



**Research article**

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**Three new species of *Willowsia* (Collembola: Entomobryidae)  
from Guizhou Province, China**

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<sup>1</sup> [urn:lsid:zoobank.org:author:E68EE28F-3773-4123-BBEC-320461569E2B](https://zoobank.org/author:E68EE28F-3773-4123-BBEC-320461569E2B)

<sup>2</sup> [urn:lsid:zoobank.org:author:14F92F90-863A-46EB-B056-41EB3FA341A0](https://zoobank.org/author:14F92F90-863A-46EB-B056-41EB3FA341A0)

**Abstract.** Three new species of *Willowsia* collected from Guizhou Province, China are described here: *W. sexachaeta* sp. nov., *W. christianseni* sp. nov., and *W. tanae* sp. nov. They have spinulate scales on the body. Colour pattern and dorsal chaetotaxy are the main diagnostic characters for these species. A table summarizing the main differences between all Chinese *Willowsia* species is given.

**Keywords.** Entomobryinae, taxonomy, chaetotaxy, scales, new species.

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## Introduction

The genus *Willowsia* Shoebotom, 1917 belongs to the family Entomobryidae and has the following main characters: eyes 8+8, dens without spines or scales, mucro bidentate with a basal spine, scales present on body. Scale morphology is diversified in *Willowsia*. Zhang *et al.* (2011) divided scales into four types based on surface sculpture: spinulate type, short rib type, long basal rib type and uninterrupted type.

Thirty-eight species have been described worldwide, ranging from the Arctic region to tropical areas. Among them, 26 species are from Asia and 17 from China. In this study, three new species from Guizhou Province, China are described: *W. sexachaeta* sp. nov., *W. christianseni* sp. nov. and *W. tanae* sp. nov. Similar to other *Willowsia* species from Guizhou Province, these new species also have scales of the spinulate type. Table 1 summarizes the main differences between all Chinese species of *Willowsia*.

## Material and methods

After clearing in lactic acid, specimens were mounted under a coverslip in Marc André II solution, and were studied with a Leica DM2500 microscope. Images were taken with a Hitachi SN3400 scanning electron microscope and a mounted Leica DFC300 FX digital camera, and enhanced with Photoshop CS2 (Adobe Inc.). The number of macrochaetae is given by half-tergite in the descriptions. The nomenclature

**Table 1** (continued on next page). Main differences between Chinese species of the genus *Willowsia* Shoebottom, 1917.

Characters	Scale type	Scales on		Posterior mac on labial triangle	Locality
		antennae	legs		
<i>baoshansis</i> Chai & Ma, 2017	spinulate	present	present	6 ciliate	Yunnan
<i>christianseni</i> sp. nov.	spinulate	present	present	5 ciliate	Guizhou
<i>fascia</i> Pan & Zhang, 2016	long basal rib	absent	absent	5 ciliate	Hubei
<i>formosana</i> (Denis, 1929)	long basal rib	unknown	unknown	unknown	Taiwan
<i>guangdongensis</i> Zhang, Xu & Chen, 2007	long basal rib	present	present	5 ciliate	Guangdong
<i>guangxiensis</i> Shi & Chen, 2004	spinulate	present	present	8 ciliate	Guangxi
<i>jacobsoni</i> (Börner, 1913)	long basal rib	unknown	unknown	3–5 ciliate, 2 smooth	Taiwan
<i>japonica</i> (Folsom, 1898)	short rib	absent	absent	unknown	Hubei, Jiangsu, Xinjiang, Zhejiang
<i>nigromaculata</i> (Lubbock, 1873)	long basal rib	unknown	unknown	unknown	Shanghai, Xinjiang
<i>pseudobuskii</i> Pan & Zhang, 2016	long basal rib	absent	absent	5 ciliate	Anhui
<i>pseudoplantani</i> Pan & Zhang, 2016	long basal rib	absent	absent	5 ciliate	Zhejiang
<i>pseudoshi</i> Ma, 2016	spinulate	present	present	7 ciliate	Guizhou
<i>qui</i> Zhang, Chen & Deharveng, 2011	long basal rib	absent	absent	5 ciliate	Anhui, Jiangxi, Zhejiang
<i>sexachaeta</i> sp. nov.	spinulate	present	present	5 ciliate	Guizhou
<i>shiae</i> Pan, Zhang & Chen, 2006	spinulate	present	absent	5 ciliate	Tibet
<i>similis</i> Pan & Zhang, 2016	long basal rib	absent	absent	5 ciliate	Hunan
<i>tanae</i> sp. nov.	spinulate	present	present	5 ciliate	Guizhou
<i>variabilis</i> Ma, 2016	spinulate	present	present	8–9 ciliate	Guizhou
<i>yiningensis</i> Zhang, Chen & Deharveng, 2011	long basal rib	absent	absent	5 ciliate	Xinjiang
<i>zhaotongensis</i> Chai & Ma, 2017	spinulate	present	present	6 ciliate	Yunnan

**Table 1** (continued). Main differences between Chinese species of the genus *Willowsia* Shoebbotham, 1917.

Characters	Medio- median mac on Th. II	Medio- sublateral mac on Th. II	Posterior mac on Th. II	Mac on Abd. I	Central mac on Abd. II	Central mac on Abd. III	Lateral mac on Abd. III	Central mac on Abd. IV
<i>baoshansis</i> Chai & Ma, 2017	2	2	14–18	4	4(5)	2	3	11–18
<i>christianseni</i> sp. nov.	2	2	18	4	4	3	4	10–12
<i>fascia</i> Pan & Zhang, 2016	1	2	11	3	3	3	3	7
<i>formosana</i> (Denis, 1929)	unknown	unknown	unknown	unknown	2	1	unknown	6
<i>guangdongensis</i> Zhang, Xu & Chen, 2007	0	1	3	2	3	2	3	7
<i>guangxiensis</i> Shi & Chen, 2004	2	4	19	4	5	2	4	13
<i>jacobsoni</i> (Börner, 1913)	0	1	5	8	2	2	5	5
<i>japonica</i> (Folsom, 1898)	1	1	11	3	3	2	3	7
<i>nigromaculata</i> (Lubbock, 1873)	0	1	7	3	3	3	3	7
<i>pseudobuskii</i> Pan & Zhang, 2016	1	2	12	3	3	2	3	5
<i>pseudoplatani</i> Pan & Zhang, 2016	0	1	6	3	3	2	3	7
<i>pseudoshi</i> Ma, 2016	2	2	17–19	4	4	2	5	16–19
<i>qui</i> Zhang, Chen & Deharveng, 2011	2(3)	3	12–13	4	3	2	3	6
<i>sexachaeta</i> sp. nov.	0	2	9–11	3	3	2	3	6
<i>shiae</i> Pan, Zhang & Chen, 2006	3	4	19	4	5–6	3	5	9–14
<i>similis</i> Pan & Zhang, 2016	1	2	12	3	3	3	3	7
<i>tanae</i> sp. nov.	2	3	13	3	3	1	3	7
<i>variabilis</i> Ma, 2016	2	2	23–25	7–8	5	2	3–4	10–13
<i>yiningensis</i> Zhang, Chen & Deharveng, 2011	2	2	19	4	5	3	3	7
<i>zhaotongensis</i> Chai & Ma, 2017	2	3	16–18	4	4–5	3	5	10–12

of the dorsal chaetotaxy of the head and interocular chaetae is described following Jordana & Baquero (2005) and Mari-Mutt (1986). Labial chaetae are designated following Gisin (1967). Tergal chaetae of the body are designated using the system of Szeptycki (1979).

