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Research article

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A review of Bittacidae (Mecoptera) in Guizhou, China with descriptions of three new species

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Abstract. The Bittacidae fauna in Guizhou Province, China is reviewed. Eleven species in the genera *Terrobittacus* Tan & Hua, 2009 and *Bittacus* Latreille, 1805 of Bittacidae are documented in Guizhou, including three new species: *Bittacus dilobus* sp. nov. and *Bittacus leigongshanicus* sp. nov. from Leigongshan, and *Bittacus multisetus* sp. nov. from Yushe. A key to species of Bittacidae in Guizhou is provided.

Keywords. Biodiversity, *Bittacus*, fauna, hangingfly, taxonomy.

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Introduction

The hangingflies Bittacidae Handlirsch, 1906 are unique in having three pairs of raptorial legs, with the fourth and fifth tarsomeres forming a grasping structure (Tan & Hua 2008a). They are unable to stand on a surface, but hang on the edges of leaves or twigs with their prehensile forelegs (Byers 2002). Bittacids bear numerous sensilla coeloconica on their antennae (Hu *et al.* 2010) and are highly sensitive to ambient humidity and temperature, often being regarded as ecological indicators (Byers & Thornhill 1983). During mating, the male usually provides a nuptial gift to the female and adopts an unusual belly-to-belly hanging mating position (Gao & Hua 2013). Female bittacids lay eggs singly on the ground at random.

The eggs of Bittacidae are spherical or cuboidal at oviposition, pale yellow when newly laid, but turning dark brown in several hours (Tan & Hua 2009c). Most species of Bittacidae overwinter in the egg stage except for the tropical species (Setty 1940). The larvae are eruciform (Tan & Hua 2009c), bearing a pair of prominent lateral compound eyes of seven ommatidia on the head and eight pairs of ventral prolegs on the abdominal segments I–VIII (Byers & Thornhill 1983; Jiang *et al.* 2015; Zheng *et al.* 2022). Pupation usually takes place in a cell prepared by the full-grown larvae in the soil. The pupae are exarate and decticous, with the wings tightly folded in sheaths (Tan & Hua 2008b).

Bittacidae is a cosmopolitan family of Mecoptera Packard, 1886 (Wang & Hua 2017), with 53 species in three genera documented in China (Zhang *et al.* 2020). The faunal studies of Bittacidae are confined to certain regions in China, especially Shaanxi Province and southern China (Huang & Hua 2005; Hua *et al.* 2008; Zhang *et al.* 2020).

Guizhou Province is situated in the southwest China, in a region belonging to the Yunnan-Guizhou Plateau. In total, eight species in two genera of Bittacidae have been reported in Guizhou (Du & Hua 2017; Wang & Hua 2017). Zhou (2003) reported the first species of *Bittacus* Latreille, 1805 from Guizhou. Zhou & Zhou (2005, 2007, 2012) described four new species of *Bittacus* in the Dashahe Nature Reserve, Leigongshan and Kuankuoshui landscapes. Tan & Hua (2009a) described one species of *Terrobittacus* Tan & Hua, 2009 from Guizhou. Chen *et al.* (2013) recorded two species of *Bittacus* from Guizhou. However, the Bittacidae fauna of Guizhou has not been reviewed to date.

In this paper, three new species of *Bittacus* are described, increasing the number of Guizhou Bittacidae to eleven. A key to species of Bittacidae in Guizhou is provided, with all characters in the key derived from the original descriptions.

Material and methods

Adult specimens were collected from the mountain regions in Guizhou (Fig. 1), and are deposited in 75% or 95% ethanol at the Entomological Museum, Northwest A & F University, China (NWAU).

Specimens were observed under a Nikon SMZ1500 microscope. Habitus photographs were taken with a Nikon D7100 digital camera and character pictures were taken using a scientific digital micrography system ZEISS SteREO Discovery V20, equipped with an auto-montage imaging system (AxioCam IC). Maps were obtained from Baidu Maps (https://map.baidu.com/). All photographs were assembled with Adobe Photoshop CS4. Measurements were made with a vernier caliper.

Terminology follows Mickoleit (1976) and Zhang *et al.* (2020).

The following abbreviations are applied in the measurements:
AL = antennal length
BL = body length
FL = forewing length
FW = forewing width
HL = hindwing length
HW = hindwing width

The following abbreviations are used in figures:
A = anal
AL = aedeagal lobe
Av = apical cross-vein between CuP and 1A
Ce = cercus
Cly = clypeus
CuA = anterior cubitus
CuP = posterior cubitus
Cuv = apical cross-vein between CuA and CuP
EA = epandrial appendage
FM = fork of media
Fr = frons
FRs = first fork of radial sector

Gcx = gonocoxite
Gs = gonostylus
L = labrum
LBP = lower branch of proctiger
LP = labial palp
M = media
MP = maxillary palp
OM = origin of media
ORs = origin of radial sector
Pcv = cross-veins between R_1 and R_2 behind the pterostigma
Pf = penisfilum
Ps = pterostigma
R_1 = first radius
S = sternum
SaP = subanal plate
Sc = subcosta
Scv = cross-vein between distal half of Sc and R_1
SgP = subgenital plate
Sp = spiracle
T = tergum
UBP = upper branch of proctiger

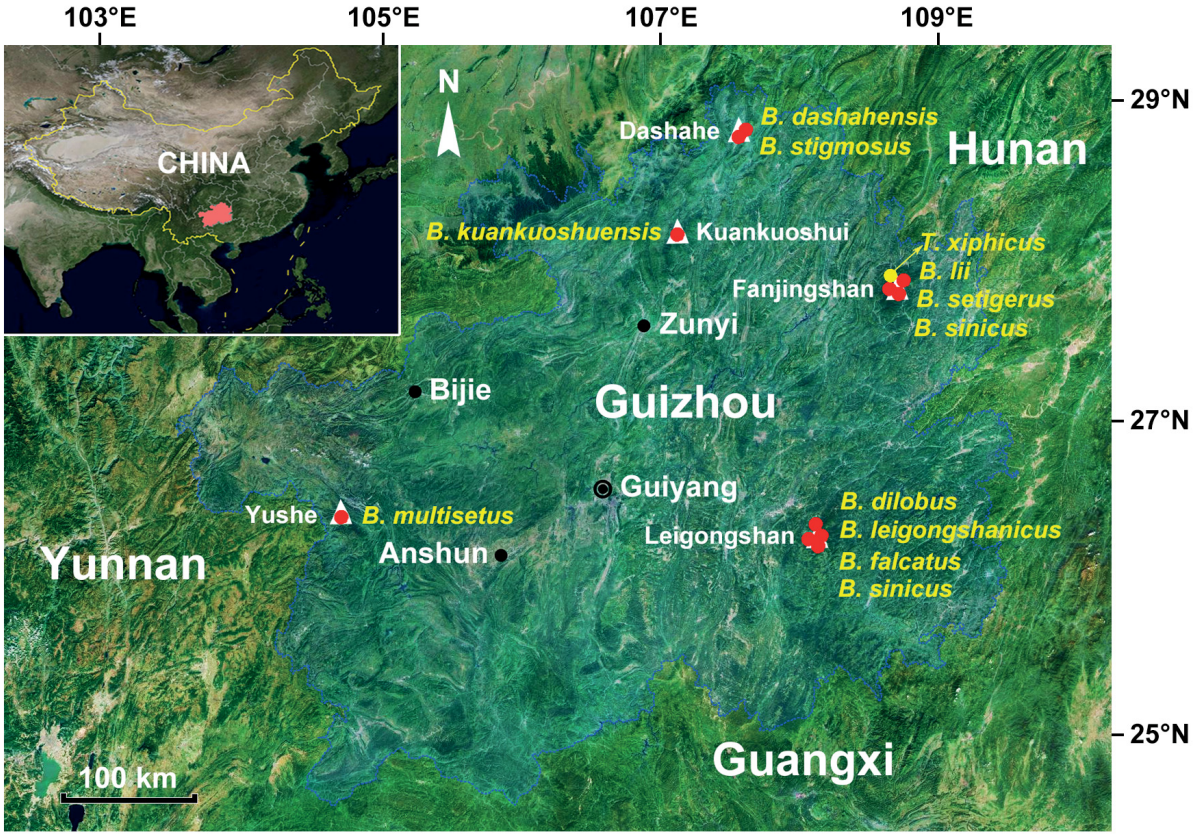

Fig. 1. Distribution map for Bittacidae Handlirsch, 1906 in Guizhou, China.

