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Two new scoliid wasps (Insecta, Hymenoptera, Scoliidae) from the Cretaceous Yixian Formation of China

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ABSTRACT

The Jehol Biota, representing the Early Cretaceous terrestrial ecosystem, has yielded numerous reports of giant insects. Herein, we describe two new scoliid species, including the largest aculeate hymenopteran species †*Liaoscolia zhangi* gen. et sp. nov., and †*Protoscolia obliqua* sp. nov., recorded from the Yixian Formation of the Jehol Biota of China. †*Liaoscolia zhangi* gen. et sp. nov. and †*Protoscolia obliqua* sp. nov. can be attributed to Scoliidae based on the following characters: pronotum closely appressed to the mesonotum, with a posterior margin deeply U-like incurved, and propodeum with two longitudinal sutures or U-shaped area. We provide an updated key to the Mesozoic Scoliidae and a checklist of all known scoliid fossil species. The new Cretaceous fossil scoliids exemplify that the climate of the Jehol Biota was likely warm and humid.

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1. Introduction

Scoliidae (Insecta, Hymenoptera) are commonly known as hairy wasps or mammoth wasps (Kumar and Pham, 2015; Khouri et al., 2022; Taylor, 2024). They are distributed worldwide but are mainly concentrated in tropical and subtropical areas (Vereecken and Carrière, 2003). Scoliid wasps are solitary parasitoids and usually dig into the soil to search for larvae. Their main hosts are the larvae of scarab beetles (Coleoptera, Scarabaeoidea), and a few also parasitize large larvae of weevils (Coleoptera, Curculionoidea) (Clausen et al., 1932; Goulet and Huber, 1993; Barratt, 2003; Kumar and Pham, 2015). Like most other aculeate parasitoids, scoliid wasps paralyze the larvae with their stingers, and then lay their eggs on them. Compared with other parasitic wasps, such as the Pteromalidae, Dryinidae, etc., scoliid wasps possess relatively large body, generally ranging from 5 to 35 mm, with a few species reaching about 50 mm (Kumar, 2009; Elliott et al., 2012; Kumar and Pham, 2015).

The taxonomic status of Scoliidae remains controversial because of the generally chaotic current state of aculeate taxonomy above the family level (cf. systems proposed during the past decade: Branstetter et al., 2017; Peters et al., 2017; Zheng et al., 2021; Blaimer et al., 2023; Song et al., 2023; Zhang et al., 2025; Vilhelmsen, 2026; Wu et al., 2026). That is why, until future research brings a new consensus, we leave Scoliidae as a member of the superfamily Vespoidea s.l. as proposed by Goulet and Huber (1993). The internal classification of Scoliidae is currently debated as well; however, the latest publications (Khouri et al., 2022; Liu et al., 2024; Taylor, 2024) make it possible to update the older ones (Rasnitsyn, 1977, 1993; Osten, 2005a; Antropov et al., 2014) and to adopt, at least for the aims of the present paper, the family as divided into five subfamilies: extant Scoliinae, Campsomerinae and Proscoliinae, and extinct †Archaeoscoliinae and †Palaeoscoliinae (Rasnitsyn, 1977, 1993; Goulet and Huber, 1993; Osten, 2005a; Antropov et al., 2014; Taylor, 2024), with Scoliinae split into two tribes, Scoliini and Trielidini.

Scoliidae comprise more than 43 genera and 560 species, with fossil records of 10 genera and 23 species, mainly from the Mesozoic (Zhang, 1989, 2004, 2006; Rasnitsyn, 1993; Rasnitsyn and Martínez-Delclòs, 1999, 2000; Zhang et al., 2002; Osten, 2007; Nel et al., 2013; Antropov et al., 2014; Zhang et al., 2015; Golfetti et al., 2025). The earliest definitive fossil records of this family date to the Barremian stage of the Lower Cretaceous, including five genera and nine species from the La Pedrera de Rubies Formation and the La Huérguina Formation of Spain, as well as specimens from the Yixian Formation

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of China (Rasnitsyn and Martínez-Delclòs, 1999, 2000; Zhang et al., 2002; Zhang et al., 2015). Additionally, several scoliid fossil species have been reported from the Cenozoic, including two genera and two species from the Eocene of the Florissant Formation and the Bembridge Marls Formation, and two genera and two species from the Miocene of the Shanwang Formation (Zhang, 1989; Rasnitsyn, 1993; Antropov et al., 2014). In addition, four fossil specimens from Germany, the United States, and Canada have not been identified to the genus or species level (Lutz, 1990; Douglas and Stockey, 1996; Archibald et al., 2018) (Table 1).

As a world-famous Lower Cretaceous fossil-rich stratigraphic unit (Wang et al., 2016; Chang et al., 2017), the Yixian Formation has yielded many extraordinarily well-preserved insect fossils (Ren et al., 2019; Gao et al., 2021). Among these, hymenopterans account for a very large proportion, with 157 species reported; at least 94 species belong to the Apocrita (Paleobiology Database, 2025).

Here, we describe two new scoliid species from the Yixian Formation. Among them, †*Liaoscolia zhangi* gen. et sp. nov. is the largest known scoliid fossil and the second-largest (or, rather, second-longest and first-largest: see Discussion) fossil wasp from the Yixian Formation. In addition, we provide a key to Mesozoic Scoliidae and a checklist of all scoliid fossils.

2. Material and methods

The holotype specimens are from the Yixian Formation, Huangbanjigou Village, Beipiao City, Liaoning Province, China. This formation has been radiometrically dated to approximately 125 Ma (Barremian/Aptian, Lower Cretaceous) (Fig. 1) (Wang et al., 2016; Chang et al., 2017; Ren et al., 2019). They are housed at the Key Laboratory of Insect Evolution and Environmental Changes, College of Life Sciences, Capital Normal University, Beijing, China. The specimens were observed using a Nikon SMZ25 microscope connected to a Nikon DS-Ri2 digital camera system to photograph and measure. All dimensions are in millimeters (mm). The nomenclature of general morphology and wing venation follows Rasnitsyn (1980) and Goulet and Huber (1993).

