

Revision of the Genus *Rudisircius* (Hymenoptera, Praesiricidae) with six new species from Jehol Biota, China



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ARTICLE INFO

Article history:

Received 9 December 2013

Accepted in revised form 5 February 2014

Available online 25 March 2014

Keywords:

Sawfly

Rudisircius

Fossil insect

Early Cretaceous

Yixian Formation

ABSTRACT

The genus *Rudisircius* Gao, Rasnitsyn, Shih & Ren, 2010 is emended. Six new species, *R. ferox* sp. nov., *R. ater* sp. nov., *R. tenellus* sp. nov., *R. parvus* sp. nov., *R. membranaceus* sp. nov. and *R. validus* sp. nov., are described and illustrated. These well-preserved specimens were all collected from the Jehol Biota, Early Cretaceous, Yixian Formation of Huangbanjigou Village in Liaoning, China. Based on the new morphological data, a key of *Rudisircius* is provided. These insects are all males that possess larger body length, stronger mandibles and thicker scapes than other Praesiricidae. These new findings and morphological characters enhance our understanding of the evolution and relationships of the enigmatic family Praesiricidae.

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1. Introduction

The superfamily Pamphilioidea comprises two extant families, Megalodontesidae and Pamphiliidae, with a Holarctic Region distribution, and two extinct families, Xyelydidae and Praesiricidae (Rasnitsyn, 1969, 1983). Rasnitsyn considered that Pamphilioidea might be a branch of Siricomorpha, with synapomorphic characters in modified head capsule with isolated mandibular foramina and modified ovipositor, which indicate the monophyly of Pamphilioidea (Rasnitsyn, 1980; Ronquist, 1999; Ronquist et al., 2012). Xyelydidae is the most basal and putatively ancestral (paraphyletic) family in Pamphilioidea (Rasnitsyn, 1968, 1969, 1980, 1983; Rasnitsyn et al., 2006), dating back to the late Early or early Middle Jurassic (Xyelydidae: *Sagulyda* spp., *Ferganolyda* spp.; Rasnitsyn, 1983). Praesiricinae has been first considered to be a subfamily of the Siricoidea (Rasnitsyn, 1968, 1969) based on only one compression fossil of a deformed insect, while some structures (e.g. mesothorax, ovipositor) were mistakenly interpreted before. After corrections of these mistakes, it was transferred from Siricoidea to Pamphilioidea by Rasnitsyn in 1983.

Several fossil praesiricids with unique characters have been described from China recently. Gao et al. (2010) reported the first praesiricids from northeastern China with much exaggerated thick

scapes. Wang et al. (2013) described a sawfly with the third antennal segment consisting of tightly connected primary antennomeres. Gao et al. (2013a) reported the hitherto largest fossil hymenopteran with the body length estimated at about 55.0 mm long. Up to date, there are seven genera and nine species described within Praesiricidae (Taeger et al., 2010), mainly distributed in Central Asia. Praesiricidae is composed of three subfamilies, Praesiricinae Rasnitsyn, 1968 including *Praesirex* Rasnitsyn, 1968 and *Turgidontes* Rasnitsyn, 1990; Rudisircinae Gao, Rasnitsyn, Ren & Shih, 2010 including *Aulidontes* Rasnitsyn, 1983 and *Rudisircius* Gao, Rasnitsyn, Ren & Shih, 2010; and Archoxyelydinae Wang, Rasnitsyn & Ren, 2013 including *Xyelydotes* Rasnitsyn, 1983 and *Archoxyelyda* Wang, Rasnitsyn & Ren, 2013. However, *Hoplitolyda* Gao, Shih, Rasnitsyn & Ren, 2013 is unplaced to any subfamily now.

Recently, we collected eleven well-preserved fossil praesiricids (including two with part and counterpart) from the Early Cretaceous (Late Barremian), Yixian Formation of northeastern China, which belongs to the famous Jehol Biota (Ren et al., 1997; Ren et al., 2010; Ren et al., 2012). It comprises many ephemeropterans (Huang et al., 2007), some odonates (Li et al., 2012) and heteropterans (Yao et al., 2013; Zhang et al., 2013), a lot of mecopterans (Ren et al., 2009; Qiao et al., 2012), a few hymenopterans (Shih et al., 2010; Shi et al., 2013), many diverse neuropterans (Shi et al., 2012), and basal and transitional fleas (Gao et al., 2012, 2013b), etc. The exact age of the Yixian Formation is still debated, and we tentatively consider the age as the Early Cretaceous (Late Barremian) (Wang et al., 2005).

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Gao et al. (2010) have erected a genus *Rudisircius* with three species and a subfamily Rudisirciinae. Based on the new characters of these newly collected fossils, six new species, *R. ferox* sp. nov., *R. ater* sp. nov., *R. tenellus* sp. nov., *R. parvus* sp. nov., *R. membranaceus* sp. nov. and *R. validus* sp. nov., are described and assigned to *Rudisircius*. The diagnoses of *Rudisircius* are emended.

2. Materials and methods

All of these seven specimens described herein are housed at the Key Laboratory of Insect Evolution and Environmental Changes, College of Life Sciences, Capital Normal University, Beijing, China (CNUB; Dong Ren, Curator). The specimens are examined and photographed, either dry or wetted with 95% ethanol, under Leica MZ 16.5 dissecting microscope (Leica, Wetzlar, Germany) with attached digital camera Leica DFC500. The line drawings are prepared using Adobe Illustrator CS2 and Adobe Photoshop CS5 software. The wing venation nomenclature used in is modified after Rasnitsyn (1969, 1980).

