

RESEARCH PAPER

New and little-known species of the genus *Dicerapanorpa* from northwestern Yunnan, China (Mecoptera: Panorpidae)

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Abstract. The genus *Dicerapanorpa* Zhong & Hua, 2013 previously comprised 20 known species that are endemic to central and southwestern China. Herein, I present new knowledge of this genus from northwestern Yunnan, including descriptions of four new species, *Dicerapanorpa harmonia* sp. nov., *Dicerapanorpa huangguocongi* sp. nov., *Dicerapanorpa nakhi* sp. nov., and *Dicerapanorpa yangqichengi* sp. nov. In addition, three little-known species, *Dicerapanorpa tenuis* Hu, Wang & Hua, 2019, *Dicerapanorpa tjederi* Carpenter, 1938, and *Dicerapanorpa triclada* (Qian & Zhou, 2001) are redescribed and illustrated based on new materials. An updated key to all known 24 species of *Dicerapanorpa* is provided, and a distributional map of *Dicerapanorpa* species from Yunnan is presented. The evolution and biology of *Dicerapanorpa* are briefly discussed.

Key words. Mecoptera, Panorpidae, scorpionflies, biodiversity, taxonomy, Yunnan, China, Oriental Region

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Introduction

The Mountains of Southwest China is a biodiversity hotspot designated by the Conservation International, including the Hengduan Mountains, the Three Parallel Rivers area, and the Qionglai-Minshan Mountains, etc. Due to the dramatic variations in climate and topography, this region supports a wide array of habitats, and harbors a high genetic diversity and a great number of endemic species (LEI et al. 2015; HE et al. 2016; WAN et al. 2021). For the insect order Mecoptera in this region, an underestimated diversity has been recently reported for the scorpionfly family Panorpidae, regarding the genera *Dicerapanorpa* Zhong & Hua, 2013 (HU & HUA 2019, 2020; HU et al. 2019a, c), *Neopanorpa* van der Weele, 1909 (WANG & HUA 2018a, b; WANG 2021), and *Panorpa* Linnaeus, 1758 (WANG & HUA 2016, 2017; LI & HUA 2020; WANG & GONG 2021).

The genus *Dicerapanorpa* was erected for eight species of the *Panorpa dicerias* group (sensu CARPENTER 1938) due to their males bearing a pair of anal horns, i.e., a pair of finger-like tergal processes on the dorsal apex of the sixth abdominal segment (MACLACHLAN 1894; ESBEN-PETERSEN 1915, 1934; TJEDER 1936; CARPENTER 1938, 1948; CHENG 1957; CHOU et al. 1981; QIAN & ZHOU 2001; ZHONG &

HUA 2013). In *Dicerapanorpa magna* (Chou, 1981), the anal horns are utilized to clasp the female's terminal abdomen during copulation (ZHONG et al. 2015). Recently, more species of this genus were described from central and southwestern China (HU & HUA 2019, 2020; HU et al. 2019a, c). The monophyly of *Dicerapanorpa* has been supported by both morphological (WANG & HUA 2021) and molecular analyses (HU et al. 2015, MIAO et al. 2019). The recently erected, single anal horn-bearing genus *Megapanorpa* Wang & Hua, 2019, was suggested to be the sister-taxon of *Dicerapanorpa* (WANG & HUA 2021). Taxonomically, *Dicerapanorpa* can be categorized into two species groups, namely the *D. magna* group (rostrum lacking black frontal stripes; wings yellowish, subhyaline, with well-developed dark brown markings; five species distributed in the Qinling, Bashan, and Minshan Mountains) and the *D. dicerias* group (rostrum bearing a pair of black frontal stripes; wings mostly colorless, hyaline, with greatly reduced markings or lacking markings; 15 species found in the Hengduan Mountains and the Yunnan-Guizhou Plateau).

Members of *Dicerapanorpa* have cool-climate preference and weak dispersal ability, providing a good model system to explore how the Cenozoic climate changes



have influenced the dispersal and speciation of insects in eastern Asia (HU et al. 2019a, b). The known *Dicerapanorpa* species generally inhabit mountainous area above 2000 m a.s.l., and exhibit an intriguing C-shaped distributional pattern around the Sichuan Basin. Although a taxonomical revision (HU & HUA 2020) was published for 20 known species, larger diversity is still expected for *Dicerapanorpa* in the unexplored area of the Mountains of Southwest China.

Recently, four undescribed species of *Dicerapanorpa* were collected from northwestern Yunnan, China. I herein present illustrations and descriptions of these new species. In addition, new materials were obtained for three little-known species, *Dicerapanorpa tenuis* Hu, Wang & Hua, 2019, *D. tjederi* Carpenter, 1938, and *D. triclada* (Qian & Zhou, 2001). I also provide redescriptions of these species in order to complement their biological and morphological information. A key to species and a distributional map are also provided for all 24 species of *Dicerapanorpa*.

Material and methods

All the materials examined in this study are deposited in the Biological Science Museum, Dali University (DALU). Adult scorpionflies were caught with a collecting net or Malaise traps, preserved in 95% ethanol or pinned. Photographs of the insects were taken with a Nikon D850 or D7000 digital camera in conjunction with a Nikkor AF-S Micro 105 mm f/2.8 lens (habitus), or a Canon MP-E 65 mm f/2.8 1–5× macro lens with a handmade mount adapter (the other images). The measurements follow WANG & GONG (2021). The female habitus images were modified to omit the left antenna, wings, and legs. The distribution map was obtained from Maps-For-Free (<https://maps-for-free.com>) and modified with Adobe Illustrator CC. All pictures were adjusted and grouped with Adobe Photoshop CC. The terminology follows WANG & HUA (2021).

The following acronyms are applied in the main text:

A1	the first abdominal segment (and so forth for other segments);
AbL	abdomen length;
AtL	antenna length;
BL	body length;
FL	forewing length;
FW	forewing width;
HL	hindwing length;
HW	hindwing width;
T1	the first tergum (and so forth for other terga).

Taxonomy

Checklist of *Dicerapanorpa* species

Dicerapanorpa magna group

<i>D. baiyunshana</i> Zhong & Hua, 2013	Henan: Funiu Mountains
<i>D. hualongshana</i> Hu & Hua, 2019	Shaanxi: Mt. Hualong; Chongqing: Chengkou
<i>D. magna</i> (Chou, 1981)	Shaanxi: Qinling Mountains; Gansu: Wenxian
<i>D. minshana</i> Hu & Hua, 2019	Sichuan: Minshan Mountains
<i>D. shennongensis</i> Zhong & Hua, 2013	Hubei: Shennongjia

Dicerapanorpa diceras group

<i>D. bifurcata</i> Hu & Hua, 2020	Sichuan: Pingwu
<i>D. diceras</i> (MacLachlan, 1894)	Sichuan: Kangding, Shimian
= <i>Panorpa grahami</i> Carpenter, 1938 [Synonymized by CARPENTER (1948).]	

<i>D. degenensis</i> Hu, Wang & Hua, 2019	Yunnan: Deqen
<i>D. harmonia</i> sp. nov.	Yunnan: Weixi
<i>D. huangguocongi</i> sp. nov.	Yunnan: Gongshan
<i>D. kimminsi</i> (Carpenter, 1948)	Sichuan: Mt. Emei
<i>D. lativalva</i> Hu & Hua, 2019	Sichuan: Shimian
<i>D. luojishana</i> Hu & Hua, 2019	Sichuan: Mt. Luoji
<i>D. macula</i> Hu, Wang & Hua, 2019	Yunnan: Shangri-La
<i>D. nakhi</i> sp. nov.	Yunnan: Lijiang
<i>D. stotzneri</i> (Esben-Petersen, 1934)	Yunnan: Kangding, Guanxian
<i>D. tanae</i> Hu, Wang & Hua, 2019	Yunnan: Gongshan
<i>D. tjederi</i> (Carpenter, 1938)	Yunnan: Lijiang
<i>D. triclada</i> (Qian & Zhou, 2001)	Yunnan: Mt. Cangshan
<i>D. tenuis</i> Hu, Wang & Hua, 2019	Yunnan: Lijiang
<i>D. yangqichengi</i> sp. nov.	Yunnan: Lushui
<i>D. yijunae</i> Hu & Hua, 2019	Sichuan: Chongzhou
<i>D. zhongdianensis</i> Hu, Wang & Hua, 2019	Yunnan: Shangri-La
<i>D. zhengkuni</i> Hu & Hua, 2020	Guizhou: Mts Fanjing and Leigong

Key to *Dicerapanorpa* species (males)

(updated from HU & HUA 2020)

