The wood-feeding genus Cryptocercus (Blattodea: Cryptocercidae), with description of two new species based on female genitalia

Zong-Qing Wang, Yang Li, Yan-Li Che* and Jin-Jun Wang

Abstract

Two new Chinese Cryptocercus (Blattodea: Cryptocercidae) species, C. arcuatus sp. nov. and C. convexus sp. nov., are described together with photographs. This description includes the external structure of the adults and structures of the female genitalia. A comparative study of female genitalia was based on the 5 Chinese species in the family Cryptocercidae. Significant differences in female genitalia of Cryptocercidae are summarized. A key to these 5 species and a checklist of the species of Cryptocercus worldwide are provided.

Key Words: Cryptocercidae; termite; genitalia; China

Material and Methods

Specimens were collected by chopping logs and were preserved in 100% ethanol or pinned. Terminology used in this paper mainly follows McKittrick (1964). Adult males and females were examined under the microscope. The genital segments of the examined specimens were macerated in 10% NaOH and observed in glycerin jelly using a Motic K400 stereomicroscope. Photographs of the female genitalia of species were made by a Leica M205A microscope by a Leica DFC camera. Images were produced by the software version LAS (Leica Application Suite) V3.7. All specimens studied are deposited in the College of Plant Protection of Southwest University (SWU), Beibei, China.

Results

Genus Cryptocercus Scudder, 1862


Body medium, glossy brown to dark brown with dorsal surface finely punctured. Pronotum coarse with peculiar shape, disc depressed with protuberances, also with a protruding fore margin. Both male and
female wingless. All legs powerful and armed with stout, articulated spines; front femur Type D₄, D₅, or D₆, tarsus with pulvilli, tarsal claws symmetrical and unspecialized. Abdomen of female slightly fuller than the male. Tergite VII extending backwards and covering the remaining segments. Styli invisible (generally sheltered by tergite VII), female and male are difficult to distinguish. Genital segments of Cryptocercidae differ from other cockroaches: tergite VII expands backwards completely concealing tergites VIII, IX and X.

Key to species of Cryptocercus in China (females)

1. Pronotum blackish brown with feeble punctuations ................................................................. C. hirtus
2. Tergite VII with posterior margin slightly truncate at middle .............................................. 3
   — Tergite VII with posterior margin weakly concave at middle (Fig. 49) ......................... C. convexus sp. nov.
3. Vestibular sclerite with anterior margin slightly concave at middle (Fig. 58), valvule II strongly protruding at base, lateral margins slightly sclerotized at middle (Fig. 61) ........................................................................................................... C. arcuatus sp. nov.
   — Vestibular sclerite with anterior margin arched, valvule II not protruding at base .......... 4
4. Front femur type varied greatly, and laterosternites IX with 1 short protuberance (Fig. 45) ........................................................................................................... C. meridianus
   — Front femur type not varied greatly, and laterosternites IX without protuberance (Fig. 25) ........................................................................................................... C. primarius

Checklist of the species of Cryptocercus

Cryptocercus punctulatus Scudder, 1862 (USA: Virginia)
C. relictus Bey-Bienko, 1935 (China: Northeast region; Russia: Ussuri region; Korea: Jeolla Province)
C. primarius Bey-Bienko, 1938 (China: Sichuan Province)
C. clevelandi Nalepa et al., 1997 (USA: Oregon)
C. darwini Burnside et al., 1999 (USA: Alabama)
C. garciai Burnside et al., 1999 (USA: Georgia)
C. wrighti Burnside et al., 1999 (USA: North Carolina)
C. matilei Grandcolas, 2000 (China: Sichuan Province)
C. kyebangensis Grandcolas et al., 2001 (South Korea: Gangwon Province)
C. hirtus Grandcolas & Bellés, 2005 (China: Gansu Province)
C. meridianus Grandcolas & Legendre, 2005 (China: Yunnan Province)
C. parvus Grandcolas & Park, 2005 (China: Heilongjiang Province)
C. convexus sp. nov. (China: Sichuan Province)
C. arcuatus sp. nov. (China: Yunnan Province)

1. Cryptocercus primarius Bey-Bienko, 1938 (Figs. 1-3, 16-25)

Cryptocercus primarius Bey-Bienko, 1938: 237.

