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Two New Fossil Sawflies (Hymenoptera, Xyelidae, Xyelinae) from the Middle Jurassic of China

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Abstract: Two new genera with two new species of sawflies, *Cathaxyela extensa* gen. et sp. nov. and *Aequixyela immensa* gen. et sp. nov., from the Middle Jurassic Jiulongshan Formation of southeastern Inner Mongolia, China, are assigned to the subfamily Xyelinae (Hymenoptera, Xyelidae). *Cathaxyela* gen. nov. can be distinguished by the third antennal article longer than the head; mesoprescutum and mesoscutellum nearly equal in length; the forewing with Sc meeting C before the junction of 1-M and 1-Rs; a weak and narrow pterostigma; and 3-Cu at least 1.5 times longer than the 1m-cu. *Aequixyela* gen. nov. is characterized by the third antennal article nearly as long as the head; the forewing with Rs+M approximately equal to 2-Rs in length; 2m-cu inclined toward the wing base and nearly reaching the middle of cell 3rm; 1m-cu as long as the 2-Cu and 3-Cu; and the cell 2cua of regular hexagonal shape.

Key words: Invertebrate paleontology, taxonomy, Arthropoda, Daohugou, Inner Mongolia

1 Introduction

The family Xyelidae has a special significance in the evolutionary history of the hymenopterans. The earliest appearance of the Hymenoptera has been reported in the Middle or Late Triassic (Riek, 1955; Rasnitsyn, 1964, 1969, 1980; Schlüter, 2000; Engel, 2005). Xyelids are well supported to take the most basal position in the order, that is, either the ancestral (a classic approach, e.g. Rasnitsyn, 1988, 2002), or the sister position in respect to the remaining Hymenoptera (a cladistic approach, Grimaldi and Engel, 2005). The Xyelidae is composed of four subfamilies: Macroxyelinae Ashmead, 1898; Xyelinae Newman, 1834; Archexyelinae Rasnitsyn, 1964; and Madygellinae Rasnitsyn, 1969 (Rasnitsyn 1980). So far, 48 fossil genera with 96 species of fossil Xyelidae have been described (Taeger et al., 2010; Gao et al., 2011; Wang et al., 2012). The subfamily Xyelinae is composed of two tribes – Liadoxyelini and Xyelini (Rasnitsyn, 1966, 1969, 1985) with ten genera: *Liadoxyela* Martynov, 1937, *Kirghizoxyela* Rasnitsyn, 1966, *Lydoxyela* Rasnitsyn, 1966, *Anomoxyela* Rasnitsyn, 1966 and *Orthoxyela* Rasnitsyn, 1983 in Liadoxyelini, and *Xyela* Dalman, 1819, *Eoxyela* Rasnitsyn, 1965, *Enneoxyela* Rasnitsyn, 1966,

Spathoxyela Rasnitsyn, 1969, and *Xyelisca* Rasnitsyn, 1969 in the Xyelini.

The Daohugou area in China is one of the most important localities for Middle Jurassic insects and contains abundant, diverse and many excellently preserved fossils (Gao and Ren, 2006; Ren et al., 2010a, 2012), for example, salamanders (Gao and Shubin, 2003), pterosaurs (Wang et al., 2002), feathered dinosaurs (Xu and Zhang, 2005), birds (Zhang et al., 2008), gymnosperm forests (Mi et al., 1996), and wonderful insects (Ren et al., 2009, 2010b; Wang and Ren, 2009; Wang et al., 2010; Zhang et al., 2010; Zhang et al., 2011; Gu et al., 2012; Yao et al., 2012; Shi et al., 2013), especially some hymenopteran fossils (Gao et al., 2009; Shih et al., 2009; Rasnitsyn and Zhang, 2010; Liu et al., 2011; Wang et al., 2012; Li et al., 2013). Recently we collected two well-preserved fossils (including one with part and counterpart) from the Jiulongshan Formation in Daohugou Village, Shantou Township, Ningcheng County, Inner Mongolia, China. Based on these well-preserved specimens, two new genera have been established.

2 Materials and Methods

All the materials were collected near Daohugou Village,

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Shantou Township, Ningcheng County, Inner Mongolia, China (see Fig 1). The wing venation nomenclature used in this paper (Figs. 2D, 3C-D) is modified after Rasnitsyn (1969, 1980). The specimens were examined using a Leica MZ 12.5 dissecting microscope and illustrated with the aid of a drawing tube attachment. The figures were drawn using Adobe Illustrator CS2 and Photoshop CS 5.1. All fossil specimens are housed in the Key Lab. of Insect Evolution & Environmental Changes, College of Life Sciences, Capital Normal University, Beijing, China (CNUB; Dong Ren, Curator).

3 Systematic Paleontology

Order Hymenoptera Linnaeus, 1758

Suborder "Symphyta" Gerstaecker, 1867

Superfamily Xyeloidea Newman, 1834

Family Xyelidae Newman, 1834

Subfamily Xyelinae Newman, 1834

Comments: Diagnostic characters of the Xyelinae differing from the Macroxyelinae are C apex only slightly

widened, if at all, and not connected to R, with no desclerotization there (except for *Orthoxyela* Rasnitsyn, 1983). The pterostigma is not strongly sclerotized (dark) except for, sometimes, the surrounds of its veins, which are clearly seen, and the ovipositor is long and not very wide, except in *Aequixyela* gen. nov. (see below).

Tribe Xyelini Newman, 1834

Comments: The diagnostic characters of the Liadoxyelini that differ from the Xyelini are 1-Rs at most slightly longer than 1-M, and 3-Cu usually more than 1.5 times as long as 1m-cu (except for *Aequixyela* gen. nov., see below). Genera included are shown in Table 1.

Cathaxyela gen. nov.

Type species: *Cathaxyela extensa* sp. nov.

Diagnosis: Head with third antennal article longer than head, flagellum still longer, with at least 12 articles, pronotum wide and nearly trapezoid, meso- and mesoscutella nearly equal in length, forewing with R almost straight, with no backward bent at or before Rs base, Sc touching R except apically, meeting C just before