Results

Class Insecta Linnaeus, 1758
Order Mecoptera Packard, 1886

Family **Bittacidae** Handlirsch, 1906

Checklist of the Bittacidae from Guizhou

Bittacus dashahensis Zhou & Zhou, 2005 (type locality: Dashahe, Guizhou)
Bittacus dilobus sp. nov. (type locality: Leigongshan, Guizhou)
Bittacus falcatus Zhou & Zhou, 2007 (type locality: Leigongshan, Guizhou)
Bittacus kuankuoshuensis Zhou & Zhou, 2012 (type locality: Kuankuoshui, Guizhou)
Bittacus leigongshanicus sp. nov. (type locality: Leigongshan, Guizhou)
Bittacus lii Zhou, 2003 (type locality: Fanjingshan, Guizhou. Distribution: Guizhou, Hubei, Hunan, and Sichuan)
Bittacus multisetus sp. nov. (type locality: Yushe, Guizhou)
Bittacus setigerus Chen & Hua, 2013 (type locality: Tiansanping, Hubei. Distribution: Guizhou and Hubei)
Bittacus sinicus Issiki, 1931 (type locality: Mount Emei, Sichuan. Distribution: Guizhou, Hainan, Hubei, Shaanxi, Gansu, and Sichuan)
Bittacus stigmosus Zhou & Zhou, 2005 (type locality: Dashahe, Guizhou)
Terrobittacus xiphicus Tan & Hua, 2009 (type locality: Fanjingshan, Guizhou. Distribution: Guizhou and Hunan)

Key to species of Bittacidae in Guizhou

1. Male tergum X completely absent. Epandrial appendages prominently shorter than half length of gonocoxites; acute tooth protrusion on ventral margin subbasally ..... ***T. xiphicus*** Tan & Hua, 2009
− Male tergum X degenerate more or less into two slender lateral plates. Epandrial appendages approximately equal to or longer than half length of gonocoxites; no denticulate protrusion on ventral margin 2

2. One pale streak on meso- and metanotum 3
− No obvious streak on meso- and metanotum 4

3. Wings tinged with light yellowish brown, without markings except pterostigma; Pcv one .... ***B. falcatus*** Zhou & Zhou, 2007
− Wings tinged with yellowish brown or blackish brown, with numerous markings, Pcv two 5

4. Sc ending beyond FRs and FM, Av one, without nygmata; upper branch of proctiger slender, male cerci slender ..... ***B. kuankuoshuensis*** Zhou & Zhou, 2012
− Sc ending before FRs and FM, no Av, nygmata at median of wings; upper branch of proctiger expanded distally, male cerci clavate ..... ***B. multisetus*** sp. nov.

5. Wing with large darkish brown marking from Sc to A1 ending .... ***B. stigmosus*** Zhou & Zhou, 2005
− Wing with small discrete flecks 6

6. Wings with four conspicuous markings at OM, ORs, FRs and CuP ending, respectively .... ***B. dashahensis*** Zhou & Zhou, 2005
− Wings with more or less markings 7

7. Epandrial appendages subquadrangular in lateral aspect, straight on ventral and dorsal edges, without protrusions or long setae ..... ***B. sinicus*** Issiki, 1931
− Epandrial appendages irregularly shaped in lateral aspect, crooked on ventral or dorsal margins, with protrusions or long setae 8

8. Epandrial appendage with row of long blackish brown setae on ventral margin ..... ***B. setigerus*** Chen & Hua, 2013
− Epandrial appendage without setae on ventral margin 9

9. Epandrial appendages greatly elongated into paired long sinuous lobes ..... ***B. leigongshanicus*** sp. nov.
− Epandrial appendages not elongated 10

10. Caudal portion of gonocoxites with paired lobes ..... ***B. dilobus*** sp. nov.
− Caudal portion of gonocoxites with V-shaped membrane ..... ***B. lii*** Zhou, 2003

Descriptions of new species

Genus *Bittacus* Latreille, 1805

Bittacus dilobus sp. nov.
urn:lsid:zoobank.org:act:141D3F0D-62D0-4250-870D-6BB70C8C6AC5
Figs 2–4

Diagnosis

The new species is unique in having the male gonocoxites with two triangular caudal lobes, elongated aedeagal lobes with distal half broadened into an acute distal process and a greatly elongated and coiled penisfilum.

Etymology

The specific epithet is derived from the Greek ‘di-’ (two, double) and ‘lob-’ (a lobe), referring to the male gonocoxites with a pair of triangular lobes.

Type material

Holotype

CHINA • ♂; Guizhou Province, Leishan County, Leigongshan; 26°22′12″ N, 108°7′48″ E; 1440–1500 m a.s.l.; 15 Jul. 2021; Le-Le He leg.; NWAU.

Paratypes

CHINA • 3 ♀♀; same collection data as for the holotype; NWAU.

Description

Measurements. AL 7.4–8.1 mm, BL 16.1–19.6 mm, FL 22.4–22.7 mm, FW 5.1–5.5 mm, HL 19.0–19.4 mm, HW 4.4–4.7 mm.

Head (Fig. 2B). Vertex yellowish brown; frons grayish brown; ocellar triangle black, median ocellus smaller than lateral ocelli; clypeus and labrum yellowish to blackish brown, lateral sides darker; maxillary palp blackish brown except distal segment yellowish brown. Antennae yellowish brown; flagellum ciliated, with distinct segments basally and obscure beyond 16th segment.