3. Systematic paleontology

Order: Hymenoptera Linnaeus, 1758

Suborder: Symphyta Gerstaecker, 1867

Superfamily: Pamphilioidea Cameron, 1890

Family: Praesiricidae Rasnitsyn, 1968

Subfamily: Rudisirciinae Gao, Rasnitsyn, Ren & Shih, 2010

Genus *Rudisircius* Gao, Rasnitsyn, Ren & Shih, 2010

Type species. *Rudisircius belli* Gao, Rasnitsyn, Ren & Shih, 2010

Emended diagnosis. Head large, wider than thorax. Antenna with 17–24 segments, scape long, thick or thickened apical, about as long as head and at least twice as long as wide, subcylindrical, long ovate or subclavate. 3rd segment at least 0.5 times as long as the scape, thicker than following segments and about as long as 4th–6th ones combined. Mandible sickle-shaped, robust. Forewing with 1-RS at most half as long as RS+M, M lacking free apex (Cu possessing it), cell 2a well surpassing crossvein cu-a. Hind wing with M and 1A lacking free apex (Cu possessing it), 1-M aligned with 1r-m.

Species included. Type species, *R. crassinodus* Gao, Rasnitsyn, Ren & Shih, 2010, *R. celsus* Gao, Rasnitsyn, Ren & Shih, 2010, *R. ferox* sp. nov. (Fig. 1), *R. ater* sp. nov. (Fig. 2), *R. tenellus* sp. nov. (Fig. 3), *R. parvus* sp. nov. (Fig. 4), *R. membranaceus* sp. nov. (Fig. 5) and *R. validus* sp. nov. (Fig. 6 and 7), all from the Early Cretaceous Yixian Formation of northeastern China.

Remarks. *Rudisircius* was erected based on only 3 specimens. After studying eleven well-preserved fossils attributed to *Rudisircius*, we add some diagnostic characters of the antennae, mandibles, and forewings. In addition, since one specimen *R. tenellus* sp. nov. reported here has no dark transverse band in its forewings, we no longer consider this character as a generic diagnosis. Apparently all known specimens represent males: no undisputable female is known.

The only other described genus of Rudisirciinae, *Aulidontes* Rasnitsyn, 1983 from the Upper Jurassic of Kazakhstan, differs from *Rudisircius* in having head narrower than thorax, 3rd segment thin throughout, 1-RS longer than RS+M, M with free apex, cell 2a short

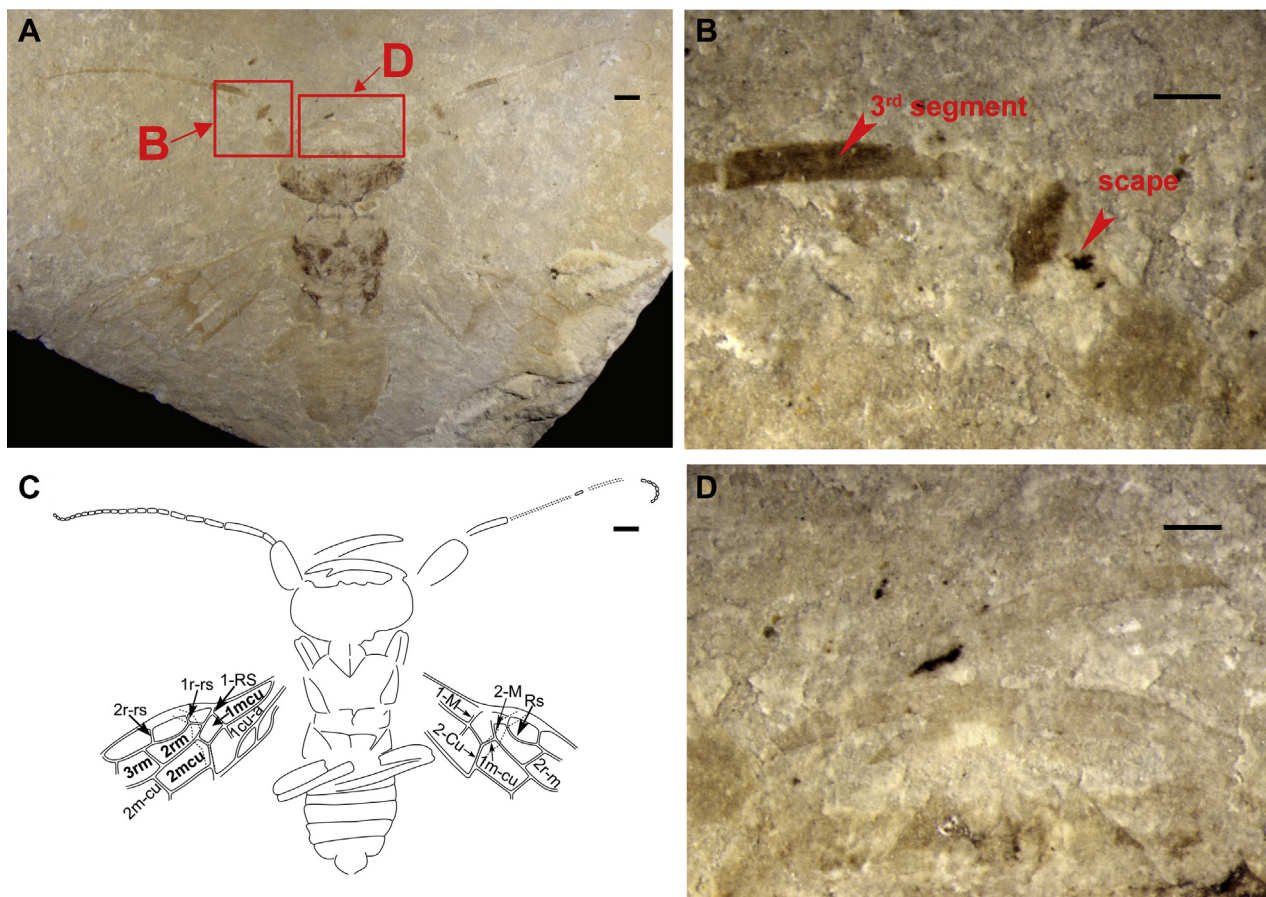


Fig. 1. *Rudisircius ferox* sp. nov. Holotype, CNU-HYM-LB-2012115. A, Photo of habitus. B, Part of left antenna. C, Line drawing. D, Mandible. Scale bars: 1 mm in A and C; 0.5 mm in B and D. In all figures, cell symbols are bold and vein symbols are thin.

