

ORIGINAL ARTICLE

Comparative morphological study on the genus *Leptura* Linnaeus of China (Coleoptera: Cerambycidae: Lepturinae)

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Abstract A comparative morphological research was done based on the morphological characters of 21 species from *Leptura* in this paper. The results indicated that 18 morphological characters, such as the ratio of the lower eye lobe to genae, the relative length of antennae segments, the shape of maxillary palpi apex, prothorax, elytra apex and elytral maculae can be used to identify species in the genus. Meanwhile, the color of elytra and the size of elytral maculae could not be used to identify species from *Leptura*. In addition, the shape of 7th abdominally sternal apex, the length of antennae and the ratio of the first hind tarsal segment to the second can be used to distinguish the male and the female.

Key words Comparative morphology, Cerambycidae, *Leptura*, China.

1 Introduction

The genus *Leptura*, established by Linnaeus in 1758 based on the type species *Leptura quadrifasciata* Linnaeus, 1758, is one of the largest groups in the tribe Lepturini (Coleoptera: Cerambycidae: Lepturinae). Up to now, the genus includes more than sixty species all over the world, of which 30 species are recorded in China (Gressitt, 1940; Nakamura *et al.*, 1992; Hua *et al.*, 2009; Löbl *et al.*, 2010; Ohbayashi *et al.*, 2013).

There are quite a few works focused on the genus. Most of them refers to species description, correction and regional taxonomic revision (Gahan, 1906; Plavilstshikov, 1936; Gressitt, 1940, 1951, 1970; Kusama, 1984; Ohbayashi, 1992; Holzschuh, 1998, 2003, 2006; Chiang *et al.*, 2001; Hua *et al.*, 2009; Ohbayashi *et al.*, 2013). Few works refer to the larvae and pupae of the genus *Leptura* (Duffy, 1968; Chiang, 1989; Nakamura, 1981).

However, many species of the genus *Leptura* Linnaeus have small differences in morphological characters. Some species, such as *L. auratopilosa* (Matsushita, 1931) and *L. aurosericans* Fairmaire, 1895, are often confused (Chiang *et al.*, 2001; Yang *et al.*, 2011). To identifying species rapidly and collecting morphological data for future phylogenetic research, a morphological comparative study was done in this paper.

2 Materials and methods

2.1 Specimens

Totally 187 specimens of 21 species are studied in this paper. The materials were provided separately by Southwest University (SWU), Sun Yat-Sen University (SYSU), Hebei University (HBU), Shaanxi Normal University (SNNU),

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Northeast Forestry University (NEFU), Shenyang Agricultural University (SYAU), Tibet University (TU), North West Agriculture & Forestry University (NWAUFU), China Agricultural University (CAU) and Nankai University (NKU) (Table 1). The photographs of 14 type specimens are from Ehime University, Guangxi Normal University, Sun Yat-Sen University, Online Image Database of Cerambycid Primary Types of the Smithsonian Institution (Lingafelter *et al.*, 2014).

Table 1. Specimens information of 21 species of *Leptura*.

Species name	Locality	Collection and literature	Amount
<i>L. aethiops</i> Poda, 1761	Fujian, Heilongjiang, Sichuan	SWU, NEFU, SNNU, SYAU, HEU	17
<i>L. alticola</i> Gressitt, 1948	Tibet, Yunnan	Gressitt, 1948	-
<i>L. ambulatrix</i> (Gressitt, 1951)	Jiangxi, Anhui, Fujian	SWU, SYSU, HBU	10
<i>L. arcifera</i> (Blanchard, 1871)	Sichuan, Yunnan, Guizhou	SWU, SYSU, NKU	11
<i>L. arcuata</i> Panzer, 1793	Heilongjiang, Jilin, Hebei, Sichuan	SWU, SYAU, SNNU, NEFU, HBU	24
<i>L. auratopilosa</i> (Matsushita, 1931)	Guangxi, Zhejiang, Fujian, Sichuan	SWU, SYSU, CAU, HBU, NWAUFU	31
<i>L. aurosericans</i> Fairmaire, 1895	Guangxi, Jiangxi, Zhejiang, Guizhou, Sichuan	SWU, SYSU, HBU, SNNU, CAU, SYAU, NWAUFU	48
<i>L. duodecimguttata</i> Fabricius, 1801	Heilongjiang, Shaanxi, Hebei	SWU, SYSU, HBU, NEFU	14
<i>L. fisheriana</i> Gressitt, 1938	Fujian, Hubei, Sichuan	Gressitt, 1938	-
<i>L. formosomontana</i> Kano, 1933	Taiwan	Kano, 1933; Ohbayashi <i>et al.</i> , 2013	-
<i>L. gradatula</i> Holzschuh, 2006	Shaanxi	SWU	1
<i>L. grahamiana</i> Gressitt, 1938	Sichuan	SYSU	2
<i>L. linwenhsini</i> Ohbayashi & Chou, 2013	Tibet	HBU	1
<i>L. lavinia</i> Gahan, 1906	Tibet, Yunnan	SWU, TU	5
<i>L. ochraceofasciata ochrotela</i> Bates, 1873	Hubei	SWU	1
<i>L. quadrifasciata</i> Linnaeus, 1758	Shaanxi, Sichuan, Tibet	SWU, NEFU, TU, NWAUFU	8
<i>L. subtilis</i> Bates, 1884	Hubei	SWU	2
<i>L. taranan</i> (Kano, 1933)	Taiwan	SWU	2
<i>L. tatsienlua</i> Gressitt, 1948	Sichuan, Tibet	Gressitt, 1948	-
<i>L. tattakana</i> (Kano, 1933)	Taiwan	Kano, 1933; Ohbayashi <i>et al.</i> , 2013	-
<i>L. zonifera</i> (Blanchard, 1871)	Sichuan, Chongqing, Yunnan	SWU, NEFU, HBU	10