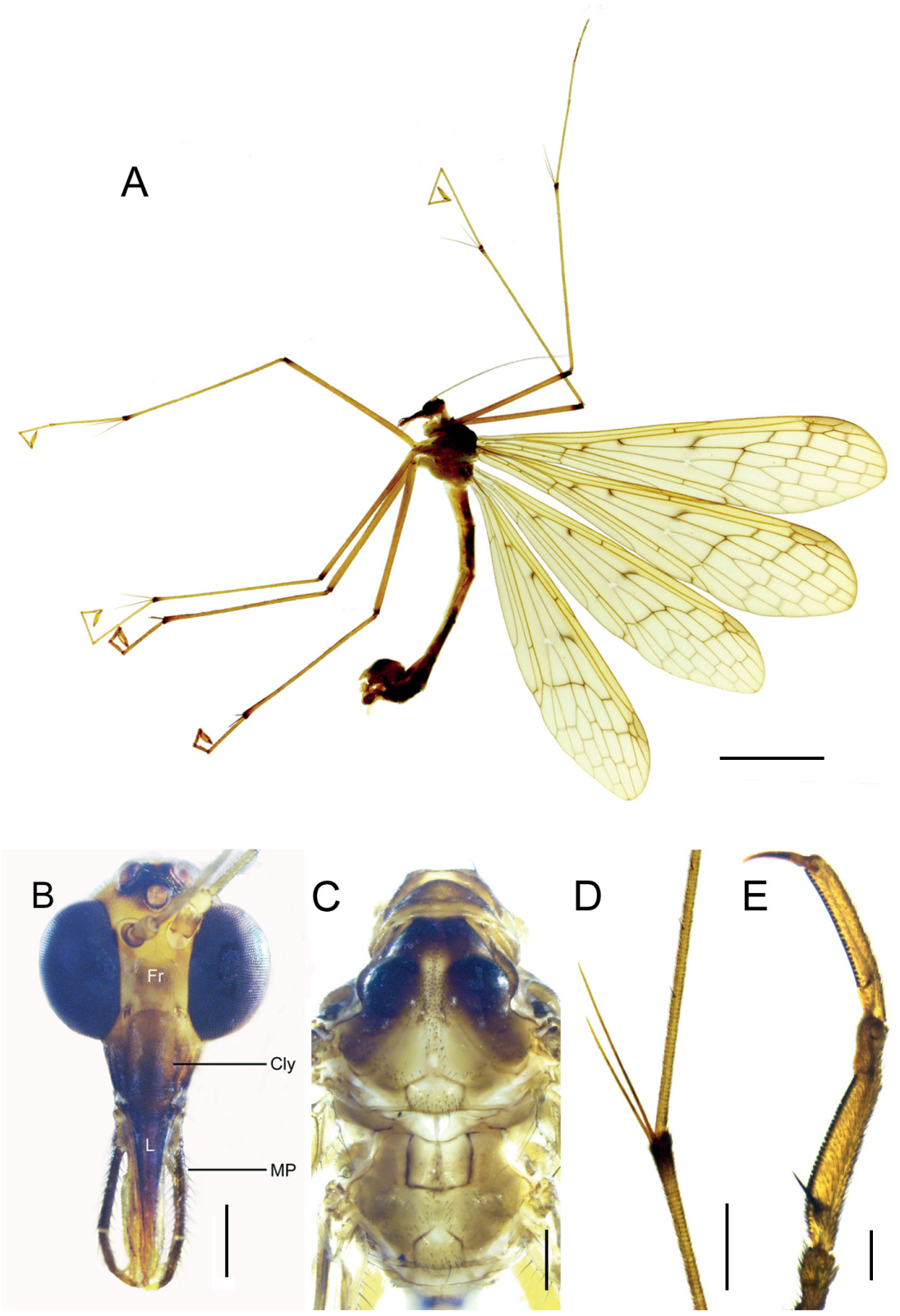

Fig. 2. *Bittacus dilobus* sp. nov., ♂, holotype (NWAU). **A**. Habitus in lateral view. **B**. Head in frontal view. **C**. Thorax in dorsal view. **D**. Tibia with two apical tibial spurs of left foreleg. **E**. Tarsomeres IV, V and claw of left foreleg. Abbreviations: see Material and methods. Scale bars: A = 5.0 mm; B–C, E = 0.5 mm; D = 1.0 mm.

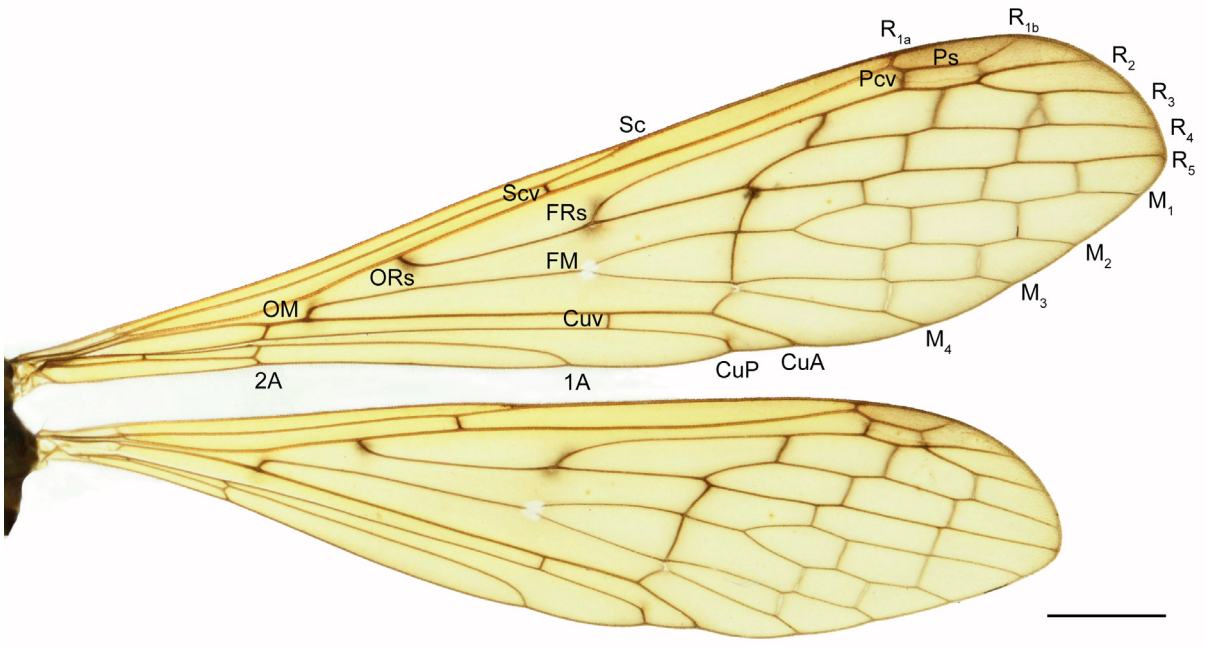

Fig. 3. Right wings of *Bittacus dilobus* sp. nov., ♂, holotype (NWAU). Abbreviations: see Material and methods. Scale bar = 2.0 mm.

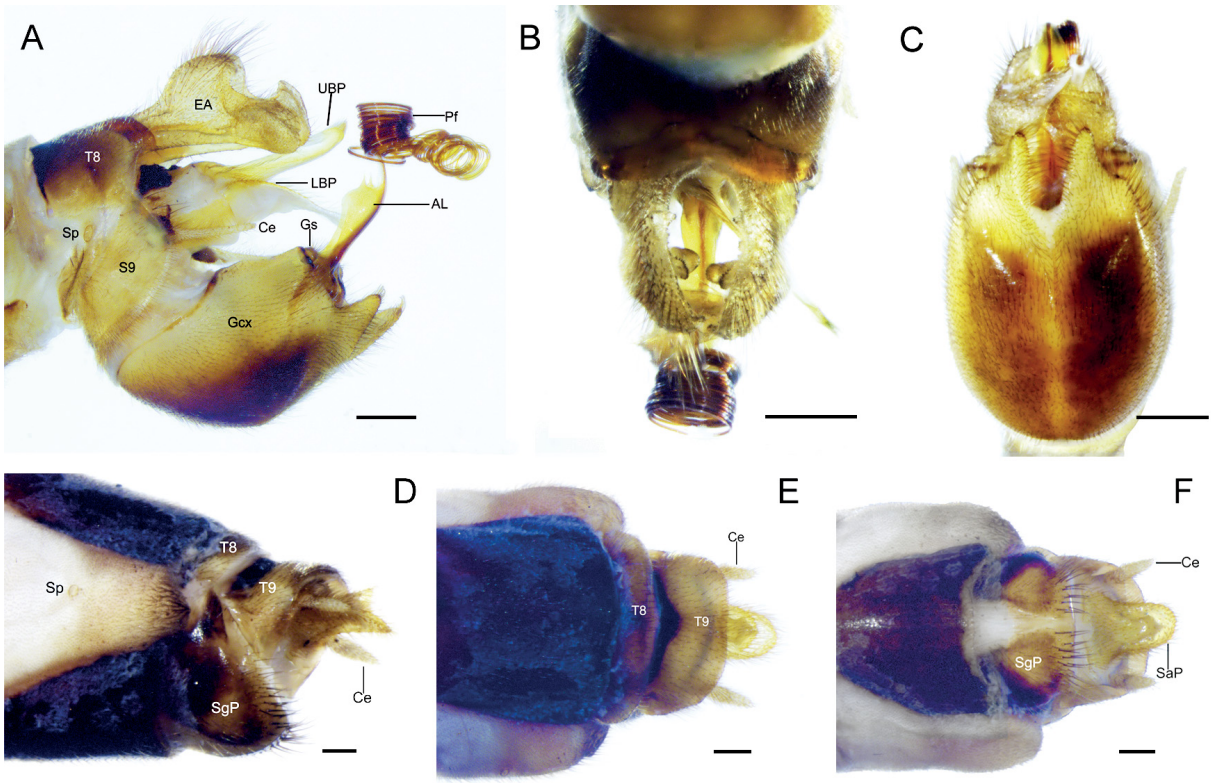

Fig. 4. *Bittacus dilobus* sp. nov. **A–C**. ♂, holotype (NWAU). **A**. Terminalia in lateral view. **B**. Terminalia in dorsal view. **C**. Terminalia in ventral view. **D–E**. ♀, paratype (NWAU). **D**. Terminalia in lateral view. **E**. Terminalia in dorsal view. **F**. Terminalia in ventral view. Abbreviations: see Material and methods. Scale bars: A–C = 0.5 mm; D–F = 0.2 mm.

Thorax (Fig. 2C). Pronotum unevenly blackish brown, with setae along anterior margin; mesonotum blackish brown in anterior two-thirds; remaining parts and metanotum yellowish brown, with light brown median streak; two setae along posterior margins of meso- and metanotum respectively. Pleura pale yellowish brown. Legs unevenly yellowish brown; femora and tibiae with black apices (Fig. 2A); length ratio of two apical tibial spurs as 2:3 (Fig. 2D); hind basitarsus as long as tarsomeres II–IV together, each succeeding tarsomere shorter in turn; each side of basal tarsomere IV with one black seta (Fig. 2E).

