



New fossil rhopalids (Heteroptera: Coreoidea) from the Middle Jurassic of Inner Mongolia, China

YUNZHI YAO¹, WANZHI CAI^{1,2,3}, DONG REN^{2,3} & CHUNGKUN SHIH²

¹Department of Entomology, China Agricultural University, Yuanmingyuan West Road, Beijing 100094, China.
E-mail: caiwz@cau.edu.cn

²Key Lab of Insect Evolution & Environmental Changes, Capital Normal University, Beijing 100037, China.
E-mail: rendong@mail.cnu.edu.cn

³Corresponding author

Abstract

Three new genera and three species of fossil rhopalid, *Originicorizus pyriformis* **gen. & sp. nov.**, *Quatlocellus liae* **gen. & sp. nov.**, and *Grandicaputus bipunctatus* **gen. & sp. nov.**, are described and illustrated. They were discovered from the Middle Jurassic Jiulongshan Formation of Eastern Inner Mongolia, China. The present discovery demonstrates that the early diversification of rhopalids was well underway by the Middle Jurassic.

Key words: Heteroptera, Coreoidea, Rhopalidae, fossil, Middle Jurassic, Jiulongshan Formation, Daohugou, China

Introduction

The extant Rhopalidae contains two subfamilies, the Serinethinae with 3 genera, and the Rhopalinae with 17 genera (Göllner-Scheiding 1983), and most of them occur in the Palearctic Region (Schaefer & Chopra 1982, Schaefer 1992). In China, 36 species of extant rhopalids have been described and most species are distributed in the Inner Mongolia and Xinjiang Autonomous Regions (Liu *et al.* 1994, Hsiao *et al.* 1977, Nonnaizab *et al.* 1988). Only two fossil genera and species of the family Rhopalidae have been recorded from China prior to this study: *Miracorizus punctatus* Yao, Cai & Ren 2006 and *Longiclavula calvata* Yao, Cai & Ren 2006 from the same locality and stratum as the new species described here. According to the distribution pattern of extant rhopalids and fossil data, the most parsimonious hypothesis is that the basal species of this family initially radiated in Northeast China.

Recently we recovered 19 fossil specimens of Rhopalidae representing three new genera and species: *Originicorizus pyriformis* gen. & sp. nov., *Quatlocellus insolentis* gen. & sp. nov., and *Grandicaputus bipunctatus* gen. & sp. nov. All specimens were collected from Jiulongshan Formation in Daohugou Village, Shantou Township, Ningcheng County, Inner Mongolia, China. The formation has provided a large number of fossil insect groups, such as Blattaria, Ephemeroptera, Odonata, Orthoptera, Plecoptera, Heteroptera, Homoptera, Neuroptera, Tricoptera, Coleoptera, Hymenoptera, and Diptera (Hong 1983, Ren *et al.* 1995, Ren & Krzemiński 2002). It also contains some freshwater conchostracans (Zhang & Shen 1987), salamanders (Gao & Shubin 2003), and some dinosaurs (Ji & Yuan 2002). At the time of deposition, gymnosperm forests were dominated by Coniferopsida (*Pityophyllum*, *Rhipidiocladus*, *Elatocladus*, *Schizolepis*, *Podozamites*), Cycadopsida (*Anomozamites*), Filicopsida (*Todites*, *Coniopteris*), Ginkgopsida (*Ginkgoites*, *Ginkgo*, *Baiera*, *Czekanowskia*, *Phoenicopsis*), Lycoposidas (*Lycopodites*, *Selaginellites*), and Sphenopsida (*Equisetum*) (Mi *et al.* 1996). These paleontological data taken together suggest strongly that the climate at the time of deposition was humid and warm-temperate (Tan & Ren 2002). The age of the Jiulongshan Formation is still controversial, but many biostratigraphical correlations and radiometric dates have been published supporting the belief that the Formation is Middle Jurassic (Chen *et al.* 2004, Ren *et al.* 1995, Ren *et al.* 2002, Wang 2000, Shen *et al.* 2003).

Material and methods

All the type specimens of the new species are housed at the Key Lab of Insect Evolution & Environmental Changes, Capital Normal University, Beijing, China. All drawings were made using a camera lucida attached to a Leica MZ12.5 stereomicroscope. Morphological terminology mainly follows Schuh & Slater (1995). The wing venation nomenclature is based on the interpretation of Wootton & Betts (1986). All measurements are in millimeters.

Systematics

Suborder Heteroptera Latreille, 1810

Infraorder Pentatomomorpha Leston, Pendergrast & Southwood, 1954

Superfamily Coreoidea Reuter, 1910

Family Rhopalidae Amyot & Serville, 1843

Genus *Originicorizus* Yao, Cai & Ren, gen. nov.

Type species. *Originicorizus pyriformis* Yao, Cai & Ren, sp. nov.

Diagnosis: Body elongate-oval. Head large, width and length subequal, longer than pronotum, anteocular portion longer than postocular, apex surpassing first antennal segment, clypeus surpassing mandibular plates; eyes relatively small, round; antenna 4-segmented, longer than head and pronotum combined, first segment shortest, second longest and slender, fourth segment fusiform, thickest, shorter and stouter than third; rostrum arising from apex of head, stout, extending to second abdominal sternite, first segment concealed between bucculae, acute distally. Pronotum trapezoidal, length shorter than width, without collar; scutellum triangular, longer than pronotum at midline, wider than length; femora distinctly thicker and shorter than tibiae, mid legs longer than fore legs, hind legs longest, tarsus 3-segmented, subequal in thickness, first and second subequal in length, third longest; hemelytron macropterous, long and narrow, apical margin rounded, reaching to tip of abdomen, with distinct embolium, corium slightly elongated on costal margin, corium venation prominent, main veins form four cells, two large and two small, C present, connected with Sc at basal 1/3 of corium, and forming a merged vein, C+Sc, this ending at apex of corium, Sc separating from Sc+R at basal 1/4 of corium, very short, Sc+R and Cu diverging at a single point at basal of fore wing, and forming a large cell, a cross vein near corium-membrane boundary joined with C+Sc, R, M, and Cu to form three cells, outside cell largest; 1A on middle of clavus, posterior claval vein 2A along hind margin of clavus and ending apex; clavus considerably large, forming claval commissure, membrane with some longitudinal veins. Abdomen oval, with wide connexivum, ovipositor very long, not projecting beyond last paratergites, extending through last three abdominal segments.

Distribution. China.

Etymology: The generic name is a combination of the Latin *origo* (“ancestor”) and *Corizus* (a genus of modern Rhopalidae).