- Rostrum lacking black frontal stripes; wings yellowish, subhyaline, with well-developed dark brown markings (*D. magna* group). 2
 - Rostrum with two black frontal stripes; wings mostly colorless, hyaline, with greatly reduced markings or lacking markings (*D. diceras* group). 6
- Paramere with greatly elongated ventral branch extending to apex of aedeagus; middle branch elongated and extending to middle tooth of gonostylus. *D. baiyunshana* Zhong & Hua, 2013
 - Paramere with ventral and middle branches shorter. ... 3
- Middle branch of paramere straight. *D. shennongensis* Zhong & Hua, 2013
 - Middle branch of paramere curved. 4
- Ventral branch of paramere elongated and at least half as long as dorsal branch. *D. hualongshana* Hu & Hua, 2019
 - Ventral branch of paramere shorter than half length of dorsal branch. 5
- Ventral branch of paramere slightly elongated, straight, or curved caudad. *D. magna* (Chou, 1981)
 - Ventral branch of paramere very short and hook-like. *D. minshana* Hu & Hua, 2019
- Head with black spots on vertex. 7
 - Head lacking black spots on vertex. 13
- Terga mostly black with indistinct yellow middle stripe; genital bulb mostly black or dark brown. *D. triclada* (Qian & Zhou, 2001)
 - Terga black laterally with distinct yellow middle stripe; genital bulb mostly yellowish brown. 8
- Middle branch of paramere bifurcated in distal 1/3. *D. tjederi* (Carpenter, 1938)
 - Middle branch of paramere simple. 9
- Ventral branch of paramere greatly elongated, extending beyond basal lobe of gonostylus. *D. macula* Hu, Wang & Hua, 2019
 - Ventral branch of paramere not exceeding basal lobe of gonostylus. 10
- Abdomen with yellow middle stripe wider than half width of T1–T5. *D. degenensis* Hu, Wang & Hua, 2019

- Abdomen with yellow middle stripe narrower than half width of T1–T5. 11
- 11. Paramere with dorsal branch longer than middle branch. ***D. nakhi* sp. nov.**
- Paramere with dorsal branch shorter than middle branch. 12
- 12. Paramere with ventral branch longer than dorsal branch. ***D. harmonia* sp. nov.**
- Paramere with ventral branch slightly shorter than dorsal branch.
- ***D. zhongdianensis*** Hu, Wang & Hua, 2019
- 13. Paramere bifurcated. 14
- Paramere trifurcated. 15
- 14. Paramere lacking middle branch, with dorsal branch not extending to middle tooth of gonostylus.
- ***D. yangqichengi* sp. nov.**
- Paramere lacking ventral branch, with middle branch exceeding middle tooth of gonostylus.
- ***D. bifurcata*** Hu & Hua, 2020
- 15. Hypovalve with apical portion nearly as wide as base. 16
- Hypovalve greatly expanded apically. 18
- 16. Hypovalve greatly elongated, extending far beyond basal lobe of gonostylus.
- ***D. zhengkuni*** Hu & Hua, 2020
- Hypovalve shorter, not exceeding basal lobe of gonostylus. 17
- 17. Paramere with middle branch greatly elongated, extending far beyond middle tooth of gonostylus.
- ***D. yijunae*** Hu & Hua, 2019
- Paramere with middle branch shorter, not exceeding middle tooth of gonostylus.
- ***D. kimminsi*** (Carpenter, 1948)
- 18. Hypovalves truncated apically.
- ***D. stotzneri*** (Esben-Petersen, 1934)
- Hypovalves rounded apically. 19
- 19. T5–T8 and genital bulb black; paramere with extremely shortened, barb-like ventral branch.
- ***D. huangguocongi* sp. nov.**
- T5–T8 and genital bulb yellow or yellowish brown; paramere with ventral branch elongated. 20
- 20. Genital bulb broadly spherical; paramere with ventral branch shorter than half length of middle branch.
- ***D. tanae*** Hu, Wang & Hua, 2019
- Genital bulb long elliptical; paramere with ventral branch at least half as long as middle branch. 21
- 21. Paramere with ventral branch half as long as middle branch. ***D. tenuis*** Hu, Wang & Hua, 2019
- Paramere with ventral branch longer than half length of middle branch. 22
- 22. Paramere with three branches closely aligned basally.
- ***D. diceras*** (MacLachlan, 1894)
- Paramere with three branches widely separated basally. 23
- 23. Paramere with ventral branch greatly elongated, only slightly shorter than middle branch, and curved laterad in distal portion. ***D. luojishana*** Hu & Hua, 2019
- Paramere with ventral branch less elongated, nearly 2/3 as long as middle branch, and relatively straight.
- ***D. lativalva*** Hu & Hua, 2019

Description of species

Dicerapanorpa harmonia sp. nov.

(Figs 1–6)

Type material. HOLOTYPE: CHINA: YUNNAN: ♂ (DALU: CN-21Di00059), Diqing Tibetan Autonomous Prefecture, Weixi County, northern hillside in an alpine ravine, 27°20'58.92"N, 99°18'12.23"E, 2940 m, 17.vii.2021, leg. Ji-Shen Wang. PARATYPE: 1 ♀ (DALU: CN-21Di00058), same data except 16.vii.2021.

Diagnosis. The new species superficially resembles *D. zhongdianensis*, but can be differentiated from the latter by the following characters: 1) male paramere with ventral branch longer than half length of middle branch (Fig. 3) (*vs.* shorter), and 2) female medigynium with main plate narrower towards base (Fig. 6) (*vs.* with parallel lateral margins).

Description. Measurements (mm). Male (holotype): AtL 11.3, AbL 10.8, BL 14.8, FL 14.1, FW 3.3, HL 12.8, HW 3.2. Female (paratype): AtL 11.5, AbL 7.4, BL 12.3, FL 14.9, FW 3.7, HL 13.0, HW 3.6.

Male. Head (Fig. 1). Vertex yellow, with large black spot on each side, and three smaller, blurred spots encircling each large one. Ocellar triangle black. Rostrum yellow, with two black frontal stripes.

Thorax (Fig. 1). Pronotum with five black thick setae along each side of anterior margin. Meso- and metanotum black laterally, with yellow median stripe.

Wings (Fig. 1). Membrane colorless and hyaline, with greatly reduced, spot-like pterostigmal band. Pterostigma light yellowish brown.

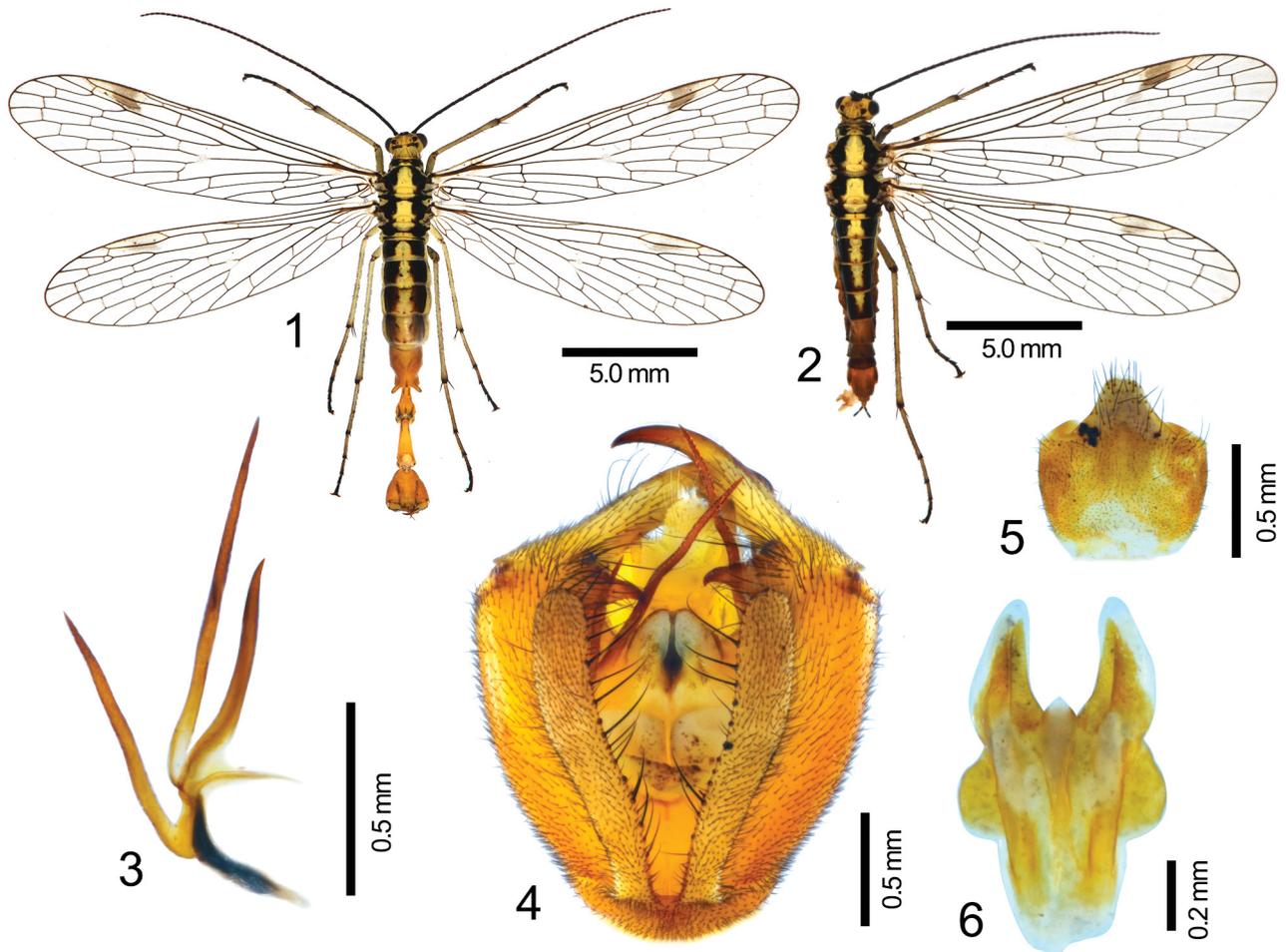
Abdomen (Fig. 1). T2–T5 black laterally, with broad yellow median stripe. A6 yellowish brown with pair of divergent anal horns on dorsal apex. A7 and A8 greatly constricted at base, yellowish brown with irregular black textures.