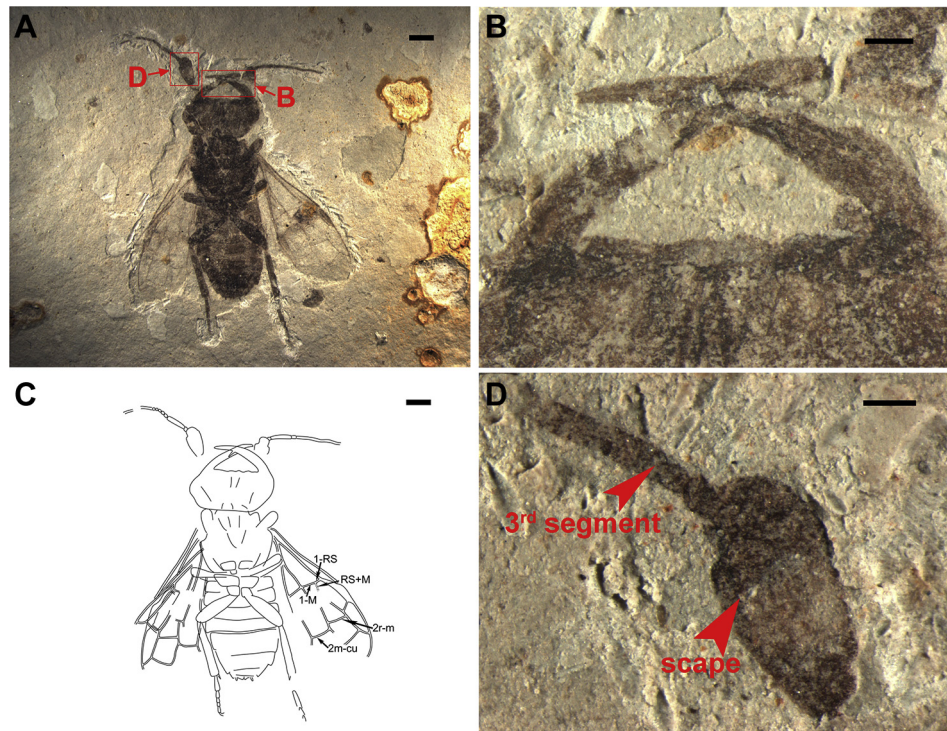


Fig. 2. *Rudisiricius ater* sp. nov. Holotype, CNU-HYM-LB-2012124. A, Photo of habitus. B, Mandibles. C, Line drawing. D, Part of left antenna. Scale bars: 1 mm in A and C; 0.5 mm in B and D.

and scarcely surpassing cu-a, hind wing with M and 1A possessing free apex, and 1-M angled with 1r-m. Except for the shortened forewing 2a cell which is putatively apomorphic (2a cell long for the remaining Symphyta including the most basal family Xyelidae),

all the above characters are most probably plesiomorphic, in agreement with the older age of *Aulidontes*.

***Rudisiricius ferox* sp. nov. (Fig. 1)**

Derivation of name. The specific name is derived from the Latin word “ferox” referring to strong and thick scape.

Type Materials. Holotype, No. CNU-HYM-LB-2012115.

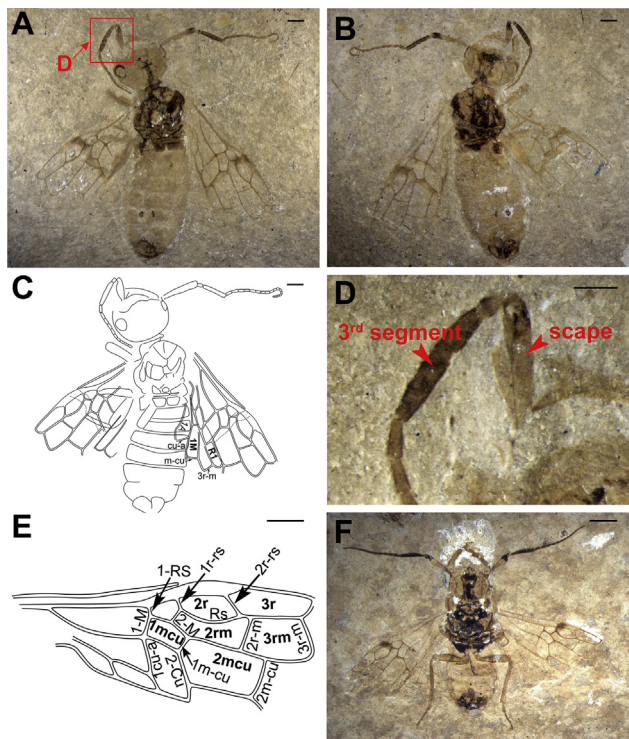


Fig. 3. *Rudisiricius tenellus* sp. nov. Holotype (A–E), CNU-HYM-LB-2012114 p/c; Paratype (F), CNU-HYM-LB-2012122. A, Photo of part. B, Photo of counterpart. C, Line drawing of part. D, Antenna of part. E, Line drawing of right wing of part. F, Photo of habitus. Scale bars: 1 mm in A, B, C, E and F; 0.5 mm in D.