Remarks: The venation and cells of the corium of *Originicorizus* are very similar to those of some modern Rhopalidae. The new genus retains a primitive pattern of corium venation, a distinct C+Sc forming a large cell, C+Sc (Fig. 8). This venation is not preserved in extant Coreoidea, but occurs in the extinct Pachymeridiidae (Upper Triassic to Lower Cretaceous), which is considered ancestral to Coreoidea (Popov 1986, 1990; Shcherbakov & Popov 2002; Popov, Dolling & Whalley 1994). In recent rhopalids, C is absent; and Sc has three patterns: (1) Sc is fused to R at basal 3/4 of corium and, with R, forms a cell (e.g., *Liorhyssus*) (Fig. 9); (2) Sc substitutes as C on the costal margin (e.g. *Brachycarenum*) (Fig. 10); (3) Sc is reduced, free, very short, on the submargin (e.g. *Serinetha*) (Fig. 11). The new genus most closely resembles the first pattern, but differs in that Sc is fused to R at basal 1/3 of corium and R forms a large cell (vs. Sc is fused to R at basal 3/4 of corium and with R forming a small cell). In addition, cell M has two forms: trilateral and quadrilateral. Cell M of *Originicorizus* and a majority of extant rhopalids is quadrilateral, so a trilateral cell M is probably apomorphic.

The new genus can be easily distinguished from the fossil genera *Miracorizus* Yao, Cai & Ren, 2006 and *Longiclavula* Yao, Cai & Ren, 2006, in the ratio of the second antennal segment to the third, which about 1.4:1 (vs. over 1.5:1); pronotum without collar (vs. with distinct collar); and with claval commissure (vs. without claval commissure).

***Originicorizus pyriformis* Yao, Cai & Ren, sp. nov.**

(Figs. 1–7)

Description: Body oval, about 2.9 times (σ) or 2.3 times (φ) as long as wide. Head slightly longer than pronotum; antenna slender, longer than head, pronotum and scutellum combined, second segment about 1.38 (σ) or 1.15 (φ) times as long as third, 1.8 (σ) or 1.4 (φ) times as long as fourth; eyes somewhat prominent, interocular space about 2 times as wide as eye diameter. Pronotum moderately transverse, nearly 2 times as wide as long, anterior margin about 0.5 times as long as posterior, lateral sides convex, posterior angles feebly rounded; scutellum longer than pronotum at midline; all femora stout, about 2 times as thick as corresponding tibiae, fore and mid tibiae subequal and about 1.3 times as long as corresponding femora, third tarsomere longest, almost 1.4 times as long as second; hind legs distinctly longer than fore and mid legs, tibia longer than femur, tarsi similar to fore and mid tarsi. Fore wing long, costal margin slightly convex, anterior margin of corium about 0.75 times as long as hemelytron, posterior margin of corium subequal to membranal suture in length, clavus wide, nearly 4.8 times as long as wide. Abdomen oval, ovipositor one-fifth as long as body.

Dimensions (in mm): Body length 6.95 (σ), 6.67 (φ); maximum width of abdomen 2.43 (σ), 2.89 (φ); head length 1.1 (σ), 1.2 (φ), width 1.1 (σ), 1.1 (φ); length antennal segments I–V: 0.3, 1.24, 0.9, 0.7 (σ), 0.27, 1.33, 1.16, 0.93 (φ); length rostrum 2.9 (σ), 3.3 (φ); length pronotum 0.7 (σ), 0.9 (φ), width 1.8 (σ), 2.0 (φ); length scutellum 1.2 (σ), 1.0 (φ), width 1.7 (σ), 1.56 (φ); length hemelytron 5.9 (σ), 4.89 (φ), width 1.9 (σ), 1.9 (φ), length anterior margin of corium 3.4 (σ), 3.7 (φ), length clavus 1.9 (σ), 2.1 (φ), width 0.33 (σ), 0.44 (φ); length fore leg: femur 1.0 (σ), tibia 1.38 (σ), 1.69 (φ), tarsomeres I–III: 0.2, 0.2, 0.33 (σ), 0.2, 0.2, 0.31 (φ); length middle leg: femur 1.4 (σ), 1.6 (φ), tibia 1.7 (σ), 2.0 (φ), tarsomeres I–III: 0.2, 0.2, 0.33 (σ); length hind leg: femur 1.57 (σ), 1.87 (φ), tibia 2.4 (σ), 2.7 (φ), tarsomeres I–III: 0.2, 0.2, 0.4 (σ), 0.2, 0.2, 0.35 (φ); length ovipositor 1.4.

Material: Holotype, φ , CNU-HE-NN2006007 (dorsoventrally compressed); paratypes, 4 σ , CNU-HE-NN2006008/009/122 (dorsoventrally compressed), CNU-HE-NN2006013 (laterally compressed); 1 φ , CNU-HE-NN2006014 (laterally compressed).

Locality and horizon: Daohugou Village, Shantou Township, Ningcheng County, Inner Mongolia, China. Middle Jurassic, Jiulongshan Formation.

Etymology: The name is derived from the Latin *pyriformis* (“pyriform”).

