Short communication

Two new Jurassic stoneflies (Insecta: Plecoptera) from Daohugou, Inner Mongolia, China

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Abstract

Two new genera and two new species of family Taeniopterygidae, *Mengitaenioptera multiramis* gen. et sp. nov. and *Noviramonemoura trinervis* gen. et sp. nov. are described. These fossils were collected from Daohugou Village (the Middle Jurassic), Inner Mongolia, China. Hitherto, these fossil species from Daohugou are the oldest taeniopterygids. Both simple and complex venations simultaneously occurred in this group, which reveals that the early diversification of taeniopterids was well underway by the Middle Jurassic. Therefore, we prefer to adopt the Comstock's opinion that the venation of taeniopterids was derived from the simple venation of the older group (such as *Palaeonemouridae*) at much ancient geological time ago. Some of the descendants carried this simple venation; others evolved into complex venation with many additional crossveins and branches.

Keywords: Plecoptera; Taeniopterygidae; Daohugou; Inner Mongolia; Middle Jurassic

1. Introduction

Taeniopterygidae is a medium-sized family of extant stoneflies consisting of about 80 species which are Holarctic in distribution. The fossil species of this family are rare. In recent years, we collected numerous well-preserved fossil stoneflies from Daohugou Village, which is located in Shantou Township, Ningcheng County, Inner Mongolia, China. Among them, a number of fossil specimens have been assigned to extinct groups [1], and a few specimens belong to extant families, such as Taeniopterygidae. We have found previously nine fossil taeniopterygids, which possess typical characters of Taeniopterygidae, such as venation, tarsus and cerci [2]. Now, we have found two more fossil specimens that are similar to taeniopterygids in venation and legs.

The age of Daohugou beds is still under debate, ranging from the early Middle Jurassic to the Early Cretaceous by various authors [3–6]. Even the same authors, as their research progressed, provided different opinions at different times [7]. Recently, Ar–Ar and SHRIMP U–Pb dating showed that the age of intermediate-acidic volcanic rocks overlying the Daohugou fossil-bearing beds (N41° 18.979', E119° 14.318') is about 164–165 Ma, and the age of Daohugou beds is older than or equal to that [8]. Liu et al. estimated the age of the Daohugou section (N41° 23.10', E119° 09.61') and drew a similar conclusion that the average age of the Daohugou beds was 162 ± 2 Ma [9]. This conclusion, supported by palaeontological evidence from conchostracans and insects, is the most definitive evidence for the Middle Jurassic (Aalenian–Bathonian) age of the Daohugou beds [10].

2. Materials and methods

All the fossils described herein were collected from Daohugou Village, Chifeng City, Inner Mongolia, China, Middle Jurassic. They were examined using a LEICA
MZ12.5 dissecting microscope and illustrated with the aid of a drawing tube. Line drawings were processed using CorelDraw 12 graphic software; the fossil photos were made by using EPSON PERFECTION 1650 flated scanner and LEICA camera. The systematic arrangement we follow is that of Zwick [11].

Type specimens described here are housed in the Key Laboratory of Insect Evolutionary and Environment Change, College of Life Sciences, Capital Normal University, Beijing, China.

3. Systematic palaeontology

Order Plecoptera Latreille, 1802
Suborder Arctoperlaria Zwick, 1969
Family Taeniopterygidae Klapálek, 1905
Genus Mengitaenioptera gen. nov.
Type species: Mengitaenioptera multiramis gen. et sp. nov.

Etymology: A combination of the prefix “mengi” and “Taenioptera” (a genus of Taeniopterygidae), referring to taeniopterids collected from Inner Mongolia.

Diagnosis: Wings of macropterous, translucent. No additional veinlets on the costal area, c-r present but very faint, and close to the wing tip, grey pterostigma present in the terminal space of forewings; Rs with five branches, M and CuA with two long branches, and fork at level of midlength of forewings; 6–9 crossveins in the median and cubital areas.

Remarks: The new genus Mengitaenioptera differs from all the fossils and extant known genera of Taeniopterygidae by Rs with five branches, while Rs generally with two or three branches in the known genera of Taeniopterygidae, only Mesyatsia lunata frequently has Rs with four branches [12–14].

Mengitaenioptera multiramis gen. et sp. nov. (Fig. 1).

Etymology: Specific epithet is from “multiramis”, referring to Rs with many branches in this fossil species.

Holotype: CNU, NMDHG189, a well-preserved body with part of wings, but abdomen preserved imperfectly.

Description: Length of body (combined length of head, thorax and five segments of abdomen) 14 mm, to tip of wings 23 mm. Head large, same length as the maximal width; two basal segments of antenna robust, third segment narrow, others unpreserved. Cervix narrow, prothorax transverse, twice as wide as long, mesothorax and metathorax developed.

Forewings – 22 mm length. Costal area without additional veinlets, Sc terminates at R nearly two-thirds of the total wing length, R long, c-r faint, far from the Sc tip and grey pterostigma presents in the terminal space of forewings. Rs departs from R at one-sixth of the base, possesses five branches and forks first at two-thirds of the total wing length. r-rs short, almost vertical to Rs, M bifurcates at the midlength of wing and its branches are 1.5× as long as M stem, rs-m straight, connects with Rs almost at level of r-rs and terminates at the one-sixth of the MA. Cross-vein m-cua straight, connected the basal of MP and terminated the CuA stem. CuA forks almost at level of M forks, its anterior branch long, almost twice as long as the posterior branch, 6 crossveins at the median areas and 9 crossveins at the cubital areas.