2.2 Morphological characters

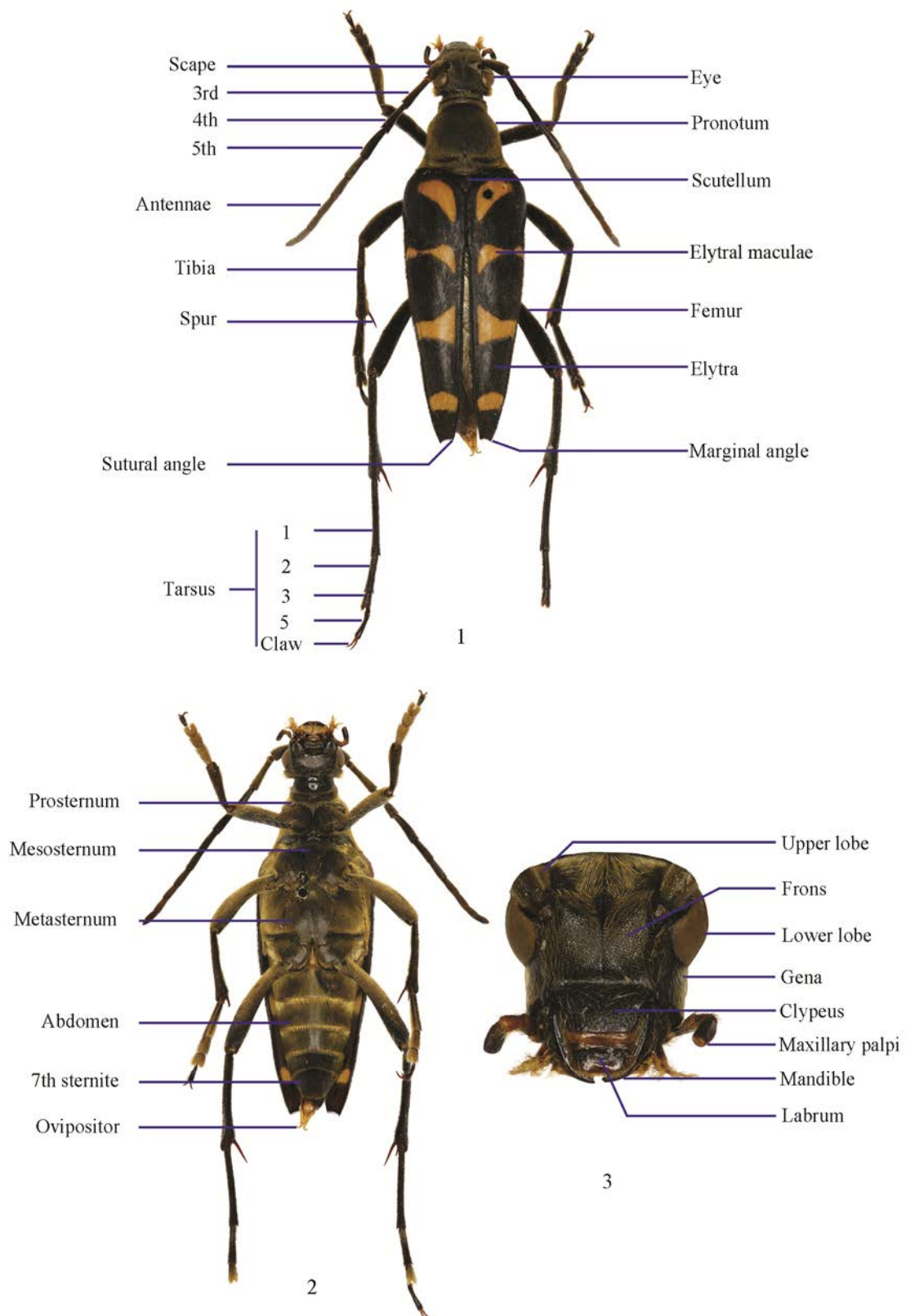
Morphological structures of *Leptura* are shown in Figs 1–3.

Characters of *Leptura* were observed with the help of a stereoscopic microscope. Specimens were identified based on their original description and pictures of types. The whole adult photos were captured using Canon-EOS-7D; segmental adult photos were taken using a stereoscopic microscope, Leica M205A. Photos were revised with Adobe Photoshop®.

The abbreviations used for elytral maculae in general are as follows: M1=first macula near base; ML= humeral lateral macula separated from M; M2 = second macula before middle; M3=third macula behind middle; M4=fourth macula near apex.

2.3 Female genitalia

Abdomen was preserved in 75% alcohol, then cut down and boiled for 3 minutes. Female genitalia was carefully pulled out from abdomen, kept in 10% KOH about 30 seconds, then washed and dissected under stereoscopic microscope, kept in 70% alcohol mixed with little glycerin.



Figs 1–3. Structures of *Leptura* (*L. aurosericans* Fairmaire, 1895, female). 1. Dorsal view. 2. Ventral view. 3. Head, frontal view.

3 Results and analysis

3.1 Comparative morphology results

Based on former works (Chiang *et al.*, 2001) and specimens examined, 50 morphological characters were chosen for comparative morphological research. By comparing the interspecific and intraspecific morphological differences of *Leptura*, 18 morphological characters were selected which have both intraspecific stability and interspecific differences, and 2 characters were selected which can be used to distinguish male and female. Comparative results of morphological characters in 21 species are listed in the Tables 2–3 and Figs 4–39.

3.1.1 Taxonomically characters

Compared 50 morphological characters in *Leptura*, the results indicated that 18 characters can be used to identifying species in *Leptura*. Take following characters for example.

Ratio of the lower eye lobe to genae. The lower eye lobe is less than, subequal to or greater than 1.5 times of genae length. For example: the ratio of *L. lavinia* is between 1.2 and 1.3, less than 1.5; the ratio of *L. ambulatorix* is between 1.4 and 1.6, subequal to 1.5; the ratio of *L. grahamiana* is between 1.6 and 1.7, greater than 1.5.

Width-height ratio of frons. The frons width is less than 1.5 times height, greater than 1.5 times height and less than 2.0 times height, or greater than 2.0 times height. For example: the ratio of *L. arcuata* is between 1.1 and 1.2, less than 1.5; the ratio of *L. lavinia* is between 1.6 and 1.7, greater than 1.5 and less than 2.0; the ratio of *L. quadrifasciata* is between 2.0 and 2.3, greater than 2.0.

Maxillary palpi. Apex truncate, obtusely round, or obliquely truncate; penultimate segment longer than, shorter than or equal to a half of apical segment. For example: *L. ochraceofasciata ochrotela* has truncate apex (Fig. 45), penultimate segment equal to a half of apical segment; *L. taranan* has obtusely round apex (Fig. 46), penultimate segment longer than a half of apical segment; *L. arcuata* has obliquely truncate apex (Fig. 47), penultimate segment of *L. auratopilosa* shorter than a half of apical segment.

Relative length of antennae segments. Segment 3 is subequal to, longer than, or shorter than segment 5; segment 3 is subequal to or longer than scape; segment 4 is subequal to, longer than, or shorter than scape. For example: relative length of segments in *L. arcifera* is 3rd=5th=scape>4th; relative length of segments in *L. auratopilosa* is 3rd=5th>scape=4th; relative length of segments in *L. linwenhsiniis* 5th>3rd>4th=scape; relative length of segments in *L. taranan* is 3rd>5th>4th=scape.

