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## Research article

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# Two new species of Nemouridae (Insecta: Plecoptera) from China

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**Abstract.** *Nemoura* Latreille, 1796 and *Amphinemura* Ris, 1902 are the two largest genera of Nemouridae in China. In this paper, two new species are described and illustrated from China: *Nemoura lixiana* sp. nov. from Sichuan Province and *Amphinemura jiaoheensis* sp. nov. from Jilin Province. The two new species are diagnostic from congeners by the genitalic structures in males and females.

**Keywords.** Stoneflies, taxonomy, morphology, new taxon, biodiversity.

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## Introduction

The nemourid genus *Nemoura* Latreille, 1796 contains over 190 valid species distributed in the Holarctic and Oriental regions (Baumann 1975; DeWalt *et al.* 2020). *Nemoura* is the second largest genus of Nemouridae in China, with 40 species described. Most recent contributions to *Nemoura* from China have been made by Yang *et al.* (2015), Chen & Du (2017a, 2017b), Qian *et al.* (2018) and Mo *et al.* (2020).

Another nemourid genus, *Amphinemura* Ris, 1902, is also a large genus, including over 200 valid species from the Holarctic and Oriental regions (Baumann 1975; DeWalt *et al.* 2020). In China, *Amphinemura* is the largest genus of Nemouridae, with 92 known species. Recent contributions to *Amphinemura* include Yang *et al.* (2015), Li *et al.* (2016, 2017a, 2017b, 2018a, 1028b) and Mo *et al.* (2017, 2019).

The present contribution is devoted to the description of two new species of *Nemoura* and *Amphinemura* from Sichuan Province of western China and Jilin Province of northeastern China, respectively (Fig. 1).

## Material and methods

Specimens used in this study were collected by hand and preserved in 75% ethanol. Abdomens of the males were cleared in 10% NaOH. Observations and measurements were performed with a SDPTOP SZM45 stereo microscope. Color images were taken using a Canon EOS 6D digital camera with a Canon MP-E 65 mm 5× macro lens and optimized with Adobe Photoshop CS6. All pictures were adjusted and assembled into plates with Adobe Photoshop CS6. Holotypes and paratypes are deposited in the Insect Collection of Jiangsu University of Science and Technology, Jiangsu Province, China (ICJUST).

## Abbreviations

The following abbreviations are used in the figures:

BL	=	body length
FL	=	forewing length
HL	=	hindwing length
ST1	=	first abdominal sternum (and so forth for other segments)
T1	=	first abdominal tergum (and so forth for other segments)
ae	=	aedeagus
ce	=	cerci
ds	=	dorsal sclerite of epiproct
ep	=	epiproct
hp	=	hypoproct
ics	=	inner cercal spine
il	=	inner lobe of paraproct
ml	=	median lobe of paraproct
ocs	=	outer cercal spine
ol	=	outer lobe of paraproct
pgp	=	pregenital plate
pp	=	paraproct
sgp	=	subgenital plate



**Fig. 1.** Collecting localities of *Nemoura lixiana* sp. nov. (red spot) and *Amphinemura jiaoheensis* sp. nov. (pink spot) in China. General distribution of *Nemoura geei* Wu, 1929 is marked with blue spots or blue text.

ve = vesicle  
vs = ventral sclerite of epiproct

## Results

Class Insecta Linnaeus, 1758  
Order Plecoptera Burmeister, 1839  
Family Nemouridae Billberg, 1820

Genus *Nemoura* Latreille, 1796

*Nemoura* Latreille, 1796: 101. Type species: *Perla cinerea* Retzius, 1783.

## Diagnosis

### Adult

Cervical gills absent but with single small membranous, gill-like nubs outside of lateral cervical sclerites.

### Male

Paraprocts divided into 2 lobes; inner lobe short and narrow; outer lobe sclerotized ventrally and membranous dorsally, very large and triangular or elongate in shape. Cerci mostly sclerotized, lateral sclerotized strip usually terminates at apex in 1 to 3 spines or hooks. Dorsal sclerite of epiproct large and broad at base, mostly darkly sclerotized, extending dorsolaterally, narrower around lateral knobs and then very large, usually completely covering lateral aspects of epiproct and part of ventral aspect, anterior area usually lightly sclerotized; ventral sclerite darkly sclerotized, broad at base, with lateral knobs at basolateral corners, tapering toward apex, forming parallel ridges, one on each side of midline, usually covered by dorsal sclerite near tip of epiproct, extending inward and upward to dorsal surface, visible portion paired and quite variable in shape, often bearing spines or hooks.

### Female

Sternum 7 enlarged and extended posteriorly, covering part or all of sternum 8, produced area sclerotized. Sternum 8 narrow and mostly membranous, with small sclerotized area at genital opening. Cerci mostly sclerotized.

*Nemoura lixiana* sp. nov.

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Figs 1–5, 7

## Diagnosis

*Nemoura lixiana* sp. nov. exhibits the typical body color and genitalic characters of genus *Nemoura* (Figs 2–5). The new species is most similar to *Nemoura geei* Wu, 1929 by sharing similar characteristics of male epiproct and female pregenital plate (Shimizu 1997; Teslenko & Zhiltzova 2009; Yang *et al.* 2015). However, males of the new species can be distinguished from *N. geei* by the presence of extra stout spines on inner membrane of cerci (Figs 2C, 3A, 4E), which are absent in *N. geei* (Fig. 6A–C); the median lobe of paraprocts is projected inwards and covers half of inner lobe in *N. lixiana* sp. nov. (Fig. 4E), but hardly reaches the inner lobe in *N. geei* (Fig. 6A–C); in the epiproct of *N. lixiana* sp. nov., the dorsal sclerite has two apparently angled lateral sclerites which are thick, with transverse anterior margins and very stout posterior humps (Fig. 4B), while in *N. geei*, the lateral sclerites are thinner and not angled, with oblique anterior margins and low posterior humps (Fig. 6D–F). The females of *N. lixiana* sp. nov. have two oval lateral sclerites on sternum 8 but without small lateral pits on sterna 7–8 (Fig. 5B–C), whereas in *N. geei*, sternum 8 has two long transverse sclerites and sterna 7–8 have paired lateral pits (Fig. 6G–H). In addition, type locality of *N. lixiana* sp. nov. is in southwestern China

(Fig. 1), which is apparently isolated from the known ‘northeastern Asian’ distribution of *N. geei* in Beijing, Henan, Shandong, Inner Mongolia, Korea, Japan and the Russian Far East (Yang *et al.* 2015; DeWalt *et al.* 2020).

### Etymology

The new species is named after the type locality, Lixian County.

### Material examined

#### Holotype

CHINA • ♂; Sichuan Province, Lixian County, side of Xuemeng Road, a small unnamed stream (Fig. 7); 31°33'56" N, 103°17'32" E; 1634 m a.s.l; 5 Oct. 2019; Zhi-Teng Chen leg.; ICJUST.

