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New fossil records of bizarre *Ferganolyda* (Hymenoptera: Xyelydidae) from the Middle Jurassic of China

MEI WANG, ALEXANDR P. RASNITSYN, CHUNGKUN SHIH and DONG REN

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Two new species of *Ferganolyda* Rasnitsyn, 1983, *F. eucalla* and *F. insolita*, are described. Also, *F. scylla* Rasnitsyn, Zhang & Wang, 2006 and *F. chungkuei* Rasnitsyn, Zhang & Wang, 2006 are re-described based on new materials in this study. All of these well-preserved specimens were collected from the latest Middle Jurassic Jiulongshan Formation of Daohugou Village in Inner Mongolia, China. Based on the new morphological data, a key to the eight species of *Ferganolyda* is provided. This genus has significant sexual dimorphism, and the new materials show that males have head capsules with ratios of width to length ranging from 3.1 to 3.6, whereas females have ratios from 1.9 to 2.1. These new findings enhance our understanding of the evolution and relationships of the extinct Xyelydidae (Hymenoptera).

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Key words: fossil insects, Xyelydidae, sawflies, Mesozoic, sexual dimorphism, Jiulongshan Formation, Daohugou.

XYELYDIDAE, a relatively little-known, extinct family of sawflies, is considered to be a basal group within superfamily Pamphilioidea (Rasnitsyn 1969, 1980, 1983, Grimaldi & Engel 2005). It has plesiomorphic characters in vein SC being two branched in the forewings, the mesopseudosternum positioned distant from the fore-margin of the ventropleuron, and vein R being angular or bent near the origin of 1-RS (Rasnitsyn 1983). However, the monophyly of Xyelydidae is questionable; it may be paraphyletic and can not be transformed to become holophyletic or split into holophyletic groups based on current knowledge (Rasnitsyn 2002, Ronquist *et al.* 2012).

To date, seven genera with 18 species of xyelydids have been recognized within this family (vide table 1 of Wang *et al.* 2014b). The lineage is known from the Middle Jurassic to the Early Cretaceous (Rasnitsyn 1963, 1968, 1983, Rasnitsyn *et al.* 2006, Gao *et al.* 2013a). They have a mostly Eurasian distribution and are described from many countries, such as Kyrgyzstan, Kazakhstan, China and Russia.

Ferganolyda, first established based on three isolated forewings by Rasnitsyn (1983), was later emended by Rasnitsyn *et al.* (2006) using three particularly ‘bizarre’ fossil species in 2006, which were collected from the Middle Jurassic Jiulongshan Formation in China.

Recently, we collected six well-preserved fossil *Ferganolyda* specimens (including two with part and counterpart) from the same stratum. The geological age of the Daohugou fossil-bearing beds was considered formerly as mid-Middle Jurassic *ca* 165 Ma (Gao & Ren 2006, Ren *et al.* 2010, 2012). Because of new calibrations for the Jurassic System, this deposit should now be considered as latest Middle Jurassic (late Callovian) in age (Walker *et al.* 2013). This locality has produced many diverse taxa of insects, including odonates (Li *et al.* 2013), heteropterans (Zhang *et al.* 2012), mecopterans (Ren *et al.* 2009, Y Wang *et al.* 2012), neuropterans (Shi *et al.* 2013), hymenopterans (M Wang *et al.* 2012, 2014a), dermapterans (Zhao *et al.* 2011), mantophasmatodeas (Huang *et al.* 2008) and embiopterans (Huang & Nel 2009), among other groups.

Based on new characters available from the studied fossils, two new species, *F. eucalla* and *F. insolita* are described and assigned to *Ferganolyda*. Two other species, *F. scylla* Rasnitsyn, Zhang & Wang, 2006, *F. chungkuei* Rasnitsyn, Zhang & Wang, 2006, are re-described. In addition, a key to *Ferganolyda* is provided. The new findings also elucidate the functional morphology and ecology of these bizarre insects.

Materials and methods

All six specimens described herein are housed in the Key Laboratory of Insect Evolution and Environmental

Taxa	Specimen ID number	Locality and formation
<i>Ferganolyda cubitalis</i> Rasnitsyn, 1983	PIN 3073/135	Sai-Sagul, Fergana, Kyrgyzstan; Lower or Middle Jurassic Sogul Formation
<i>F. radialis</i> Rasnitsyn, 1983	PIN 3073/129	Sai-Sagul, Fergana, Kyrgyzstan; Lower or Middle Jurassic Sogul Formation
<i>F. sogdiana</i> Rasnitsyn, 1983	PIN 3073/134	Sai-Sagul, Fergana, Kyrgyzstan; Lower or Middle Jurassic Sogul Formation
<i>F. scylla</i> Rasnitsyn, Zhang & Wang, 2006	NND118/NIGP139303 CNU-HYM-NN-2012134	Daohugou, Inner Mongolia, China; Middle Jurassic Jiulongshan Formation
<i>F. charybdis</i> Rasnitsyn, Zhang & Wang, 2006	NND119/NIGP139304	Daohugou, Inner Mongolia, China; Middle Jurassic Jiulongshan Formation
<i>F. chungkuei</i> Rasnitsyn, Zhang & Wang, 2006	NND301/NIGP139305 NND462/NIGP139306 CNU-HYM-NN-2012135(P/C)	Daohugou, Inner Mongolia, China; Middle Jurassic Jiulongshan Formation
<i>F. eucalla</i> sp. nov.	CNU-HYM-NN-2012132 CNU-HYM-NN-2012133	Daohugou, Inner Mongolia, China; Middle Jurassic Jiulongshan Formation
<i>F. insolita</i> sp. nov.	CNU-HYM-NN-2012136 CNU-HYM-NN-2012137(P/C)	Daohugou, Inner Mongolia, China; Middle Jurassic Jiulongshan Formation

Table 1. List of all reported *Ferganolyda*.