Table 1
Checklist of the published fossil species of Scoliidae.

Genus	Species	Locality	Series	Body Length (mm)	Reference
†*Araripescolia* Nel et al., 2013	†*Araripescolia magnifica* Nel et al., 2013	Brazil	Lower Cretaceous	24.5	Nel et al. (2013)
†*Archaeoscolia* Rasnitsyn, 1993	†*Archaeoscolia hispanica* Rasnitsyn and Martínez-Delclòs, 1999	Spain	Lower Cretaceous	≥16.0	Rasnitsyn and Martínez-Delclòs (1999)
	†*Archaeoscolia senilis* Rasnitsyn, 1993	Mongolia	Lower Cretaceous	≥20.0	Rasnitsyn (1993)
†*Cretaproscolia* Rasnitsyn and Martínez-Delclòs, 1999	†*Cretaproscolia asiatica* Zhang, 2006	China	Lower Cretaceous	15.1	Zhang (2006)
	†*Cretaproscolia josai* Rasnitsyn and Martínez-Delclòs, 1999	Brazil	Lower Cretaceous	≥8.4	Rasnitsyn and Martínez-Delclòs (1999)
†*Cretoscolia* Rasnitsyn, 1993	†*Cretoscolia brasiliensis* Osten, 2007	Brazil	Lower Cretaceous	13.0	Osten (2007)
	†*Cretoscolia conquensis* Rasnitsyn and Martínez-Delclòs, 2000	Spain	Lower Cretaceous	–	Rasnitsyn and Martínez-Delclòs (2000)
	†*Cretoscolia formosa* Zhang, 2004	China	Lower Cretaceous	15.7	Zhang (2004)
	†*Cretoscolia laiyangica* Zhang, 2004	China	Lower Cretaceous	10.3	Zhang (2004)
	†*Cretoscolia montsecana* Rasnitsyn and Martínez-Delclòs, 1999	Spain	Lower Cretaceous	≥21.0	Rasnitsyn and Martínez-Delclòs (1999)
	†*Cretoscolia patiens* Rasnitsyn, 1993	Kazakhstan	Upper Cretaceous	–	Rasnitsyn (1993)
	†*Cretoscolia promissiva* Rasnitsyn, 1993	Russia	Upper Cretaceous	≥30.0	Rasnitsyn (1993)
	†*Cretoscolia rasnitsyni* Zhang, 2004	China	Lower Cretaceous	17.8	Zhang (2004)
†*Floriscolia* Rasnitsyn, 1993	†*Floriscolia relicta* Rasnitsyn, 1993	USA	Eocene	30.0	Rasnitsyn (1993)
†*Liaoscolia* Wei, Rasnitsyn and Gao gen. nov.	†*Liaoscolia zhangi* Wei, Rasnitsyn and Gao gen. et sp. nov.	China	Lower Cretaceous	48.9	This paper
†*Palaeoscolia* Antropov et al., 2014	†*Palaeoscolia relicta* Antropov et al., 2014	UK	Eocene	–	Antropov et al. (2014)
†*Protoscolia* Zhang et al., 2002	†*Protoscolia imperialis* Zhang et al., 2002	China	Lower Cretaceous	32.2	Zhang et al. (2002)
	†*Protoscolia normalis* Zhang et al., 2002	China	Lower Cretaceous	18.9	Zhang et al. (2002)
	†*Protoscolia obliqua* Wei, Rasnitsyn and Gao sp. nov.	China	Lower Cretaceous	15.4	This paper
	†*Protoscolia sinensis* Zhang et al., 2002	China	Lower Cretaceous	22.4	Zhang et al. (2002)
†*Sinoproscolia* Zhang et al., 2015	†*Sinoproscolia yangshuwanziensis* Zhang et al., 2015	China	Lower Cretaceous	≥24.3	Zhang et al. (2015)
Megacampsomeris Betrem, 1928	*Megacampsomeris prismatica* Smith, 1855	China	Miocene	20.4	Zhang (1989)
Scolia Fabricius, 1775	†*Scolia distincta* Zhang, 1989	China	Miocene	10.5	Zhang (1989)
Scoliidae gen. et sp. indet.	–	Germany	Eocene	–	Lutz (1990)
Scoliidae gen. et sp. indet.	–	Canada	Eocene	≥10.7	Douglas and Stockey (1996)
Scoliidae gen. et sp. indet.	–	USA	Eocene	16.6	Archibald et al. (2018)
Scoliidae gen. et sp. indet.	–	USA	Eocene	15.0	Archibald et al. (2018)

