Pauropsylla tikouae sp. nov. (Hemiptera: Triozidae), a new psyllid from Yunnan, China in leaf galls on *Ficus tikoua* (Moraceae)

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Abstract: A new species of psyllid, *Pauropsylla tikouae* Xu & Zheng **sp. nov.**, is described from Kunming, Yunnan, China based on the morphology of adults. This new species is associated with leaf galls on the important horticultural plant *Ficus tikoua*. It is easily distinguished from closely-related *Pauropsylla* species by having different host plants, and the morphology of anterior wings in Rs extension direction and a length ratio of M/M_{1+2}. Molecular data show that *P. tikouae* **sp. nov.** has the highest identity of 83.1% with the *COI* gene of congeneric species. Field observations show that approximately five generations of psyllids emerge per year, which significantly impacts the visual appeal of *F. tikoua* as ground cover ornamentals.

Key words: Psylloidea; taxonomy; gall

中国云南地果叶片致瘿新种——地果小木虱（半翅目：个木虱科）

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摘要：记述采自中国云南昆明的 1 个木虱新种：地果小木虱 *Pauropsylla tikouae* **sp. nov.**，该新种可在重要园艺植物地果 *Ficus tikoua* 叶片上形成虫瘿。地果小木虱可通过形态特征和宿主植物与近缘物种进行区分，尤其是前翅脉 Rs 的延伸方向和 M 与 M_{1+2} 的比值；分子数据显示地果小木虱与近缘物种现有 *COI* 基因序列的一致性最高为 83.1%。田间观察表明，地果小木虱每年大约发生 5 代，形成的叶片虫瘿影响了地果作为地被观赏植物的视觉吸引力。

关键词：木虱总科；分类；虫瘿

Introduction

Psyllids or jumping plant lice are small phloem-sucking insects that can form leaf galls on dicots (Chen 2008; Li 2011; Percy *et al*. 2016). *Pauropsylla* was originally described as belonging to the family Triozidae Löw (1879) by Rübsaamen (1899), based on the type species *P. udei* from Liberia (Ouvrard 2015), which is associated with *F. variegata* (Moraceae) (Percy *et al*. 2016). Subsequently, the genus *Pauropsylla* was regarded as a new family of Neotriozidae Li (2011). Recently, it was returned back to the family Triozidae based on integrating molecular and morphological evidence (Burckhardt *et al*. 2021). *Pauropsylla*

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currently contains 23 described species worldwide (Li 2011; Malenovsky & Burckhardt 2014; Ouvrard 2015), and three are distributed in China. Generally, related psyllid species develop on related host taxa (Li 1994; Burckhardt 2005; Li *et al*. 2015). Until now, a total of 40 psyllid species have been reported to develop on more than 20 *Ficus* plant species (Li 2011), such as the psyllid *P. buxtoni* Laing (1924) on *F. carica*, but their appearance was unknown on *F. tikoua*.

In recent years, a new *Pauropsylla* psyllid has been found on the leaves of *F. tikoua*, a ground cover plant, in Kunming, Yunnan Province, China. The psyllid-forming galls significantly impact the visual appeal of *F. tikoua* (Fig. 1). *F. tikoua* is an evergreen prostrate liana distributed in southwestern China, northeastern India (Assam), northern Vietnam, and Laos (Chen *et al.* 2011). In addition to its use as ornamentals, *F. tikoua* produces sweet edible berries that are rich in trace minerals and amino acids (Chen *et al*. 2011). *F. tikoua* is also utilized for ecological remediation due to its positive impact on soil and water conservation and its strong adaptability (Mubarak *et al*. 2016; Wang *et al*. 2016). Furthermore, the phloem fiber of the *F. tikoua* vines can be used as raw material for manufacturing cloth, rope or paper towels (Xu *et al*. 2011). Whole plants of *F. tikoua* are also utilized as a traditional Chinese herbal medicine (Guo *et al*. 2011).

In this study, we describe a new *Pauropsylla* species in spherical leaf galls on *F. tikoua* based on adults together with biological notes, mitochondrion-encoded cytochrome oxidase subunit 1 (*COI*) sequence comparisons, and the identification key of *Pauropsylla* species from China.