MEASUREMENTS

Male, pronotum: length × width: 6.0-6.5 × 8.0-9.0 mm, body length: 23.0 mm; female, pronotum: length × width: 5.9-6.0 × 8.0 mm, body length: 22.5-23.0 mm.

DESCRIPTION

Body medium, brown to dark brown (Fig. 1). Vertex pale brown, ocellar spot dark brown; head with strong punctuation. Antenna brown, apex pale brown and scape gradually darker. Vertex with interocular space slightly less than distance between antennal sockets. Maxillary palps reddish brown and apical segment with tiny hairs (Fig. 2). Pronotum blackish brown with peculiar shape, disc depressed with 2 pairs of well delimited but feeble protuberances, the fore ones more or less sharp; also with a protruding fore margin (Fig. 3). Front femur Type D₄ (only 4 large spines), tarsus with pulvilli, tarsal claws symmetrical and unspecialized. Abdominal tergites brown, margins of tergites slightly upturned and sternae pale brown; both tergites and sternae punctured, tergite VII and sternite with minute hairs. Area between tergites II and III slightly depressed.

Tergite VII with anterior margin arched and posterior margin slightly truncate at middle (Fig. 19). Sternum VII produced at apical part, posterior margin truncate; with a conspicuous pair of intersternal shelves (ints.f.) at apex, which are slightly sclerotized at apex and highly sclerotized at base. Vestibular sclerite (vst.s.) broad, well delimited and unmusculated (Fig. 18). Tergite X rounded at apex; paraprocts (pp.) developed, whose apices extending beyond posterior margin of tergite X (Fig. 16).

FEMALE GENITALIA

In the roof of the genital chamber, basivalvulæ (bsv.) well-developed and elliptical; darker at apex and base, also highly sclerotized (Fig. 23). Spermatheca, sitting beyond the basivalvulæ, fused with them. Valve I (v.I) bases situated posterior to the basivalvulæ, but not fused with valvifers I (v.f.I) small and posterolateral to base of valve I, almost covered by inserted muscles; paratergites (pt.) long and slightly curved, situated between valvifers I and base of valve I. Valvifer II ring (v.f.II) well sclerotized, located at the central apodeme (c.a.) that is well-developed. Anterior arch (a.a.) with punctures in the middle (Fig. 22). Laterosternites IX (ltst.IX) small and sheet-like, fused with the bases of paratergites (Fig. 25). Laterosternal shelf (ltst.sh.) large and translucent, nearly oblong; with dense spinules at apical half which are denser near the anterior margin (Fig. 24).

MATERIAL EXAMINED

Figs. 1-15. 1-3. Cryptocercus primarius Bey-Bienko, 1938, female: (1) dorsal view; (2) ventral view; and (3) lateral view. 4-6 Cryptocercus hirtus Grandcolas & Belles, 2005, female: (4) dorsal view; (5) ventral view; and (6) lateral view. 7-9 Cryptocercus meridianus Grandcolas & Legendre, 2005, female: (7) dorsal view; (8) ventral view; and (9) lateral view. 10-12 Cryptocercus convexus sp. nov., female: (10) Paratype, dorsal view; (11) same, ventral view; and (12) same, lateral view. 13-15 Cryptocercus arcuatus sp. nov., female: (13) Paratype, dorsal view; (14) same, ventral view; (15) same, lateral view. (Scale bars = 1.0 cm). This figure is displayed in color in the online version.
**REMARKS**

Pronotum of this species has inconspicuous punctation similar to *C. convexus* sp. nov. and *C. arcuatus* sp. nov. (Figs. 3, 12, 15). Paraprocts with apices are nearly or slightly extending to the posterior margin of tergite X (Fig. 16).