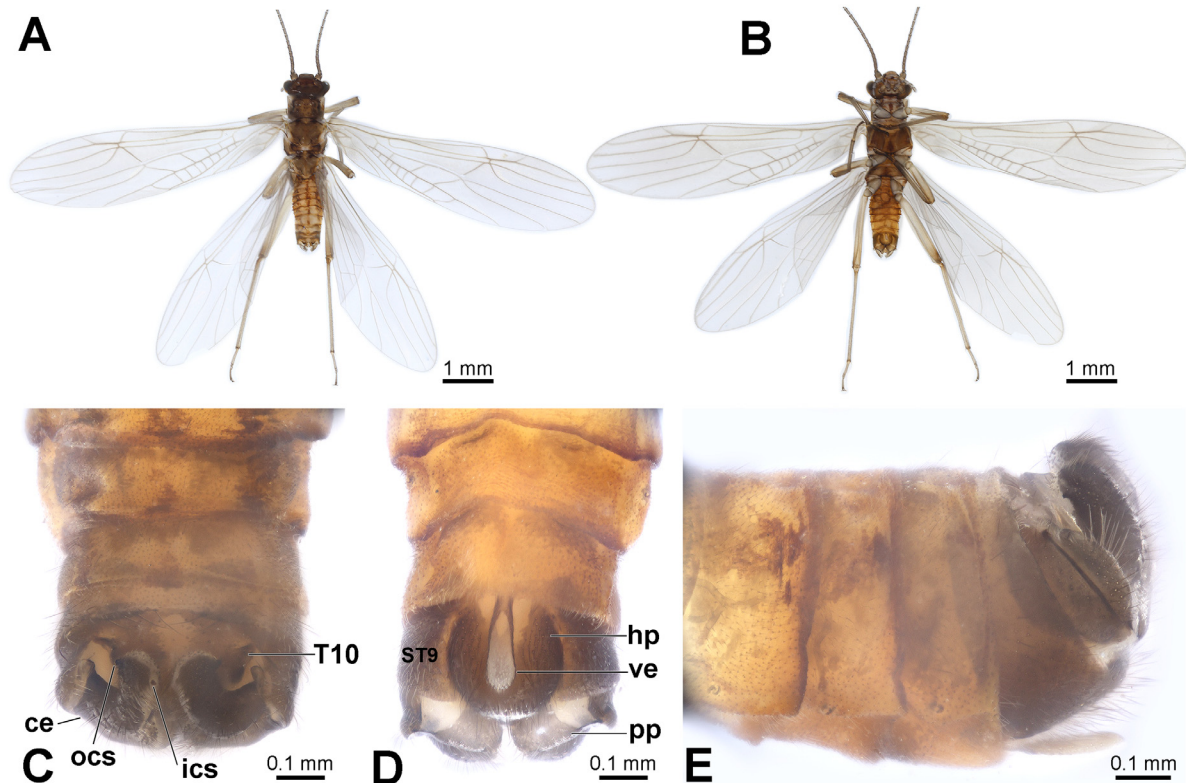
#### Paratypes

CHINA • 8 ♂♂, 4 ♀♀; same collection data as for holotype; ICJUST.

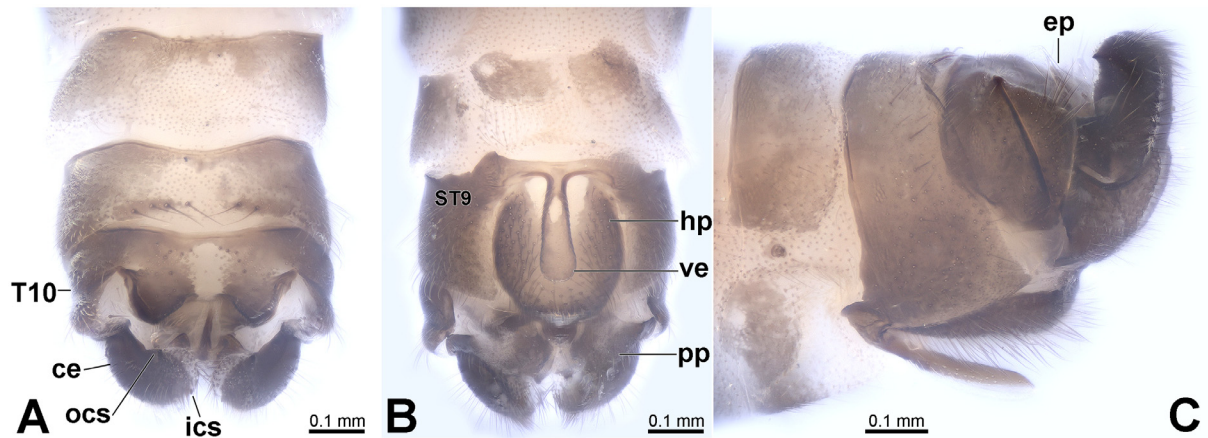
### Description

#### Male

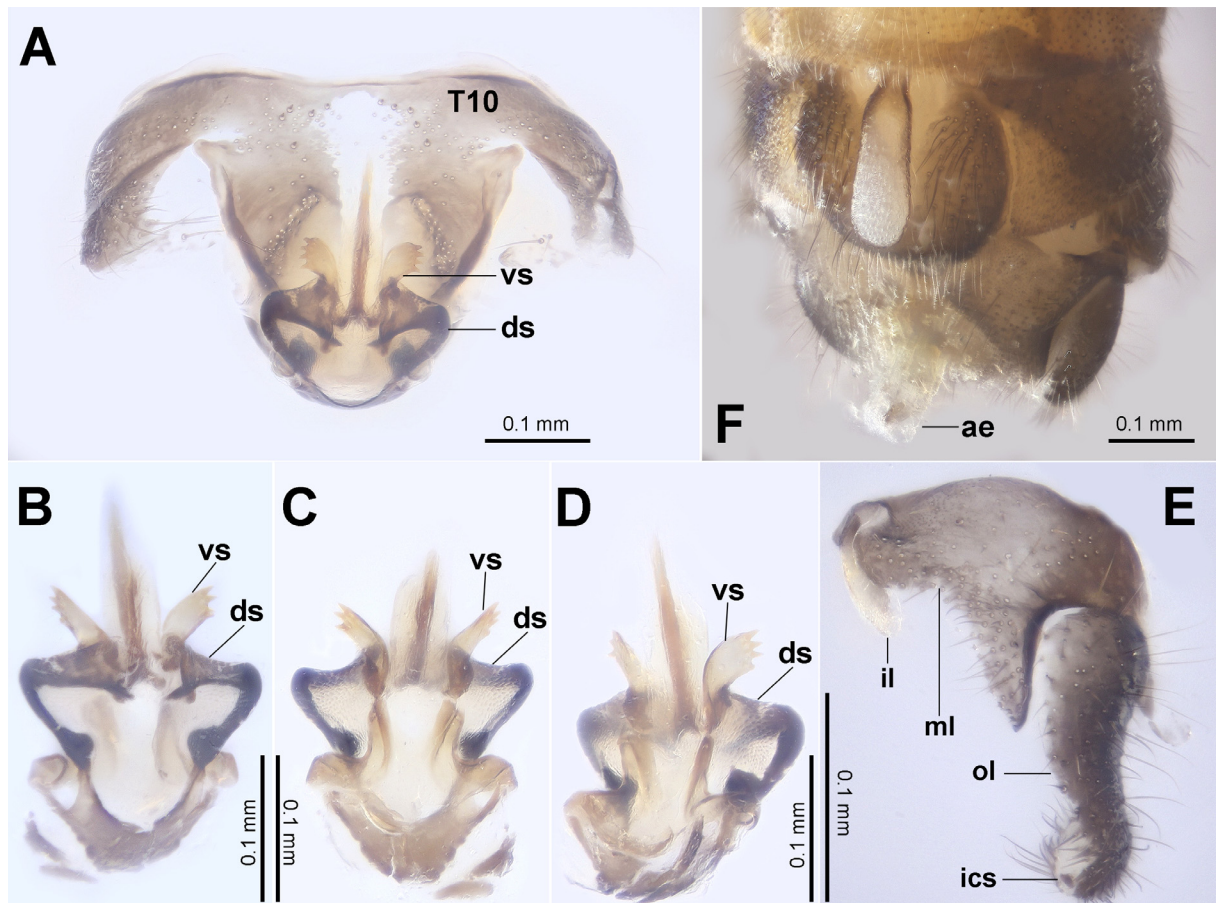
MEASUREMENTS. Holotype: BL = 3.5 mm; FL = 6.3 mm; HL = 4.5 mm. Other specimens: BL = 3.5–4.5 mm; FL = 6.0–7.0 mm; HL = 4.5–6.0 mm.