Material and methods

Branches of *F. tikoua* with fresh galls (Fig. 1) were collected in Chenggong (102°51′45″ E, 24°51′58″ N), Kunming, China, and transported to the lab. Adult psyllids were extracted from the galls and immersed in 70% ethanol for slide preparation and 95% ethanol for DNA extraction. Specimens were deposited in the Museum of Kunming University of Science and Technology (KUST).

Specimens were dissected and mounted on slides using Canada balsam. All measurements were taken from slide-mounted specimens at 40–200× magnification with a Leica compound microscope fitted with an eyepiece reticle and measurements are given either in micrometers or as ratios. Photographs were taken from slide-mounted specimens using a microscope (LC-SMS-4 and Nikon 80i), and images were processed by Adobe Photoshop. Terminology for morphological features following Hollis (2004) and Li (2011).

Adult psyllids were also identified by sequencing the *COI* gene. Genomic DNA was then extracted using the TSP201 Animal Genomic DNA Kit. The mitochondrial *COI* gene was amplified using the gene-specific primers F (TTYTCWACWAAYCATAARGAYATTGG) and R (ATRTADACTTCWGGRTGHCCAAARAATCA). Polymerase chain reaction (PCR) amplification was carried out using standard protocols (Hébert *et al*. 2022) with an annealing temperature of 55 ℃. Following amplification, the products were sequenced by an ABI 3730 automated sequencer (Applied Biosystems, Foster City, USA) at the Zanna Biological Company, China. The sequence data were deposited in GenBank (https://www.ncbi.nlm.nih.gov/genbank/) and BLAST was utilized to search for similar

sequences in the NCBI database (https://www.ncbi.nlm.nih.gov/orffinder/). The *COI* genes of related species were downloaded from GenBank. All the sequences were aligned with MAFFT implemented in Geneious R10 (Biomatters Ltd., Auckland, New Zealand).

Figure 1. Habitat of *Pauropsylla tikouae* **sp. nov.** A. Host plant *F. tikoua*; B. Leaf gall-bearing immature nymphs; C. Leaf gall with an adult.

Taxonomy

***Pauropsylla tikouae* Xu & Zheng sp. nov.** (Figs 2–5)
http://zoobank.org/urn:lsid:zoobank.org:pub:589F3662-3A3B-47EB-8BB8-CAE3FF887C58.

Description. Adults. Head yellow, front edge and rear leaf edge of middle seam eye black, covered with long hairs (Figs 2C, 2G). No buccal cone (Figs 2E, 2G). Female single-eye reddish brown, compound eye reddish brown (Figs 2A, 2C), male single-eye yellow (Fig. 2G). The first-, second- and third-most tentacles (Fig. 2D) are yellow, with gradually deepening color later for the first and second segments. The third end and 4–10 segments are black. Front chest back panel black, with yellow edges (Figs 2C, 2E). Middle chest anterior shield black, with yellow or yellowish brown on both sides. Posterior edge of middle chest shield yellow, while the small shield and the posterior chest initially turns yellow and then gradually turns black. Chest side belly yellowish brown. Feet (Fig. 2F) yellowish brown, basal tarsal nodes black brown, distal tarsal nodes black, posterior base yellow. Abdomen yellowish brown to dark brown, posterior margin of each segment yellow, reproductive nodes yellowish brown (Figs 2I, 2J).

Structure. The length of the male body is 1.96–2.31 mm, and the length of the body wing is 3.86–4.16 mm (Figs 2A, 2C). The head tilts forward and extends slightly downward, with a head width of 0.71–0.85 mm. The width of the top of head is 0.38–0.51 mm, the rear edge is slightly arcuate, and the front edge protrudes forward, without cracks. The middle monocular eye is located at the middle seam end, invisible from the back (Fig. 3A). The head length is 0.22–0.32 mm, and the middle seam length is 0.13–0.18 mm. The antennal length is 1.26–1.41 mm, 1.48–2.11 times to the head width, and the length ratio of each segment is 0.5 : 0.6 :