Male genitalia (Figs 3, 4). Genital bulb oval. Epandrium (T9) broad, deeply emarginated terminally and forming pair of finger-like processes laterally. Hypandrium (S9) split into pair of long, stripe-like hypovalves. Hypovalve with row of long stout bristles along inner margin. Gonostylus shorter than gonocoxites, with well-developed basal lobe and subtriangular middle tooth. Paramere trifurcate: ventral branch long and straight; median branch longest and straight; dorsal branch slightly longer than half length of middle branch and slightly curved. Ventral valves of aedeagus membranous with rounded apex.

Female. Habitus (Fig. 2) similar to males. Subgenital plate (Fig. 5) broad, with apex greatly narrowed and subtriangular, bearing long stout setae marginally. Medigynium (Fig. 6) with main plate narrower towards base, and pair of earlobe-like processes on lateral margin.

Etymology. The new species is named after *Harmonia*, the immortal goddess of harmony and concord in the Greek mythology, to commemorate a harmonious and high-yielding expedition in northwestern Yunnan (July, 2021) conducted by the author and his companions (Drs Hao Xu, Lu Qiu, and Mr. Guo-Cong Huang). Noun in apposition.

Distribution. China: Yunnan (Weixi) (Fig. 54).



Figs 1–6. *Dicerapanorpa harmonia* sp. nov. 1, 3, 4 – male. 2, 5, 6 – female. 1, 2 – habitus, dorsal view. 3 – right paramere, right-lateral view. 4 – genital bulb, ventral view. 5 – subgenital plate, ventral view. 6 – medigynium, ventral view.

Dicerapanorpa huangguocongi sp. nov.

(Figs 7–12)

Type material. HOLOTYPE: CHINA: YUNNAN: ♂ (DALU: CN-21Di00028), Nujiang Lisu Autonomous Prefecture, Gongshan County, western slope of the Peacock Mountain, 28°00'41.60"N, 98°43'13.15"E, 2510 m, 13.vii.2021, leg. Ji-Shen Wang & Guo-Cong Huang. PARATYPE: 1 ♀ (DALU: CN21Di00029), same data except 28°02'42.29"N, 98°44'43.83", leg. Guo-Cong Huang.

Diagnosis. The new species can be readily recognized by the combination of the following characters: 1) head yellow, lacking black spots on vertex (Fig. 7); in males, 2) A5–A9 mostly black (Fig. 7); 3) paramere with ventral branch extremely short and barb-like (Fig. 9); and in females, 4) medigynium with basal portion of main plate broader than base of posterior arms (Fig. 12).

Description. Measurements (mm). Male (holotype): AtL 9.8, AbL 9.5, BL 13.6, FL 13.2, FW 3.3, HL 12.3, HW 3.2. Female (paratype): AtL 13.8, AbL 8.7, BL 13.0, FL 15.9, FW 4.1, HL 14.4, HW 3.8.

Male. Head (Fig. 7). Vertex yellow without black spots. Ocellar triangle black. Rostrum yellow, with two black frontal stripes.

Thorax (Fig. 7). Pronotum with five black thick setae along each side of anterior margin. Meso- and metanotum

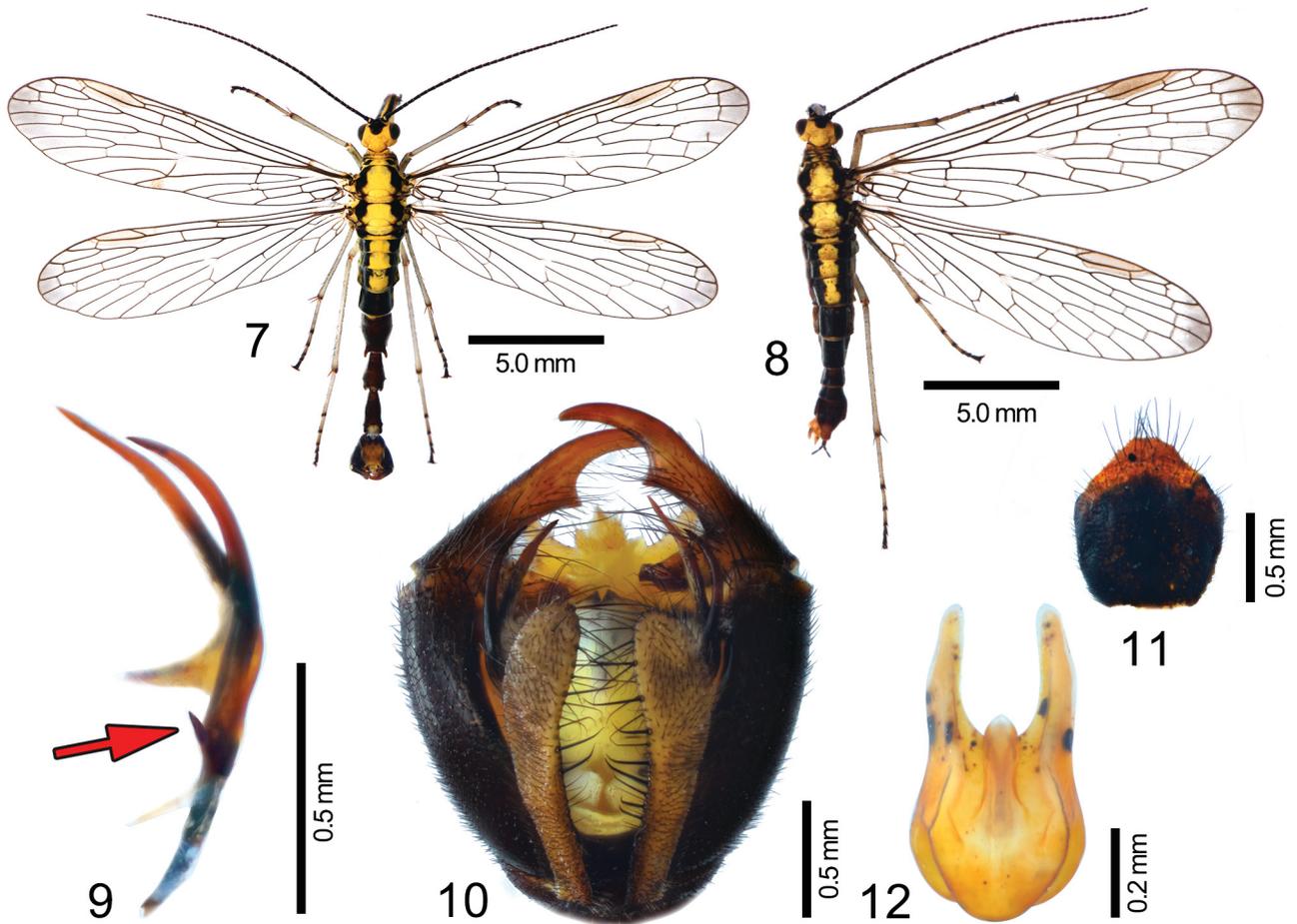
black laterally, with broad yellow median stripe.

Wings (Fig. 7). Membrane with slight grayish tinge, hyaline, lacking distinct markings, and slightly deepened at apex. Pterostigma light yellowish brown.

Abdomen (Fig. 7). T2–T4 black laterally, with broad yellow median stripe. T5 black with only indistinct narrow median stripe. A6 black with pair of divergent anal horns on dorsal apex. A7 and A8 black, greatly constricted at base.

Male genitalia (Figs 9, 10). Genital bulb broad oval, mostly black with epandrium and hypandrium dark yellowish brown. Epandrium broad, deeply emarginated terminally and forming pair of finger-like, divergent processes laterally. Hypandrium split into pair of hypovalves. Hypo valve with row of long stout bristles along inner margin. Gonostylus shorter than gonocoxites, with well-developed basal lobe and subtriangular middle tooth. Paramere trifurcate: ventral branch extremely short and barb-like; median branch slightly shorter than dorsal branch and curved inward; dorsal branch slightly curved inward. Ventral valves of aedeagus membranous with rounded apex; dorsal valves sclerotized with subacute apex.