### Abbreviations

Abd. = abdominal segment  
Ant. = antennal segment  
Mac = macrochaeta(e)  
ms = S-microchaeta(e) (microsensillum, -a)  
sens = ordinary S-chaeta(e)  
Th. = thoracic segment

### Institutional abbreviations

NTU = Nantong University, Nantong, China

### Results

Class Collembola Lubbock, 1873  
Order Entomobryomorpha Börner, 1913  
Family Entomobryidae Tömösvary, 1882  
Subfamily Entomobryinae Schäffer, 1896

Genus *Willowsia* Shoebotam, 1917

### Diagnosis

Moderate size, usually 1–2 mm; eyes 8+8; antennae four segmented; mucro bidentate with a basal spine; dens without spines or scales; body with various types of scales in different species.

*Willowsia sexachaeta* sp. nov.

[urn:lsid:zoobank.org:act:972AD9E1-C147-43A0-ADA4-184AEB45550B](https://doi.org/10.2301/972AD9E1-C147-43A0-ADA4-184AEB45550B)

Figs 1–4, Tables 1–2

### Diagnosis

A longitudinal stripe present from eyepatch to Th. III along lateral side; Abd. I with 3 mac; Abd. II with 3 central mac; Abd. III with 2 central and 3 lateral mac; scales spinulate type and present on Ant. I–II, dorsal side of head and terga, coxa to tibiotarsus, anterior face of ventral tube and ventral side of manubrium.

### Etymology

Named after the characteristic six (Latin word “sex-”) macrochaetae present on the central part of Abd. IV.

### Type material

#### Holotype

CHINA: ♀, on slide, Louna Village, Dingxiao Town, Xingyi City, Guizhou Province, 25°09'33" N, 105°02'35" E, 1300 m a.s.l., in rotten stem of maize and litter, 21 Apr. 2014, Shangze Wu leg. (collection number 1132, NTU).

**Table 2.** Comparison of *W. sexachaeta* sp. nov., *W. baoshanensis* Chai & Ma, 2017 and *W. japonica* Folsom 1898.

Characters	<i>W. sexachaeta</i> sp. nov.	<i>W. baoshanensis</i>	<i>W. japonica</i>
Scale type	spinulate	spinulate	short rib
Scales on antennae, legs and manubrium	present	present	absent
Mac m2 on Th. II	absent	present	present
Mac m4i on Th. II	present	present	absent
Mac a2 & a3 on Th. III	absent	absent	present
Mac on Abd. I	3	4	3
Central mac on Abd. II	3	4(5)	3
Central mac on Abd. IV	6	11–18	7
Uncrenulated dens/ mucro	1.4–1.7	1.5–1.7	2.2–2.9

**Paratypes**

CHINA: 9 ♀♀, on slides, same data as holotype.

**Description**

MEASUREMENTS. Body length up to 1.6 mm.

COLOUR. Ground colour pale yellow. Antennae with scattered blue pigment, especially distal part of each segment. Eyepatches dark blue. Longitudinal stripe present from eyepatch to Th. III along lateral side (Figs 1A–1B).

HEAD. Antenna 0.4–0.6 × as long as body. Antennal segments ratio as I: II: III: IV= 1.0: 1.7–2.2: 1.7–2.3: 2.8–3.5. Distal part of Ant. IV with many sensory chaetae, normal ciliate chaetae and a bilobed apical bulb (Fig. 2A). Dorsal cephalic chaetotaxy with 5–7 antennal (An), 4 median (M) and 8 sutural (S) mac. Interocular chaetae as p, s, t, all finely ciliate (Fig. 2B). Eyes 8+8, G and H smaller (Fig. 2B).