2. *Cryptocercus hirtus* Grandcolas & Bellés, 2005

(Figs. 4-6, 26-35)


**DESCRIPTION**

Body medium, brown to dark brown (Fig. 4). Vertex pale brown, ocellar spot dark brown; head with strong punctation. Antenna brown, apex pale brown and scape gradually darker. Vertex with interocular space slightly less than distance between antennal sockets. Maxillary palps reddish brown and apical segment with tiny hairs (Fig. 5). Pronotum blackish brown with strong punctation, anterior margin elevated; disc depressed with 4 protuberances, the fore 2 small but sharp; protuberances also strongly depressed, and narrowing posteriorly to median incised line and terminating at short transverse groove (Fig. 6). Front femur Type D (only 4 large spines), tarsus with pulvilli, tarsal claws symmetrical and unspecialized. Abdominal tergites brown, margins of each tergite slightly upturned, sterna pale brown. Both tergites and sterna punctured, tergite VII and sternum with minute hair; area between tergites II and III slightly depressed.

**MEASUREMENTS**

Male, pronotum: length × width: 7.0 × 9.5 mm, body length: 27.0 mm; female, pronotum: length × width: 6.6-8.0 × 9.3-10.0 mm, body length: 24.1-25.0 mm.
Figs. 26-35. Cryptocercus hirtus Grandcolas & Belles, 2005: (26) supraanal plate, ventral view; (27) supraanal plate, dorsal view; (28) subgenital plate, dorsal view; (29) tergum VII, dorsal view; (30) valvule I, ventral view; (31) valvule II, ventral view; (32) valvule III, ventral view; (33) basivalvula and spermatheca (1 absent), ventral view; (34) laterosternal shelf, dorsal view; (35) laterosternite IX and paratergites, ventral view. (Scale bars = 1.0 mm). This figure is displayed in color in the online version.
Tergite VII with anterior margin slightly truncate and posterior margin obtuse (Fig. 29). Sternum VII slightly produced at apex, posterior margin truncate; with a conspicuous pair of intersternal shelves (ints.f.) at apex which are slightly sclerotized at anterior margins. Vestibular sclerite (vst.s.) broad, clearly defined, with anterior margin slightly concave in the middle and unmosculated; membrane surrounding vestibular sclerite which is connected with tergite X (TX) (Fig. 28). Tergite X rounded at apex; paraprocts (pp.) developed with apices extending to the posterior margin of tergite X, with the gap between paraprocts narrow (Fig. 26).

FEMALE GENITALIA

In the roof of the genital chamber, the basivalvulae (bsv.) well-developed and divided into 2 parts which are symmetrical, left basivalvula nearly elliptical, apex slightly dilated on the left, and slightly narrow on the right, with 1 long and narrow prominence (Fig. 33). Spermatheca, sitting between the basivalvulae and fused with them. Valve I (v.I) bases situated posterior to the basivalvulae but not fused with valvifers I (Fig. 30). Valvifers I (vif.I) small and posterolateral to bases of valve I, almost covered by inserted muscles; paratergites (pt.) slightly straight and situated between valvifers I and base of valve I (Fig. 35). Valvifer II ring (vlf.II) highly sclerotized, located at the central apodeme (c.a.) that is well-developed. Anterior arch (a.a.) dark, with punctures in the middle (Fig. 32). Laterosternites IX (ltst.IX) large and irregular, fused with the bases of paratergites (Fig. 35). Laterosternal shelf (ltst.sh.) large and translucent, nearly oblong, with dense spinules at apical half (Fig. 34).

MATERIAL EXAMINED


REMARKS

Pronotum of this species has conspicuous punctuation, like that of C. meridianus (Figs. 6, 9). But tergite VII is obtuse at posterior margin (Fig. 29) and sternum VII is slightly produced at apex (Fig. 28). Valvule II of this species is highly sclerotized at lateral margins, clearly forming 2 pale yellow stripes (Fig. 31).

3. Cryptocercus meridianus Grandcolas & Legendre, 2005 (Figs. 7-9, 36-45)


MEASUREMENTS

Male, pronotum: length × width: 6.0 × 7.5 mm, body length: 25.0 mm; female, pronotum: length × width: 5.0 × 8.0 mm, body length: 19.9 mm.

