Zoological Systematics, 40(2): 197–211 (April 2015), DOI: 10.11865/zs.20150205

ORIGINAL ARTICLE

Comparative morphology study of the male genitalia in the tribe Astathini from China (Coleoptera: Cerambycidae)

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Abstract The male genitalia of 13 species from four genera of Astathini were described and analyzed. The result showed that five genital characters, such as shape of the apex of 8th abdominal tergaum and sternum, ratio of the length of lateral lobes to tegmen, can be used to identify genera of Astathini; six characters, such as ratio of the length of lateral lobes to tegmen, ratio of the length of roof to lateral lobes, shape of the apex of ventral plate of median lobe, can be used to identify species in *Bacchisa*.

Key words Astathini, *Bacchisa*, male genitalia, comparative morphology, China.

1 Introduction

The tribe Astathini, established by Thomson based on the type genus *Astathes* Newman, 1842 (= *Tetraophthalmus* Dejean, 1835), includes 17 genera and 186 species (subspecies) worldwide, and six genera and 43 species (subspecies) in China (Thomson, 1857, 1864; Pascoe, 1867; Gahan, 1901; Pic, 1912; Gressitt, 1951; Breuning, 1956; Pu, 1991; Hua, 2002; Hubweber *et al*., 2010). Since the tribe was established, most research of it focused on species description (Dejean, 1835; Newman, 1842; Blanchard, 1845; Thomson, 1857, 1864, 1865; Pascoe, 1867; Gahan, 1901; Pic, 1911, 1912; Gressitt, 1935, 1937, 1939, 1940, 1942, 1951; Breuning, 1956, 1961, 1968, 1969; Rondon & Breuning, 1970; Hua *et al*., 2009; Pu, 1991, 1992) and regional taxonomic list (Hua, 1982, 2002; Hubweber *et al*., 2010). Male genitalia play an important role on mophylogeny (Chen, 1986; Wang, 1998, 2002; Du, 1992; Feng, 2010; Ma, 2012; Liu *et al*., 2013; Zhang & Chen, 2013). In China, only two species , *Plaxomicrus ellipticus* Thomson, 1857 and *Tetraophthalmus episcopalis* (Chevrolat, 1852) were reported their male genitalia (Wang, 1998).

In this paper, the male genitalia of 13 species from four genera of Astathini were described, and a comparative morphology based on male genitalia was done, in order to add diagnose characters of Astathini, and preliminarily investigate the genetic relationships among genera and species of Astathini.

2 Material and methods

2.1 Specimens

Totally 56 individuals of 13 species were examined. The materials were provided separately by the following collection: China Agricultural University (CAU), China West Normal University (CWNU), Hebei University (HBU), Guangxi Academy of Agricultural Sciences (GAAS), Nanjing Agricultural University (NAU), South China Agricultural University (SCAU), Southwest University (SWU) and Sun Yat-Sen University (SYSU).

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Received 19 September 2014, accepted 20 November 2014

Table 1. Specimens information of 13 species in Astathini from China.