**Fig. 2.** *Nemoura lixiana* sp. nov. **A.** Male habitus, dorsal view. **B.** Male habitus, ventral view. **C.** Male terminalia before NaOH treatment, dorsal view. **D.** Male terminalia before NaOH treatment, ventral view. **E.** Male terminalia before NaOH treatment, lateral view.



**Fig. 3.** *Nemoura lixiana* sp. nov. **A.** Male terminalia after NaOH treatment, dorsal view. **B.** Male terminalia after NaOH treatment, ventral view. **C.** Male terminalia after NaOH treatment, lateral view.



**Fig. 4.** *Nemoura lixiana* sp. nov. **A.** Male tergum 10 and epiproct, dorsal view. **B.** Male epiproct, dorsal view. **C.** Male epiproct, ventral view. **D.** Male epiproct, ventrolateral view. **E.** Male paraproct, dorsal view. **F.** Male paratype with aedeagus extruded, ventral view.

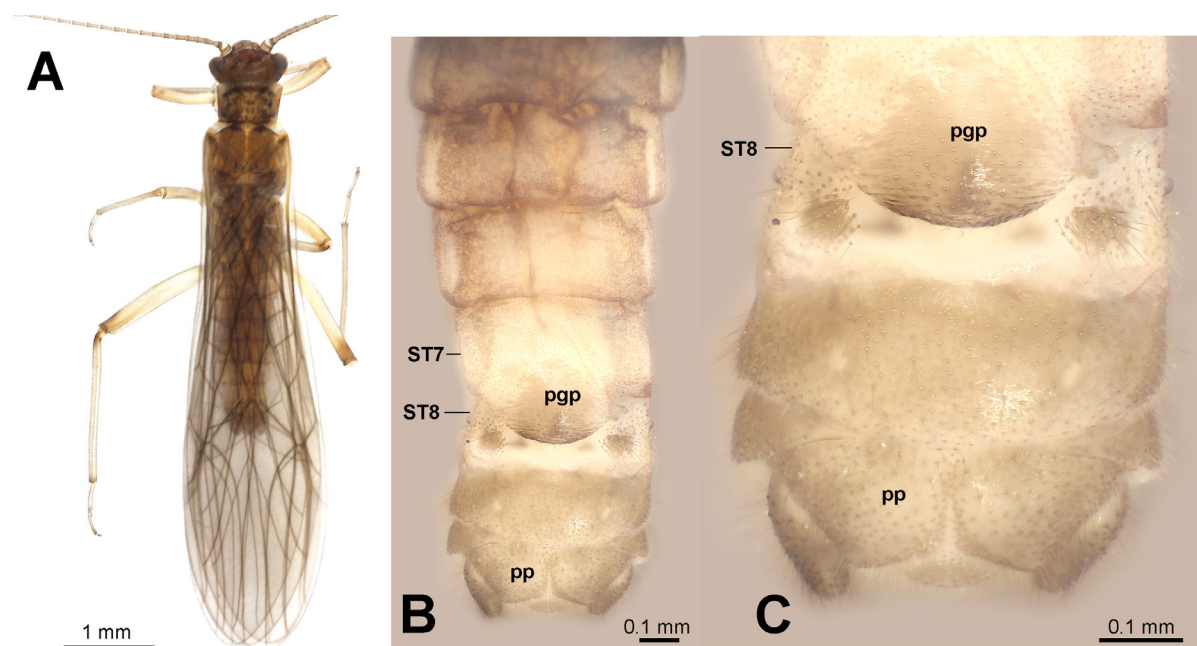
**HEAD** (Fig. 2A–B). Head dark brown; two ocelli pale; compound eyes dark and protruded; antennae slender and dark brown, much longer than body length; mouthparts brown.

**THORAX** (Fig. 2A–B). Brown. Pronotum brown, with dark rugosities, corners angulate; anterior margin arcuate, posterior margin concave. Legs pale brown, joints of each segment darker.

**WINGS** (Fig. 2A–B). Macropterous, wing membrane subhyaline, veins brown; margins of wings fringed with short bristles.

**ABDOMEN** (Figs 2–4). Abdominal segments generally pale brown; abdominal terga with an obscure longitudinal stripe. Posterior margin of tergum 9 with a row of long bristles. Tergum 10 with a membranous median area anterior of median area, with two small lateral patches of sensilla basiconica; posterior margin of tergum 10 with two sclerotized coniform lobes. Cerci prolonged and upcurved, covered by dense long hairs; inner part membranous, subapically with a stout inner spine; outer surface of cerci sclerotized, outer sclerite kidney-shaped, subapically with a small back-curved spine.

