



Research article

[urn:lsid:zoobank.org:pub:39894204-DA29-4378-B378-F2F5C10BB345](https://zoobank.org/pub:39894204-DA29-4378-B378-F2F5C10BB345)

**Two new species of the genus *Terrobittacus* Tan & Hua, 2009
(Mecoptera: Bittacidae) from southwestern China with a key to species**

Wei DU¹ & Bao-Zhen HUA^{2,*}

^{1,2}Key Laboratory of Plant Protection Resources and Pest Management, Ministry of Education,
Entomological Museum, Northwest A&F University, Yangling, Shaanxi 712100, China.

* Corresponding author: huabzh@nwfau.edu.cn

¹ Email: duweiedu@nwfau.edu.cn

¹ [urn:lsid:zoobank.org:author:A0626819-271A-40BF-92E8-BCE8D13F2B8C](https://zoobank.org/author:A0626819-271A-40BF-92E8-BCE8D13F2B8C)

² [urn:lsid:zoobank.org:author:C02F1E14-1B20-4B92-BA8F-57937D3D3137](https://zoobank.org/author:C02F1E14-1B20-4B92-BA8F-57937D3D3137)

Abstract. Two new species of hangingflies, *Terrobittacus rostratus* sp. nov. and *Terrobittacus angustus* sp. nov., are described and illustrated from Yunnan, southwestern China, increasing the species number of *Terrobittacus* Tan & Hua, 2009 to six. *Terrobittacus rostratus* sp. nov. differs from its congeners by wings devoid of markings and epandrial appendages slightly longer than half the length of the gonocoxites. *Terrobittacus angustus* sp. nov. can be recognized by wing markings along R_5 distally. A key to species of the genus is updated to include the two new species.

Key words. Hangingflies, taxonomy, biodiversity, Yunnan, China.

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>

Introduction

Bittacidae Handlirsch, 1906, a cosmopolitan family of Mecoptera Packard, 1886, is peculiar for the adults having three pairs of raptorial legs, each with a grasping structure formed by the fourth and fifth tarsomeres (Tan & Hua 2008). They usually use their prehensile tarsi to hang themselves from the edge of leaves or twigs of plants; therefore, they are commonly called hangingflies (Byers 2002). The bittacids are mostly found in moist, shady woodlands and have strict habitat requirements (Setty 1940; Byers & Thornhill 1983). During mating, the male frequently provides an insect prey as a nuptial gift to the female, and twists his abdomen temporarily up to 180° to form a belly-to-belly hanging copulation position with the female (Gao & Hua 2013).

As the second largest family in Mecoptera, Bittacidae comprises 18 extant genera and over 200 described species in the world (Bicha 2011; Byers 2011; Chen *et al.* 2013). Thirty-five species in three genera (*Bittacus* Latreille, 1805, *Bicaubittacus* Tan & Hua, 2009 and *Terrobittacus* Tan & Hua, 2009) have been recorded in China to date (Cheng 1957; Tan & Hua 2009a, 2009b; Chen *et al.* 2013; Du *et al.* 2015).

The genus *Terrobittacus* is endemic to China – it is known from the Shaanxi, Henan, Hunan, Guizhou, and Fujian provinces – and has *Bittacus implicatus* Huang & Hua in Cai *et al.*, 2006 as its type species. Herein, two undescribed species of *Terrobittacus* from Yunnan, southwestern China, are described as new to science, thereby increasing the species number of *Terrobittacus* to six. A key to species of the genus is updated to include the two new species.

Material and methods

Type specimens were collected from montane areas in Yongde County, Yunnan Province, and are deposited in 75% ethanol at the Entomological Museum, Northwest A&F University, China (NWAU).

Specimens were observed under a Nikon SMZ1500 microscope. Photographs were taken with a Nikon D7000 digital camera, and stacked with Zerene stacker (version 1.04) software. For scanning electron microscopy (SEM), the samples were dehydrated in a graded ethanol series, replaced by tertiary butanol, dried in a CO₂ critical-point dryer, sputter-coated with gold and examined under a Hitachi S-3400N scanning electron microscope (Hitachi, Tokyo, Japan) at 15 kV. The measurements were obtained with a vernier caliper, and are presented as mean ± SD (standard deviation).

Abbreviations

The following abbreviations are used in measurements:

BL = body length
FL = forewing length
FW = forewing width
HL = hindwing length
HW = hindwing width

The following abbreviations are used in describing wing venation:

Av = apical cross-vein between CuP and 1A
CuA = anterior cubitus
CuP = posterior cubitus
Cuv = apical cross-vein between CuA and CuP
FM = fork of media
FRs = first fork of radial sector
ORs = the origin of radial sector
Pcv = cross-veins between R₁ and R₂ behind the pterostigma
R₁ = first radius
Sc = subcosta
Scv = cross-vein between distal half of Sc and R₁

Results

Class Insecta Linnaeus, 1758
Order Mecoptera Packard, 1886
Family Bittacidae Handlirsch, 1906

Genus *Terrobittacus* Tan & Hua, 2009

Terrobittacus Tan & Hua, 2009b: 2938. Type species: *Bittacus implicatus* Huang & Hua in Cai *et al.*, 2006 by original designation.

Diagnosis

The genus can be recognized by the following characters: 1) wings with one pterostigmal cross-vein; 2) tarsomere IV with one spine on each side; 3) male epandrial appendages distinctly shorter than half the length of the gonocoxites, except for *T. rostratus* sp. nov. with epandrial appendages slightly longer than half the length of the gonocoxites; aedeagal lobes small and acute; tergum X strongly vestigial dorsally; sex pheromone glands single-lobed; 4) the two halves of the subgenital plate almost fused completely in the female.