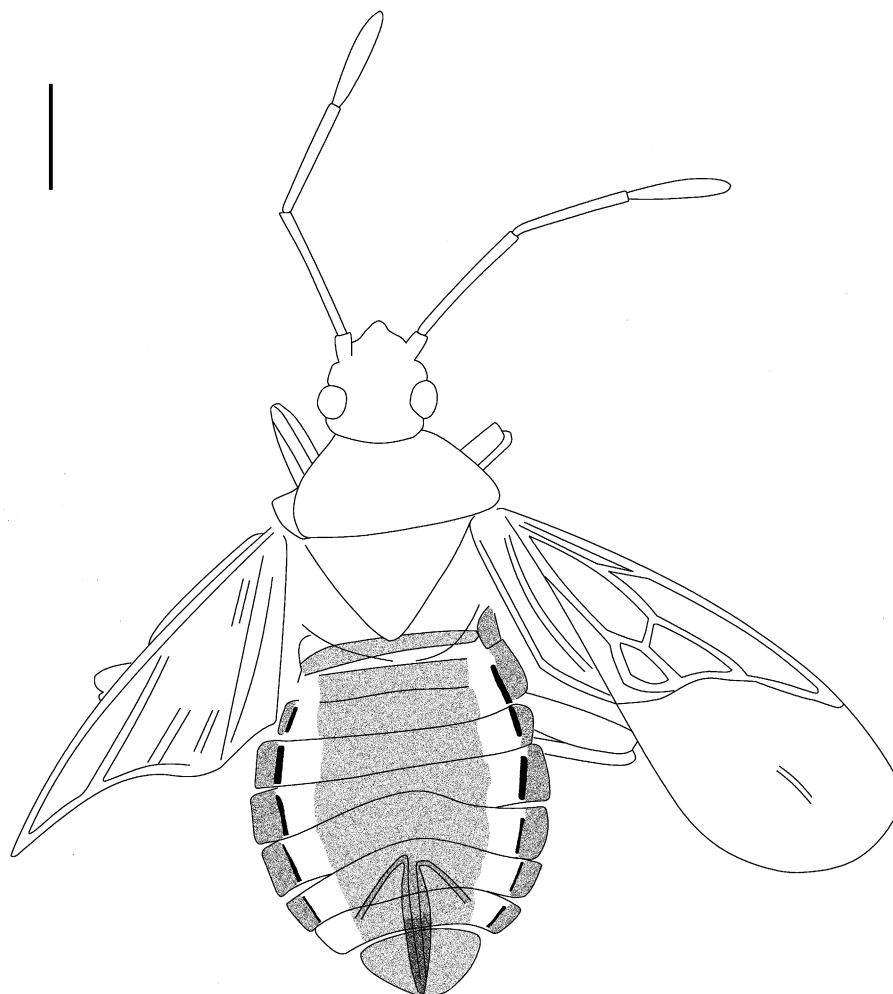


FIGURE 1. *Originicorizus pyriformis* gen. & sp. nov. Holotype, habitus (dorsal view) ♀, CNU-HE-NN2006007. Scale bar = 1 mm.

Genus *Quatlocellus* Yao, Cai & Ren, gen. nov.

Type species. *Quatlocellus insolentis* Yao, Cai & Ren, sp. nov.

Diagnosis: Body elongate, lateral sides subparallel. Head large, width and length subequal, longer than pronotum, antecular portion longer than postocular; eyes round, widely separated; antenna 4-segmented, longer than head and pronotum combined, first segment shortest, second longest and slender, fourth segment fusiform, thickest, shorter than third; rostrum slightly stout, arising from apex of head, short, extending to fore coxae, all segments subequal in thickness, first segment concealed between bucculae, subequal to third in length, second longest, fourth shorter than third, acute distally. Pronotum trapezoi-

dal, length shorter than width, without collar; scutellum triangular, longer than pronotum at midline, wider than length; femora distinctly thicker and shorter than tibiae, fore and mid legs subequal in length, hind leg longer than mid leg, tarsus 3-segmented, tarsomeres subequal in thickness, first and second subequal in length, third longest; fore wing macropterous, venation of corium and clavus prominent, main veins form four cells, two large and two small, C present, connected with Sc at basal 1/4 of corium, forming a fused vein, C+Sc, this ending at apex of corium, Sc separating from Sc+R at basal 1/4 of corium, very short, Sc+R and Cu diverging at a single point at base of fore wing, and forming a large cell, a cross vein near corium-membrane boundary joined with C+Sc, R, M, and Cu, forming three cells, outside cell largest; 2A along hind margin of clavus, ending at apex, clavus quite large, forming claval commissure. Abdomen oval, ovipositor very long, not projecting beyond last paratergites, extending through last three abdominal segments.

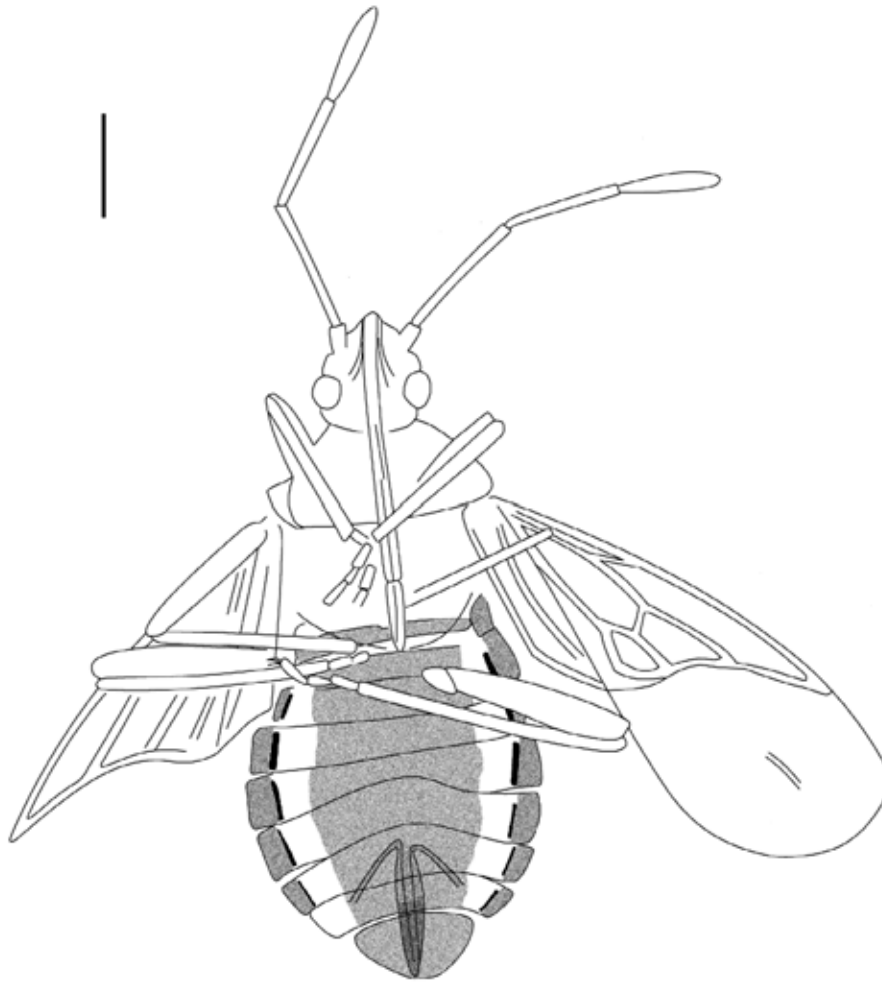


FIGURE 2. *Originicorizus pyriformis* gen. & sp. nov. Holotype, habitus (ventral view) ♀, CNU-HE-NN2006007.dorsal view. Scale bar = 1 mm.

Distribution. China.

Etymology: The generic name is a combination of the Latin *quattuor* (“four”) and *locellus* (cell).

Remarks: The new genus is closely related to *Originicorizus* gen. & sp. nov., but differs from the latter in the body length over 8 mm (vs. *Originicorizus*, less than 7 mm), rostrum short, not extending to mesocoxae (vs. extending to third abdominal sternite).