**GENITALIA** (Figs 2C–E, 3–4). Dorsal sclerite of epiproct with two elbow-shaped, dark lateral sclerites; inner apex of each lateral sclerite forked; apex of epiproct with a prolonged median sclerite covered by membrane; ventral sclerite with a C-shaped base and two sinuous lateral sclerites, which project forwards and form two apically dentate arms, the arms each with three or four apical teeth. Vesicle of sternum 9 mostly membranous, claviform and slightly constricted basally; hypoproct broad and elliptical, apex extended backwards, with a long triangular sclerite. Paraprocts bilobed; inner lobe weakly sclerotized, finger-shaped with a blunt tip, near half as long as outer lobe; outer lobe strongly sclerotized, broad basally, posteromedial margin forming a long triangular sclerite, inner margin with a projected basal hump covering half of inner lobe. The accidentally extruded aedeagus in a paratype cylindrical, mostly membranous, apex with one or two obscure small lobes.



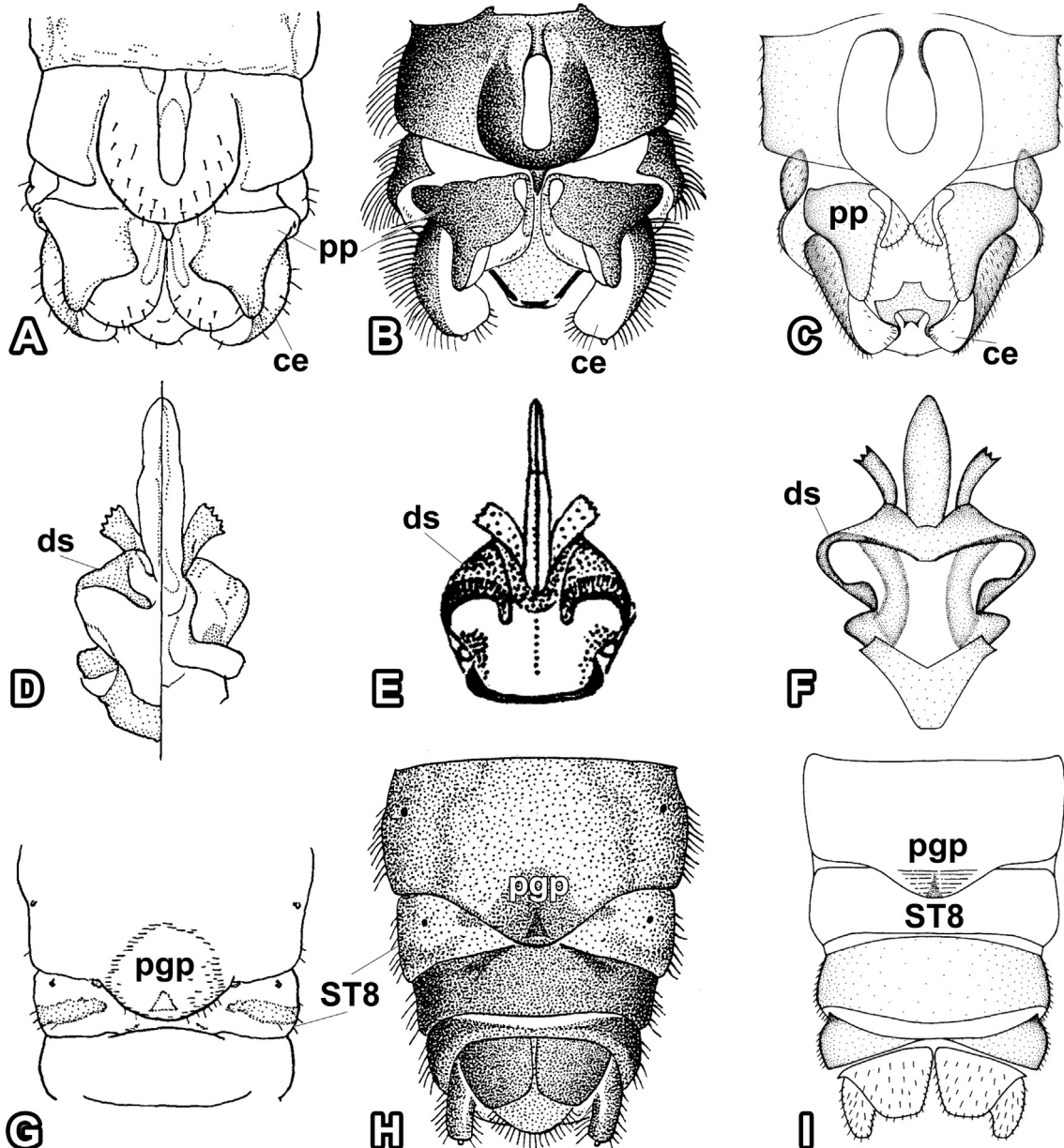
**Fig. 5.** *Nemoura lixiana* sp. nov. **A.** Female habitus, dorsal view. **B.** Female abdomen, ventral view. **C.** Female terminalia, ventral view.

**Female**

Similar to males in body coloration (Fig. 5A).

MEASUREMENTS. BL = 4.5–5.2 mm; FL = 7.0–8.5 mm; HL = 6.0–7.5 mm.

GENITALIA (Fig. 5B–C). Pregenital plate of sternum 7 rounded and sclerotized, reaching half-length of sternum 8. Sternum 8 with two oval-shaped, dark brown lateral spots. Paraprocts near trapezoidal and fused basally.



