

# A new species of *Foveopsis* Shcherbakov (Hemiptera: Fulgoroidea: Fulgoroidea: Perforissidae) from mid-Cretaceous Burmese amber



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## ABSTRACT

A new species, *Foveopsis heteroidea* sp. nov. is described from the mid-Cretaceous Burmese amber based on four well-preserved specimens. The abundance and distribution of sensory pits in adult Perforissidae may not be considered as classification character. Well-preserved wing-coupling apparatus and nodal line indicate Perforissidae should have a moderately versatile flight capability, and with the help of atmospheric flow, Perforissidae had a broad geographical distribution in Cretaceous. Sexual difference of new species is briefly discussed, indicates it in planthopper has already existed in the Cretaceous.

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## 1. Introduction

The extinct planthopper family Perforissidae Shcherbakov, 2007 is currently placed in the 'Cixiidae-like' planthoppers (Szwedo, 2009). This peculiar group presents a combination of particular morphological characters not to be found among either extinct or extant Fulgoroidea (Szwedo et al., 2013).

So far, Perforissidae comprise two subfamilies and seven monospecific genera, fossil records are fairly rare, only from the Cretaceous: subfamily Perforissinae, comprising *Perforissus muii* Shcherbakov, 2007 from the Late Cretaceous of New Jersey and *Cretargus emeljanovi* Shcherbakov, 2007 from the Late Cretaceous of Taimyr; subfamily Cixitettiginae, comprising *Cixitettix yangi* Shcherbakov, 2007 from the Late Cretaceous of Taimyr, *Foveopsis fennahi* Shcherbakov, 2007 from the mid-Cretaceous of Myanmar, *Tsaganema oshanini* Shcherbakov, 2007 from the Early Cretaceous of Mongolia, *Iberofoveopsis miguelesi* Peñalver and Szwedo, 2010 from the Early Cretaceous of Spain and *Aafrita biladalsama* Szwedo et al., 2013 from the Early Cretaceous of Lebanon. Nymphs belonging to this family were also recorded in the Early Cretaceous Jordanian amber (Kaddumi, 2007). Herein we find several amber specimens with well-preserved sensory pits and wing-coupling apparatus from the mid-Cretaceous of Burmese.

Sexual difference exists in some extant planthoppers, including Issidae, Eurybrachidae, Cixiidae, Delphacidae, Caliscelidae, expressed by the difference of body coloration and shape, wing reduction, and drumming organ (Hoch, 1988; O'Brien, 1988; Asche, 1990; Constant, 2006; Gnezdilov et al., 2014). But sexual difference is quite rare in fossil planthoppers, only reported from Perforissidae (Shcherbakov, 2007), in this article, we describe a new sexual difference also from this family.

## 2. Materials and methods

The type specimens studied herein derive from amber deposits in Kachin (Hukawng Valley) of Northern Myanmar, the age of Burmese amber is documented as  $98.79 \pm 0.62$  Ma (Shi et al., 2012). The Burmese amber deposits contain diversity of fossil insect, such as hymenopterans (Guo et al., 2016), dipterans (Gao et al., 2016), dermapterans (Ren et al., 2017), neuropterans (Yuan et al., 2016), etc. The type specimens are housed in the Key Lab of Insect Evolution and Environmental Changes, College of Life Sciences, Capital Normal University, Beijing, China.

The amber specimens were examined and photographed by using a Nikon SMZ 25 microscope with a Nikon DS-Ri 2 digital camera system. Line drawings were prepared by using Adobe Illustrator CS6 and Photoshop CS6. Venation terminology follows the interpretations proposed by Szwedo and Žyia (2009), and Nel et al. (2012).

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### 3. Systematic palaeontology

Order Hemiptera Linnaeus, 1758

Suborder Fulgoromorpha Evans, 1946

Superfamily Fulgoroidea Latreille, 1807

Family Perforissidae Shcherbakov, 2007

Subfamily Cixitettiginae Shcherbakov, 2007

Genus *Foveopsis* Shcherbakov, 2007

Type species: *Foveopsis fennahi* Shcherbakov, 2007

Included species. *Foveopsis fennahi* Shcherbakov, 2007 and *Foveopsis heteroidea* sp. nov.

Revised diagnosis. Transverse carina of vertex interrupted medially; forewing RP with 2 branches, M single, M + CuA stem about as long as basal cell, the bifurcation of CuA slightly apicad of claval veins junction, CuA<sub>2</sub> single, clavus open. Mesonotum with median depression and rudimentary Y-shaped median carinae and lateral carinae. Hind tibia, basitarsomere and midtarsomere widened apically, tibial pecten with less than 10 teeth. Ovipositor developed, ensiform, shorter than hind tibia, bent to pygophore.

***Foveopsis heteroidea* sp. nov.** (Figs. 1–7)

Etymology. The specific name is from a Latin word '*heteroideus*' (meaning 'heteromorphic'), referring the sexual difference.

Type material. Holotype: CNU-HOM-MA2017003, adult female, well preserved. Paratypes: CNU-HOM-MA2017001, adult female, with mid leg missing; CNU-HOM-MA2017002, adult female, abdomen partly obscured by large gas bubble; CNU-HOM-MA2017004, adult male, ventral view covered with thick milky layer.