2.3 : 1.4 : 0.7 : 1.2 : 1.0 : 1.1 : 1.2 : 1.1, respectively. Chest width is 0.82–0.90 times wider than head width. The anterior chest retracts under the middle anterior shield and is covered by the skull. The middle chest is very bulging, and the center of the shield is flat. The tibia of the posterior foot has no basal teeth, with 8 apical spurs. The posterior basal process is short and fingerlike. The front wing is oval, 2.89–3.35 mm long, 1.36–1.51 mm wide, and the length is 2.12–2.26 times longer than the width. The veins are not trifurcate, with R similar or longer to R_1, and Rs extending to the apex of the wing. M and Cu_1 have a short common handle M+ Cu_1, which is 1/3 length of R. M divided into two branches, extending to the rear corner of the wing, M being 1.98 times the length of M_{1+2}. Cu_{1a} is 1.15 times as long as Cu_1. The rear wing has a length of 2.11–2.56 mm, a width of 0.71–0.83 mm, and a length 3.06 times the width. The ventral margin of the lower genital plate is swollen, the telomere enlarged, and globose. The parameres are elongated, with tapered ends, shorter than the anal segment (Figs 2I, 3C).

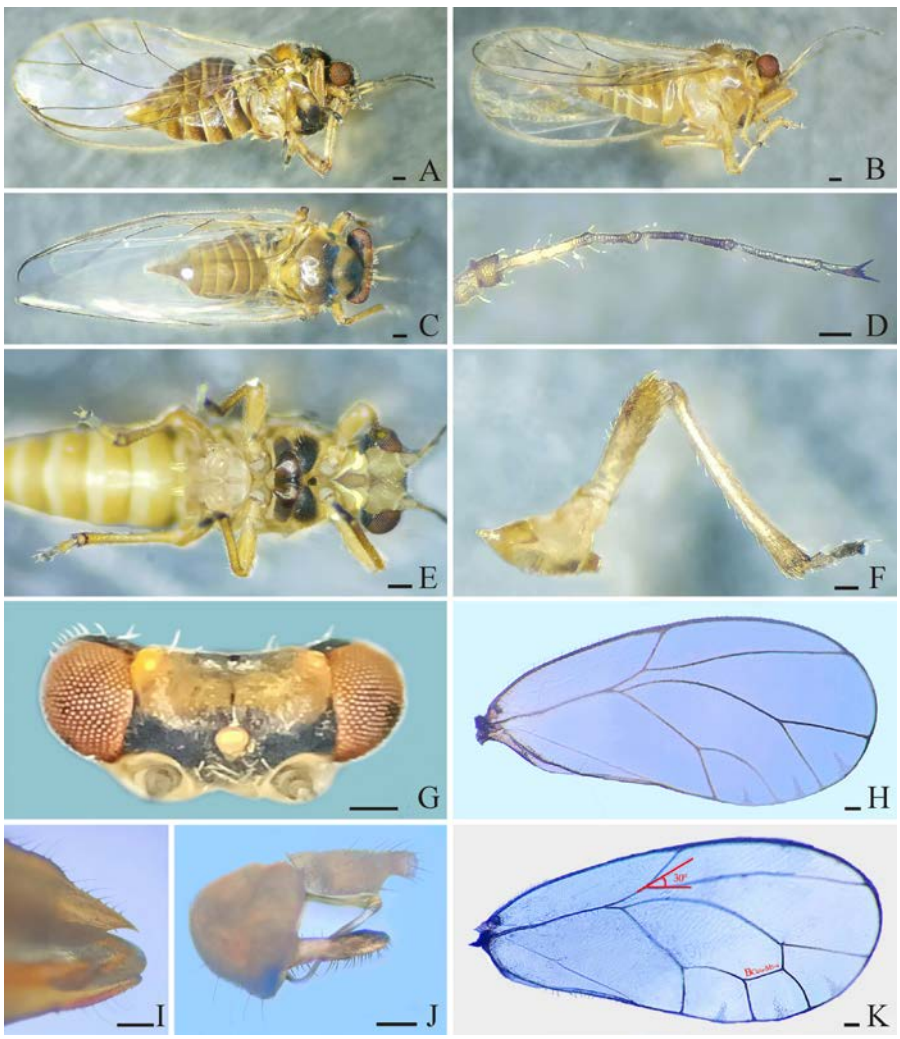

Figure 2. *Pauropsylla tikouae* **sp. nov.**, adult. A. Adult female, in profile; B. Adult male, in profile; C. Adult female, dorsal view; D. Antenna; E. Adult male, ventral view; F. Hindleg; G. Head, frontal view; H. Forewing; I. Male terminalia, in profile; J. Female terminalia, in profile; K. Forewing. Scale bars = 0.1 mm.