Key to the species of *Terrobittacus* (♂, modified from Tan & Hua 2009b)

1. Thorax with a distinct pale yellowish streak mesally; wings with cross-veins r-m and m connected at fork of M_{1+2} (FM_{1+2}); cerci longer than epandrial appendages; gonocoxites with one to three pairs of long convergent bristles apically *T. longisetus* Tan & Hua, 2009
 - Thorax without a distinct mesal streak; cross-veins r-m and m connected before FM_{1+2} ; cerci shorter than epandrial appendages; gonocoxites without long bristles apically 2
2. Blackish brown cloudings diffused along most cross-veins forming two noticeable bands or along R_5 with a brown fleck; proctiger pointed, with its apex rounded 3
 - No noticeable marked bands along cross-veins; apex of proctiger not rounded 4
3. Epandrial appendages roughly trapezoid in lateral view
 - *T. echinatus* (Hua & Huang in Hua *et al.* 2008)
 - Epandrial appendages clavate in lateral view *T. angustus* sp. nov.
4. Proctiger slender, sabre-shaped, curved caudad, acute apically *T. xiphicus* Tan & Hua, 2009
 - Proctiger relatively thick; apex curved caudoventrally into a hook, like rostrum of a parrot 5
5. Epandrial appendages boot-shaped in lateral view *T. rostratus* sp. nov.
 - Epandrial appendages triangular in lateral view ... *T. implicatus* (Huang & Hua in Cai *et al.*, 2006)

***Terrobittacus rostratus* sp. nov.**

urn:lsid:zoobank.org:act:35A77A25-C607-46F1-8E5E-869BFC75BCBD

Figs 1–4, 9C

Diagnosis

The new species differs from its congeners by the following characters: 1) wings hyaline without clouded markings; 2) male epandrial appendages boot-shaped in lateral view, upper branch of proctiger broad with two round lateral flanks and a beak-like apex; 3) female subgenital plate black basally, yellowish brown distally, and with a narrow membranous line mesally.

Etymology

The specific epithet is derived from the Latin ‘*rostratus*’ (beak-shaped), referring to the beak-shaped upper branch of the proctiger in the male.

Type material**Holotype**

CHINA: ♂, Yunnan Province, Yongde County, Mount Daxueshan, 24°01'30" N, 99°15'15" E, 2000 m, 29 Aug. 2015, coll. Ji-Shen Wang (NWAU).

Paratypes

CHINA: 34 ♂♂, 16 ♀♀, same data as holotype, 29–30 Aug. 2015; 20 ♂♂, 20 ♀♀, Yunnan Province, Yongde County, Mount Tanglishan, 24°01'17" N, 99°14'23" E, 1400–2000 m, 11–26 Aug. 2015, coll. Ji-Shen Wang (NWAU).

Description

MEASUREMENTS. Male ($n = 20$): BL = 11.16 ± 0.94 mm; FL = 15.80 ± 0.42 mm, FW = 3.66 ± 0.19 mm; HL = 13.93 ± 0.39 mm, HW = 3.21 ± 0.13 mm. Female ($n = 20$): BL = 11.5 ± 0.84 mm; FL = 15.76 ± 1.16 mm, FW = 3.73 ± 0.14 mm; HL = 13.96 ± 1.13 mm, HW = 3.28 ± 0.15 mm (Fig. 1A).

HEAD. Vertex and frons yellowish brown; clypeus lighter than frons; genae pale; labrum yellowish brown, darker basally and laterally; maxillary and labial palps dark brown; fifth segment of maxillary palp slightly longer than fourth (Fig. 1B). Ocellar triangle black; three ocelli almost equal in diameter; median ocellus accompanied with two bristles. Antennae filiform and ciliated; scape and flagellum dark brown, pedicel pale brown; flagellum with distinct segments basally and obscure beyond 13th segment.

THORAX. Pronotum black, with two long setae on anterior margin, and a few setae on posterior margin. Anterior two-thirds of mesonotum black, remaining part and metanotum unevenly brown; meso- and metascutellum each with two long black setae (Fig. 1C). Pleura unevenly pale brown. Legs yellowish brown, except coxae pale brown, femora and tibiae darker apically (Fig. 1A); fourth tarsomere with one spine on each side; hind basitarsus longer than second and third tarsomeres together.

