

A Checklist and Key to Species of the Genus *Betacixius* Matsumura (Hemiptera: Fulgoromorpha: Cixiidae) with Descriptions of Two New Species from Guizhou Province, China

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A CHECKLIST AND KEY TO SPECIES OF THE GENUS *BETACIXIUS* MATSUMURA (HEMIPTERA: FULGOROMORPHA: CIXIIDAE) WITH DESCRIPTIONS OF TWO NEW SPECIES FROM GUIZHOU PROVINCE, CHINA

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ABSTRACT

Two new species of *Betacixius* Matsumura, 1914 (Hemiptera: Fulgoromorpha: Cixiidae: Cixiini), *B. bispinus* Zhang and Chen **sp. nov.** (China: Guizhou) and *B. flagellihamus* Zhang and Chen **sp. nov.** (China: Guizhou), from southwest China, are described and illustrated. A key for identifying 23 known species of *Betacixius* is provided.

Key Words: Hemiptera, Fulgoroidea, Cixiidae, Oriental region, *Betacixius*, new species, China

RESUMEN

Se describen e ilustran dos nuevas especies de *Betacixius* Matsumura, 1914 (Hemiptera: Fulgoromorpha: Cixiidae: Cixiini), *B. bispinus* Zhang y Chen **sp. nov.** (China: Guizhou) y *B. flagellihamus* Zhang y Chen **sp. nov.** (China: Guizhou) del suroeste de China. Se provee una clave para identificar las 23 especies conocidas de *Betacixius*.

The cixiid planthopper genus *Betacixius* (Cixiinae: Cixiini) was established by Matsumura (1914) for the type species, *B. ocellatus* Matsumura, 1914, from Japan. To date, 21 species with 2 subspecies have been recorded worldwide and all species occur in the southern region (Matsumura 1914; Schumacher 1915; Metcalf 1936; Jacobi 1944; Fennah 1956; Hori 1982; Chou et al. 1985, 1988; Tsaur et al. 1991; Hua 2002).

During the course of studying species biodiversity of the suborder Auchenorrhyncha in southwest China, 2 specimens belonging to undescribed species of the genus *Betacixius* were found. The purpose of this paper is to describe these 2 new species and to provide an identification key to all species of *Betacixius*.

MATERIALS AND METHODS

Morphological terminology follows Löcker et al. (2006). Dry specimens were used for the description and illustration. External morphology was observed under a stereoscopic microscope and characters were measured with an ocular micrometer. The genital segments of the examined specimens were macerated in 10% KOH and drawn from preparations in glycerin jelly with the aid of a Leica MZ 12.5 stereomicroscope. Illus-

trations were scanned with Canon CanoScan LiDE 200 and imported into Adobe Photoshop 8.0 for labeling and plate composition. Specimens examined are deposited in the Institute of Entomology, Guizhou University, Guiyang, Guizhou Province, China (IEGU).

DESCRIPTIVE TAXONOMY

Betacixius Matsumura, 1914 (Figs. 1-25)