Changes, College of Life Sciences, Capital Normal University, Beijing, China (CNUB; Dong Ren, Curator).

The specimens were examined, then photographed, either dry or moistened with 95% ethanol, using a Leica MZ 16.5 dissecting microscope (Leica, Wetzlar, Germany) with a Leica DFC500 digital camera attached. The line drawings were prepared using Adobe Illustrator CS2 and Adobe Photoshop CS5 software. The wing venation nomenclature used in this article was modified after Rasnitsyn (1969, 1980).

Systematic palaeontology

Order Hymenoptera Linnaeus, 1758

Suborder Symphyta Gerstaecker, 1867

Superfamily Pamphilioidea Cameron, 1890

Family Xyelydidae Rasnitsyn, 1968

Ferganolyda Rasnitsyn, 1983

Type species. *Ferganolyda cubitalis* Rasnitsyn, 1983

Other species included. *Ferganolyda radialis* Rasnitsyn, 1983 and *F. sogdiana* Rasnitsyn, 1983 from the Middle Jurassic Sogul Formation of Kyrgyzstan; *F. scylla* Rasnitsyn, Zhang & Wang, 2006, *F. charybdis* Rasnitsyn, Zhang & Wang, 2006, and *F. chungkuei* Rasnitsyn, Zhang & Wang, 2006 from the latest Middle Jurassic Jiulongshan Formation of Inner Mongolia, China.

Ferganolyda scylla Rasnitsyn, Zhang & Wang, 2006

2006 *Ferganolyda scylla* Rasnitsyn, Zhang & Wang, p. 912, fig. 2.

New material. CNU-HYM-NN-2012134, collected near Daohugou Village, Shantou Township, Ningcheng County, Inner Mongolia, China; latest Middle Jurassic.

Description of new material (Fig. 1).

Head (Fig. 1A) widest slightly anterior of its midlength, twice as wide as mesonotum; eyes located at anterior corners of head and near mandible base, three ocelli in close triangle; posterior margin of head convex; mandibles apparently straight and nearly symmetrical, reaching opposite side of head when closed.

Pronotum with arched anterior and posterior margins, 0.35 times as long as wide; mesoprescutum length 1.1 mm, width 1.8 mm, almost 0.4 times as long as mesonotum; scutellum short, 0.3 times as long as mesonotum. Metanotum short but longer than abdominal terga, metascutellum small.

Legs, as preserved, with nearly similar size of femora and tibia for all three pairs; femora fusiform, shorter than mesonotum length, not particularly wide; fore femur about four times as long as wide. Tibiae comparatively narrow, fore tibia 0.5 times as wide as, and as long as, fore femora; hind tibia 10 times as long as wide, and 0.6 times as wide as hind femur (Fig. 1A).

Abdomen with eight segments visible, comparatively wide but short, 6.5 times as wide as long, with no terga split; ovipositor poorly preserved.

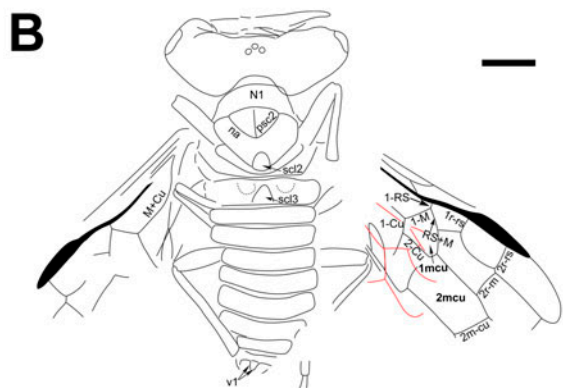


Fig. 1. *Ferganolysda scylla* Rasnitsyn, Zhang & Wang, 2006. CNU-HYM-NN-2012134, latest Middle Jurassic, Inner Mongolia, China. A, Photo of habitus. B, Line drawing. Scale bars = 2 mm. N1, pronotum; psc2, mesoprescutum; na, notaulus; scl2, mesoscutellum; v1, valvulae 1. In all figures, cell symbols are bold and vein symbols are in regular lettering.

Forewing (Fig. 1B) with narrow, completely sclerotized pterostigma; 1-RS present, 0.3 times as long as 1-M, RS+M reaching midlength of anterior margin of cell 1mcu, M+Cu with a slight S-shape bend in its basal part and then curved sharply, 1-Cu about half as long as 2-Cu; 1r-rs 0.6 times as long as 2r-rs and parallel to it; 2r-m interstitial, curved towards wing base, 2m-cu positioned proximal to cell 3rm midlength, cell 1mcu 1.4 times as long as wide, and 0.5 times as long as cell 2mcu; no supernumerary cu-a present.