DESCRIPTION

Body medium, brown to dark brown (Fig. 7). Vertex pale brown, ocellar spot dark brown, densely scattered with punctures. Antenna moniliform, brown, apex pale brown and scape gradually darker. Vertex with interocular space slightly more than distance between antennal sockets. Maxillary palps reddish brown and apical segment with tiny hairs (Fig. 8). Pronotum blackish brown with dense punctuation, anterior margin elevated; disc depressed with faint protuberances, protuberances also strongly depressed and narrowing posteriorly to median incised line and terminating at short transverse groove (Fig. 9). Front femur Type D (only 4 large spines) or D, males with different left and right front femur types; tarsus with pulvilli, tarsal claws symmetrical and unspecialized. Abdominal tergites brown, margins of each tergite slightly upturned, sternella pale brown. Both tergites and sterna punctured, the tergite VII and sternum with minute hair; area between tergites II and III slightly depressed.

Tergite VII with anterior margin slightly arched and posterior margin truncate, which is strongly extending backwards (Fig. 39). Sternum VII strongly produced at apex, posterior margin truncate; with a conspicuous pair of intersternal shelves (ints.f.) at apex, which are slightly sclerotized at anterior margins, dark and with punctures. Vestibular sclerite (vst.s.) broad, clearly defined, anterior margin arched, apex with dark and linear marks; the whole sclerite unmosculated, membrane surrounding vestibular sclerite which is connected with tergite X (TX) (Fig. 38). Tergite X rounded at apex; paraprocts (pp.) developed, triangular, with apices not extending to the posterior margin of tergite X, with the gap between paraprocts narrow (Fig. 36).

FEMALE GENITALIA

In the roof of the genital chamber, the basivalvulae (bs.v) well-developed and similar, nearly triangular or elliptic, anterior and posterior parts obscure and dark brown, anterior area sheet-like, and posterior area linear, both highly sclerotized (Fig. 43). Spermatheca, sitting behind the basivalvulae and fused with them. Valve I (v.I) bases finger-like, highly sclerotized at base, situated posterior to the basivalvulae but not fused with the valvifers I (Fig. 40). Valvifers I (vif.I) small and posterolateral to base of valve I, almost covered by inserted muscles; paratergites (pt.) weakly curved, situated between valvifers I and base of valve I (Fig. 45). Valvifer II ring (vlf.II) highly sclerotized, located at the central apodeme (c.a.) that is well-developed. Anterior arch (a.a.) dark, sheet-like in the middle (Fig. 42). Laterosternites IX (ltst.IX) large and irregular, fused with the bases of paratergites (Fig. 45). Laterosternal shelf (ltst.sh.) nearly oblong, with dense spinules at apical half (Fig. 44).

MATERIAL EXAMINED


REMARKS

Pronotum of this species has inconspicuous punctuation (Fig. 9). Front femur type of this species is greatly varied, D5 or D, and different types of left and right femur only exist in males.

4. Cryptocercus convexus sp. nov. (Figs. 10-12, 46-55)

MEASUREMENTS

Male, pronotum: length × width: 6.5 × 9.5 mm, body length: 23.5 mm; female, pronotum: length × width: 6.0 × 8.0-9.5 mm, body length: 21.0-24.0 mm.