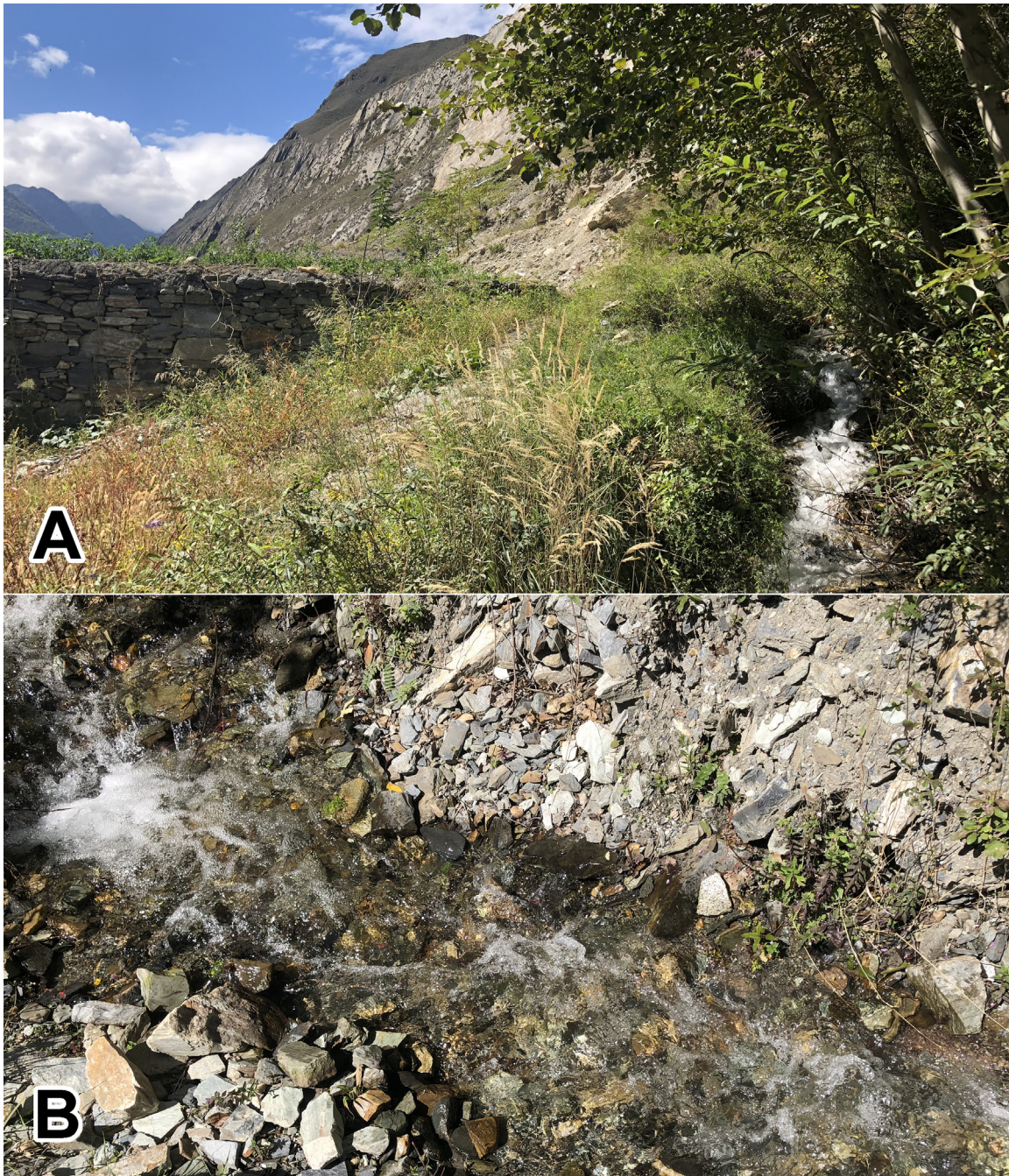
**Fig. 6.** Drawings of *Nemoura geei* Wu, 1929. A–C. Male terminalia, ventral view. D. Male epiproct in dorsal view (left) and ventral view (right). E–F. Male epiproct in dorsal view. G–I. Female terminalia, ventral view. A, D and G modified from Shimizu (1997); B, E and H modified from Teslenko & Zhiltzova (2009); C, F and I modified from Yang *et al.* (2015). Scale bars unavailable from original source.

### **Distribution**

China: western Sichuan Province (Fig. 1).

### **Remarks**

This species was collected in the afternoon of 5 Oct. 2019, when the adults were emerging massively. The habitat, a very small unnamed stream flows down from a dried mountain (Fig. 7), geographically



**Fig. 7.** Habitat of *Nemoura lixiana* sp. nov. in China, Sichuan Province. **A.** Unnamed stream flowing down from a mountain. **B.** Photo of the stream.



isolated from other known water systems. An undescribed new genus of Elmidae (Coleoptera) was simultaneously collected in this unique stream, but no mayflies or caddisflies or other aquatic insects were found at that time.

Genus *Amphinemura* Ris, 1902

*Amphinemura* Ris, 1902: 384. Type species: *Nemoura sulcicollis* Stephens, 1836.

**Diagnosis**

**Adult**

Cervical gills highly branched.

**Male**

Paraprocts divided into 3 lobes and with spines or prongs on middle or outer lobes. Cerci membranous, short and unmodified. Dorsal sclerite of epiproct large and broad at base, extending dorsolaterally toward apex, with sclerotized lateral arms, apical portion large and extending laterally over ventral sclerite, bearing small spines or sclerotized scales; ventral sclerite strongly sclerotized, broad at base and tapering toward apex, forming median keel-shaped ridge, apical portion inserted between folds of dorsal sclerite and variously modified, bearing large spines.

**Female**

Sternum 7 produced at distal margin, forming a small pregenital plate which covers part of sternum 8. Sternum 8 forming a subgenital plate of variable size but usually small and bifid.

*Amphinemura jiaoheensis* sp. nov.

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Figs 8–11, 13

**Diagnosis**

*Amphinemura jiaoheensis* sp. nov. exhibits the typical body color and genitalic characters of genus *Amphinemura* (Figs 8–11). The new species is apparently distinctive from all congeners by the following combination of characters: 1) male T9 with paired posterior projections which are covered by thick spines; 2) male T10 with two long bunches of stout spines; 3) ventral sclerite of epiproct long, triangular and ventrally fringed with thick spines; 4) median lobe and outer lobe of male paraprocts embracing a membrane, margin of the membrane with long spines; 5) female with a small pregenital plate and a medially divided subgenital plate. The deep posterior notch of tergum 9 together with the long bunches of stout spines on tergum 10 are rarely found in *Amphinemura* (Figs 9A, 10A). Although a similar notch and spines are also found in *Amphinemura leigong* Wang & Du, 2006 from Guizhou Province of southwestern China, the structures of the epiproct and paraprocts are entirely different between *A. leigong* and the new species (Fig. 12).

**Etymology**

The new species is named after the type locality, Jiaohe City.

**Material examined**

**Holotype**

CHINA • ♂; Jilin Province, Jiaohe City, Sidaogou Mountain, a small unnamed stream (Fig. 13); 43°44'40" N, 127°03'05" E; 600 m a.s.l.; 22 July 2019; Zhi-Teng Chen leg.; ICJUST.

### Paratypes

CHINA • 1 ♂, 2 ♀♀; same collection data as for holotype; ICJUST.