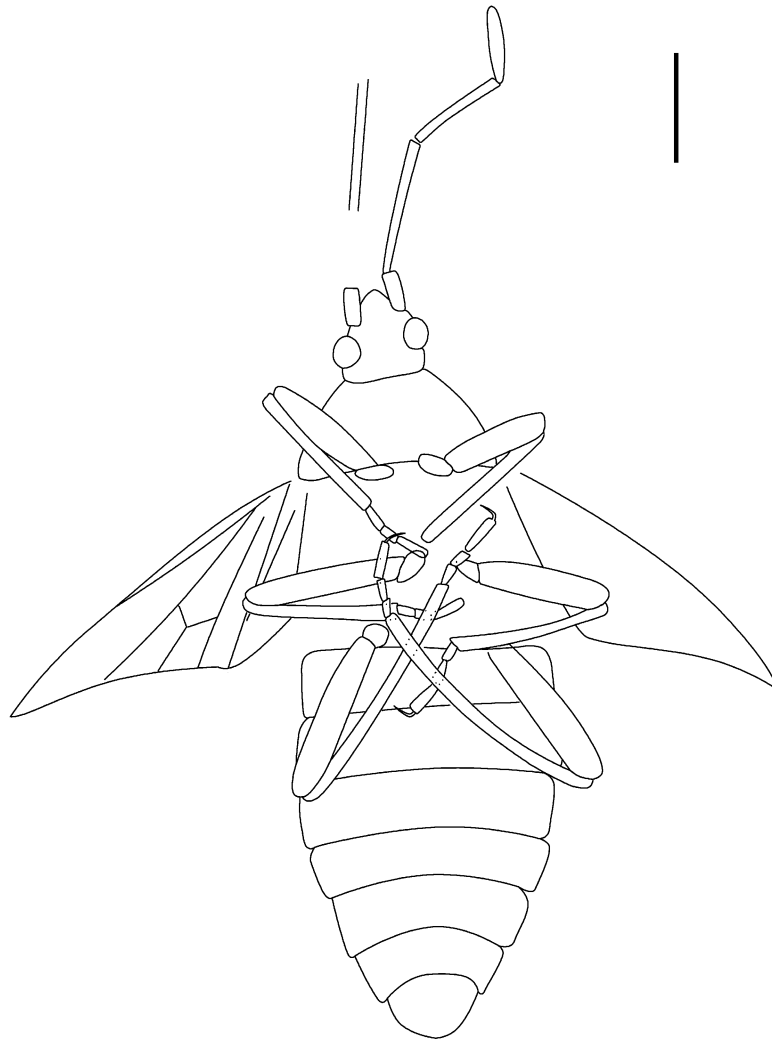
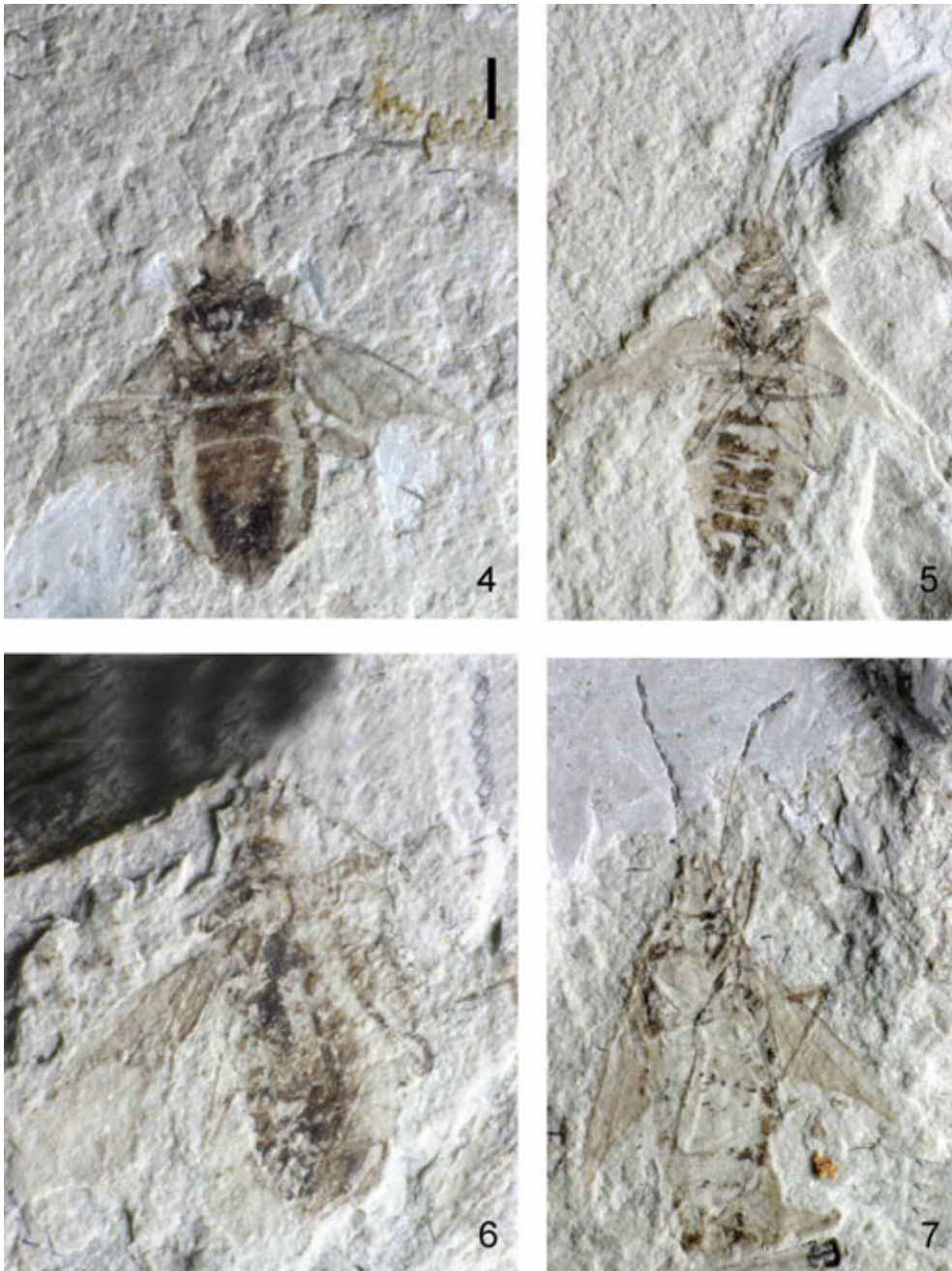
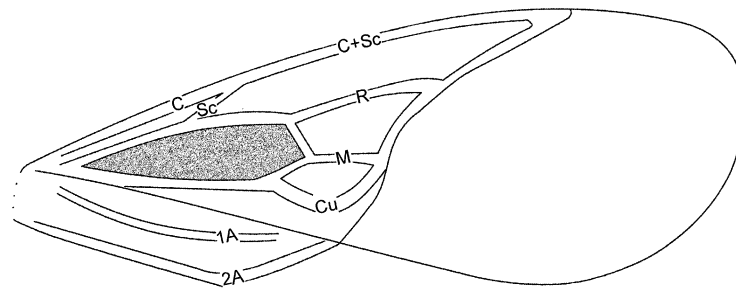