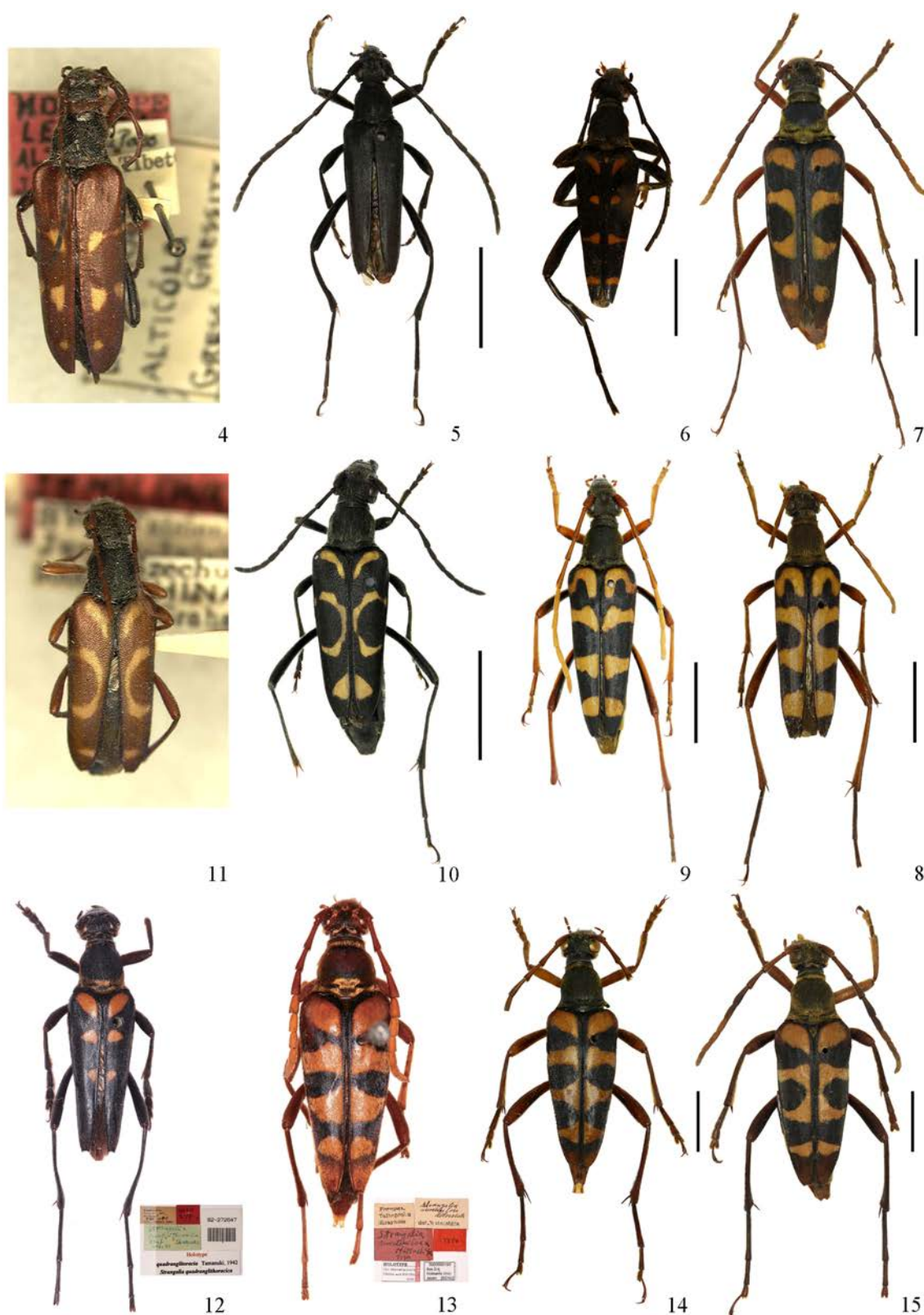
Pronotum. Pronotum strongly, moderately, or unevenly convex. For example: pronotum of *L. zonifera* is strongly convex (Fig. 40); *L. duodecimguttata* is moderately convex (Fig. 41); *L. lavinia* is unevenly convex (Fig. 42). Pronotum length is less than or subequal to width. For example: length *L. auratopilosa* is subequal to width; *L. lavinia* is less than width. The basal width of pronotum is less than, greater than, or subequal to 2.0 times apex. Example: The basal width of *L. zonifera* is less than 2.0 times apex, *L. grahamiana* is equal to 2.0 times apex, *L. lavinia* is greater than 2.0 times apex.

Elytra. Elytral apex obliquely emarginated, truncate, or obliquely truncate. For example: apex of *L. ambulatorix* is truncated; *L. auratopilosa* is obliquely emarginated; *L. lavinia* is obliquely truncate. Elytral maculae and lateral maculae have presence or absence, the number of elytral maculae, the shape of each maculae. For example: *L. aethiops* has no macula and lateral macula, other species looks black, elytral maculae close to yellowish brown; *L. arcifera* has 3 pairs of maculae and 2 pairs of lateral maculae; *L. aurosericans* has 4 pairs of maculae and a pair of lateral maculae; *L. lavinia* has 3 pairs of lateral maculae; M1 of *L. arcifera* obliquely subsinuous line (Fig. 51); M1 of *L. arcuata* downward arc-shaped (Fig. 52); M1 of *L. aurosericans* crescent shaped (Fig. 53); M1 of *L. taranan* oblique oval in shape (Fig. 54).