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

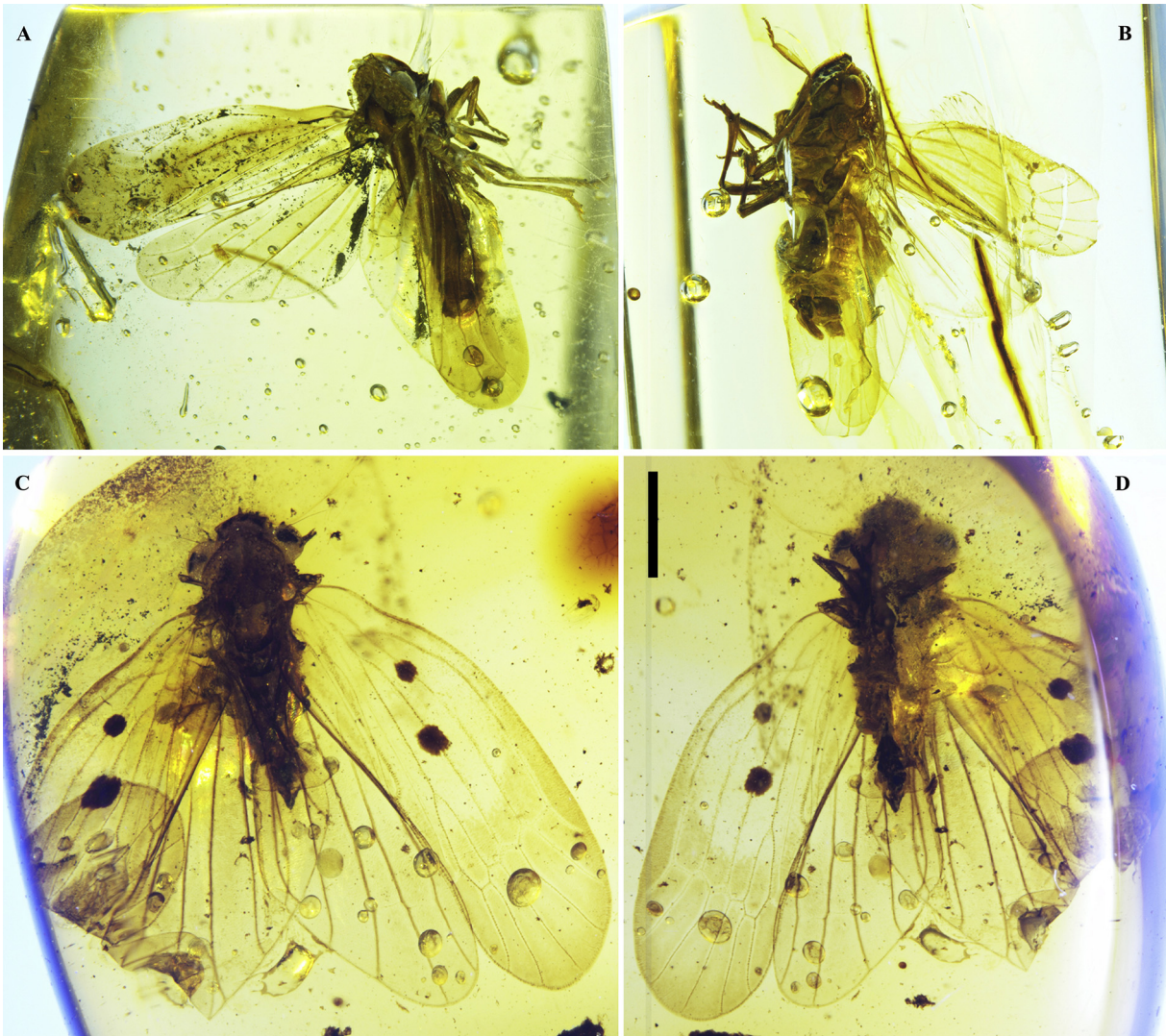
Diagnosis. Hind tibia without lateral spine, tibio-metatarsal formula 9(9): 7(7): 5(5), tegmen with two black spots, costal margin gibbous slightly proximad of midlength, ScRA single, ScRA and RP leaving basal cell from a same point.

Sexual difference, female: vertex anterior margin two corners steeply arched; mesonotum with shallow median depression. Male: vertex longer, anterior margin two corners angulate, mesonotum with deeper median depression, and narrower than female at mid line.

Remarks. The new species belongs to the family Perforissidae mainly based on the unique characters: presence of sensory pits in adult, tegmina narrow with four main stems and little distal branching, pronotum deeply cleft posteriorly and produced between eyes, apical pecten of hind tibia setigerous. *F. heteroidea* sp. nov. can be referred to the subfamily Cixitettiginae based on the presence of uniserial apical pectens on hind tibia, first and second tarsomeres. This new species is excluded from the other genera of



**Fig. 1.** Holotype of *Foveopsis heteroidea* sp. nov. A, Photograph of dorsal view. B, Photograph of ventral view. C, Line drawing of dorsal view. D, Line drawing of ventral view. Scale bar = 1 mm.



**Fig. 2.** Paratypes of *Foveopsis heteroidea* sp. nov. Photographs. A, CNU-HOM-MA2017001. B, CNU-HOM-MA2017002. C, Dorsal view CNU-HOM-MA2017004. D, Ventral view CNU-HOM-MA2017004. Scale bar = 1 mm.

Cixitettiginae mainly by the combination of characters: forewing RP with 2 branches (RP single in *Iberofoveopsis*), M single (M with two branches in *Iberofoveopsis* and *Aafrita*), M + CuA stem about as long as basal cell (M + CuA stem longer than basal cell in *Cixitettix*), clavus open (clavus closed in *Iberofoveopsis*), mesonotum with median depression and rudimentary Y-shaped median carinae and lateral carinae (without this character in other genera).