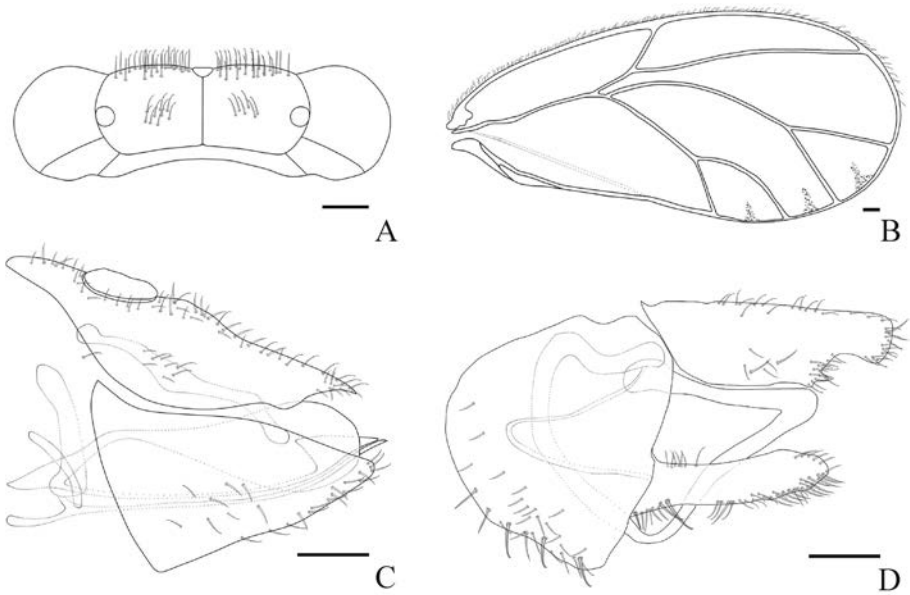

Figure 3. Adults of *Pauropsylla tikouae* **sp. nov.** A. Head, dorsal view; B. Forewing; C. Male terminalia, in profile; D. Female terminalia, in profile. Scale bars = 0.1 mm.

The length of the female body is 2.23–2.46 mm, and the length of the body wing is 3.97–4.23 mm (Figs 2B, 2E). Head width 0.79–0.90 mm, and top head width 0.40–0.54 mm. The middle seam length is 0.18–0.22 mm; the antennal length is 1.40–1.54 mm. It is 1.56–1.94 times the head width, and the length ratio of each segment is 0.5 : 0.5 : 2.6 : 1.6 : 1.2 : 1.5 : 1.2 : 1.4 : 1.0 : 1.0, respectively. Chest width 0.82–0.93 mm. The front wing has a length of 3.23–3.46 mm, a width of 1.48–1.56 mm, and a length of 2.07–2.32 times the width. The rear wing has a length of 2.60–2.83 mm, a width of 0.84–0.91 mm, and a length of 3.10 times the width. The structure and pulse sequence of the head, chest, and foot are similar to those of male psyllids. The gonads are laterally tapered. The anal segment is swollen, broad and thick, with a finger-shaped end and a concave dorsal margin. The subgenital plate is triangular with a bulging base. The top of the anal segment is cracked, with a wedge-shaped apex (Figs 2J, 3D).