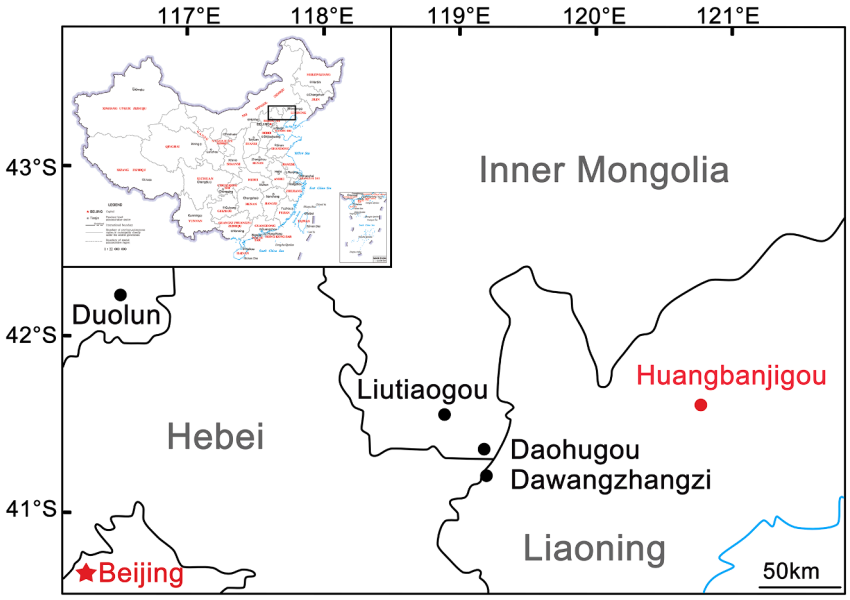


Fig. 1. Geographical sketch map of western Liaoning Province showing the fossil site at Huangbanjigou, marked by a red dot (41.615°, 120.835°). The map originates from the Standard Map Service System of the Ministry of Natural Resources (Approval No. GS(2019)1682), and the base map remains unaltered.

3. Systematic palaeontology

Order Hymenoptera Linnaeus, 1758.
Suborder Apocrita Gerstaecker, 1867.
Superfamily Vespoidea Latreille, 1802.
Family Scoliidae Latreille, 1802.
Subfamily incertae sedis.

Remarks. The new genus described below cannot be attributed to any of the known subfamilies in Scoliidae because, unlike Proscoliinae, †Archaeoscoliinae, †Palaeoscoliinae, it has veins C and R continuous with the pterostigma (a putative synapomorphy for Scoliinae and Campsomerinae). At the same time, it differs from the latter two subfamilies in having the outer wing zone free of dense corrugation — dense corrugation being a putative synapomorphy of Scoliinae and Campsomerinae. Unfortunately, we can identify no putative synapomorphy of the new genus (possibly due to incomplete preservation of the fossil). That is why we have to refrain from establishing a distinct subfamily of its own, and consider it a subfamily incertae sedis within Scoliidae, even though its phylogenetic position as the sister group to (Scoliinae + Campsomerinae) looks likely.

Genus †***Liaoscolia*** **Wei, Rasnitsyn and Gao gen. nov.**
LSID: urn:lsid:zoobank.org:act:48C0E8D5-3ABD-4319-B75C-CB473F087F27
Type species. †*Liaoscolia zhangi* Wei, Rasnitsyn and Gao sp. nov.
Species included. Type species only.

Etymology. The generic name is derived from Liaoning Province, China, in reference to the type locality where the type species was discovered.
Diagnosis. Notauli long and percurrent. Fore wing with outer (veinless) zone not corrugated; 2+3-Rs strongly bent at the base; 2r-rs distant from 2r-m; 2r-m strongly bent outwards; 2m-cu meeting M near 2r-m; cu-a distinctly postfurcal.
Remarks. The new genus (Fig. 2) can be assigned to the Scoliidae based on the characters that body large and robust, pronotum closely appressed to the mesonotum, with a posterior margin deeply U-like incurved, and propodeum with two longitudinal sulci.

†***Liaoscolia zhangi*** **Wei, Rasnitsyn and Gao sp. nov.** (Fig. 2)
LSID: urn:lsid:zoobank.org:act:4B891D8D-4906-44FB-8D31-F338F01B34DA

Material. Holotype, CNU-HYM-LB2024601P/C, part and counterpart, male. The imprint of a relatively complete specimen includes the head, mesosoma, right mid leg, hind leg, and metasoma. The fore wing is preserved almost entirely intact, while the hind wing is partially visible, with wing bases slightly overlapping. Additionally, the counterpart lacks the head.
Etymology. The specific epithet "zhangi" is established in honor of Professor Haichun Zhang, in recognition of his outstanding contributions to the study of scoliid fossils.
Horizon and locality. The specimen was collected from the Yixian Formation, Lower Cretaceous, Huangbanjigou Village, Beipiao City, Liaoning Province, China.
Diagnosis. As for the genus.
Description. Male (female unknown). Exceptionally large insect. Body length 48.9 mm (excluding antennae), more than 5× as long as wide (Fig. 2A, B, C). Color totally pale as preserved. Head medium-sized and transversely oval, about 1.6× as wide as long. Antennae poorly preserved, slender, with individual antennomeres not discernible. Occipital carina complete at least dorsally. Compound eyes and mouthparts not discernible.
Mesosoma relatively large, 1.4× as long as wide. Pronotum short and arcuate, about 4× as wide as long medially, and nearly half as long as mesoscutum. Mesoscutum transversely broad, with length 0.6× its maximum width; notauli deep and percurrent. Scutellum large and subcircular. Metanotum short, with no detail visible. Propodeum large, about 1.5× as long as wide in dorsal aspect, with two longitudinal impressed sulci.
Fore wing with pterostigma narrow, widened apically, confluent basally with C and R, with 2r-rs at its apex. 1-Rs slightly shorter than 1-M; 1r-rs lost, and 2+3-Rs strongly bent in its place. 2r-rs and 2r-m widely separated on Rs; cell 3r 1.6× as long as pterostigma and 2.6× as long as wide. 1m-cu meeting M slightly distal to midpoint of cell 2rm; 2m-cu joining cell 2rm before its end; 2r-m strongly bent outward. Cell 2cua nearly rectangular, 1.8× as long as wide; 1cu-a distinctly postfurcal. Hind wing with Rs, M+Cu, M, Cu and A preserved, M+Cu fork slightly basal of RS base (Fig. 2D, E).