*F. heteroidea* sp. nov. is compared with *F. fennahi* Shcherbakov, 2007 in the following characters: new species hind tibia without lateral spine (vs. a tiny lateral spine), tibio-metatarsal formula 9(9): 7(7): 5(5) (vs. 7(7): 7(7): 5(5)), tegmen with contrasting pale and dark pattern, with two black spots (vs. unicolorous), costal margin gibbous slightly proximad of midlength (vs. the same level of midlength), ScRA single (vs. forked), ScRA and RP leaving basal cell from a same point (vs. from a short common stalk).

**Description.** Mainly based on holotype, unless indicated as on paratype. A well-preserved holotype but abdomen unclear, adult female, total length of body female about 3.03 mm (Fig. 1A), male about 2.62 mm (Fig. 2C).

**Head.** Head including compound eyes 1.13 mm wide, slightly wider than pronotum (Fig. 1A, C). Vertex posteriorly covered by anterior

margin of pronotum, length of visible portion 0.08 mm at mid line; lateral edges carinate, slightly converging anteriorly; transverse carina interrupted medially; anterior margin in dorsal view carinate, angulate at junction with slightly arched median carina of frons and two corners steeply arched (vertex apparently longer, two corners angulate in male (Fig. 2C)). Frons (based on paratype CNU-HOM-MA2017001) subrectangular, slightly longer than broad at mid line; median carina complete, distinct and protruded, slightly arched in lateral view; lateral margins of frons forming a marked keel; 12 large sensory pits present on each half of frons. Junction between frons and clypeus almost straight. Median carina and lateral carinae present on postclypeus and extending to anteclypeus; length of rostrum unclear, apical segment of rostrum slightly longer than wide, shorter than penultimate one, apex dark, with a group of flocculent sensilla, stylets produced from labial tip (Fig. 4A). Compound eyes large. Ocelli present and distinct, adjacent to the lateral carinae of frons. Antennal foveae elevated, scape very short, ring-like; pedicel subcylindrical; flagellum whip-like, about 0.29 mm long (Fig. 4B).

**Thorax.** Pronotum narrower than head (including compound eyes), anterior margin rounded, extends forward beyond posterior of eyes and vertex; posterior margin with deep acutangular incision;

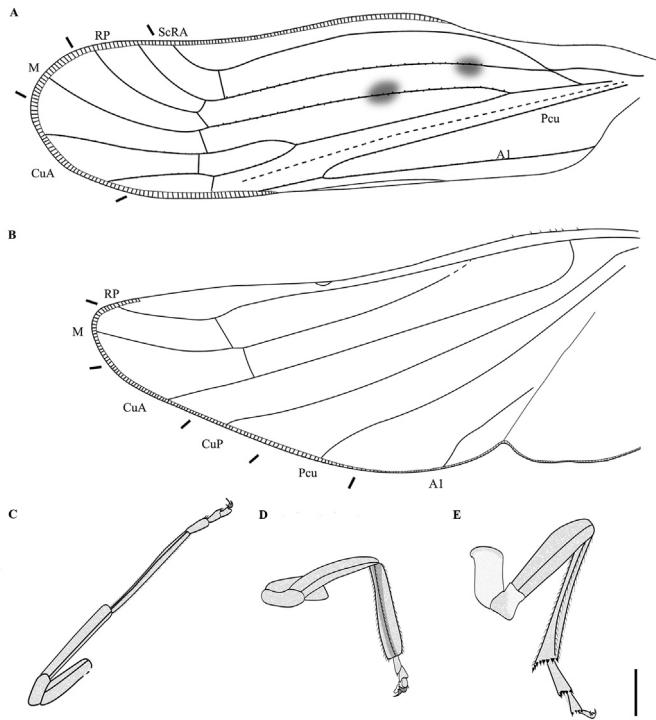


Fig. 3. Holotype line drawings of *Foveopsis heteroidea* sp. nov. A, Left forewing. B, Left hind wing. C, Fore leg. D, Mid leg. E, Hind leg. Scale bar = 0.25 mm.

anterior and posterior margins carinate; median carinae on pronotum present nearly throughout; about 30 sensory pits of different sizes on each half of disc, at least 7 sensory pits present on lateral lobes of pronotum. Mesonotum with shallow median depression and rudimentary Y-shaped median and lateral carinae, with three sensory pits at left side in posterolateral portions and two at right side. In male paratype mesonotum slightly narrower than in female, and with deeper median depression (Fig. 2C). Tegula small, angulate.

Wings. Wings open, tegmen (Fig. 3A) about 3 times as long as wide (3.28 mm long, 1.03 mm wide), with contrasting pale and dark pattern, and two black spots; costal margin gibbous slightly proximad of midlength, several small spines on surface at base, veins with tubercles (Fig. 4G), margin of tegmen from claval apex to base of costal area transversely wrinkled; clavus open, position of claval apex in apical half of tegmen, coupling lobe about midlength. Costal margin slightly widened at base, basal cell elongate, about 5 times as long as wide, ScRA and RP leaving basal cell from a same point, ScRA not forked before apex, curved at about 3/4 wing length to costal margin, RP forked, with 2 branches, stems M and CuA running from basal cell with a short common stalk (about as long as basal cell), M single, the bifurcation of CuA slightly apicad of claval veins junction, branch CuA<sub>2</sub> simple, Pcu and A1 fused nearly the same level of midlength, free stem of Pcu longer than common stem Pcu + A1. Transverse veinlet *ir* placed slightly proximad of the bifurcation of RP, veinlet *r-m* little more apicad, veinlet *m-cu* nearly the same level of *r-m*, veinlet *icua* little more apicad than *m-cua*, intercubital veinlet between CuA<sub>2</sub> and tornus (postclaval margin) connected to wing margin apicad of claval apex.

