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A new fossil psyllid, *Cacopsylla trigona* sp. nov. (Hemiptera: Psylloidea: Psyllidae), from the Miocene of China

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Psyllinae, a subfamily of Psyllidae, currently includes 29 genera (Burckhardt & Ouvrard, 2012; Ouvrard, 2018), of which *Cacopsylla* Ossiannilsson, 1970 is the most species-rich genus, distributed mainly in the Northern Hemisphere (Li, 2011; Ouvrard, 2018). In China, more than 300 extant species of *Cacopsylla* have been reported (Yang *et al*., 2004; Li, 2011; Luo *et al*., 2012, 2016). Based on recent molecular phylogenetic analyses, *Cacopsylla* in its current sense is a polyphyletic genus (Percy *et al*., 2018; Cho *et al*., 2019).

To date, fossil records of *Cacopsylla* in Miocene have been very scarce and only ten species have been described: four from the Early Miocene Argun Formation of Ukraine (Klimaszewski, 1993), and six from the Middle Miocene Karagan Formation of Russia (Becker-Migdisova, 1964, Klimaszewski, 1993). Herein, we describe a new fossil species of *Cacopsylla*, *C. trigona* **sp. nov.**, which was collected from the Garang Formation at Caergen Village (N35°21′3.67″, E101°38′24.97″, 3700 m), Zeku County, eastern Qinghai Province (eastern part of Tibetan Plateau), China. The age of the Garang Formation is Middle Miocene (16–19 Ma) (Li *et al*., 2016; Yang *et al*., 2018) and fossils constitute a lacustrine-fluvial sedimentary succession (Guo, 1980; Fang *et al*., 2005). These exposed oil shale beds attributed to the Garang Formation yield not only abundant, exquisitely saved fossil plants (Wu *et al*., 2019; Li *et al*., 2017), but also diverse fossil insects, such as Diptera, Hemiptera, Hymenoptera, and Neuroptera (Li *et al*., 2016; Yang *et al*., 2018).

Material and methods

Our work was based on female and male adult specimens. The fossils were examined under a Nikon NI-SSR microscope with an attached Nikon DS-RI 2 digital camera system. The line drawings were composed from part and counterpart and drawn with the aid of Adobe Photoshop® CC and Adobe Illustrator® CC software. The total body length was measured along the midline from the top of the head anterior margin to the fore wing apex. The vertex width was measured between the inner margins of compound eyes. The antennal length excludes the terminal setae. The length of hind legs excludes claws. Measurements are provided in millimeters (mm).

The morphological terminology follows Hodkinson & White (1979), Brown & Hodkinson (1988) and Ossiannilsson (1992).

All type specimens are deposited in the Key Lab of Insect Evolution and Environmental Changes, Capital Normal University, Beijing, China (CNU; Yunzhi Yao, curator).

Systematic palaeontology

Order Hemiptera Linnaeus, 1758
Suborder Sternorrhyncha Amyot & Audinet-Serville, 1843
Superfamily Psylloidea Latreille, 1807
Family Psyllidae Latreille, 1807
Subfamily Psyllinae Latreille, 1807
Genus *Cacopsylla* Ossiannilsson, 1970

Type species. *Chermes mali* Schmidberger, 1836; by original designation.

***Cacopsylla trigona* sp. nov.**
(Figs. 1–2)

Diagnosis. Head inclined from longitudinal body axis at about 45°, wider than mesoscutum (Fig. 1). Forewing broadly rounded apically, with nearly straight anterior