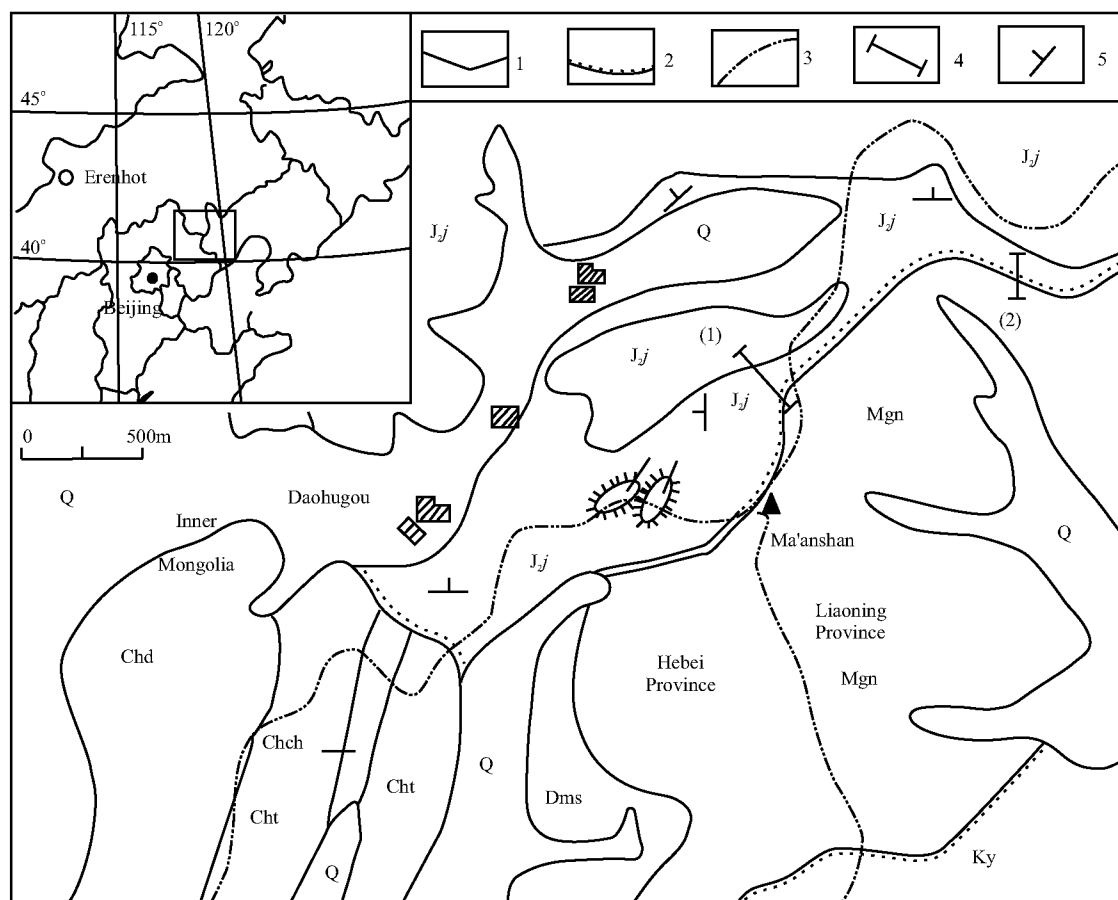


Fig. 1. Simplified geological map of Daohugou area at juncture of three provinces (autonomous region) of Liaoning, Hebei, and Inner Mongolia (after Gao and Ren, 2006).

1, stratigraphic boundary; 2, unconformity; 3, provincial boundary; 4, location of geological section; 5, strike and dip; Chc, Changchou-gou Fm.; Chch, Chuanlinggou Fm.; Chd, Dahongyu Fm.; Cht, Tuanshanzi Fm.; Dms, Dalaizingzi erosion surface; Jj, Jiulongshan Fm.; Ky, Yixian Fm.; Q, Quaternary; Mgn, Maanshan gneiss.

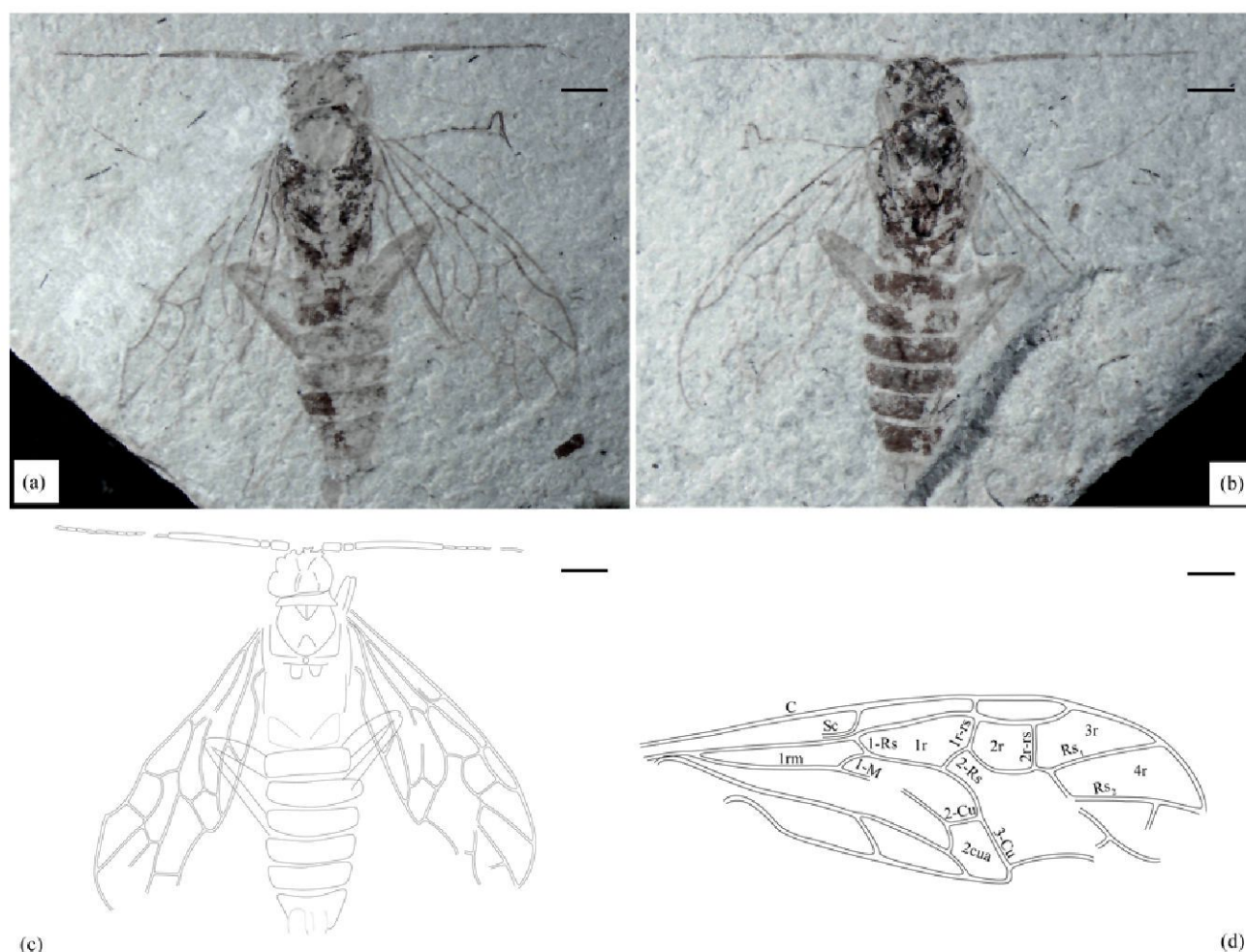


Fig. 2. *Cathayxyela extensa* sp. nov. Holotype, CNU-HYM-NN-2012106(p/c).

(a) Photograph in dorsal view. (b) Photograph in ventral view. (c) Line drawing of dorsal view. (d) Line drawing of right forewing. Scale bar = 1 mm. Venation symbols: C, Sc, R, M, Cu –main (longitudinal) veins; 1-Rs, 1-M, 2-Cu, etc.–sections of these veins; 1r-rs, 2r-rs, etc.–crossveins; 1r, 2r, 2cua, etc.–cells.

junction of 1-Rs and 1-M, pterostigma pale and narrow, 1-Rs much shorter than 1-M, 1r-rs shorter than 2r-rs, 3-Cu at least 1.5 times as long as 1m-cu.

Etymology: The generic name is a combination of Latin prefix “*Cathay*” referring to an ancient name for China, and the genus name *Xyela*. The gender is feminine.

Composition: Type species only.

Comments: The costal space and pterostigma are without sclerotization, which indicate the position of the new genus in Xyelinae. The 1-Rs is shorter than 1-M, and 3-Cu is at least 1.5 times as long as 1m-cu, in the tribe Liadoxyelini. Within the latter, a combination of a straight R and present Sc is characteristic of *Orthoxyela*, which differs in the Sc running distant of R. From the coeval *Aequixyela*, *Cathayxyela* differs in having Rs+M longer than 2-Rs, 1m-cu much shorter than 3-Cu, the third antennal segment longer than the head, and the flagellum still longer.

Cathayxyela extensa sp. nov.

(Fig. 2)

Diagnosis: In addition to the generic diagnosis, 1-M bends toward wing base; 1m-cu longer than half of 2-Rs.

Etymology: The specific name *extensa* (feminine gender of the Latin for extended) refers to the fossil preserved stretched and extended.

Type material: Holotype: male, CNU-HYM-NN-2012106 (p/c).

Locality and horizon: Daohugou Village, Shantou Township, Ningcheng County, Inner Mongolia, China: Jiulongshan Formation, Middle Jurassic (Callovian-Bathonian boundary).