### Description

#### Male

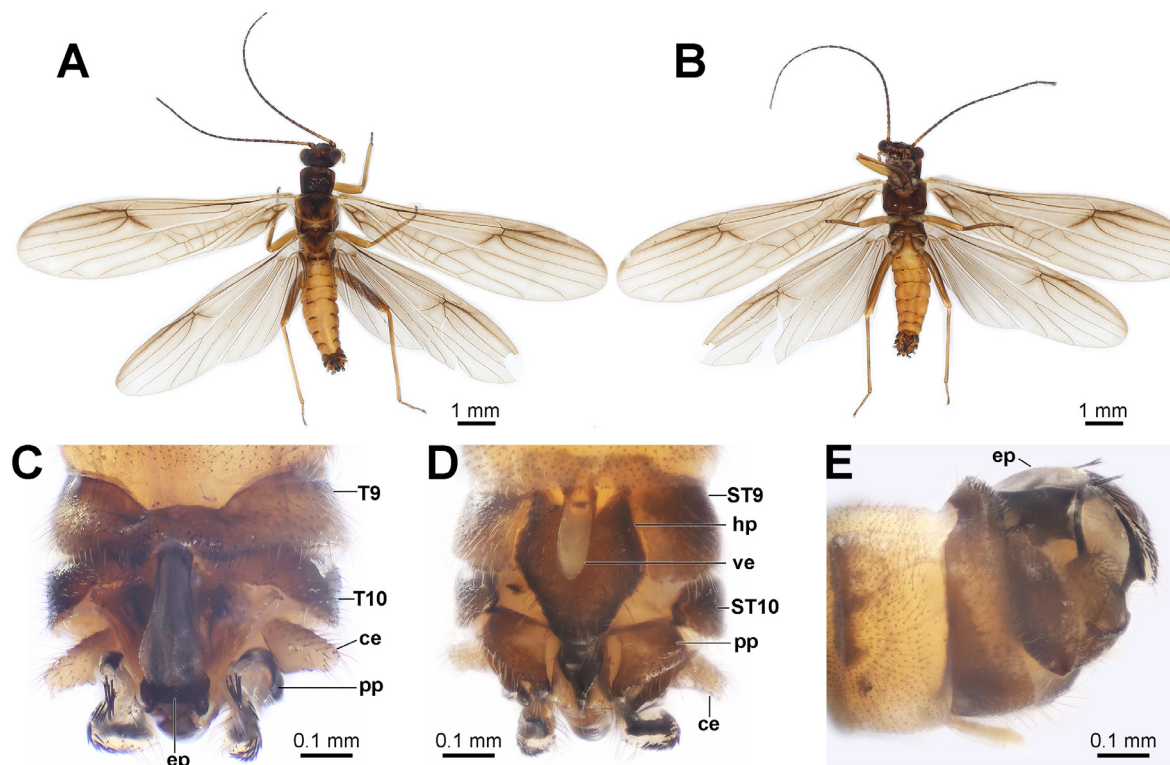
MEASUREMENTS. Holotype: BL = 6.0 mm; FL = 7.0 mm; HL = 6.0 mm. Other specimen: BL = 3.8 mm; FL = 6.0 mm; HL = 5.0 mm.

HEAD (Fig. 8A–B). Dark; three ocelli pale; compound eyes dark and rounded; antennae slender and dark brown, much longer than body length; mouthparts brown.

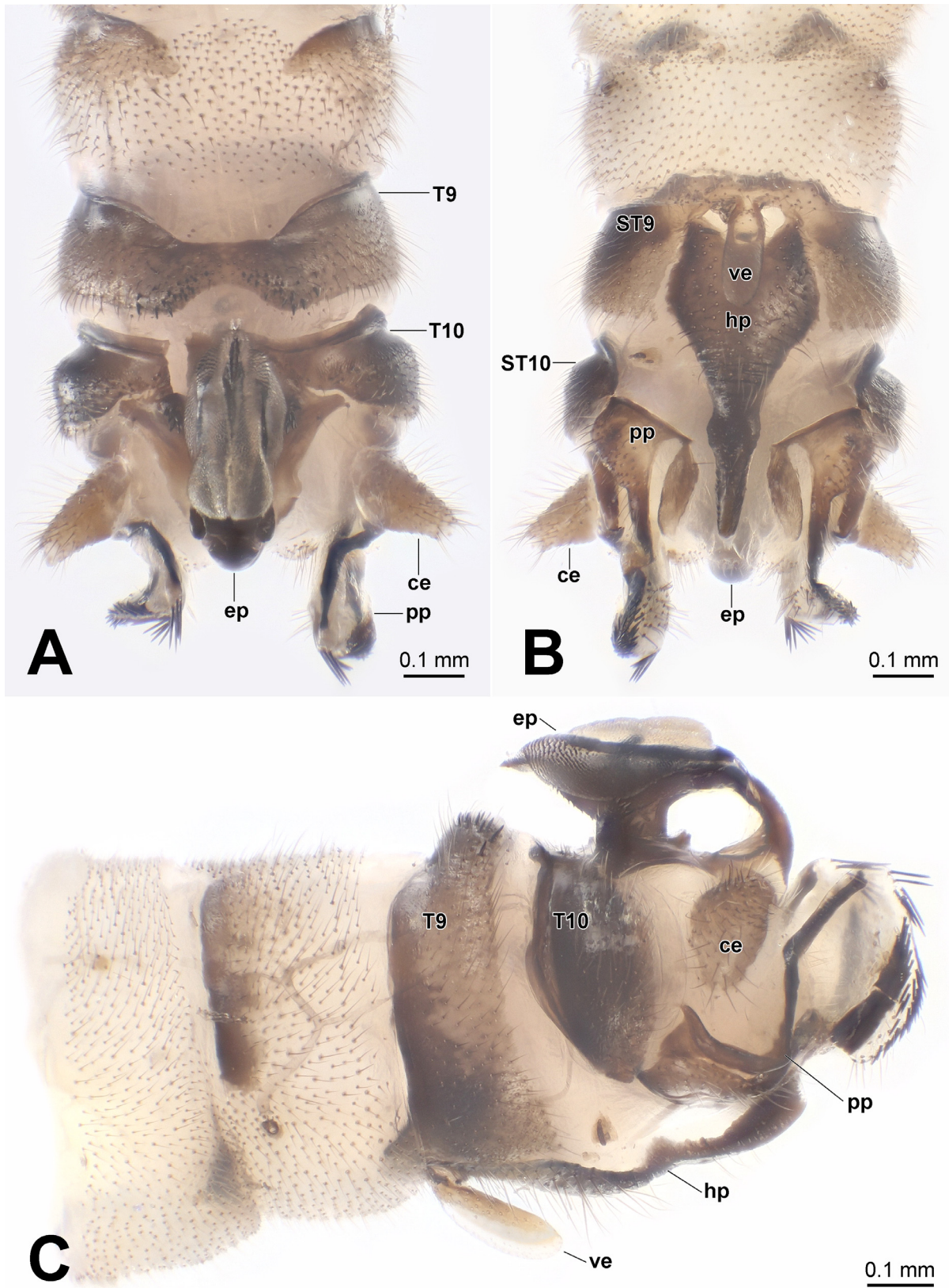
THORAX (Fig. 8A–B). Dark brown. Pronotum dark brown, with dark rugosities, corners blunt; anterior margin arcuate, posterior margin concave. Legs pale brown.

WINGS (Fig. 8A–B). Macropterous, wing membrane subhyaline, veins dark brown; margins of wings fringed with short bristles.

ABDOMEN (Figs 8–9, 10A). Abdominal segments generally pale brown; anterior margins of abdominal terga 3–8 each with two dark lateral sclerites; sterna 3–8 each with two dark lateral sclerites. Tergum 9 strongly sclerotized, anterior margin concave, posterior half elevated and with a transverse patch of stout spines. Tergum 10 darkly sclerotized, with a membranous median area, each side of median area with a knob bearing stout spines. Cerci dark brown, coniform and covered by long hairs.