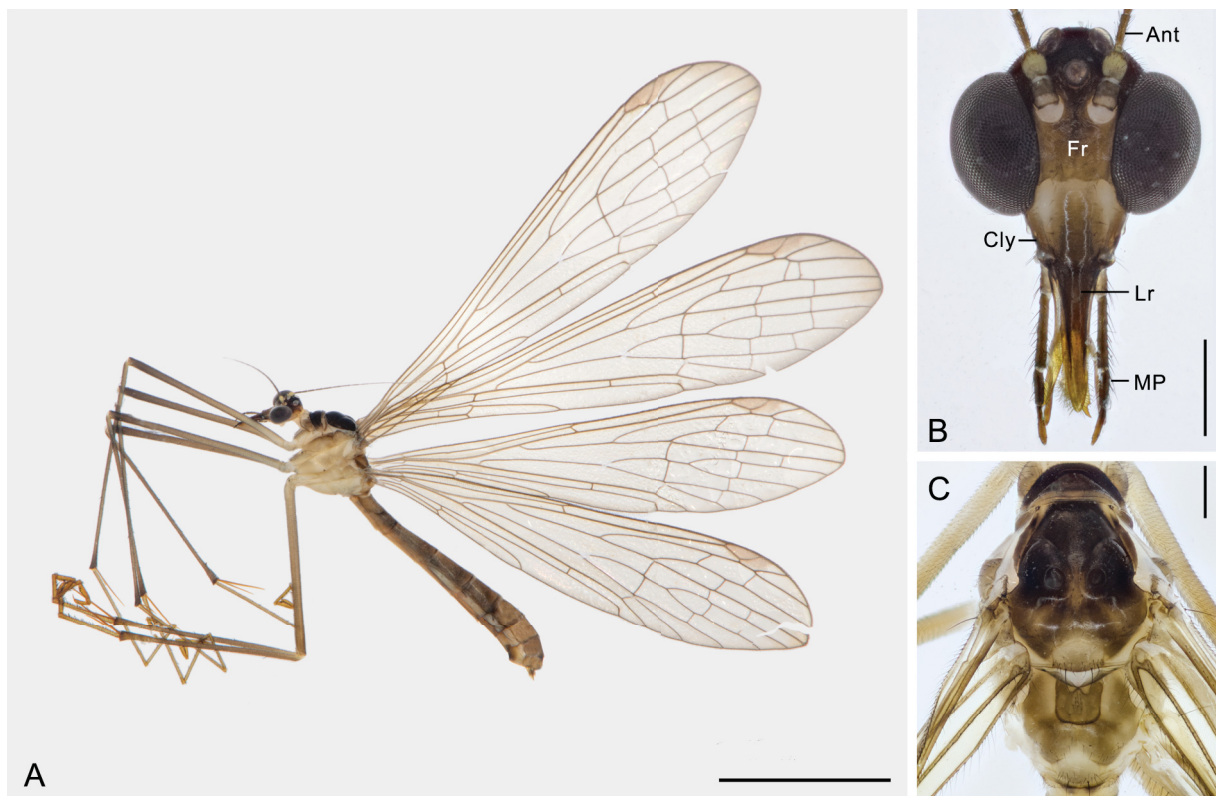


Fig. 1. *Terrobittacus rostratus* sp. nov. **A.** ♀, habitus in lateral view. **B.** Head in frontal view. **C.** Thorax in dorsal view. Abbreviations: Ant = antenna; Cly = clypeus; Fr = frons; Lr = labrum; MP = maxillary palp. Scale bars: A = 5.0 mm; B–C = 0.5 mm.

WINGS. Forewing membrane hyaline and tinged with yellowish brown; pterostigma brown; apical margin slightly infuscate; thyridium at FM conspicuous; two nygmata each in cells R_{4+5} and $1R_5$; one Pcv; Sc ending beyond the level of FRs; Cuv near level of FM; CuA ending slightly beyond Sc terminus, CuP terminating near level of Scv; Av absent, 1A terminating beyond the level of ORs; apical cross-veins roughly arranged in three lines. Hindwings similar to forewings, but Sc terminating at level of midpoint between ORs and FRs; 1A coalesced with CuP subbasally; apical cross-veins fewer than those of forewings (Fig. 2).

ABDOMEN OF MALE. Terga II–VIII light brown to dark brown, each with a black narrow antecosta; tergum VIII emarginated on posterior margin. Sterna II–VIII pale to dark brown, sternum IX lighter than sternum VIII. Sex pheromone glands single-lobed, each at intersegmental areas between terga VI–VII and between terga VII–VIII (Fig. 3A). Epandrial appendages (tergum IX) yellowish brown, slightly longer than half the length of gonocoxites, boot-shaped in lateral view, with basal third broad and distal two-thirds narrowed toward rounded apex; inner surface with two patches of small black spines each at apex and dorsal process (Fig. 3B–C), and margin from dorsal process to apex also with sparse spines. Tergum X strongly vestigial dorsally with two slender lateral plates extending to base of lower branch of proctiger. Upper branch of proctiger flat, strongly sclerotized with two broad lateral flanks bearing scattered setae, apex curved caudoventrad into a beak; lower branch of proctiger shorter than upper branch, curved downward and tapering apically (Fig. 3D). Cerci conical, almost one-third as long as gonocoxites (Fig. 3A). Gonocoxites yellowish brown, caudal portion with a pale U-shaped membranous area (Fig. 3E). Gonostyli stout basally, distal portion curved cephalad and tapering toward apex. Aedeagus broad basally, with two aedeagal lobes acute and median penisfilum coiled greatly (Fig. 3A, E).

ABDOMEN OF FEMALE. Terga II–IX yellowish brown or unevenly brown, each with a narrow black antecosta. Sterna II–VII yellowish brown, or pale in sterna II–IV and unevenly dark brown in sterna V–VII. Subgenital plate black basally, yellowish brown distally (Fig. 4A), and with a rather narrow membranous line mesally, which is broadened at distal half (Fig. 4B); a pair of acute processes each

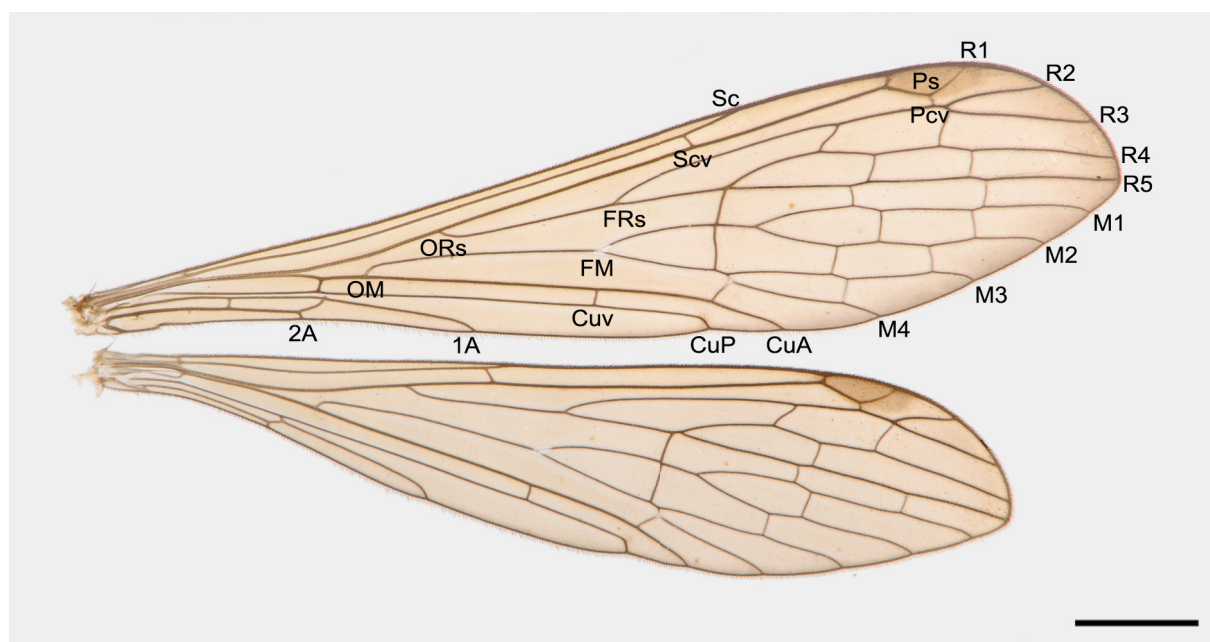


Fig. 2. Right wings of a male specimen of *Terrobittacus rostratus* sp. nov. Scale bar = 2.0 mm.