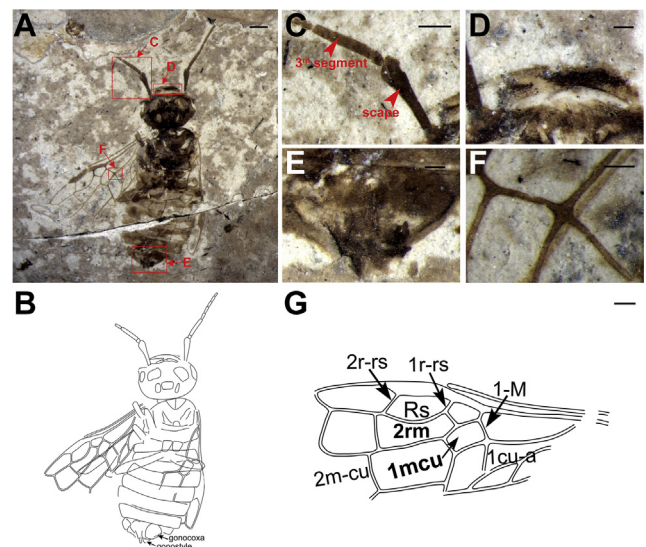


Fig. 4. *Rudisiricius parvus* sp. nov. Holotype, CNU-HYM-LB-2012116. A, Photo. B, Line drawing. C, Part of left antenna. D, Mandible. E, Genitals. F, 1-M and 1cu-a in left wing. G, Line drawing of forewing. Scale bars: 1 mm in A and B; 0.5 mm in C and G; 0.2 mm in D, E and F.

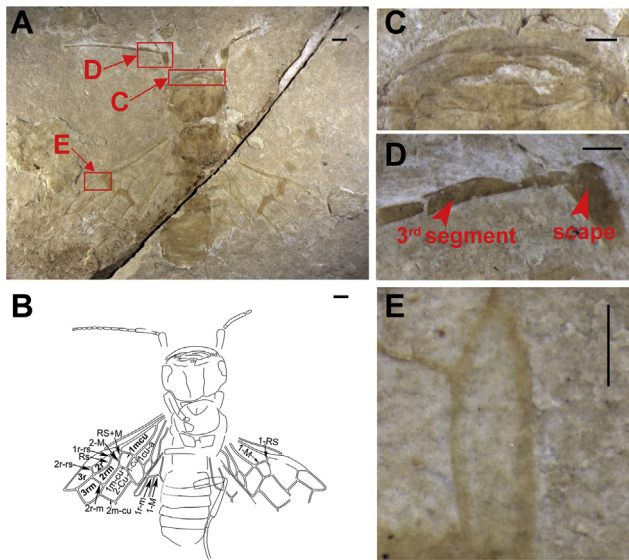


Fig. 5. *Rudisiricius membranaceus* sp. nov. Holotype, CNU-HYM-LB-2012121. A, Photo of habitus. B, Line drawing. C, Mandible. D, Part of left antenna. E, Pterostigma. Scale bars: 1 mm in A and B; 0.5 mm in C, D and E. md: mandible, cly: clypeus.

Horizon and locality. Early Cretaceous, Yixian Formation; Huangbanjigou, Chaomidian Village, Shangyuan Township, Beipiao City, Liaoning Province, China.

Diagnosis. Antenna with scape thick, ovate, 2.2 times as long as wide. Clypeal margin toothed. Forewing with 1-RS proclival, aligned with RS+M, 1cu-a interstitial.

Description (Fig. 1): Color not reliably known because of absence of counterpart fossil. As preserved, body, including mandibles, flagellum, legs and abdomen, moderately pale, with hind half of head, thorax, scape apex and 3rd segment darker (Fig. 1A).

Head about 1.45 times as wide as thorax and abdomen, twice as wide as long, widest near midlength, its fore (clypeal) margin with three teeth; mandible sickle-shaped, reaching opposite side of head when closed, with long apical tooth and short, curved subapical one placed at about 0.7 mandible length (Fig. 1D). Antenna much longer than head width, with nearly 19–20 visible segments, scape ovate, thicker than other segments (0.7 mm in width), 2.2 times as long as wide, with dark apex, nearly 0.8 times as long as head length, 1.2 times as long as, and 3.1 times as thick as, the 3rd segment (Fig. 1B).

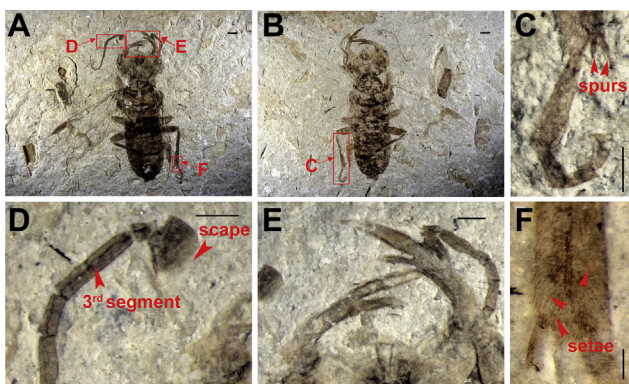


Fig. 6. *Rudisiricius validus* sp. nov. Holotype, CNU-HYM-LB-2012119 p/c. A, Photo of part. B, Photo of counterpart. C, Tibia of counterpart. D, Antenna of part. E, Mandible of part. F, Setae on the femora of part. Scale bars: 1 mm in A and B; 0.5 mm in C, D and E; 0.2 mm in F.