DESCRIPTION

Body medium, brown to dark brown (Fig. 10). Vertex pale brown, ocellar spot dark brown, head with dense punctuation. Antenna brown, apex pale brown and scape gradually darker. Vertex with interocular space slightly less than distance between antennal sockets. Maxillary palps reddish brown and apical segment with tiny hairs (Fig. 11). Pro-
Figs. 36-45. Cryptocercus meridianus Grandcolas & Legendre, 2005: (36) supraanal plate, ventral view; (37) supraanal plate, dorsal view; (38) subgenital plate, dorsal view; (39) tergum VII, dorsal view; (40) valvule I, ventral view; (41) valvule II, ventral view; (42) valvule III, ventral view; (43) basivalvula and spermatheca (1 absent), ventral view; (44) laterosternal shelf, dorsal view; (45) laterosternite IX and paratergites, ventral view. (Scale bars = 1.0 mm). This figure is displayed in color in the online version.
Figs. 46-55. Cryptocercus convexus sp. nov.: (46) supraanal plate, ventral view; (47) supraanal plate, dorsal view; (48) subgenital plate, dorsal view; (49) tergum VII, dorsal view; (50) valvule I, ventral view; (51) valvule II, ventral view; (52) valvule III, ventral view; (53) basivalvula and spermatheca (1 absent), ventral view; (54) laterosternal shelf, dorsal view; (55) laterosternite IX and paratergites, ventral view. (Scale bars = 1.0 mm). This figure is displayed in color in the online version.
notum blackish brown, trapezoid with dense punctuation, anterior margin elevated; disc depressed with faint protuberances, protuberances also strongly depressed, and narrowing posteriorly to median incised line and terminating at short transverse groove (Fig. 12). Front femur Type D, D, or D, sometimes left and right femur type different; tarsus with pulvilli, tarsal claws symmetrical and unspecialized. Abdominal tergites brown, margins of each tergite slightly upturned, sterna pale brown. Both tergites and sterna punctured, the tergite VII and sternum with minute hairs; area between tergites II and III slightly depressed.

Tergite VII with anterior margin arched and posterior margin obtuse, weakly concave at middle (Fig. 49). Sternum VII distinctly produced at apex, posterior margin truncate; with a conspicuous pair of intersternal shelves (ints.f) at apex which are slightly scleritized at anterior margins. Vestibular sclerite (vst.s.) broad, clearly delimited and unmusculated; membrane surrounding vestibular sclerite, which is connected with tergite X (TX) (Fig. 48). Tergite X finely acute at apex; paraprocts (pp.) developed, with apices extending to the posterior margin of tergite X, with the gap between paraprocts narrow (Fig. 46).

**FEMALE GENITALIA**

In the roof of the genital chamber, the basivalvulae (bsv.) well-developed, elliptical, and similar, posterior parts obscure and dark brown, narrow margin of anterior area dark brown, both highly scleritized (Fig. 53). Spermatheca, sitting beyond the basivalvulae, fused with them. Valve I (v.I) bases situated posterior to the basivalvulae, but not fused with valvifer I (Fig. 50). Valvifer I (vlf.I) small and posterolateral to the valve I base, almost covered by inserted muscles; paratergites (pt.) slightly curved, situated between valvifers I and base of valve I (Fig. 55). Valvifer II ring (vlf.II) highly scleritized, located at the central apodeme (c.a.) that is well-developed. Anterior arch (a.a.) dark, with punctures in the middle (Fig. 52). Laterosternites IX (ltst.IX) small and irregular, fused with the bases of paratergites (Fig. 55). Laterosternal shelf (ltst.sh.) large and light yellow, nearly oblong, and brown at disc, with dense spinules at apical half (Fig. 54).

**MATERIAL EXAMINED**

HOLOTYPE, male, CHINA: Sichuan Prov., Yaan City, Baoxin Mt. Jiajinshan, 3,300m, 6-VIII-2011, coll. Dong Wang and Keliang Wu. PARATYPES, 3 males and 2 females, same data as holotype.

**DISTRIBUTION**

China (Sichuan).

**ETYMOLOGY**

The specific epithet “convexus” is derived from the Latin and refers to the hind margin inter-stylus being distinctly convex.

**REMARKS**

This species resembles other Cryptocercus species in structure, but can be distinguished as follows: pronotum of this species has inconspicuous punctuation (Fig. 12); there are 3 main types of front femur, D, D, or D, and sometimes different types of left and right femur; tergite VII is weakly concave at posterior margin (Fig. 49) and tergite X is slightly acute at apex (Fig. 47).