Abdomen preserved incompletely, only with five visible segments. Legs long, hind femur robust, nearly twice as wide as tibia, tibia slender, about 1.3× as long as femur, tarsus only first segment and part second segment preserved, second segment may be as long as first segment according to the faint impression.

Genus Noviramonemoura gen. nov.
Type species: Noviramonemoura trinervis gen. et sp. nov.

Etymology: A combination of the Latin prefix “novi” and Ramonemoura (a similar genus), referring to this new genus similar to the genus Ramonemoura.

Diagnosis: Wings of macropterous, translucent. No additional veinlets on the costal area, c-r absent, grey pterostigma present in the terminal space of forewings; Rs with three branches, M with two long branches and CuA with three branches; M and CuA fork distinctly before midlength of forewing.

Remarks: The new genus Noviramonemoura differs from all the fossil and extant known genera of family Taeniopterygidae by both Rs and CuA with three branches, while in the known genera of Taeniopterygidae, Rs with three branches or CuA with three branches, but not both Rs and CuA possess three branches [12–14].

In addition, this new genus Noviramonemoura is very similar to extinct genus Ramonemoura in the venation (Fig. 2(a)), which was collected from south Fergana Valley (an area of Junction of Uzbekistan, Kirghizia and Tadzhikistan), the late Middle or earlier Late Triassic, and Sinitshenkova assigned it to the family Perlariopseidae [14]; Noviramonemoura differs from Ramonemoura by grey pterostigma present.

Fig. 1. Mengitaenioptera multiramis gen. et sp. nov. holotype, CNU, NMDHG189 (scale bars represent 5 mm). (a) Line drawing; (b) photograph.
In this new genus, tarsus of hind leg with three equal length segments was preserved clearly, so we assign it in the family Taeniopterygidae which generally possesses three segments of tarsus with the same length; while Perlariopseidae possesses shorter second segment of tarsus. Sinitshenkova erected Ramonemoura only by forewing, and assigned it to the family Perlariopseidae; furthermore, Ramonemoura is earlier than the new genus by about 65 Ma [14]. The taxonomy of Ramonemoura at the family level should be discussed again.

Noviramonemoura trinervis gen. et sp. nov. (Figs. 2(b), 3, 4).

Etymology: Specific epithet is from “trinervis”, referring to both Rs and CuA with three branches in this fossil species.

Holotype: CNU, NMDHG190, a well-preserved body with fore wings, but abdomen preserved faintly.

Description: Length of body 10 mm, to tip of wings 16 mm. Head large, its length is as long as the maximal width; antenna shorter than body, two basal segments robust; three distal segments of maxillary palp preserved clearly, same length. Prothorax transverse, twice as wide as long, mesothorax and metathorax developed.

Forewings – 13 mm length. Costal area without additional veinlets, Sc terminates at R nearly two-thirds of the total wing length, R long, c-r absent and grey pterostigma presents in the terminal space of forewings. Rs possesses three branches and forks after r-rs. r-rs short, oblique, M bifurcates distinctly before the midlength of wing, and its branches are twice as long as M stem, rs-m straight, parallel to r-rs, connects with Rs before r-rs and terminates at the one fifth of the MA. Crossvein m-cua straight, connecting M stem and CuA stem. CuA possesses three branches and forks first before M forks, its first branch long, almost as long as MP. Crossveins at the median cubital areas preserved incompletely, only 2 crossveins can be seen.

Abdomen preserved faintly, as long as thorax and head combined, its segment indistinct.

Legs robust, coxa and trochanter wide, femur short and brawny, nearly twice as wide as tibia, tibia slender, tarsi long, nearly half a length of tibia, the first segment slightly longer than the second one, which is equal to the third segment (Fig. 4). Claw short, wide basally.
4. Discussion

Comstock proposed that the Plecoptera have been evolved from a primitive form that veins Rs, M and CuA should have only two branches, respectively. In some descendants of this primitive stonefly, reduction of these veins has been carried still farther; in others, additional branches have been developed for these veins, but in a very erratic manner [15]. Ricker and Ross also thought that the extra branches of Rs and CuA should be regarded as derived characters, similarly with costal crossveins and the occasional apical crossveins; the genera *Taeoniropyx* and *Kohnoperla* with simple venation should be primitive on other aspects in the extant Taeniopteridae [12].

We have described two fossil genera *Jurataenionema* and *Prototaenionema* belonging to Taeniopteridae from Daohugou, which possess this primitive and simple venation [2]. Now, we also found these two new genera *Mengtaeniontera* and *Noviramonemoura*, which possess Rs and CuA with additional branches. Taeniopterids with simple and complex venation have simultaneously occurred in the Middle Jurassic. It reveals that the early diversification of taeniopterids was well underway by the Middle Jurassic. It may be just as Comstock assumed, the venation of taeniopterids was derived from the simple venation of the older group at much ancient geological time. Some descendants carried this simple venation still farther, others got complex venation with many additional crossveins and branches.

In fact, the primitive vein form that Comstock assumed occurred first in Permian, such as *Palaeonemoura petaloidea* (Fig. 5), which was the oldest stonefly coming from the upper Permian Kungurian deposits of the Urals and assigned to the extinct family Palaeonemouridae [16]. At present, many described fossil taxon [14] and analysis [17] of molecular marker on extant taxon resulted in debate on the character polarity, therefore, the proper phylogeny of Plecoptera is more difficult to be reconstructed.

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