Dimensions (in mm). Body length (excluding antenna) 14.3, head length without mandible 1.6, width 6.9, forewing length estimated *ca* 11.4.

Remarks. The new material is attributed to *F. scylla* mainly owing to the following characters: Similar head shape, head widest before midlength; pronotum wider than long; forewing with narrow and completely sclerotized pterostigma; 1-RS distinct; M+Cu curved sharply and 1cu-a postfurcal, and 1-Cu (0.63 mm) much shorter than 2-Cu (1.2 mm). The holotype, definitely a male based on its well-preserved male genitalia, has a relatively large body size. Its body length may reach 27.5 mm (vs 14.3 mm for the new specimen), and forewing

length 18.0 mm (vs 11.4 mm for the new material). The new specimen has a notably smaller body size, but with a similar body structure and venation; hence, we tentatively deem this new fossil to be a female of *F. scylla*.

Ferganolysda chungkuei Rasnitsyn, Zhang & Wang, 2006

2006 *Ferganolysda chungkuei* Rasnitsyn, Zhang & Wang, p. 913, fig. 3.

New material. CNU-HYM-NN-2012135(P/C), collected near Daohugou Village, Shantou Township, Ningcheng County, Inner Mongolia, China; latest Middle Jurassic.

Description of new material (Fig. 2).

Head not preserved. As preserved, thorax and part of right wing covered by white (carbonate) film, otherwise body moderately infuscated except for meso- and metathorax; mesonotum fully punctate (Fig. 2A, B).

Pronotum with anterior margin arching, 0.2 times as long as wide. Mesonotum with all main sulci present, mesoprescutum relatively large, occupying 0.4 times the length of mesonotum and 1.2 times as long as mesoscutellum, with notauli short and meeting at angle of 101°; mesopostnotum rectangular, with small round foramen centrally. Cenchi relatively long, reaching nearly the midlength of metanotum, metascutellum rounded triangular, comparatively small.

Abdomen with only three segments partially preserved, with no terga split medially; hind femur, as preserved, almost equal to mesonotum in length, nearly four times as long as wide. Hind tibia long and narrow, scarcely widening apically.

Forewing (Fig. 2E, counterpart) with pterostigma sclerotized completely. SC located in the middle of cell C, two branched, SC2 oblique, and as long as SC1; R very straight proximal to RS base. Vein 1-RS distinct and relatively long, 0.5 times as long as 1-M; RS+M reaching about two-fifths length of anterior margin of cell 1mcu. Crossvein 1r-rs vertical to R, 2r-rs oblique towards wing apex, 2r-m separated from 2r-rs by half its own length, 3r-m separated from apex of cell 3r by less than its own length. M+Cu curved sharply at basal half, then with a kink and a supernumerary r-m vein in right wing (left in counterpart), forming extra cell (Fig. 2C), and short stub in left wing (Fig. 2D). Vein 1cu-a at middle of cell 1mcu, 1-Cu nearly equal to length of 2-Cu; vein 1m-cu 0.5 times as long as 3-Cu, 2m-cu positioned proximal to middle of cell 3rm. Cell 1mcu 1.5 times as long as wide, and 0.7 times as long as cell 2rm.

Dimensions (in mm). Body length estimated *ca* 21.2; forewing length up to end of cell 3r 17.6.

Remarks. The new material is attributed to *F. chungkuei* based mainly on the following characters: anterior margin of pronotum arched; mesoprescutum almost the