Description: Antenna with third antennal article straight, and nearly twice as long as the head; the following 12 articles nearly 1.2 times as long as the third article as preserved. The head capsule 1.6 times as wide as long, widest behind the middle. The pronotum ordinary, and the mesopostnotum with a round foramen centrally; metanotum with cenchri comparatively long and wide. Legs with femora and tibia long and narrow, femora

Table 1 Distribution of taxa within the subfamily Xyelinae

Taxa	Locality and horizon	Wing length (mm)	Body length (mm)	Ovipositor length (mm)
Tribe Liadoxyelini				
<i>Aequixyela immensa</i> sp. nov.	China; Middle Jurassic	4.5	5.3	< 1
<i>Anomoxyela incerta</i> Rasnitsyn, 1963	Kazakhstan; Upper Jurassic	7.8	9.6	NA
<i>Cathaxyxela extensa</i> sp. nov.	China; Middle Jurassic	5.8	7.5	NA
<i>Kirghizoxyela mirabilis</i> Rasnitsyn, 1966	Kirgizia; Lower Jurassic	6	NA	NA
<i>Liadoxyela praecox</i> Martynov, 1937	Kirgizia; Lower Jurassic	10	NA	NA
<i>Liadoxyela iensis</i> Rasnitsyn, 1969	Siberia; Lower or Middle Jurassic	8	NA	NA
<i>Liadoxyela buriatica</i> Rasnitsyn, 1983	Transbaikalia; Middle Jurassic	7.5	8.5	NA
<i>Lydoxyela excellens</i> Rasnitsyn, 1966	Kazakhstan; Upper Jurassic	7	10	3
<i>Orthoxyela rectiradiata</i> Rasnitsyn, 1983	Transbaikalia; Early or Middle Jurassic	6	NA	NA
<i>Platixyela unica</i> Wang, Shih & Ren, 2012	China; Middle Jurassic	12.3	16.5	6.3
Tribe Xyelini				
<i>Enneoxyela crassicauda</i> Rasnitsyn, 1966	Kazakhstan; Upper Jurassic	7	12	4.5
<i>Enneoxyela compressicauda</i> Rasnitsyn, 1966	Kazakhstan; Upper Jurassic	6.5	10	2.7
<i>Enneoxyela karatavica</i> Rasnitsyn, 1965	Kazakhstan; Upper Jurassic	5.3	6.7	2.2
<i>Eoxyela sibirica</i> Rasnitsyn, 1965	Transbaikalia; Early Cretaceous	5.3	6.7	NA
<i>Eoxyela punctata</i> Rasnitsyn, 1965	Kazakhstan; Upper Jurassic	NA	5.8	NA
<i>Eoxyela scoliura</i> Rasnitsyn, 1965	Kazakhstan; Upper Jurassic	5	6	1.8
<i>Eoxyela atra</i> Rasnitsyn, 1966	Kazakhstan; Upper Jurassic	NA	14.6	3.9
<i>Eoxyela tugnuica</i> Rasnitsyn, 1983	Transbaikalia; Early or Middle Jurassic	5.5	6	0.9
<i>Spathoxyela fossilis</i> Rasnitsyn, 1965	Transbaikalia; Lower Cretaceous	3	5.25	2.7
<i>Spathoxyela pinicola</i> Rasnitsyn, 1982	Transbaikalia; Lower Cretaceous	4.8	7.5	1.9
<i>Xyela angustipennis</i> Statz, 1936	Germany; Lower Miocene	2.8	4.8	1.12
<i>Xyela graciosa</i> Statz, 1936	Germany; Lower Miocene	3.5	5.5	1.3
<i>Xyela latipennis</i> Statz, 1936	Germany; Lower Miocene	3.3	4.8	1.56
<i>Xyela magna</i> Statz, 1936	Germany; Lower Miocene	4.5	7	1.95
<i>Xyela cenozoica</i> Zhang, 1989	China; Lower Miocene	5.8	7.5	2.1
<i>Xyela florissantensis</i> Rasnitsyn, 1995	Colorado; Upper Eocene	3.8	6.7	2.7
<i>Xyela micrura</i> Rasnitsyn, 1995	Germany; Lower Miocene	3.5	4.2	1.3
<i>Xyelisca leptopoda</i> Rasnitsyn, 1969	Transbaikalia; Lower or Middle Jurassic	6	9	NA
<i>Yanoxxyela hongii</i> Ren, Lu, Guo & Ji, 1995	China; Lower Cretaceous	4	6	NA

NA = not available

longer than the width of mesonotum, and hind femora longer and thicker than the fore one; tibia about 1.6 times as long as the femora. The forewing with Sc touching R except for a sharp bend toward C apically, meeting C just after Rs base; costal area wide before the origin of Rs, and the pterostigma narrow, not at all sclerotized. The 1-Rs 0.5-0.7 as long as 1-M depending on the left vs. right wing (asymmetrical); 1-M almost aligned with Rs+M, 1m-cu longer than half of 2-Rs, 1r-rs shorter than 2r-rs. The apex of Rs₁ closer to the apex of Rs₂ than to the pterostigma; Rs+M five times as long as 1-Rs; the length proportion of cells 1rm, 1r, 2r, 3r, and 4r = 2.7:1.8:1:1.4:2; the length proportion of 1m-cu, 2-Cu, and 3-Cu = 1:1.4:2.5 (Fig. 2D). The abdomen only slightly wider than the mesonotum, terga with no laterotergite separation apparent on the dorsal surface. Male genitalia poorly preserved.

Measurements: Body length (excluded antenna) 7.5 mm, head width 1.3 mm, length without mandible 0.8 mm, third antennal segment as preserved 1.8 mm, forewing length up to end of cell 4r 5.8 mm, left femur and tibia as preserved 1.4 mm and 2.1 mm, respectively.

Aequixyela gen. nov.

Type species: *Aequixyela immensa* sp. nov.

Diagnosis: Third antennal article nearly as long as head, following flagellum much shorter; pterostigma diffusely

darkened, particularly so toward base, R almost straight, with no backward bend at or before Rs base; Sc touching R except apically, meeting C at level of junction of 1-Rs and 1-M; Rs+M approximately equal to 2-Rs in length; 1m-cu as long as 2-Cu and 3-Cu and 0.7 times as long as 2-M; cell 2cu regular hexagonal; ovipositor very short.

Etymology: The generic name is a combination of Latin prefix “*aequi-*” referring to Rs+M equal to 2-Rs, and the genus name *Xyela*. The gender is feminine.

Composition: Type species only.

Comments: A wide and lanceolate (strikingly convex below) pterostigma, which is weakly and diffusely darkened is unknown in the Macroxyelinae and Archexyelinae and so suggests a position of the new genus in the Xyelinae, even though the short ovipositor is more characteristic of the Macroxyelinae. Additionally, Sc touching R except apically is also common in the Xyelinae and unknown in other Xyelidae. Concerning the distinction between tribes of Xyelinae, we can see a contradiction between 1-Rs and 1-M subequal in length, which is characteristic of the Liadoxyelini, and a comparatively short 3-Cu, which is unusual there (Rasnitsyn, 1966, 1969).

The contradictions observed make urgent a general taxonomic reconsideration of the Xyelinae. For the present, we tentatively attribute this genus to the tribe

Liadoxyelini. Within this tribe, *Aequixyela* differs easily from all genera in having Rs+M short (approximately equal to 2-Rs), 1m-cu as long as the 3-Cu, and cell 2cua of a near-regular hexagonal form.

***Aequixyela immensa* sp. nov.**

(Fig. 3)

Diagnosis: As for genus.

Etymology: The specific name *immensa* (gender feminine of the Latin for immense) refers to the wide pterostigma.

Type material: Holotype: female, CNU-HYM-NN-2012107.

Locality and horizon: Daohugou Village, Shantou Township, Ningcheng County, Inner Mongolia, China: Jiulongshan Formation, Middle Jurassic (Callovian-Bathonian boundary).