Female. Habitus (Fig. 2) similar to males. Subgenital plate (Fig. 11) broad, with distal 2/5 subtriangular and bearing long stout setae marginally. Medigynium (Fig. 12)



Figs 7–12. *Dicerapanorpa huangguocongii* sp. nov. 7, 9, 10 – male; 8, 11, 12 – female. 7, 8 – habitus, dorsal view. 9 – right paramere, ventral view. 10 – genital bulb, ventral view. 11 – subgenital plate, ventral view. 12 – medigynium, ventral view. Red arrow indicates barb-like ventral branch of paramere.

with basal portion of main plate broader than base of posterior arms; posterior arms slightly shorter than main plate.

Etymology. The specific epithet is dedicated to my friend Mr. Guo-Cong Huang, the first discoverer and collector of the new species. Noun in the genitive case.

Distribution. China: Yunnan (Gongshan) (Fig. 54).

***Dicerapanorpa nakhi* sp. nov.**

(Figs 13–18, 47)

Type materials. HOLOTYPE: CHINA: YUNNAN: ♂ (DALU: CN-21Di00001), Lijiang City, southern slope of Yulong (Jade Dragon) Snow Mountain, Alpine *Rhododendron* bushes, 26°59′48.32″N, 100°10′39.14″E, 3300 m, leg. Hai-Tian Song, Zhi-Hao Qi and Ji-Shen Wang. PARATYPES: 2 ♂♂ 5 ♀♀ (DALU: CN21Di00002–CN21Di00008), same data.

Diagnosis. The new species is superficially similar to *Dicerapanorpa triclada*, but can be differentiated from the latter by the following characters: in males, 1) T2–T5 black with distinct yellow median stripe (Fig. 13) (*vs.* lacking) and A6–A9 yellowish brown (Fig. 13) (*vs.* mostly black); 2) ventral valves of aedeagus short (Fig. 16) (*vs.* strongly protruded); and in females, 3) medigynium broadening from base towards apex (Fig. 18) (*vs.* nearly parallel marginally in distal half).

Description. Measurements (mm). Male (holotype): AtL 12.5, AbL 13.3, BL 18.0, FL 14.2, FW 3.3, HL 13.0, HW 3.2. Male (paratypes): AtL 12.3–12.5, AbL 13.2–13.3, BL 18.0–18.2, FL 14.0–14.2, FW 3.2–3.3, HL 13.0–13.1, HW 3.1–3.2. Female (paratypes): AtL 13.0–13.2, AbL 10.0–12.5, BL 14.0–16.8, FL 14.2–14.6, FW 4.0–4.2, HL 13.0–13.3, HW 3.8–4.0.

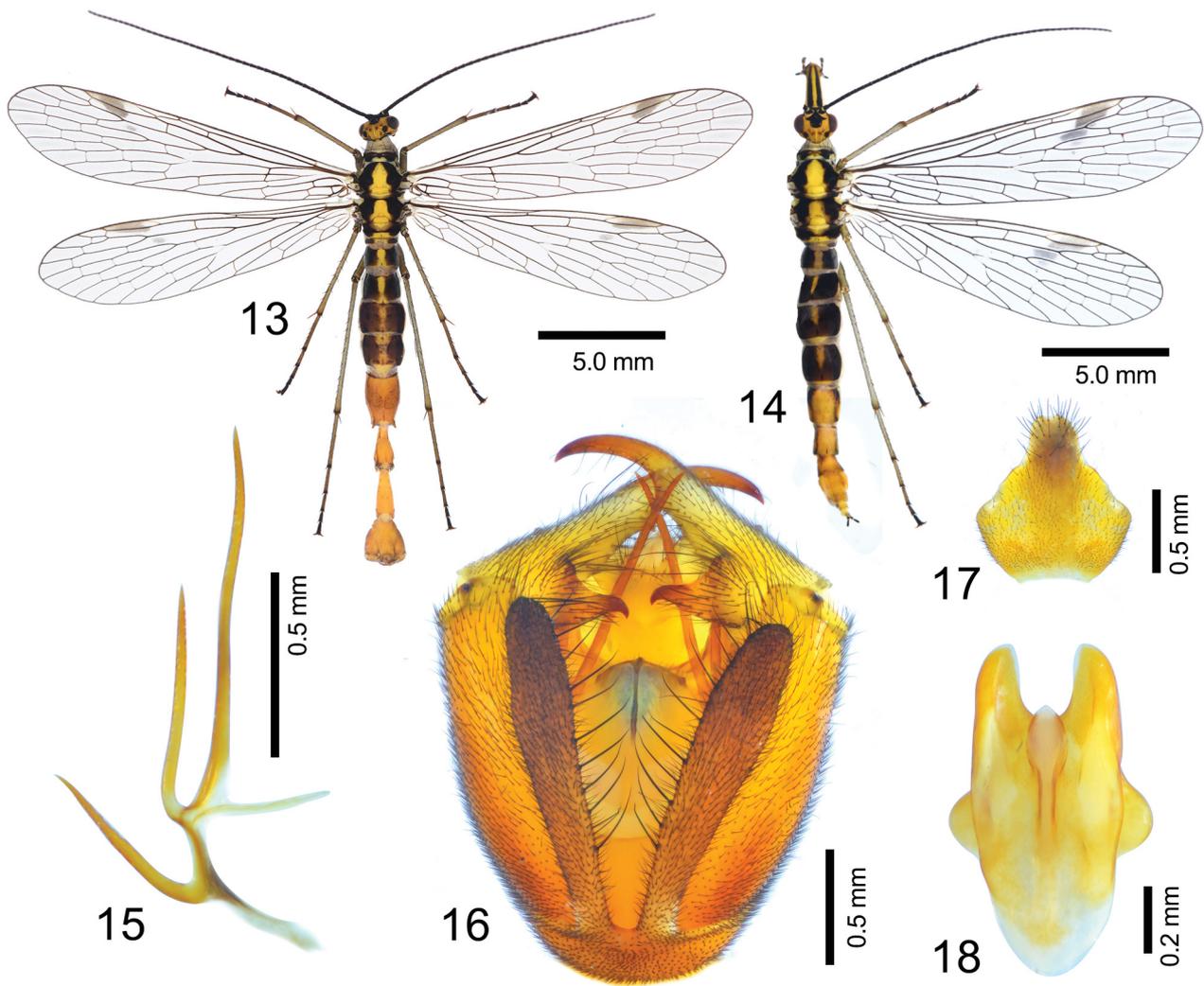
Male. Head (Fig. 13). Vertex yellow, with large black spot on each side, and three smaller, blurred spots encircling each large one. Rostrum yellow, with two black frontal stripes.

Thorax (Fig. 13). Pronotum with six black thick setae along each side of anterior margin. Meso- and metanotum black laterally, with yellow median stripe.

Wings (Fig. 13). Membrane colorless and hyaline. Pterostigmal band presented as a small spot. Pterostigma light yellowish brown.

Abdomen (Fig. 13). T2–T5 black laterally, with narrow yellow median stripe. A6 yellowish brown with pair of divergent anal horns on dorsal apex. A7 and A8 yellowish brown, greatly constricted at base.

Genitalia (Figs 15, 16). Genital bulb broad oval, yellowish brown. Epandrium broad, deeply emarginated terminally and forming pair of finger-like, divergent pro-



Figs 13–18. *Dicerapanorpa nakhi* sp. nov. 13, 15, 16 – male. 14, 17, 18 – female. 13, 14 – habitus, dorsal view. 15 – right paramere, right-lateral view. 16 – genital bulb, ventral view. 17 – subgenital plate, ventral view. 18 – medigynium, ventral view.

cesses laterally. Hypandrium split into pair of hypovalves. Hypovalve dark brown with row of long stout bristles along inner margin. Gonostylus shorter than gonocoxites, with well-developed basal lobe and subtriangular middle tooth; basal lobe with greatly curved, hook-like apex. Paramere trifurcate: ventral branch elongated; median branch slightly longer than ventral branch; dorsal branch slightly longer than twice length of ventral branch. Ventral valves short with rounded apex.

Female. Habitus (Fig. 14) similar to males. Subgenital plate (Fig. 17) subtrapezoidal with apex greatly narrowed, and bearing long stout setae marginally. Medigynium (Fig. 18) with main plate slightly broadening from base towards apex; earlobe-like process in middle of each side of main plate; posterior arms shorter than 1/3 of main plate.

Etymology. The new species is named after the Nakhi People, a Chinese ethnic group inhabiting the foothills of the Yulong Snow Mountain. Noun in apposition.