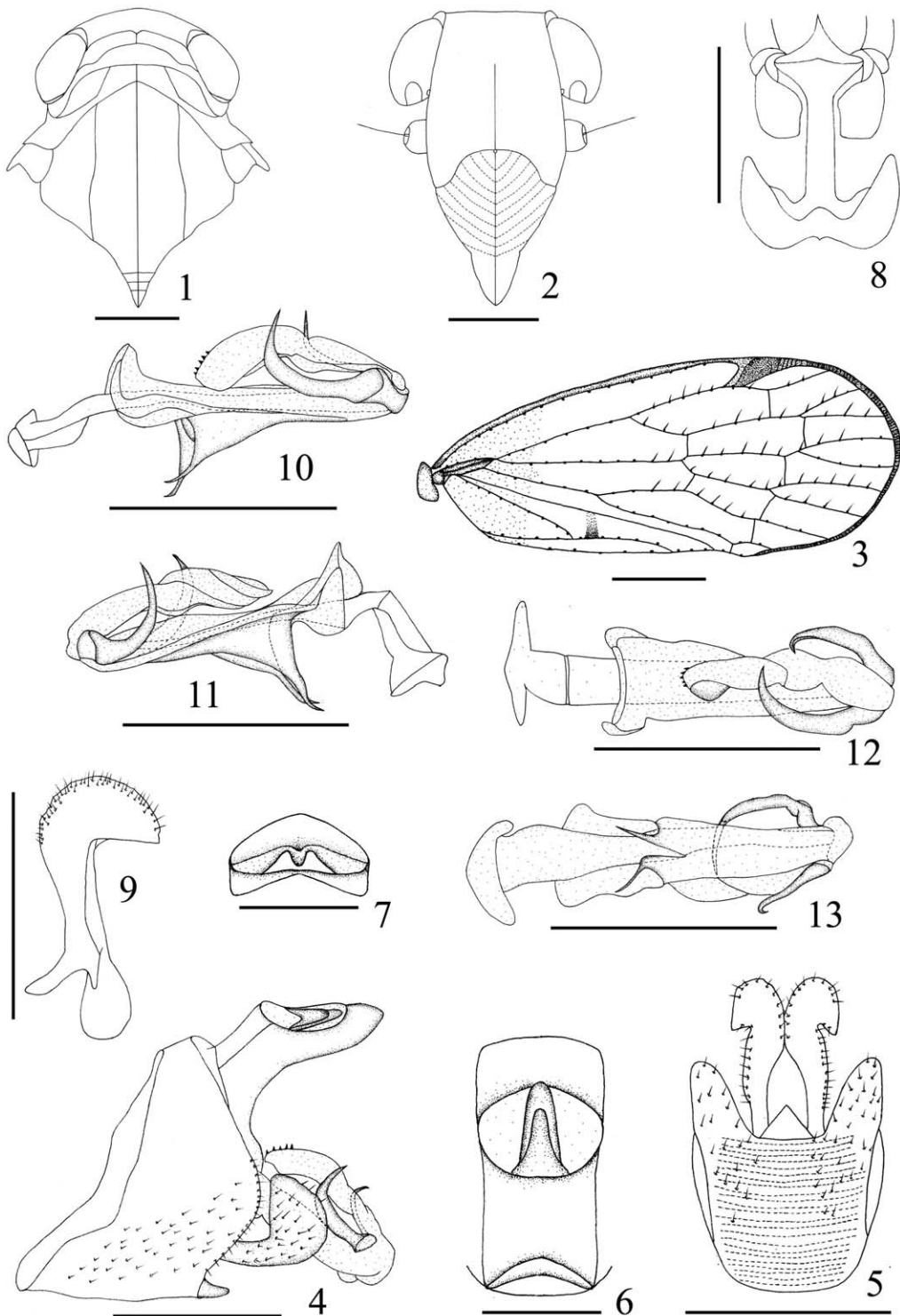
Betacixius Matsumura 1914: 412; Chou et al. 1985: 23; Tsaur et al. 1991: 27.

Type species: *Betacixius ocellatus* Matsumura 1914, by original designation.

Description. This is a redescription incorporating the descriptions previously published by Chou et al. (1985) and Tsaur et al. (1991) as follows.

Body Size and Coloration. Small to medium-size cixiids (4.3-7.3 mm). Body coloration varying from green, brown to fulvous, mostly bearing special markings on anteclypeus; lateroapical parts of frons, otherwise unicolorous throughout.

Head and Thorax. Head including eyes slightly narrower than pronotum. Vertex much wider than long in midline, widest basally or



Figs. 1-13. *Betacixius bispinus* Zhang and Chen **sp. nov.** 1. Head and thorax, dorsal view; 2. Frons; 3. Forewing; 4. Male genitalia, lateral view; 5. Pygofer and genital styles, ventral view; 6. Anal segment, dorsal view; 7. Anal segment, caudal view; 8. Connective, caudal view; 9. Right genital style, ventral view; 10. Aedeagus, left side; 11. Aedeagus, right side; 12. Aedeagus, dorsal view; 13. Aedeagus, ventral view. Scale bars = 0.25 mm (Figs. 6, 7), 0.5 mm (Figs. 1, 2, 4, 5, 8-13), 1 mm (Fig. 3).