Description: Color not reliably known owing to absence of the counterpart, which might have shown a different color pattern. As preserved the body with part thorax, abdomen and the legs much darker than the antenna and pterostigma. The forewing somewhat infuscated, particularly so in the costal area along the veins. Antenna with scape probably short (and not

preserved well); third antennal article straight, and the flagellum with nearly 8 antennal articles preserved; length 0.3 mm. The mandibles outstretched but difficult to be interpreted. The head capsule as preserved nearly rounded, 1.1 times as wide as long, widest in the middle, with oval eyes apparently occupying its lateral corners. The pronotum not well preserved; the mesoprescutum with medial mesoscutal suture, occupying less than half of the length of mesonotum; mesoscutellum large and nearly half as long as mesonotum. The metathoracic structure poorly known. Legs with femora and tibia narrow and long, the fore and mid femora short, hind one long (more than 4 times as long as wide). The forewing with an anterior branch of Sc meeting C beyond the origin of Rs, and the hind branch of Sc invisible; R straight, pterostigma wide, weakly sclerotized basally, wide and nearly as wide as cell 2r; 1-Rs equal to 1-M, 1m-cu shorter than half of 2-Rs, 1r-rs shorter than 2r-rs, 2r-rs half as long as its distance to 1r-rs, 2-M about as long as 3-M; apex of Rs₁ closer to Rs₂ than to pterostigma; 1m-cu as long as 2-Cu and 3-Cu; 2m-cu inclined toward wing base and nearly in middle of cell 3rm; cell 2cua regular hexagonal, 1-Rs ca. 0.5 as long as Rs+M; length proportion of cells 1rm, 1r, 2r, 3r, and 4r = 2.3:1.7:1:1.4:1.9.

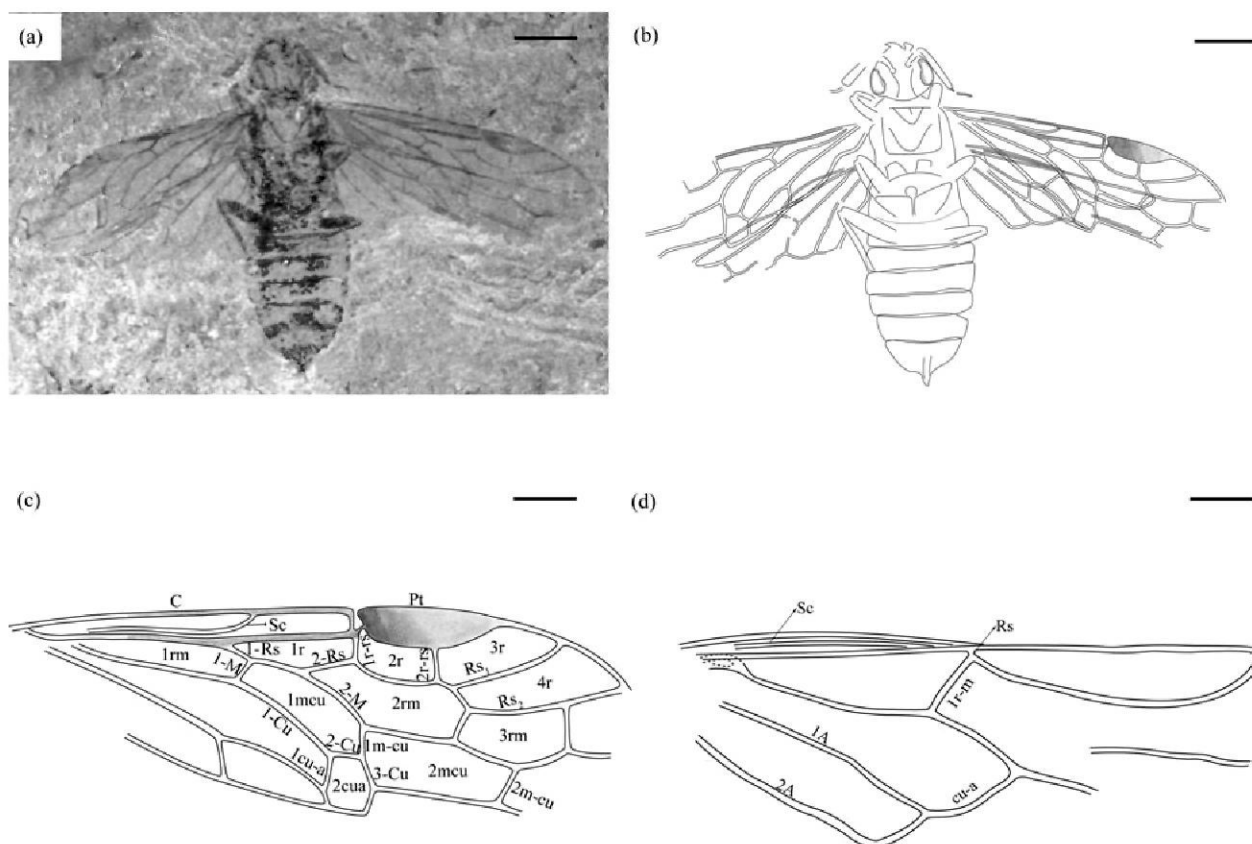


Fig. 3. *Aequixyela immensa* sp. nov. Holotype, CNU-HYM-NN-2012107.

(a) Photograph of holotype. (b) Line drawing of holotype. (c) Line drawing of right forewing. (d) Line drawing of right hind wing. Scale bar = 1 mm.

In the hind wing, Sc developed, meeting R, base of Rs almost in the middle of hind wing anterior margin, 2r-m not developed, 1-Rs very short, 2-Rs weak except distally, m-cu not preserved, cu-a at about level of 0.3 of cell r, Cu and possibly A with no free end (Figs. 3C-D). Abdomen only slightly wider than mesonotum, terga with no laterotergite separation apparent on dorsal surface, tergum 2 apparently entire. Ovipositor extraordinary short and structures indiscernible.

Measurements: Body length (excluded antenna) 5.3 mm, head width 0.9 mm, length without mandible 0.8 mm, third antennal segment as preserved 0.7 mm, forewing length up to end of cell 4r 4.5 mm, left hind femur and tibia as preserved 0.9 mm and 1.1 mm, respectively.

4 Discussion

Aequixyela displays a contradictory combination of characters that obscure its taxonomic position. The short ovipositor is characteristic of Macroxyelinae rather than Xyelinae. However, in the Macroxyelinae, the ovipositor is normally wide, so even when the fossil is buried in dorsoventral position, the ovipositor is usually buried slightly obliquely, so the sheaths are still identifiable as wide. The present fossil shows nothing like this, hence indicating that the ovipositor is narrow like in many Xyelinae. This suggests that it is a secondarily shortened ovipositor of Xyelinae type. The pterostigma is diffusely darkened, with a smooth transition toward the pale apical part; this unusual pattern fits better to the pale pterostigma in the Xyelinae rather than to the partially or completely dark one in the Macroxyelinae (or Archexyelinae). Additionally, the wide lanceolate pterostigma and Sc touching R except apically are known only in the Xyelinae. Therefore, we assign *Aequixyela* to Xyelinae.

The position and shape of vein Sc in the forewing of sawflies are very diverse. Gao et al. (2009) summarized the changes of Sc in lower hymenopterans as from multi-branches to absence. In *Cathaxyela* and *Aequixyela*, the Sc runs close to R and has a strong bend forward apically, which might suggest a trend toward their approaching and merging, resulting in the Sc apex turning into a crossvein (as in many Tenthredinoidea).

5 Conclusions

Rasnitsyn and Zhang (2004) summarized the composition of the Daohugou hymenopteran assemblage, and so many hymenopterans were reported from the Jiulongshan Formation of northeastern China. Adding the new findings from China, the localities and horizons of all

species of the Xyelinae are listed in Table 1. The Xyelinae are prolific in the Mesozoic and Tertiary, and particularly the Tertiary faunas were strongly dominated by the Xyelini (Rasnitsyn, 1995). All these facts indicated a humid and warm-temperate climate. Given that their phylogenetic position is confirmed, the new taxa are among the earliest for the Xyelinae.