Wings (Fig. 3). Forewing membrane hyaline with yellowish tinge; pterostigma brown; small blackish brown cloudings at OM, ORs and FRs; Pcv two. Sc ending beyond level of FRs; Scv before FM; CuP ending near FM_{3+4}; Cuv two; 1A ending near FM; 2A ending before OM; Av absent. Hindwing similar to forewing, but Sc ending before level of FRs and FM.

Abdomen of male (Fig. 4A–C). Terga II–VIII yellowish brown, each with a black antecosta; tergum VIII slightly emarginate in V-shape on posterior margin. Epandrial appendages yellowish brown, longer than half length of gonocoxites, ventral margin almost straight, but dorsal margin sags and crests with long hairs; with two conspicuous protrusions on inner surface, one ear-like on ventro-distal process, the other small triangular-shape on dorsal process, both bearing black spines apically. Tergum X black, greatly vestigial. Proctiger stout basally, sclerotized dorsally and ventrally; upper branch of proctiger finger-like, bearing a bunch of short yellow hairs apically; lower branch of proctiger curved caudoventrad and tapering caudally, but enlarged apically. Cerci slender, longer than half length of gonocoxites. Gonocoxites yellowish brown except ventral portion blackish-brown, with a pair of triangular caudal lobes divided by V-shaped emargination. Gonostylus yellowish brown, greatly shortened, with hairs apically. Aedeagal lobes elongated, with distal half broadened into acute distal process; penisfilum greatly elongated and coiled.

Abdomen of female (Fig. 4D–F). Terga II–VI yellowish brown, terga VII–VIII dull blackish brown, each with a black antecosta. Subgenital plate sclerotized, yellowish to blackish brown, divided mesially by conspicuous membrane, bearing 12–15 black setae distally; membranous emargination indistinct. Tergum IX yellowish brown, truncated distally, with a black, obtusely triangular fleck basally in dorsal view. Tergum X extending ventrally and beyond base of cerci. Supraanal plate shorter than subanal plate, longer than cerci.

Distribution

Guizhou Province, China.

Remarks

The new species resembles *B. triangularis* Issiki, 1929 from Liaoning Province in appearance, but can be separated from the latter by the following traits: the lower branch of the proctiger expanded apically (cf. the lower branch of the proctiger tapering caudally); the gonocoxites unevenly colored, with two caudal lobes (cf. the caudal portion of the gonocoxites long and curved dorsally); and the aedeagal lobe enlarged apically (cf. the aedeagal lobe tapering toward the apex).

Bittacus leigongshanicus sp. nov.
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Figs 5–7

Diagnosis

The new species can be readily recognized from its congeners by the following characters: 1) wings with numerous dark brown markings, Av one; 2) terga II–V dark brown in the basal three-fourths, light

brown in the distal fourth; terga VI–VIII black; and 3) male epandrial appendage greatly elongated into a sinuous lobe in the distal half.

Etymology

The specific epithet refers to the type locality, Leigongshan.

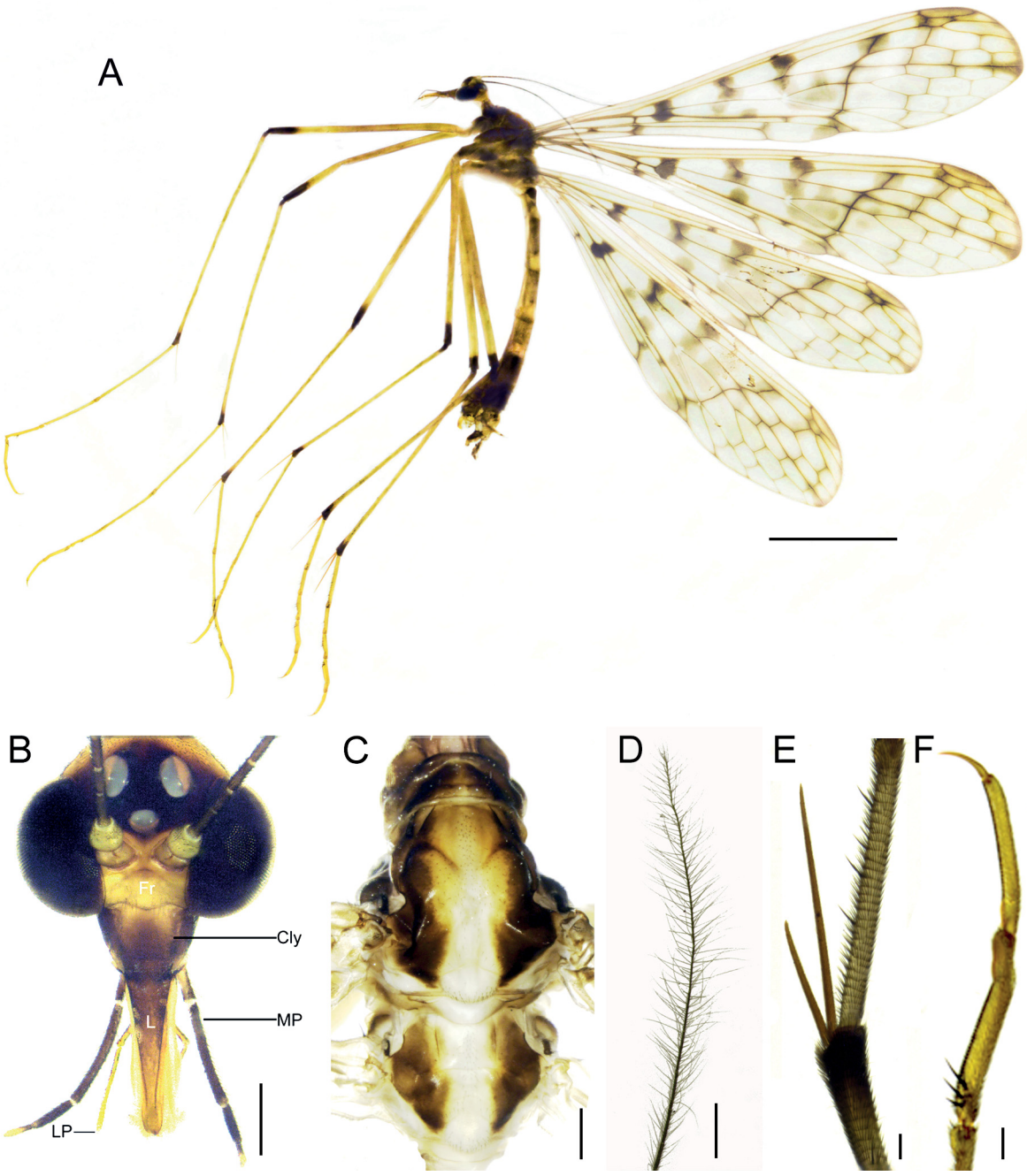

Fig. 5. *Bittacus leigongshanicus* sp. nov., ♂, holotype (NWAU). **A**. Habitus in lateral view. **B**. Head in frontal view. **C**. Thorax in dorsal view. **D**. Flagellum of antenna. **E**. Tibia with two apical tibial spurs of left foreleg. **F**. Tarsomeres IV, V and claw of left foreleg. Abbreviations: see Material and methods. Scale bars: A = 5.0 mm; B–D = 0.5 mm; E–F = 0.2 mm.

Type material

Holotype

CHINA • ♂; Guizhou Province, Leishan County, Leigongshan; 26°22′12″ N, 108°7′48″ E; 1440–1500 m a.s.l.; 15 Jul. 2021; Le-Le He leg.; NWAU.

Paratypes

CHINA • 2 ♀♀, same collection data as for the holotype; NWAU.

Description

Measurements. AL 7.3–7.9 mm, BL 17.5–18.5 mm, FL 22.8–24.1 mm, FW 4.8–5.5 mm, HL 21.4–22.4 mm, HW 4.5–5.0 mm.