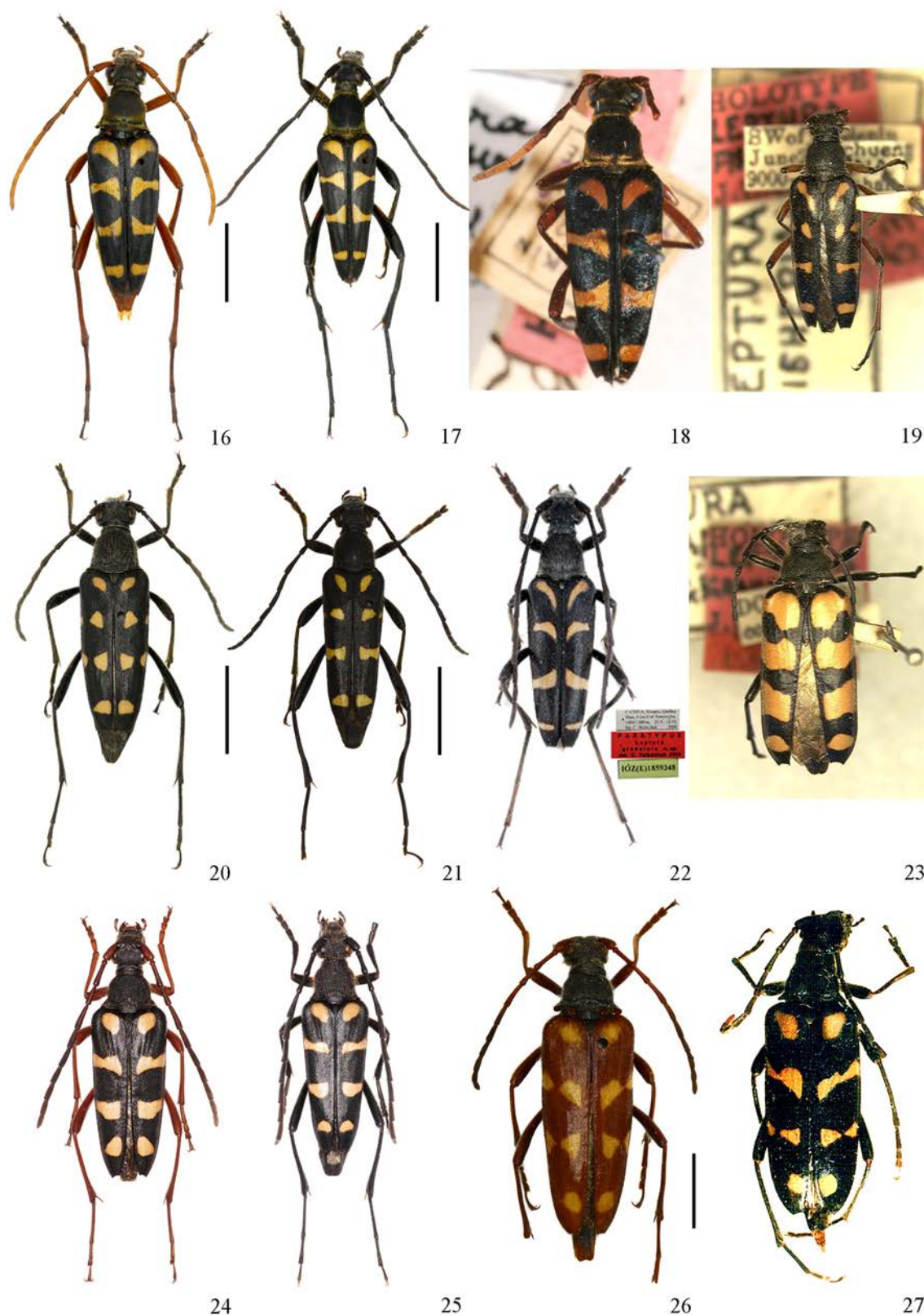
3.1.2 Sexual characters

Compared 50 morphological characters in *Leptura*, it is suggested that there are 2 characters which can be used to distinguishing between male and female.

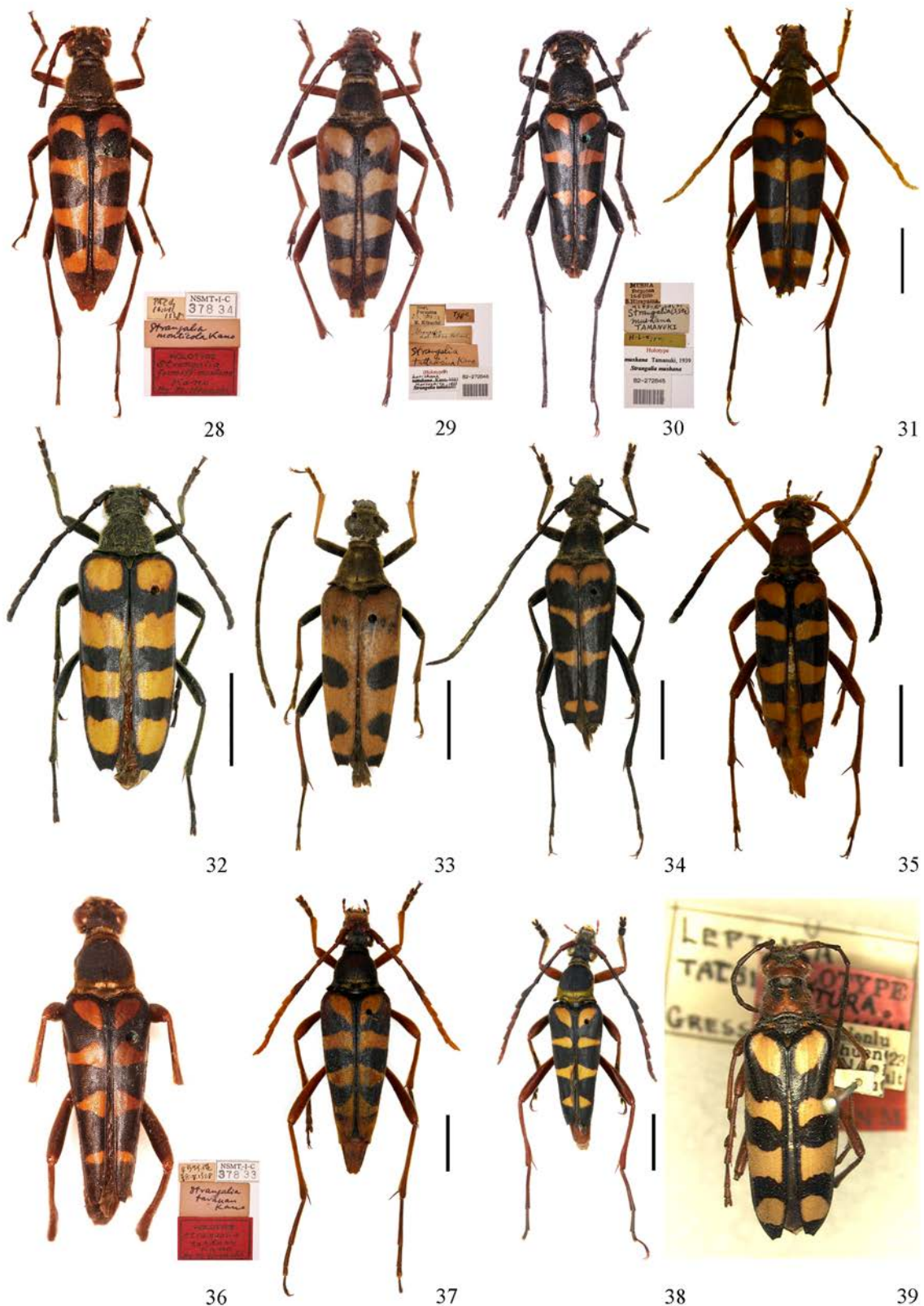
Antennae. The antennae are shorter than the body in both sexes, but the male antennae are longer than the female. *L. duodecimguttata* looks to be more specific, with the female antennae reaching apical 1/4 of elytra and the male antennae reaching apical 1/9 of elytra.