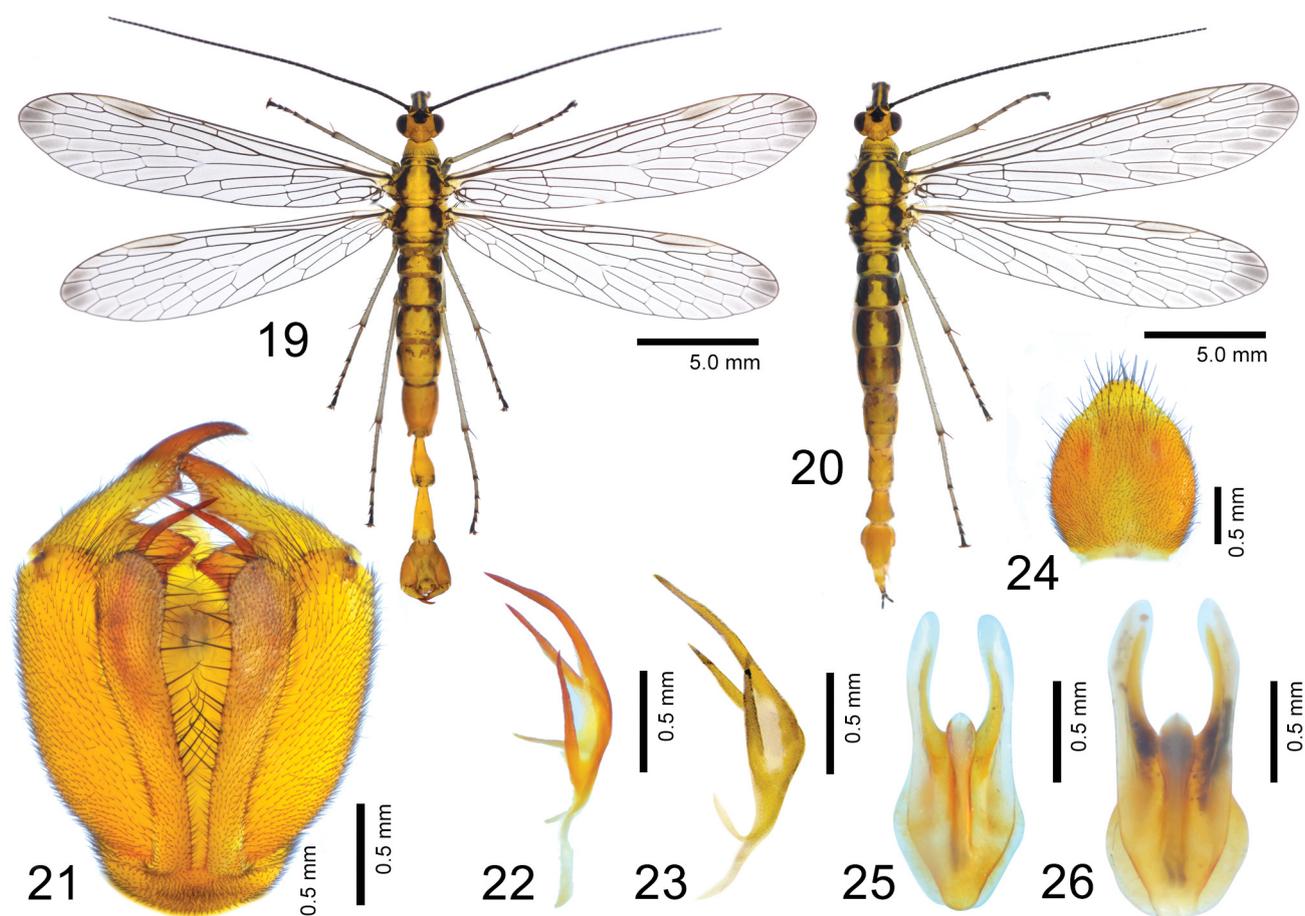
Distribution. China: Yunnan (Lijiang) (Fig. 54).

Dicerapanorpa tenuis Hu, Wang & Hua, 2019

(Figs 19–26, 49)

Material examined. CHINA: YUNNAN: 3 ♂♂ 4 ♀♀ (DALU: CN21Di00009–CN21Di00013), Dali Bai Autonomous Prefecture, Heqing County, southeastern slope of Ma'er (Horse Ear) Mountain, 26°11'51.44"N, 100°8'42.95"E, 2550 m, 5.vi.2021, leg. Hai-Tian Song, Zhi-Hao Qi and Ji-Shen Wang; 1 ♀ (DALU: CN21Di00014), Lijiang City, Yulong County, Yuhu Village, irrigation canal with dense herbaceous ground cover in cultivated land, 27°0'46.46"N, 100°12'53.02"E, 2700 m, 5.vi.2021, leg. Ji-Shen Wang; 1 ♀ (DALU: CN21Di00015), Lijiang City, southern slope of Yulong (Jade Dragon) Snow Mountain, Forest near Fuguo Buddhist Temple, 26°57'22.87"N, 100°11'51.74"E, 2690 m, 6.vi.2021, leg. Zhi-Hao Qi.

Emended diagnosis. This species can be readily recognized by the combination of the following characters: 1) head yellow without black spots on vertex (Figs 19, 20); 2) wings with speckled apical band (Figs 19, 20); in males, 3) paramere with ventral and dorsal branches short and straight, and median branch long and curved inward (Figs 22, 23); and in females, 4) medigynium with slender posterior arms nearly as long as main plate (Figs 25, 26).



Figs 19–26. *Dicerapanorpa tenuis* Hu, Wang & Hua, 2019. 19, 21–23 – male. 20, 24–26 – female. 19–22, 24, 25 – specimens from Mt. Ma'er. 23, 26 – specimens from Lijiang (topotypical). 19, 20 – habitus, dorsal view. 21 – genital bulb, ventral view. 22, 23 – right paramere, ventral view. 24 – subgenital plate, ventral view. 25, 26 – medigynium, ventral view.

Redescription. Measurements (mm). Male: AtL 12.8–13.3, AbL 14.0–15.0, BL 19.0–22.0, FL 15.0–16.2, FW 3.6–4.0, HL 13.0–15.0, HW 3.4–3.8. Female: AtL 12.5–14.0, AbL 13.0–15.5, BL 18.5–22.3, FL 15.5–17.8, FW 3.7–4.4, HL 13.5–16.5, HW 3.6–4.3.

Female. Habitus (Fig. 20) similar to males (Fig. 19). Subgenital plate (Fig. 24) oval with basal half nearly rectangular and distal half subtriangular, and bearing long setae marginally. Medigynium (Fig. 25) with main plate subtriangular in basal half and rectangular in distal half; rounded basal plate enclosing basal half of main plate; posterior arms slender, nearly as long as main plate, and curved convergently in distal half.

Distribution. China: Yunnan (Lijiang and Heqing) (Fig. 54).

Remarks. The original description, saying “medigynium with main plate slender and elliptical; posterior arms long and divergent, with apex curved inward”, was based on a single female paratype (HU et al. 2019c: fig. 4F). In this study, two topotypical females and four females from the Ma'er Mountain conform to the paratype in morphology except for their medigynia, which are all broad with inwardly curved posterior arms. In fact, the female medigynium in Panorpidae can often be deformed due to dehydration. Specifically, the lateral margin of the main plate can be twisted, and the convergent or parallel

posterior arms can be diverged (see HU & HUA 2020: figs 2F vs. 3C, and figs 4J vs. 5C). It is highly possible that the medigynium HU et al. (2019c) described was from a teneral female, and deformed due to dehydration. Therefore, the medigynial morphology of *D. tenuis* is redescribed here.

Dicerapanorpa tjederi (Carpenter, 1938)

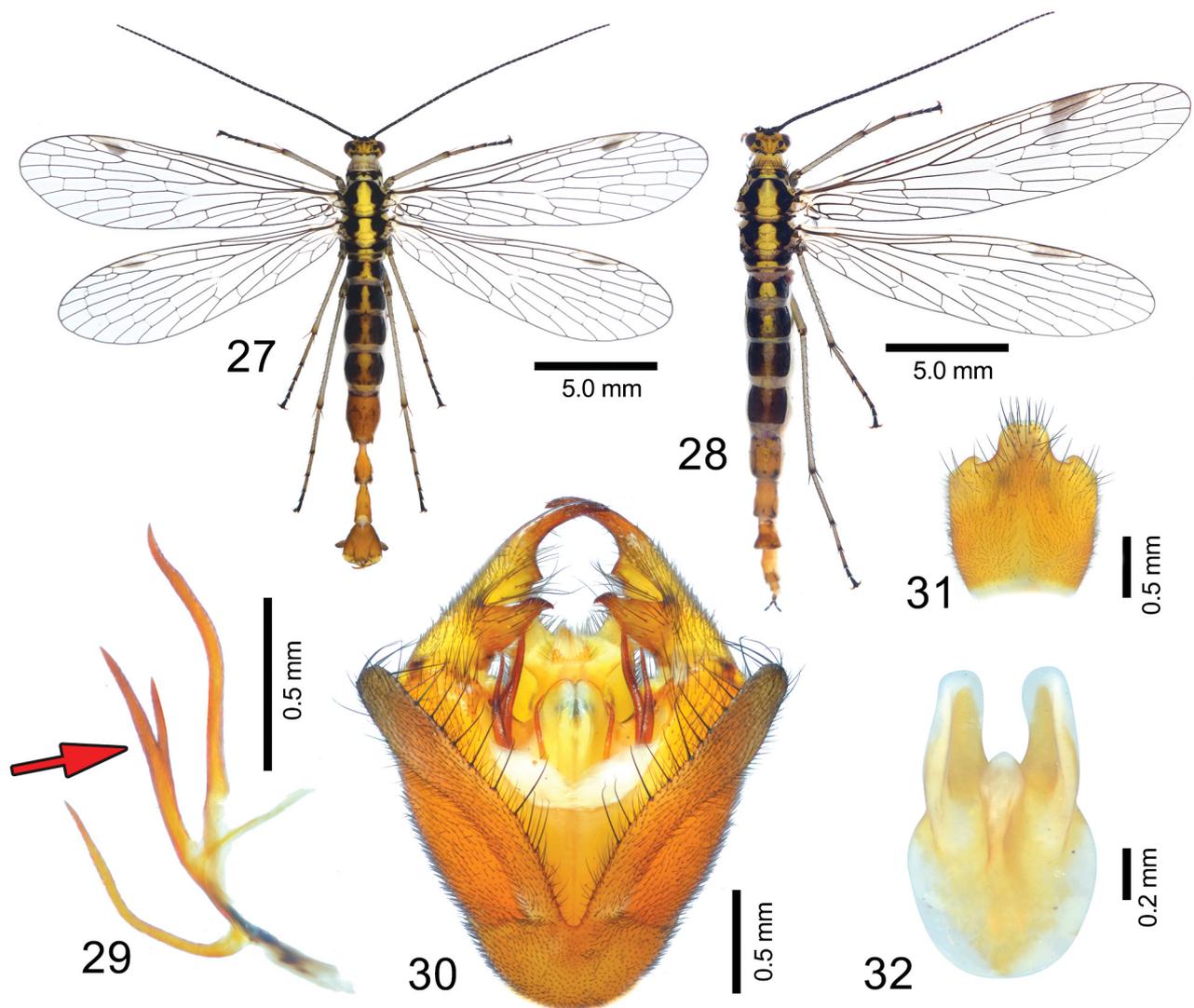
(Figs 27–32, 51)