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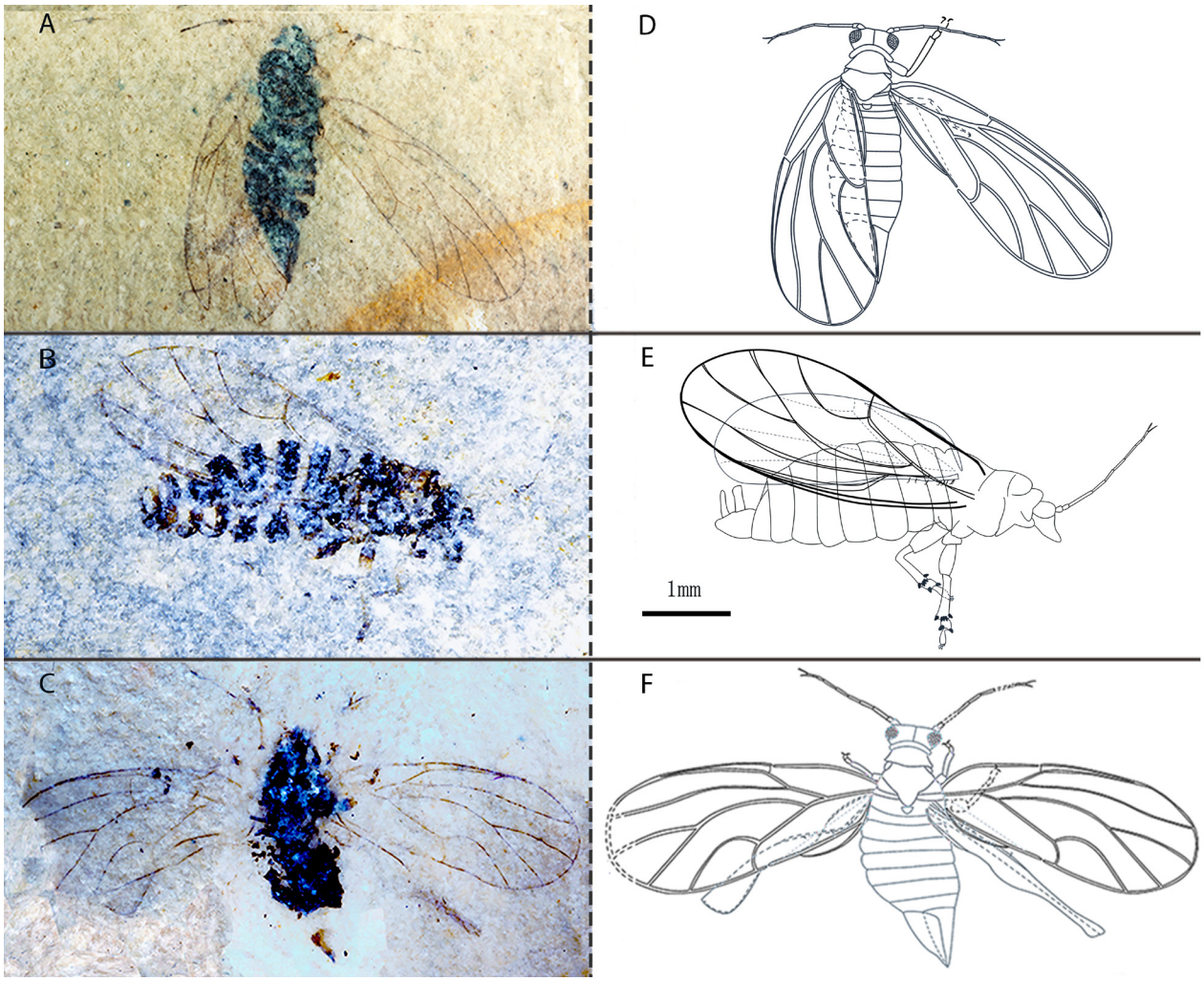

FIGURE 1. *Cacopsylla trigona* **sp. nov.**, photographs under alcohol (left) and outlines (right). **A** and **D**, Holotype, female (CNU-HOM-PS2018001). **B** and **E**, Paratype, male (CNU-HOM-PS2018002). **C** and **F**, Paratype, female (CNU-HOM-PS2018003).

margin medially, pterostigma long, narrowly triangular, costal break situated in basal 1/3 of costal margin, Cu_{1b} short, strongly curved at apex, cell cu_1 slightly longer than m_1. Male proctiger straight, produced posteriad apically. Paramere slender, nearly straight, narrowly rounded apically. Female terminalia elongate, cuneate.

Etymology. The specific name is derived from the Greek adjective '*trigonos*', meaning 'three-angled', referring to the triangular proctiger of males.

Type material. Holotype (only one part). Female. No. CNU-HOM-PS2018001; Paratypes: 1 male, No. CNU-HOM-PS2018002, and 1 female, No. CNU-HOM-PS2018003.