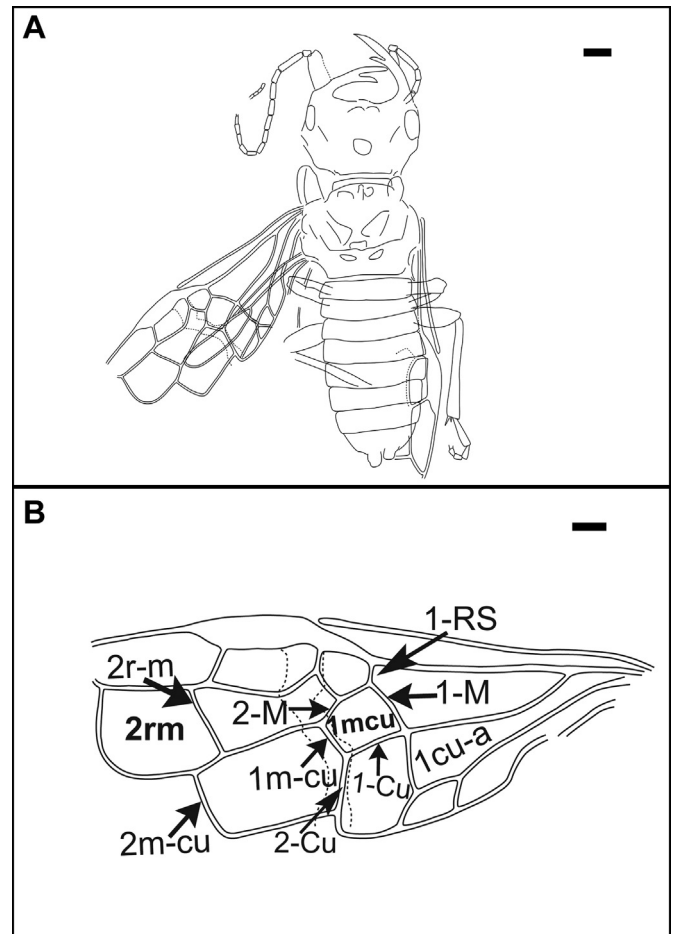


Fig. 7. Line drawing of *Rudisiricius validus* sp. nov., Holotype. A, Body. B, Left forewing. Scale bars: 1 mm in A and B.

Pedicle elongate, rectangular. 3rd segment approximately as long as the following two combined. Remaining segments gradually shortened toward apex, subquadrate.

Forewing (Fig. 1C) with pterostigma rather pale but apparently sclerotized throughout, darkened basally as part of transverse wing band. 1-RS shorter than half length of 1-M, distinctly oblique towards wing apex and almost aligned with RS+M. RS+M equal to the length of 2-M. 1r-rs distinctly shorter than 2r-rs, with Rs arching between them, cell 1mcu 1.6 times as long as wide, nearly as long as cell 2mcu, 0.4 times as long as cell 2rm, 2m-cu distant from 2r-m for half its length. Crossvein 1cu-a interstitial. Distinct brownish translucent band distal of 1-RS, RS+M, 1m-cu and 2-Cu.

Dimensions (in mm). Body length (excluding antenna) 11.9, head length without mandible 2.1, width 4.9, forewing length up to end of cell 3r 8.7.

Rudisiricius ater sp. nov. (Fig. 2)

Derivation of name. The specific name is derived from the Latin word “ater”, referring to the dark body of this sawfly.

Type Materials. Holotype, No. CNU-HYM-LB-2012124.

Horizon and locality. Early Cretaceous, Yixian Formation; Huangbanjigou, Chaomidian Village, Shangyuan Township, Beipiao City, Liaoning Province, China.

Diagnosis. Antenna with scape thick with abruptly narrower apex, 2.1 times as long as wide. Clypeal margin waved. Forewing with 1-RS slightly reclival, aligned with 1-M, 1cu-a interstitial.

Description (Fig. 2): Color not reliably known because of absence of counterpart fossil. As preserved, body, including antenna, head and thorax, very dark, legs slightly darker than abdomen, forewing with narrow transverse band (Fig. 2A).

Head large, 1.2 times as wide as mesothorax, twice as wide as long, widest before midlength (narrowing behind), its fore (clypeal) margin slightly waved; mandibles long, sickle-shaped, with subapical tooth short, straight, acute, placed twice as close to mandible apex as to its base (Fig. 2B). Scape thick, widening towards apex and abruptly narrowed there forming distinct apical knob, 2.1 times as long as wide, about 1.25 times as long as, and 3.8 times as wide as, the 3rd segment (Fig. 2D). Pedicel scarcely longer than wide. Flagellum as long as head wide, flagellar segments other than three basal ones not individually discernible.

Forewing (Fig. 2C) with pterostigma sclerotized completely. 1-RS vertical to RS+M, about 0.4 times as long as 1-M. 2m-cu distant from 2r-m shorter than half its length.

Fore and mid femora nearly equal in length, and 0.73 times as long as hind femora. Hind tibia, with only one apical spur observable, about 1.23 times as long as hind femora, and 0.75 times as long as length of sternum 3, length of tarsal segments 1:2:3:4:5 = 4.13:1.88:1.34:1:1.62.

Dimensions (in mm). Body length (excluding antenna) 10.3, head length without mandible 1.8, width 3.75, forewing length up to end of cell 3r 6.6.

***Rudisircius tenellus* sp. nov. (Fig. 3)**

Derivation of name. The specific name is derived from the Latin word “tenellus”, referring to the relatively narrower scape.

Type Materials. Holotype, No. CNU-HYM-LB-2012114 p/c (part and counterpart) and Paratype, No. CNU-HYM-LB-2012122.

Horizon and locality. Early Cretaceous, Yixian Formation; Huangbanjigou, Chaomidian Village, Shangyuan Township, Beipiao City, Liaoning Province, China.

Diagnosis. Scape long, narrow, widened apically, more than 4 times (4.3–5.4 times) as long as wide, Clypeal margin slightly protruding. Forewing with pterostigma not sclerotized, 1cu-a interstitial, 1-RS vertical to R and nearly aligned with 1-M, 1-M vertical to RS+M and 1-Cu.

Description. Holotype (part and counterpart) (Fig. 3A–E). Pale with thorax including coxae, middorsal head stripe, antenna and abdominal apex darkened (scape only apically dark), forewing with narrow transverse band, pterostigma pale (Fig. 3A, B).

Head massive, nearly 1.12 times as wide as thorax, almost 1.5 times as wide as long, eyes small and oval, placed anteriolateral. Mandibles incompletely preserved, with subapical tooth short, acute, deviating inward. Antenna about 2.3 times as long as head width, with 20 segments preserved. Scape as long as head, somewhat flattened, in narrow projection 5.4 times as long as wide, in wide projection almost twice widened subapically, with narrow apex; 1.55 times as long as, and 1.6 times as thick as, the 3rd segment (Fig. 3D). Pedicel trapezoid, narrower basal. 3rd segment about as long as following four combined. Remaining segments elongate, growing shorter toward the apex. Clypeal margin slightly protruding, probably with slight medial notch. Mandibles with subapical tooth short, acute, placed near its midlength.