Material examined. CHINA: YUNNAN: 3 ♂♂ 2 ♀♀ (DALU: CN-21Di00016–CN21Di00020), Lijiang City, southern slope of Yulong (Jade Dragon) Snow Mountain, dense *Prinsepia* and *Rubus* shrubs, 26°56'59.12"N, 100°11'11.39"E, 2960 m, leg. Hai-Tian Song, Zhi-Hao Qi and Ji-Shen Wang.

Redescription. Measurements (mm). Male: AtL 10.5–11.0, AbL 12.5–13.0, BL 17.0–17.8, FL 13.0–13.8, FW 3.4–3.8, HL 12.0–12.7, HW 3.3–3.5. Female: AtL 11.0–12.4, AbL 9.0–13.5, BL 15.0–20.0, FL 15.8–16.5, FW 4.0–4.4, HL 14.5–15.2, HW 3.9–4.3.

Distribution. China: Yunnan (Lijiang) (Fig. 54).

Remarks. Although the bifurcated median branch in male paramere is regarded as a diagnostic character of this species, a considerable variation was observed in one of the male specimens: the median branch of right paramere is not forked, while the left one is bifurcated as in the other specimens (Fig. 30).



Figs 27–32. *Dicerapanorpa tjederi* (Carpenter, 1938). 27, 29, 30 – male; 28, 31, 32 – female. 27, 28 – habitus, dorsal view. 29 – right paramere, right-lateral view. 30 – genital bulb, ventral view. 31 – subgenital plate, ventral view. 32 – medigynium, ventral view. Red arrow indicates bifurcated middle branch of paramere.

Dicerapanorpa triclada (Qian & Zhou, 2001)

(Figs 33–39, 53)

Material examined. CHINA: YUNNAN: 2 ♂♂ 3 ♀♀ (DALU: CN-99Di00004–CN99Di00008), Dali Bai Autonomous Prefecture, Mt. Cangshan, Huadianba, 2960 m, 7.vi.1999, leg. Ji-Shan Xu; 2 ♂♂ 2 ♀♀ (DALU: CN06Di00060–CN06Di00063), same locality, 4.vi.2006, leg. Anonymous; 2 ♂♂ 2 ♀♀ (DALU: CN21Di00021–CN21Di00024), Dali Bai Autonomous Prefecture, Mt. Cangshan, subarid alpine meadow near Xiaohuadian, 25°52′49.13″N, 100°01′30.69″E, 3250 m, 2.vi.2021, leg. Ji-Shen Wang.

Emended diagnosis. This species can be recognized by the combination of the following characters: 1) head yellow with black spots on vertex (Fig. 33); 2) wings with greatly reduced, spot-like pterostigmal band (Fig. 33); in males, 3) abdomen mostly black (Fig. 33); and in females, 4) medigynium with earlobe-like process on each side of main plate (Fig. 39).

Redescription. Measurements (mm). Male: AtL 10.5–12.0, AbL 10.0–11.4, BL 13.0–16.0, FL 13.0–14.0,

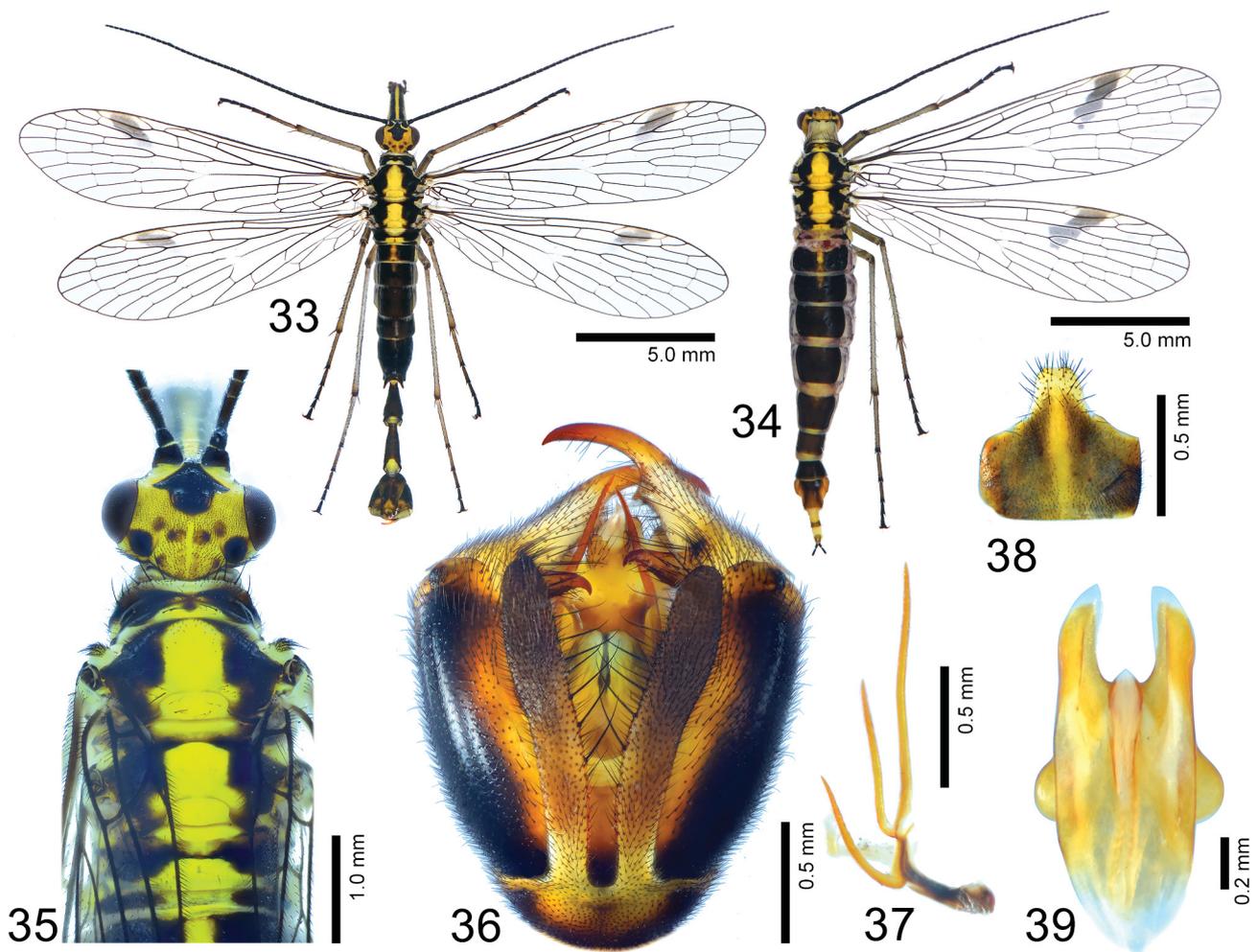
FW 3.5–3.6, HL 12.0–13.0, HW 3.4–3.5. Female: AtL 12.0–13.2, AbL 8.0–11.5, BL 13.0–15.7, FL 13.8–14.5, FW 4.1–4.4, HL 12.5–13.4, HW 3.9–4.2.

Male. Head (Figs 33, 35). Vertex yellow with large black spot on each side, and three smaller, blurred spots encircling each large one. Ocellar triangle enclosed by thick, arrow-shaped black pattern. Rostrum yellow, with two black frontal stripes.

Thorax (Fig. 33). Pronotum with six black thick setae along each side of anterior margin. Meso- and metanotum black laterally, with broad yellow median stripe.

Wings (Fig. 33). Membrane colorless and hyaline, with greatly reduced, spot-like pterostigmal band. Pterostigma light yellowish brown.