Hind wing (Fig. 3B) membranous, slightly wider than tegmen, with transversely wrinkled margin, coupling lobe about midlength, several microspines on the costal margin at base, branch RP curved nearly to hind wing apex, M fused with ScR basally of midlength, stem CuA separated from common stalk of ScR + M at the base of

wing, single up to margin, CuP and Pcu nearly straight, anal lobe developed with A1, secondary fold present in the anal area, jugal lobe wide.

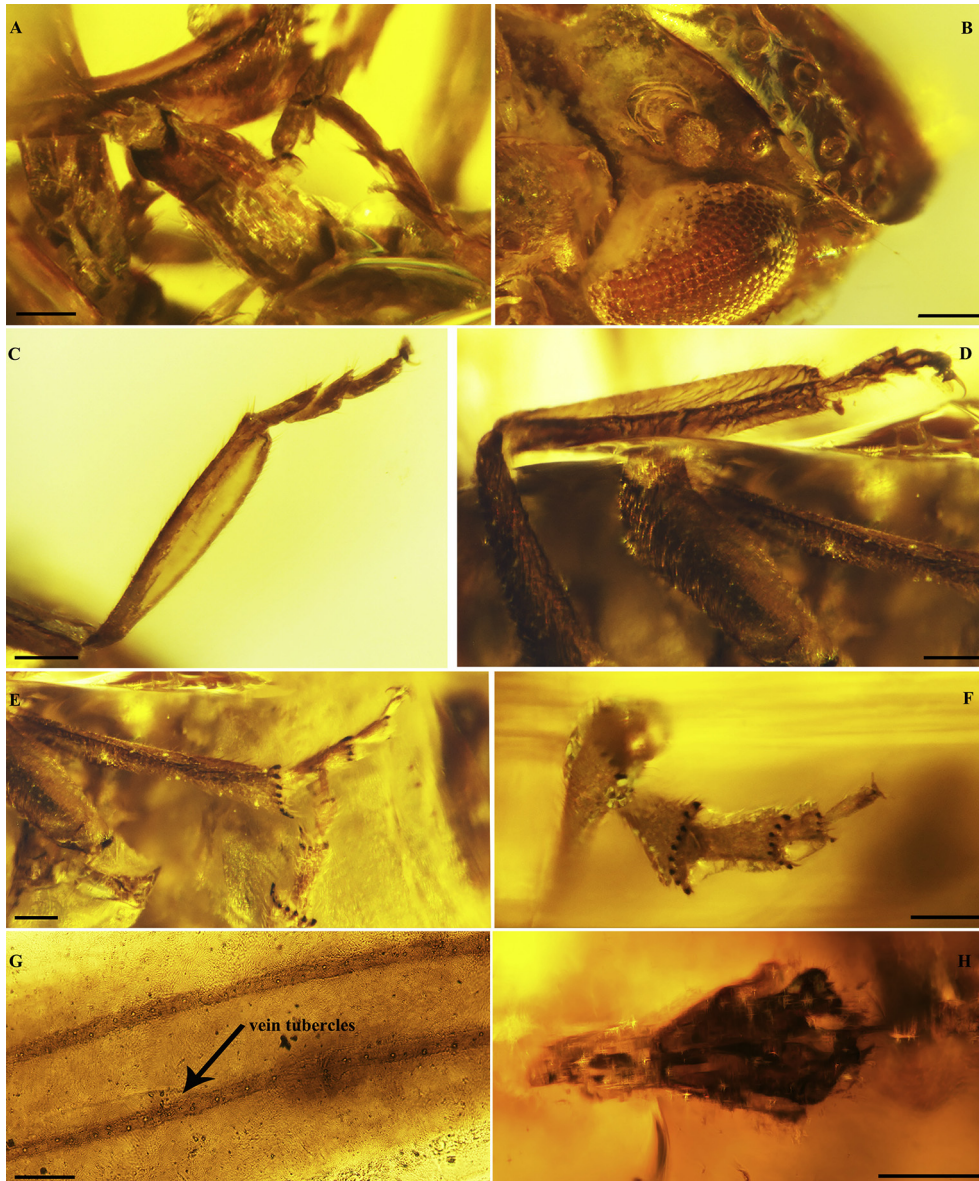
Legs. Fore leg (Fig. 3C) 1.75 mm long, coxa carinate; fore femur about as long as tibia, carinate, subquadrate in cross section; fore tibia margins carinate, covered with short setae, flattened and widened towards apex (Fig. 4C); length of fore tarsomeres: I 0.1 mm, II 0.08 mm, III 0.08 mm, tarsal claws and arolium developed. Mid leg (Fig. 3D) 1.58 mm long, mid femur carinate, subquadrate in cross section; mid tibia margins carinate, covered with short setae, flattened and widened towards apex (Fig. 4D); length of mid tarsomeres: I 0.09 mm, II 0.06 mm, III 0.06 mm, tarsal claws and arolium as in fore leg. Hind leg (Fig. 3E) slender, 1.98 mm long with uniserial tibial and tarsal apical pectens; hind coxae stick together, hind femur about 0.49 mm long, carinate, subquadrate in cross section, hind tibia about 0.72 mm long, without lateral spine, carinate, covered with short setae, widened towards apex, with 9 apical setigerous teeth separated by interval (Fig. 4E); basitarsomere 0.17 mm long with 7 apical setigerous teeth, shorter than common length of mid and apical tarsomeres; midtarsomere 0.12 mm long, with 5 apical setigerous teeth; apical tarsomere (0.1 mm) shorter than midtarsomere, tarsal claws and wide arolium developed. Tibio-metatarsal formula 9(9): 7(7): 5(5) (Fig. 4F).