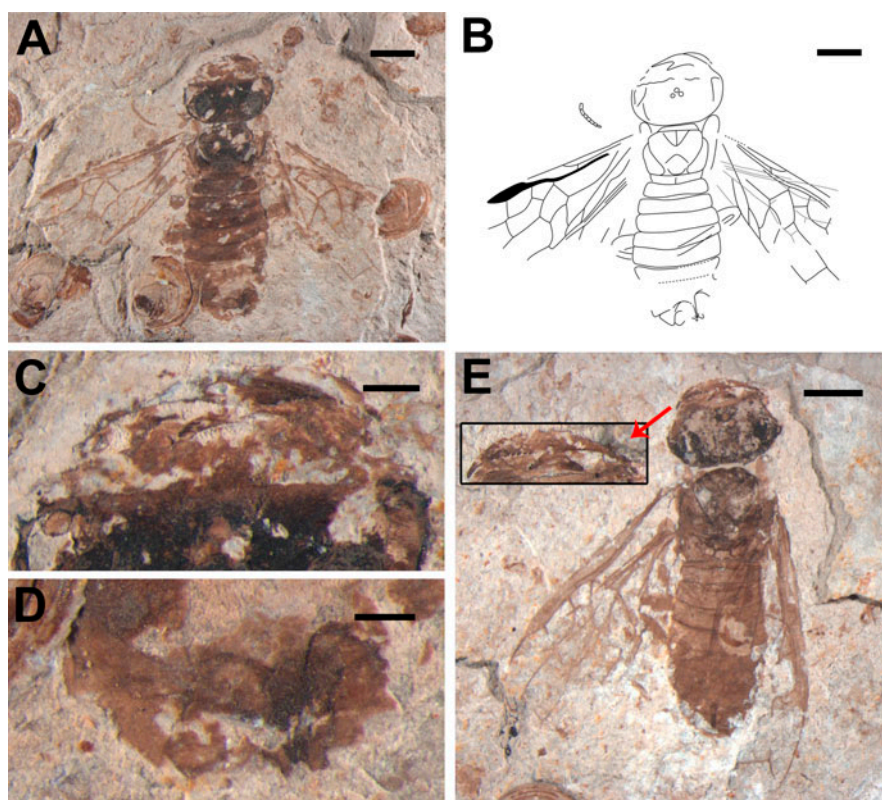


Fig. 3. *Ferganolyda eucalla* sp. nov. Holotype (A–D), CNU-HYM-NN-2012132; Paratype (E), CNU-HYM-NN-2012133, latest Middle Jurassic, Inner Mongolia, China. A, Photo of habitus. B, Line drawing. C, Mandibles. D, Ovipositor. E, Photo of habitus containing a black border with mandibles. Scale bars = 2 mm in A, B and E, 0.5 mm in C and D.

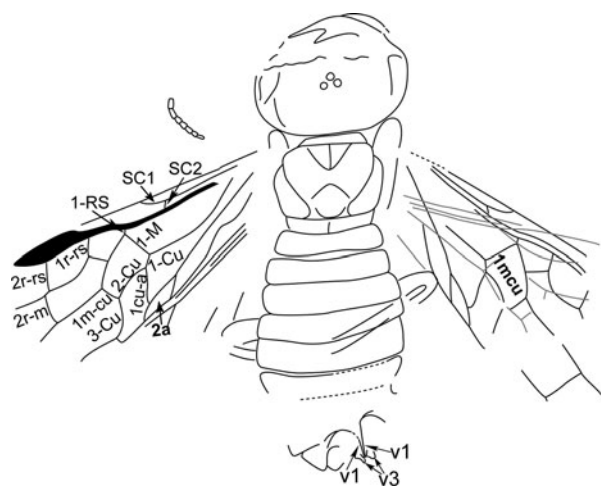


Fig. 4. Interpretations of *Ferganolyda eucalla* sp. nov. Holotype, CNU-HYM-NN-2012132. V3, valvulae 3.

as mesoscutellum, and occupying half of mesonotum in length, with short notauli at an angle of 92.5° ; other detailed structures not distinctive as preserved.

Legs, as preserved, femora shorter than mesonotum width, tibia comparatively thin and long. Abdomen with six basal terga clearly preserved, with no terga split, fourth to sixth being slightly wider than first three. Ovipositor (Fig. 3D) badly preserved; if correctly interpreted, very short, with stylets widely apart basally and meeting only at their apices.

Forewing (Fig. 4) with SC two branched; SC1 3.2 times as long as SC2; SC2 oblique and nearly the same length as 1-RS, meeting R very proximal to RS base. Pterostigma thin (1.9 mm long, 0.5 mm wide), sclerotized completely. R nearly straight, bent at the base of RS; 1-RS proclival, 0.2 times as long as 1-M; 1r-rs curved towards wing apex, 2r-rs originating from pterostigma nearly distal to its middle, about 1.5 times as long as width of pterostigma. RS+M nearly equal to length of R between SC2 and 1-RS. M+Cu curved towards posterior margin of wing; cell 1m-cu subrectangular, 1.78 times as long as wide, RS+M reaching midlength of its anterior margin. Crossvein 1cu-a post-furcal, 2-Cu curved anteriorly, three times as long as 1-Cu; 3-Cu bent towards wing base, and 1m-cu 0.48 times as long as 3-Cu. No supernumerary cu-a present, cell 2a almost three times as long as wide.

Paratype: CNU-HYM-NN-2012133 (female): Colour not reliably known owing to absence of counterpart fossil; as preserved, body colour the same as that of the holotype. Head 1.6 times as wide as mesonotum, 1.87 times as wide as long, with ocelli as in holotype; mandible strong and acute, with about six small inner teeth arranged in a line, near the apex (Fig. 3E); subapical tooth small, placed in the middle of mandible; clypeus short and slightly wavy. Forewing with pterostigma sclerotized completely; 1-RS rather short, M reaching R

rather than RS. Cell 1mcu 2.1 times as long as wide, RS+M reaching midlength of anterior margin of cell 1mcu; 1cu-a interstitial, 2-Cu about five times as long as 1-Cu (Fig. 3E).

Dimensions (in mm). CNU-HYM-NN-2012132: Body length (excluding antenna) 11.7, head length without mandible 2.1, width 4.0, forewing length estimated *ca* 8.6; CNU-HYM-NN-2012133: Body length (excluding antenna) 11.8, head length without mandible 2.1, width 3.8, forewing length estimated *ca* 9.8.

Ferganolyda insolita sp. nov.

Etymology. The specific name is derived from the Latin word ‘*insolitus*’, referring to the unusual fossil specimens with strange morphologies.

Type materials. Holotype, No. CNU-HYM-NN-2012136; Paratype, No. CNU-HYM-NN-2012137(P/C).

Type unit, locality and age. Jiulongshan Formation; Daohugou Village, Shantou Township, Ningcheng County, Inner Mongolia, China (41°18.979'N, 119°14.318'E); latest Middle Jurassic (late Callovian) age.