Abdomen (Fig. 33). T2 and T3 black laterally, with indistinct yellow median stripe; T4 and T5 entirely black. A6 black with pair of divergent anal horns on dorsal apex. A7 and A8 greatly constricted at base, black.



Figs 33–39. *Dicerapanorpa triclada* (Qian & Zhou, 2001). 33, 35–36 – male. 34, 38, 39 – female. 33, 34 – habitus, dorsal view. 35 – head and thorax, dorsal view. 36 – genital bulb, ventral view. 37 – right paramere, right-lateral view. 38 – subgenital plate, ventral view. 39 – medigynium, ventral view.

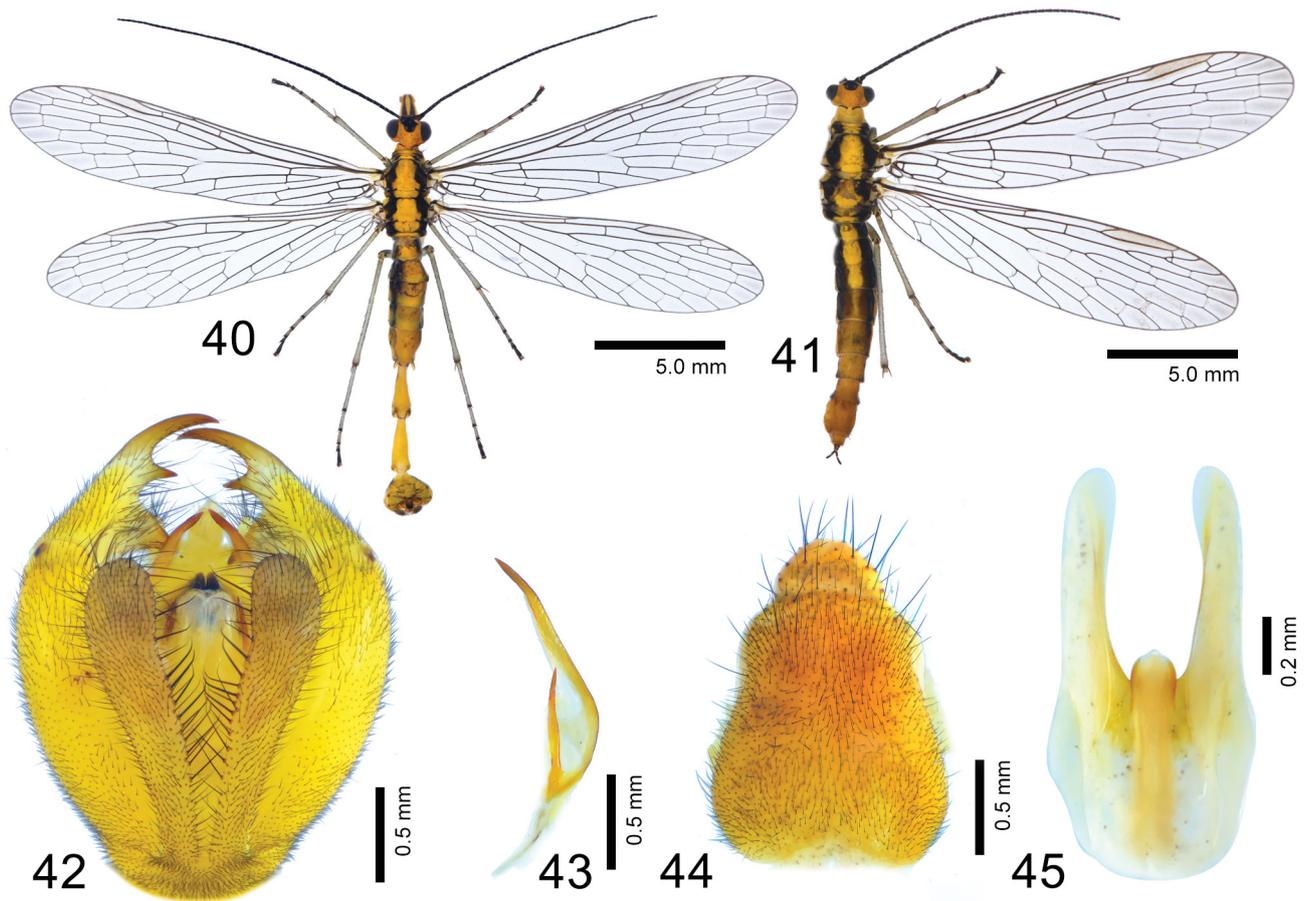
Male genitalia (Figs 36, 37). Genital bulb broadly oval, mostly black except for dark brown epandrium, hypandrium, gonostylus, and inner portion of gonocoxites. Epandrium broad, deeply emarginated terminally and forming pair of finger-like processes laterally. Hypandrium split into pair of long, stripe-like hypovalves. Hypovalve with row of long stout bristles along inner margin. Gonostylus shorter than gonocoxites, with well-developed, hook-like basal lobe and subtriangular middle tooth. Paramere trifurcate: ventral branch long; median branch nearly as long as ventral branch; dorsal branch longest, slightly shorter than twice length of middle branch and straight. Ventral valves of aedeagus greatly protruded, membranous with rounded apex.

Female. Habitus (Fig. 34) similar to males. Subgenital plate (Fig. 38) broad, with basal half rectangular and distal half greatly narrowed and subtriangular, and bearing long stout setae marginally in distal half. Medigynium (Fig. 39) with main plate slightly broadening from base towards middle, and nearly parallel at lateral margins in distal half; earlobe-like process in middle of each side of main plate; posterior arms approximately 1/3 as long as main plate.

Distribution. China: Yunnan (Dali) (Fig. 54).

Remarks. This species was originally described from an odd and unlocated place “Chadiantian (茶甸填)” in Mt. Cangshan and lacked further records. The author explored Mt. Cangshan in 2015–2020 but failed to rediscover this species. Fortunately, according to Drs Ji-Shan Xu and Zi-Zhong Yang’s photographs, memories and collections, the author confirmed that the type locality “Chadiantian” was erroneously transcribed from the handwritings of “Huadianba (花甸坝)” by QIAN & ZHOU (2001). Literally meaning “flower-meadowland” in Chinese, “Huadianba” is an alpine grassland in the northern part of Mt. Cangshan with extensive farming and grazing activities.

In 2021, an attempt to rediscover this species was successful near Xiaohuadian (Lesser Huadianba), a higher alpine grassland east of Huadianba. *Dicerapanorpa triclada* inhabits an alpine, subarid, windy, and rocky meadow, perches on the leaves and twigs of *Quercus guyavifolia* shrubs (Figs 52, 53), and holds wings roof-like over abdomen (Fig. 53). By then (June 2), the locality was in a severe drought before the rain season, and no water sources were found nearby.



Figs 40–45. *Dicerapanorpa yangqichengi* sp. nov. 40, 42, 43 – male. 41, 44, 45 – female. 40, 41 – habitus, dorsal view. 42 – genital bulb, ventral view. 43 – right paramere, ventral view. 44 – subgenital plate, ventral view. 45 – medigynium, ventral view.

***Dicerapanorpa yangqichengi* sp. nov.**

(Figs 40–45)

Type material. HOLOTYPE: CHINA: YUNNAN: ♂ (DALU: CN-21Di00025), Nujiang Lisu Autonomous Prefecture, Lushui City, Yaojiaping, 2327 m, 13.v.2021, leg. Qi-Cheng Yang. PARATYPES: 1 ♂ 1 ♀ (DALU: CN21Di00026, CN21Di00027), same data.

Diagnosis. This new species can be readily recognized by the combination of the following characters: 1) head yellow without black spots (Fig. 40); 2) wings without markings (Fig. 40); in males, 3) paramere bifurcated, lacking middle branch (Fig. 43); and in females, 4) medigynium with posterior arms longer than main plate (Fig. 45).

Description. Measurements (mm). Male (holotype): AtL 11.3, AbL 12.0, BL 16.5, FL 14.5, FW 3.5, HL 13.5, HW 3.4. Male (paratype): AtL 11.2, AbL 11.5, BL 15.0, FL 14.3, FW 3.3, HL 13.2, HW 3.2. Female (paratype): AtL 12.2, AbL 9.8, BL 15.0, FL 16.5, FW 3.8, HL 15.4, HW 3.8.

Male. Head (Fig. 40). Yellow without spots on vertex. Ocellar triangle enclosed by black arrow-shaped pattern. Rostrum yellow with two black frontal stripes.

Thorax (Fig. 40). Pronotum with five black thick setae along each side of anterior margin. Meso- and metanotum black laterally, with broad yellow median stripe.

Wings (Fig. 40). Membrane hyaline, lacking markings. Pterostigma indistinct.

Abdomen (Fig. 40). T2–T5 mostly yellow, dark brown laterally. A6 yellowish brown with pair of divergent anal horns on dorsal apex. A7 and A8 greatly constricted at base, yellowish brown.