Head (Fig. 5B). Vertex and frons yellowish brown; ocellar triangle black, dark ocellar stripe extending to compound eyes; lateral ocelli twice as large as median ocellus; compound eyes spherical; clypeus and labrum unevenly brown, lateral sides darker; maxillary palps dull yellowish brown except terminal segments brown, 3rd segment approximately twice as long as 4th and 5th segments combined; labial palps yellowish brown. Antennae ciliated with long hairs (Fig. 5D), with basal 15 flagellomeres distinct, but distal segments obscure.

Thorax (Fig. 5C). Pronotum dark brown, without setae along anterior or posterior margins. Meso- and metanotum dark brown laterally, with a pale brown median stripe. Pleura unevenly blackish brown. Legs yellowish brown, femora and tibiae with black apices (Fig. 5A); length ratio of two apical tibial spurs as 2:1 (Fig. 5E). Hind basitarsus as long as tarsomeres II and III together, tarsomere IV with three subbasal setae on lateral side (Fig. 5F).

Wings (Fig. 6). Forewing membrane hyaline with grayish brown tinge, dark brown markings distinct; pterostigma prominent; large marking running from R_1 to or before CuA, through FRs and FM, turned outward and ending at R_{4+5}; conspicuous small flecks at OM, ORs, and ends of Cu; longitudinal strip

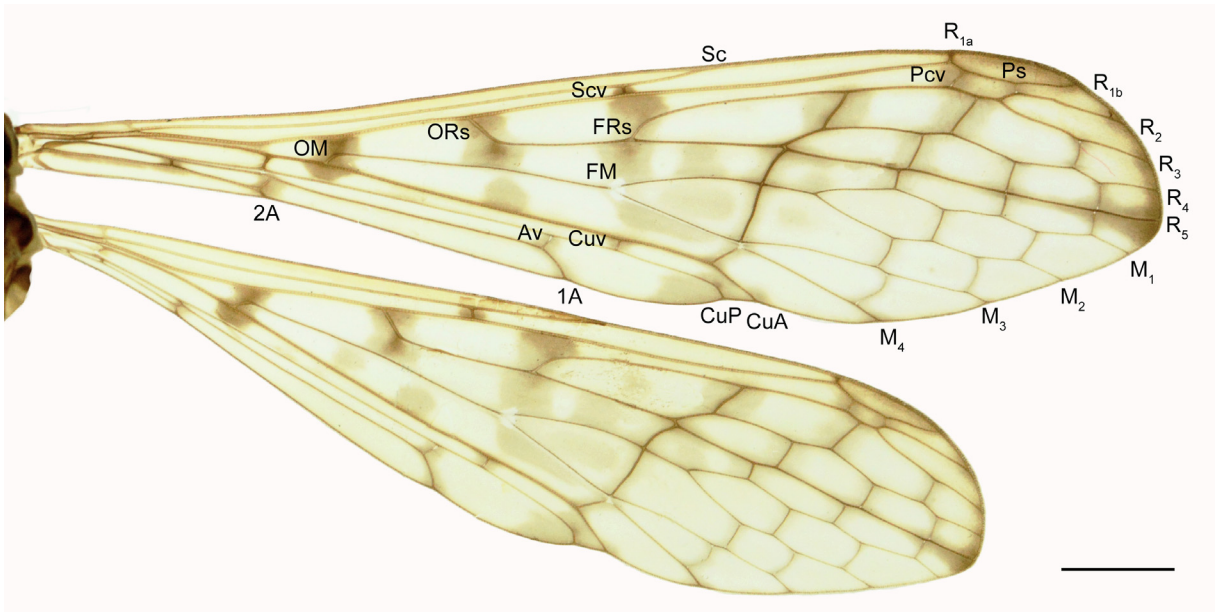

Fig. 6. Right wings of *Bittacus leigongshanicus* sp. nov., ♀, paratype (NWAU). Abbreviations: see Material and methods. Scale bar = 2.0 mm.

along R_5, broader apically; outer margin deeply darker from R_{1a} to or slightly before M_1; dark brown clouding along cross-veins; small hyaline spot at FM_{3+4}; Pcv two. Sc ending beyond level of FRs; Scv and Cuv near level of FM; CuP ending near FM_{3+4}; Cuv two; 1A ending before FM; 2A ending before OM; Av one. Hindwing similar to forewing, but Scv distinctly proximal to level of FM.

Abdomen of male (Fig. 7A, C). Terga II–V dark brown in basal three-fourths, light brown in distal fourth; terga VI–VIII black; each tergum with black narrow antecosta (Fig. 5A); tergum VIII slightly emarginate on posterior margin. Epandrial appendages dull yellowish brown, approximately twice as long as gonocoxites, pentagon-shaped in basal half and elongated into a sinuous lobe in distal half; a patch of long yellow hairs on outer surface and diffuse black spines along inner surface of elongated lobes. Tergum X saddle-like, with two lateral plates extending around base of cerci. Upper branch of proctiger yellowish to blackish brown, finger-like, protruding dorsally between epandrial appendages, apically bearing a bundle of yellow hairs; lower branch of proctiger yellowish brown and thin, shorter than upper branch. Cerci subacute distally, half as long as gonocoxites. Gonocoxites slightly curved dorsally. Gonostylus shortened, subquadrangular in lateral aspect, slightly constricted subapically, bearing long hairs on outer surface. Aedeagus stout, with two elongated aedeagal lobes and a greatly coiled penisfilum.

Abdomen of female (Fig. 7B, D). Terga II–IX blackish to light brown, each with a narrow, black antecosta. Subgenital plate blackish brown, bearing a bunch of black setae distally, consisting of two

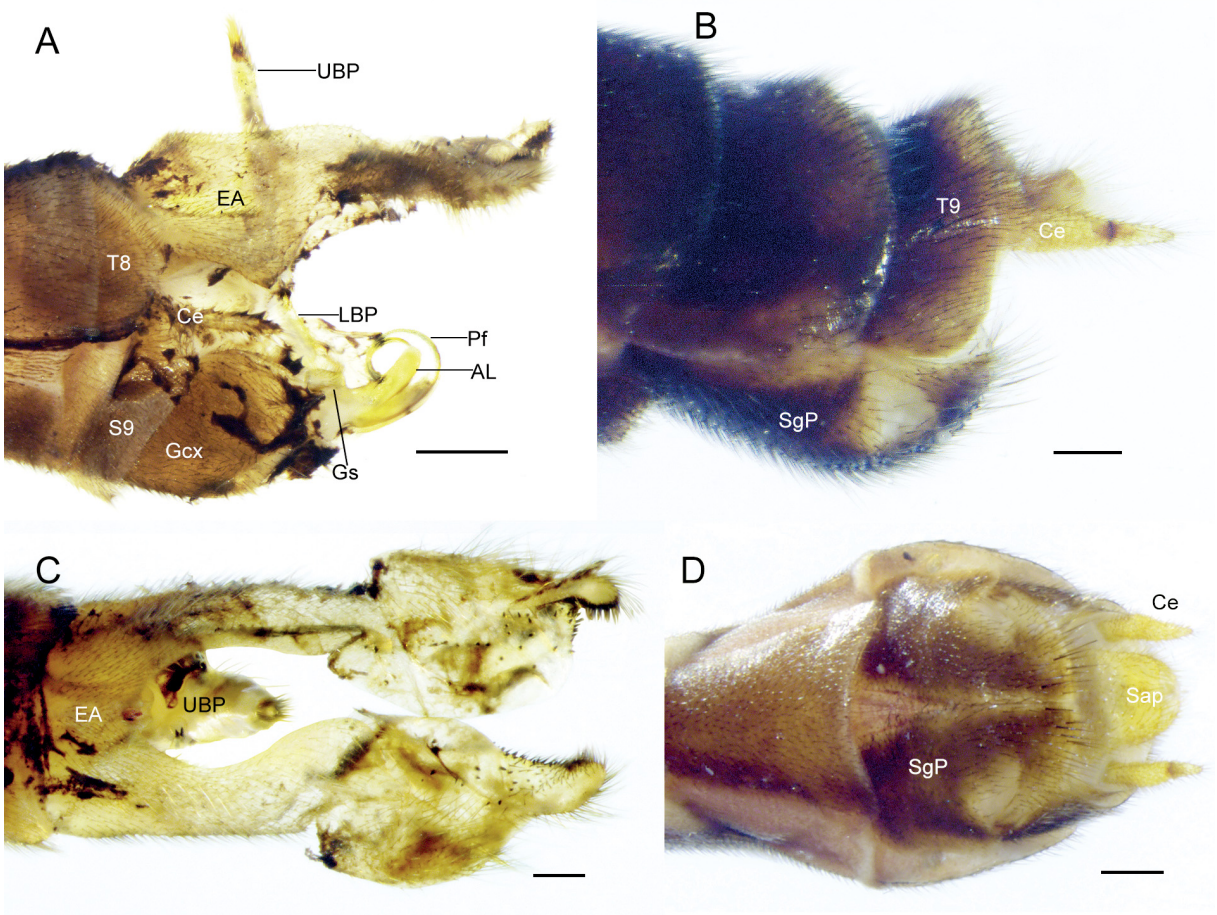

Fig. 7. *Bittacus leigongshanicus* sp. nov. **A, C**. ♂, holotype (NWAU). **B, D**. ♀, paratype (NWAU). **A**–**B**. Terminalia in lateral view. **C**–**D**. Terminalia in ventral view. Abbreviations: see Material and methods. Scale bars: A = 0.5 mm; B–D = 0.2 mm.