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Two New Fossil Sawflies (Hymenoptera, Xyelidae, Xyelinae) from the Middle Jurassic of China

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Abstract: Two new genera with two new species of sawflies, *Cathaxyela extensa* gen. et sp. nov. and *Aequixyela immensa* gen. et sp. nov., from the Middle Jurassic Jiulongshan Formation of southeastern Inner Mongolia, China, are assigned to the subfamily Xyelinae (Hymenoptera, Xyelidae). *Cathaxyela* gen. nov. can be distinguished by the third antennal article longer than the head; mesoprescutum and mesoscutellum nearly equal in length; the forewing with Sc meeting C before the junction of 1-M and 1-Rs; a weak and narrow pterostigma; and 3-Cu at least 1.5 times longer than the 1m-cu. *Aequixyela* gen. nov. is characterized by the third antennal article nearly as long as the head; the forewing with Rs+M approximately equal to 2-Rs in length; 2m-cu inclined toward the wing base and nearly reaching the middle of cell 3rm; 1m-cu as long as the 2-Cu and 3-Cu; and the cell 2cua of regular hexagonal shape.

Key words: Invertebrate paleontology, taxonomy, Arthropoda, Daohugou, Inner Mongolia

1 Introduction

The family Xyelidae has a special significance in the evolutionary history of the hymenopterans. The earliest appearance of the Hymenoptera has been reported in the Middle or Late Triassic (Riek, 1955; Rasnitsyn, 1964, 1969, 1980; Schlüter, 2000; Engel, 2005). Xyelids are well supported to take the most basal position in the order, that is, either the ancestral (a classic approach, e.g. Rasnitsyn, 1988, 2002), or the sister position in respect to the remaining Hymenoptera (a cladistic approach, Grimaldi and Engel, 2005). The Xyelidae is composed of four subfamilies: Macroxyelinae Ashmead, 1898; Xyelinae Newman, 1834; Archexyelinae Rasnitsyn, 1964; and Madygellinae Rasnitsyn, 1969 (Rasnitsyn 1980). So far, 48 fossil genera with 96 species of fossil Xyelidae have been described (Taeger et al., 2010; Gao et al., 2011; Wang et al., 2012). The subfamily Xyelinae is composed of two tribes – Liadoxyelini and Xyelini (Rasnitsyn, 1966, 1969, 1985) with ten genera: *Liadoxyela* Martynov, 1937, *Kirghizoxyela* Rasnitsyn, 1966, *Lydoxyela* Rasnitsyn, 1966, *Anomoxyela* Rasnitsyn, 1966 and *Orthoxyela* Rasnitsyn, 1983 in Liadoxyelini, and *Xyela* Dalman, 1819, *Eoxyela* Rasnitsyn, 1965, *Enneoxyela* Rasnitsyn, 1966,

Spathoxyela Rasnitsyn, 1969, and *Xyelisca* Rasnitsyn, 1969 in the Xyelini.

The Daohugou area in China is one of the most important localities for Middle Jurassic insects and contains abundant, diverse and many excellently preserved fossils (Gao and Ren, 2006; Ren et al., 2010a, 2012), for example, salamanders (Gao and Shubin, 2003), pterosaurs (Wang et al., 2002), feathered dinosaurs (Xu and Zhang, 2005), birds (Zhang et al., 2008), gymnosperm forests (Mi et al., 1996), and wonderful insects (Ren et al., 2009, 2010b; Wang and Ren, 2009; Wang et al., 2010; Zhang et al., 2010; Zhang et al., 2011; Gu et al., 2012; Yao et al., 2012; Shi et al., 2013), especially some hymenopteran fossils (Gao et al., 2009; Shih et al., 2009; Rasnitsyn and Zhang, 2010; Liu et al., 2011; Wang et al., 2012; Li et al., 2013). Recently we collected two well-preserved fossils (including one with part and counterpart) from the Jiulongshan Formation in Daohugou Village, Shantou Township, Ningcheng County, Inner Mongolia, China. Based on these well-preserved specimens, two new genera have been established.

2 Materials and Methods

All the materials were collected near Daohugou Village,

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Shantou Township, Ningcheng County, Inner Mongolia, China (see Fig 1). The wing venation nomenclature used in this paper (Figs. 2D, 3C-D) is modified after Rasnitsyn (1969, 1980). The specimens were examined using a Leica MZ 12.5 dissecting microscope and illustrated with the aid of a drawing tube attachment. The figures were drawn using Adobe Illustrator CS2 and Photoshop CS 5.1. All fossil specimens are housed in the Key Lab. of Insect Evolution & Environmental Changes, College of Life Sciences, Capital Normal University, Beijing, China (CNUB; Dong Ren, Curator).

3 Systematic Paleontology

Order Hymenoptera Linnaeus, 1758

Suborder "Symphyta" Gerstaecker, 1867

Superfamily Xyeloidea Newman, 1834

Family Xyelidae Newman, 1834

Subfamily Xyelinae Newman, 1834

Comments: Diagnostic characters of the Xyelinae differing from the Macroxyelinae are C apex only slightly

widened, if at all, and not connected to R, with no desclerotization there (except for *Orthoxyela* Rasnitsyn, 1983). The pterostigma is not strongly sclerotized (dark) except for, sometimes, the surrounds of its veins, which are clearly seen, and the ovipositor is long and not very wide, except in *Aequixyela* gen. nov. (see below).

Tribe Xyelini Newman, 1834

Comments: The diagnostic characters of the Liadoxyelini that differ from the Xyelini are 1-Rs at most slightly longer than 1-M, and 3-Cu usually more than 1.5 times as long as 1m-cu (except for *Aequixyela* gen. nov., see below). Genera included are shown in Table 1.

Cathaxyela gen. nov.

Type species: *Cathaxyela extensa* sp. nov.

Diagnosis: Head with third antennal article longer than head, flagellum still longer, with at least 12 articles, pronotum wide and nearly trapezoid, meso- and mesoscutella nearly equal in length, forewing with R almost straight, with no backward bent at or before Rs base, Sc touching R except apically, meeting C just before