Male genitalia (Figs 42, 43). Genital bulb spherical. Epandrium broad, deeply emarginated terminally and forming pair of finger-like processes laterally. Hypandrium split into pair of long, stripe-like hypovalves. Hypoalve slightly broadening towards apex, with row of long stout bristles along inner margin. Gonostylus shorter than gonocoxites, with well-developed basal lobe and elongated, acute middle tooth. Paramere bifurcate: ventral branch long and straight; median branch lacking; dorsal branch slightly longer than twice length of ventral branch and slightly curved subapically. Ventral valves of aedeagus membranous with rounded apex; dorsal valves subacute.

Female. Habitus (Fig. 41) similar to males. Subgenital plate (Fig. 44) subtriangular, bearing long stout setae in apical portion. Medigynium (Fig. 45) with main plate rounded; posterior arms extremely elongated, longer than main plate.

Etymology. The new species is named after the author's friend Mr. Qi-Cheng Yang, who collected and donated the precious specimens. Noun in the genitive case.

Distribution. China: Yunnan (Lushui) (Fig. 54).



Figs 46–53. Habitats and habitus of *Dicerapanorpa* spp. 46, 48, 50, 52 – habitats. 47, 49, 51, 53 – habitus. 47 – female. 49, 51, 53 – male. 46, 47 – *D. nakhi* Wang, sp. nov. 48, 49 – *D. tenuis* Hu, Wang & Hua, 2019. 50, 51 – *D. tjederi* Carpenter, 1938. 52, 53 – *D. triclada* (Qian & Zhou, 2001). Red arrows indicate positions where the specimens were caught.

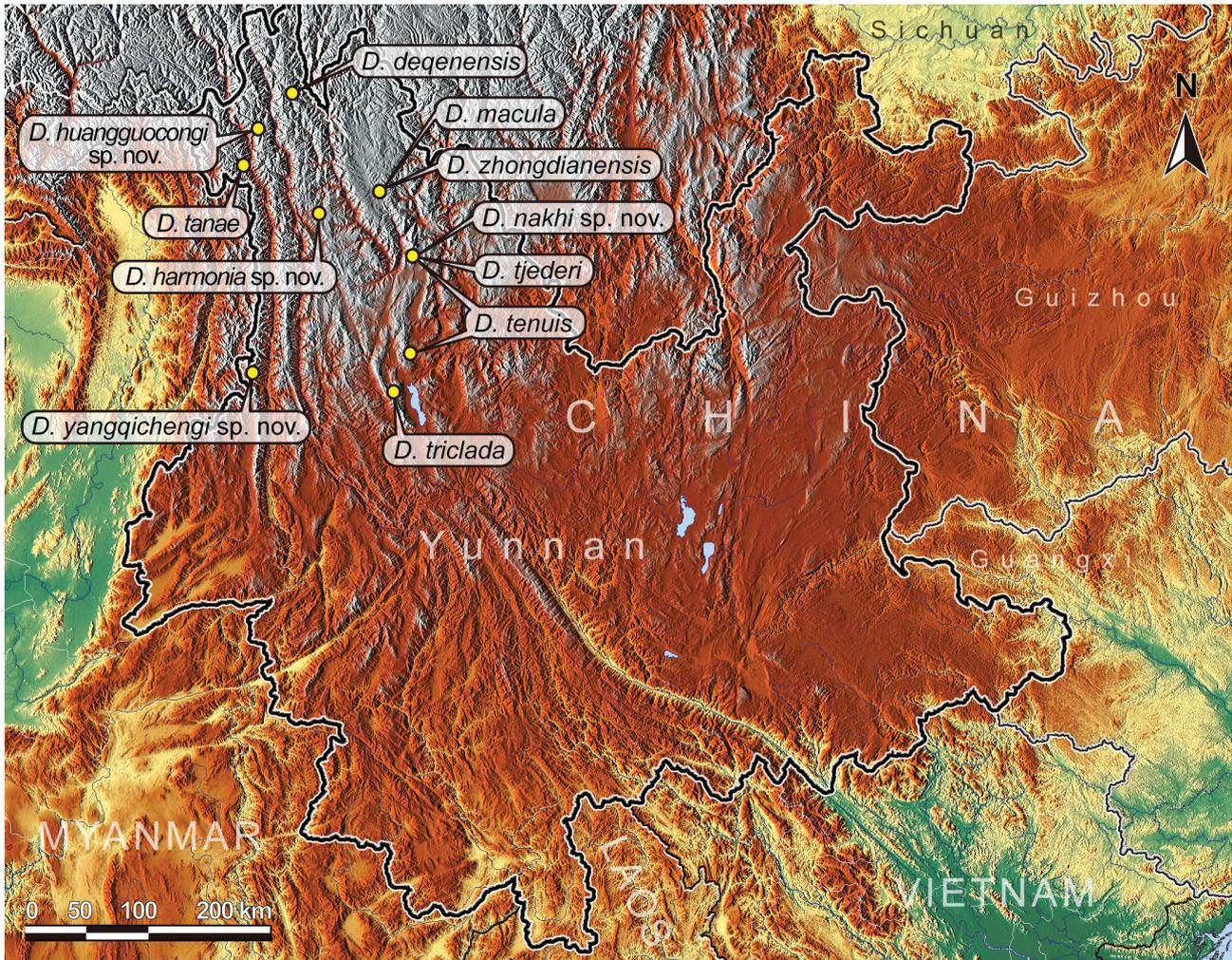


Fig. 54. Distribution of *Dicerapanorpa* spp. in Yunnan, China.

Remarks. *Dicerapanorpa bifurcata* Hu & Hua, 2020 was thought to be the only member of *Dicerapanorpa* that bears bifurcated parameres in the male genitalia, while all its congeners bear trifurcated parameres; *D. yangqichengi* is the second known species which shares this trait.

Discussion

Geographical isolations and climate fluctuations are regarded as the driving forces of the allopatric speciation and the current distribution of the cool-climate scorpionflies (HU et al. 2019a, b; WANG & HUA 2020). According to recent estimations of divergence time, the origin and early divergence of *Dicerapanorpa* were dated in the Miocene (ca. 20–6 mya), corresponding to the uplift of the Qinghai-Tibet Plateau and the orogeny of the Hengduan Mountains (HU et al. 2019b; MIAO et al. 2019). Among the high mountain ranges and the deep river gorges in southwest China, the early lineages of *Dicerapanorpa* continuously diversified due to geographical isolation. During the cold ice age, some ancestral *Dicerapanorpa* species likely migrated to the lower or southern areas, but subsequently migrated back to the higher or northern areas during the warmer interglacial period (HU et al. 2019a, b).

The Mountains of Southwest China are primarily

north-south oriented mountain ranges that effectively separate the lowlands in northern Myanmar from the Sichuan Basin (Fig. 54), providing ideal corridors for the migrations of *Dicerapanorpa* species during the Pleistocene glacial-interglacial climate fluctuations (HU et al. 2019b). Consequently, *Dicerapanorpa* species are mostly restricted to the high elevations (2000–3000 m) in the Hengduan Mountains, while a few members dispersed to other regions by two possible ways: eastward through the Yunnan-Guizhou Plateau to the Fanjing and Leigong Mountains (*D. zhengkuni* in the *D. diceraspis* group), and northeastward through the Qionglai-Minshan Mountains to the Qinling and Bashan Mountains (five species in the *D. magna* group). Therefore, the species of *Dicerapanorpa* currently display a C-shaped distributional pattern around the Sichuan Basin (generally lower than 1000 m).

In this study, the species number of *Dicerapanorpa* is raised to 24. To date, this genus has only been recorded from Chongqing, Gansu, Guizhou, Henan, Hubei, Shaanxi, Sichuan, and Yunnan (HU et al. 2019b). However, because some species have been recorded from provincial or national frontiers, such as *D. huangguocongii* and *D. tanae* from Gongshan, bordering Kachin (northeastern Myanmar) to the West and Tibet (western China) to the

North, it is highly possible that some known or unknown species can be found in adjacent areas of Tibet or Kachin. Accordingly, there is likely a third dispersal path for some *Dicerapanorpa* species: westward through mountains in northeastern Yunnan to the southern slopes of the Himalayas. In the genus *Neopanorpa*, such a corridor was reported to link the faunas from southern China, Southeast Asia, and the southern slopes of the Himalayas (WANG 2021, WANG & HUA 2021). Further expeditions in these regions are requisite to confirm whether this third path exists for *Dicerapanorpa*.

Contrary to most members of the family Panorpidae (including the *D. magna* group) which rely on highly moist environments and often perch on the leaves under tree shade (WANG & HUA 2016, WANG & GONG 2021), some species in the *D. dicerans* group can tolerate dryer climate and be active in open areas. For example, *D. deqenensis*, *D. harmonia*, *D. macula*, *D. nakhi*, *D. tenuis*, and *D. zhongdianensis* can be found in open grassland or shrubs with abundant sunshine (Figs 52–59). The extreme case is *D. triclada*, which inhabits an alpine, subarid, windy, and rocky meadow in Mt. Cangshan, Yunnan (Fig. 52). After the monsoon arrived (mid-July, 2021), the locality received abundant rainfall, and no individuals were collected during subsequent expeditions.

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