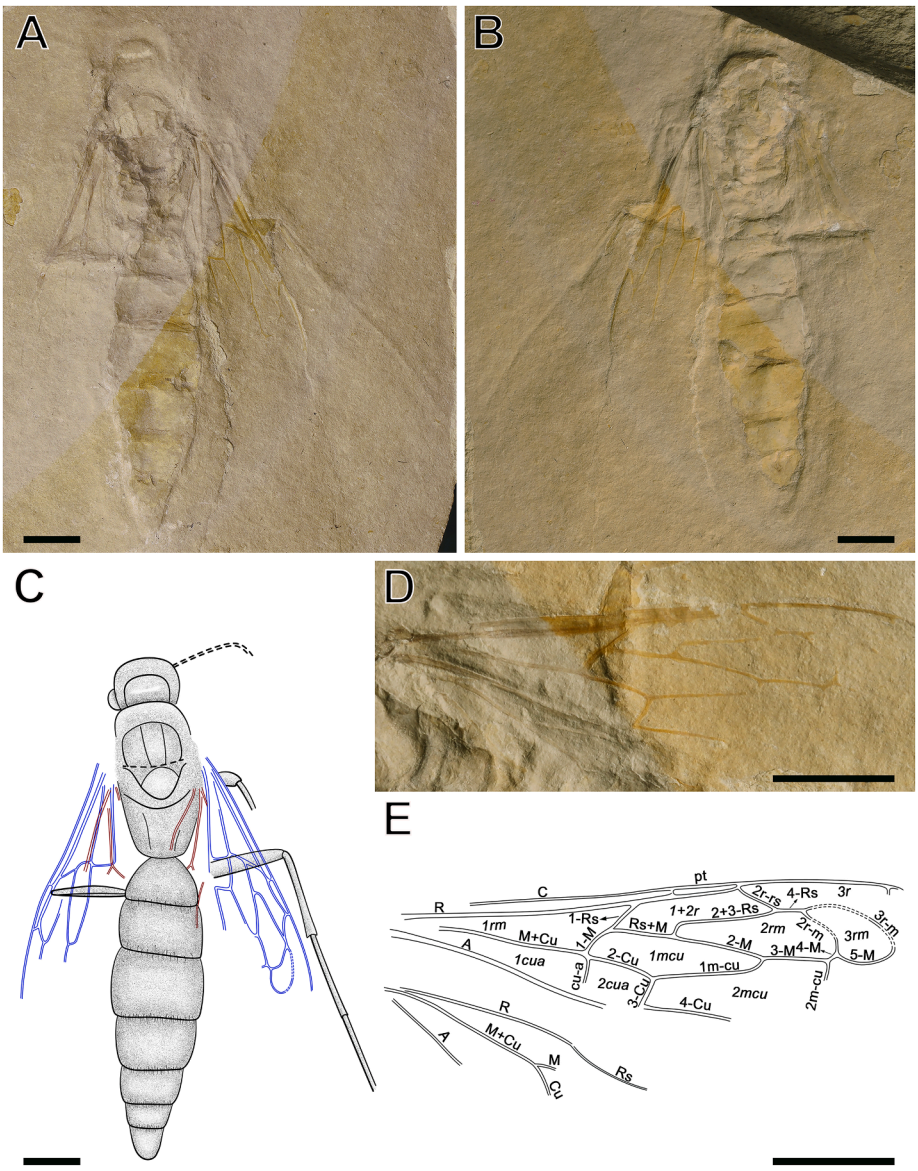


Fig. 2. †*Liaoscolia zhangi* gen. et sp. nov., holotype CNU-HYM-LB2024601P/C. **A** and **B.** Part and counterpart. **C.** Line drawing in dorsal view. **D** and **E.** photograph and line drawings of the right fore and hind wings. Scale bars: 5 mm.

Only the right mid leg and both hind leg preserved. Legs slender. Hind femur slightly thicker, 2× as wide as tibia; tibia long and widened apically, about 11× as long as wide; tarsus slender and long, half as wide as tibia; basitarsomere as long as tibia. Claws not visible. Metasoma relatively narrow and long, with seven visible segments, clearly longer than combined length of head and mesosoma. Metasoma approximately fusiform, with first to third segments gradually widening, third one widest, and fourth to seventh ones becoming narrower. First segment nearly trapezoid, as long as second and fourth ones, about 0.7× as long as third one; sixth segment shortest, nearly 0.8× as long as fifth and seventh ones. Genitalia hard to observe.

Measurements (mm). Total body length (excluding antenna) 48.9; head length 4.3, width 7.0; forewing length 23.6; first metasomal segment length 4.6, metasoma length 27.9.

Subfamily †Archaeoscoliinae Rasnitsyn, 1993.
Genus †*Protoscolia* Zhang et al., 2002.
Type species. †*Protoscolia sinensis* Zhang et al., 2002.
Species included. †*P. imperialis* Zhang et al., 2002; †*P. normalis* Zhang et al., 2002; †*P. obliqua* Wei, Rasnitsyn and Gao sp. nov.

†***Protoscolia obliqua* Wei, Rasnitsyn and Gao sp. nov.** (Figs. 3 and 4)
LSID: urn:lsid:zoobank.org:act:3D77814B-284C-4F1B-B919-3C18F6F24ED8

Material. Holotype, CNU-HYM-LB2024602, female. A nearly complete specimen retains mesosoma, left hind leg, metasoma and ovipositor sheaths. The fore wing is almost completely preserved, while the hind wing is partially visible.
Etymology. The specific epithet is derived from the Latin adjective "*obliquus*", meaning "slanting" or "oblique", to indicate the 1r-rs is not parallel to Rs+M in this species.
Horizon and locality. The specimen was collected from the Yixian Formation, Lower Cretaceous, Huangbanjigou Village, Beipiao City, Liaoning Province, China.
Diagnosis. U-shaped propodeal enclosure approximately of equal length and width, or may be shorter. Fore wing with rudiment of 1r-rs short and not parallel to Rs+M; petiole between cells 3r and