Abdomen. Based on female paratype CNU-HOM-MA2017002 (Fig. 5A, B), abdomen partly blocked by large gas bubble, pygofer with nearly straight posterior margin, anal tube elongate, apex clearly defined, anal style visible; ovipositor developed, about 0.6 mm long, shorter than hind tibia, ensiform with inner valvulae cutting, up curved, basal portion of gonapophysis VIII visible, well developed, gonoplasts relatively developed, elongated, insertion attached by a large base well sclerotized, apex acutely rounded (Fig. 5C, D). Male abdomen apparently smaller than female, male genitals poorly preserved, only gonostylus visible (Fig. 4H).

#### 4. Discussion

Sensory pits are specific organs in fulgoroid nymphs and very rare in adults (Emeljanov, 2001), usually placed on head and thorax (Peñalver and Szwedo, 2010). The role of sensory pits as hygro-receptors was postulated by Šulc (1928), but it is still not supported by experimental evidence. Arrangement of sensory pits is usually applied in classification of nymphs (Zhou et al., 1985). At the late instars or adults, sensory pits usually disappear, but are sometimes retained and used in adults' classification (Szwedo, 2008; Emeljanov, 2014). In adults Perforissidae, this pedomorphic character is also retained (Szwedo et al., 2013). Peñalver and Szwedo (2010) distinguished two genera of Perforissidae from sensory pits, but our new specimens show this character is unreliable, e.g. In paratype CNU-HOM-MA2017001, 12 sensory pits present on each half of frons (Fig. 6A). In paratype CNU-HOM-MA2017002, left half of frons with 14 but right half with 15 sensory pits (Fig. 6B). In holotype, right half of frons with at least 14 visible sensory pits (Fig. 6C); and 3 sensory pits at mesonotum left side, but 2 at right side (Fig. 6E). These indicate, in adults Perforissidae, the abundance and distribution of pedomorphic sensory pits is variable, to some extent, this character could not be considered as classification basis.

Wing-coupling apparatus is well preserved in the new species (Fig. 7A, B), forewing with a longitudinal wing-coupling fore fold (WCFF), hind wing with a short lobe (the wing coupling lobe-WCL). A row of peg-like setae present on the hind wing costal margin at base (Fig. 7C), according to D'urso and Ippolito (1994), in all observed cercopids, cicadellids, membracids and some species of Fulgoromorpha, 1 or 2 rows of sensillae are present along the costal margin of hind wing, between the WCA and wing articulation.



**Fig. 4.** Detailed photographs of *Foveopsis heteroidea* sp. nov. A–C, Paratype CNU-HOM-MA2017002. A, Rostrum. B, Head lateral view. C, Fore leg. D, Mid leg of holotype. E, Hind leg of holotype. F, Hind tarsus of paratype CNU-HOM-MA2017001. G, Forewing veins tubercles of holotype. H, Male genitals of paratype CNU-HOM-MA2017004. Scale bar = 0.1 mm.

These sensillae have real bristles, are peg-like setae, and are probably involved in the perception of coupling and uncoupling movements of the wings. The coupled fore and hind wings can operate together as a single aerofoil, hind wing gain most anterior support from forewing, in effect, form an additional deformable area, and increase flight versatility (Wootton, 1992, 1996). Another wing component in Perforissidae is nodal line, in many Hemiptera, nodal line is a most obvious form of gentle curve in wing ventral transverse flexion (Wootton, 1996). It seems probable these flexion lines allow a wider range of speeds, in the interest of flight versatility, transverse ventral bending in the upstroke may become still more useful in insects where fore and hind wings are coupled into a single functional aerofoil (Wootton, 2003). Perforissidae should have a higher capacity of flight. Some extant species of Delphacidae are capable of producing macropterous (long-winged) adults, move to new patches of suitable habitat response to higher population density or resource shortages. Wing-coupling apparatus and nodal line also contribute to their flight. In their migratory flights, they are

assisted by convection and favorable winds, migrations may cover hundreds of kilometers even across the vast sea (Chen et al., 1989; Dietrich, 2009). Perforissidae is a small extinct family, known only from the Cretaceous, fossils recorded from about 125 Ma to 85 Ma, only span 40 Ma. According to Szwedo et al. (2013), the representatives of Perforissidae had been widespread along both southern and northern shores of the Peritethys Sea, reaching far north to Mongolia. So we presume a higher migration ability may contribute to broad geographical distribution of Perforissidae in such a short period, like some delphacids, its broad geographical distribution may also associate with the moderately versatile flight capability and helpful atmospheric flow.

We attribute male and female specimens to the same species based on their common features: tegmen with two black spots in the same position, costal margin gibbous slightly proximad of midlength, ScRA not forked, ScRA and RP leaving basal cell from a same point, Cu<sub>2</sub> single, clavus open, mesonotum with median depression and rudimentary Y-shaped median carinae and lateral

