retained in imagines, some researchers attributed several extinct planthopper families to a pre-cixioid group, including Surijokocixiidae, Fulgoridiidae, Lalacidae,

Perforissidae, Mimarachnidae and Dorytocidae (Shcherbakov, 2007b; Emeljanov and Shcherbakov, 2018). But many families in this group apparently be inconsistent with its features, such as sensory pits retained in imagines is not observed in Lalacidae, Fulgoridiidae, Surijokocixiidae and Dorytocidae; hind tibial pecten setigerous is not observed in Fulgoridiidae, Surijokocixiidae and Dorytocidae. Besides that, there are also great differences in main characters of these families, for instance, Mimarachnidae wings with irregular meshwork veinlets, mesonotum median carinae double; Perforissidae pronotum produced between compound eyes and deeply cleft posteriorly; Dorytocidae legs foliaceous, etc. Therefore, it's inappropriate for the group to include these extinct families only on the basis of the above two characters. On the other hand, the Jurassic family 'Fulgoridiidae' (paraphyletic unit) were believed as ancestors of highly diversified extinct and recent planthopper families (Szwedo et al., 2011), and some cixiidae like taxa present in the early Cretaceous (e.g. Cixiidae, Lalacidae, Achilidae), probably derived from some lineages of 'Fulgoridiidae'. But the Cretaceous new family Jubisentidae and Perforissidae apparently differ from Fulgoridiidae in many structures, e.g. body compact, pronotum much produced between eyes, hind tibial pecten setigerous, sensory pits retained in imagines, or tegula and hind wing absent, legs foliaceous, body and tegmina covered with long and dense setae, and they also don't possess common plesiomorphies with Fulgoridiidae. Therefore, Jubisentidae as well as Perforissidae seem to be not closely related to the known 'Fulgoridiidae'. These indicate the complex relationships of Mesozoic early planthoppers are possibly beyond our imagination, their exact placements are quite challenging.

Jubisentidae tegula and hind wing absent, this feature is very rare in Fulgoroidea, usually occur in some extreme resident planthoppers, such as members of strongly troglitic delphacids and cixiids (Hoch et al., 2003, 2006); representatives of Orgeriinae (Fulgoroidea: Dictyopharidae) associated with arid regions (Woodward, 1960; Song et al., 2018); and some caliscelids inhabiting native grassland remnants (Bess, 2005). These planthoppers without tegula and hind wings are usually paralleled by reduction of flight capability. Besides that, according to Hoch (2002), tegmina and hind wings cease to function, muscular apodemes of mesothorax degenerate, could result in a weakly carinate and planate mesonotum. Jubisentidae tegula and hind wing absent, mesonotum small and planate, without carinae, these characters possibly suggest a reduced flight capability of this new family.

Jubisentidae fore and mid femur and tibia, hind tibia are foliaceous. In adult planthoppers, the foliaceous legs are thought to be widely homoplastic (Hamilton, 2011), known in many extant families, such as Issidae, Caliscelidae, Eurybrachidae, Lophopidae, Delphacidae and Dictyopharidae (Soulier-Perkins, 1998; O'Brien, 2002; Constant, 2005; Hamilton, 2011; Chen et al., 2014; Song et al., 2018); and the extinct family Dorytocidae (nymphs with foliaceous fore and mid tibia) (Emeljanov and Shcherbakov, 2018). The function of foliaceous legs has been postulated to help planthoppers living on plants mask shadows, seems to be adaptive for crypsis (Cott, 1940; Emeljanov and Shcherbakov, 2018). On the other hand, Jubisentidae tegmina subbrachypterous, for planthoppers inhabiting rain forests, this wing type is probably related to mimicry (Gnezdilov, 2013), it's interesting that Burmese amber forest is a typical wet and tropical rainforest at that time (Selden and Ren, 2017), therefore, we presume the new family wing is possibly also related to mimicry. The foliaceous legs, subbrachypterous tegmina, as well as body and tegmina covered with long and dense setae, these unique features seem to imply a cryptic lifestyle of these flightless insects, they may live on some peculiar surface of habitat, plant or background.

5. Conclusions

A new family Jubisentidae fam. nov. with two new genera and species from mid-Cretaceous Burmese amber are documented, include *Jubisentis hui* gen. et sp. nov. and *Furtivirete zhuoi* gen. et sp. nov. The new family may be closely related to Perforissidae, both of them are not close relatives of Fulgoridiidae. The 'pre-cixioid group' is probably inappropriate. Some unique characters of this new family possibly imply its reduced flight capability and a cryptic survival strategy.

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