**5. Cryptocercus arcuatus sp. nov.** (Figs. 13-15, 56-65)

**MEASUREMENTS**

Male, pronotum: length × width: 6.0 × 9.0 mm, body length: 21.0 mm; female, pronotum: length × width: 6.0 × 9.0 mm, body length: 22.0 mm.

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**Table 1.** Principal characters to distinguish the 5 Chinese Cryptocercus species.

<table>
<thead>
<tr>
<th>Cryptocercus primarius C.</th>
<th>Cryptocercus convexus C.</th>
<th>Cryptocercus arcuatus sp. nov.</th>
<th>Cryptocercus meridianus C.</th>
<th>Cryptocercus dimeridianus C.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Protuberances of the pronotum</strong></td>
<td><strong>Protuberance</strong></td>
<td>Strong, more or less tapered</td>
<td>More or less arched</td>
<td>More or less arched</td>
</tr>
<tr>
<td><strong>Paratergites</strong></td>
<td><strong>Paratergites</strong></td>
<td>With long or short protuberance</td>
<td>Without protuberance</td>
<td>Without protuberance</td>
</tr>
<tr>
<td><strong>Paraprocts</strong></td>
<td><strong>Paraprocts</strong></td>
<td>Nearly to or slightly beyond the posterior margin of tergite X</td>
<td>Nearly to or slightly beyond the posterior margin of tergite X</td>
<td>Nearly straight</td>
</tr>
<tr>
<td><strong>The anterior margins of the vestibular sclerites</strong></td>
<td><strong>The anterior margins of the vestibular sclerites</strong></td>
<td>With long or short protuberance</td>
<td>With long or short protuberance</td>
<td>Weakly curved</td>
</tr>
<tr>
<td><strong>Sternum VII</strong></td>
<td><strong>Sternum VII</strong></td>
<td>Rounded at apex</td>
<td>Rounded at apex</td>
<td>Rounded at apex</td>
</tr>
<tr>
<td><strong>Spermatheca</strong></td>
<td><strong>Spermatheca</strong></td>
<td>Slightly sclerotized</td>
<td>Slightly sclerotized</td>
<td>Slightly sclerotized</td>
</tr>
</tbody>
</table>

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Figs. 56-65. *Cryptocercus arcuatus* sp. nov.: (56) supraanal plate, ventral view; (57) supraanal plate, dorsal view; (58) subgenital plate, dorsal view; (59) tergum VII, dorsal view; (60) valvule I, ventral view; (61) valvule II, ventral view; (62) valvule III, ventral view; (63) basivalvula and spermatheca (1 absent), ventral view; (64) laterosternal shelf, dorsal view; (65) laterosternite IX and paratergites, ventral view. (Scale bars =1.0 mm). This figure is displayed in color in the online version.
DESCRIPTION

Body medium, brown to dark brown (Fig. 13). Vertex pale brown, ocellar spot dark brown, head with dense punctuation. Antenna brown, apex pale brown and scape gradually darker. Vertex with interocular space slightly less than distance between antennal sockets. Maxillary palps reddish brown and apical segment with tiny hairs (Fig. 14). Pronotum blackish brown with punctuation indistinct, anterior margin elevated; disc depressed with faint protuberances, protuberances also strongly depressed, and narrowing posteriorly to median incised line and terminating at short transverse groove (Fig. 15). Front femur Type D, (only 4 big spines), tarsus with pulvilli, tarsal claws symmetrical and unspecialized. Abdominal tergites brown, margins of each tergite slightly upturned, sterna pale brown. Both tergites and sterna punctured, the tergite VII and sternum with minute hairs; area between tergites II and III slightly depressed.

Tergite VII with anterior margin arched, and posterior margin slightly truncate at middle (Fig. 59). Sternum VII distinctly produced at apex, posterior margin truncate; with a conspicuous pair of intersternal shelves (ints.f.) at apex, which are slightly sclerotized at anterior margin (Fig. 64). Tergites of all 5 species are developed and are sclerotized at anterior margin (Figs. 28, 39, 59); but that of Cryptocercus hirtus is slightly produced at the apex (Fig. 28), but the sterna show wide variations in the front femur type. Cryptocercus convexus sp. nov. has 3 main types of front femur, D3, D4 or D5; and sometimes a specimen has a different type of left femur than the right femur. Cryptocercus meridianus has 2 types of front femur, i.e., D3 and D5; and left and right femur differ only in males. However, the front femur type of the remaining 3 species is D3.