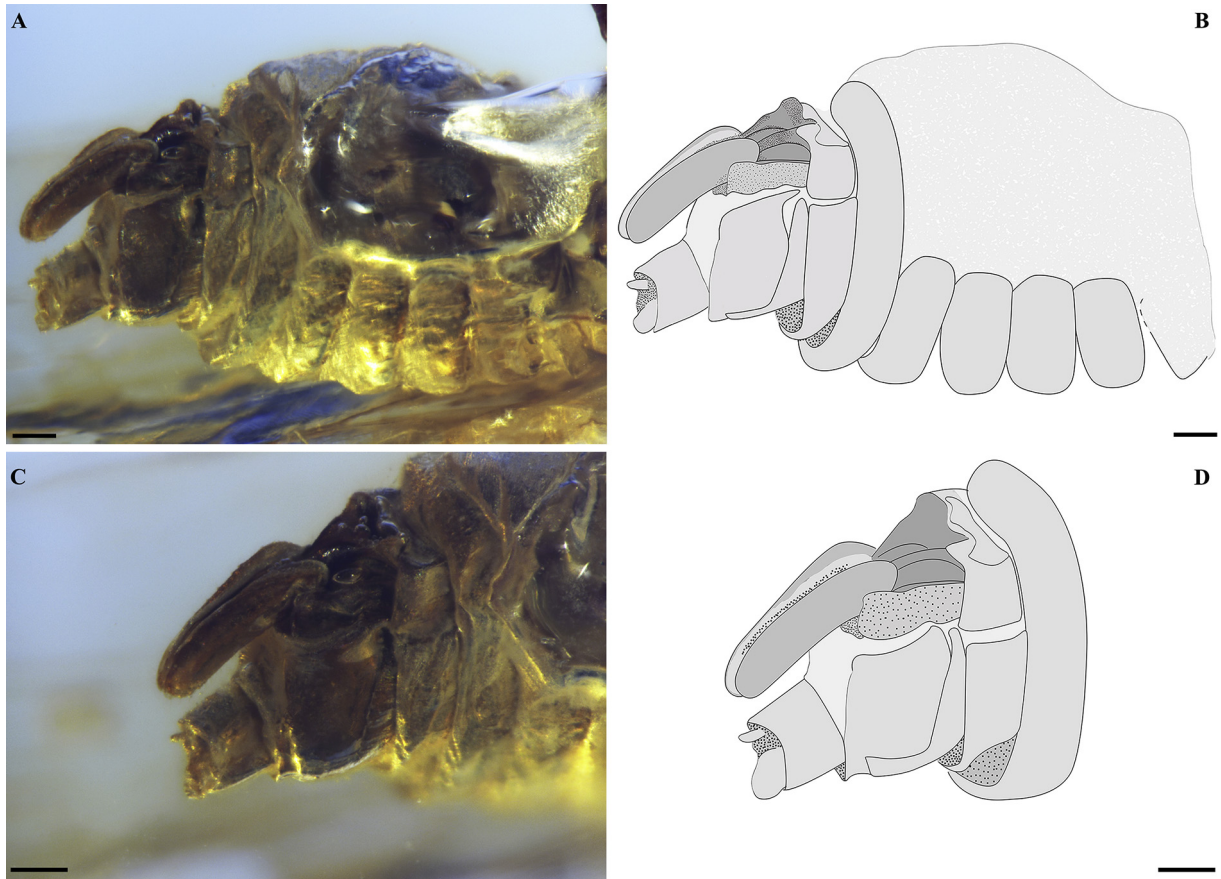


Fig. 5. Photographs and Line drawings of paratype CNU-HOM-MA2017002. *Foveopsis heteroidea* sp. nov. A–B, Abdomen. C–D, Female genitalia. Scale bar = 0.1 mm.

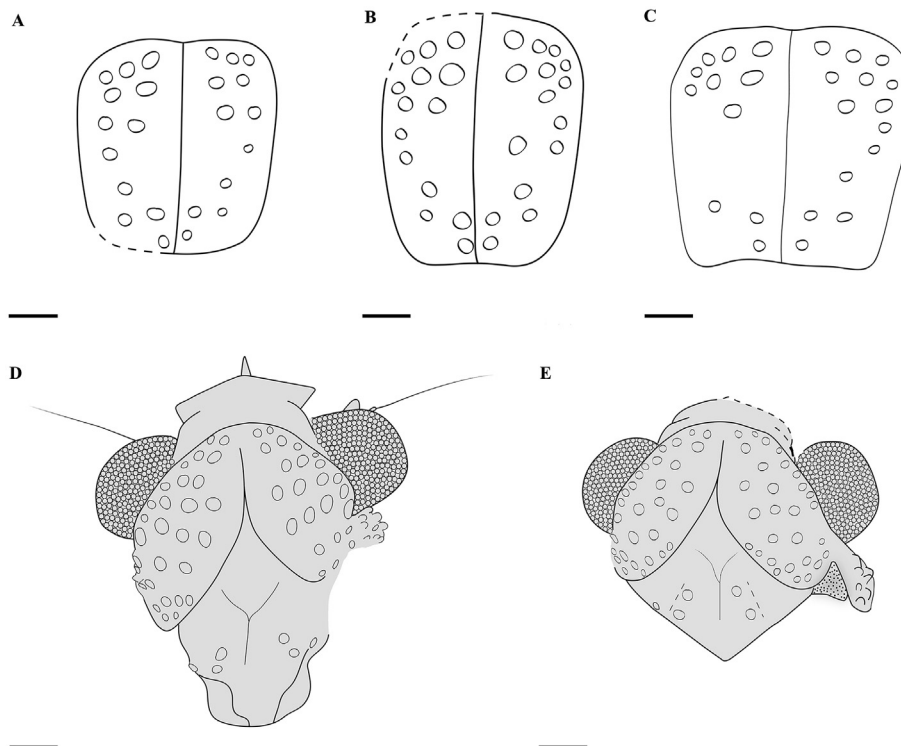
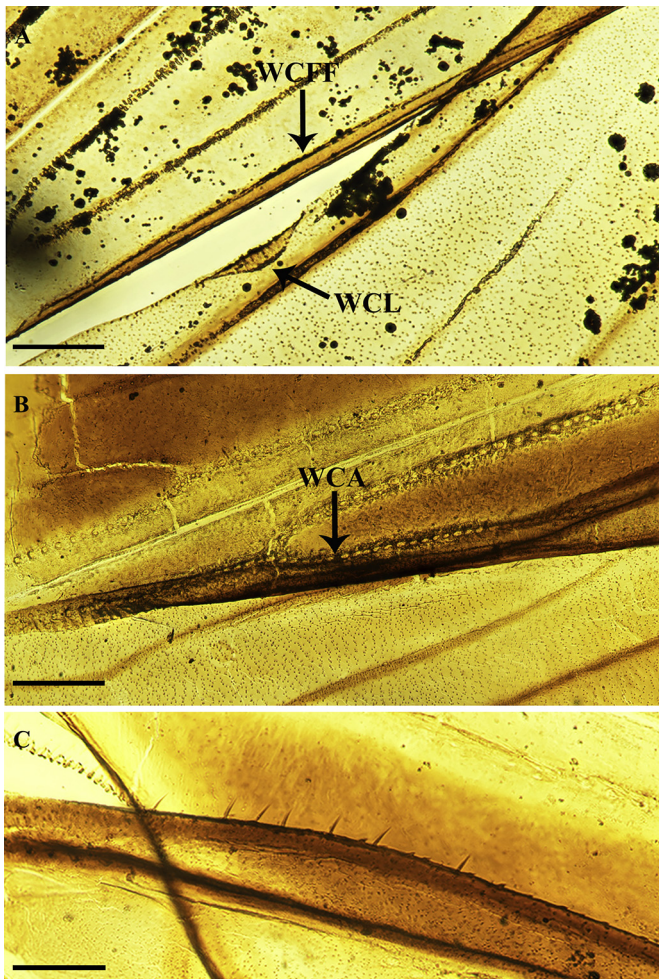