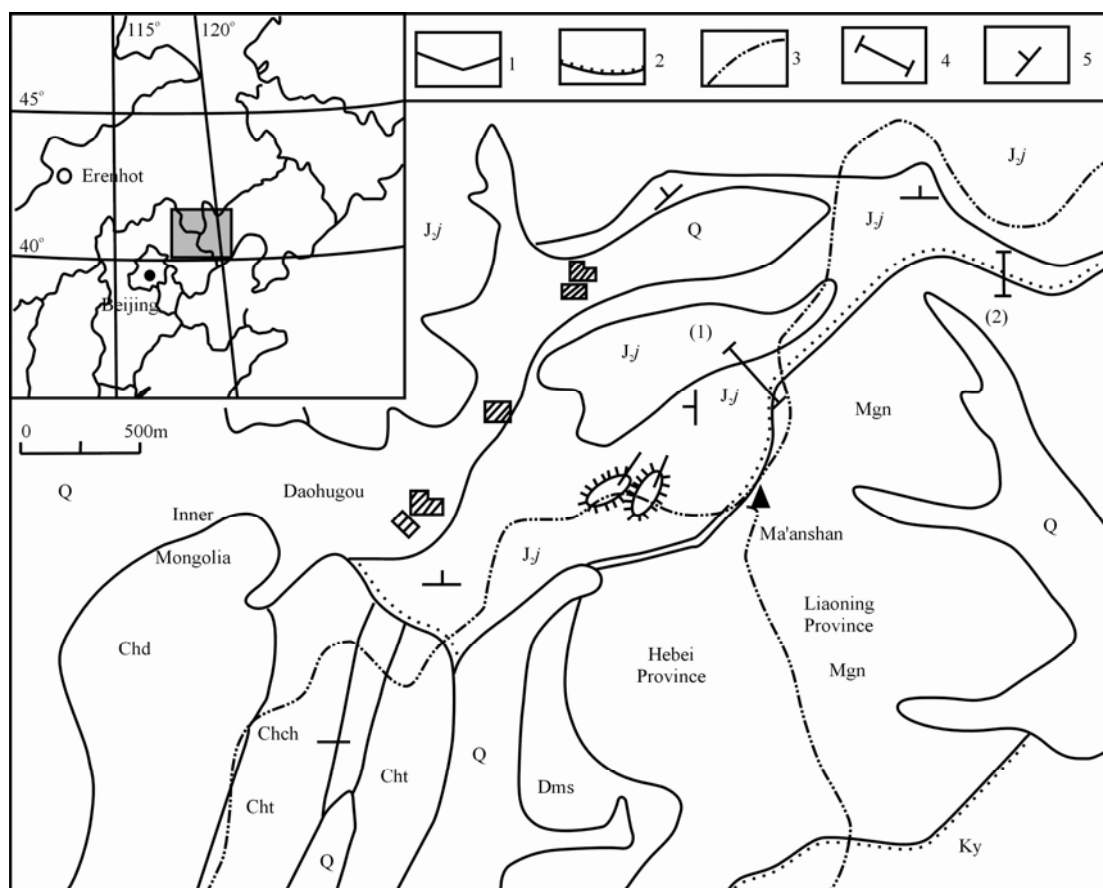


Fig. 1. Simplified geological map of Daohugou area at juncture of three provinces (autonomous region) of Liaoning, Hebei, and Inner Mongolia (after Gao and Ren, 2006).

1, stratigraphic boundary; 2, unconformity; 3, provincial boundary; 4, location of geological section; 5, strike and dip; Chc, Changchou-gou Fm.; Chch, Chuanlinggou Fm.; Chd, Dahongyu Fm.; Cht, Tuanshanzi Fm.; Dms, Dalaiyingzi erosion surface; J2j, Jiulongshan Fm.; Ky, Yixian Fm.; Q, Quaternary; Mgn, Maanshan gneiss.

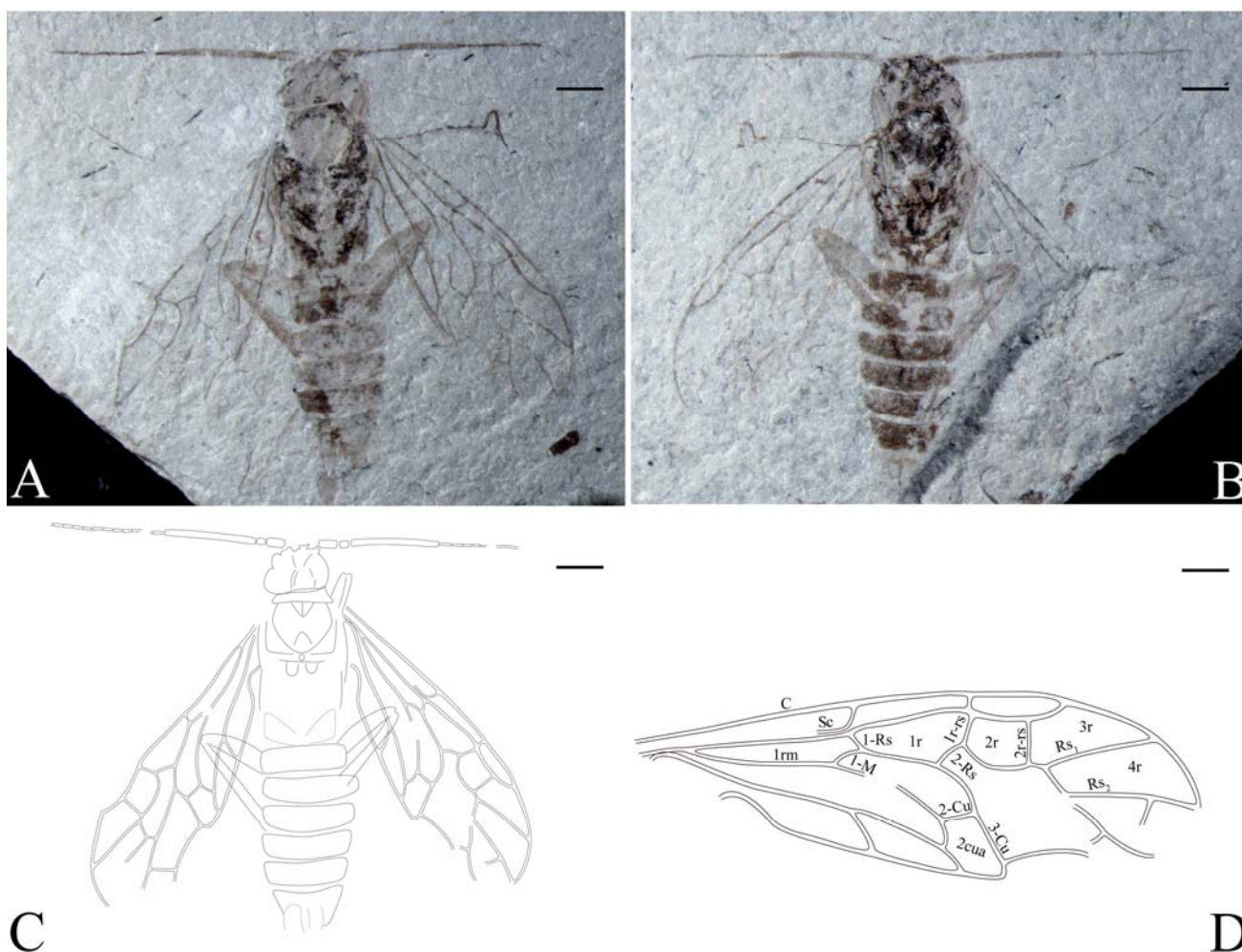


Fig. 2. *Cathayxyela extensa* sp. nov. Holotype, CNU-HYM-NN-2012106(p/c).

(A) Photograph in dorsal view. (B) Photograph in ventral view. (C) Line drawing of dorsal view. (D) Line drawing of right forewing. Scale bar = 1 mm. Venation symbols: C, Sc, R, M, Cu –main (longitudinal) veins; 1-Rs, 1-M, 2-Cu, etc.–sections of these veins; 1r-rs, 2r-rs, etc.–crossveins; 1r, 2r, 2cua, etc.–cells.

junction of 1-Rs and 1-M, pterostigma pale and narrow, 1-Rs much shorter than 1-M, 1r-rs shorter than 2r-rs, 3-Cu at least 1.5 times as long as 1m-cu.

Etymology: The generic name is a combination of Latin prefix “*Cathay*” referring to an ancient name for China, and the genus name *Xyela*. The gender is feminine.

Composition: Type species only.

Comments: The costal space and pterostigma are without sclerotization, which indicate the position of the new genus in Xyelinae. The 1-Rs is shorter than 1-M, and 3-Cu is at least 1.5 times as long as 1m-cu, in the tribe Liadoxyelini. Within the latter, a combination of a straight R and present Sc is characteristic of *Orthoxyela*, which differs in the Sc running distant of R. From the coeval *Aequixyela*, *Cathayxyela* differs in having Rs+M longer than 2-Rs, 1m-cu much shorter than 3-Cu, the third antennal segment longer than the head, and the flagellum still longer.

***Cathayxyela extensa* sp. nov.**

(Fig. 2)

Diagnosis: In addition to the generic diagnosis, 1-M bends toward wing base; 1m-cu longer than half of 2-Rs.

Etymology: The specific name *extensa* (feminine gender of the Latin for extended) refers to the fossil preserved stretched and extended.

Type material: Holotype: male, CNU-HYM-NN-2012106 (p/c).

Locality and horizon: Daohugou Village, Shantou Township, Ningcheng County, Inner Mongolia, China: Jiulongshan Formation, Middle Jurassic (Callovian-Bathonian boundary).