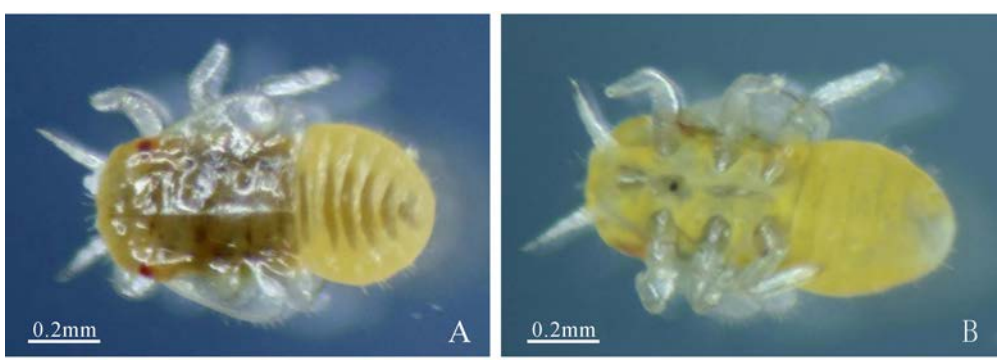

Figure 4. *Pauropsylla tikouae* **sp. nov.**, fifth instar immature. A. Dorsal view; B. Ventral view.

Fifth instar immature. Color. Dorsal sclerites and wing pads yellowish-brown, membranes whitish. Eyes red (Fig. 4A). Antenna and legs grayish white. Ventral yellow (Fig. 4B). Structure. Body 2.2–2.3 times as long as broad. Antenna 0.6 times as long as forewing pad.

Molecular sequence. A 607-bp fragment of the *COI* gene was obtained as described previously and deposited in GenBank (accession No. OP628083). The subsequent BLAST analysis showed that the sequence had the highest identity of 83.1% (76 different bases, Fig. 5) with the *COI* gene of *Pauropsylla triozoptera* Crawford. These data indicate that the gall-forming species in *F. tikoua* is genetically distinct at the generic level from all other congeneric species for which DNA sequence data are available.

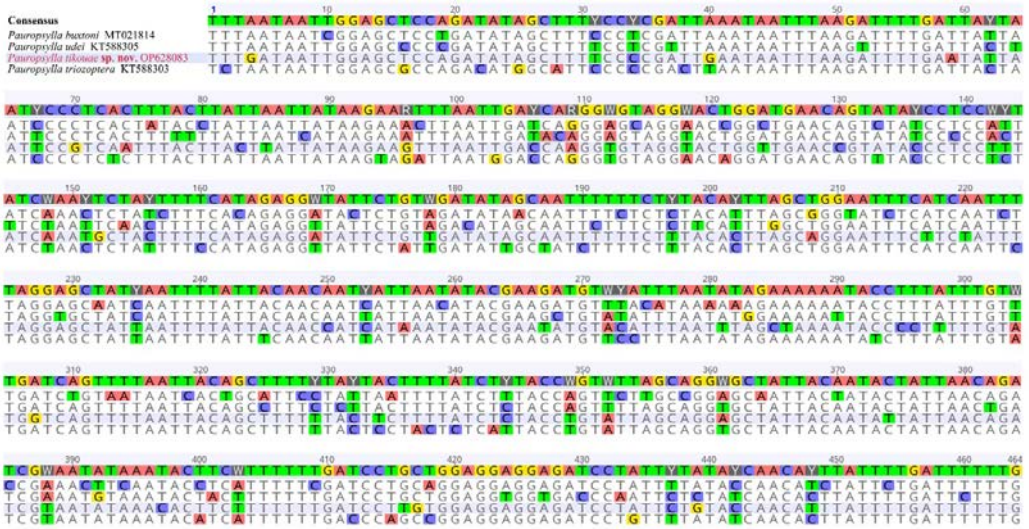

Figure 5. The *COI* locus of *Pauropsylla tikouae* **sp. nov.** compared with congeneric species.

Holotype. ♂, **China**, Yunnan Province, Kunming, Chenggong, 102°51′45″ E, 24°51′58″ N, 16-IX-2020 (KUST, dry and slide mounted). **Paratypes**. 8♂9♀, **China**, same data as holotype, 08-IX-2022, (KUST, dry and slide mounted, 95% ethanol).

Etymology. It is named after its host plant *F. tikoua*.

Host plant. *F. tikoua* Bur. (Moraceae).