Fig. 6. Line drawings of *Foveopsis heteroidea* sp. nov. A, Frons of paratype CNU-HOM-MA2017001. B, Frons of paratype CNU-HOM-MA2017002. C, Frons of holotype. D, Male head and thorax of paratype CNU-HOM-MA2017004. E, Female head and thorax of holotype. Scale bar for A–C = 0.1 mm; D–E = 0.2 mm.



**Fig. 7.** Photographs of *Foveopsis heteroidea* sp. nov. A, Wing-coupling apparatus of paratype CNU-HOM-MA2017001, uncoupled. B, Wing-coupling apparatus of holotype, coupled. C, Microspines at base of hind wing of holotype. Scale bar = 0.1 mm. Abbreviation: WCF, wing-coupling fore fold; WCL, wing coupling lobe; WCA, wing-coupling apparatus.

carinae, fore and mid tibia flattened and widened. Perforissidae is a small extinct family, only seven monospecific genera have been reported, abundance and diversity relatively lower. Both male and female specimens from the same deposits Burmese amber. On the basis of insect population biology, combined with their common morphological features, we think these specimens should be attributed to a same species. For their sexual difference (Fig. 1A, 2C, 6D, E): male specimen size smaller, abdomen narrower and smaller than female, vertex longer, two corners of anterior margin angulate relative to female steeply arched, mesonotum with deeper median depression, and narrower than female at mid line. *P. muiri* Shcherbakov, 2007 also showed similar difference in the shape of head. Sexual difference of fossil planthoppers only reported from this family, this discovery indicates sexual difference in planthoppers has already existed in the Cretaceous.

## 5. Conclusions

*Foveopsis heteroidea* sp. nov. is assigned to Perforissidae on the basis of morphological characters of venation and body. We find the abundance and distribution of sensory pits is variable in adults Perforissidae and could not be considered as classification feature. Well-preserved wing-coupling apparatus and nodal line indicate

Perforissidae with a capability of moderately versatile flight, its broad geographical distribution in Cretaceous may associate with this flight capability and helpful atmospheric flow. New sexual difference is also reported from this family, indicates this difference in planthoppers has already existed in the Cretaceous.