strongly sclerotized halves, divided mesially by acute triangular membrane; each half with a pale triangular membranous emargination subdistally along lateral edge. Tergum X narrow, extending ventrad. Supraanal and subanal plates broad, truncated anteriorly. Cerci yellowish brown, tapering toward apex, longer than anal plates.

Distribution

Guizhou Province, China.

Remarks

The new species is similar to *B. monastyrskiyi* Bicha, 2007 from Guangxi Province in appearance, but can be distinguished from the latter by the following features: epandrial appendage elongated into a sinuous lobe (cf. epandrial appendage split medially into two lobes, a short dorsal one and a long ventral one); upper branch of proctiger stout and finger-like with yellow apical hairs (cf. upper branch of proctiger slender, bearing a stout apical spine); aedeagal lobes elongated, broad distally (cf. aedeagal lobes semicircular).

Bittacus multisetus sp. nov.
urn:lsid:zoobank.org:act:C5F64A5A-1EF3-4CB2-B5A4-5763792CD230
Figs 8–10

Diagnosis

The new species can be distinguished from its congeners by the following features: 1) few markings on wings (Fig. 9); 2) the epandrial appendages greatly elongated, subrectangular in lateral aspect (Fig. 10A); 3) the upper branch of the proctiger elongated, expanded distally, bent anteriorly, bearing an apical hair bundle (Fig. 10A); and 4) numerous long setae along the lateral sides of the female subgenital plates (Fig. 10F).

Etymology

The specific epithet '*multisetus*' is derived from the Latin '*mult-*' (many) and '*set-*' (bristle), referring to the numerous setae along the lateral margins of the female subgenital plates.

Type material

Holotype

CHINA • ♂; Guizhou Province, Shuicheng County, Yushe National Forest Park; 26°27′36″ N, 104°48′36″ E; 1900–2200 m a.s.l.; 4–6 Jul. 2012; Jing Chen and Ying Miao leg.; NWAU.

Paratypes

CHINA • 2 ♀♀; Guizhou Province, Shuicheng County, Yushe National Forest Park; 26°27′36″ N, 104°48′36″ E; 2100–2200 m a.s.l.; 10 Jul. 2021; Le-Le He leg.; NWAU.

Description

Measurements. AL 5.2–6.8 mm, BL 13.1–15.2 mm, FL 17.4–18.3 mm, FW 4.5–5.7 mm, HL 15.4–16.9 mm, HW 3.3–4.2 mm.

Head (Fig. 8B). Vertex blackish brown; frons yellowish brown; median ocellus similar to lateral ocelli; black transverse band passing through ocellar triangle to compound eyes; clypeus and labrum blackish brown; maxillary palps unevenly colored, most segments black except distal segment yellowish brown; 3rd segment slightly longer than 4th and 5th segments combined. Antennae yellowish brown, filiform.

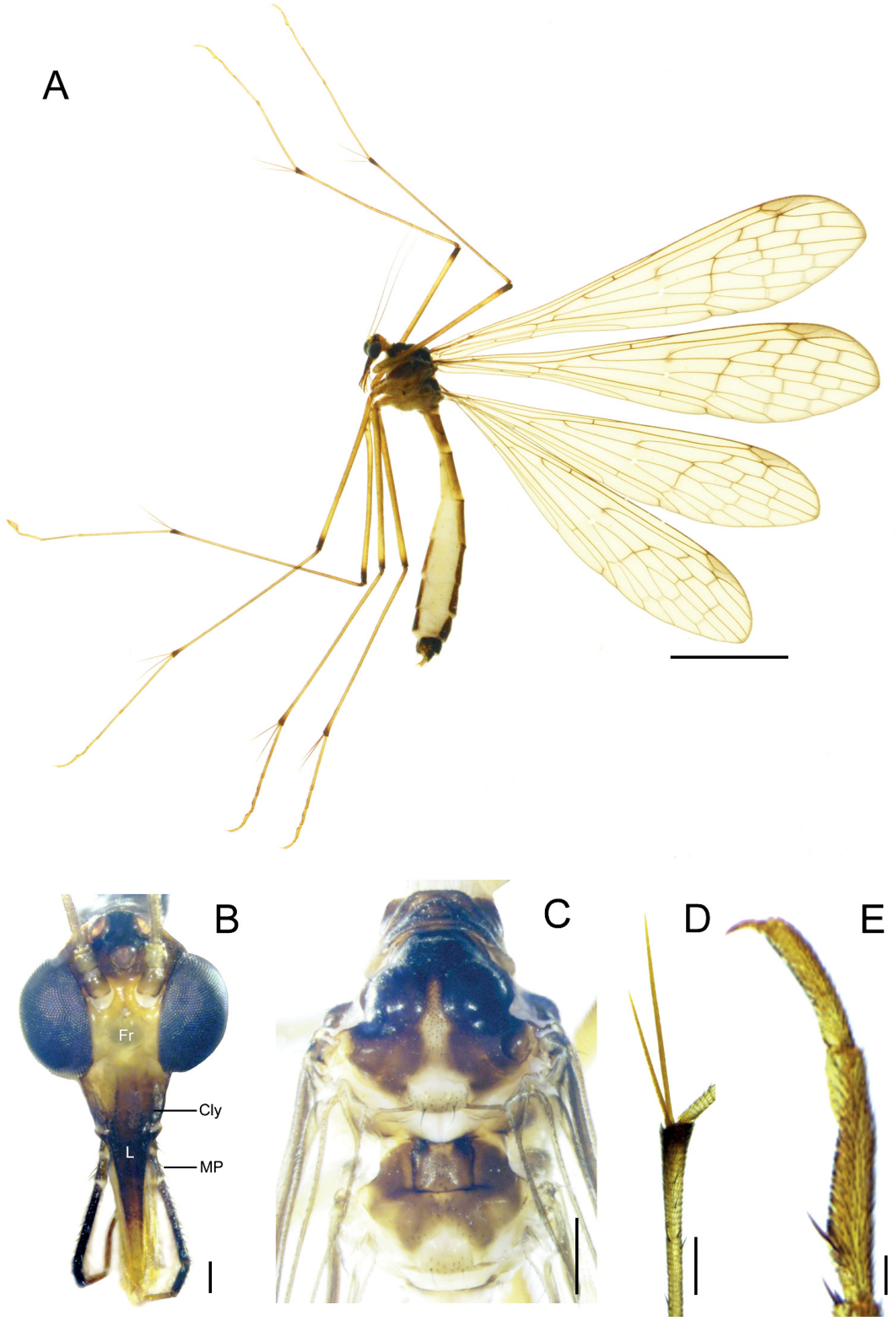

Fig. 8. *Bittacus multisetus* sp. nov., ♀, paratype (NWAU). **A**. Habitus in lateral view. **B**. Head in frontal view. **C**. Thorax in dorsal view. **D**. Tibia with two apical tibial spurs of left foreleg. **E**. Tarsomeres IV, V and claw of left foreleg. Abbreviations: see Material and methods. Scale bars: A = 5.0 mm; B = 0.2 mm; C–D = 0.5 mm; E = 0.1 mm.