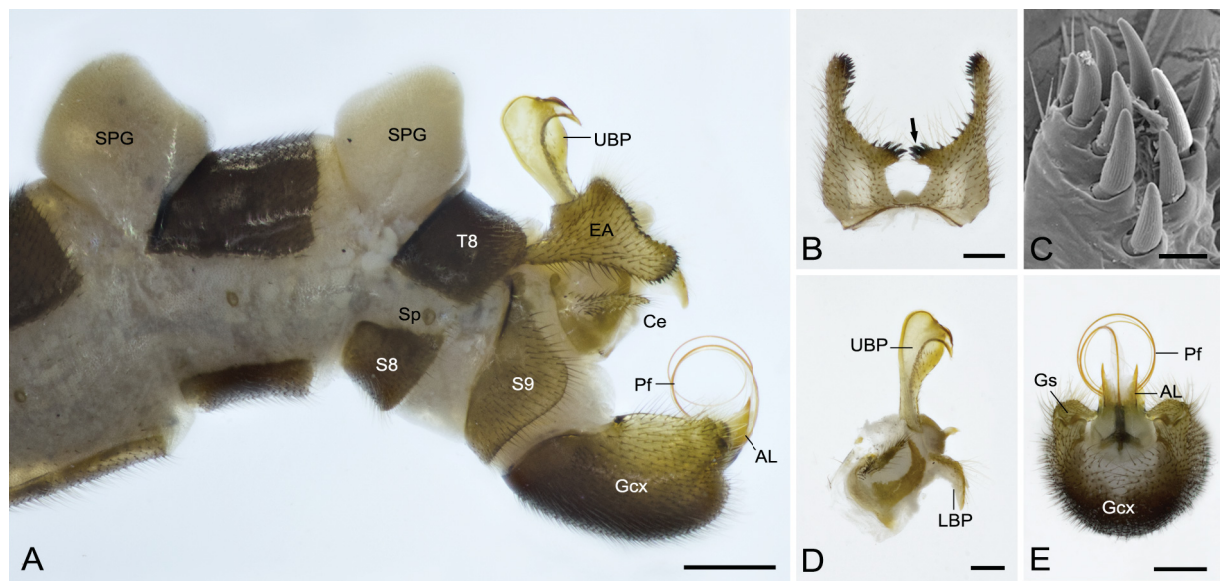


Fig. 3. Male genitalia of *Terrobittacus rostratus* sp. nov. **A.** Terminalia in lateral view. **B.** Epandrial appendages in dorsal view = arrow shows the dorsal process. **C.** Spines on dorsal process of epandrial appendages = SEM micrograph. **D.** Abdominal segment X and proctiger in lateral view. **E.** Genitalia in caudal view. Abbreviations: AL = aedeagal lobe; Ce = cercus; EA = epandrial appendage; Gcx = gonocoxite; Gs = gonostylus; LBP = lower branch of proctiger; Pf = penisfilum; S = sternum; Sp = spiracle; SPG = sex pheromone gland; T = tergum; UBP = upper branch of proctiger. Scale bars: A = 0.5 mm; B, D–E = 0.2 mm; C = 25 μ m.

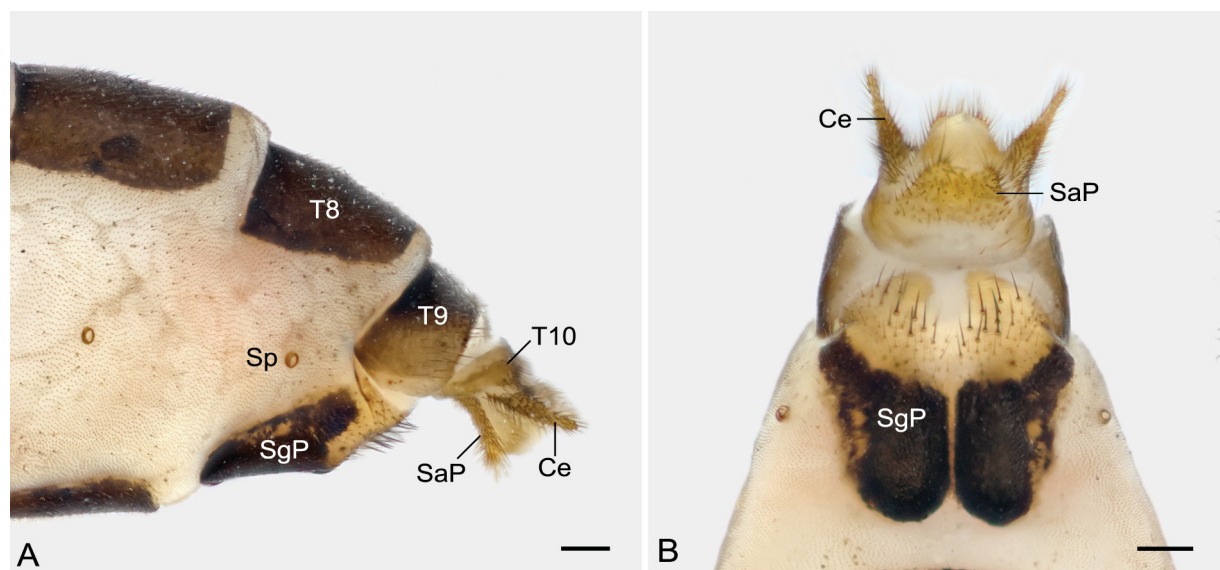


Fig. 4. Female terminalia of *Terrobittacus rostratus* sp. nov. **A.** Lateral view. **B.** Ventral view. Abbreviations: Ce = cercus; SaP = subanal plate; SgP = subgenital plate; Sp = spiracle; T = tergum. Scale bars = 0.2 mm.