Diagnosis. Forewing with pterostigma narrow and sclerotized completely. SC2 subvertical and long, nearly equal to the length of SC1; 1-RS not distinct or only present as a very short stub; M+Cu with S-like bend at base, then curved sharply towards posterior margin of wing, and 1cu-a interstitial, at the base of cell 1mcu; RS+M and cell 2a small and short.

Description (Figs 5, 6, 7).

Holotype (Male) CNU-HYM-NN-2012136: Colour not reliably known owing to absence of counterpart fossil; as preserved, body infuscated slightly, uniformly, including head, antennae, wing, thorax and abdomen. Anterolateral and posterolateral margins of head, mesoscutum except anterior roughly punctate (Fig. 5A).

Head capsule widest distal to midlength, with hind contour biconvex with deep central excision about 0.6 mm deep; eyes about half of head length, occupying much of head flanks from near mandibular base (Fig. 5B). Clypeus short, slightly wavy. Three well-preserved ocelli form close obtuse-angled triangle near anterior margin of head, two lines diverging forward from occipital foramen towards transverse line (sulcus?) behind ocelli. Antennae very long even though incomplete, almost 0.9 times as long as body length as preserved; third and fourth segment straight and thick (Fig. 5C), the former nearly 3.1 times as long as wide, the fourth one nearly twice as long as, and 0.8 times as wide as, the third segment; remaining flagellomeres much narrower and longer (Figs 5A, 6), at least 1.2 times as long as the fourth one.

Pronotum trapezoid, anterior margin nearly straight, 3.8 times as wide as long. Mesoscutum about 0.4 times as long as mesonotum, with short notauli at angle of 95.6°. Mesoscutellum small and oval, about 2.2 times as long as mesopseudonotum. Mesopostnotum short and rectangular, with small circular foramen centrally. Cenchri relatively long, equal to the length of metascutellum, and the latter trapezoidal.

Legs badly preserved, femora thick, fore femora as thick as hind one, about 0.8 times as wide as pronotum length; tibia comparatively narrow and short, fore tibia nearly as long as mesonotum width, and the apex of it

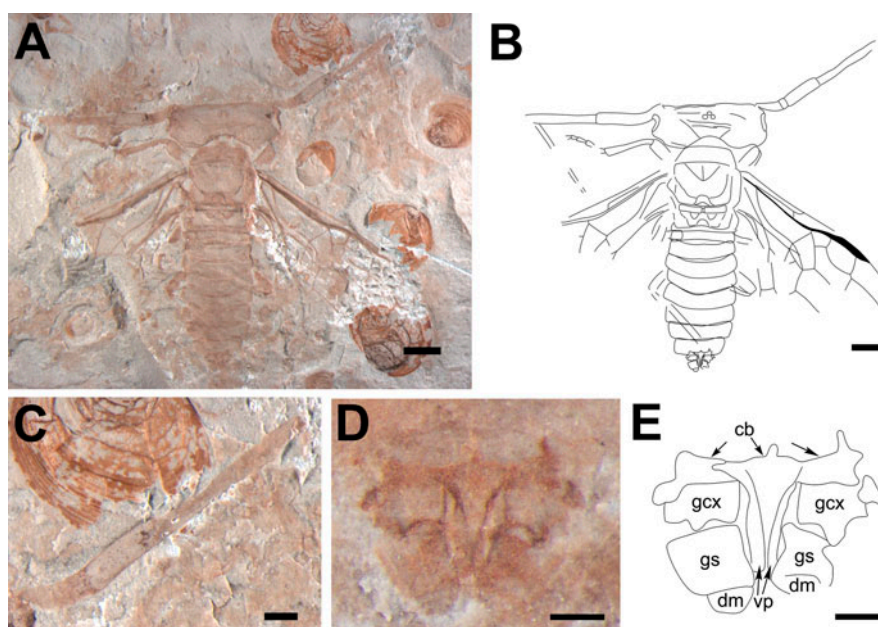


Fig. 5. *Ferganolyda insolita* sp. nov., holotype, CNU-HYM-NN-2012136, latest Middle Jurassic, Inner Mongolia, China. A, Photo of habitus. B, Line drawing. C, Right antenna. D, Male genitalia. E, Interpretations of male genitalia. Scale bars = 2 mm in A and B, 0.5 mm in C, 0.2 mm in D and E. cb, basal ring; gcx, gonocoxa; gs, gonostyle; vp, penial valve; dm, membranous disk.

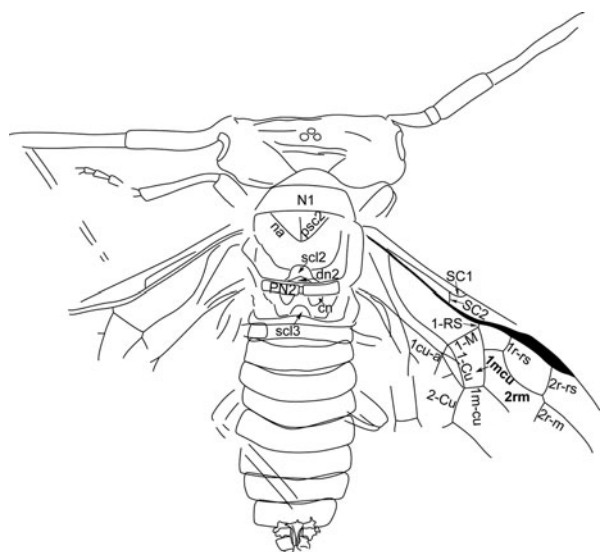


Fig. 6. Interpretations of *Ferganolyda insolita* sp. Nov., holotype, CNU-HYM-NN-2012136. dn2, mesopseudonotum.

about 0.6 times as wide as fore femora; tarsi with four segments preserved, the first interrupted, and 2–4 tarsomeres subtriangular.