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## References

- Asche, M., 1990. Vizcayinae, a new subfamily of Delphacidae with revision of Vizcaya Muir (Homoptera: Fulgoroidea) – a significant phylogenetic link. *Bishop Museum Occasional Papers* 30, 154–187.
- Chen, R.C., Ding, J.H., Tan, H.Q., Hu, G.W. (Eds.), 1989. *The migration of Entomology*. Agricultural Press, Beijing, China, pp. 348–351.
- Constant, J., 2006. Revision of the Eurybrachidae (VII). The Australian genera *Hackerobrachys* and *Fletcherobrachys* (Hemiptera: Fulgoromorpha: Eurybrachidae). *Entomologie* 76, 31–40.
- Dietrich, C.H., 2009. Auchenorrhyncha: (Cicadas, Spittlebugs, Leafhoppers, Treehoppers, and Planthoppers). In: Dietrich, C.H. (Ed.), *Encyclopedia of Insects*. Elsevier Inc, pp. 56–64.
- D'Urso, V., Ippolito, S., 1994. Wing-coupling apparatus of Auchenorrhyncha (insecta: Homoptera). *International Journal of Insect Morphology & Embryology* 23 (3), 211–224.
- Emeljanov, A.F., 2001. Larval characters and their ontogenic development in Fulgoroidea (Cicadina). *Zoosystematica Rossica* 9 (1), 101–121.
- Emeljanov, A.F., 2014. A new tribe, a new genus, and a new species of the subfamily Dictyopharinae (Homoptera, Dictyopharinae) from Chile. *Entomological Review* 94 (9), 1323–1328.
- Evans, J.W., 1946. External morphology and systematic position (Part 1). In: Evans, J.W. (Ed.), *A natural classification of the leaf-hoppers (Jassoidea, Homoptera)*. Transactions of the Royal Entomological Society, London 96 (3), 47–60.
- Gao, J.Q., Shih, C.K., Ren, D., 2016. New species of Limoniidae (Diptera) from Myanmar amber, Upper Cretaceous. *Cretaceous Research* 58, 42–48.
- Gnezdilov, V.M., Bourgoïn, T., Soulier-Perkins, A., 2014. A new genus of the tribe Caliscelini (Hemiptera, Fulgoroidea, Caliscelidae) from Vietnam. *Zootaxa* 3900 (2), 255–262.
- Guo, L.C., Shih, C.K., Li, L.F., Ren, D., 2016. New peleciniid wasps (Hymenoptera: Peleciniidae) from Upper Cretaceous Myanmar amber. *Cretaceous Research* 67, 84–90.
- Hoch, H., 1988. A new cavernicolous planthopper species (Homoptera: Fulgoroidea: Cixiidae) from Mexico. *Mitteilungen der Schweizerischen Entomologischen Gesellschaft* 61, 295–302.
- Kaddumi, H.F. (Ed.), 2007. *Amber of Jordan: the oldest prehistoric insects in fossilized resin*, Second ed. Publications of the Eternal River-Museum of Natural History, Amman (Jordan), p. 268.
- Latreille, P.A. (Ed.), 1807. *Genera Crustaceorum et Insectorum secundum ordinem naturalem in familias disposita, iconibus exemplisque plurimis explicata*. Armand Koenig, Paris & Argentorat, 2 (80), 258.
- Linnaeus, C. (Ed.), 1758. *II. Hemiptera. Systema Naturae, per regna tria naturae, secundum classes, ordines, genera, species cum characteribus, differentiis, synonymis, locis. Editio decima, reformata* 1, pp. 1–824.
- Nel, A., Prokop, J., Nel, P., Grandcolas, P., Huang, D.Y., Roques, P., Guilbert, E., Dostál, O., Szwedo, J., 2012. Traits and evolution of wing venation pattern in paraneopteran insects. *Journal of Morphology* 273, 480–506.
- O'Brien, L.B., 1988. Taxonomic changes in North American Issidae (Homoptera: Fulgoroidea). *Annals of the Entomological Society of America* 81 (6), 865–869.
- Peñalver, E., Szwedo, J., 2010. Perforissidae (Hemiptera: Fulgoroidea) from the Lower Cretaceous San Just amber (Eastern Spain). *Alavesia* 3, 97–103.
- Ren, M.Y., Zhang, W.T., Shih, C.K., Ren, D., 2017. A new earwig (Dermaptera: Pygidicranidae) from the Upper Cretaceous Myanmar amber. *Cretaceous Research* 74, 137–141.
- Shcherbakov, D.E., 2007. An extraordinary new family of Cretaceous planthoppers (Homoptera: Fulgoroidea). *Russian Entomological Journal* 16, 139–154.
- Shi, G., Grimaldi, D.A., Harlow, G.E., Wang, J., Yang, M., Lei, W., Li, Q., Li, X., 2012. Age constraint on Burmese amber based on U-Pb dating of zircons. *Cretaceous Research* 37, 155–163.
- Šulc, K., 1928. Die Wachsdrüse und ihre Produkte bei den Larven der Cixiinen (Homoptera). *Biologické Spisy Vysoké školy Zvěrolékařské* 7 (3), 1–32.

- Szwedo, J., 2008. A new tribe of Dictyopharidae planthoppers from Eocene Baltic amber (Hemiptera: Fulgoromorpha: Fulgoroidea), with a brief review of the fossil record of the family. *Palaeodiversity* 1, 75–85.
- Szwedo, J., 2009. First discovery of Neazoniidae (Insecta, Hemiptera, Fulgoromorpha) in the Early Cretaceous amber of Archingeay, SW France. *Geodiversitas* 31, 105–116.
- Szwedo, J., Żyła, D., 2009. New Fulgoridiidae genus from the Upper Jurassic Karatau deposits, Kazakhstan (Hemiptera: Fulgoromorpha: Fulgoroidea). *Zootaxa* 2281, 40–52.
- Szwedo, J., Azar, D., Nohra, Y., 2013. First record of Perforissidae from the Early Cretaceous Lebanese amber (Hemiptera: Fulgoromorpha: Fulgoroidea). In: Azar, D., Engel, M.S., Jarzembowski, E., Krogmann, L., Nel, A., Santiago-Blay, J. (Eds.), *Insect evolution in an Amberiferous and stone Alphabet*. Brill, Leiden, pp. 145–163.
- Wootton, R.J., 1992. Functional morphology of insect wings. *Annual Review of Entomology* 37, 113–140.
- Wootton, R.J., 1996. Functional wing morphology in Hemiptera systematics. In: Schaefer, C.W. (Ed.), *Studies on Hemiptera phylogeny*. Thomas Say Publications in Entomology, Proceedings, Lanham, Maryland, pp. 179–198.
- Wootton, R.J., 2003. Reconstructing insect flight performance from fossil evidence. *Acta Zoologica Cracoviensia* 46, 89–99.
- Yuan, D.D., Ren, D., Wang, Y.J., 2016. New beaded lacewings (Neuroptera: Berthoidea) from Upper Cretaceous Myanmar amber. *Cretaceous Research* 68, 40–48.
- Zhou, Y., Lu, J.S., Huang, J., Wang, S.Z. (Eds.), 1985. *Economic insect fauna of China, Fasc. 36, Homoptera Fulgoroidea*. Science Press, Beijing, China, p. 15.