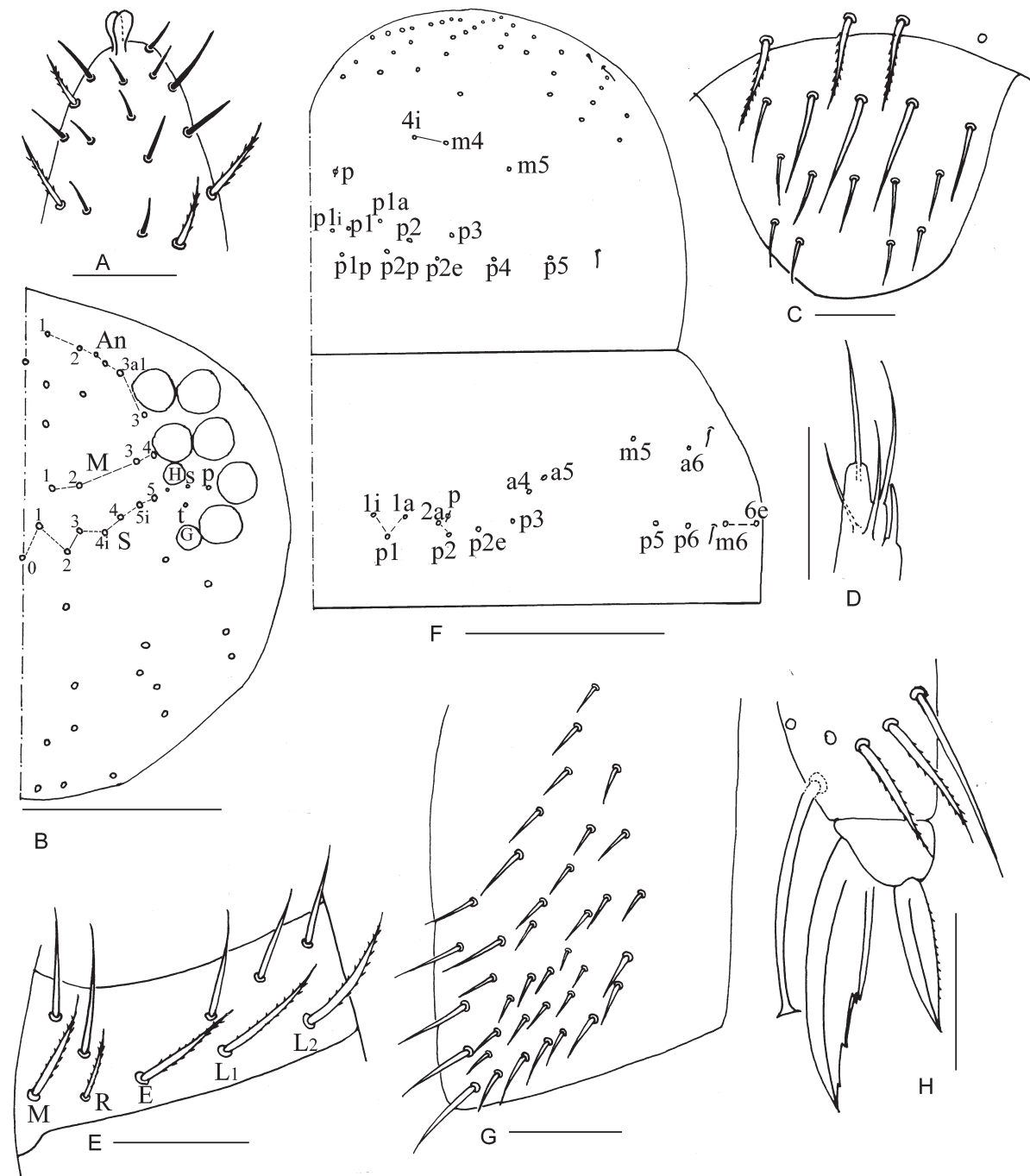


A —————

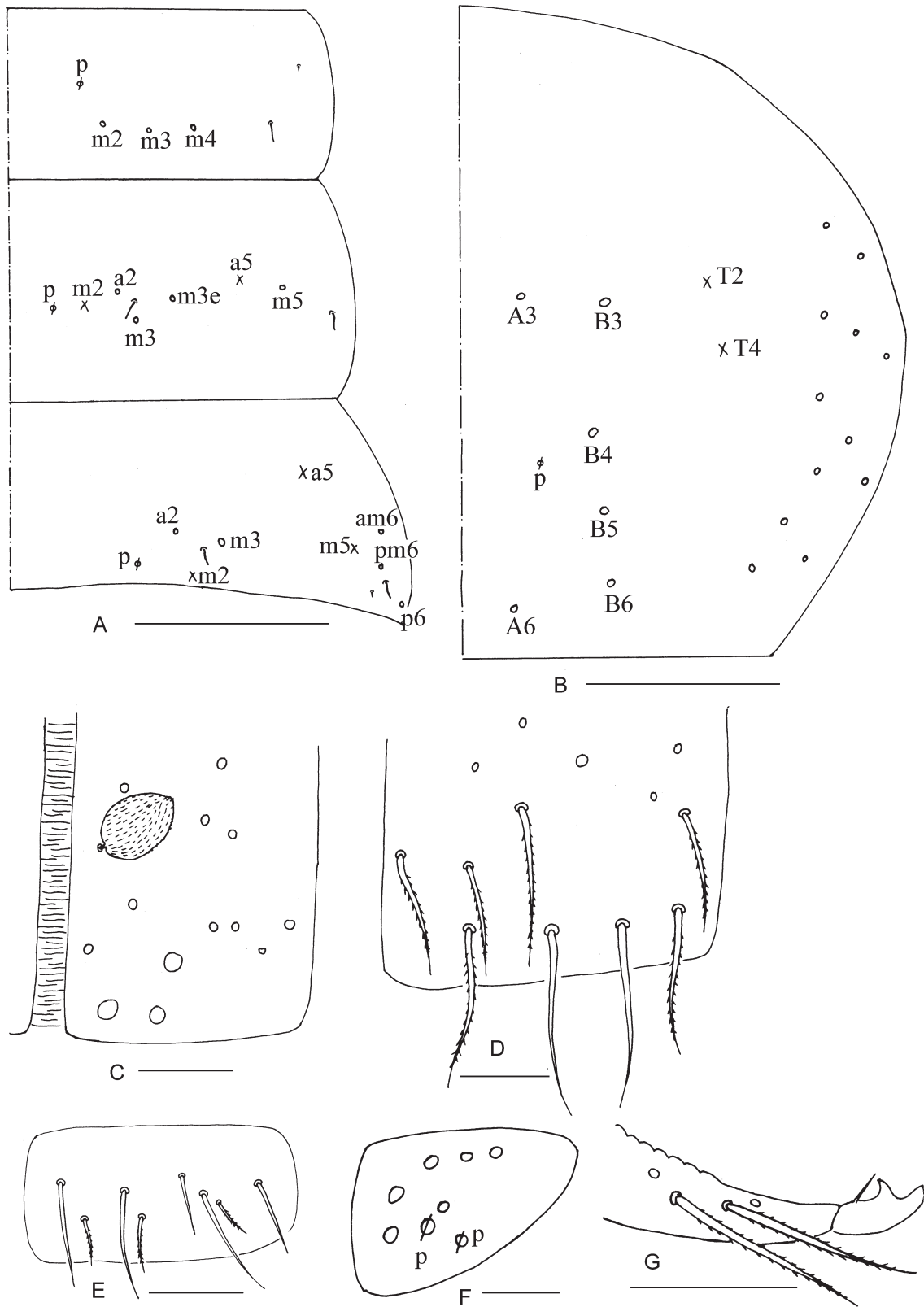


B —————

**Fig. 1.** *Willowsia sexachaeta* sp. nov. A–B. Habitus. Scale bars: 500 µm.



**Fig. 2.** *Willowsia sexachaeta* sp. nov. **A.** Apex of Ant. IV. **B.** Dorsal chaetotaxy of head. **C.** Labrum. **D.** Lateral process of labial palp. **E.** Labium. **F.** Chaetotaxy of Th. II–III. **G.** Trochanteral organ. **H.** Foot complex. Scale bars: A, C–E, G–H = 20 µm; B, F = 100 µm.



**Fig. 3.** *Willowsia sexachaeta* sp. nov. **A.** Chaetotaxy of Abd. I-III. **B.** Chaetotaxy of Abd. IV. **C.** Anterior face of ventral tube. **D.** Posterior face of ventral tube. **E.** Lateral flap of ventral tube. **F.** Manubrial plaque. **G.** Distal part of dens and mucro. Scale bars: A-B = 100  $\mu$ m; C-G = 20  $\mu$ m.

Labral chaetae as 4/5, 5, 4, all slender; prelabral chaetae ciliate, other smooth; labral papillae not clearly seen (Fig. 2C). Lateral process of labial palp curved, slightly thicker than normal chaetae, with tip not reaching apex of labial papilla (Fig. 2D). Labial triangular chaetae as MREL<sub>1</sub>L<sub>2</sub>, all finely ciliate (Fig. 2E).