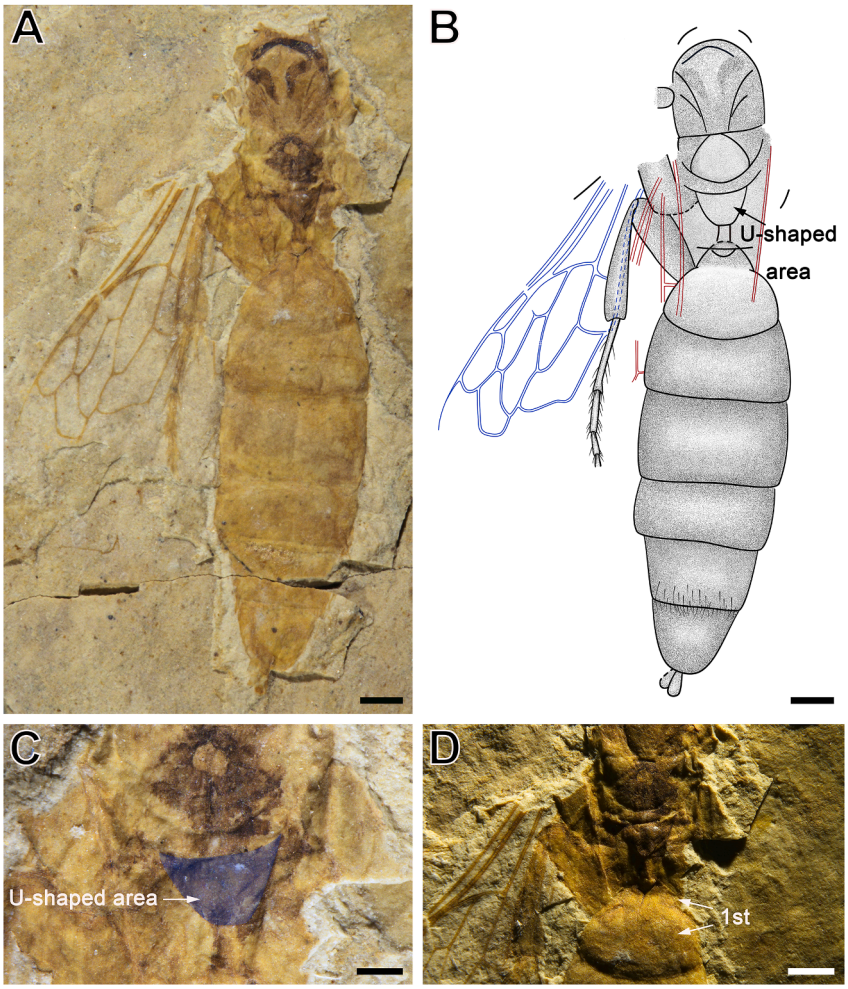


Fig. 3. †*Protoscolia obliqua* sp. nov., holotype CNU-HYM-LB2024602. **A** and **B.** Photograph and line drawing. **C.** Propodeum, the arrow showing the U-shaped area. **D.** First segment of the metasoma under oblique light. Scale bars: 1 mm (A, B, D); 0.5 mm (C).

2rm (4-Rs) elongate, meeting cell 3r at its midpoint; 2m-cu joining cell 2rm before its end.

Description. Female (male unknown). Body of medium size, with a length of approximately 15.4 mm as preserved (without head), more than 4× longer than wide. Head not visible (Fig. 3A, B). Color as preserved pale with dark vertical part of pronotum, two crescent-like spots between notauli, and dorsal and middle of back (declivitous) part of propodeum.

Mesosoma relatively large, length approximately 1.5× width. Pronotum incompletely preserved. Mesoscutum elongated and roughly square-shaped, 2× as long as scutellum; notauli deep and percurrent. Scutellum large and subcircular, nearly equal in length and width. Metanotum short. Propodeum with longitudinal sulci converging posteriorly on dorsal surface and further running parallel and close to each other on declivity, with transverse carina in-between on boundary between dorsal and back surfaces, with the resulting 'U-shaped enclosure' dorsally being of subequal length and width (Fig. 3C, D).

Fore wing with pterostigma narrow, widened apically, not connected with C and R basally. 1-Rs slightly shorter than 1-M; 1r-rs rudiment not parallel to Rs+M, about 0.3× as long as 2-Rs. 3-Rs meeting 2r-m before 2r-rs and so leaving petiole (4-Rs); cell 3r wide and short, about 1.3× as long as pterostigma and 2.7× as long as wide. 1m-cu meeting cell 2rm at its midpoint, 2m-cu joining cell 2rm before its end. Crossvein cu-a joining Cu slightly behind fork of M+Cu; cell 2cua nearly rectangular. Hind wing with C, R, Rs, M+Cu and r-m partially visible (Fig. 4A, B).

Only left hind leg preserved. Hind femur slightly thickened, at least 0.7× as long as tibia; tibia long and widened apically, length about 5.0× width, with setation not sufficiently visible; tarsus slender and long, with only four tarsomeres preserved, each tarsomere apically covered with dense setae; basitarsomere longest and narrowest, shorter than combined length of following tarsomeres; second tarsomere approximately 2× as long as third one; third tarsomere wider than first and second ones; fourth tarsomere incomplete.

Metasoma (Fig. 3D) relatively narrow and long, with six segments visible, about 2× as long as mesosoma; approximately fusiform, with first to fourth segments gradually widening, fourth segment widest, and fifth to sixth segments becoming narrower. First segment nearly semicircular and the longest; third segment about 1.2× as long as second one; fifth and sixth segments subequal in length, each about 1.2× as long as fourth one. Hind margins of fifth and sixth segments covered with conspicuously short, thick setae. Sting sheaths slightly protruding.