Thorax somewhat deformed. Abdomen little wider than thorax, with 8 segments visible (Fig. 3C). Legs poorly preserved, femora short, tibiae comparatively narrow and long, mid-tibiae 2.8 times as wide as mid-femur.

Forewing (Fig. 3E) with pterostigma pale. R much thickening before pterostigma, about as wide here as 1r-rs long. Vein 1-RS vertical to R (right wing). Vein 1r-rs parallel to 2r-rs, inclined toward wing apex, Rs arching gently between 1r-rs and 2r-rs. M+Cu arching strongly, 1cu-a very long, interstitial, as long as the length of segment of CuA distal of 1m-cu. Vein 1m-cu 0.47 times as long as 1cu-a, 0.4 times as long as 2-Cu, 2m-cu before mid-length of cell 3rm. Cell 1mcu 0.85 times as long as wide, and 0.45 times as long as cell 2rm. Vein 2r-rs inclined toward wing apex, while 2r-m toward wing base, 3r-m separated from apex of cell 3r by less than its length. RS+M nearly as long as 1-M and 2-M. Hind wing with cu-a nearly in the middle of cell 1M, 3r-m separated from apex of cell R1 for less than its own length.

Paratype CNU-HYM-LB-2012122 (Fig. 3F): Color not reliably known because of absence of counterpart fossil, as preserved, similar to holotype except that head more widely dark along midline and wing band visible only at pterostigma base and near 1r-rs.

Head as wide as thorax, eyes not preserved. Mandibles sickle-shaped, slightly curved, with no subapical teeth preserved. Antenna with 18 visible segments preserved. Scape nearly 4.3 times as long as wide, similar to that of holotype in form, 1.52 times as long as, and 1.65 times as thick as, 3rd segment (in right scape). Pedicel narrow and elongate (similar to 8th segment). 3rd segment 1.2 times as long as following three combined. Remaining segments growing shorter and narrower toward the apex, elongate and rectangle.

Mesoscutum occupied 3.7 times of mesothorax. Hind coxae trapezoid, about 3 times as long as trochanter, hind tibia, with two apical and at least one subapical spurs, equal to the length of mesothorax, length of tarsal segments 1:2:3:4:5 = 4.1:1.8:1.2:1:2.2, including two claws. Pale ventral apical patches of tarsal segments 1–4 probably represent plantae.

Forewing with pterostigma pale. R much thicker behind origin of RS, 1-RS vertical to R, 1r-rs parallel to 1-RS, 2r-rs inclined toward wing apex, Rs arching gently between 1r-rs and 2r-rs. M+Cu arching strongly, 1cu-a very long, interstitial. Vein 1m-cu approximately 0.57 times as long as 1cu-a, 0.55 times as long as 2-Cu, 2m-cu before mid-length of cell 3rm. Cell 1mcu approaching rectangle, 1.8 times as long as wide, and 0.55 times as long as cell 2rm. RS+M nearly as long as 1-M and 2-M. Hind wing with 1-RS curved, nearly as long as 1r-m, and 1r-m aligned with 1-M, 3r-m separated from cell R1 by equal to its length.

Dimensions (in mm). CNU-HYM-LB-2012114: Body length (excluding antenna) 12.9, head length without mandible 2.3, width 3.4, length up to end of cell 3r 8.9; CNU-HYM-LB-2012122: Body length (excluding antenna) 18.5, head length without mandibles about 4.3, width 5.0, forewing length up to end of cell 3r 13.3.

***Rudisircius parvus* sp. nov. (Fig. 4)**

Derivation of name. The specific name is derived from the Latin word “parvus”, referring to the short body length of this sawfly.

Type Materials. Holotype, No. CNU-HYM-LB-2012116.

Horizon and locality. Early Cretaceous, Yixian Formation; Huangbanjigou, Chaomidian Village, Shangyuan Township, Beipiao City, Liaoning Province, China.

Diagnosis. Scape thin, much widened apical, longer and thicker than other segments, almost 4 times as long as wide. Clypeal margin slightly protruding. Forewing with 1cu-a interstitial, 1-RS vertical to R, 1-M vertical to RS+M and 1-Cu, RS+M as long as 2-M.

Description (Fig. 4): Color not reliably known because of absence of counterpart fossil. As preserved, body and appendages dark, thorax less dark, head with small elongate sublateral spots behind and apparently with larger roundish ones in front of these (Fig. 4A, B). Forewing with no transverse band.

Head 1.15 times as wide as thorax. Antenna with scape (1.6 mm in length) thin, straight, widened toward apex (Fig. 4C), nearly 0.6 times as long as head length, almost 4 times as long as wide, 1.2 times as long as, and 1.7 times as thick as, the 3rd segment. The 3rd segment possibly as long as the following 4th–6th ones combined. Clypeal margin slightly protruding, probably with slight medial notch. Mandibles incompletely preserved, apparently with short, acute tooth near midlength (Fig. 4D).

In forewing (Fig. 4G), pterostigma sclerotized completely. R much thicker before pterostigma, about as wide as 1r-rs long. Vein 1r-rs nearly 0.6 times as long as 2r-rs, both inclining to wing apex, section of Rs between 1r-rs and 2r-rs arching gently. Cell 1mcu 1.67 times as long as wide. Vein 1cu-a originating from Cu a short distance after separation of 1-M (Fig. 4F). Vein 2m-cu near 2r-m.

Dimensions (in mm). Body length (excluding antenna) 9.3, head length without mandible 1.9, width 3.1, forewing length up to end of cell 3r 6.3.

***Rudisircius membranaceus* sp. nov. (Fig. 5)**

Derivation of name. The specific name is derived from the Latin word “membranaceous”, referring to the pterostigma not sclerotized.

Type Materials. Holotype, No. CNU-HYM-LB-2012121.

Horizon and locality. Early Cretaceous, Yixian Formation; Huangbanjigou, Chaomidian Village, Shangyuan Township, Beipiao City, Liaoning Province, China.