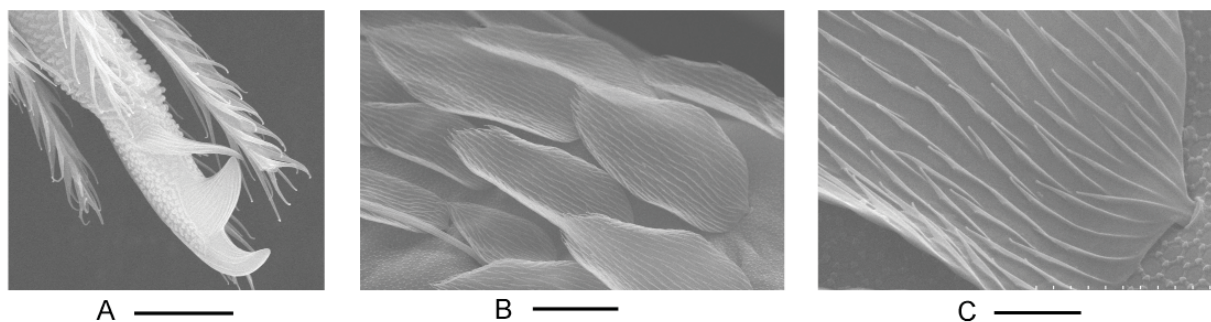
THORAX. Th. II with 2 (m4, m4i) medio-sublateral, 9–11 posterior mac (p4 sometimes absent, p6 rarely present), 1 ms and 2 sens (Fig. 2F). Th. III with 8–9 (p1i sometimes present) median, 6 (m5, a6, p5, p6, m6, m6e) lateral mac and 2 sens, p5 rarely absent (Fig. 2F). Trochanteral organ with 27–38 smooth spiny chaetae (Fig. 2G). Unguis with 4 inner teeth, one pair located about 0.5 from base of inner edge of unguis, distal unpaired two at about 0.7 and 0.9 distance from base respectively. Unguiculus acuminate and outer edge serrate. Tenent hair thick with clavate tip, almost equal to or slightly longer than inner edge of unguis (Fig. 2H).

ABDOMEN. Abd. IV 3.0–4.5 times as long as Abd. III along dorsal midline. Dorsal mac shown in Fig. 3A–B. Abd. I with 3 (m2, m3, m4) mac, 1 ms and 1 sens; sens inner to ms. Abd. II with 3 (a2, m3, m3e) central, 1 (m5) lateral mac and 2 sens. Abd. III with 2 (a2, m3) central, 3 (am6, pm6, p6) lateral mac, 1 ms and 2 sens (Fig. 3A). Abd. IV with 6 (A3, A6, B3, B4, B5, B6) central and 11–13 lateral mac (Fig. 3B). Ventral tube anteriorly with 11–16 ciliate chaetae (Fig. 3C), posteriorly with 2 apical smooth chaetae and 7–11 ciliate chaetae (Fig. 3D), laterally with 5 smooth and 2–3 ciliate chaetae (Fig. 3E). Manubrial plaque with 6–7 ciliate chaetae and 2 (rarely 3) pseudopores (Fig. 3F). Dens without spines, uncrenulated dens 1.4–1.7 times as mucro in length. Mucro bidentate, two teeth subequal and tip of basal spine reaching subapical tooth (Figs 3G, 4A).

SCALES. Hyaline, spinulate type, leaf-like and present on Ant. I–II, dorsal side of head and terga, coxa to tibiotarsus, anterior face of ventral tube and ventral side of manubrium (Figs 4B–4C).

### Remarks

The new species is similar to another Chinese species, *W. baoshanensis* Chai & Ma, 2017, in colour pattern and scale morphology, but the difference between them in chaetotaxy is great. It is also similar to the species *W. japonica* (Folsom, 1897) in colour pattern on the body and three mac on Abd. I, but scale morphology is of the spinulate type in the former and the short rib type in the latter (Table 1). The differences between the three species are great, as shown in Table 2.



**Fig. 4.** *Willowsia sexachaeta* sp. nov. A. Distal part of dens and mucro. B–C. Scale(s). Scale bars: A = 5  $\mu$ m; B = 10  $\mu$ m; C = 2.5  $\mu$ m.



*Willowsia christianseni* sp. nov.

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Figs 5–7, Tables 1, 3

**Diagnosis**

Anterior margin of Th. II and lateral margin of Th. II–III with blue pigment, an interrupted blue stripe present along posterior margins of Abd. I and II respectively; Abd. I with 4 mac; Abd. II with 4 central mac; Abd. III with 3 central and 4 lateral mac; Scales spinulate type and present on Ant. I–II, dorsal side of head and terga, coxa to tibiotarsus, anterior face of ventral tube and ventral side of manubrium.

**Etymology**

In memory of Kenneth Christiansen, who gave me much help in the taxonomy of Collembola.

**Material examined**

**Holotype**

CHINA: ♀, on slide, collected from outside of Shangdiwan Cave, Louna Village, Dingxiao Town, Xingyi City, Guizhou Province, 25°09'33" N, 105°02'35" E, 1300 m a.s.l., in rotten stem of maize, 28 Apr. 2014, Shangze Wu leg (Collection number 1144, NTU).

**Paratype**

CHINA: 1 ♀, on slide, same data as holotype.

**Description**

MEASUREMENTS. Body length up to 1.8 mm.



A —————



B —————

**Fig. 5.** *Willowsia christianseni* sp. nov. A–B. Habitus. Scale bars: 500 µm.

**COLOUR.** Ground colour pale yellow. Eyepatches dark blue. Ant. I–IV almost blue pigmented except proximal part of each segment. Anterior margin of Th. II and lateral margin of Th. II–III with blue pigment. An interrupted blue stripe present along posterior margins of Abd. I and II respectively. Blue pigment also present on posterior part of Abd. III–V, distal part of femora of middle and hind legs (Figs 5A–5B).

**HEAD.** Antenna 0.5–0.6 times as long as body. Antennal segments ratio as I: II: III: IV = 1: 1.7–2.2: 1.7–2.0: 3.0–3.3. Distal part of Ant. IV with many sensory chaetae, normal ciliate chaetae and a bilobed apical bulb (Fig. 6A). Dorsal cephalic chaetotaxy with 6 antennal (An), 4 median (M) and 8 sutural (S) mac (Fig. 6B). Interocular chaetae as p, s, t, all finely ciliate (Fig. 6B). Eyes 8+8, G and H smaller (Fig. 6B). Labral chaetae as 4/5, 5, 4, all slender; prelabral chaetae ciliate, other smooth; distal margin of labrum with 4 papillae, each with a denticle (Fig. 6C). Lateral process of labial palp curved, slightly thicker than normal chaetae, with tip exceeding apex of labial papilla (Fig. 6D). Labial triangular chaetae as in Fig. 6E, MREL<sub>1</sub>L<sub>2</sub> all finely ciliate.