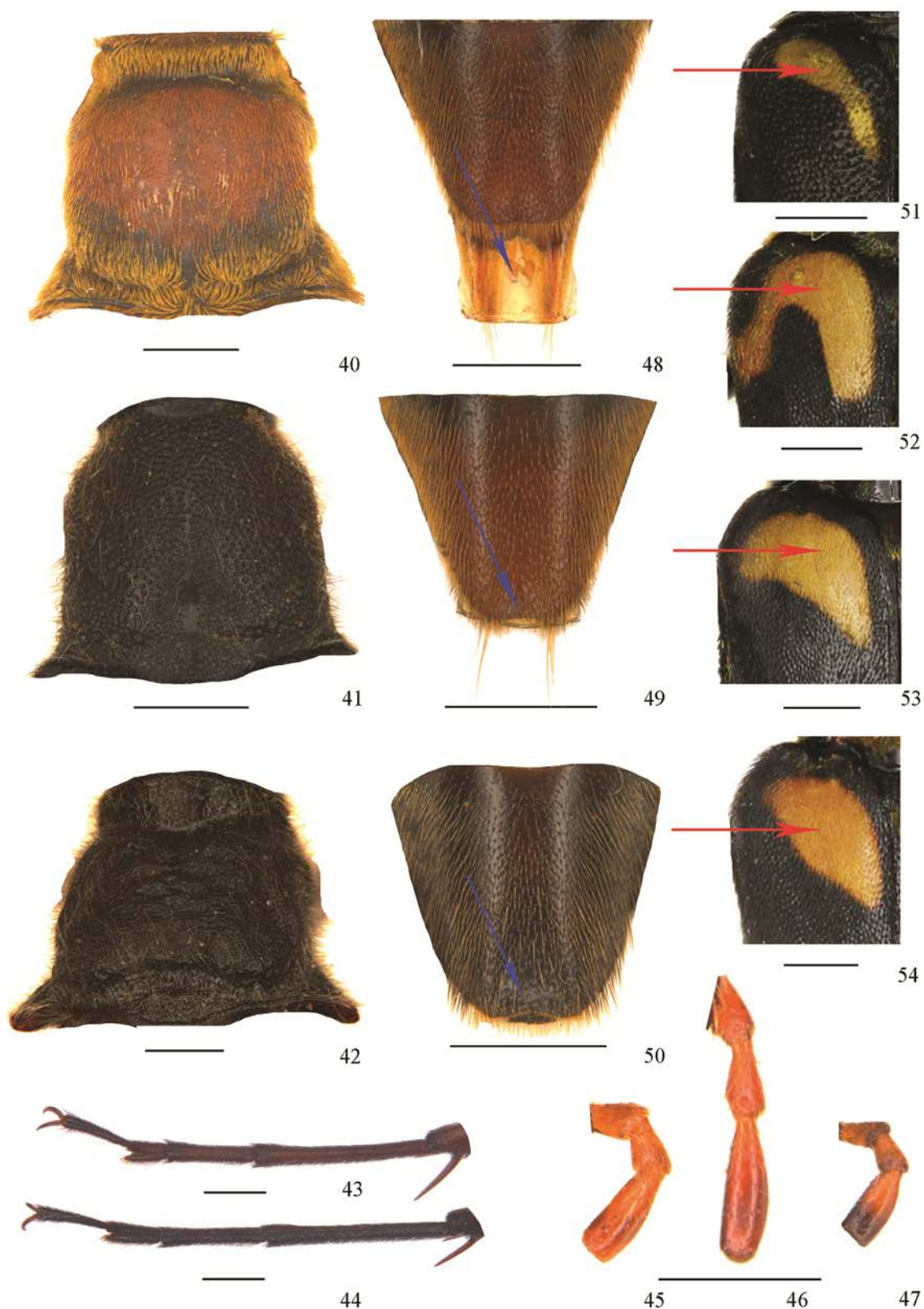
Figs 4–15. Adults of *Leptura*, dorsal view. 4. *L. alticola* Gressitt, holotype. 5. *L. aethiops* Poda. 6. *L. ambulatrix* (Gressitt), holotype. 7. *L. ambulatrix* (Gressitt). 8–9. *L. arcuata* Panzer. 10–11. *L. arcifera* (Blanchard). 12–15. *L. auratopilosa* (Matsushita). 11. *L. semilunata* Gressitt, holotype, synonym of *L. arcifera*. 12. *Strangalia quadranglithoracica* Tamanuki, holotype, synonym of *L. auratopilosa*. 13. *S. auratopilosa* Matsushita, holotype, synonym of *L. auratopilosa*. 4, 7–11, 13–15. Female. 5–6, 12. Male. Scale bars = 5 mm.



Figs 16–27. Adults of *Leptura*, dorsal view. 16–18. *L. aurosericans* Fairmaire. 19. *L. fisheriana* Gressitt, holotype. 20–21. *L. duodecimguttata* Fabricius. 22. *L. gradatula* Holzschuh, paratype. 23. *L. grahamiana* Gressitt, holotype. 24–25. *L. linwenhsini* Ohbayshi & Chou. 26–27. *L. lavinia* Gahan. 18. *L. aurosericans* Fairmaire, holotype. 24. *L. linwenhsini* Ohbayshi & Chou, paratype. 25. *L. linwenhsini* Ohbayshi & Chou, holotype. 27. *L. lavinia* Gahan, holotype. 16, 19–20, 23–24, 26–27. Female. 17–18, 21–22, 25. Male. Scale bars= 5 mm.



Figs 28–39. Adults of *Leptura*, dorsal view. 28. *L. formosomontana* Kano, holotype. 29–30. *L. tattakana* (Kano, 1933). 31. *L. ochraceofasciata ochrotela* Bates. 32. *L. quadrifasciata* Linnaeus. 33–34. *L. subtilis* Bates. 35. *L. zonifera* (Blanchard). 36–38. *L. taranan* (Kano) 39. *L. tatsienlua* Gressitt, holotype. 29. *S. horishana* Matsushita, holotype, synonym of *L. tattakana*. 30. *S. mushana* Tamanuki, holotype, synonym of *L. tattakana*. 36. *L. taranan* (Kano), holotype. 28–29, 31–33, 35, 37, 39. Female. 30, 34, 36, 38. Male. Scale bars= 5 mm.



Figs 40–54. *Leptura* spp. 40–42. Pronotum, 40. *L. zonifera* (Blanchard), 41. *L. duodecimguttata* Fabricius, 42. *L. lavinia* Gahan. 43–44. Hind tarsus of *L. aurosericans* Fairmaire. 45–47. Maxillary palpi. 45. *L. ochraceofasciata ochrotela* Bates, 46. *L. taranan* (Kano), 47. *L. arcuata* Panzer. 48–50. 7th abdominally sternite of *L. aurosericans* Fairmaire. 51–54. Elytral first macula (M1). 51. *L. arcifera* (Blanchard), 52. *L. arcuata* Panzer, 53. *L. aurosericans* Fairmaire, 54. *L. taranan* (Kano). 43, 48, 49. Female. 44, 50. Male. Scale bars = 1 mm.

Table 2. Comparison of morphological characters in 21 species in *Leptura*. Part 1.