projecting from lateral margins distally, and extending to anterior edge of tergum IX; distal portion of subgenital plate with long thick setae directed caudad (Fig. 4A–B). Tergum X yellowish brown, extending ventrad. Supraanal plate and subanal plate truncated apically. Cerci setose, slightly longer than supraanal plate.

Distribution

Yunnan Province, China.

Remarks

The new species differs from other species of *Terrobittacus* in its male epandrial appendages, which is slightly longer than half the length of the gonocoxites.

Terrobittacus rostratus sp. nov. resembles *T. longisetus* and *T. implicatus* in general appearance, especially the hook-like proctiger in the male genitalia. However, it can be separated from the latter two species by its boot-shaped epandrial appendages. In addition, wings are devoid of markings in *T. rostratus* sp. nov., but have clouded markings in the latter two species. Females of *T. rostratus* sp. nov. can also be differentiated from congeners by the unique coloration of its subgenital plate, which is black basally and yellowish brown distally.

Terrobittacus angustus sp. nov.

[urn:lsid:zoobank.org:act:6279AC78-C9AA-4108-A537-F752F9B31318](https://doi.org/10.21203/rs.3.rs-1111111/v1)

Figs 5–8, 9D

Diagnosis

The new species is distinguished from its congeners by the following characters: 1) wings with a clouded brown fleck along R_5 distally; 2) male epandrial appendages narrow, with small black spines on inner



Fig. 5. *Terrobittacus angustus* sp. nov. **A.** ♂, habitus in lateral view. **B.** Head in frontal view. **C.** Thorax in dorsal view. Abbreviations: Ant = antenna; Cly = clypeus; Fr = frons; Lr = labrum; MP = maxillary palp. Scale bars: A = 5.0 mm; B = 0.2 mm; C = 0.5 mm.

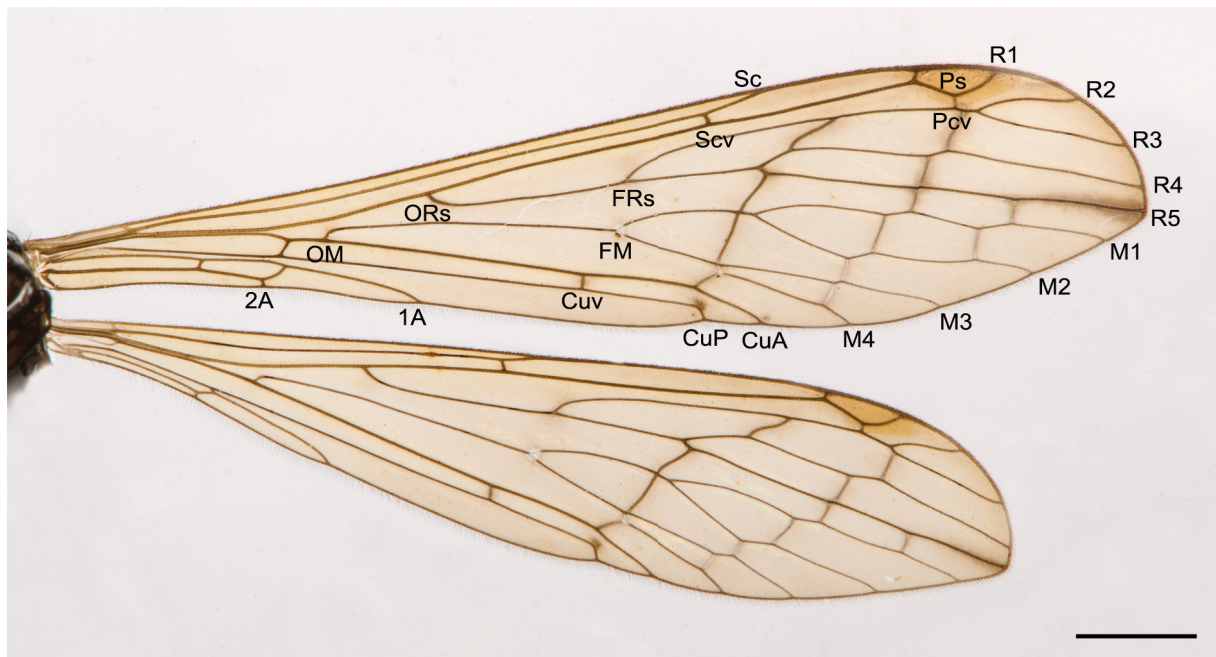


Fig. 6. Right wings of a male specimen of *Terrobittacus angustus* sp. nov. Scale bar = 2.0 mm.