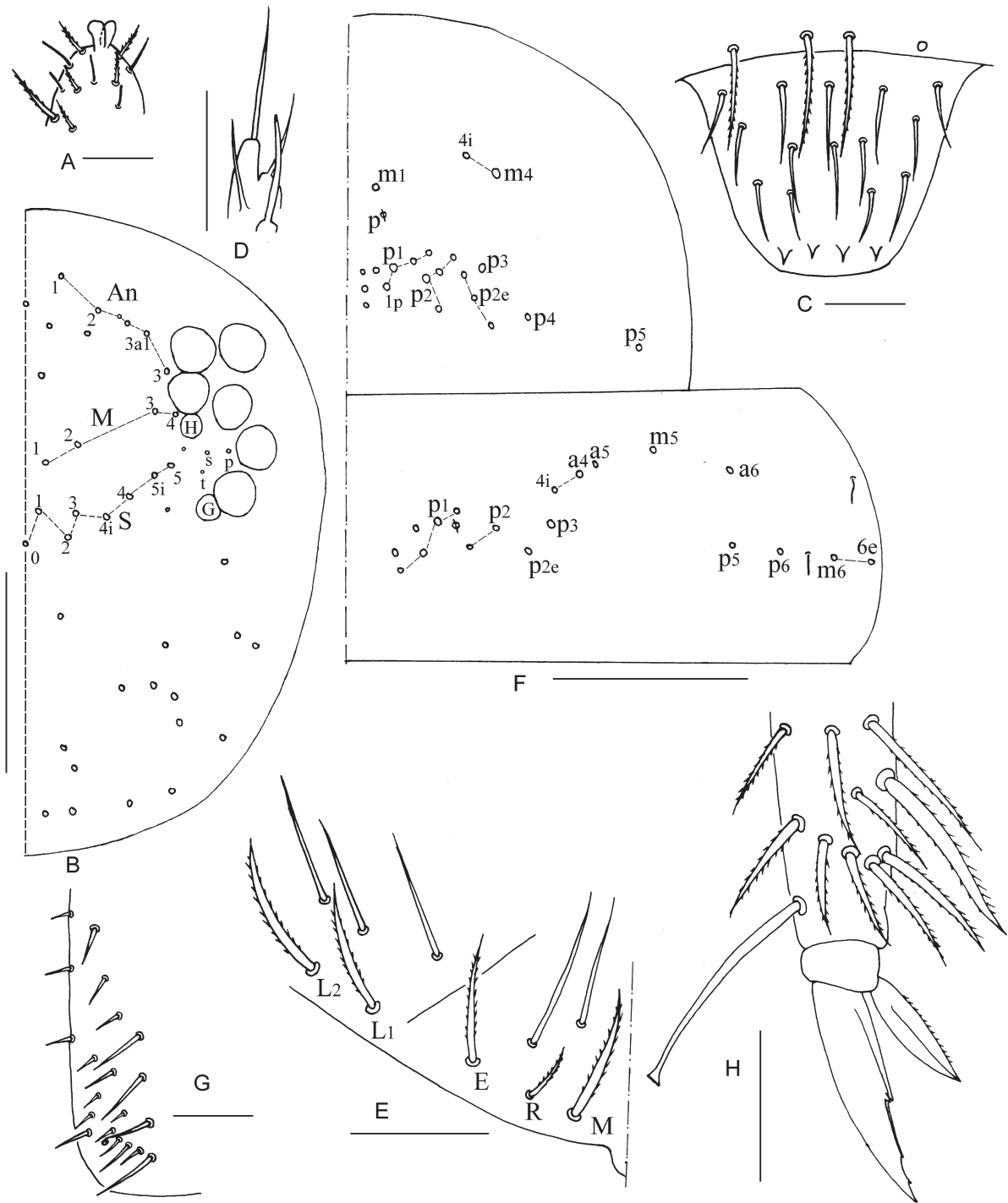
**THORAX.** Dorsal macrochaetae shown as in Fig. 6F. Th. II with 1 (m1) medio-median, 2 (m4, m4i) medio-sublateral and 18 posterior mac, m5, ms and sens not clearly seen. Th. III with 13 median, 6 (m5, a6, p5, p6, m6, m6e) lateral mac and 2 sens on each side. Trochanteral organ with 21 smooth spiny chaetae (Fig. 6G). Unguis with 4 inner teeth, one pair located 0.5 from base of inner edge of unguis, distal unpaired two at 0.8 and 0.9 distance from base respectively. Unguiculus acuminate and outer edge serrate. Tenent hair thick with clavate tip, slightly longer than length of inner edge of unguis (Fig. 6H).

**ABDOMEN.** Abd. IV 4.0 times as long as Abd. III along dorsal midline. Dorsal mac shown in Figs 7A–7B. Abd. I with 4 (m2, m3, m4, a5) mac, 1 ms and 1 sens; sens inner to ms. Abd. II with 4 (a2, m3, m3e, m3ep) central, 1 (m5) lateral mac and 2 sens. Abd. III with 3 (a2, a3, m3) central, 4 (am6, pm6, p6, m7) lateral mac, 1 ms and 2 sens (Fig. 7A). Abd. IV with 10–12 central (A3, A4, A6, B3, B4, B5, B6 always present) and about 14 lateral mac as in Fig. 7B. Ventral tube anteriorly with about 15 ciliate chaetae (Fig. 7C), posteriorly and laterally not clearly seen. Dens without spines, uncrenulated dens about 2.5 × as long as mucro in. Mucro bidentate, two teeth subequal and tip of basal spine reaching subapical tooth (Fig. 7D).

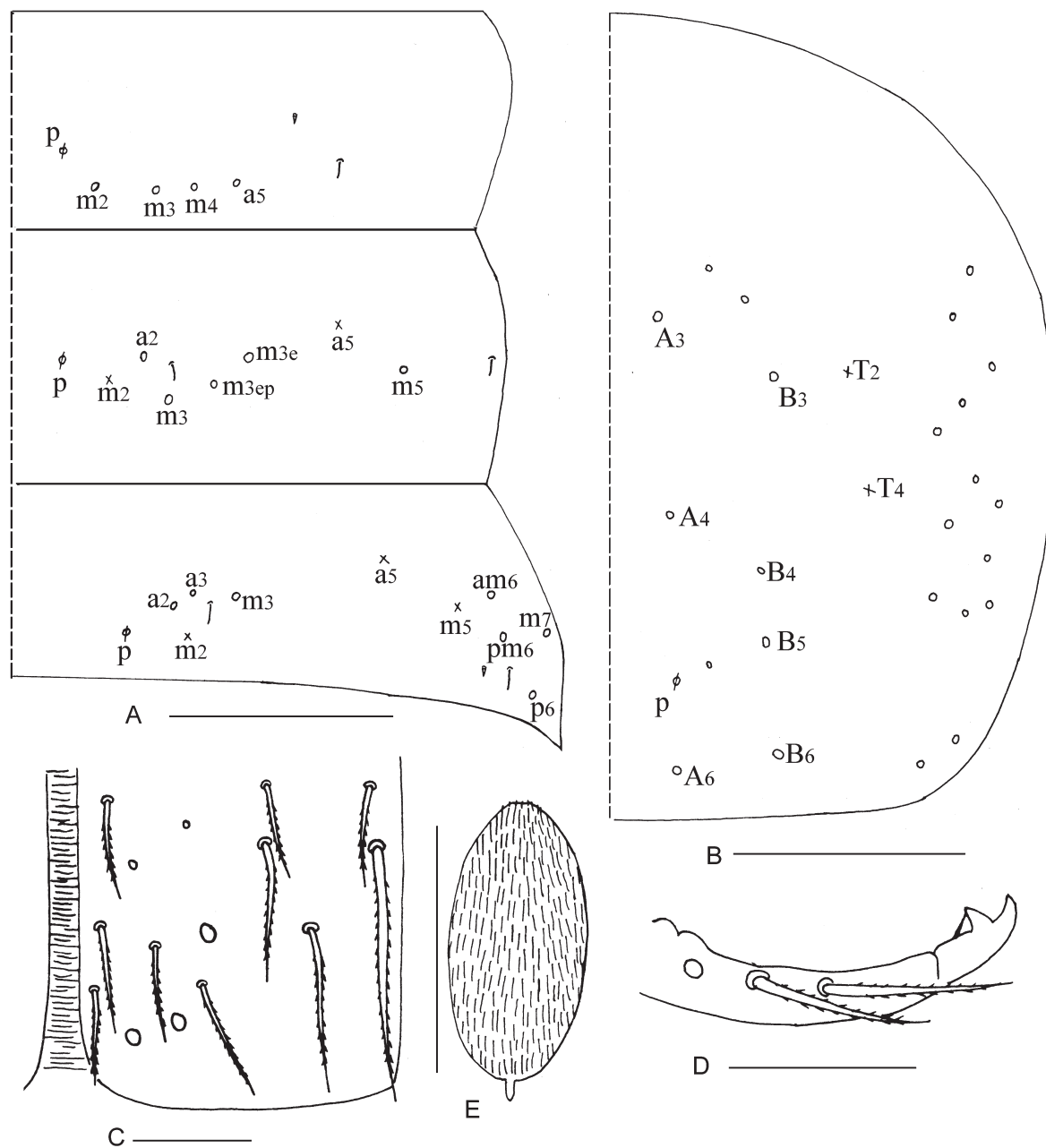
**SCALES.** Hyaline, spinulate type, leaf-like and present on Ant. I–II, dorsal side of head and terga, coxa to tibiotarsus, anterior face of ventral tube and ventral side of manubrium (Fig. 7E).