Species	R1	R2	S1	R3	The length of antennae	L	R4	R5	S2	Em	N
<i>L. aethiops</i>	1.2–1.3	1.2–1.4	Obliquely truncate	>	♀ slightly extending beyond middle of elytra ♂ reaching elytral apex	3rd=5th>scape>4th	0.82–0.94	1.8–2.0	Moderately convex	Absence	–
<i>L. alticola</i>	-	-	-	-	♀ two-thirds as long as body	5th>scape>3rd>4th	0.80	1.4	Unevenly convex	Presence	3
<i>L. ambulatrix</i>	1.4–1.6	1.5–1.7	Truncate	>	♀ slightly extending beyond middle of elytra ♂ reaching to last elytral band	3rd>5th>scape=4th	0.94–0.95	1.9–2.0	Subevenly convex	Presence	4
<i>L. arcifera</i>	1.3–1.4	1.7–2.0	Obtusely round	=	♀ reaching the middle of elytra ♂ two thirds as long as body	3rd=5th=scape>4th	0.79–0.89	1.6–1.9	Moderately convex	Presence	3
<i>L. arcuata</i>	1.1–1.2	1.1–1.2	Obliquely truncate	>	♀ two thirds as long as body ♂ reaching elytral apex	3rd=5th>scape=4th	0.82–0.99	1.7–2.1	Moderately convex	Presence	4
<i>L. auratopilosa</i>	1.5–1.6	1.4–1.7	Obtusely round	<	♀ slightly extending beyond middle of elytra ♂ reaching apical 1/5–1/6 of elytra	3rd=5th>scape=4th	0.84–1.2	1.8–2.0	Strongly convex	Presence	4
<i>L. aurosericans</i>	1.1–1.5	1.4–1.5	Truncate	♀=< ♂=<	♀ reaching apical 1/4 of elytra ♂ reaching apical 1/10 of elytra	3rd>4th>5th=scape	0.81–0.97	2.0–2.2	Moderately convex	Presence	4
<i>L. duodecimguttata</i>	1.1–1.6	1.6–2.0	Obliquely truncate	>	♀ reaching apical 1/4 of elytra ♂ reaching apical 1/9 of elytra	3rd=5th>scape=4th	0.80–0.91	1.7–2.0	Moderately convex	Presence	4
<i>L. fisheriana</i>	-	-	-	-	♀ two thirds as long as body	3rd=5th>scape=4th	0.80	1.8	Moderately convex	Presence	4
<i>L. formosomontana</i>	-	-	Truncate	♀< ♂=	♀ reaching the middle of elytra ♂ reaching apical 1/6 of elytra	3rd=5th>scape=4th	0.81–1.1	1.9–2.3	Moderately convex	Presence	4
<i>L. gradatula</i>	1.5–1.6	1.7–1.8	Obtusely round	<	♀ reaching apical 1/10 of elytra ♂ reaching elytral apex	5th>3rd>4th>scape	1.1	2	Strongly convex	Presence	4
<i>L. grahamiana</i>	1.6–1.7	1.7–1.8	Obtusely round	>	♀ two thirds as long as body	5th>3rd>4th=scape	0.75	2.0–2.2	Moderately convex	Presence	4
<i>L. linwenhsini</i>	1.4	1.5	Truncate	>	♀ reaching apical 1/5 of elytra ♂ reaching apical 1/9 of elytra	5th>3rd>4th=scape	0.80–1.0	1.8–2.0	Moderately convex	Presence	4
<i>L. lavinia</i>	1.2–1.3	1.6–1.7	Truncate	>	♀ slightly extending beyond middle of elytra	5th>3rd>4th=scape	0.66–0.79	2.1–2.2	Unevenly convex	Presence	4
<i>L. ochraceofasciata</i> <i>ochrotera</i>	1.5	1.2	Truncate	=	♀ reaching apical 1/8 of elytra	3rd=5th>scape=4th	0.70	2.0–2.2	Strongly convex	Presence	4

Table 2. (continued)

Species	R1	R2	S1	R3	The length of antennae	L1	R4	R5	S2	Em	N1
<i>L. quadrifasciata</i>	1.0–1.2	2.0–2.3	Truncate	>	♀ slightly extending beyond middle of elytra ♂ reaching elytral apex	3rd=5th=scape>4th	0.57–0.67	1.6–1.9	Unevenly convex	Presence	4
<i>L. subtilis</i>	1.0–1.5	1.2–1.3	Obliquely truncate	>	♀ slightly extending beyond middle of elytra ♂ reaching elytral apex	3rd=5th>4th=scape	0.76–0.77	2.0–2.3	Strongly convex	Presence	4
<i>L. taranan</i>	1.0–1.3	1.3–1.5	Obtusely round	>	♀ slightly extending beyond middle of elytra ♂ reaching apical 1/4 of elytra	3rd>5th>4th=scape	0.82–0.91	2.0–2.3	Strongly convex	Presence	4
<i>L. tatsienlua</i>	-	-	-	-	♀ three fourths as long as body	5th>3rd=scape >4th	0.67	1.8	Unevenly convex	Presence	4
<i>L. tattakana</i>	-	-	Truncate	♀= ♂<	♀ slightly extending beyond middle of elytra ♂ reaching apical 1/5 of elytra	3rd=5th>scape=4th	0.70–0.90	1.8–2.1	Moderately convex	Presence	4
<i>L. zonifera</i>	1.0–1.2	1.1–1.4	Obtusely round	♀= ♂<	reaching the middle of elytra	5th>3rd>4th=scape	0.72–0.77	1.8–1.9	Strongly convex	Presence	4

Notes. R1= ratios of the lower eye lobe to genae, R2= width- height ratios of frons, S1= shape of maxillary palpi apex, R3= ratios of maxillary palpi penultimate segment to a half of apical, L1= relative length of antennae segments, R4= length-width ratios of pronotum, R5= ratios of pronotum basal width to apical width, S2= shape of pronotum, EM= whether elytra have maculae, N1= number of maculae on the central of elytra.

Table 3. Comparison of morphological characters in 21 species in *Leptura*. Part 2.