apically, lateral carinae moderately elevated, disc shallowly hollowed on each side of median carina. Frons rounded at base, usually with incomplete median carina not reaching anterior margin of vertex, lateral carinae slightly elevated below level of eyes, with small median ocellus and semicircular frontoclypeal suture. Clypeus tricarinate, convex to midline. Pronotum small, with distinct median carina, intermedian carinae curving laterad, angularly rounded posteriorly. Mesonotum tricarinate, convex between lateral carinae, flattened posteromedially. Forewings broadest at apical third, rounded at apex, with 4-5 subapical cells and 8-9 apical cells, hyaline, sometimes with an oblique band or ocellated stripe. Hind tibia with 2-4 lateral spines and 6 apical spines. Chaetotaxy of hind tarsus 7/7.

Male Genitalia. Pygofer symmetrical, U-shaped, with thumb-shaped dorsolateral angles in ventral view. Medioventral process triangular or subtriangular in ventral view, generally wider at base than long in midline. Anal segment tubular. Genital styles symmetrical in ventral view. Aedeagus slender in lateral view.

Distribution. Oriental and Palaearctic regions.

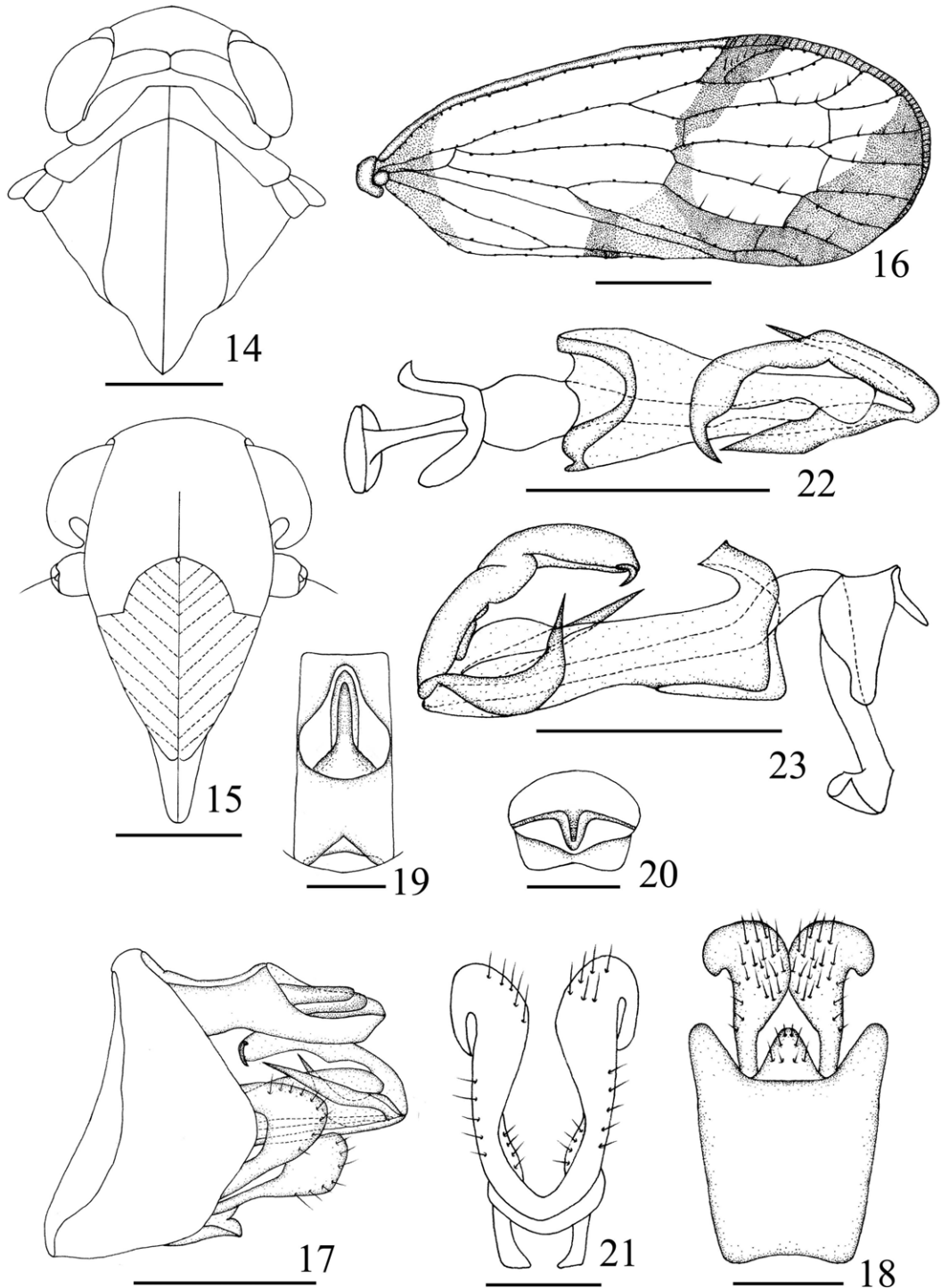
Remarks. This genus may be easily distinguished from other genera of Cixiini by the presence of 4-5 subapical cells and 8-9 apical cells on the forewing, vertex much wider than long in midline, frons with incomplete median carina distinct near frontoclypeal suture, and chaetotaxy of hind tarsus 7/7. The 2 new species, *B. bispinus* Zhang and Chen **sp. nov.** (China: Guizhou) and *B. flagellihamus* Zhang and Chen **sp. nov.** (China: Guizhou), fit into the genus by the presence of features as above.