Abdomen with eight segments clearly preserved, becoming narrower from the 6th abdominal segment, with no terga split medially. Male genitalia (Figs 5D, E) distinct, gonocoxa trapezoidal, relatively small and short, about 0.7 times as long as wide, posterior margin curved inward, gonostyle quadrangular, large and long, 1.4 times as long as wide, with apical membranous disc; penial valve long, approaching subrectangular.

Forewing (Fig. 6) with pterostigma narrow and sclerotized completely. SC two-branched, SC2 oblique and long, similar to *F. scylla*; 1-RS not distinct, M reaching R rather than 1-RS; 1r-rs vertical, 2r-rs parallel to 2r-m and oblique towards wing apex; RS+M reaching about two-fifths length of anterior margin of cell 1m-cu. Vein 1cu-a interstitial, bent towards wing base. Vein 1m-cu 0.5 times as long as 2-Cu. Cell 1m-cu 2.2 times as long as wide, and 0.85 times as long as cell 2m.

Allotype (Female) CNU-HYM-NN-2012137(P/C): As preserved, body moderately infuscated (Figs 7A, B).

Head oval, widest slightly behind midlength (if measured including closed mandibles), with hind contour straight; eyes placed at its lateral corner; three well-preserved ocelli forming a close equilateral triangle in the middle of head (but near clypeus); mandible thin and narrow, distinctly arching in basal half, with subapical tooth short, at its middle; antenna long, subequal to the length of forewing, with third antennal segment long, thick and straight (Fig. 7G), almost 0.7 times as long as head length, 6.7 times as long as wide, but narrower than that in holotype male; the fourth segment relatively narrow, almost 0.6 times as wide as third one, but nearly equal to the length of the latter (Fig. 7C).

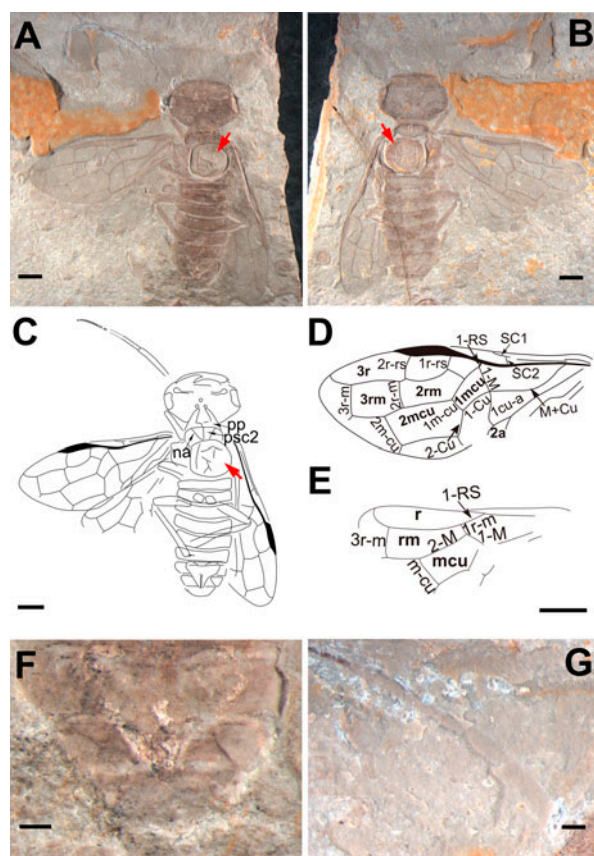


Fig. 7. *Ferganolyda insolita* sp. nov., paratype, CNU-HYM-NN-2012137(P/C), latest Middle Jurassic, Inner Mongolia, China. A, Photo of part. B, Photo of counterpart. C, Line drawing of part. D, Line drawing of forewing of part. E, Line drawing of hind wing of part. F, Ovipositor. G, Antennae of part. Scale bars = 2 mm in A–E, 0.5 mm in F and G. pp, propleura. Red arrows indicate a crustacean shell.

Propleura huge, with long anterior (narrow) parts, meeting medial in hind part only, with maximum common width slightly more than that of mesonotum; structure of meso- and metathorax unknown (obscured by overlying crustacean shell) except for anterior mesoscutum with short notauli forming angle of 102°.

Legs partly preserved, femora long and narrow, of similar length for all three pairs of femora; hind femora thick, about 1.8 times as wide as fore- and mid-femora; tibia comparatively narrow and long, hind one nearly equal to the width of first abdominal segment, about nine times as long as wide, with two apical spurs, the outer spur nearly twice as long as the inner one. Ovipositor with stylets widely spaced basally and meeting only at their apices (Fig. 7F).