FEMALE GENITALIA

In the roof of the genital chamber, the basivalvulae (bsv.) well-developed, elliptical, obscure at apex and base, which are highly sclerotized (Fig. 63). Spermatheca sitting beyond the basivalvulae and fused with them. Valve I (v.I) bases situated posterior to the basivalvulae, but not fused with the valvifers I (Fig. 60). Valvifers I (vfl.I) small and posterolateral to the valve I bases, almost covered by inserted muscles; paratergites (pt.) slightly curved and situated between valvifers I and base of valve I (Fig. 65). Valvifer II ring (vfl.II) highly sclerotized, located at the central apodeme (c.a.) that is well-developed. Anterior arch (a.a.) dark, with punctures in the middle (Fig. 62). Laterosternites IX (ltsr.IX) small and sheet-like, fused with the bases of paratergites (Fig. 65). Laterosternal shelf (ltsr.sh.) very large and translucent, nearly oblong; with dense spines at apical half, which are denser near the anterior margin (Fig. 64).

ETYMOLOGY

The specific epithet is derived from the Latin adjective "arcuatus" referring to the posterior margin between 2 styli being rounded.

REMARKS

The following characteristics make this new species distinctive and easily noticed. Firstly, the pronotum of this species has inconspicuous punctuation (Fig. 15). Secondly, valvule II is strongly protruding at base and lateral margins are slightly sclerotized at middle (Fig. 61).

Discussion

These 5 Cryptocercus species are closely similar in morphology and they are difficult to distinguish. The differences are in the protuberances of the pronotum and the front femur type, etc. (Table 1). Cryptocercus hirtus has strong protuberances on the pronotum, and these protuberances are towering and more or less tapered. However, the protuberances of C. primarius, C. arcuatus sp. nov., C. meridianus and C. convexus sp. nov. are flat and obtuse, distinctly smaller and shorter than in the former species (Figs. 3, 6, 9, 12, 15). In addition, C. meridianus and C. convexus sp. nov. show wide variations in the front femur type. Cryptocercus convexus sp. nov. has 3 main types of front femur, D3, D4 or D5; and sometimes a specimen has a different type of left femur than the right femur. Cryptocercus meridianus has 2 types of front femur, i.e., D3 and D5; and left and right femur differ only in males. However, the front femur type of the remaining 3 species is D3.