WORLD CHECKLIST OF SPECIES OF *BETACIXIUS* MATSUMURA

- B. bispinus* Zhang and Chen **sp. nov.**; southwestern China (Guizhou).
- B. brunneus* Matsumura (1914); China (Taiwan), Japan.
- B. clypealis* Matsumura (1914); China (Taiwan).
- B. clypealis vittifrons* Matsumura (1914); China (Taiwan).
- B. delicatus* Tsaur & Hsu (1991); China (Taiwan).
- B. euterpe* Fennah (1956); China (Guangdong).
- B. flagellihamus* Zhang and Chen **sp. nov.**; southwestern China (Guizhou).
- B. flavovittatus* Hori (1982); China (Taiwan).
- B. fuscus* Tsaur & Hsu (1991); China (Taiwan).
- B. herbaceus* Tsaur & Hsu (1991); China (Taiwan).
- B. kumejimae* Matsumura (1914); South China, Japan (Okinawa).
- B. maculosus* Tsaur & Hsu (1991); China (Taiwan).
- B. michioi* Hori (1982); China (Taiwan).
- B. nelides* Fennah (1956); China (Zhejiang, Guangdong).
- B. nigromarginalis* Fennah (1956); China (Hubei).
- B. obliquus* Matsumura (1914); South China, Japan (Gifu).
- B. obliquus pallens* Matsumura (1914); Japan (Tokyo, Harima, Kumanoto).
- B. ocellatus* Matsumura (1914); China (Taiwan), Japan.
- B. pallidior* Jacobi (1944); South China (Fujian).
- B. rinkihonis* Matsumura (1914); China (Taiwan), Japan.
- B. robustus* Jacobi (1944); South China (Fujian).
- B. shirozui* Hori (1982); China (Taiwan).
- B. sparsus* Tsaur & Hsu (1991); China (Taiwan).
- B. tonkinensis* Matsumura (1914); South China, Vietnam.
- B. transversus* Jacobi (1944); South China (Fujian).

KEY TO SPECIES OF THE GENUS *BETACIXIUS* MATSUMURA

- 1. Forewings with markings (Figs. 3, 16, 24, 25) 2
- Forewings without any markings 9
- 2. Forewings with a large ocellate marking in apical half (Figs. 16 and 25) 3



Figs. 14-23. *Betacixius flagellihamus* Zhang and Chen **sp. nov.** 14. Head and thorax, dorsal view; 15. Frons; 16. Forewing; 17. Male genitalia, lateral view; 18. Pygofer and genital styles, ventral view; 19. Anal segment, dorsal view; 20. Anal segment, caudal view; 21. Genital styles, ventral view; 22. Aedeagus, dorsal view; 23. Aedeagus, right side. Scale bars = 0.25 mm (Figs. 18-21), 0.5 mm (Figs. 14, 15, 17, 22, 23), 1 mm (Fig. 16).