Description. Body elongate, irregularly fusiform.

Head in dorsal view (Fig. 1A, C, D, F) slightly wider than mesoscutum, vertex inverted-trapezoidal; in lateral view (Fig. 1B, E), inclined by about 45° from longitudinal body axis, keeping within an arched dorsal outline with thorax. Genal processes in lateral view moderately long, subacute (Fig. 1E). Compound eyes subglobular, extended ventrally. Median and lateral ocelli not visible. Antenna (Figs. 1, 2G) 3.5–3.9 times as long as head width in dorsal view, with ten elongate cylindrical flagellomeres.

Forewing (Fig. 2A) oblong oval, over twice longer than wide, widest in apical third, apex broadly rounded. Costal margin convex basally, straight medially; costal break distinct; pterostigma long and slender, triangular, extending to apical third of r_1. $R+M+Cu_1$ branching into R and $M+Cu_1$; R more than 1.5 times longer than $M+Cu_1$; Rs slightly sinuate; M twice longer than M_{3+4}; M_{3+4} straight, cell m_1 triangular; Cu_1 about three times longer than $M+Cu_1$, Cu_{1a} strongly arched medially, Cu_{1b} short, strongly curved apically. Forewing membrane with dense surface spinules; reduced in cell c+sc; radular spinules forming small rounded or fan-shaped patches at outer margins of cells r_2, m_1, m_2 and cu_1. Hindwing (Fig. 2B) membranous, with $M+Cu_1$ present, costal margin with eight ungrouped costal setae basally and one seta medially.

Legs (Fig. 2C) with femora stout, cylindrical; tibiae straight, metatibia distinctly widening apically, with five sclerotized apical spurs arranged in 1+3+1. Meracanthus subacute, with apex slightly curved downwards.