Species	Shape of M1	Shape of M2	Shape of M3	Shape of M4	N2	L2	S3
<i>L. aethiops</i>	-	-	-	-	-	-	Truncate
<i>L. alticola</i>	Triangular, beyond basal quarter	Triangular, behind middle, larger than M1	Subround, near apex	-	2	M1L, a small transverse spot, on M1 lateral; M2L, a triangular spot on M2 lateral	Obliquely truncate
<i>L. ambulatorix</i>	Crescent shape, parallel to scutellar margin, separated from small M1L	A subrounded spot near suture	A narrow incomplete transverse band broadened at its sutural end, slightly behind middle	A slightly arched band	2	M1L, a minute spot below humerus; M2L, a small transverse spot near external margin, beyond basal quarter	Obliquely emarginated
<i>L. arcifera</i>	An oblique, subsinuous line from base, near humerus, to near suture, separated from small M1L	Arc-shaped, gap towards lateral, on the middle of elytra, the two together form x-shaped	Triangular, near apex	-	2	M1L, a minute spot below humerus; M2L, a minute spot on M2 latera	Obliquely truncate
<i>L. arcuata</i>	Downward arc-shaped, connected to M1L	Transversely subtriangular, slightly anterior to the middle, with the marginal part substantially narrowed	Transverse with a slight slant, narrowed towards laterad	Broadly triangular	1	M1L, a spot below humerus	Obliquely truncate
<i>L. auratopilosa</i>	Oblique oval , ♀ connected to M1L by reddish humerus and ♂ separated from small M1L	Transverse, ♀ reaching to lateral side and ♂ slightly projected anteriorly beside suture	Triangular	Triangular, smaller than M3 and ♂ sometimes reduced or disappeared	1	M1L, a small spot below humerus	Obliquely emarginated
<i>L. aurosericans</i>	Crescent shape, parallel to scutellar margin, separated from small M1L	Transversely subtriangular, slightly anterior to the middle, with the marginal part substantially narrowed	The shape similar to M2 but the size larger and the marginal part broader	Transverse, narrow and slightly broadened suturally	1	M1L, a elongate spot below humerus	Obliquely truncate
<i>L. duodecimguttata</i>	Oblong oval, parallel to scutellar margin	Triangular, subparallel to suture	Triangular, sometimes completely united M2L to form an obliquely transverse fascia constricted in the middle	Triangular, sometimes transverse	2	M1L and M2L triangular, separately located on the M2, M3 lateral	Obliquely emarginated

Table 3. (continued)

Species	Shape of M1	Shape of M2	Shape of M3	Shape of M4	N2	L2	S3
<i>L. fisheriana</i>	An oblique, subsinuous line from base, near humerus, to near suture	An oblique spot, near end of first third	A transverse band just behind middle, constricted in middle, more closely approaching external margin than suture	A slightly wider transverse bar a short distance before apex, not quite touching margin and suture	1	Transverse, near end of first third, closely approaching external margin	Subemarginate-truncate
<i>L. formosomontana</i>	Semicircular bow or crescent shaped along basal margin, sometimes connected to M1L	Transverse with a slight slant	Transverse with a slight slant	Very small, transverse band or triangular	1	M1L, a minute spot below humerus	Obliquely emarginated
<i>L. gradatula</i>	An oblique, subsinuous line from base, near humerus, to near suture, separated from small M1L	Obliquely transverse, slightly projected posteriad beside suture	Obliquely transverse, slightly projected anteriad beside suture	Very small, transverse band	1	M1L, a small spot below humerus	Truncate
<i>L. grahamiana</i>	Oblong oval or subround along basal margin, sometimes connected to M1L	Broadly transverse, curve, reaching lateral margine	Obliquely transverse, broad, reaching lateral margine, narrowed beside suture	Oblong or subsquare	1	M1L, a minute spot below humerus	Obliquely emarginated
<i>L. linwenhsini</i>	Oblique kidney-shape, widely separated from rather developed M1L	Transverse with anterior margin slightly emarginated, reaching lateral side	Inflated posteriorly, then attenuated laterad	Semicircular, more or less crescent shaped	1	M1L, a spot below humerus	Obliquely emarginated
<i>L. lavinia</i>	Oblong oval, separated from small M1L	Triangular, sometimes completely united M2L to form an obliquely transverse fascia constricted in the middle	Triangular, sometimes completely united M3L to form an obliquely transverse constricted in the middle	Oval-shaped, more or less subround	3	M1L, a oblong spot below humerus; M2L and M3L, triangular, near external margin, M2L before middle, M3L behind middle	Obliquely truncate
<i>L. ochraceofasciata ochrotera</i>	Crescent shape, bow Along basal margin	Transverse, slightly projected posteriad beside suture, and narrowed laterad	Straightly transverse, reaching lateral margine	Broadly triangular	1	M1L, a minute spot below humerus	Truncate

Table 3. (continued)

Species	Shape of M1	Shape of M2	Shape of M3	Shape of M4	N2	L2	S3
<i>L. quadrifasciata</i>	Oblique oval, separated from small M1L	Obliquely transverse, broad, reaching lateral margine	Straightly transverse, reaching lateral margine	Subsquare or round	1	M1L, a minute spot below humerus	Obliquely emarginated
<i>L. subtilis</i>	Semicircular bow or crescent shaped along basal margin, sometimes connected to M1L, ♀ full conjoint to M2	Transversely subtriangular, slightly posterior to the middle, with the marginal part substantially narrowed	Transverse, slightly projected anteriad and posteriad beside suture, and narrowed laterad	Triangular, not reaching lateral margine	1	M1L, a minute spot below humerus;	Obliquely emarginated
<i>L. taranan</i>	Oblique oval, separated from small M1L	Transverse, narrowed towards laterad, reaching lateral margine	Triangular, not reaching lateral margine	Triangular, not reaching lateral margine, smaller than M3	1	M1L, a spot below humerus	Obliquely emarginated
<i>L. tatsienlua</i>	Oblique oval	Obliquely transverse, slightly projected posteriad beside suture, and narrowed laterad	Broadly transverse	Subsquare, sometimes subround	-	-	Obliquely emarginated
<i>L. tattakana</i>	Oblique oval , separated from small M1L	Transverse and slightly projected anteriad beside suture, and narrowed laterad	Triangular	Triangular, smaller than M3 and ♂ sometimes reduced or absent	1	M1L, a spot below humerus	Obliquely emarginated
<i>L. zonifera</i>	Oblique oval, separated from small M1L	Transverse, narrowed towards laterad, reaching lateral margine	Transversely subtriangular, slightly anterior to the middle, with the marginal part substantially narrowed	Transverse, Sometimes Subsquare	1	M1L, a small spot below humerus	Obliquely emarginated

Note. N2= number of elytral lateral maculae, L2= location of elytral lateral maculae, S3= shape of elytral apex.

Hind tarsal. The ratio of the female first hind tarsal segment length to the second is greater than male. In *L. aurosericans*, the female has its first hind tarsal segment 2.1–2.2 times as long as second segment (Fig. 43), while the male has its first hind tarsal segment 1.7–1.8 times as long as second segment (Fig. 44).

In addition, the shape of 7th abdominally sternal apex can be used to distinguishing between male and female too. The female usually has exposed ovipositor, while the male does not have. The 7th abdominally sternite of female has apical margin nearly truncate or slightly emarginated with long hair, while male has apical margin medially depressed deeper than female, arc concave with short hair (e.g. *L. aurosericans* (Figs 48–50)).