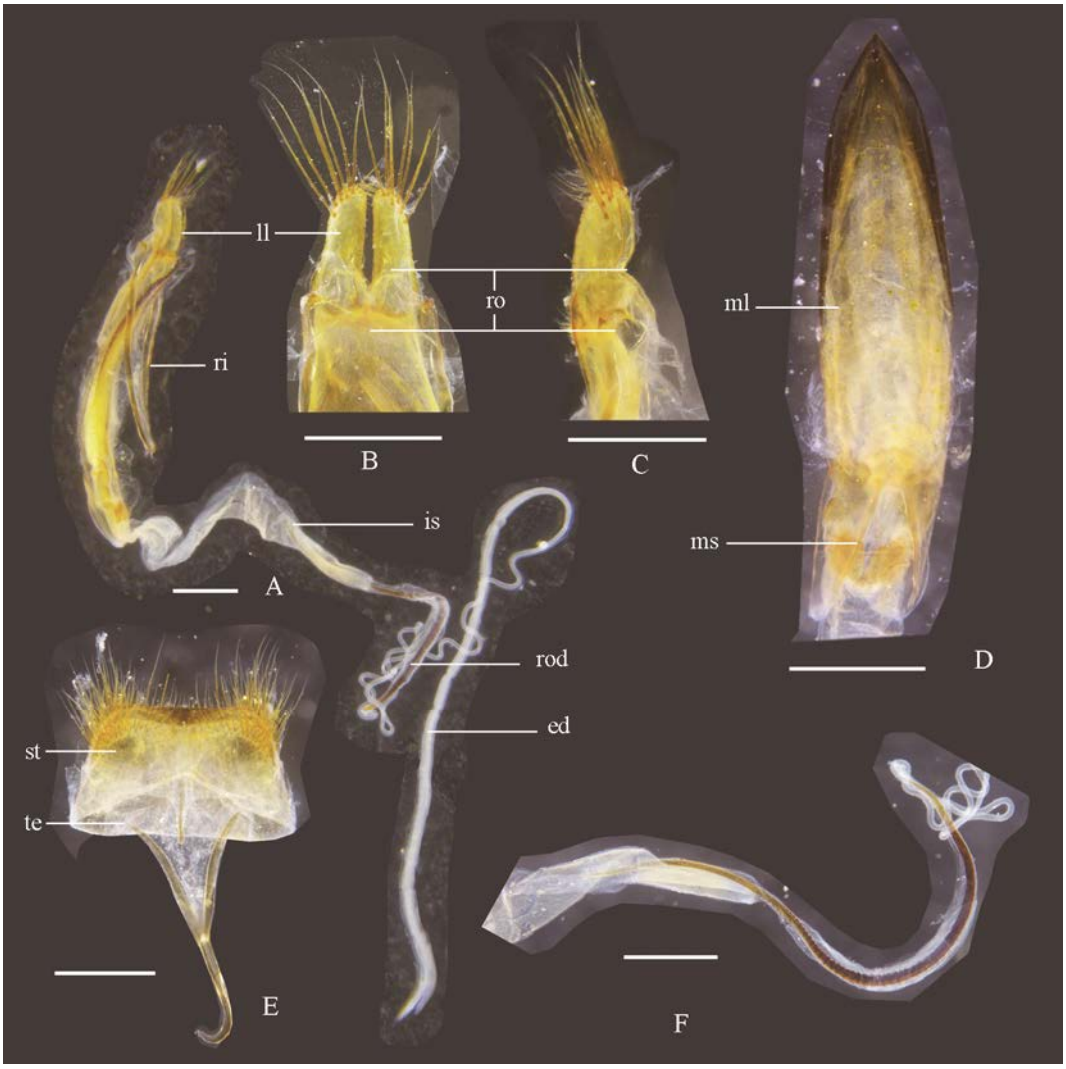
Species	Number	Locality	Collection
Anastathes parva hainana Gressitt, 1942	1	Junzishan Mountain, Shizong County, Qujing City, Yunnan	HUB
	2	Sichuan	CWNU
	3	Tianlin County, Baise City, Guangxi	GAAS
	4	Tianlin County, Baise City, Guangxi	GAAS
A. robusta Gressitt, 1940	5	Fengkai County, Zhaoqing City, Guangdong	SYSU
	6	Jinagfenling, Hainan	SYSU
	7	Longgang County, Shenzhen City, Guangodng	SCAU
	8	Changjiang County, Hainan	HBU
Bacchisa atritarsis (Pic, 1912)	9	Ruyuan County, Shaoguan City, Guangdong	SYSU
	10	Meitan County, Guizhou	SWU
B. basalis (Gahan, 1894)	11	Longjin County, Zunyi City, Guangxi	CAU
	12	Longzhou County, Chongzuo City, Guangxi	CAU
B. comata (Gahan, 1901)	13	Xishuangbanna, Yunnan	SWU
	14	Pingxiang County, Chongzuo City, Guangxi	CAU
B. dioica (Fairmaire, 1878)	15	Jinyunshan Mountain, Beibei City, Chongqing	SWU
	16	Jinyunshan Mountain, Beibei City, Chongqing	SWU
	17	Jinyunshan Mountain, Beibei City, Chongqing	SWU
	18	Jinyunshan Mountain, Beibei City, Chongqing	SWU
	19	Jinyunshan Mountain, Beibei City, Chongqing	SWU
	20	Chengdu City, Sichuan	SWU
	21	Chengdu City, Sichuan	SWU
	22	Southwest University, Beibei City, Chongqing	SWU
B. fortunei (Thomson, 1857)	23	Guiyang City, Guizhou	SWU
	24	Lian County, Qingyuan City, Guangdong	SYSU
B. guerryi (Pic, 1911)	25	Fengkai County, Zhaoqing City, Guangdong	SYSU
	26	Simao County, Puer City, Yunnan	SWU
	27	Honghe City, Yunnan	SWU
B. rigida (Gressitt, 1942)	28	Chengdu City, Sichuan	NAU
	29	Chengdu City, Sichuan	NAU
Plaxomicrus ellipticus Thomson, 1857	30	Beibei City, Chongqing	SWU
	31	Chengdu City, Sichuan	NAU
Tetraophthalmus episcopalis (Chevrolat, 1852)	32	Beibei City, Chongqing	SWU
	33	Beibei City, Chongqing	SWU
	34	Beibei City, Chongqing	SWU
	35	Beibei City, Chongqing	SWU
	36	Beibei City, Chongqing	SWU
	37	Beibei City, Chongqing	SWU
	38	Beibei City, Chongqing	SWU
	39	Beibei City, Chongqing	SWU
	40	Chengdu City, Sichuan	SWU
	41	Chengdu City, Sichuan	SWU
	42	Chengdu City, Sichuan	SWU
	43	Guilin City, Guangxi	SWU
	44	Guilin City, Guangxi	SWU
	45	Hanzhong City, Shanxi	SWU
	46	Wen County, Longnan City, Gansu	SWU
	47	Wen County, Longnan City, Gansu	SWU
	48	Wen County, Longnan City, Gansu	SWU
T. janthinipennis cyanopterus (Gahan, 1900)	49	Limushan Mountain, Hainan	HBU
	50	——	SYSU

Table 1 (continued)

Species	Number	Locality	Collection
T. janthinipennis janthinipennis (Fairmaire, 1895)	51	Wangmo County, Xingyi City, Guizhou	SWU
	52	Luxi County, Honghe City, Yunnan	SWU
	53	Simao County, Puer City, Yunnan	SWU
	54	Daqingshan Mountain, Longzhou County, Chongzuo City, Guangxi	CAU
	55	Damingshan Mountain, Wuming County, Nanning City, Guangxi	CAU
	56	——	SWU

2.2 Male genitalia

The abdomen of specimen was softened and dissected. Then take out the male genitalia, put it into 10% NaOH solution boil 3–5 minutes by water bathing, dissect and clean it. Finally, the male genitalia were kept into 75% alcohol



Figs 1. Male genitalia of Astathini (*Anastathes robustus* Gressitt, 1940). A. Male genitalia, lateral view. B. Base of tegmen, dorsal view. C. Base of tegmen, lateral view. D. Median lobe plus median struts, dorsal view. E. 8th abdominal sternum. F. Rod at apex of internal sac. Abbreviation: ed. ejaculatory duct; is. internal sac; ll. lateral lobes; ml. median lobe; ms. median struts; ri. ringed part; ro. roof; rod. rod; sg. spiculum gastrale; st. sternum; te. tergaum. Scale bars = 0.5 mm.

solution and sealed by a few drops of glycerol. All photos were taken using Leica M205A Stereomicroscope and all pictures were edited by Adobe Photoshop® CS5. The male genitalia of Astathini were shown as Fig. 1. The terminology follows Jiang and Chen (2001) and Shôzô (1954).