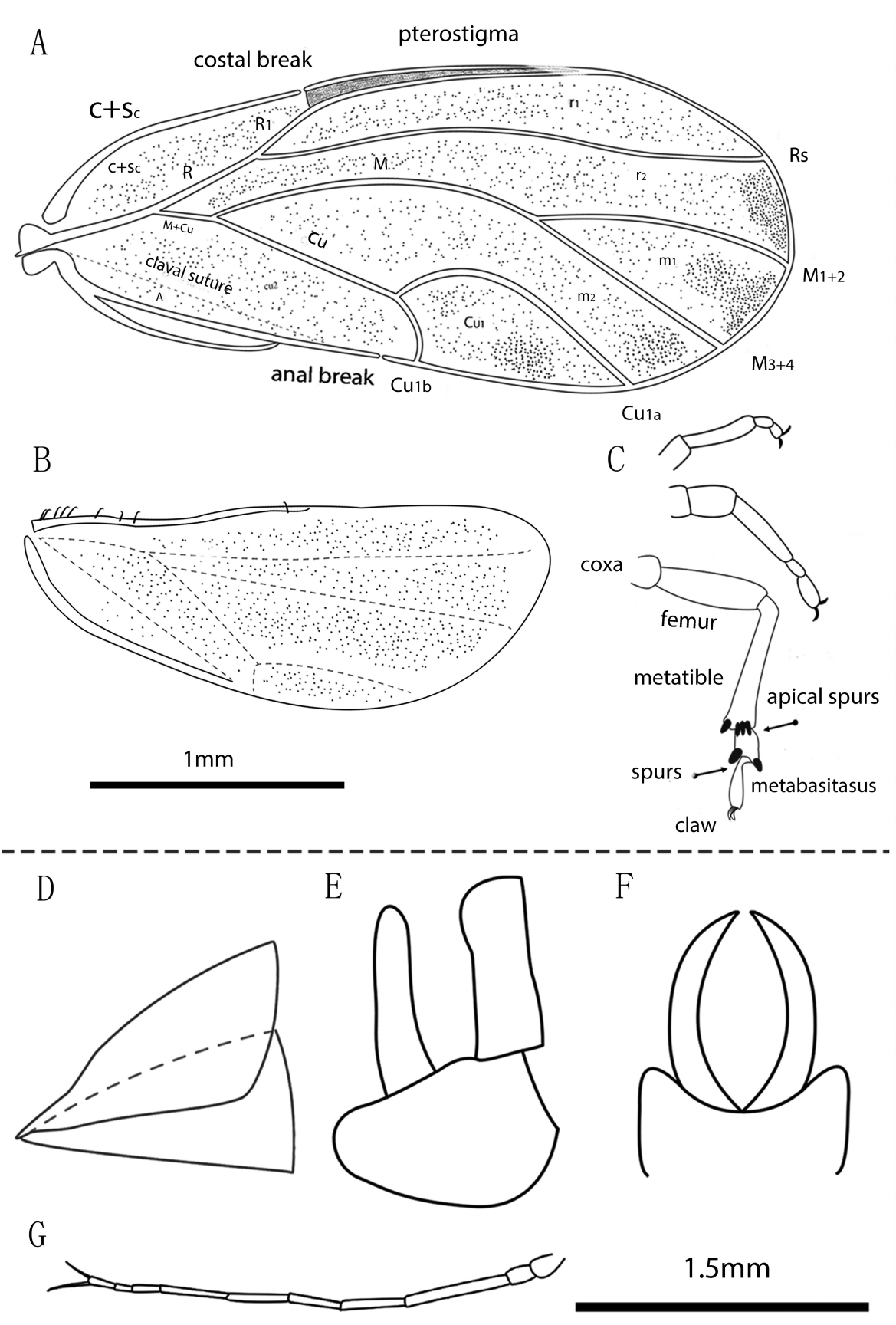

FIGURE 2. *Cacopsylla trigona* **sp. nov.**, outline drawings. **A**, Right forewing with areas of surface and radular spinules. **B**, Right hindwing. **C**, Legs. **D**, Female terminalia, lateral view. **E**, Male terminalia, lateral view. **F**, Parameres, posterior view. **G**, Antenna. Scale bars = 1.0 mm (**A**–**C**), 1.5 mm (**D**–**G**).

Female terminalia (Fig. 2D) elongate, cuneate; proctiger tapered apically, longer than sub-genital plate. Subgenital plate slightly curved upwards apically. Male terminalia (Fig. 2E, F) with subgenital plate elongate, irregularly ovoid; proctiger slender, produced posteriad subapically; paramere narrowly lamellar, narrowly rounded apically in lateral view, slender, regularly arched and pointed apically in posterior view.

Measurements (in mm). Female: total body length 3.51–3.84; body length excluding wings 2.75; head width (HW) 0.31–0.35; antennal length (AL) 1.22; forewing length (FL) 2.54–2.92; forewing width (FW) 1.27; pterostigma length 1.55, pterostigma basal width 0.21; hind wing length 1.84; ratios: AL/HW 0.66; FL/FW. Male: total body length 2.34–3.45; body length excluding wings 2.57; HW 0.25–0.28; AL 1.03; genal process length 0.33; FL 2.41–3.06; FW 1.20; hind wing length 1.69; hind leg length 1.06; metatibia length 0.38; ratios: AL/HW 0.61.

Remarks. *C. trigona* **sp. nov.** can be assigned in *Cacopsylla* by the following combination of characters: genal processes developed, relatively stout, with subacute apices; forewing broadly oval, with straight anterior margin medially, pterostigma present and narrowly triangular, R+M+Cu_1 split into R and M+Cu_1, and R 1.5 times as long as M+Cu_1; metabasitarsus with a pair of sclerotized spurs, metatibia with 5 apical spurs arranged in (1+3+1).

Locality and horizon. Caergen Village, Zeku County, Qinghai Province, Northeastern China; Garang Formation, Miocene.

Discussion

This new species resembles several extant Palaearctic *Cacopsylla* species associated with *Acer* (Aceraceae), such as *C. lineaticeps* (Kwon, 1983), *C. verticillida* Li & Yang 1989 and *C. abieti* (Kuwayama, 1908), in the subapically widened paramere and, short conical, not sinuate or curving female proctiger. However, its forewing shape and venation, including the relatively long and narrow cell m_1, and the flat cell cu_1, resemble the two large complexes that are associated respectively with *Salix* (Salicaceae) and Elaeagnaceae. However, no conclusion about the group placement of the species can be made here. Further better preserved materials are required to reveal the affinity of *Cacopsylla trigona* **sp. nov.**.

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