## Remarks

The new species is similar to the species *W. nigromaculata* (Lubbock, 1873) in colour pattern, but scale morphology is of the spinulate type in the former and the long basal rib type in the latter. It is also similar to another species from Guizhou Province, *W. pseudoshi* Ma, 2016, in chaetotaxy of Th. III and Abd. I–II, but the colour pattern and chaetotaxy of Abd. III–IV are not the same. The differences between the three species are great, as shown in Table 3.



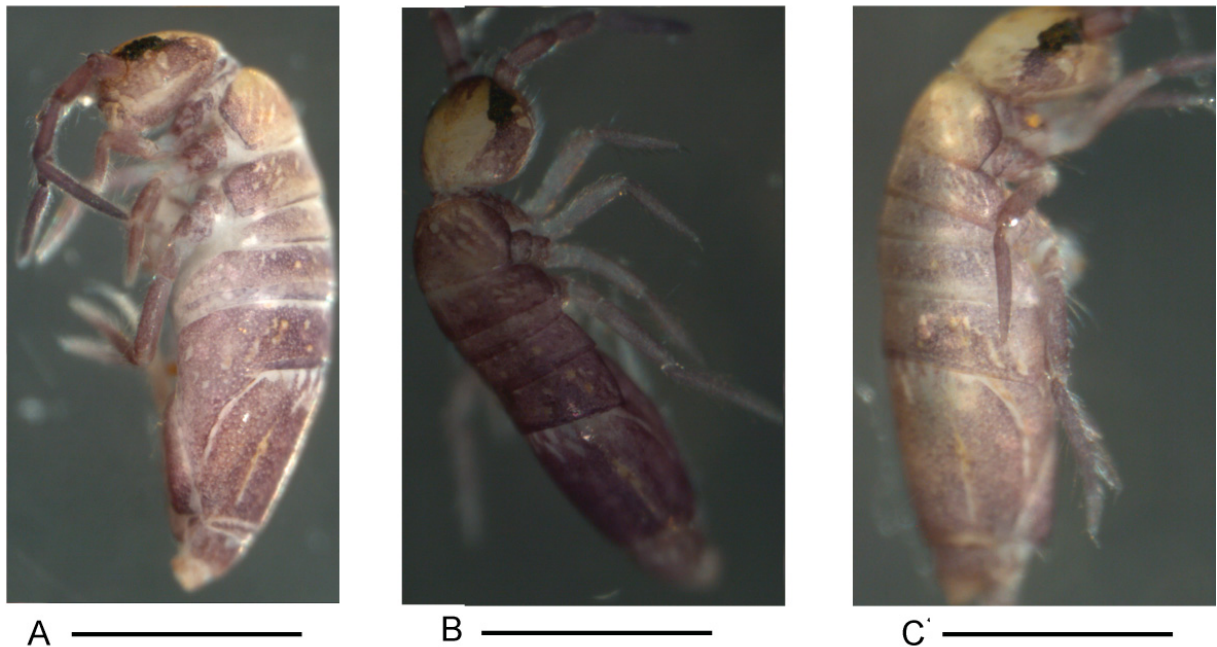
**Fig. 6.** *Willowsia christianseni* sp. nov. **A.** Apex of Ant. IV. **B.** Dorsal chaetotaxy of head. **C.** Labrum. **D.** Lateral process of labial palp. **E.** Labium. **F.** Chaetotaxy of Th. II-III. **G.** Trochanteral organ. **H.** Foot complex. Scale bars: A, C-E, G-H = 20  $\mu$ m; B, F = 100  $\mu$ m.



**Fig. 7.** *Willowsia christianseni* sp. nov. **A.** Chaetotaxy of Abd. I–III. **B.** Chaetotaxy of Abd. IV. **C.** Anterior face of ventral tube. **D.** Distal part of dens and mucro. **E.** Scale. Scale bars: A–B = 100  $\mu$ m; C–E = 20  $\mu$ m.

**Table 3.** Comparison of *Willowsia christianseni* sp. nov., *W. nigromaculata* (Lubbock, 1873) and *W. pseudoshi* Ma, 2016.

Characters	<i>W. christianseni</i> sp. nov.	<i>W. nigromaculata</i>	<i>W. pseudoshi</i>
Colour of antennae	blue	yellow with blue pigment	yellow
Colour of head	yellow with blue patches	yellow with blue patches	almost blue wholly
Scale type	spinulate	long basal rib	spinulate
Median mac on dorsal head	4	unknown	5
Posterior mac on Th. II	18	7	17–19
Central mac on Th. III	13	4	15–16
Mac on Abd. I	4	3	4
M3ep on Abd. II	present	absent	present
Central mac on Abd. III	3	3	2
Lateral mac on Abd. III	4	3	5
Central mac on Abd. IV	10–12	7	16–19



**Fig. 8.** *Willowsia tanae* sp. nov. A–C. Habitus. Scale bars: 500 µm.

*Willowsia tanae* sp. nov.

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Figs 8–10, Tables 1, 4

**Diagnosis**

Antennae and legs almost wholly blue pigmented and blue pigment present on most part of dorsum from Th. III to Abd. V; Abd. I with 3 mac; Abd. II with 3 central mac; Abd. III with 3 central and 3 lateral mac; Scales spinulate type and present on Ant. I–II, dorsal side of head and terga, coxa to tibiotarsus, anterior face of ventral tube and ventral side of manubrium.

**Etymology**

Named after Ms Hongdan Tan, who collected the specimens.

**Material examined**

**Holotype**

CHINA: ♀, on slide, Shangkanzhe Village, Laochang Town, Pan County, Guizhou Province, 25°39'34" N, 104°48'27" E, 1366 m a.s.l., in litter, 22 Jan. 2016, Hongdan Tan leg. (Collection number 1166, NTU).