Fig. 2. Tegmen in dorsal view. A. *Anastathes parvus hainana*. B. *A. robustus*. C. *Bacchisa fortunei*. D. *Plaxomicrus ellipticus*. E. *Tetraophthalmus episcopalism*. F. *T. janthinipennis cyanopterus*. G. *T. janthinipennis janthinipennis*. Scale bar = 0.5 mm.

3 Results

3.1 Description

3.1.1 *Anastathes parva hainana* Gressitt, 1942 (Figs 2A, 3A, 4A–B)

Tegmen about 3.1 times as long as wide, slightly curved; lateral lobes short, about 1/7 times as long as tegmen, apex narrower than base, with long hairs; roof short, about 0.4 times as long as lateral lobes; ringed part converging at apex, apex flat. Median lobes plus median struts slightly curved, about 4.9 times as long as wide; median lobes twice as long as median struts; dorsal plate shorter than ventral plate, apex pointed. Internal sac with rod at apex, rod longer than median lobe plus median struts and thicker at apical half. 8th abdominal tergaum transverse, 0.7 times as long as wide; apex slightly concave, narrower than base, with dense long setae on lateral sides; 8th abdominal sternum slightly shorter and narrower than tergaum, apex slightly concave, with dense long setae on lateral sides; spiculum gastrale long, about 1.6 times as long as tergaum.

3.1.2 *Anastathes robustus* Gressitt, 1940 (Figs 2B, 3B, 4C–D)

Tegmen about 3.6 times as long as wide, slightly curved; lateral lobes about 2/9 times as long as tegmen, cylindrical, with dense long hairs at apex; roof short, about 0.7–0.8 times as long as lateral lobes; apex dehiscent; basal margin straight

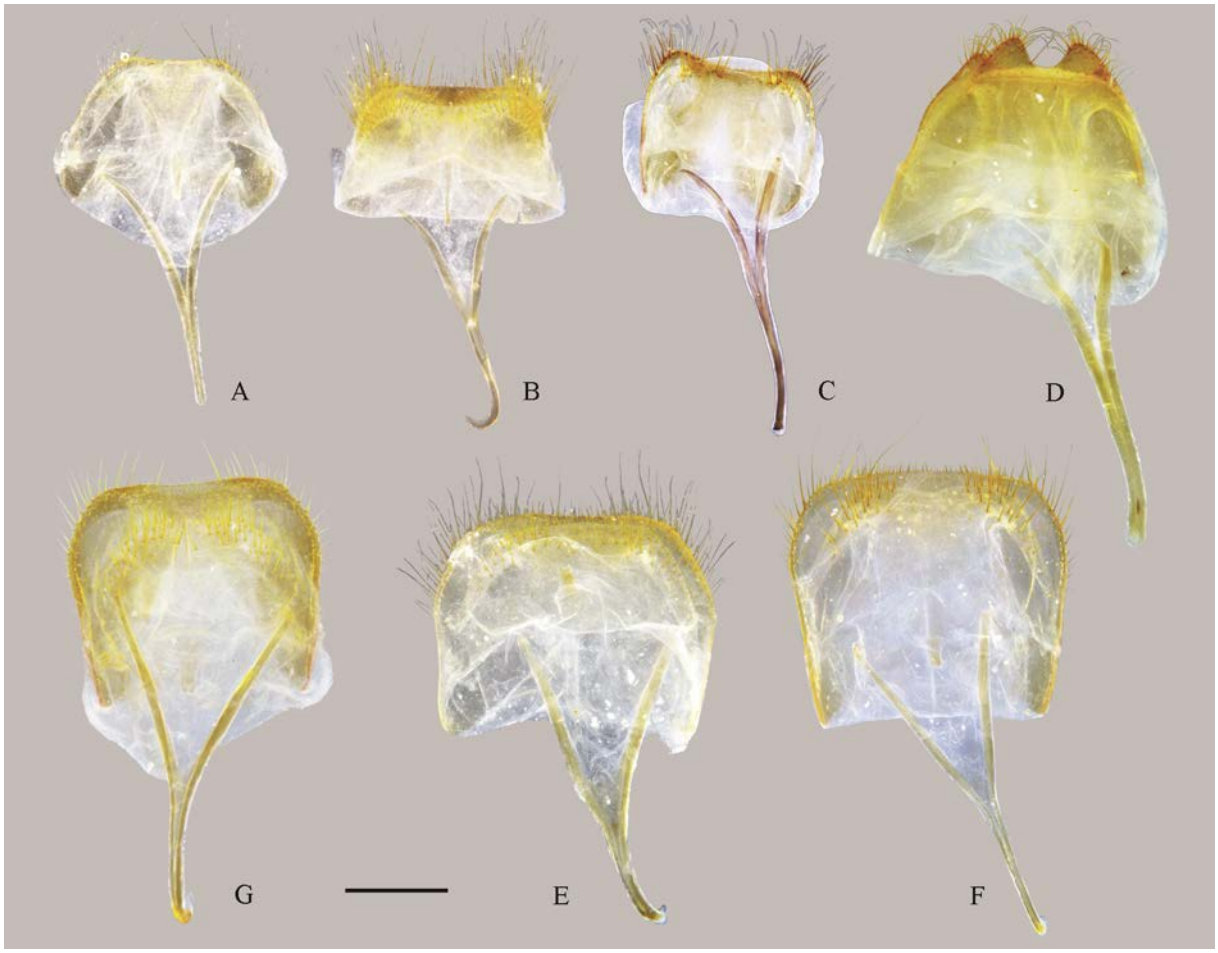


Fig. 3. 8th abdominal segment, ventral view. A. *Anastathes parvus hainana*. B. *A. robustus*. C. *Bacchisa atritarsis*. D. *Plaxomicrus ellipticus*. E. *Tetraophthalmus episcopalism*. F. *T. janthinipennis cyanopterus*. G. *T. janthinipennis janthinipennis*. Scale bar = 0.5 mm.