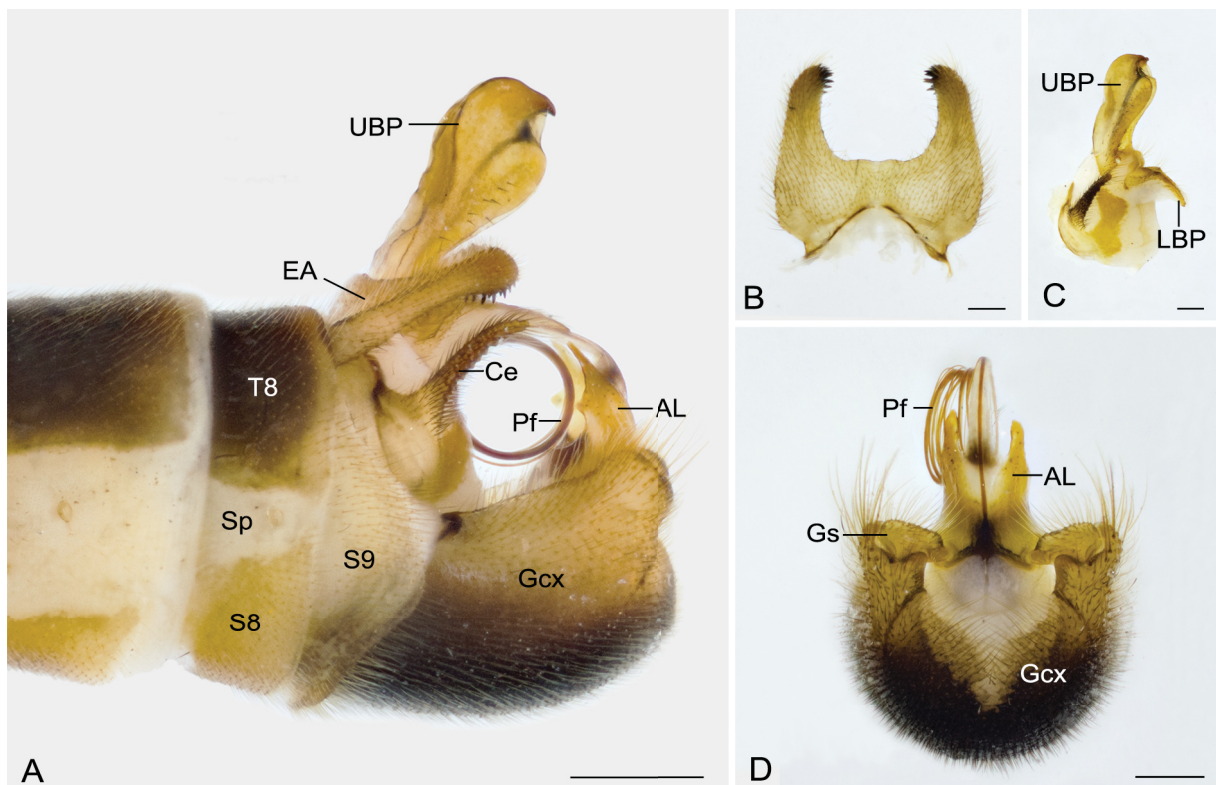


Fig. 7. Male genitalia of *Terrobittacus angustus* sp. nov. **A.** Terminalia in lateral view. **B.** Epandrial appendages in dorsal view. **C.** Abdominal segment X and proctiger in lateral view. **D.** Genitalia in caudal view. Abbreviations: AL = aedeagal lobe; Ce = cercus; EA = epandrial appendage; Gcx = gonocoxite; Gs = gonostylus; LBP = lower branch of proctiger; Pf = penisfilum; S = sternum; Sp = spiracle; T = tergum; UBP = upper branch of proctiger. Scale bars: A = 0.5 mm; B–D = 0.2 mm.

surface of rounded apex; 3) female subgenital plate with a triangular membranous area basally and deeply cleft distally, two black sclerotized carinae at anterior portion.

Etymology

The specific epithet is derived from the Latin ‘*angustus*’ (narrow), referring to the narrow shape of the epandrial appendages in lateral view.

Type material

Holotype

CHINA: ♂, Yunnan Province, Yongde County, Mount Daxueshan, 24°01′30″ N, 99°15′15″ E, 1600–2500 m, 21 Aug. 2015, Ji-Shen Wang leg. (NWAU).

Paratypes

CHINA: 3 ♂♂, 3 ♀♀, same data as holotype, 21–23 Aug. 2015 (NWAU).

Description

MEASUREMENTS. Male ($n = 4$): BL = 13.86 ± 0.61 mm; FL = 18.72 ± 0.34 mm, FW = 4.16 ± 0.13 mm; HL = 16.61 ± 0.32 mm, HW = 3.60 ± 0.16 mm. Female ($n = 3$): BL = 13.37 ± 0.38 mm; FL = 18.31 ± 0.36 mm, FW = 4.19 ± 0.15 mm; HL = 16.17 ± 0.49 mm, HW = 3.61 ± 0.12 mm (Fig. 5A).

HEAD. Vertex yellowish brown; frons dark brown; clypeus unevenly brown; genae pale yellow; labrum yellowish brown, with lateral edges darker; maxillary and labial palps brown; fourth maxillary palpomere slightly longer than fifth (Fig. 5B). Ocellar triangle black, median ocellus accompanied with two bristles and slightly smaller than others in diameter. Antennae filiform and ciliated; scape and flagellum yellowish brown, pedicel yellowish; flagellum ca 17-segmented and indistinctly segmented apically.

THORAX. Pronotum dark brown, with 2–4 long black setae along anterior edge, and few setae along posterior edge. Anterior two-thirds of mesonotum dark brown, the remaining portion and metanotum