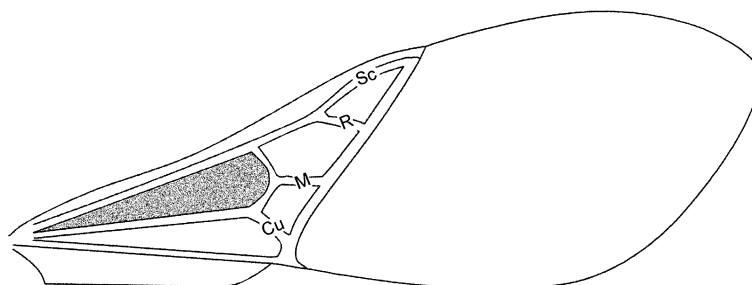
FIGURE 3. *Originicorizus pyriformis* gen. & sp. nov. Paratype, habitus ♂, CNU-HE-NN2006122. Scale bar = 1 mm.



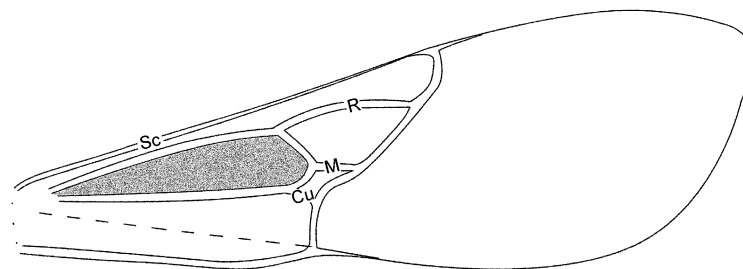
FIGURES 4–7. *Originicorizus pyriformis* gen. & sp. nov. 4. Holotype, ♀, CNU-HE-NN2006007. 5. paratype, ♂, CNU-HE-NN2006122. 6. paratype, ♀, CNU-HE-NN2006014. 7. paratype, ♂, CNU-HE-NN2006009. Scale bar = 1 mm.



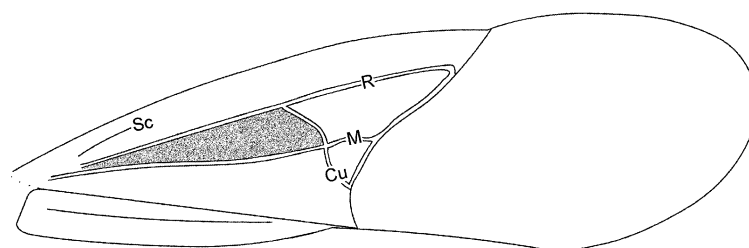
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9



10



11

FIGURES 8–11. Hemelytral venation in *Originicorizus* and some genera of extant Rhopalidae, 8. *Originicorizus*; 9. *Liorhyssus hyalinus* (based on Nonnaizab 1988); 10. *Brachycarenum tigrinus* (based on Li & Zheng 1994); 11. *Serinetha* sp. (based on Hsiao et al. 1977). Basal cell shaded. Scale bar = 1 mm.

Quatlocellus liae Yao, Cai & Ren, sp. nov.

(Figs. 12–18)

Description: Body narrow, about 2.6 times (σ) or 2.1 times (φ) as long as wide. Antenna slender, longer than head, pronotum, and scutellum combined, second segment about 1.4 (σ) or 1.2 (φ) times as long as third, 1.8 (σ) or 1.4 (φ) times as long as fourth; eyes somewhat prominent, diameter about 0.5 times as wide as interocular space. Pronotum moderately transverse, nearly 2.4 times as wide as long, anterior margin about 0.5 times as long as posterior, lateral sides slightly convex, posterior angles feebly rounded; scutellum longer than pronotum at midline, about 1.4 times as wide as long. Femora stout, over 2 times as thick as corresponding tibiae, fore and mid tibiae 1.2 as long as corresponding femora in length, third tarsomere longest, almost 1.6 times as long as second, hind legs distinctly longer than fore and mid legs, tibia almost 1.6 times as long as femur, tarsi longer than fore and mid tarsi, first tarsomere slightly longer than second, third 1.8 times as long as first and 2.3 times as long as second; posterior margin of corium subequal to membranal suture in length.

Dimensions (in mm): Body length 8.2 (σ), 8.38 (φ); maximum width of abdomen 3.2 (σ), 4.05 (φ); length head 1.3 (σ), 1.2.9 (φ), width 1.2 (σ), 1.2 (φ); length antennal segments I–V: 0.29, 1.52, 1.0, 0.86 (σ), 0.25, 1.2, 1.0, 0.8 (φ); length rostral segments I–IV: 0.6, 0.7, 0.6, 0.5 (σ), 0.6, 0.7, 0.6, 0.5 (φ); length pronotum 0.9 (σ), 0.9 (φ), width 2.3 (σ), 2.5 (φ); length anterior margin of corium 4.0 (σ), 4.8 (φ); length fore leg: femur 1.33 (σ), 1.65 (φ), tibia 1.62 (σ), 2.0 (φ), tarsomeres I–III: 0.25, 0.25, 0.36 (σ), 0.29, 0.29, 0.42 (φ); length mid leg: femur 1.52 (σ), 1.7 (φ), tibia 1.9 (σ), 1.85 (φ), tarsomeres I–III: 0.25, 0.25, 0.43 (σ), 0.26, 0.26, 0.42 (φ); length hind leg: femur 2.0 (σ), 1.9 (φ), tibia 3.3 (σ), 3.0 (φ), tarsomeres I–III: 0.38, 0.29, 0.52 (σ), 0.3, 0.23, 0.52 (φ); length ovipositor 1.2.

Material: Holotype, σ , CNU-HE-NN2006010 (dorsoventrally compressed); paratypes, 5 σ , CNU-HE-NN2006018/123/127 (laterally compressed, later specimen was donated by Chungkun Shih), CNU-HE-NN2006012 (dorsoventrally compressed); 7 φ , CNU-HE-NN2006011/015/017/121/124 (dorsoventrally compressed), CNU-HE-NN2006125-126 (part and counterpart), CNU-HE-NN2006026 (laterally compressed).

Locality and horizon: Daohugou Village, Shantou Township, Ningcheng County, Inner Mongolia, China. Middle Jurassic, Jiulongshan Formation.