and protruding at middle; ringed part converging at apex, apex flat. Median lobe plus median struts slightly curved, about 5.6 times as long as wide; median lobes 3.1 times as long as median struts; dorsal plate shorter than ventral plate, apex pointed. Internal sac with rod at apex, the rod approximately as long as median lobe plus median struts and slightly thick. 8th abdominal tergaum sub-trapezoidal, 0.6 times as long as wide; apex flat, narrower than base, with dense long setae on lateral sides, sparsely covered with short hairs at middle; 8th abdominal sternum approximately as wide as but shorter than

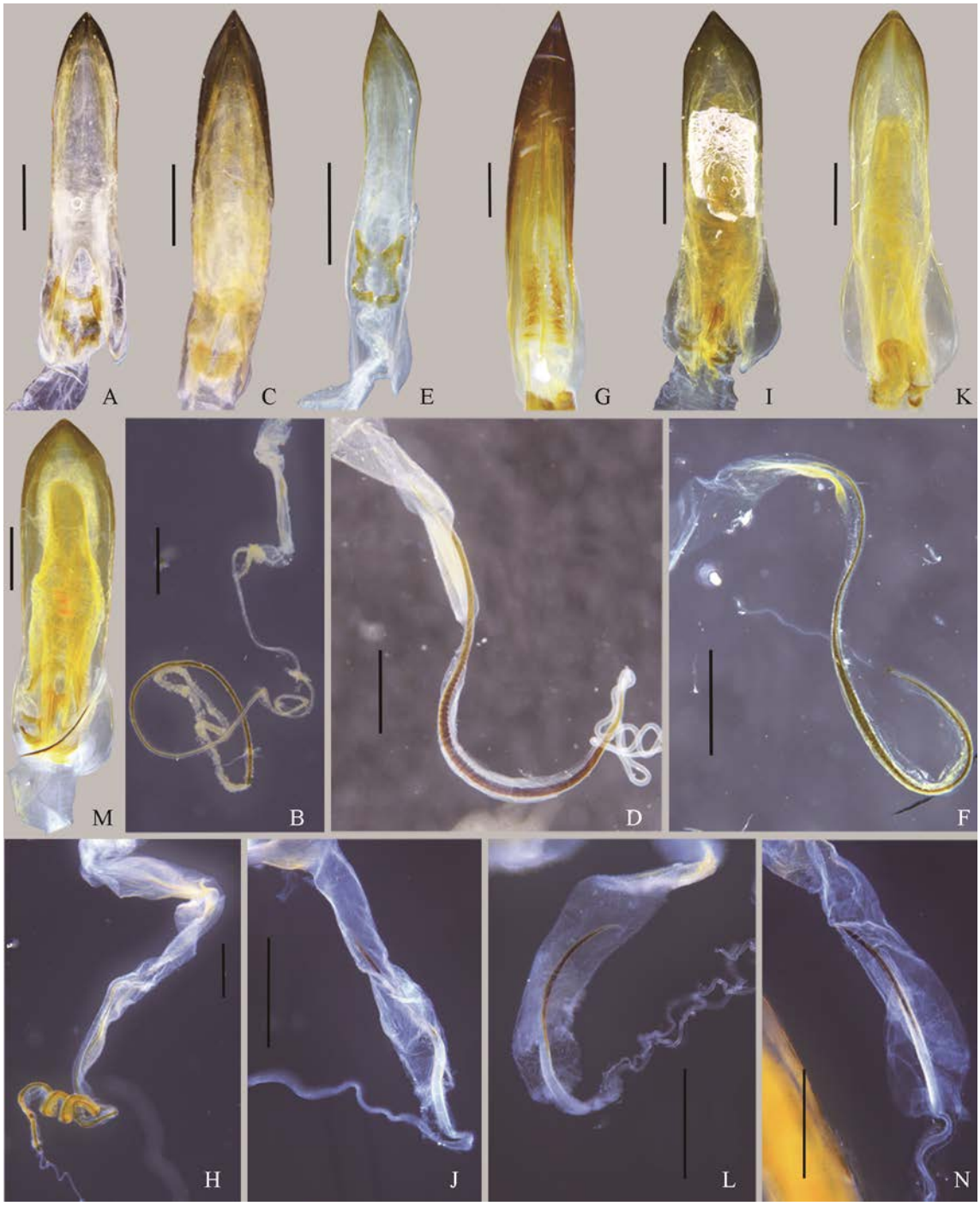


Fig. 4. Median lobe plus median struts and rod at apex of internal sac, dorsal view. A–B. *Anastathes parvus hainana*. C–D. *A. robustus*. E–F. *Bacchisa dioica*. G–H. *Plaxomicrus ellipticus*. I–J. *Tetraophthalmus episcopalism*. K–L. *T. janthinipennis cyanopterus*. M–N. *T. janthinipennis janthinipennis*. Scale bars = 0.5 mm.

dorsal plate; apex slightly concave, densely covered with long hairs on lateral sides; spiculum gastrale long, about 2.0 times as long as tergaum.