3.2 *L. auratopilosa* and *L. aurosericans*

L. auratopilosa (Matsushita) and *L. aurosericans* Fairmaire can be easily distinguished by morphology, but the identification of the two species is inconsistent (Chiang *et al.*, 2001; Yang *et al.*, 2011). Based on the examination of types and a series of specimens from 10 universities and relevant units in China, these two species were widely distributed in Southern China.

Five specimens of *L. auratopilosa* (Matsushita) and four specimens of *L. aurosericans* Fairmaire were dissected, the result shows that both species are very similar in the structures of the female genitalia. However, there are significant variations between these two species. They can be distinguished by the characters showed in the Table 4 and Figs 55–58.

Table 4. Comparison of female genitalia between *L. auratopilosa* and *L. aurosericans*.

Characters	<i>L. auratopilosa</i>	<i>L. aurosericans</i>
Length-width ratios of ovipositor	9.4–10	6.6–7.0
Whether the base of valvifer baculum projected lateral, triangular	No	Yes
Thickness of baculum	Fine	Thick
Shape of proctiger baculum base	With 3 subbranches, combined at terminal part of subbranches	Triangular
Vaginal plate	Stubby	Slender
Whether the base part of spermatheca obviously thicken	No	Yes

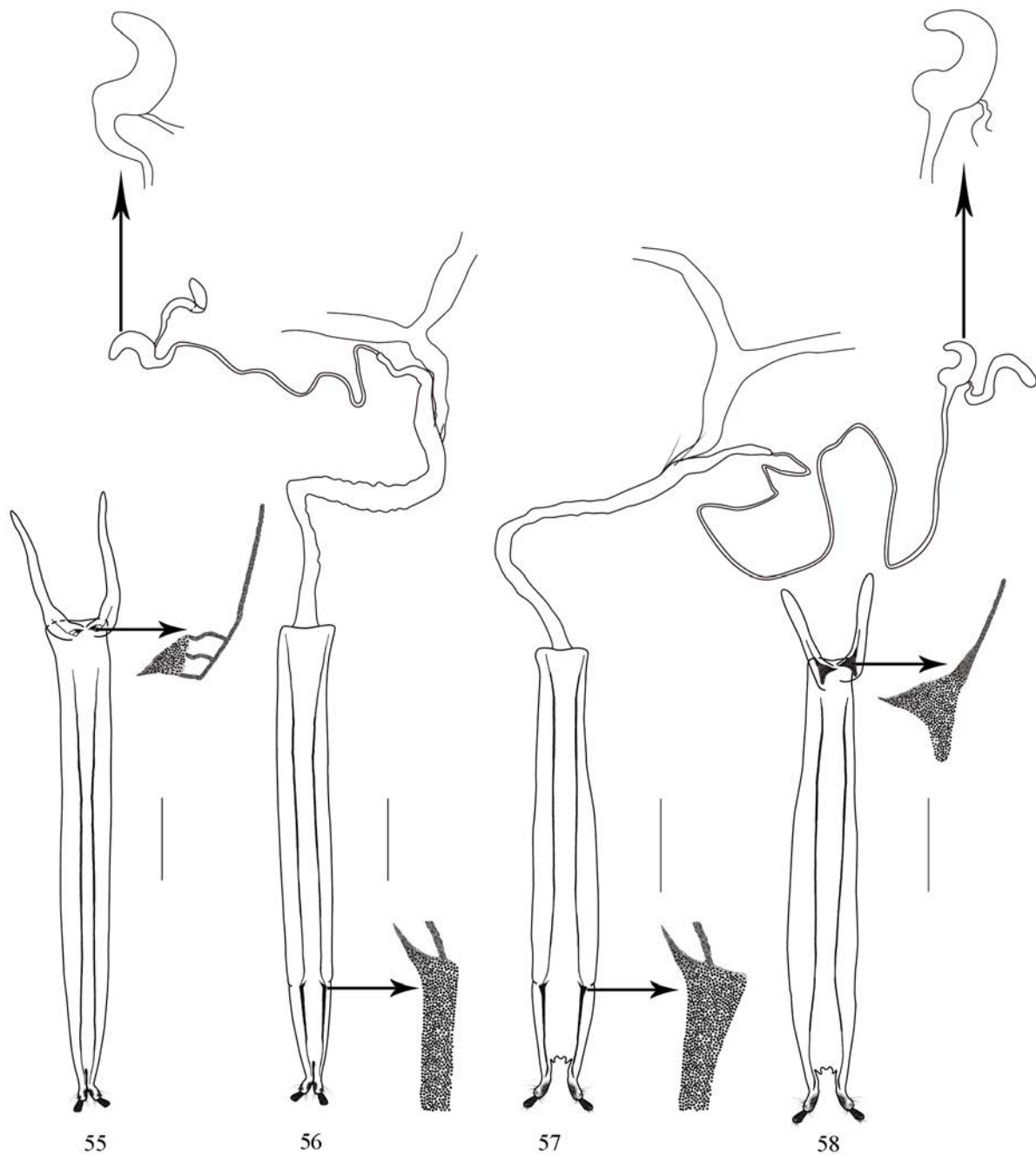
4 Discussion and conclusion

4.1 Discussion

In this paper, we distinguished the species in *Leptura* by morphological characters, and found that it is necessary to select more taxonomically significant characters for easier identification. The color of elytra and the size of elytral maculae are important characters for identifying species of *Leptura* (Chiang *et al.*, 1985, 2001). The comparative morphological results indicated that the color of elytra and the size of elytral maculae should not be used for identification in the genus. The elytral color of *L. duodecimguttata* Fabricius, *L. arcifera* (Blanchard) and *L. lavinia* Gahan is various, and the variation of these species is universal, from elytra brown to black such as *L. arcifera* (Blanchard), *L. lavinia* Gahan (Figs 10–11, 26–27). Additionally, although elytral maculae shows similar shape in the single species, it also shows intraspecific various in size, e.g. *L. arcifera* (Blanchard), *L. auratopilosa* (Matsushita), *L. aurosericans* Fairmaire (Figs 8–9, 13–15, 16–18). Therefore, it should be avoided using these characters when selected taxonomic characters.

4.2 Conclusion

The morphological comparative results indicated that there were 18 morphological characters which can be used for identification in the genus, such as the ratios of the lower eye lobe to genae, the width-height ratios of frons, the relative length of antennae segments, the shape of maxillary palpi apex, prothorax, elytra and elytral maculae and so on. The length of antennae and the ratio of the first hind tarsal segment length to the second could be used to distinguish between male and female. The results also show that *L. auratopilosa* and *L. aurosericans* are two species widely distributed in Southern



Figs 55–58. Female genitalia. 55–56. *L. auratopilosa* (Matsushita). 57–58. *L. aurosericans* Fairmaire. 55, 57. Dorsal view. 56, 58. Ventral view, with ovipositor. Scale bars= 1 mm.

China, with female genitalia of the two species compared, and the female genitalia could be used to identifying the two species.

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