Etymology: This species is named after Ms Jie Li for her assistance and contribution in collecting Liaoning fossils.

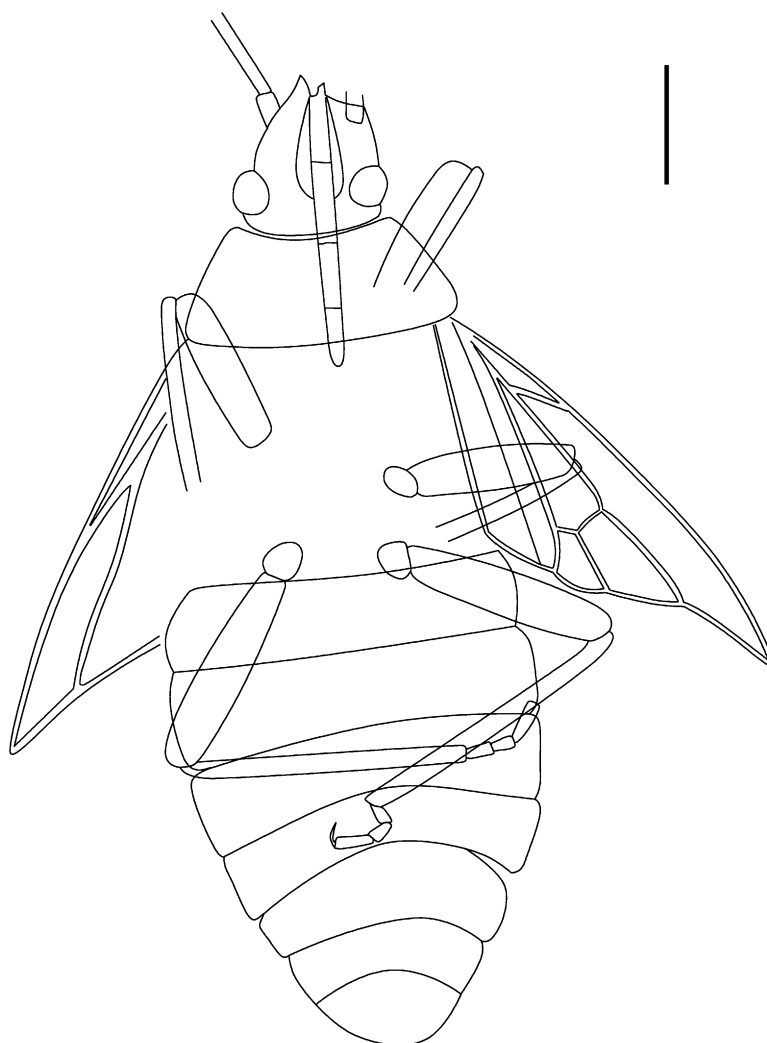


FIGURE 12. *Quatlocellus insolentis* gen. & sp. nov. Holotype, ♂, CNU-HE-NN2006010. Scale bar = 1 mm.

Genus *Grandicaputus* Yao, Cai & Ren, gen. nov.

Type species: *Grandicaputus bipunctatus* Yao, Cai & Ren, sp. nov.

Diagnosis: Body moderately sized, elongate, general body plan resembling lygaeids', dorsal surface densely punctate. Head large, wider than long, slightly shorter than pronotum, apex surpassing first antennal segment, clypeus distinctly surpassing mandibular plates; antenna 4-segmented, longer than half of body, first segment short and thick, second and third segments slender, second longest, fourth fusiform, shorter than third; eyes

moderately large, round and prominent, interocular space distinctly wider than eye diameter. Pronotum trapezoidal, slightly transverse, without collar; femora distinctly thicker than tibiae, fore and mid legs subequal in length, hind leg longer than mid leg, tibia longer than femur, with densely setae, tarsus 3-segmented, subequal in thickness, first tarsomere feebly shorter than second, third longest; hemelytron macropterous, long and narrow, apical margin rounded, reaching tip of abdomen, with distinct embolium, corium slightly elongated on costal margin; with claval commissure; membrane with nearly 20 longitudinal veins distally.

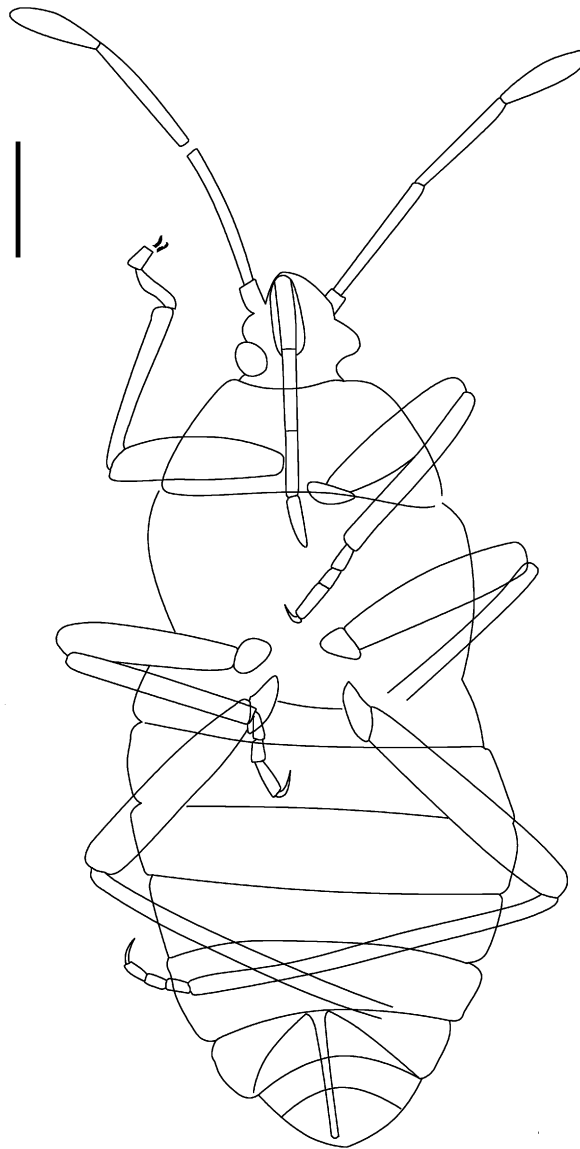


FIGURE 13. *Quatlocellus insolentis* gen. & sp. nov. Paratype, ♀, CNU-HE-NN2006017. Scale bar = 1 mm.