**Paratypes**

CHINA: 6 ♀♀, on slide, same data as holotype.

**Description**

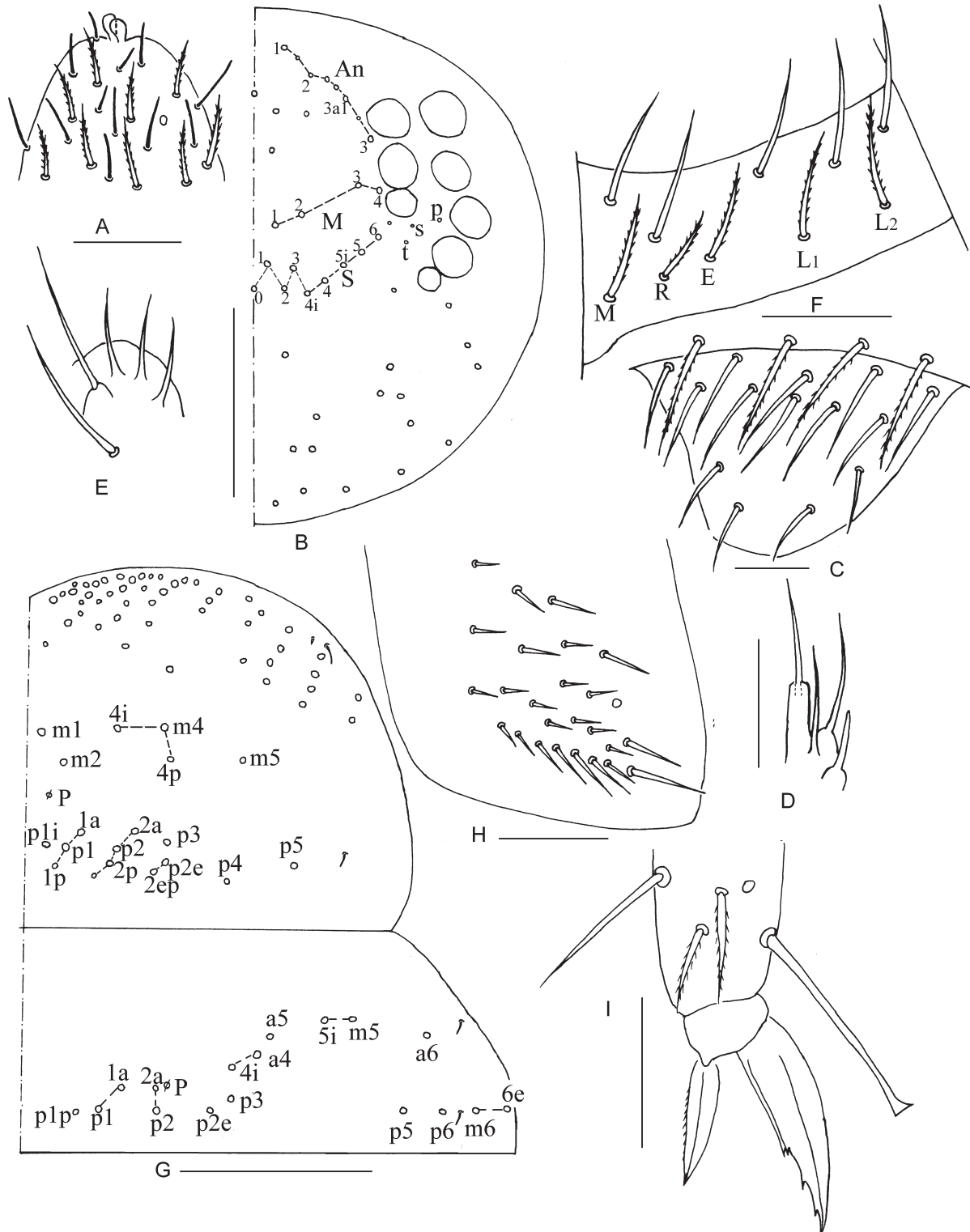
MEASUREMENT. Body length up to 1.5 mm.

COLOUR. Ground colour pale yellow. Eyepatches dark blue. Antennae and legs almost wholly blue pigmented. Lateral side of Th. II and head behind eyepatches with blue pigment. Blue pigment present on most part of dorsum from Th. III to Abd. V (Figs 8A–8C).

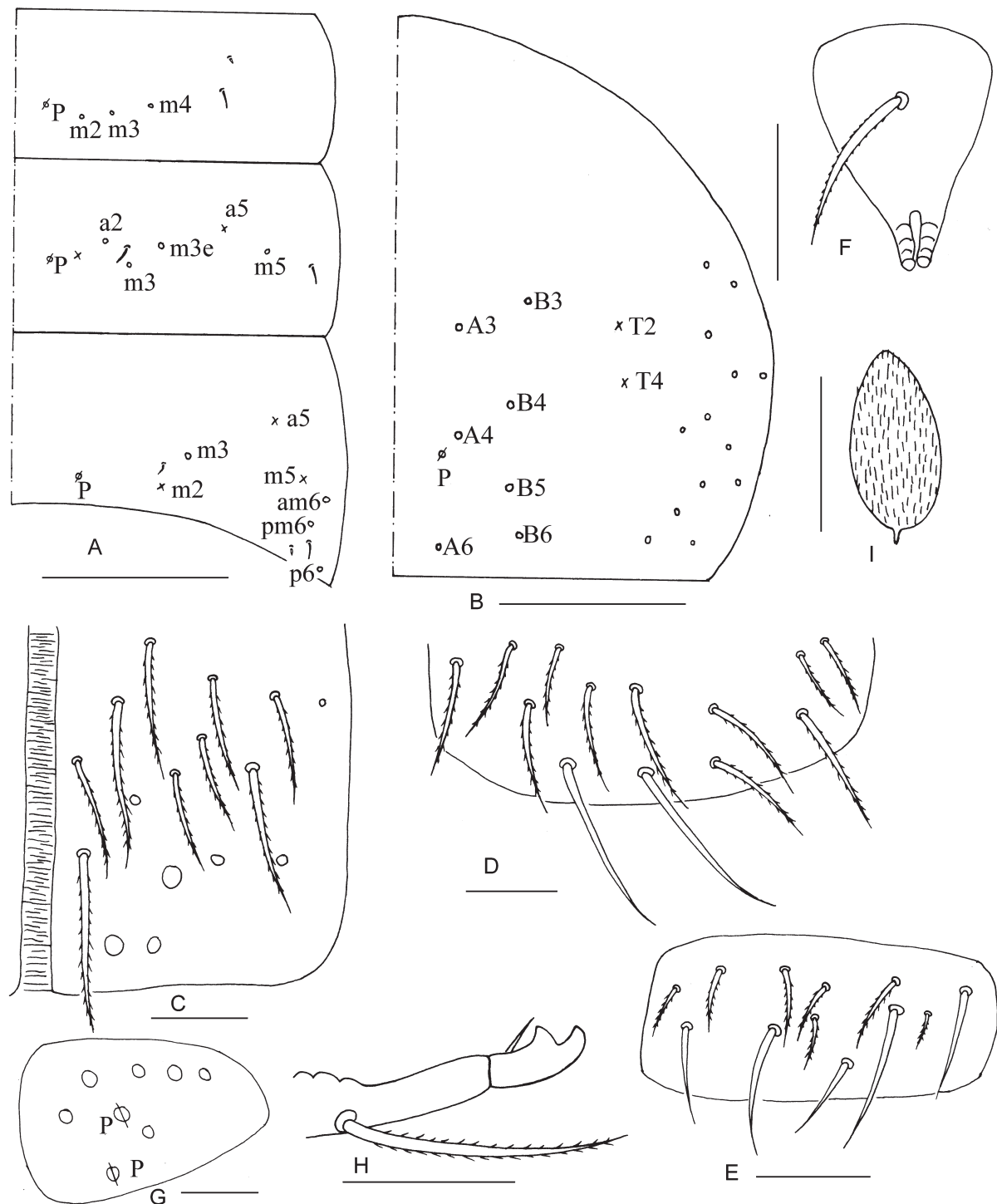
HEAD. Antenna 0.3–0.4 × as long as body. Antennal segments ratio as I: II: III: IV = 1: 1.4–1.7: 1.4–1.7: 2.1–2.9. Distal part of Ant. IV with many sensory chaetae, normal ciliate chaetae and a bilobed apical bulb (Fig. 9A). Dorsal cephalic chaetotaxy with 7–8 antennal (An), 4 median (M) and 9 sutural (S) mac (Fig. 9B). Interocular chaetae as p, s, t, all finely ciliate (Fig. 9B). Eyes 8+8, G and H smaller (Fig. 9B). Labral chaetae as 4/5, 5, 4, all slender; prelabral chaetae ciliate, other smooth, labral papillae not clearly seen (Fig. 9C). Lateral process of labial palp almost as thick as normal chaetae, with tip not reaching apex of labial papilla (Fig. 9D). Subapical chaeta of maxillary outer lobe equal to apical one, three smooth hairs on sublobal plate (Fig. 9E). Labial triangular chaetae as in Fig. 9F, MREL<sub>1</sub>L<sub>2</sub> all finely ciliate.