Forewing (Fig. 7D) with pterostigma narrow and sclerotized completely. SC two branched, with SC1 oblique and long, SC2 subvertical, about 0.67 times as long as the former; 1-RS very short, 0.14 times as long as 1-M. RS+M reaching about 0.45 of anterior margin of cell 1m-cu; crossveins 1r-rs and 2r-rs bent towards wing apex, 2r-m separated from 2r-rs by distance shorter than its own half length, located distal to middle of cell 2m-cu; 3r-m separated from apex of cell 3r by

0.7 times its own length; 1cu-a interstitial, 1-Cu equal to 1cu-a in length. Vein 1m-cu 0.58 times as long as 3-Cu, 2m-cu proximal to middle of cell 3r-m. Cell 1mcu twice as long as wide, and 0.86 times as long as cell 2r-m. No supernumerary cu-a crossvein present, cell 2a about 1.7 times as long as wide.

In hind wing (Fig. 7E), cell r tapering apically, 1-RS nearly equal to length of 1-M, crossvein 1r-m distant from bases of both RS and M, about 0.5 times as long as 1-RS, 3r-m near apex of cell r. Crossvein m-cu long and oblique towards wing base, joining 2-M distal to midlength of cell rm, separated from 3r-m by a distance equivalent to nearly its length.

Dimensions (in mm). CNU-HYM-NN-2012136: Body length (excluding antenna) 14.3, head length without mandible 1.7, width 6.1, forewing length up to end of cell 3r 11.9; CNU-HYM-NN-2012137(P/C): Body length (excluding antenna) 16.9, head length without mandible 3.4, width 5.8, forewing length up to end of cell 3r 13.1.

Remarks. The female specimen is attributed to the present species with some reservation. Despite its differently shaped head capsule, antenna and larger body size, it has the following similar wing venation features: SC two branched, moderately short hind branch; M+Cu arched sharply, with S-like bend; short RS+M, and a combination of 1cu-a interstitial and pterostigma sclerotized completely.

Key to the known species of Ferganolyda Rasnitsyn, 1983, modified from Rasnitsyn (1983)

- 1 Forewing M+Cu with S-like bend at base, then curved sharply posterior 2
- Forewing M+Cu without an S-like bend at base, curved gently posterior 3
- 2 1cu-a postfurcal; RS+M long, equal to length of 2-M; SC2 meeting R slightly basal of 1-RS
.....*F. scylla* Rasnitsyn, Zhang & Wang, 2006
- 1cu-a interstitial; RS+M shorter than 2-M; SC2 meeting R far basal of 1-RS*F. insolita* sp. nov.
- Length of cell 1mcu no more than 1.5 times as long as wide.....*F. chungkuei* Rasnitsyn, Zhang & Wang, 2006
- Length of cell 1mcu more than 1.5 times as long as wide.....4
- 4 1cu-a interstitial.....*F. eucalla* sp. nov.
- 1cu-a postfurcal.....5
- 5 1-RS very short or not distinct; cell 1r small.....
.....*F. charybdis* Rasnitsyn, Zhang & Wang, 2006
- 1-RS relatively long, at least 1/3 that of 1-M; cell 1r large, equal to cell 2r in length.....6
- 6 Cell 1mcu twice as long as wide; 2r-m inclined and far from 2r-rs.....*F. cubitalis* Rasnitsyn, 1983
- Cell 1mcu less than twice as long as wide; 2r-m nearly in line with 2r-rs.....7

- 7 Pterostigma very narrow; 3r-m separated from apex of cell 3r for less than its own length
.....*F. sogdiana* Rasnitsyn, 1983
- Pterostigma moderately narrow; 3r-m separated from apex of cell 3r by nearly its own length.....
.....*F. radialis* Rasnitsyn, 1983

Discussion

Various morphological characters of *Ferganolyda* from the Yanliao Biota of northeastern China during the latest Middle Jurassic highlight their broad diversity (Rasnitsyn *et al.* 2006). Currently, *Ferganolyda* is reported only from the Middle Jurassic of Kyrgyzstan and China (Tables 1, 2) (a late Early Jurassic age is not excluded for the Kyrgyzstan fossils, cf. Sukacheva & Rasnitsyn 2004). Eight species with 13 specimens from the Middle Jurassic have a wide range of morphological differences, for example, body lengths from 11.7 to 25 mm, forewing lengths from 8.6 to 18.5 mm, and the ratios of body length/forewing length ranging from 1.16 to 1.39. Based on the vast and extensive CNUB collections of more than 250 thousand insect fossils, including more than 100 xyelydid fossils from northeastern China, we have never found any specimens of *Ferganolyda* from the Early Cretaceous Yixian Formation. Equally, they are not recorded in the extensive collection of the Early Cretaceous insects from Siberia and Mongolia kept at the Borissiak Paleontological Institute, RAS, in Moscow, Russia. Therefore, *Ferganolyda* appeared and diversified no later than the Middle Jurassic, and likely declined or even disappeared before the Early Cretaceous. It is interesting to note that many species of Praesiricidae, also with large heads and robust mandibles even though lesser developed than in *Ferganolyda*, have been reported from the Middle Jurassic and the Early Cretaceous of northeastern China, the Late Jurassic of southern Kazakhstan and the Early Cretaceous of Russia and Mongolia. These two sawfly taxa coexisted and might have competed for the same ecospace during the Middle Jurassic of China.