- Forewings without such a marking in apical half (Figs. 3 and 24) 6
- 3. Forewings with an oblique brown band extending from clavus across middle of corium *B. tonkinensis*
- Forewings without such a band (Figs. 16 and 25) 4
- 4. Flagellum of aedeagus with 1 spine, hook-shaped (Figs. 22 and 23) *B. flagellihamus* **sp. nov.**
- Flagellum of aedeagus with 2 spines, not hook-shaped. 5
- 5. Aedeagus with 2 L-shaped processes apically *B. maculosus*
- Aedeagus with 1 nearly straight and 1 arched process apically. *B. ocellatus*
- 6. Forewings with an oblique band extending from stigma passing through its middle part 7
- Forewings without such a band (Figs. 3 and 24) 12
- 7. Frons with median carina distinct on apical third; hind basitarsus much longer than the 2nd and 3rd segment put together. *B. michioi*
- Frons and hind basitarsus without features as above. 8
- 8. Forewings with apical cells of M and Cu strongly infusate. *B. transversus*
- Forewings with apical cells not infusate. 9
- 9. Forewings with apical margin black or distinctly darkened. 10
- Forewings with apical margin fuscous or not distinctly darkened 11
- 10. Frons with a pallid spot at centre of lateral margins, clypeus dark, mesonotum testaceous *B. kumejimae*
- Frons without such spots; mesonotum, except scutellum, castaneous-piceous *B. euterpe*
- 11. Forewings with an oblique dark band extending from clavus into centre of corium, slightly distad of level of union of claval veins. *B. obliquus*
- Forewings with a spot near sutural margin of clavus near union of claval veins, no oblique dark band at this level extending into corium *B. pallidior*
- 12. Forewings with a long black stripe from base, along clavus extending to Rs *B. fuscus*
- Forewings without such a stripe (Figs. 3 and 24) 13
- 13. Fore tibiae with black, longitudinal stripes 14
- Fore tibiae without such stripes 15
- 14. Mid- and hind- tibiae with black, longitudinal stripes *B. delicatus*
- Mid- and hind- tibiae without such stripes *B. sparsus*
- 15. Forewings infuscated at base, extending along clavus to end of Cu₁; mesonotum with a large, very distinct brown marking between lateral carinae *B. shirozui*
- Forewings and mesonotum without spots as above (Figs. 3 and 24) 16
- 16. Forewings with apical margin black or very dark (Figs. 3 and 24) 17
- Forewings with apical margin not particularly dark. 18
- 17. Medioventral process of pygofer in ventral view right-angled triangular, pointed at apex (Fig. 5); on ventral margin, perianthrium with lobate processes, 2 broad processes basally, bending forward, directed ventrocephalad, flagellum semisclerotised, with several serrated processes near apex (Figs. 10 and 12) *B. bispinus* **sp. nov.**
- Medioventral process in ventral view subtriangular, rounded at apex; perianthrium without lobate processes, but with serrated processes basally, flagellum, without any processes *B. rinkihonis*
- 18. First apical cell of forewing piceous *B. robustus*
- A dark suffusion over all apical cells and across base of forewing *B. nelides*

19. Aedeagus with a curved spine on left near apex and a short ledge in a similar position on right; flagellum arising above left margin, sides parallel for most of length, distally a short curved spine directed cephalad, and a subquadrate plate with a stout spine directed ventrad *B. nigromarginalis*
- Aedeagus and flagellum without features as above 20
20. Frons without median carina *B. clypealis*
- Frons with median carina 21
21. Frons with white or yellowish lateroapical parts; anteclypeus entirely black *B. flavovittatus*
- Frons and clypeus unicolorous 22
22. Body pale brown; flagellum of aedeagus with 2 processes on right side *B. brunneus*
- Body green; flagellum of aedeagus with one process on each side *B. herbaceus*