3.1.3 *Bacchisa atritarsis* (Pic, 1912) (Figs 3C, 5A, 6A, 7A)

Tegmen about 4.0 times as long as wide, slightly curved; lateral lobes short, about 1/9–1/10 times as long as tegmen, cylindrical, about 2.2–2.3 times as long as wide; apex transparent; with dense long hairs at middle; roof short, about 0.7–0.8 times as long as lateral lobes; apex dehiscent; ringed part converging at apex, apex flat. Median lobe plus median

Fig. 5. Tegmen of *Bacchisa*, dorsal view. A–F. R2 > 1/20. A. *B. atritarsis*. B. *B. basalis*. C. *B. comate*. D. *B. dioica*. E. *B. fortunei*. F. *B. rigida*. G. R2 < 1/20, *B. guerryi*. Scale bar = 0.5 mm.

struts slightly curved, about 5.8 times as long as wide; median lobes 3.4 times as long as median struts; dorsal plate significantly shorter than ventral plate, apex sharp-pointed. Internal sac with rod at apex, rod longer than median lobe plus median struts and slender. 8th abdominal tergaum sub-square , 0.9 times as long as wide; apex slightly concave, with dense long setae on lateral sides; 8th abdominal sternum about as long as but slightly narrower than dorsal plate; apex flat, with dense long setae on lateral sides; spiculum gastrale long, about 1.8 times as long as tergaum.

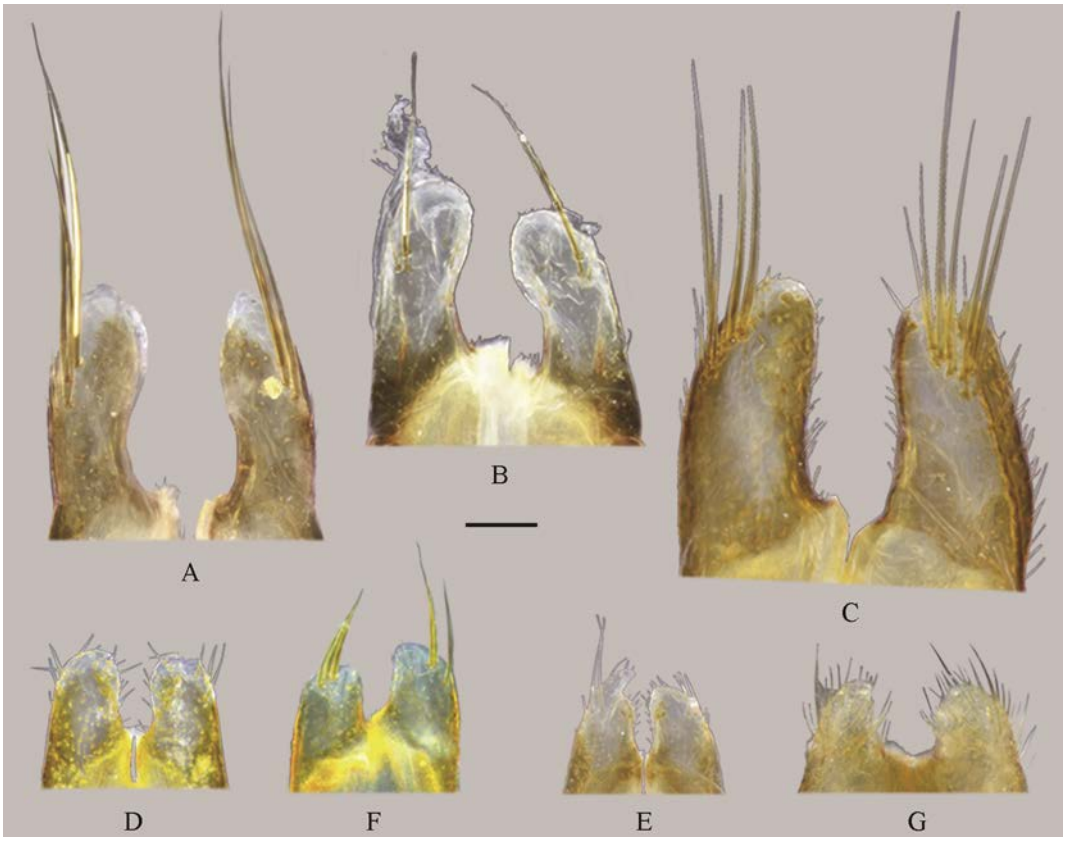


Fig. 6. Lateral lobes of *Bacchisa*, dorsal view. A–B. R3≈2. A. *B. atritarsis*. B. *B. basalis*. C. R3≈1.5, *B. comate*. D–F. R3≈1. D. *B. dioica*. E. *B. fortunei*. F. *B. rigida*. G. R3<1, *B. guerryi*. Scale bar = 0.1 mm.

3.1.4 *Bacchisa basalis* (Gahan, 1894) (Figs 5B, 6B, 7D)

Tegmen about 4.5 times as long as wide, curved; lateral lobes short, about 1/8 times as long as tegmen, sub-cylindrical, about twice as long as wide; transparent except base; with dense long hairs at middle; roof nearly as long as lateral lobes; apex dehiscent; apical margin arcuate; ringed part converging at apex, apex fishtail. Median lobe plus median struts curved, about 5.9 times as long as wide; median lobes 1.6 times as long as median struts; dorsal plate slightly shorter than ventral plate, apex pointed. Internal sac with rod at apex, rod longer than median lobe plus median struts. 8th abdominal tergaum sub-trapezoidal, 0.8 times as long as wide; apex slightly concave, with dense long setae; 8th abdominal sternum slightly shorter and narrower than tergaum, apex strong concave, with dense long setae on lateral sides; spiculum gastrale long, about 1.9 times as long as tergaum.