Description: Antenna with third antennal article straight, and nearly twice as long as the head; the following 12 articles nearly 1.2 times as long as the third article as preserved. The head capsule 1.6 times as wide as long, widest behind the middle. The pronotum ordinary, and the mesopostnotum with a round foramen centrally; metanotum with cenchri comparatively long and wide. Legs with femora and tibia long and narrow, femora

Table 1 Distribution of taxa within the subfamily Xyelinae

Taxa	Locality and horizon	Wing length (mm)	Body length (mm)	Ovipositor length (mm)
Tribe Liadoxyelini				
<i>Aequixyela immensa</i> sp. nov.	China; Middle Jurassic	4.5	5.3	< 1
<i>Anomoxyela incerta</i> Rasnitsyn, 1963	Kazakhstan; Upper Jurassic	7.8	9.6	NA
<i>Cathaxyxela extensa</i> sp. nov.	China; Middle Jurassic	5.8	7.5	NA
<i>Kirghizoxyela mirabilis</i> Rasnitsyn, 1966	Kirgizia; Lower Jurassic	6	NA	NA
<i>Liadoxyela praecox</i> Martynov, 1937	Kirgizia; Lower Jurassic	10	NA	NA
<i>Liadoxyela iensis</i> Rasnitsyn, 1969	Siberia; Lower or Middle Jurassic	8	NA	NA
<i>Liadoxyela buriatica</i> Rasnitsyn, 1983	Transbaikalia; Middle Jurassic	7.5	8.5	NA
<i>Lydoxyela excellens</i> Rasnitsyn, 1966	Kazakhstan; Upper Jurassic	7	10	3
<i>Orthoxyela rectiradiata</i> Rasnitsyn, 1983	Transbaikalia; Early or Middle Jurassic	6	NA	NA
<i>Platyxyela unica</i> Wang, Shih & Ren, 2012	China; Middle Jurassic	12.3	16.5	6.3
Tribe Xyelini				
<i>Enneoxyela crassicauda</i> Rasnitsyn, 1966	Kazakhstan; Upper Jurassic	7	12	4.5
<i>Enneoxyela compressicauda</i> Rasnitsyn, 1966	Kazakhstan; Upper Jurassic	6.5	10	2.7
<i>Enneoxyela karatavica</i> Rasnitsyn, 1965	Kazakhstan; Upper Jurassic	5.3	6.7	2.2
<i>Eoxyela sibirica</i> Rasnitsyn, 1965	Transbaikalia; Early Cretaceous	5.3	6.7	NA
<i>Eoxyela punctata</i> Rasnitsyn, 1965	Kazakhstan; Upper Jurassic	NA	5.8	NA
<i>Eoxyela scoliura</i> Rasnitsyn, 1965	Kazakhstan; Upper Jurassic	5	6	1.8
<i>Eoxyela atra</i> Rasnitsyn, 1966	Kazakhstan; Upper Jurassic	NA	14.6	3.9
<i>Eoxyela tugnuica</i> Rasnitsyn, 1983	Transbaikalia; Early or Middle Jurassic	5.5	6	0.9
<i>Spathoxyela fossilis</i> Rasnitsyn, 1965	Transbaikalia; Lower Cretaceous	3	5.25	2.7
<i>Spathoxyela pinicola</i> Rasnitsyn, 1982	Transbaikalia; Lower Cretaceous	4.8	7.5	1.9
<i>Xyela angustipennis</i> Statz, 1936	Germany; Lower Miocene	2.8	4.8	1.12
<i>Xyela graciosa</i> Statz, 1936	Germany; Lower Miocene	3.5	5.5	1.3
<i>Xyela latipennis</i> Statz, 1936	Germany; Lower Miocene	3.3	4.8	1.56
<i>Xyela magna</i> Statz, 1936	Germany; Lower Miocene	4.5	7	1.95
<i>Xyela cenozoica</i> Zhang, 1989	China; Lower Miocene	5.8	7.5	2.1
<i>Xyela florissantensis</i> Rasnitsyn, 1995	Colorado; Upper Eocene	3.8	6.7	2.7
<i>Xyela micrura</i> Rasnitsyn, 1995	Germany; Lower Miocene	3.5	4.2	1.3
<i>Xyelisca leptopoda</i> Rasnitsyn, 1969	Transbaikalia; Lower or Middle Jurassic	6	9	NA
<i>Yanoxyela hongqi</i> Ren, Lu, Guo & Ji, 1995	China; Lower Cretaceous	4	6	NA

NA = not available

longer than the width of mesonotum, and hind femora longer and thicker than the fore one; tibia about 1.6 times as long as the femora. The forewing with Sc touching R except for a sharp bend toward C apically, meeting C just after Rs base; costal area wide before the origin of Rs, and the pterostigma narrow, not at all sclerotized. The 1-Rs 0.5-0.7 as long as 1-M depending on the left vs. right wing (asymmetrical); 1-M almost aligned with Rs+M, 1m-cu longer than half of 2-Rs, 1r-rs shorter than 2r-rs. The apex of Rs₁ closer to the apex of Rs₂ than to the pterostigma; Rs+M five times as long as 1-Rs; the length proportion of cells 1m, 1r, 2r, 3r, and 4r = 2.7:1.8:1:1.4:2; the length proportion of 1m-cu, 2-Cu, and 3-Cu = 1:1.4:2.5 (Fig. 2D). The abdomen only slightly wider than the mesonotum, terga with no laterotergite separation apparent on the dorsal surface. Male genitalia poorly preserved.

Measurements: Body length (excluded antenna) 7.5 mm, head width 1.3 mm, length without mandible 0.8 mm, third antennal segment as preserved 1.8 mm, forewing length up to end of cell 4r 5.8 mm, left femur and tibia as preserved 1.4 mm and 2.1 mm, respectively.

***Aequixyela* gen. nov.**

Type species: *Aequixyela immensa* sp. nov.

Diagnosis: Third antennal article nearly as long as

head, following flagellum much shorter; pterostigma diffusely darkened, particularly so toward base, R almost straight, with no backward bend at or before Rs base; Sc touching R except apically, meeting C at level of junction of 1-Rs and 1-M; Rs+M approximately equal to 2-Rs in length; 1m-cu as long as 2-Cu and 3-Cu and 0.7 times as long as 2-M; cell 2cu regular hexagonal; ovipositor very short.

Etymology: The generic name is a combination of Latin prefix “*aequi-*” referring to Rs+M equal to 2-Rs, and the genus name *Xyela*. The gender is feminine.

Composition: Type species only.

Comments: A wide and lanceolate (strikingly convex below) pterostigma, which is weakly and diffusely darkened is unknown in the Macroxyelinae and Archexyelinae and so suggests a position of the new genus in the Xyelinae, even though the short ovipositor is more characteristic of the Macroxyelinae. Additionally, Sc touching R except apically is also common in the Xyelinae and unknown in other Xyelidae. Concerning the distinction between tribes of Xyelinae, we can see a contradiction between 1-Rs and 1-M subequal in length, which is characteristic of the Liadoxyelini, and a comparatively short 3-Cu, which is unusual there (Rasnitsyn, 1966, 1969).

The contradictions observed make urgent a general

taxonomic reconsideration of the Xyelinae. For the present, we tentatively attribute this genus to the tribe Liadoxyelini. Within this tribe, *Aequixyela* differs easily from all genera in having Rs+M short (approximately equal to 2-Rs), 1m-cu as long as the 3-Cu, and cell 2cua of a near-regular hexagonal form.

***Aequixyela immensa* sp. nov.**

(Fig. 3)

Diagnosis: As for genus.

Etymology: The specific name *immensa* (gender feminine of the Latin for immense) refers to the wide pterostigma.

Type material: Holotype: female, CNU-HYM-NN-2012107.

Locality and horizon: Daohugou Village, Shantou Township, Ningcheng County, Inner Mongolia, China: Jiulongshan Formation, Middle Jurassic (Callovian-Bathonian boundary).