Betacixius bispinus Zhang and Chen **sp. nov.**

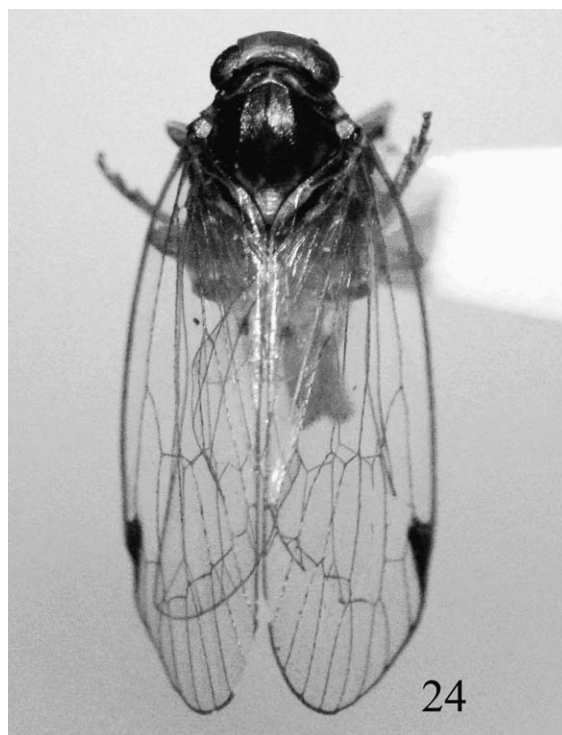
(Figs. 1-13, 24)

Description. Body length (from apex of vertex to tip of forewings): male 5.0-6.1mm ($n = 2$), female 5.5-6.8mm ($n = 7$); forewing length: male 4.0-4.9mm ($n = 2$), female 4.5-5.7mm ($n = 7$).

Coloration. General color brown. Body slightly covered with powdery wax. Eyes yellowish brown to blackish brown; ocelli reddish yellow. Vertex yellowish brown. Pronotum blackish brown except median carina yellowish brown. Mesonotum blackish brown, with yellowish brown area pos-

teromedially, carinae concolorous. Frons yellowish brown except lateral carinae blackish brown. Postclypeus yellowish brown, anteclypeus blackish brown. Rostrum generally yellowish brown, blackish brown near tip. Forewings pale brown, hyaline; veins brown, tubercles dark brown; stigma black; clavus with a short transversal brown band, just distad of fork PCu+A₁. Hind-tibiae yellowish brown, lateral- and apical- spines yellowish brown basally, black apically; platellae of tarsi dark brown. Abdomen black ventrally.

Head and Thorax. Vertex narrowing to apex as shown in Figs. 1 and 24, wider than distance be-



Figs. 24-25. Body of adult in dorsal view. 24. *Betacixius bispinus* Zhang and Chen **sp. nov.**; 25. *Betacixius flagellihamus* Zhang and Chen **sp. nov.**

tween eyes, 2.5 times wider than long in midline; anterior margin arched convex, with small emargination at midpoint, posterior margin arched concave; median carina indistinct, lateral carinae without branches, subapical carina absent. Median ocellus very small, located the centre of the frontoclypeal suture. Pedicel of antenna 1.6 times longer than wide. Frons broad, with small spots on middle area, widest at level of lateral ocelli, narrowing to both ends, 1.25 times longer than wide in midline; median carina indistinct, extending from slightly above level of lateral ocelli to median ocellus, lateral carinae distinct and ridged, arched convex; anterior margin arched concave. Clypeus with median carina distinct and elevated throughout, widest at level of endpoints of frontoclypeal suture; lateral carinae distinct and elevated. Rostrum relatively short, reaching hind coxae, apical and subapical segments equally long. Pronotum short and narrow, collar-like, twice as long as vertex in midline; median carina distinct and complete; intermediate carinae corrugated and curving into posterior margin which is concave in obtuse angle. Mesonotum 1.89 times longer than pronotum and vertex combined; 3 longitudinal carinae all reaching anterior and posterior margins, median carina indistinct on posteromedian area, which bears transverse striations. Forewings 2.22 times longer than wide, with sparse setae on surface, tubercles along veins, claval veins without tubercles; 2 indistinct subapical lines of cross veins; fork Sc+RP distad of fork CuA1+CuA2; r-m crossvein slightly distad of fork MA+MP; RP apically bifid, MA apically bifid, MP apically bifid; fork PCu+A1 slightly basad of centre of clavus; Sc+R and M fused at superior-outside angle of basal cell; fork MA1+MA2 distad of fork MP1+MP2. 2nd hind-tarsus with 5 platellae; hind-tibia with 4 lateral spines, 6 apical spines: 2 large, 1 medium, 3 small, divided into 2 groups.