3.1.5 *Bacchisa comata* (Gahan, 1901) (Figs 5C, 6C, 7B)

Tegmen about 3.6 times as long as wide; lateral lobes short, about 1/10–1/11 times as long as tegmen, sub-cylindrical, about 1.5–1.6 times as long as wide; with dense short hairs, apex covered with long hairs; roof approximately as long as lateral lobes; apex dehiscent; basal margin arcuate, apical margin sinuate; ringed part converging at apex, apex flat. Median lobe plus median struts slightly curved, about 5.3 times as long as wide; median lobes 3.3 times as long as median

struts; dorsal plate slightly shorter than ventral plate, apex sharp-pointed. Internal sac with rod at apex, rod longer than median lobe plus median struts. 8th abdominal segment tergaum sub-square, 0.9 times as long as wide; apex flat, with dense long setae on lateral sides; 8th abdominal sternum slightly longer and narrower than tergaum, apex slightly concave, with dense long hairs; spiculum gastrale long, about 1.6 times as long as tergaum.

Fig. 7. Median lobe plus median struts of *Bacchisa*, dorsal view. A–C. R5>2.5. A. *B. atritarsis*. B. *B. comate*. C. *B. dioica*. D–G. R5>2.5. D. *B. basalis*. E. *B. fortunei*. F. *B. guerryi*. G. *B. rigida*. Scale bar = 0.5 mm.

3.1.6 *Bacchisa dioica* (Fairmaire, 1878) (Figs 4E–F, 5D, 6D, 7C)

Tegmen about 3.5 times as long as wide, slightly curved; lateral lobes short, about 1/12–1/14 times as long as tegmen, sub-cylindrical, about 0.7–1.0 times as long as wide; with sparse hairs; roof long, about 2.0–2.3 times as long as lateral lobes; apex dehiscent; ringed part converging at apex, apex fishtail. Median lobe plus median struts slightly curved, about 6.2 times as long as wide; median lobes 2.7 times as long as median struts; dorsal plate slightly shorter than ventral plate, apex pointed. Internal sac with rod at apex, rod longer than median lobe plus median struts and a little thicker at middle. 8th abdominal tergaum square; apex slightly concave, densely covered with long hairs on lateral sides; 8th abdominal sternum shorter and narrower than tergaum, apex slightly concave, with dense long hairs; spiculum gastrale long, about 1.4 times as long as dorsal plate.

3.1.7 *Bacchisa fortunei* (Thomson, 1857) (Figs 2C, 5E, 6E, 7E)

Tegmen about 3.5 times as long as wide, abrely curved; lateral lobes short, about 1/16 times as long as tegmen, sub-cylindrical, about 0.9–1.0 times as long as wide; with short hairs, much longer at middle; roof long, about 2.2 times as long as lateral lobes; apex dehiscent; ringed part converging at apex, apex slightly fishtail. Median lobe plus median struts curved, about 6.2 times as long as wide; median lobes 1.7 times as long as median struts; dorsal plate slightly shorter than ventral plate, apex pointed. Internal sac with rod at apex, rod longer than median lobe plus median struts. 8th abdominal tergaum sub-square, 0.9 times as long as wide; apex slightly concave, with dense long setae on lateral sides; 8th abdominal sternum slightly shorter and narrower than tergaum, apex slightly round, with dense setae; spiculum gastrale long, about 1.5 times as long as tergaum.

3.1.8 *Bacchisa guerryi* (Pic, 1911) (Figs 5G, 6G, 7F)

Tegmen about 3.9–4.7 times as long as wide; lateral lobes very short, about 1/30 times as long as tegmen, about 0.8–0.9 times as long as wide; with dense hairs; roof long, about 4.0–4.4 times as long as lateral lobes; apex dehiscent; ringed part converging at apex, apex slightly fishtail. Median lobe plus median struts slightly curved, about 7.1 times as long as wide; median lobes 2.0 times as long as median struts; dorsal plate slightly shorter than ventral plate, apex sharp-pointed. Internal sac with rod at apex, rod longer than median lobe plus median struts and a little thicker at apical half. 8th abdominal tergaum sub-square, 0.9 times as long as wide; apex slightly concave, with dense setae except middle; 8th abdominal sternum slightly shorter than tergaum and as wide as it, apex flat, with dense setae; spiculum gastrale long, about 1.6 times as long as tergaum.

3.1.9 *Bacchisa rigida* (Gressitt, 1942) (Figs 5F, 6F, 7G)

Tegmen about 4.0 times as long as wide; lateral lobes short, about 1/14–1/18 times as long as tegmen, sub-cylindrical, about 0.9–1.0 times as long as wide; apex transparent and with little hairs; roof long, about 1.9–2.3 times as long as lateral lobes; apex dehiscent; ringed part converging at apex, apex fishtail. Median lobe plus median struts slightly curved, about 4.4 times as long as wide; median lobes 1.8 times as long as median struts; dorsal plate slightly shorter than ventral plate, apex pointed. Internal sac with rod at apex, rod longer than median lobe plus median struts and a little thicker at apical half. 8th abdominal tergaum sub-trapezoidal, 0.8 times as long as wide; apex round, with dense setae on lateral sides; 8th abdominal sternum slightly shorter than tergaum and as wide as it, apex concave, with dense long setae; spiculum gastrale a little short, about 1.2 times as long as tergaum.

3.1.10 *Plaxomicrus ellipticus* Thomson, 1857 (Figs 2D, 3D, 4G–H)

Tegmen about 3.8 times as long as wide, barely curved; lateral lobes very short, about 1/17–1/21 times as long as tegmen, sub-cylindrical, about 1.3–1.5 times as long as wide; with little long hairs at middle; roof very long, about 2.4–3.0 times as long as lateral lobes; apex dehiscent; apical margin arcuate; ringed part converging at apex, apex fishtail. Median lobe plus median struts slightly curved, about 6.2 times as long as wide; median lobes 2.6 times as long as median struts; dorsal plate shorter than ventral plate, apex sharp-pointed. Internal sac with rod at apex, rod longer than median lobe plus median struts and thicker at apical half. 8th abdominal tergaum sub-trapezoidal, 0.9 times as long as wide; apex flat, lateral

sides arched and with dense short setae; 8th abdominal sternum slightly longer than tergaum; apex flat, lateral sides arched and with dense short setae; spiculum gastrale short, about 1.2 times as long as tergaum.