The female genitalia of these 5 Cryptocercus species are similar. These 5 species differ in the shape of some sclerites. The hind margin of Tergite VII of C. primarius, C. meridianus and C. arcuatus sp. nov. is rather truncate (Figs. 19, 39, 59); but that of C. convexus sp. nov. is weakly concave (Fig. 49) and that of C. hirtus is more or less arched (Fig. 29). Sternum X of C. convexus is a little acute at apex (Fig. 47), but rounded at apex in the other 4 species (Figs. 17, 27, 37, 57). Paraprocts of all 5 species are developed and the gap between paraprocts is very narrow. The paraprocts of C. primarius have apices extending nearly to or slightly beyond the posterior margin of tergite X (Figs. 36, 46, 56), and those of C. hirtus extend well beyond the posterior margin of tergite X (Fig. 26). Sternum VII of C. hirtus is slightly produced at the apex (Fig. 28), but the sterna of C. primarius, C. meridianus, C. convexus sp. nov. and C. arcuatus sp. nov. do not extend to the posterior margin of tergite X (Figs. 36, 46, 56), and those of C. hirtus extend well beyond the posterior margin of tergite X (Fig. 26). Sternum VII of C. hirtus is slightly produced at the apex (Fig. 28), but the sterna of C. primarius, C. meridianus, C. convexus sp. nov. and C. arcuatus sp. nov. protruded at apex (Figs. 17, 37, 47, 57). The intersternal shelves of all 5 species are developed and are sclerotized at the anterior margin (Figs. 18, 28, 38, 48, 58). The anterior margins of the vestigial sclerites of C. hirtus and C. arcuatus sp. nov. are slightly concave at the middle (Figs. 28, 58); however, those of the other 3
species are distinctly arched (Figs. 18, 38, 48). Valvulae I in these 5 species are finger-shaped and merely differ in the degree of sclerotization (Figs. 20, 30, 40, 50, 60). Valvulae II of the 5 species are all slender and long, those of Cryptocercus hirtus have highly sclerotized lateral margins and clearly have the shape of 2 pale yellow stripes (Fig. 31), but the valvulae II of Cryptocercus arcuatus sp. nov. have only slightly sclerotized lateral margins (Fig. 61). Except for Cryptocercus hirtus and Cryptocercus primarius, valvulae II of the remaining 3 species are upturned at the base (Figs. 41, 51, 61). Valvulae III of these 3 species are all broad and sheet-like, but those of some species are highly sclerotized and those of other species are slightly sclerotized (Figs. 22, 32, 42, 52, 62). Laterosternites IX of these 5 Cryptocercus species are sheet-like. Except for Cryptocercus primarius and Cryptocercus arcuatus sp. nov. (Figs. 25, 65), the laterosternites IX of the remaining 3 species have 1 long or short protuberance (Figs. 35, 45, 55). Paratergites of these 5 Cryptocercus species are slender and long, but those of Cryptocercus hirtus are nearly straight, and those of the other 4 species weakly curved. It is worth mentioning that basivalvulae of Cryptocercus hirtus (Fig. 33) differs greatly from the basivalvulae of the other 4 species (Figs. 23, 43, 53, 63). Laterosternal shelves are all nearly rectangular, but the distribution of marks and spinules is different (Figs. 24, 34, 44, 54, 64). In addition, these 5 Cryptocercus species each has a pair of spermatotheca but they are shaped differently in the different species (Figs. 23, 33, 43, 53, 63).

As can be seen above, the female genitalia of different Cryptocercus species are uniformly structured, but the shape of the same structure across different species is notably different. Inward et al. (2007) found that Cryptocercidae has a close phylogenetic relationship with termites (Isopoda), even closer than with other Blattodea families. The structures of female genitalia of termites are also similar to those of Cryptocercidae (McKittrick 1964; Nalepa & Lenz 2000). Meanwhile, the results of Belyaeva & Doggobrod (2006) showed that only the female genitalia of termites could be used to classify and identify termite species. However, the male genitalia of these 5 Cryptocercus species are not materially different. For example, the shape of the hind margins of subgenital plates and middle aedeagus vary but these differences also exist across individuals of the same species. So compared with the characteristics of external morphology and male genitalia, it can be concluded that features of female genitalia have greater value for the identification of each of the 5 Cryptocercus species from China. According to our results, the morphological diversity of Cryptocercus species is not more pronounced in East Asia than among North American species. And this conclusion is consistent with the results of Grandcolas et al. (2005).

In recent years, we have collected Cryptocercus species from the Provinces of Sichuan, Hubei, Gansu, Yunnan, Shaanxi, Henan and Chongqing City, China. They usually live in natural forests (Fig. 66) at a high altitude (1,200 m to 3,600 m), where in general there is abundant rainfall. Trees with high water content are more suitable for the survival of Cryptocercus species (Figs. 67-68). They are not selective for rotten or soft wood and a large number can be collected in hard wood (Z. Q. Wang, pers. obs.).

Acknowledgments

We are sincerely grateful to Prof. J. R. Schrock (Department of Biological Sciences, Emporia State University, USA) for reviewing this manuscript and providing valuable comments. This study is supported by the National Natural Science Foundation of China (NSFC-30900146, 31093430) and also partly by the Fundamental Research Funds for the Central Universities (XDJK2012B025, XDJK2013B013).

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