Male Genitalia. In ventral view, pygofer stout, slightly concave medially, widening laterally; dorsal margin caudad obliquely raised in lateral view, inferior part with bristles; lateral lobes symmetrical, medium-inferior part arched convexly in lateral view. Medioventral process right-angled triangular in ventral view, relatively broad, 1.5 times wider than long, distance between tips of 2 lateral lobes 3.06 times as long as width of medioventral process; narrow triangular in lateral view, covered basally. Anal segment short and stout as shown in Figs 4, 6 and 7; 2.13 times longer than wide in dorsal view; incompletely connected with pygofer, freely movable; anal style, finger-like apically, not beyond anal segment; anal opening nearly subelliptical in dorsal view. Genital styles as shown in Figs. 4, 5 and 9, in ventral view, widening to apex, apical margin truncated, with sharp angle outside, internal processes broad,

touching each other; in lateral view, ventral margin curving upward, outside slightly corrugated, dorsal margin smooth and bent forming a right angle approximately; incompletely connected with connective, freely movable; apical margin with bristles in ventral view. Aedeagus broad, short, connected with anal segment by 2 points; each side with broad spine arising at apex of aedeagal shaft, curving upward; periandrium ventrally with lobate processes, basally 2 broad processes, bending forward, directed ventrocephalad. Connective anchor-like, relatively long, the width of aedeagal shaft 1.65 times as wide as width of connective plus ventral arm. Flagellum semi-sclerotised, structure simple, generally curving left, with several serrated processes near apex.

Type Material. Holotype: ♂, Mayanghe National Natural Reserve (600m), Yanhe County, Guizhou Province, China, 5-12 June 2007, X.-S. Chen. Paratypes: 1♂, 7♀, same data as holotype.

Etymology. The name is derived from the Latin words *bi-* (double) and *spinus* (spine), which refers to the 2 spines on ventral margin of periandrium.

Distribution: Southwest China (Guizhou Province).

Remarks. This new species is similar in appearance to *B. rinkihonis*, but differs from the latter in the shape of the medioventral process and the anal segment and by having 2 spines on the ventral margin of the periandrium and several serrated processes near apex of flagellum.

Betacixius flagellihamus Zhang and Chen **sp. nov.**
(Figs. 14-23, 25)

Description. Body length (from apex of vertex to tip of forewings): male 5.0-5.8mm ($n = 13$), female 5.4-6.2mm ($n = 15$); forewing length: male 4.5-5.0mm ($n = 13$), female 4.6-5.1mm ($n = 15$).

Coloration. General color brown. Body covered with powdery wax. Median area of eyes black, ventral margin yellow, other part reddish brown to blackish brown. Median ocellus pale yellow, semihyaline; lateral ocelli red. Vertex pale yellow. Pronotum pale yellow. Mesonotum brown. Frons generally brown, bright yellow above frontoclypeal suture; postclypeus yellow to brown, with oblique streaks; anteclypeus black. Apical segment of rostrum brown, subapical segment yellow. Forewings pale brown, semihyaline, with ocellated marking as shown in Figs. 16 and 25; veins and tubercles brown; stigma brown to dark brown; clavus with dark brown stain on apical third, sometimes extending to end of clavus; clavus suture brown. Hind-tibia brown, lateral- and apical-spines brown at base, black apically; membranous tooth of tarsi dark yellow. Abdomen black ventrally.