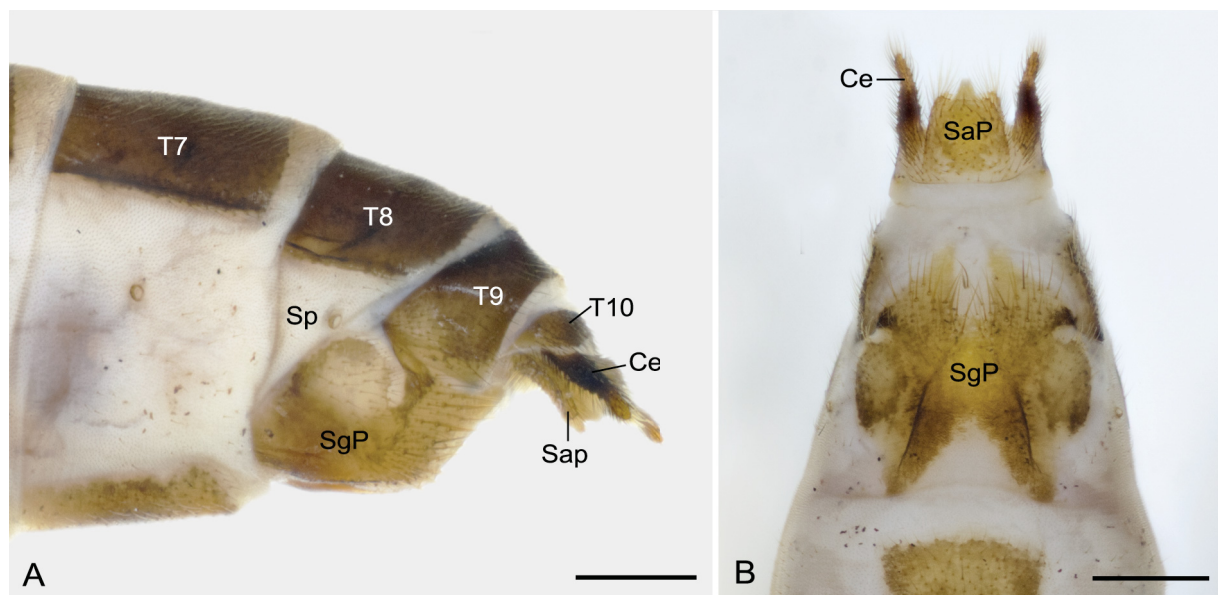


Fig. 8. Female terminalia of *Terrobittacus angustus* sp. nov. **A.** Lateral view. **B.** Ventral view. Abbreviations: Ce = cercus; SaP = subanal plate; SgP = subgenital plate; Sp = spiracle; T = tergum. Scale bars = 0.5 mm.

unevenly yellowish brown; meso- and metascutellum each with two long setae (Fig. 5C). Pleura unevenly pale brown, with scattered setae. Legs yellowish brown except coxae pale brown, femora and tibiae darker apically (Fig. 5A); fourth tarsomere with one spine on each side, hind basitarsus longer than second and third tarsomeres together.

WINGS. Forewing membrane hyaline and tinged with faint yellowish brown, costal margin and apical margin from pterostigma to R_5 slightly darkened; pterostigma conspicuous; brown clouded at ORs, FRs, OM and subdistal CuP, also along apical cross-veins; posterior portion of R_5 with a brown clouded fleck broadening toward apex; two thyridia each at FM and at base of M_4 ; apex of wing almost right-angled and outer margin from R_5 to M_3 straight; one Pcv; Sc ending beyond level of FRs; CuA ending at level of Sc terminus; CuP ending before level of Scv; Cuv before level of FM; 1A ending at level of ORs, or slightly beyond level of ORs; Av absent; apical cross-veins roughly arranged in two lines; cross-veins between M_2 to M_4 transparent. Hindwings similar to forewings, but Sc terminated before FRs, 1A and CuP coalesced subbasally (Fig. 6).

ABDOMEN OF MALE. Terga II–VIII yellowish brown to dark brown, each with a black narrow antecosta; tergum VIII slightly emarginated on posterior margin. Sterna II–VI pale yellow, sterna VII–IX yellowish brown. Pleura pale. Epandrial appendages rather narrow, clavate in lateral view, broad basally and narrowing toward rounded apex, and distinctly shorter than half of gonocoxites (Fig. 7A); inner surface with a patch of small black spines apically (Fig. 7B). Tergum X vestigial dorsally, with two lateral plates extending to and surrounding bases of cerci. Upper branch of proctiger strongly sclerotized and with two lateral flanks bearing scattered short setae, its apex slightly curved into a hook; lower branch of proctiger curved downward and shorter than upper branch (Fig. 7C). Cerci dark brown and slightly curved apically, slightly shorter than epandrial appendages. Gonocoxites yellowish brown dorsally and dark brown ventrally, completely joined ventrally and with a V-shaped membranous area posteriorly (Fig. 7A, D); in one specimen, gonocoxites separated by a rather narrow membranous area in ventral aspect. Gonostyli setose and tapering toward apex. Aedeagus with two acute aedeagal lobes each projecting a triangular process from anterior margin mesally; penisfilum greatly elongated, coiled (Fig. 7A, D).

ABDOMEN OF FEMALE. Terga II–IX unevenly dark brown, each with narrow black antecosta. Sterna II–VII pale yellow to yellowish brown. Subgenital plate yellowish brown with pale triangular membranous area basally, and deeply cleft apically; lateral margins oval at basal half, and each projecting a slender process extending to anterior edge of tergum IX distally (Fig. 8A); subgenital plate with long thick setae at posterior portion, and a pair of black carinae at anterior portion (Fig. 8B). Tergum X yellowish brown and extending ventrad. Supraanal plate and subanal plate truncated apically with long setae, posterior edge of supraanal plate with a small process mesally.

Distribution

Yunnan Province, China.

Remark

Terrobittacus angustus sp. nov. is similar to *T. rostratus* sp. nov. in the general coloration and wing venation, but its wings have clouded markings at forks of major veins, along most apical cross-veins and the distal half of R_5 (cf. wings devoid of markings). They can also be readily separated by the external genitalia, for *T. angustus* sp. nov. has male epandrial appendages clavate in lateral view (cf. epandrial appendages boot-shaped), and female subgenital plate lacking a narrow membranous line mesally (cf. subgenital plate with the membrane in mesal line).