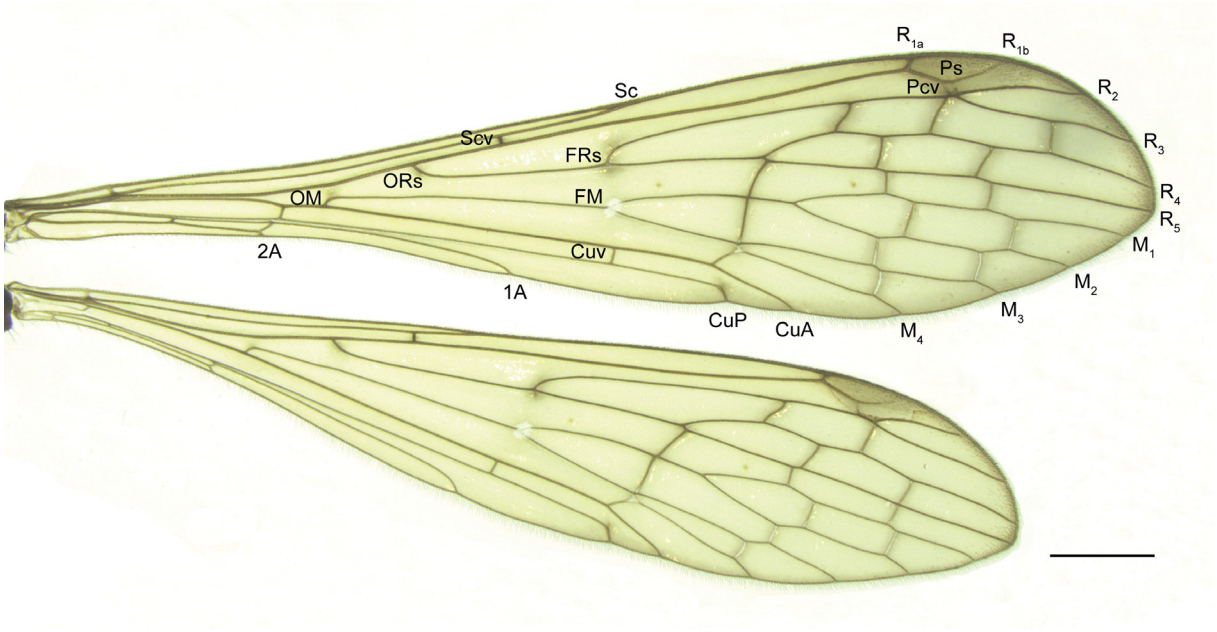

Fig. 9. Right wings of *Bittacus multisetus* sp. nov., ♀, paratype (NWAU). Abbreviations: see Material and methods. Scale bar = 2.0 mm.

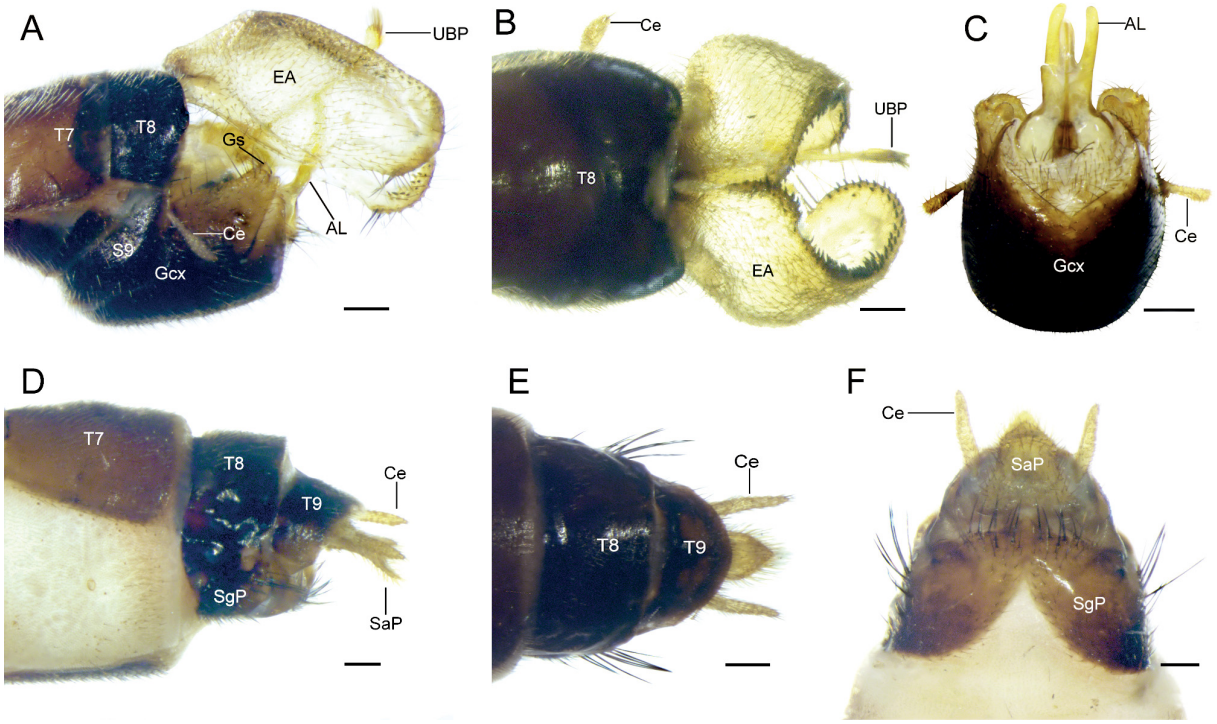

Fig. 10. *Bittacus multisetus* sp. nov. **A–C**. ♂, holotype (NWAU). **A**. Terminalia in lateral view. **B**. Terminalia in dorsal view. **C**. Terminalia in posterior view. **D–E**. ♀, paratype (NWAU). **D**. Terminalia in lateral view. **E**. Terminalia in dorsal view. **F**. Terminalia in ventral view. Abbreviations: see Material and methods. Scale bars = 0.2 mm.

Thorax (Fig. 8C). Pronotum blackish brown, without setae along anterior or posterior margins; mesonotum dark brown except scutum and median part light brown, two long setae along posterior margin; metanotum brown to light brown. Pleura unevenly yellowish brown. Legs yellowish brown, with femora and tibiae darker apically; two tibial spurs long (Fig. 8D); hind basitarsus as long as tarsomeres II−IV together, one black spine along each side of proximal tarsomere IV (Fig. 8E).

Wings (Fig. 9). Forewing membrane hyaline with light brown tinge, apex faintly subacute; pterostigma brown; three small grayish brown clouding speckles on OM, ORs, and FRs respectively; remaining cross-veins with diffuse light grayish brown cloudings; sparse short spinules along outer margin. Pcv two. Sc ending slightly beyond level of FRs; Scv before FRs; Cuv near level of FM; CuP near FM_{3+4}; Cuv two; 1A ending far before FM; 2A ending before OM; Av absent. Hindwing similar to forewing, but Sc ending before FRs, Pcv one.

Abdomen of male (Fig. 10A–C). Terga II–IV yellowish to light brown; terga V–VIII blackish brown; tergum VIII slightly emarginate on posterior margin; each with a dark antecosta. Epandrial appendage pale brown, approximately twice as long as gonocoxite, subrectangular with caudal margin rounded, two or three rows of black spines on inner surface along dorsal and apical margins, bearing a cluster of long black subapical setae on ventral margin. Tergum X greatly vestigial. Upper branch of proctiger yellowish brown, expanded distally, bent anteriorly, with apical hair bundle; lower branch of proctiger shorter, tapering toward apex. Cerci yellowish brown, clavate, longer than half length of gonocoxites. Gonocoxites blackish brown, shortened; distal portion protruding into subtriangular lobes separated by a deep V-shaped membranous median area; gonostylus with a process on inner side, and surrounded by sparse black setae. Aedeagus with paired elongated lobes; penisfilum coiled.

Abdomen of female (Fig. 10D–F). Terga II–IV yellowish to light brown; terga V–X blackish brown; a black antecosta on each tergum. Subgenital plate dull yellowish brown, greatly sclerotized; subgenital plate connected basally with lateral margin of tergum VIII, and curved dorsally for distal portion in lateral view; proximal two-thirds of plates prominently separated by V-shaped membrane, with a row of black setae along distal margin; approximately seven long black setae at median and lateral edge of each subgenital plate. Tergum X extending to base of cerci. Supra- and subanal plate acute caudally, bearing dense yellow hairs. Cerci yellowish brown, tapering toward apex, longer than supraanal plate.