THORAX. Dorsal macrochaetae shown as in Fig. 9G. Th. II with 2 (m1, m2) medio-median, 3 (m4, m4i, m4p) medio-sublateral, 13 posterior mac, 1 ms and 2 sens. Th. III with 9 (10, p1p rarely present) median, 6–7 (m5, a6, p5, p6, m6, m6e, m5i sometimes absent) lateral mac and 2 sens. Trochanteral organ with 25–26 smooth spiny chaetae (Fig. 9H). Unguis with 4 inner teeth, one pair located 0.5–0.6 from base of inner edge of unguis, distal unpaired two respectively at 0.7 and 0.9 distance from base. Unguiculus acuminate and outer edge serrate. Tenent hair thick with clavate tip, slightly longer than length of inner edge of unguis (Fig. 9I).

ABDOMEN. Abd. IV 2.5–3.2 × as long as Abd. III along dorsal midline. Dorsal mac shown in Figs 10A–10B. Abd. I with 3 (m2, m3, m4) mac, 1 ms and 1 sens; sens inner to ms. Abd. II with 3 (a2, m3, m3e) central, 1 (m5) lateral mac and 2 sens. Abd. III with 1 (m3) central, 3 (am6, pm6, p6) lateral mac, 1 ms and 2 sens (Fig. 10A). Abd. IV with 7 central (A3, A4, A6, B3, B4, B5, B6) and 11–13 lateral



**Fig. 9.** *Willowsia tanae* sp. nov. **A.** Apex of Ant. IV. **B.** Dorsal chaetotaxy of head. **C.** Labrum. **D.** Lateral process of labial palp. **E.** Maxillary outer lobe. **F.** Labium. **G.** Chaetotaxy of Th. II-III. **H.** Trochanteral organ. **I.** Foot complex. Scale bars: A, C-F, H-I = 20  $\mu$ m; B, G = 100  $\mu$ m.



**Fig. 10.** *Willowsia tanae* sp. nov. **A.** Chaetotaxy of Abd. I–III. **B.** Chaetotaxy of Abd. IV. **C.** Anterior face of ventral tube. **D.** Posterior face of ventral tube apically. **E.** Lateral flap of ventral tube. **F.** Tenaculum. **G.** Manubrial plaque. **H.** Distal part of dens and mucro. **I.** Scale. Scale bars: A–B = 100  $\mu\text{m}$ ; C–I = 20  $\mu\text{m}$ .



**Table 4.** Comparison of *Willowsia. tanae* sp. nov., *W. variabilis* Ma, 2016 and *W. sexachaeta* sp. nov

Characters	<i>W. tanae</i> sp. nov.	<i>W. variabilis</i>	<i>W. sexachaeta</i> sp. nov
Blue pigment on body	much	much	little
Medio-median mac on Th. II	2	2	0
Posterior mac on Th. II	13	23–25	9–11
Central mac on Th. III	9–10	17–18	7–8
Mac on Abd. I	3	7–8	3
Central mac on Abd. II	3	5	3
Central mac on Abd. III	1	2	1–2
Central mac on Abd. IV	7	10–13	6

mac as in Fig. 10B. Ventral tube anteriorly with 16–18 ciliate chaetae (Fig. 10C), posteriorly with 24 ciliate chaetae and 2 smooth chaetae (Fig. 10D), laterally with 6–7 ciliate chaetae and 5 smooth chaetae (Fig. 10E). Tenaculum with a striate chaeta (Fig. 10F). Manubrial plaque with 5–6 ciliate chaetae and 2 pseudopores (Fig. 10G). Dens without spines, uncrenulated dens 1.1–1.2 times as mucro in length. Mucro bidentate, two teeth subequal and tip of basal spine reaching subapical tooth (Fig. 10H).

SCALES. Hyaline, spinulate type, leaf-like and present on Ant. I–II, dorsal side of head and terga, coxa to tibiotarsus, anterior face of ventral tube and ventral side of manubrium (Fig. 10I).

### Remarks

The new species is most similar to the Chinese species *W. variabilis* Ma, 2016 in colour pattern and scale type, but Abd. I–IV with 3, 3, 1 and 7 central mac in the former respectively, but 7–8, 5, 2, 10–13 central mac in the latter. It is also similar to the species *W. sexachaeta* sp. nov. in chaetotaxy, but their colour patterns are different. The differences between the three species are shown in Table 4.

### Discussion

Scale morphology is a major character in defining species of the genus *Willowsia* and it was divided into four types (Zhang *et al.* 2011): spinulate type, short rib type, long basal rib type and uninterrupted type. Among 20 Chinese species of the genus, nine species have scales of the spinulate type and they were described or reported only from the Southwest of China, including Guangxi, Guizhou, Tibet and Yunnan provinces. Ten species with the long basal rib type and one species with the short rib type were from other provinces except the Southwest of China. No species with the uninterrupted scale type have been found in China.

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