Discussion

Hangingflies usually live in the understory of moist, shady woodlands (Fig. 9). During the field survey, we found that hangingflies were extremely vulnerable to aridness and barely survived once they were moved out of their restricted habitats. Previous research has shown that sensilla coeloconica mainly function as hygroreceptors to perceive the humidity of the environment (Altner & Loftus 1985; Tichy & Loftus 1996). The antennae of *Bittacus sinensis* Walker, 1853 possess many more sensilla coeloconica on the flagellomeres than other insects (Hu *et al.* 2010). This might be the reason why hangingflies are so sensitive to the aridness of the environment. In the natural habitats, hangingflies usually prefer the microhabitats of high humidity, frequently along streams (Fig. 9B).

During mating, the male hangingfly twists his abdomen temporarily up to 180° and clasps the subgenital plate of the female with his epandrial appendages to ensure the completion of copulation (Mickoleit & Mickoleit 1978; Gao & Hua 2013). In male *Terrobittacus*, however, the epandrial appendages are very short, and have evolved dense stout spines on the inner surface (Fig. 3C). These spines are likely to assist in clasping the female more effectively during copulation.

Acknowledgements

We are grateful to Ji-Shen Wang for assistance in collecting specimens and taking photographs. We also thank Jiang-Li Tan for comments on the early draft of the manuscript and two anonymous referees for valuable comments on the revision of the manuscript. This research was financially supported by the National Natural Science Foundation of China (Grant no. 30970386).



Fig. 9. Habitats of *Terrobittacus* spp. **A–B.** Habitats. **C.** Female specimen of *T. rostratus* sp. nov. in repose. **D.** Female specimen of *T. angustus* sp. nov. in repose. (photos by Ji-Shen Wang)

References

- Altner H. & Loftus R. 1985. Ultrastructure and function of insect thermo- and hygroreceptors. *Annual Review of Entomology* 30: 273–295. <https://doi.org/10.1146/annurev.ento.30.1.273>
- Bicha W.J. 2011. A review of the hangingflies (Mecoptera: Bittacidae) of South Asia with the description of a new species of *Bittacus* from Nepal. *Zootaxa* 3032: 60–64. Available from <http://www.mapress.com/zootaxa/2011/f/z03032p064f.pdf> [accessed 1 Mar. 2017]
- Byers G.W. 2002. Scorpionflies, hangingflies, and other Mecoptera. *The Kansas School Naturalist* 48 (1): 3–15. Available from <http://www.emporia.edu/ksn/v48n1-may2002/> [accessed 1 Mar. 2017].
- Byers G.W. 2011. Additions to the Mecoptera of Mexico. *Journal of the Kansas Entomological Society* 84 (1): 1–11. <https://doi.org/10.2317/jkes080923.1>
- Byers G.W. & Thornhill R. 1983. Biology of the Mecoptera. *Annual Review of Entomology* 28 (1): 203–228. <https://doi.org/10.1146/annurev.en.28.010183.001223>
- Cai L.-J., Huang P.-Y. & Hua B.-Z. 2006. Two new Chinese *Bittacus* Latreille (Mecoptera: Bittacidae) from Michangshan Mountains. *Entomotaxonomia* 28 (2): 127–130. Available from http://en.cnki.com.cn/Article_en/CJFDTotal-KCFL200602009.htm [accessed 1 Mar. 2017]
- 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 (21–22): 1463–1480. <https://doi.org/10.1080/00222933.2012.763065>
- Cheng F.Y. 1957. Revision of the Chinese Mecoptera. *Bulletin of the Museum of Comparative Zoology* 116: 1–118.
- Du W., Chen J. & Hua B.-Z. 2015. Discovery of *Bittacus ussuriensis* Plutenko (Mecoptera: Bittacidae) from China. *Entomotaxonomia* 37 (4): 268–272. Available from <http://www.cnki.com.cn/Article/CJFDTOTAL-KCFL201504006.htm> [accessed 6 Mar. 2017]
- 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. Available from <http://www.cnki.com.cn/Article/CJFDTOTAL-DWFL201004017.htm> [in Chinese, accessed 1 Mar. 2017]
- 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. Available from <http://mapress.com/zootaxa/2008/f/z01749p068f.pdf> [accessed 1 Mar. 2017]
- Mickoleit G. & Mickoleit E. 1978. Zum Kopulationsverhalten des Mückenhaftes *Bittacus italicus* (Mecoptera: Bittacidae). *Entomologia Generalis* 5 (1): 1–15.
- Setty L.R. 1940. Biology and morphology of some North American Bittacidae (Order Mecoptera). *American Midland Naturalist* 23 (2): 257–353. <https://doi.org/10.2307/2420667>
- Tan J.-L. & Hua B.-Z. 2008. Structure of raptorial legs in *Bittacus* (Mecoptera: Bittacidae). *Acta Entomologica Sinica* 51 (7): 745–752. [In Chinese] <https://doi.org/10.3321/j.issn:0454-6296.2008.07.011>
- Tan J.-L. & Hua B.-Z. 2009a. *Bicaubittacus*, a new genus of the Oriental Bittacidae (Mecoptera) with descriptions of two new species. *Zootaxa* 2221: 27–40. Available from <http://www.mapress.com/zootaxa/2009/f/z02221p040f.pdf> [accessed 1 Mar. 2017]

Tan J.-L. & Hua B.-Z. 2009b. *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>

Tichy H. & Loftus R. 1996. Hygroreceptors in insects and a spider: humidity transduction models. *Naturwissenschaften* 83: 255–263. <https://doi.org/10.1007/bf01149598>

Manuscript received: 4 April 2016

Manuscript accepted: 8 June 2016

Published on: 8 March 2017

Topic editor: Gavin Broad

Desk editor: Kristiaan Hoedemakers

Printed versions of all papers are also deposited in the libraries of the institutes that are members of the *EJT* consortium: Muséum national d'Histoire naturelle, Paris, France; Botanic Garden Meise, Belgium; Royal Museum for Central Africa, Tervuren, Belgium; Natural History Museum, London, United Kingdom; Royal Belgian Institute of Natural Sciences, Brussels, Belgium; Natural History Museum of Denmark, Copenhagen, Denmark; Naturalis Biodiversity Center, Leiden, the Netherlands.