Distribution

Guizhou Province, China.

Remarks

The new species is similar to *B. puripennis* Cai & Hua, 2006 from Shaanxi Province, but can be differentiated from the latter by the following characters: no prominent meso- and metanotum median streak (cf. the median meso- and metanotum streak pale); the distal margins of the epandrial appendages rounded (cf. the distal margins of the epandrial appendages acute); and the upper branch of the proctiger expanded distally, bent anteriorly (cf. the upper branch of the proctiger finger-like, straight).

Discussion

The Bittacidae are widely distributed in Guizhou, with the highest species diversity in the north, but a poor diversity in the south and central regions (Fig. 1). Such a distributional pattern may result from the ecological environment, human activities, and research intensity. Hangingflies usually inhabit the understory of moist and shady woodlands, having strict requirements for a high humidity of the habitat (Byers & Thornhill 1983; Hu *et al.* 2010). The Guizhou Plateau has a humid, sub-tropical monsoon climate, with a mean annual temperature of 15°C, a mean annual precipitation of 1100–1300 mm, and a forest cover rate of 13.7% (Luo *et al.* 2019), suitable for the survival of hangingflies. This is likely the reason that Guizhou has the second highest diversity of Bittacidae in China, preceded only by Shaanxi Province.

Three genera of Bittacidae have been documented in China to date. Among them, only *Bittacus* and *Terrobittacus* have been recorded in Guizhou (Wang & Hua 2017), whereas *Bicaubittacus* Tan & Hua, 2009 has been reported in the adjacent Yunnan and Guangxi Provinces (Tan & Hua 2009b). Therefore, *Bicaubittacus* is very likely to be found in Guizhou in the future.

At the specific level, as far as we know, seven species of Bittacidae are likely endemic to Guizhou (Wang & Hua 2017). *Bittacus dashahensis* and *B. stigmosus* were described based on females (Zhou & Zhou 2005), while *B. kuankuoshuensis* was described from males (Zhou & Zhou 2012), lacking the description of the opposite sex. *Terrobittacus xiphicus*, *Bittacus lii*, and *B. setigerus* are located in Guizhou and adjacent provinces. It is interesting that *B. sinicus* is distributed not only in the southwestern provinces, but also in the southern and northwestern regions of China, becoming the most widespread species of Bittacidae in China.

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References

Byers G.W. 2002. Scorpionflies, hangingflies, and other Mecoptera. *The Kansas School Naturalist* 48 (1): 3–15.

Byers G.W. & Thornhill R. 1983. Biology of the Mecoptera. *Annual Review of Entomology* 28: 203–228. https://doi.org/10.1146/annurev.en.28.010183.001223

Chen J., Tan J.L. & Hua B.Z. 2013. Review of the Chinese *Bittacus* (Mecoptera: Bittacidae) with descriptions of three new species. *Journal of Natural History* 47: 1463–1480. https://doi.org/10.1080/00222933.2012.763065

Du W. & Hua B.Z. 2017. Two new species of the genus *Terrobittacus* Tan & Hua, 2009 (Mecoptera: Bittacidae) from southwestern China with a key to species. *European Journal of Taxonomy* 294: 1–13. https://doi.org/10.5852/ejt.2017.294

Gao Q.H. & Hua B.Z. 2013. Co-evolution of the mating position and male genitalia in insects: a case study of a hangingfly. *PLoS ONE* 8 (12): e80651. https://doi.org/10.1371/journal.pone.0080651

Hu X.W., Liu R.Z., Liu S.Y. & Hua B.Z. 2010. Comparative ultramorphology of the antennal sensilla between Panorpidae and Bittacidae (Mecoptera). *Acta Zootaxonomica Sinica* 35 (4): 790–798.

Hua B.Z., Tan J.L. & Huang P.Y. 2008. Two new species of the genus *Bittacus* (Mecoptera: Bittacidae) from China. *Zootaxa* 1749: 62–68. https://doi.org/10.11646/ZOOTAXA.1749.1.6

Huang P.Y. & Hua B.Z. 2005. Four new species of the Chinese *Bittacus* Latreille (Mecoptera, Bittacidae). *Acta Zootaxonomica Sinica* 30: 393–398.

Jiang L., Gao Q.H. & Hua B.Z. 2015. Larval morphology of the hanging-fly *Bittacus trapezoideus* Huang & Hua (Insecta: Mecoptera: Bittacidae). *Zootaxa* 3957 (3): 324–333. https://doi.org/10.11646/zootaxa.3957.3.5.

Luo Y., Lu M.H., Wang H.Y. & Qiu A.N. 2019. Recent soil erosion in the Hongfeng catchment on the Guizhou Plateau, SW China revealed by analysis of reservoir sediments and soil loss modeling. *Journal of Paleolimnology* 61: 17–35. https://doi.org/10.1007/s10933-018-0042-z

Mickoleit G. 1976. Die Genital- und Postgenitalsegmente der Mecoptera-Weibchen (Insecta, Holometabola). II. Das Dach der Genitalkammer. *Zoomorphologie* 85: 133–156. https://doi.org/10.1007/BF00995408

Setty L.R. 1940. Biology and morphology of some North American Bittacidae (Order Mecoptera). *American Midland Naturalist* 23: 257–353. https://doi.org/10.2307/2420667

Tan J.L. & Hua B.Z. 2008a. Structure of raptorial legs in *Bittacus* (Mecoptera: Bittacidae). *Acta Entomologica Sinica* 51 (7): 745–752.

Tan J.L. & Hua B.Z. 2008b. Morphology of immature stages of *Bittacus choui* (Mecoptera: Bittacidae) with notes on its biology. *Journal of Natural History* 42: 2127–2142. https://doi.org/10.1080/00222930802209775

Tan J.L. & Hua B.Z. 2009a. *Terrobittacus*, a new genus of the Chinese Bittacidae (Mecoptera) with descriptions of two new species. *Journal of Natural History* 43 (45–48): 2937–2954. https://doi.org/10.1080/00222930903359628

Tan J.L. & Hua B.Z. 2009b. *Bicaubittacus*, a new genus of the Oriental Bittacidae (Mecoptera) with descriptions of two new species. *Zootaxa* 2221 (1): 27–40. https://doi.org/10.11646/zootaxa.2221.1.2

Tan J.L. & Hua B.Z. 2009c. Description of the immature stages of *Bittacus planus* Cheng (Mecoptera: Bittacidae) with notes on its biology. *Proceedings of the Entomological Society of Washington* 111 (1): 111–121. https://doi.org/10.4289/0013-8797-111.1.111

Wang J.S. & Hua B.Z. 2017. An annotated checklist of the Chinese Mecoptera with description of male *Panorpa guttata* Navás, 1908. *Entomotaxonomia* 39 (1): 24–42. https://doi.org/10.11680/entomotax.2017003

Zhang Y.N., Du W. & Hua B.Z. 2020. Three new species of the genus *Bittacus* Latreille, 1805 (Mecoptera: Bittacidae), with a key to the species of Bittacidae in South China. *Zootaxa* 4718 (3): 381–390. https://doi.org/10.11646/zootaxa.4718.3.6

Zheng Y.Y., Chen Q.X., Yi Q. & Hua B.Z. 2022. Ultrastructure of the larval eyes of the hangingfly *Terrobittacus implicatus* (Mecoptera: Bittacidae). *Micron* 152: 103176. https://doi.org/10.1016/j.micron.2021.103176

Zhou W.B. 2003. Four new species of Mecoptera from China. *Wuyi Science Journal* 19: 87–94.

Zhou W.B. & Zhou X. 2005. Mecoptera. *In*: Yang M.F. & Jin D.C. (eds) *Insects from Dashahe Nature Reserve of Guizhou*. Guizhou People's Publishing House, Guiyang.

Zhou X. & Zhou W.B. 2007. Mecoptera. *In*: Li Z.Z. & Jin D.C. (eds) *Insects from Leigongshan Landscape*. Guizhou Science and Technology Publishing House, Guiyang.

Zhou X. & Zhou W.B. 2012. Mecoptera. *In*: Dai R.H., Li Z.Z. & Jin D.C. (eds) *Insects from Kuankuoshui Landscape*. Guizhou Science and Technology Publishing House, Guiyang.

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