Remarks. The new species (Figs. 3 and 4) can be assigned to the Scoliidae for the basis of the propodeum divided longitudinally with two sutures (further modified to form U-like area characteristic of *Protoscolia*). The new species is classified within the †Archaeoscoliinae due to deep notauli, C and R disconnected with

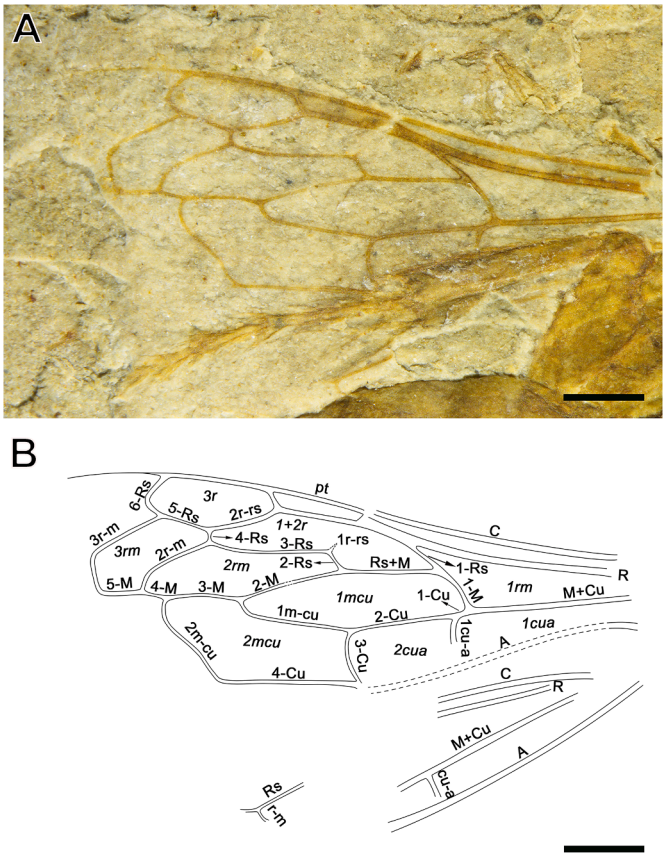


Fig. 4. †*Protoscolia obliqua* sp. nov., holotype CNU-HYM-LB2024602. **A.** Left wings. **B.** Drawing of left wings. Scale bars: 1 mm.

pterostigma, long cell 3r and closed cell 3rm, and presence of all 2r-m, 3r-m and 2m-cu crossveins. It is further assigned to †*Protoscolia* on the basis of vestigial 1-rs, U-shaped area on the propodeum, and petiolate cell 2rm. However, the new species differs from †*P. sinensis* Zhang et al., 2002 by 1r-rs not parallel to Rs+M (vs. 1r-rs parallel to Rs+M); petiole between cells 3r and 2rm relatively long (vs. petiole point-like); U-shaped propodeal 'enclosure' not longer than wide (vs. longer than wide). The new species differs from †*P. normalis* Zhang et al., 2002 in 1r-rs not parallel to Rs+M (vs. 1r-rs parallel to Rs+M); 2m-cu joining cell 2rm well before its end (vs. 2m-cu meeting M close to 2r-m). The new species differs from †*P. imperialis* Zhang et al., 2002 in vestigial 1-rs present (vs. 1r-rs lost); 2rm meeting cell 3r at its midlength (vs. 2rm meeting 3r before its midlength).

Measurements (mm). Body length without head 15.4; fore wing 8.4 long; hind femur 2.0 long; hind tibia 3.2 long; hind tarsus as preserved 3.6 long; metasoma 10.3 long.