With data from these six newly described specimens and previously described species, we document venation characters as follows: forewing with the pterostigma either sclerotized completely and heavily (*F. scylla*, *F. chungkuei*, *F. insolita*, *F. eucalla*) or just weakly, almost pale (*F. charybdis*); forewing with SC2 relatively long, almost as long as SC1 (*F. scylla*, *F. chungkuei*) or short (*F. charybdis*); vein 1-RS present and long (*F. scylla*) or very short, almost vestigial (*F. charybdis*); crossvein 1cu-a interstitial (*F. insolita*, *F. eucalla*) or postfurcal (*F. scylla*, *F. chungkuei*, *F. charybdis*); and M+Cu with a slight S-like bend at the base, then curved sharply towards the posterior margin of the wing (*F. scylla*, *F. insolita*) or gently curved towards the wing

Taxa	Sex	Body length (BL)	Forewing length (FL)	Ratio of BL/FL	Ratio of head width/length
<i>Ferganolyda cubitalis</i> Rasnitsyn, 1983	?	—	15	—	—
<i>F. radialis</i> Rasnitsyn, 1983	?	—	11	—	—
<i>F. sogdiana</i> Rasnitsyn, 1983	?	—	16	—	—
<i>F. scylla</i> Rasnitsyn, Zhang & Wang, 2006	Male	19.5	16.8	1.16	3.6
	Female	14.3	11.1	1.29	1.95
<i>F. charybdis</i> Rasnitsyn, Zhang & Wang, 2006	Male	25	18	1.39	3.1
<i>F. chungkuei</i> Rasnitsyn, Zhang & Wang, 2006	Male	22–25	18.5	1.19–1.35	3.3
	Female	12	9	1.33	2.1?
<i>F. eucalla</i> sp. nov.	Female	11.7	8.6–9.8	1.19–1.36	1.9
<i>F. insolita</i> sp. nov.	Male	14.3	11.9	1.2	3.5
	Female	16.9	13.1	1.29	1.9

Table 2. Morphological differences in *Ferganolyda* among males and females.

posterior margin (*F. chungkuei*, *F. charybdis*, *F. insolita*). These characters are considered to define the primary interspecific differences in *Ferganolyda*.

It is rare to find asymmetric wing venation and shape in fossil Hymenoptera, especially in Apocrita, owing to its relatively simple and stable venation. However, in our specimen CNU-HYM-NN-2012135(P/C) (Fig. 2), the right forewing (Fig. 2C) has a crossvein between M+Cu and R, which is long and straight, meeting R slightly before the junction of SC2 and R, thus forming an unusual extra cell next to cell 1r, whereas in the left (Fig. 2D), there is just a kink and a short stub at the same place. Regarding this additional crossvein or stub, Gao *et al.* (2013b) reported that *Hoplitolyda duolunica* Gao *et al.*, 2013b (Praesiricidae; Pamphilioidea) has a symmetrical forward stub in M+Cu on both forewings. They indicated that owing to limited specimens with this unique character, they were not sure whether ‘it is a novelty of evolutionary meaning, or simply an individual malformation’ (Gao *et al.* 2013b). The aforementioned discovery in a different but related taxon suggests that both taxa, and possibly the Pamphilioidea as a whole, possess a common aberrant developmental pathway (chreode), which causes similar individual malformations of the wing venation in related sawfly families. However, with only two samples hitherto known, we can not rule out the possible evolutionary significance of this feature, which can only be evaluated pending discovery of more fossil material in the future.

Rasnitsyn *et al.* (2006) discussed the strange morphological structures of *Ferganolyda*, such as the enormous head and the long and thin antennal flagella. They pointed out that this type of antennae also occurs in males of the dipteran family Deuterophlebiidae. Male deuterophlebiids use the antennae for patrolling flight over stream water searching for females. However, considering the habits of sawflies (Rasnitsyn *et al.* 2006), the antennae of *Ferganolyda* males were not used to serve the same function. Furthermore, the large and heavy heads of *Ferganolyda* males make patrolling flight impossible or impractical. On the size of the head

and the shape of the fourth antennal segment, Rasnitsyn *et al.* (2006) attributed them to sexual dimorphism in Hymenoptera. They pointed out that males of *Ferganolyda* have a comparatively short head capsule and fourth antennal segment, which is thin and much longer than the third segment, whereas females have a longer head capsule and fourth antennal segment that is thicker and about as long as the third. Comparing body length, forewing length, ratio of body length to forewing length, and ratio of head width to length for males and females (Table 2), we conclude that in males of *Ferganolyda*, the ratios of head width to length are greater (3.1 to 3.6) than in females (1.9 to 2.1), and can be used as a diagnostic character to distinguish the sexes when genitalia are not preserved or not discernible. Although body size (e.g., males larger than females) is considered a key character in sexual dimorphism by some workers (Gao *et al.* 2013c), *F. insolita* by contrast has male body lengths of 14.3 mm and female body lengths of 16.9 mm. Consequently, body size can be used as a reference, but it is not universally diagnostic for determining insect sexual dimorphism.

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