3.1.11 *Tetraophthalmus episcopalis* (Chevrolat, 1852) (Figs 2E, 3E, 4I–J)

Tegmen about 3.5 times as long as wide, slightly curved; lateral lobes long, about 1/4 times as long as tegmen, narrowed toward apex, about 2.3–2.4 times as long as wide; with long hairs at apical 1/2 and dense setae at base; roof very short, about 0.5 times as long as lateral lobes; apex protruding at middle; apical margin straight; ringed part converging at apex, apex slightly fishtail. Median lobe plus median struts slightly curved, about 4.6 times as long as wide; median lobes 1.6 times as long as median struts; dorsal plate slightly shorter than ventral plate, apex slightly pointed. Internal sac with rod at apex, rod thick and about 1/3 times as long as median lobe plus median struts. 8th abdominal tergaum transverse, 0.8 times as long as wide; apex slightly concave, with dense setae; 8th abdominal sternum slightly shorter and narrower than tergaum, apex round, with long setae on lateral sides; spiculum gastrale a little short, about 1.4 times as long as tergaum.

3.1.12 *Tetraophthalmus janthinipennis cyanopterus* (Gahan, 1900) (Figs 2F, 3F, 4K–L)

Tegmen about 4.0 times as long as wide, curved; lateral lobes long, about 1/4 times as long as tegmen, narrowed toward apex, about 2.1–2.6 times as long as wide; with long hairs at apical 1/2 and dense setae at base; roof very short, about 0.3–0.4 times as long as lateral lobes; apex protruding and dehiscent at middle; apical margin somewhat flat; ringed part converging at apex, apex slightly fishtail. Median lobe plus median struts strong curved, about 4.3-4.6 times as long as wide; median lobes 2.1 times as long as median struts; dorsal plate slightly shorter than ventral plate, apex slightly pointed. Internal sac with rod at apex, rod thick and about 1/3 times as long as median lobe plus median struts. 8th abdominal tergaum sub-square, 0.9 times as long as wide; apex flat, with dense setae; 8th abdominal sternum slightly shorter and narrower than tergaum, apex flat, with setae on lateral sides; spiculum gastrale long, about 1.6 times as long as tergaum.

3.1.13 *Tetraophthalmus janthinipennis janthinipennis* (Fairmaire, 1895) (Figs 2G, 3G, 4M–N)

Tegmen about 3.7 times as long as wide, curved; lateral lobes long, about 1/4 times as long as tegmen, narrowed toward apex, about 2.6 times as long as wide; with long hairs at apical 1/2 and dense setae at base; roof very short, about 0.3 times as long as lateral lobes; apex protruding and dehiscent at middle; apical margin somewhat flat; ringed part converging at apex, apex slightly fishtail. Median lobe plus median struts strong curved, about 3.8 times as long as wide; median lobes 2.2 times as long as median struts; dorsal plate slightly shorter than ventral plate, apex slightly pointed. Internal sac with rod at apex, rod thick and about 1/3 times as long as median lobe plus median struts. 8th abdominal tergaum sub-square, 0.9 times as long as wide; apex flat, with dense setae; 8th abdominal sternum slightly shorter and narrower than tergaum, apex flat, with setae on lateral sides; spiculum gastrale a little short, about 1.3 times as long as tergaum.

3.2 Comparative morphology results

Based on former works and examination of male genitalia, 27 genital characters were selected for comparative morphological study (Table 2). The result indicated that the male genitalia are much different among Astathini (Table 3), 14 genital characters were found, of which five characters could be used to distinguish genera of the tribe Astathini (Table 4), and six characters could be used to distinguish species in the genus *Bacchisa* (Table 5).

3.2.1 Tribe Astathini

By Comparing 27 genital characters from 13 species of Astathini, the results indicated that 14 characters are valuable to the taxonomic research of the tribe, and five among them can be used to identify genus (Table 4), such as ratio of the length of lateral lobe versus that of tegmen (Figs 2A–G), ratio of the length of roof versus that of lateral lobe, shape of the apex of 8th abdominal tergaum, shape of the apex of 8th abdominal sternum (Figs 3A–G) and ratio of the length of the rod at the apex of internal sac versus that of median lobe plus median struts (Figs 4A–N).

Table 2. Character chosen for morphological comparison.

Characters	Abbreviation	In detail
Curvature	C1	Median lobe plus median struts in lateral view
	C2	Tegmen in lateral view
Degree	D1	Lateral lobe arched in lateral view
	D2	Roof dehiscent
Position	P1	Ringed part of tegmen converging
Ratio	R1	Length versus width of tegmen
	R2	Length of lateral lobe versus that of tegmen
	R3	Length versus width of the lateral lobe
	R4	Length of roof versus that of lateral lobe
	R5	Length of median lobe versus that of median struts
	R6	Length versus width of meidan lobe plus median struts
	R7	Length of rod at the apex of internal sac versus that of median lobe plus median struts
Setation	S1	Lateral lobe
	S2	8th abdominal tergaum
	S3	8th abdominal sternum
Shape	SH1	Lateral lobe
	SH2	Apex of the ringed part of tegmen
	SH3	Apex of ventral plate of median lobe
	SH4	8th abdominal tergaum
	SH5	Apex of 8th abdominal tergaum
	SH6	8th abdominal sternum
	SH7	Apex of 8th abdominal sternum
Yes/No	W1	Apex of roof protruding
	W2	Apex of roof dehiscent
	W3	Apical margin of roof clear
	W4	Dorsal plate of median lobe evidently shorter than ventral plate

3.2.2 Genus *Bacchisa*

Seven selected species of the genus *Bacchisa* are very similar in body shape and color. However, the result of the morphological comparison of male genitalia indicated that their male genitalia are very different, and there are six characters were found which can be used for identification (Table 5), such as ratio of the length of lateral lobe versus that of tegmen (5A–G), ratio of the length versus width of the lateral lobe (6A–G), ratio of the length of roof versus that of lateral lobe, shape of the apex of the ringed part of tegmen, shape of the apex of ventral plate of median lobe, and ratio of the length of median lobe versus that of median struts (7A–G).