Head and Thorax. Vertex narrowing towards apex as shown in Figs. 14 and 25, wider than distance between eyes, 2.3 times wider than long in midline, separated into 2 hollow areoletts by median carina; anterior margin generally arched convex slightly, slightly concave at midpoint, posterior margin concave in obtuse angle; median carina distinct and complete, subapical carina absent. Median ocellus indistinct, in the centre of frontoclypeal suture. Frons with well-distributed small spots, widest at level of antennae, narrowing to both ends, length equal to width; median carina distinct and elevated near frontoclypeal suture; lateral carinae slightly S-shaped, elevated; apex of frons elevated and lobate; anterior margin semicircle concave. Median carina of clypeus distinct and elevated; lateral carinae of postclypeus elevated. Rostrum reaching hindfemora, apical and subapical segments equally long. Pronotum short and narrow, collar-shaped, 2.25 times longer than vertex in midline; median carina distinct and elevated; posterior margin concave in obtuse angle. Mesonotum 1.44 times longer than pronotum and vertex combined; three longitudinal carinae elevated except for median carina weakly elevated at base, all reaching anterior and posterior margins. Forewings 2.2 times longer than wide; surface of Forewings with setae, basal part less, apical part more; veins with distinct tubercles, C vein with 34 tubercles, claval apically vein with tubercles; 2 indistinct subapical lines of cross veins; fork Sc+RP distad of fork CuA1+CuA2; r-m crossvein distad of fork MA+MP; RP apically bifid, MA apically bifid, MP apically bifid; fork PCu+A1 slightly basad of centre of clavus; Sc+R and M fused at superior-outside angle of basal cell; fork MA1+MA2 distad of fork MP1+MP2. 2nd hindtarsus with 3 platellae; hind-tibia with 3 lateral spines, 6 apical spines, being divided into 2 groups by a relatively wide gap, one group with 3 equal spines, arranged closely, the other group with 1 large and 2 small, arranged sparsely.

Male Genitalia. In ventral view, pygofer stout, shallowly U-shaped, slightly widening from base to end, ventral margin slightly concave; dorsal margin caudad obliquely upward in lateral view; lateral lobes symmetrical, inferior half slightly arched concave in lateral view. Medioventral process mastoid in ventral view, with bristles, 1.25 times wider than long, distance between tips of 2 lateral lobes 2.4 times as long as width of medioventral process; tongue-shaped in lateral view. Anal segment short and stout as shown in Figs 17, 19 and 20; in dorsal view 2 times longer than wide; compactly connected with pygofer, immovable; anal styles, not beyond anal segment; anal opening pear-like in dorsal view. Genital styles as shown in Figs 17, 18 and 21, in ventral view, widening to apex, internal processes broad, not

touching each other; in lateral view, ventral margin curving upward, dorsal margin strongly bending upward; compactly connected with connective, immovable. Aedeagus stout, structure simple; each side with a broad spine at apex of aedeagal shaft, right one curving dorsad, left one relatively straight, directed up-cephalad. Connective relatively slender, the width of aedeagal shaft 1.33 times as wide as width of connective plus ventral arm. Flagellum strongly sclerotised, freely movable, structure simple, with a barb-shaped spine at apex.

Type Material. Holotype: ♂, Leigongshan National Natural Reserve, Leishan County, Guizhou Province, China, 13 May 1985, Z.-Z. Li. Paratypes: 7♂♂, 9♀♀, same data as holotype; 2♂♂, 3♀♀, Guiyang, Guizhou Province, China, June 1983, Students of Grade 79, Major Plant-protecting; 2♂♂, 1♀, Huaxi (1000m), Guiyang, Guizhou Province, 20 May 2007, Q.-Z. Song; 1♂, 2♀♀, Forest Park (1000m), Guiyang, Guizhou Province, China, 20 May 2007, X.-S. Chen.

Etymology. The name is derived from the Latin words *flagell* (flagellate) and *hamus* (hook), which refers to the hook-like spine of flagellum.

Distribution: Southwest China (Guizhou Province).

Remarks. This new species is similar in appearance to *B. ocellatus*, but differs from the latter in the shape of the anal segment and the number of spines on the flagellum.

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