Key to Mesozoic Scoliidae

1. C and R connected uninterrupted with pterostigma. Fore wing cell 3r long; cell 3rm closed. ……**2**
- C broken and R much thinned just before junction with pterostigma……**3**
2. Outer (veinless) zone of wings wide and regularly corrugated. Fore wing cell 3r with apex not contiguous with wing fore margin and reaching far basal than that of 3rm (Nel et al., 2013, fig. 2). Subfamily Scoliinae……†***Araripescolia magnifica*** **Nel et al., 2013**
- Outer (veinless) zone of wings wide but not corrugated. Fore wing cell 3r with apex almost reaching that of 3rm and apparently contiguous fore with wing margin (Fig. 2E). Subfamily incertae sedis……†***Liaoscolia zhangi*** **gen. et sp. nov.**
3. Outer (veinless) zone of wings wide and always regularly corrugated. Fore wing with 2r-m present or lost. Subfamily Proscoliinae……**4**
- Outer (veinless) zone of wings narrow and rarely regularly corrugated. Fore wing with 2r-m always present. Subfamily †Archaeoscoliinae……**6**
4. 1r-rs complete and bent (Zhang et al., 2015, fig. 2E, F); 2r-m present and cell 2rm roughly quadrangular ……†***Sinoproscolia yangshuwanziensis*** **Zhang et al., 2015**
- 1r-rs and 2r-m absent. *Cretaproscolia* Rasnitsyn and Martínez-Delclòs, 1999……**5**
5. Cell 2+3rm and 1+2r of equal length; 2m-cu nearly as long as 1m-cu (Rasnitsyn and Martínez-Delclòs, 1999, fig. 4)……†*Cretaproscolia josai* Rasnitsyn and Martínez-Delclòs, 1999
- Cell 2+3rm longer than cell 1+2r; 2m-cu shorter than 1m-cu (Zhang, 2006, fig. 2B)……†*Cretaproscolia asiatica* Zhang, 2006
6. 2+3-Rs with rudiment of 1r-rs or at least angular at its place; cell 2rm petiolate, rarely 2r-rs almost coinciding with 2r-m. †*Protoscolia* Zhang et al., 2002……**7**
- 2+3-Rs with no 1r-rs nor angular at its place; cell 2rm not petiolate, rarely 2r-rs coinciding with 2r-m……**10**
7. Cell 2rm scarcely petiolate (2r-rs almost coinciding with 2r-m) (Zhang et al., 2002, fig. 3B). Central propodeal area narrow, elongate (Zhang et al., 2002, fig. 3A) ……†*Protoscolia sinensis* Zhang et al., 2002
- Cell 2rm distinctly petiolate……**8**
8. Cell 3r more than 2× as long as pterostigma (Zhang et al., 2002, fig. 6B) ……†*Protoscolia imperialis* Zhang et al., 2002
- Cell 3r less than 1.5×as long as pterostigma……**9**
9. 1r-rs parallel to Rs+M. Hind tibia shorter than cell 1mcu (Zhang et al., 2002, fig. 5)……†*Protoscolia normalis* Zhang et al., 2002
- 1r-rs not parallel to Rs+M (Fig. 4). Hind tibia longer than cell 1mcu (Fig. 3A) ……†*Protoscolia obliqua* sp. nov.
10.Apex of cell 3r at crossvein 3r-m; cell 3rm subquadrate. †*Archaeoscolia* Rasnitsyn, 1993……**11**
- Apex of cell 3r distant from 3r-m; cell 3rm shorter than high. †*Cretoscolia* Rasnitsyn, 1993……**12**
11. Pterostigma distinctly widening apical; Rs+M almost as long as 2-M (Rasnitsyn, 1993, fig. 1) ……†***Archaeoscolia senilis*** **Rasnitsyn, 1993**
- Pterostigma not widening apical; Rs+M half as long as 2-M (Rasnitsyn and Martínez-Delclòs, 1999, fig. 1) ……†*Archaeoscolia hispanica* Rasnitsyn and Martínez-Delclòs, 1999
12. Body robust, female metasoma short and oval, wider than mesosoma. Legs short, hind tibia shorter than cell 1mcu (Osten, 2007, fig. 11.73b) ……†***Cretoscolia brasiliensis*** **Osten, 2007**
- Body slender, metasoma elongate, narrower than mesosoma. Legs long, hind tibia longer than cell 1mcu……**13**
13. Cell 2rm almost petiolate or 2r-rs coinciding with 2r-m……**14**
- Cell 2rm distinctly sessile on Rs……**16**
14.Cell 1+2r almost as long as cell 3r (Zhang, 2004, fig. 4) ……†*Cretoscolia laiyangica* Zhang, 2004
- Cell 1+2r about 1.5× as long as cell 3r……**15**

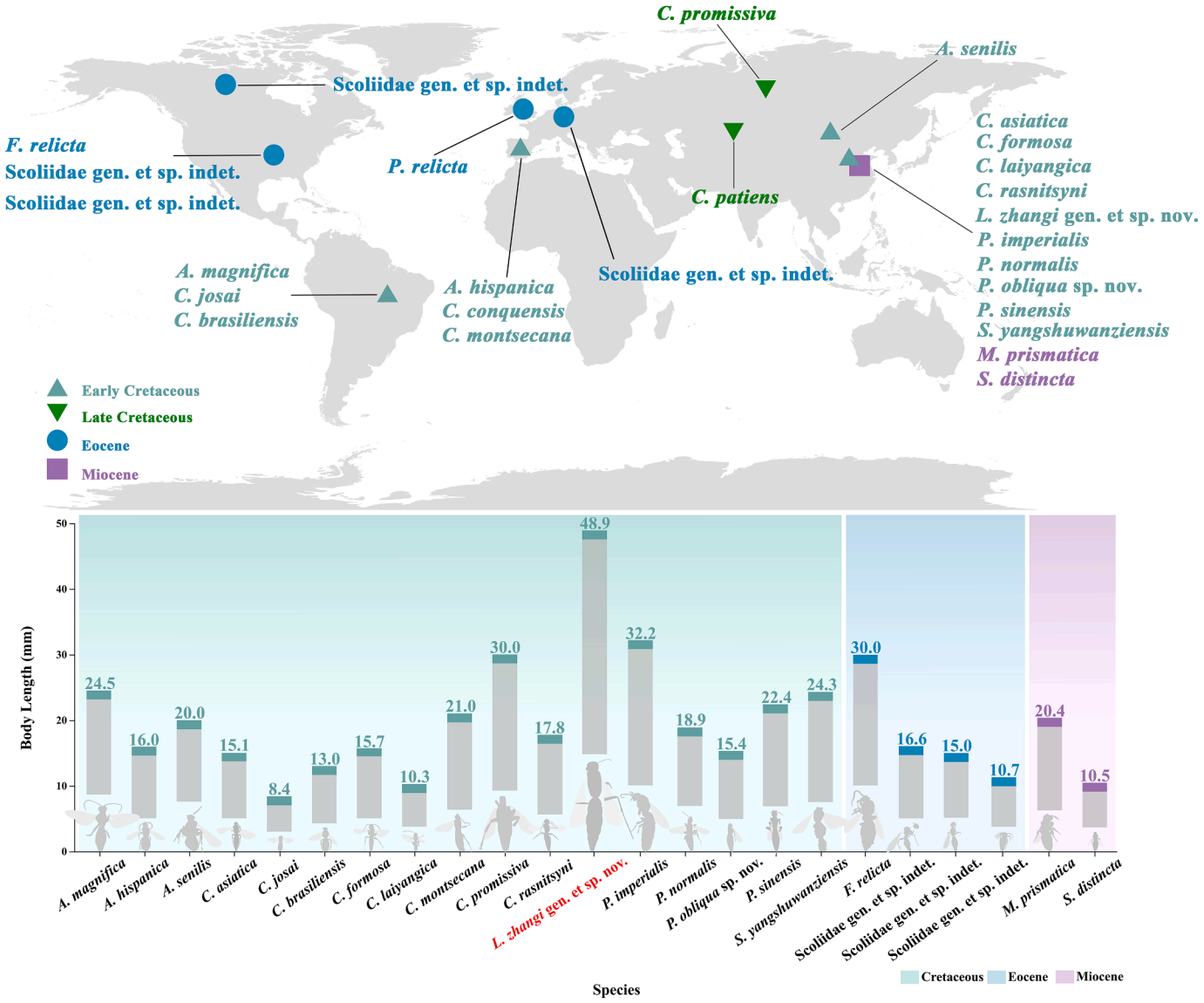


Fig. 5. Distributions and body lengths of the known Scoliidae fossil species with relatively complete bodies (based on Table 1), excluding taxa with unknown body lengths.