Diagnosis. Scape gradually widened towards apex, about 3.2 times as long as wide. Clypeal margin with distinct medial lobe. Pterostigma not sclerotized. 1-RS subvertical to R, RS+M as long as 2-M. 1cu-a interstitial.

Description (Fig. 5): Color not reliably known because of absence of counterpart fossil. As preserved, body moderately pale, with more dark antenna (except scape darkened toward apex only). Forewing (Fig. 5A) with narrow transverse band.

Head 1.25 times as wide as thorax, 1.5 times as wide as long, with clypeal margin forming distinct medial lobe. Antennae with 13 segments preserved, scape 3.2 times as long as wide, about 1.05 times as long as, and 1.85 times as wide as, 3rd segment (Fig. 5D). Mandible bent inward, when closed reaching opposite side of head (Fig. 5C). The 3rd segment possibly as long as the following two combined.

Thorax as wide as abdomen, with few details preserved. In forewing, pterostigma not sclerotized (Fig. 5E). R much thicker behind origin of RS, 1-RS vertical to R, RS+M as long as 2-M, M+Cu arching strongly, 1cu-a interstitial. Vein 1r-rs half as long as 2r-rs,

both inclining to wing apex, section of Rs between 1r-rs and 2r-rs arching gently. Vein 1m-cu approximately 0.55 times as long as 1cu-a, 0.55 times as long as 2-Cu, 2m-cu before mid-length of cell 3rm, and far from 2r-m for more than half its length. Cell 1mcu 1.36 times as long as wide, with 1-M around as long as 1-Cu, and 0.68 times as long as cell 2rm (Fig. 5B).

Legs poorly preserved.

Dimensions (in mm). CNU-HYM-LB-2012121: Body length (excluding antenna) 13.5, head length without mandible 2.7, width 4.2, forewing length up to end of cell 3r 8.8.

***Rudisircius validus* sp. nov. (Figs. 6 and 7)**

Derivation of name. The specific name is derived from the Latin word “validus”, referring to the robust mandible.

Type Materials. Holotype, No. CNU-HYM-LB-2012119 p/c.

Horizon and locality. Early Cretaceous, Yixian Formation; Huangbanjigou, Chaomidian Village, Shangyuan Township, Beipiao City, Liaoning Province, China.

Diagnosis. Antenna apparently with 20 segments or more, scape at least 2.4 times as wide as 3rd segment. Clypeal margin with distinct medial lobe. Forewing with 1-RS subvertical to RS, 2r-m reclinal, distant from 2m-cu for less than half its length, 1cu-a interstitial.

Description (Figs. 6 and 7): As preserved, body moderately dark throughout, except that scape pale and invisible except for dark apex (Figs. 6A, B, 7A).

Head as wide as thorax, transverse ovate, 1.5 times as wide as long, with eyes small, roundish, moved forwards and almost reaching mandibular bases, clypeal margin with median lobe. Antenna near two times as long as head wide, with at least 20 segments, with scape, judging from its only visible apex, thick, 2.4 times as wide as 3rd segment (Fig. 6D). The 3rd segment possibly as long as the following two combined. Mandible (about 3.5 mm in length) long and sharp, reaching opposite side of head when closed, with long apical tooth and long, slanting subapical one placed at the mid-length of mandible (Fig. 6E).

Forewing (Fig. 7B) with pterostigma sclerotized completely. R becoming thicker behind origin of RS, 1-RS vertical to R, nearly 0.33 times as long as 1-M, 1-M approximately equal to length of 1-Cu (0.94 times) and RS+M as long as 2-M. Cell 1mcu 1.22 times as long as wide, 0.53 times as long as cell 2rm. Vein 1m-cu about 0.65 times as long as 2-Cu. 2r-m reclinal, distant from 2m-cu for less than half its length, cu-a interstitial.

Legs ordinary, femora shorter than mesonotum length, fusiform, not particularly wide (hind femur 3.8 times as long as wide), widest subapical, fore and mid femora narrower than hind one. Tibiae comparatively narrow and long (hind tibia 9 times as long as wide), covered with dense setae (Fig. 6F), with apical spurs rather short (the outer one nearly twice as long as the inner one) (Fig. 6C), tarsus much shorter than tibia, with basitarsus about as long as following 3 segments combined, segments 2–4 elongate, 5th ill-preserved.

Dimensions (in mm): Body length (excluding antenna) 12.9, head length without mandible 2.7, width 4.5, forewing length up to end of cell 3r 9.7, hind tibia length 3.5, tarsal segments 1:2:3:4 = 4.8:1.9:1.3:1.