**Fig. 8.** *Amphinemura jiaoheensis* sp. nov. **A.** Male habitus, dorsal view. **B.** Male habitus, ventral view. **C.** Male terminalia before NaOH treatment, dorsal view. **D.** Male terminalia before NaOH treatment, ventral view. **E.** Male terminalia before NaOH treatment, lateral view.

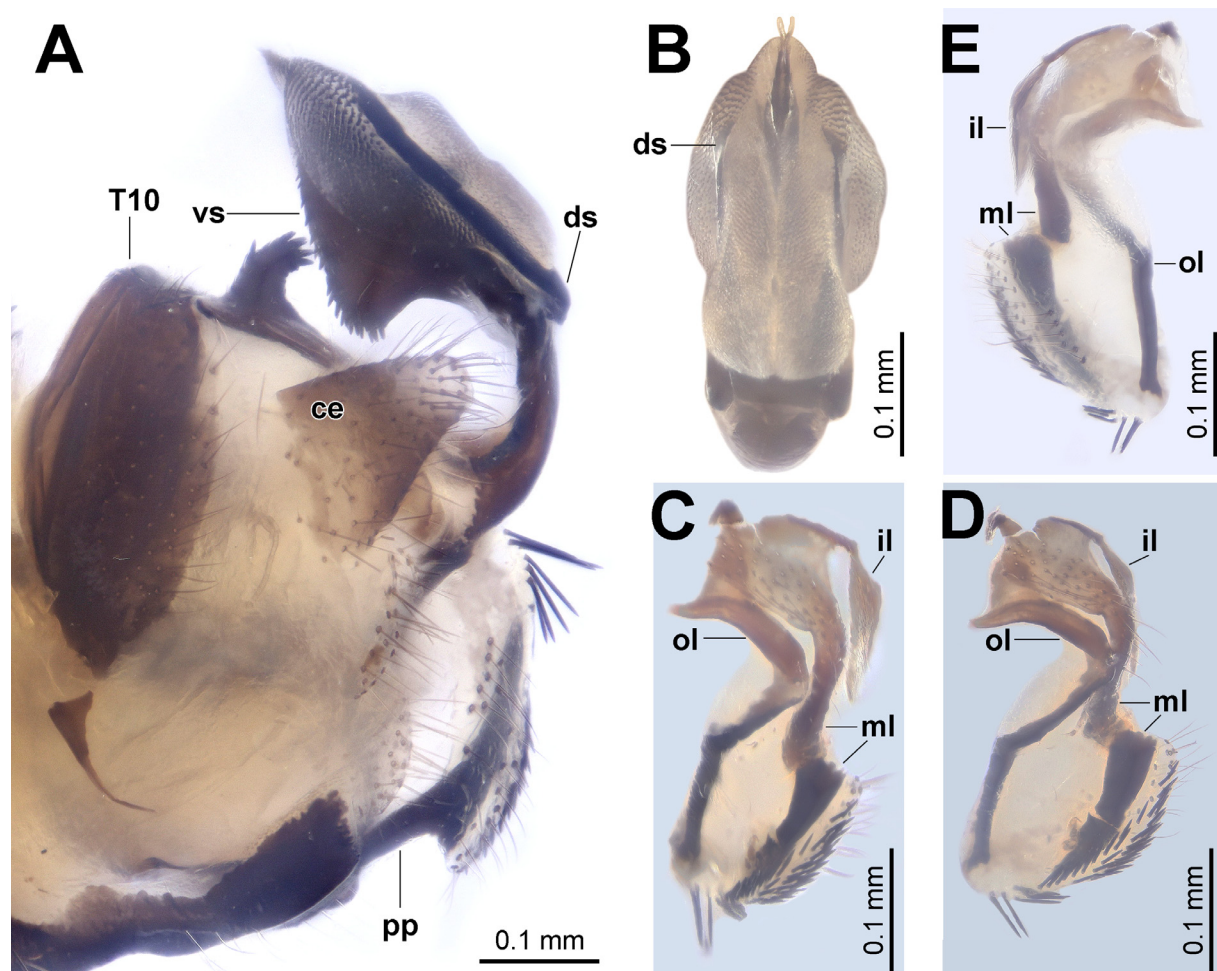


**Fig. 9.** *Amphinemura jiaoheensis* sp. nov. **A.** Male terminalia after NaOH treatment, dorsal view. **B.** Male terminalia after NaOH treatment, ventral view. **C.** Male terminalia after NaOH treatment, lateral view.

GENITALIA (Figs 8C–E, 9–10). Dorsal aspect of epiproct covered with spinulose membrane, medially grooved, apex with a pair of small lobes; apical and ventral membrane of epiproct mostly covered with scales. Dorsal sclerite of epiproct with two slender, lateral sclerites projecting to near apex; inside the membrane with a median sclerite; lateral knobs strongly sclerotized, elliptical in dorsal view. Ventral sclerite strongly sclerotized; in lateral view, ventral sclerite constricted basally, mostly forming a subtriangular sclerite fringed with stout spines, apically with more spines. Vesicle of sternum 9 mostly membranous, claviform and slightly constricted basally; hypoproct elongated, apex extended backwards, with a long finger-shaped sclerite. Paraprocts trilobed; inner lobe sclerotized, fusiform with a blunt tip, nearly as long as width of paraprocts; median lobe strongly sclerotized, broad basally, strongly curved dorsad, apex with long spines; outer lobe strongly sclerotized and curved dorsad, sinuous in lateral view; a layer of membrane present between outer lobe and inner lobe, membrane with a caudal patch of long spines and several longer dorsal spines.

### Female

Similar to males in body coloration (Fig. 11A–B).



**Fig. 10.** *Amphinemura jiaoheensis* sp. nov. **A.** Male tergum 10 and epiproct, lateral view. **B.** Male epiproct, dorsal view. **C.** Male paraproct, dorsal view. **D.** Male paraproct, dorsolateral view. **E.** Male paraproct, ventral view.

MEASUREMENTS. BL = 4.8–5.0 mm; FL = 7.0–7.5 mm; HL = 6.0–6.2 mm.

GENITALIA (Fig. 11C). Pregenital plate of sternum 7 small and semicircular. Subgenital plate of sternum 8 subquadrate, with a narrow median split, slightly extending over posterior margin of sternum 8. Paraprocts semicircular and dark brown.