15. Crossvein cu-a vertical. Middle flagellar segments less than 2× as long as wide (Zhang, 2004, fig. 3) .....†***Cretoscolia formosa* Zhang, 2004**
- Crossvein cu-a oblique. Middle flagellar segments more than 2× as long as wide (Zhang, 2004, fig. 6) .....†***Cretoscolia rasnitsyni* Zhang, 2004**
16. Crossveins 2r-rs and 2r-m very close at Rs; cell 3rm along Rs 2× as long as along M (Rasnitsyn and Martínez-Delclòs, 1999, fig. 3) .....†*Cretoscolia montsecana* Rasnitsyn and Martínez-Delclòs, 1999
- Crossveins 2r-rs and 2r-m clearly distant at Rs; cell 3rm along Rs equal to or slightly longer than along M.....**17**
17. Cell 3r far exceeding apex of cell 3rm (Rasnitsyn, 1993, fig. 5) .....†*Cretoscolia patiens* Rasnitsyn, 1993
- Cell 3r slightly exceeding or not exceeding the apex of cell 3rm.....**18**
18. Apex of cell 3r distant of wing margin; 3r-m strongly bent outward (Rasnitsyn, 1993, fig. 3) .....†***Cretoscolia promissiva* Rasnitsyn, 1993**
- Cell 3r closed near wing margin; 3r-m oblique .....†*Cretoscolia conquensis* Rasnitsyn and Martínez-Delclòs, 2000

4. Discussion

The longest known apocritan in the Yixian Formation is †*Megapelecinus changi* Shih et al., 2010 in Pelecinidae, which has a body length of 50.9 mm (Shih et al., 2010). We compiled statistics on the body lengths of all previously reported fossil groups of Scoliidae, excluding those with incompletely preserved bodies, and found that the species from the Yixian Formation generally range from 18.9 to 32.2 mm in body length, while the species from other areas have body lengths of 8.4–30.0 mm (Table 1 and Fig. 5). Therefore, †*Liaoscolia zhangi* gen. et sp. nov. with a body length of 48.9 mm described here represents the largest known fossil record of Scoliidae and also the largest Aculeata fossil from the Yixian Formation to date.

Palynological assemblages from various horizons of the Yixian Formation (Li and Liu, 1999; Ding and Zhang, 2004; Li, 2010; Cui et al., 2015), together with sedimentary features such as well-developed lacustrine varves in the Dakangpu Bed (Wang et al., 2018), consistently indicate a warm and humid paleoclimate during the deposition of the Yixian Formation (see also Zhang et al., 2004; Zhou, 2006). The associated early mammals from the Yixian Formation exhibit high diversity, which indirectly supports this interpretation of a warm and stable paleoenvironment from an ecological perspective (Meng et al., 2006).

The extant species of *Megascolia* are among the largest members of the Scoliidae, with *Megascolia procer* Illiger, 1802 reaching over 50 mm in body length (Ming and Soh, 2020; Castagnet and Cabon, 2025). They are primarily distributed along the Mediterranean coast, the Iberian Peninsula, and Southeast Asia (Betrem and Bradley, 1964; Osten, 2000, 2005b; Gupta and Jonathan, 2003; GBIF Secretariat, 2023). These regions are free from severe cold year-round, providing abundant food sources and stable habitats for these wasps (Aschmann, 1973; Page et al., 2006; Moreno et al., 2012). Similarly, the Jehol Biota of the Yixian Formation is distinctive in yielding other large-bodied hymenopteran species besides the large scoliid †*Liaoscolia zhangi* gen. et sp. nov. (Shih et al., 2010; Gao et al., 2013). These observations support the above inference of a warm and humid paleoenvironment for the Jehol Biota in Northeast China during the Early Cretaceous.

5. Conclusions

Two new species, †*Liaoscolia zhangi* gen. et sp. nov. and †*Protoscolia obliqua* sp. nov., are described herein, which represent two distinct lineages within the family Scoliidae. †*L. zhangi* gen. et sp. nov. apparently forms a basal offshoot on the stem line of Scoliinae + Campsomerinae; whilst †*P. obliqua* sp. nov. increases the past diversity of the subfamily Proscoliinae. †*L. zhangi* gen. et sp. nov. represents the largest fossil Aculeata ever recorded from the Yixian Formation: this discovery not only enriches the biodiversity of Mesozoic scoliid wasps but also provides more fossil evidence for understanding the ecology and environment of the Cretaceous Jehol Biota.

CRediT authorship contribution statement

Zheng Wei: Writing – review & editing, Writing – original draft, Software, Methodology, Formal analysis. **Zhen Wang:** Writing – review & editing, Data curation. **Alexandr P. Rasnitsyn:** Writing – review & editing, Writing – original draft, Formal analysis. **Dong Ren:** Writing – review & editing, Funding acquisition. **Taiping Gao:** Writing – review & editing, Writing – original draft, Supervision, Resources, Methodology, Funding acquisition, Conceptualization.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

No data was used for the research described in the article.

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