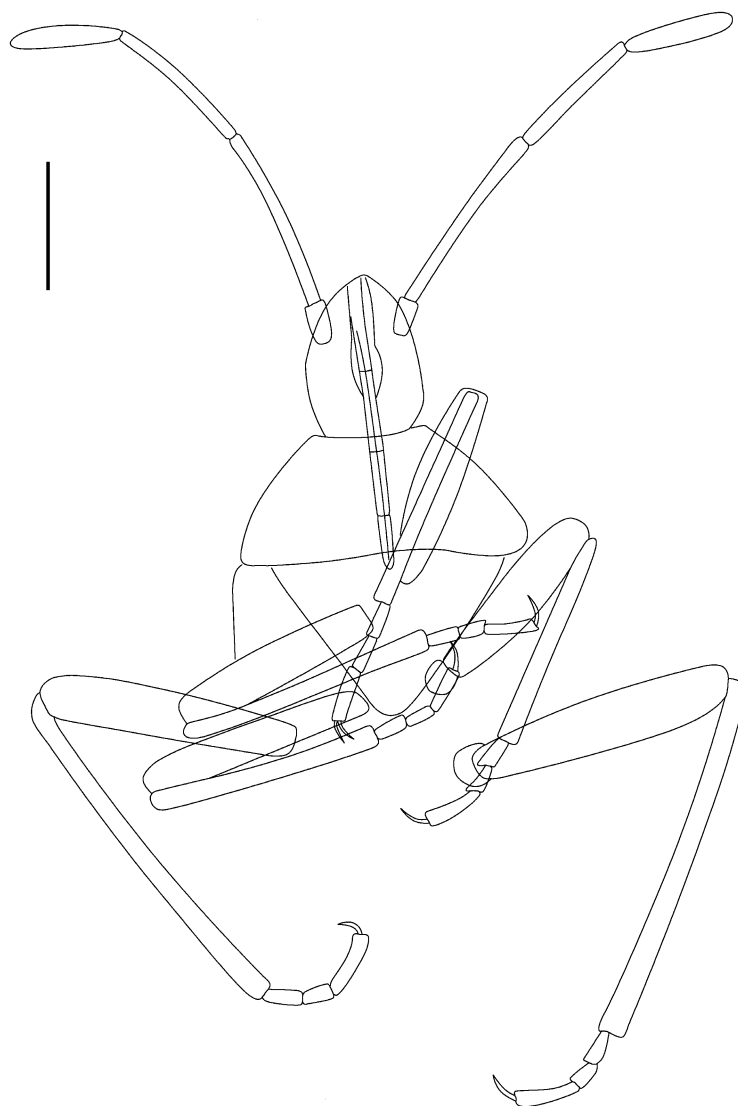


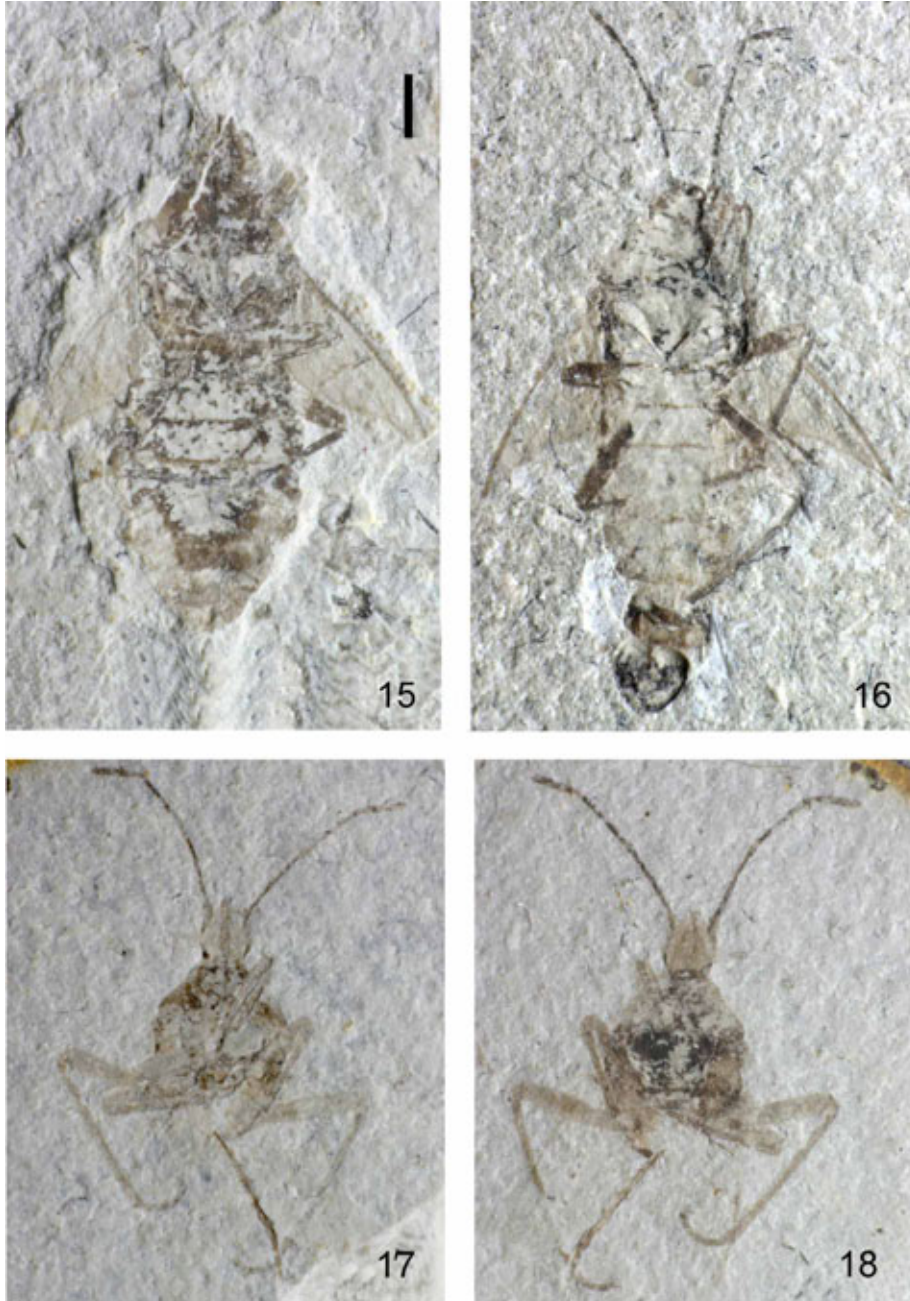
FIGURE 14. *Quatlocellus insolentis* gen. & sp. nov. Paratype, CNU-HE-NN2006125-126. Scale bar = 1 mm.

Distribution. China.

Etymology: The name is a combination of the Latin *grandis* (“large”) and *caput* (“head”), referring to the remarkably large head.