4 Discussion

The most important character of the male genitalia is with a rod at apex of internal sac in the tribe Astathini. Meanwhile, the length of the rod is consistent with that of spermathecal duct in female, which is as same as the result of the study of *Lema (Lema) coronate* (Matsumura & Yoshizawa, 2010).

In addition, the result of the morphological comparison of male genitalia indicated that the character of the genus *Anastathes* is similar to *Bacchisa* and *Tetraophthalmus*, which showed that the relationships among them were much closed. Moreover, the male genitalia of the species in the genus *Plaxomicrus* are almost same to that of the species in the genus *Bacchisa*, except for the shape of the apex of 8th abdominal tergaum and sternum. Therefore, the relationship between *Plaxomicrus* and *Bacchisa* may be much closed.

Table 3. Comparison of genital characters in Astathini.

Genus	Species	R2	R3	R4	W1	W2	W3	SH2	SH3	R5	R6	R7	S4	W4	SH5
Anastathes	*A. parvus hainana*	1/7	1.7–1.8	0.4	No	No	No	Flat	Pointed	2	4.9	>1	Slightly curved	No	Slightly concave
	A. robustus	2/9	1.7–1.9	0.7–0.8	No	Yes	No	Falt	Pointed	3.1	5.6	1	Slightly curved	No	Flat
Baccshisa	*B. atritarsis*	1/9–1/10	2.2–2.3	0.7–0.8	No	Yes	No	Flat	Sharp-pointed and elongate	3.4	5.8	>1	Slightly curved	Yes	Flat
	B. basalis	1/8	1.9–2.0	1.0	No	Yes	No	Fishtail	Pointed	1.6	5.9	>1	Curved	No	Strong concave
	B. comata	1/10–1/11	1.5–1.6	0.9–1.0	No	Yes	No	Flat	Sharp-pointed	3.3	5.3	>1	Slightly curved	No	Slightly concave
	B. dioica	1/12–1/14	0.7–1.0	2.0–2.3	No	Yes	No	Fishtail	Pointed	2.7	6.2	>1	Slightly curved	No	Slightly concave
	B. fortunei	1/16	0.9–1.0	2.2	No	Yes	No	Slightly fishtail	Pointed	1.7	6.2	>1	Curved	No	Slightly round
	B. guerryi	1/30	0.6–0.7	4–4.4	No	Yes	No	Flat	Sharp-pointed	2	7.1	>1	Slightly curved	No	Flat
	B. rigida	1/14–1/18	0.9–1.1	1.9–2.3	No	Yes	No	Fishtail	Pointed	1.8	6.1	>1	Curved	No	Round
Plaxomicrus	*P. ellipticus*	1/17–1/21	1.3–1.5	2.4–3	No	Yes	No	Fishtail	Sharp-pointed	2.6	6.2	>1	Barely curved	No	Flat, lateral sides arched
Tetraophthalmus	*T. episcopalis*	1/4	2.3–2.4	0.5	Yes	No	Yes, Slightly flat	Flat	Slightly pointed	2.6	4.6	Ca. 1/3	Strong curved	No	Slightly concave
	T. janthinipennis cyanopterus	1/4	2.1–2.6	0.3–0.4	Yes	Yes	Yes, Slightly flat	Slightly fishtail	Slightly pointed	2.1–2.4	4.3–4.6	Ca. 1/3	Strong curved	No	Flat
	T. janthinipennis janthinipennis	1/4	2.6	0.3	Yes	Yes	Yes, Slightly flat	Slightly fishtail	Slightly pointed	2.2–2.3	3.7–3.8	Ca. 1/3	Strong curved	No	Flat

Table 4. Comparison of genital characters in.the tribe Astathini.

Genus	R2	R4	SH5	SH7	R7
Anastathes	1/7–2/9	0.5–0.6	Lateral sides not arched	Lateral sides not arched	⩾1
Bacchisa	1/30–1/8	0.7–4.4	Lateral sides not arched	Lateral sides not arched	>1
Plaxomicrus	1/21–1/17	2.4–3.0	Flat, lateral sides arched	Flat, lateral sides arched	>1
Tetraophthalmus	1/6–1/4	0.3–0.5	Lateral sides not arched	Lateral sides not arched	Ca. 1/3

Table 5. Comparison of genital characters of the genus *Bacchisa.*

Species	R2	R3	R4	SH2	SH3	R5
B. atritarsis	1/9-1/10	2.2-2.3	0.7-0.8	Flat	Sharp-pointed and elongate	3.4
B. basalis	1/8	1.9-2.0	1.0	Fishtail	Pointed	1.6
B. comata	1/10-1/11	1.5-1.6	0.9-1.0	Flat	Sharp-pointed	3.3
B. dioica	1/12-1/14	0.7-1.0	2.0-2.3	Fishtail	Pointed	2.7
B. fortunei	1/16	0.9-1.0	2.2	Slightly fishtail	Pointed	1.7
B. guerryi	1/30	0.6-0.7	4-4.4	Flat	Sharp-pointed	2.0
B. rigida	1/14-1/18	0.9-1.1	1.9-2.3	Fishtail	Pointed	1.8

Acknowledgements We send great appreciation to Prof. Xin-Li Wang (CAU), Prof. Guo-Dong Ren (HBU), Prof. Hong Pang (SYSU) for providing specimens. We are also very grateful to Mr. Gui-Qiang Huang and Ms. Jian-Yue Qiu for advice in picture processing.

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