Key to the known species of *Rudisircius* Gao, Rasnitsyn, Ren & Shih, 2010

1. 1-RS proclival, aligned with RS+M. Head twice as wide as long, with clypeal margin toothed. Scape very thick (twice as long as wide). 2r-m distinctly reclivous. Mandible with subapical tooth placed at its apical 0.7 *R. ferox* sp. nov.
- 1-RS vertical or slightly reclival, more or less aligned with 1-M..... 2
2. Crossvein cu-a postfurcal. Scape thick 3
- Crossvein cu-a interstitial. 4
3. RS between 2r-rs and 2r-m shorter than half 2r-rs length. Scape asymmetrically produced apical. (Abdomen dark) *R. celsus* Gao et al., 2010
- RS between 2r-rs and 2r-m much longer. Scape apex not strongly asymmetrical. (Abdomen pale except apically) *R. crassinodus* Gao et al., 2010
4. Forewing with no dark transverse band. Crossveins 2r-m and 2m-cu distant for less than half of 2r-m length. Scape thin, widened towards apex *R. parvus* sp. nov.
- Forewing with distinct transverse band along base of cells 2r, 2r-m and 2m-cu. Crossveins 2r-m and 2m-cu distant for more than half of 2r-m length..... 5
5. Crossveins 2r-m and 2m-cu distant for less than half of 2r-m length. Scape thick with abruptly narrowed apex, before narrowing about as wide as segment 3 long. (Body uniformly dark)
- *R. ater* sp. nov.
- Crossveins 2r-m and 2m-cu distant for more than half of 2r-m length. Scape apex not abruptly narrowed except *R. tenellus* sp. nov. with (abdomen pale) and scape much narrower 6
6. 2r-m distinctly reclivous. (Body including abdomen dark, pterostigma darker than transverse wing band). Mandible with subapical tooth long, slanting, placed at mandible midlength
- *R. validus* sp. nov.
- 2r-m at most slightly reclivous. (Abdomen and pterostigma pale, pterostigma paler than transverse wing band)..... 7
7. Pterostigma about 0.6 times as wide as 1r-rs long. Scape apex less than twice as wide as 3rd segment. (Thorax dark, abdomen mainly pale) *R. tenellus* sp. nov.
- Pterostigma about as wide as 1r-rs long. Scape apex no less than twice as wide as 3rd segment 8
8. 1-M scarcely longer than 1m-cu. Scape long and narrow, ca. 5 times longer than wide, about 0.7 times as long as distance between antennal bases. (Femora darker than abdomen, except for abdominal apex) *R. belli* Gao et al., 20104
- 1-M about 1.5 times as long as 1m-cu. Scape about half as long as distance between antennal bases, apparently thicker. (Femora paler than abdomen, except for abdominal apex)
- *R. membranaceous* sp. nov.

4. Discussion

Xyelidae, first appeared in the Triassic deposits, is commonly considered to be the sister group to all other hymenopterans, and placed as the basal group in the phylogeny of Hymenoptera (Rasnitsyn, 1980, 1988; Ronquist, 1999; Grimaldi and Engel, 2005; Ronquist et al., 2012). Most notably, the elongated third antennal segment is supposed to be the ground plan character state of Hymenoptera (Rasnitsyn, 1996, 2006; Wang et al., 2012). Since the flagellar transformation in the early evolution of Hymenoptera is an old problem to paleontologists, Wang et al. suggested a hypothesis on antennal changes, and presented three different trajectories during the course of its evolution. (Wang et al., 2013).

Although the 3rd antennal segment presents diverse variations in lower hymenopterans, scapes are often quite stable with normal

and ordinary forms. In the vast fossil insect collection at CNU, we have found fourteen *Rudisircius* specimens up to now: three reported by Gao et al. in 2010, seven described in the present paper while four not identifiable to species due to poor preservation of diagnostic characters. Like many other symphytans, Rudisirciinae have elongated 3rd antennomeres. It is unusual that their scapes are robust (much longer and thicker than any other segment including the 3rd one, Table 1) that could be considered as apparently a unique specialization within this subfamily. Additionally, some *Rudisircius* and particularly *R. ferox* possess a really huge head and mandibles which approach, along with *Hoplitolyda* Gao et al. 2013 (Praesiricidae; Gao et al., 2013a), to *Ferganolyda* Rasnitsyn, 1983 (Xyelidae), whose head in proportion to body might be the largest in a broader taxa beyond Hymenoptera (Rasnitsyn et al., 2006). Unfortunately, reasons for the head and scape gigantism, their functional morphology and support, are left

Table 1Comparison of scape, pterostigma and band of *Rudisircius belli*, *R. crassinodus*, *R. celsus* and six new species.

Species	Ratio			Pterostigma sclerotized	Forewing color band
	Scape, length/width	Length, scape/3rd segment	Width, scape/3rd segment		
<i>R. belli</i> Gao et al., 2010	5.0	1.5	2.17	+	+
<i>R. crassinodus</i> Gao et al., 2010	2.78	1.87	2.34?	+	+
<i>R. celsus</i> Gao et al., 2010	2.9	1.6	3.07	+	+
<i>R. ferex</i> sp. nov.	2.2	1.2	3.1	+	+
<i>R. ater</i> sp. nov.	2.12	1.24	3.84	+	+
<i>R. tenellus</i> sp. nov., holotype	5.4	1.56	1.57	–	+
<i>R. tenellus</i> sp. nov., paratype	4.3	1.52	1.65	–	+
<i>R. membranaceus</i> sp. nov.	3.2	1.07	1.86	–	+
<i>R. parvus</i> sp. nov.	2.8	1.79	2.38	+	+
<i>R. validus</i> sp. nov.	?	?	2.4	+	–

obscure and challenging (Rasnitsyn et al., 2006; Gao et al., 2013a). Extant pamphilioids often have large heads with long and powerful mandibles in both males and females, which are used as weapons for defense (Rasnitsyn et al., 2006; Gao et al., 2013a). However, their heads and mandibles are clearly smaller than those of aforementioned extinct taxa.

All reported specimens of Rudisirciinae thus far are definite or possible males, while no definite females have been described. This is a very enigmatic case for Symphyta, for the vast majority of their fossils are females. We are not aware of any other sufficiently abundant sawfly taxa with only male fossils preserved. We are not sure whether sedentary habits of females might be a plausible explanation of their escape of burial.

An additional interesting feature of *Rudisircius* is its high diversity and comparative abundance in the hymenopteran assemblage in the Yixian Formation (14 specimens representing 9 species) and nowhere else. This might suggest a narrow spatio-temporal distribution of the genus which, however, certainly needs additional study to be used for biostratigraphic and paleobiogeographic inferences.

Acknowledgments

We acknowledge Dr. Taiping Gao for his useful advice and discussions on this article. This work was supported by the National Basic Research Program of China 973 Program Grant 2012CB821906; National Natural Science Foundation of China Grants 31172143, 31230065, and 41272006; Project of Great Wall Scholar and KEY project of Beijing Municipal Commission of Education Project (Grant KZ201310028033); the China Postdoctoral Science Foundation funded project (Grants 20110490449, 2012T50113), and the Beijing Postdoctoral Research Foundation (Grant 2011ZZ-36). For APR, the work was additionally supported by the Presidium RAS Program “Origin and evolution of the geobiological system”.

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