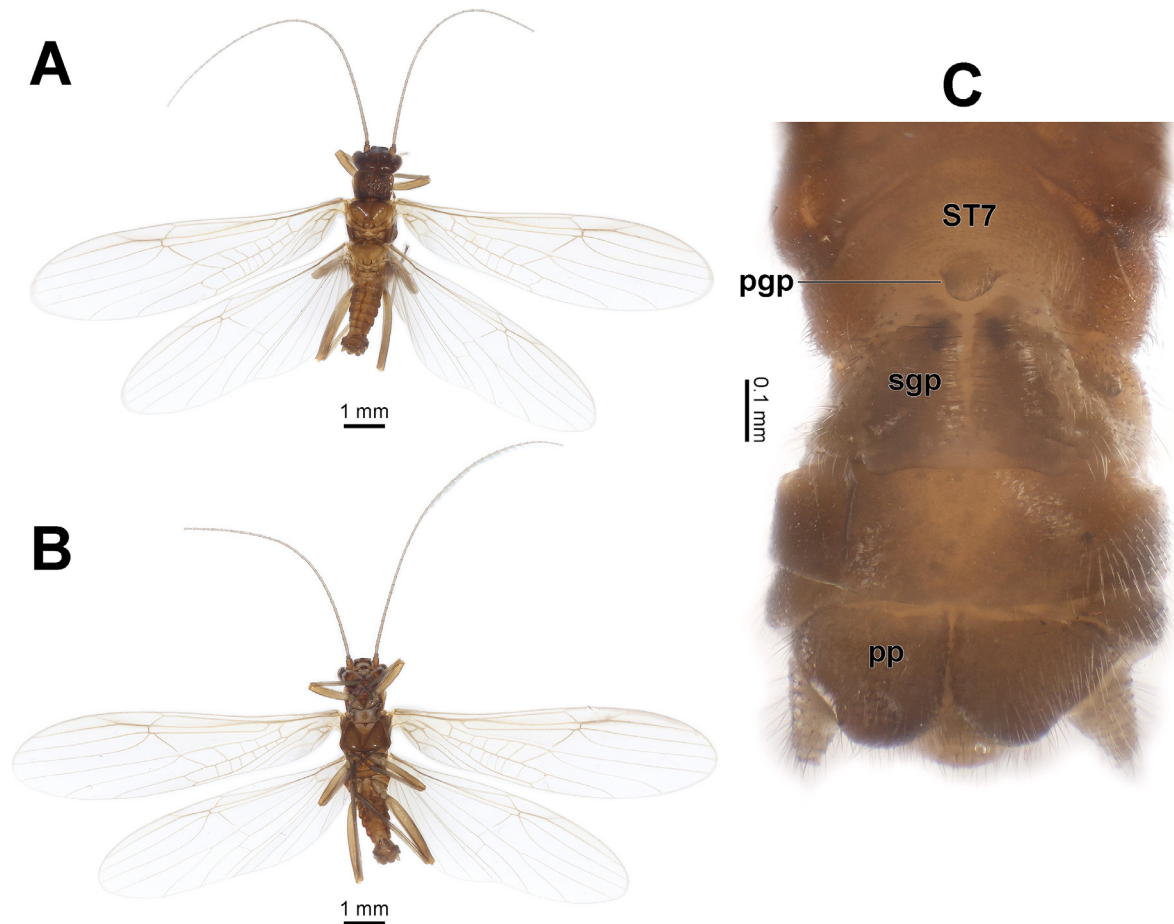
### Distribution

China: central Jilin Province (Fig. 1).

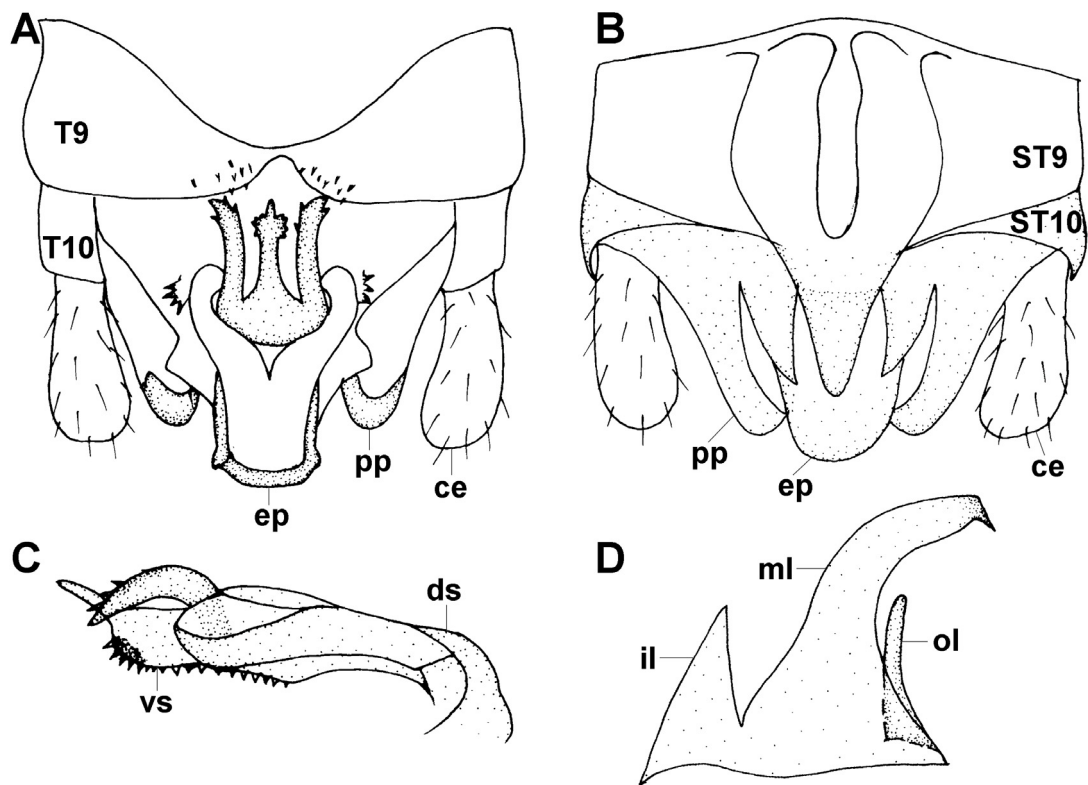
### Discussion

By describing two new species, the species numbers of *Nemoura* and *Amphinemura* from China are updated to 41 and 93, respectively.

Stoneflies of Nemouridae are frequently found and collected in the wild of China, with over 190 species described. However, these small-sized stoneflies have a relatively weak flight ability and are usually



**Fig. 11.** *Amphinemura jiaoheensis* sp. nov. **A.** Female habitus, dorsal view. **B.** Female habitus, ventral view. **C.** Female terminalia, ventral view.



**Fig. 12.** Drawings of *Amphinemura leigong* Wang & Du, 2006. **A.** Male terminalia, dorsal view. **B.** Male terminalia, ventral view. **C.** Male epiproct, lateral view. **D.** Male paraproct, ventral view. Drawings modified from Yang *et al.* (2015). Scale bars unavailable from original source.



**Fig. 13.** Habitat of *Amphinemura jiaoheensis* sp. nov. in China, Jilin Province. **A.** The unnamed stream. **B.** Adult habitus when captured by a sweeping net.

restricted to small habitats, so isolated water habitats usually have different stonefly species. Although *Nemoura* and *Amphinemura* are two species-rich genera in China, new taxa of the two genera are continuously discovered and described, suggesting a high biodiversity of Nemouridae in China.

## Acknowledgements

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