Diagnosis. The transparent wings have no fracture mark or wing nevus on the anterior margin (Figs 2H, 2K, 3B). The posterior foot base appendage has no claw-like pitch (Fig. 2F). The head has no buccal cone (Figs 2E, 2G). The front wing veins R and Cu_1 are divided into two branches, and veins M and Cu_1 share a common handle (Figs 2H, 2K, 3B). The M is 1.98 times the length of M_{1+2}. The anterior wing vein Rs extends downward 30° from R (Figs 2H, 2K, 3B). Additionally, the anterior wing sometimes (1/36 probability) has a bridge-vein connecting Cu_{1a} and M_{3+4} (Fig. 2K).

Identification keys to four existing *Pauropsylla* species from China

1. Vertex without median suture ····· *P. depressa* Crawford
-. Vertex with median suture ····· 2
2. Anterior wing Rs extending along the R ····· 3

-. Anterior wing Rs extending downward 30° from R, length M/M_{1+2} 1.98 ····· *P. tikouae* **sp. nov.**
3. Anterior wing length M/M_{1+2} 2.55····· *P. braconae* Li
-. Anterior wing length M/M_{1+2} 3.71 ····· *P. emisanensis* Li

Biology. Approximately five generations of psyllids emerged from the galls of *F. tikoua* each year. Nymphs form irregular spherical galls from green to reddish brown on the surface of leaves. The gall size increases as nymphs age, and after emergence, the adult emerges from the gap at the top of the gall (Fig. 2A). The formation of one to several galls on the leaf surface can cause the entire leaf to become a massive group of galls with many galls connected (Fig. 2A), and the diameter of spherical galls generally varies from 0.8 to 1.8 cm. Generally, there is one nymph per gall (Figs 1B, 1C), but sometimes there can be two. The initial emergence of adult insects is pale yellow, with a gradually deepening color later.

This new species originated from wild plants of *F. tikoua* in southwestern China, and has rapidly spread on cultivated plants of *F. tikoua* (no occurrence on the other *Ficus* plants, such as *F. carica*, *F. concinna*, and *F. virens*) in landscape greening. Field phenotyping indicated that an average of 81.85% of cultivated plants had leaf galls. The number of galls per leaf averaged 4.67, with a maximum of 76. Galls covered an average of 21.60% of the leaf surface, with a maximum of 94.67% coverage. The volume of individual galls averaged 0.75 cm^3, while their weight averaged 0.14 g.

Discussion. This new species is most similar to *Pauropsylla braconae* and *P. emisanensis*, which do not have *COI* sequences, but they have significant differences. *P. tikouae* **sp. nov.** is located in Kunming (102°51′E, 24°52′N), Yunnan Province, where it is geographically distant from *P. braconae* (Nonggang, Guangxi Province, E 106°52', N 22°23') and *P. emisanensis* (Emeishan, Sichuan Province, E 103°29', N 29°36'). The anterior wing Rs of *P. tikouae* **sp. nov.** extends downward 30° from R, while the anterior wing Rs extends along the R for *P. braconae* and *P. emisanensis*. The anterior wing M of *P. tikouae* **sp. nov.** is 1.98 times the length of M_{1+2}, whereas the anterior wing M is 2.55 and 3.71 times the length of M_{1+2} for *P. braconae* and *P. emisanensis*, respectively (Li 2011). In addition, the apical spurs of the hind leg of *P. tikouae* **sp. nov.** are eight, which differs from *P. braconae* (11) and *P. emisanensis* (10).

Psyllids of *Pauropsylla* can attack the fruit of the host plant, such as *P. tuberculata* (Chander 2014). The plants in this study were from landscaping ground cover and produced no fruits due to a poor soil environment. Further studies are therefore needed to determine if galls impact the production of *F. tikoua* fruit.

To our knowledge, this is the first report of a gall-forming insect on *F. tikoua*. Furthermore, the bridge-vein connecting Cu_{1a} and M_{3+4} (Fig. 2K) of the anterior wing on *P. tikouae* **sp. nov.** is also the first reported for psyllids, which may have phylogenetic importance. This study may be useful for further research aiming at protection and development of the horticultural plant *F. tikoua*.

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