Remarks: This new genus can be placed next to *Miracorizus* Yao, Cai & Ren, 2006, as both are similar in the following characters: dorsum densely punctate; antenna long and slender, the first segment shortest, not extending beyond head apex, fourth segment fusi-form; tibia longer than femur, with dense setae; hemelytron macropterous, with thick

embolium. But *Grandicaputus* gen. nov. can be easily distinguished from *Miracorizus* by its head wider than its length (vs. width and length subequal), clypeus distinctly surpassing mandibular plates (vs. mandibular plates not surpassing clypeus), pronotum without collar (vs. with distinct collar), and with claval commissure (vs. without claval commissure).



FIGURES 15–18. *Quatlocellus insolentis* gen. & sp. nov. 15. Holotype, ♀, CNU-HE-NN2006010. 16. paratype, ♂, CNU-HE-NN2006127. 17-18. paratype, CNU-HE-NN2006125-126. 17. part; 18. counterpart. Scale bar = 1 mm.

The new genus is also similar to *Longiclavula* Yao, Cai & Ren, 2006 in antenna long and slender, same ratio of antennal segments; hemelytron macropterous, with thick embolium, membrane with nearly 20 longitudinal veins. But the new genus can be distinguished from the latter by dorsum densely punctate (vs. dorsal surface smooth), pronotum without collar (vs. with distinctly collar), with claval commissure (vs. without claval commissure).

***Grandicaputus bipunctatus* Yao, Cai & Ren, sp. nov.**

(Figs. 19–20)

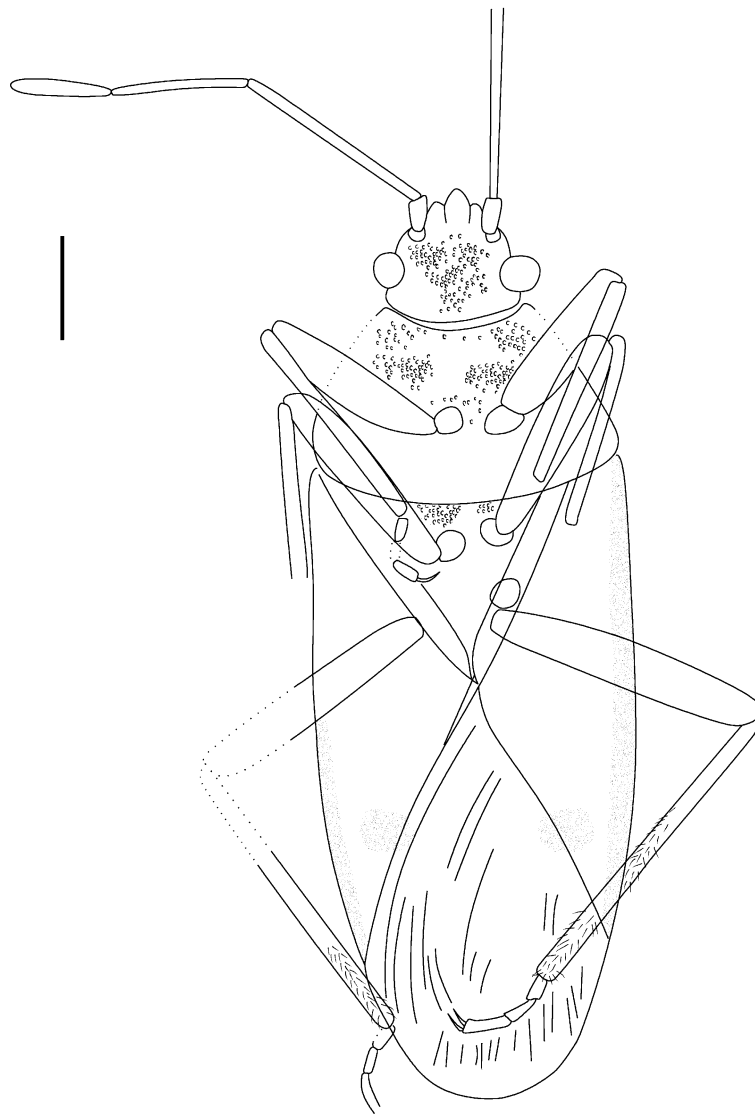


FIGURE 19. *Grandicaputus bipunctatus* gen. & sp. nov. Holotype, line drawing. Scale bar = 1 mm.



FIGURE 20. *Grandicaputus bipunctatus* gen. & sp. nov. Holotype, photograph. Scale bar = 1 mm.

Description: Sex unknown. Body almost 3 times as long as wide. Head large, more than 0.5 times as long as pronotum; antenna thin and long, second segment about 6 times as long as first, about 1.5 times as long as third, third segment about 1.3 times as long as fourth; interocular space about 3 times as wide as eye diameter in dorsal view. Pronotum slightly transverse, about 1.7 times as wide as long, posterior margin almost 2 times as long as anterior, posterior angles feebly rounded; scutellum shorter than pronotum at mid-line, surface granulate similar to those on pronotum. Femora stout, fore tibia almost 1.2 times as long as corresponding femur, third tarsomere longest, almost 1.2 times as long as second, hind legs distinctly longer than fore and mid legs, tibia longer than femur, almost 1.2 times as long as corresponding femur, with dense setae, tarsi distinctly longer than fore tarsi, third tarsomere about 2 times as long as first, 1.5 times as long as second; costal mar-

gin of hemelytron nearly straight, corium with distinctly thickened embolium and almost 0.73 times as long as hemelytron, posterior margin of corium shorter than membranal suture in length, a oval black spot at corium-membrane boundary, clavus narrow, nearly 10 times as long as wide, nearly 0.36 times of hemelytron in length, membrane large, membranal suture nearly straight.

Dimensions (in mm): Body length 9.1, maximum width of abdomen 3.2; head length 1.3, width 1.6; length antennal segments I–IV: 0.33, 2.05, 1.33, 1.0; length pronotum 1.76, width 3.05; length hemelytron 6.67, width 2.33, length anterior margin of corium 4.86, clavus length 2.38, width 0.24; length fore leg: femur 1.95, tibia 2.29, tarsomeres I–III: 0.2, 0.21, 0.24; length middle femur 2.19; length hind leg: femur 2.81, tibia 3.3, tarsomeres I–III: 0.24, 0.33, 0.48.

Holotype: An almost completely preserved, dorsoventrally compressed. No. CNU-HE-NN 2006031.

Type locality and horizon: Daohugou Village, Shantou Township, Ningcheng County, Inner Mongolia, China. Middle Jurassic, Jiulongshan Formation.

Etymology: The name is derived from the Latin *bipunctatus*, because of the two spots.

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