Description: Color not reliably known owing to absence of the counterpart, which might have shown a different color pattern. As preserved the body with part thorax, abdomen and the legs much darker than the antenna and pterostigma. The forewing somewhat

infuscated, particularly so in the costal area along the veins. Antenna with scape probably short (and not preserved well); third antennal article straight, and the flagellum with nearly 8 antennal articles preserved; length 0.3 mm. The mandibles outstretched but difficult to be interpreted. The head capsule as preserved nearly rounded, 1.1 times as wide as long, widest in the middle, with oval eyes apparently occupying its lateral corners. The pronotum not well preserved; the mesoprescutum with medial mesoscutal suture, occupying less than half of the length of mesonotum; mesoscutellum large and nearly half as long as mesonotum. The metathoracic structure poorly known. Legs with femora and tibia narrow and long, the fore and mid femora short, hind one long (more than 4 times as long as wide). The forewing with an anterior branch of Sc meeting C beyond the origin of Rs, and the hind branch of Sc invisible; R straight, pterostigma wide, weakly sclerotized basally, wide and nearly as wide as cell 2r; 1-Rs equal to 1-M, 1m-cu shorter than half of 2-Rs, 1r-rs shorter than 2r-rs, 2r-rs half as long as its distance to 1r-rs, 2-M about as long as 3-M; apex of Rs₁ closer to Rs₂ than to pterostigma; 1m-cu as long as 2-Cu and 3-Cu; 2m-cu inclined toward wing base and nearly in middle of cell 3rm; cell 2cua regular hexagonal, 1-Rs ca. 0.5 as long

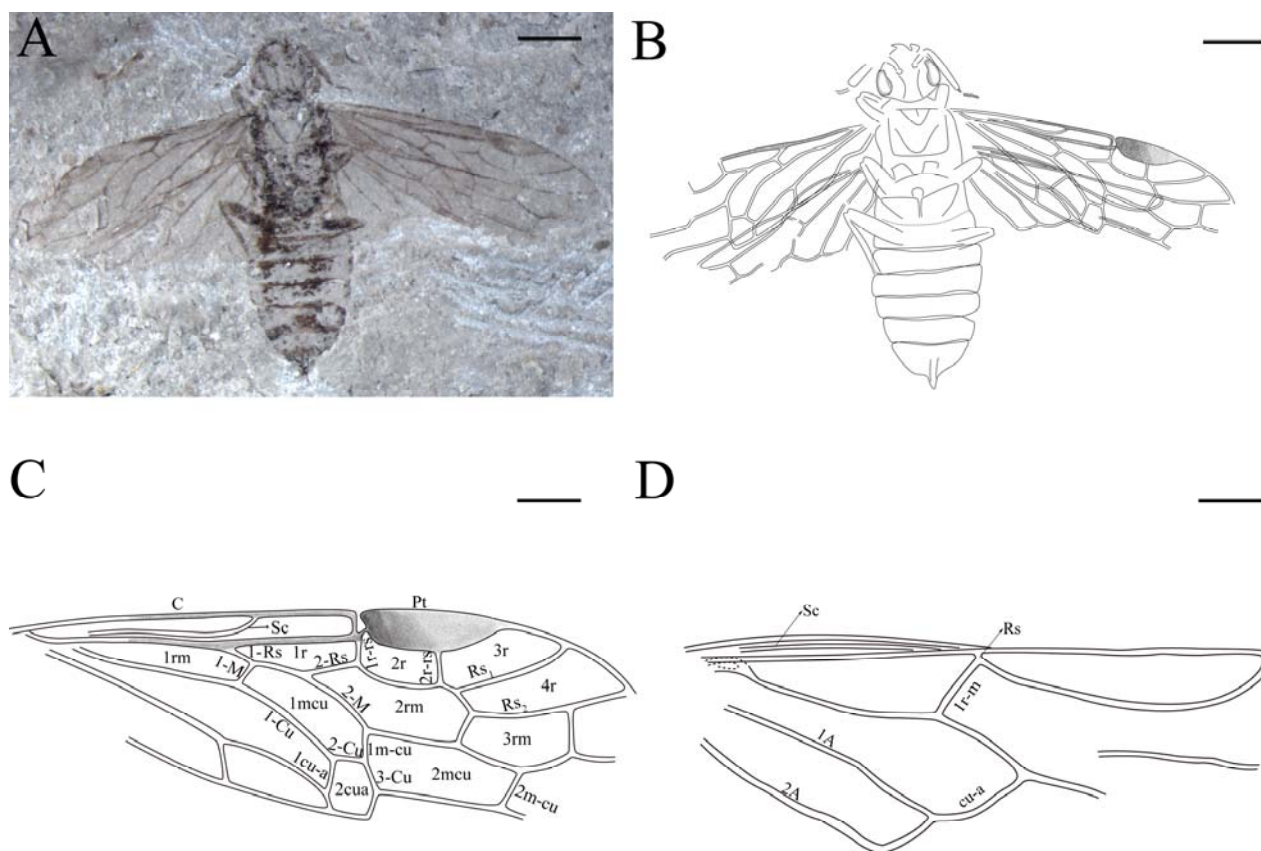


Fig. 3. *Aequixyela immensa* sp. nov. Holotype, CNU-HYM-NN-2012107.

(A) Photograph of holotype. (B) Line drawing of holotype. (C) Line drawing of right forewing. (D) Line drawing of right hind wing. Scale bar = 1 mm.

as Rs+M; length proportion of cells 1r_m, 1r, 2r, 3r, and 4r = 2.3:1.7:1:1.4:1.9.

In the hind wing, Sc developed, meeting R, base of Rs almost in the middle of hind wing anterior margin, 2r-m not developed, 1-Rs very short, 2-Rs weak except distally, m-cu not preserved, cu-a at about level of 0.3 of cell r, Cu and possibly A with no free end (Figs. 3C-D). Abdomen only slightly wider than mesonotum, terga with no laterotergite separation apparent on dorsal surface, tergum 2 apparently entire. Ovipositor extraordinary short and structures indiscernible.

Measurements: Body length (excluded antenna) 5.3 mm, head width 0.9 mm, length without mandible 0.8 mm, third antennal segment as preserved 0.7 mm, forewing length up to end of cell 4r 4.5 mm, left hind femur and tibia as preserved 0.9 mm and 1.1 mm, respectively.

4 Discussion and Conclusions

Aequixyela displays a contradictory combination of characters that obscure its taxonomic position. The short ovipositor is characteristic of Macroxyelinae rather than Xyelinae. However, in the Macroxyelinae, the ovipositor is normally wide, so even when the fossil is buried in dorsoventral position, the ovipositor is usually buried slightly obliquely, so the sheaths are still identifiable as wide. The present fossil shows nothing like this, hence indicating that the ovipositor is narrow like in many Xyelinae. This suggests that it is a secondarily shortened ovipositor of Xyelinae type. The pterostigma is diffusely darkened, with a smooth transition toward the pale apical part; this unusual pattern fits better to the pale pterostigma in the Xyelinae rather than to the partially or completely dark one in the Macroxyelinae (or Archexyelinae). Additionally, the wide lanceolate pterostigma and Sc touching R except apically are known only in the Xyelinae. Therefore, we assign *Aequixyela* to Xyelinae.

The position and shape of vein Sc in the forewing of sawflies are very diverse. Gao et al. (2009) summarized the changes of Sc in lower hymenopterans as from multi-branches to absence. In *Cathayxyela* and *Aequixyela*, the Sc runs close to R and has a strong bend forward apically, which might suggest a trend toward their approaching and merging, resulting in the Sc apex turning into a crossvein (as in many Tenthredinoidea).

Rasnitsyn and Zhang (2004) summarized the composition of the Daohugou hymenopteran assemblage, and so many hymenopterans were reported from the Jiulongshan Formation of northeastern China. Adding the new findings from China, the localities and horizons of all species of the Xyelinae are listed in Table 1. The Xyelinae

are prolific in the Mesozoic and Tertiary, and particularly the Tertiary faunas were strongly dominated by the Xyelini (Rasnitsyn, 1995). All these facts indicated a humid and warm-temperate climate. Given that their phylogenetic position is confirmed, the new taxa are among the earliest for the Xyelinae.

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