

A NEW FOSSIL GENUS OF SIPHLONURIDAE (INSECTA: EPHEMEROPTERA) FROM THE DAOHUGOU, INNER MONGOLIA, CHINA

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Abstract.— A new genus and species *Multiramificans ovalis* gen. and sp. nov. of the family Siphonuridae s.l., is described from the Middle Jurassic Jiulongshan Formation of the Daohugou, Inner Mongolia in China. Detailed description and illustration of the specimen along with a brief review of fossil Siphonuridae s.l. are given. The problems of association between nymphs and adults, and palaeoenvironment are briefly discussed.



Key words.— Ephemeroptera, Siphonuridae, *Multiramificans*, *Multiramificans ovalis*, new genus, new species, fossils, Daohugou, Middle Jurassic, China.

INTRODUCTION

The mayfly family Siphonuridae s.l., Bank, 1900 is not only a fairly large extant group, but also numerous in fossil records. Until now, 24 genera and 35 species of fossil mayflies of this family have been reported (see below), ranging from early Middle Triassic to Upper Miocene. Among them, 3 genera and 4 species have been described from China. The most ancient representative of the family is *Triassonurus doliiformis* Sinitshenkova (Sinitshenkova *et al.* 2005) which was collected from the Vosges in France (early Middle Triassic). In addition, the species of this family were found in diverse localities all over the world. They are reported from Siberia (*Mesobaetis* Brauer, Redtenbacher et Ganglbauer, 1889, *Mogzonurella* Sinitshenkova, 1985, *Mogzonurus* Sinitshenkova, 1985, *Cretoneta* Tshernova, 1971), Transbaikalia (*Stackelergisca* Tshernova, 1967, *Proameletus* Sinitshenkova, 1976, *Bolbonyx* Sinitshenkova, 1990, *Siphangarus* Sinitshenkova, 2000), Mongolia (*Mesobaetis*, *Mogzonurella*,

Mogzonurus, *Albisca* Sinitshenkova, 1989), China (*Mesonetopsis* Ping, 1935, *Sinoephemera* Ping, 1935, *Mesobaetis*), Baltic (*Siphonurus* Eaton, 1868, *Baltameletus* Demoulin, 1968, *Balticophlebia* Demoulin, 1968, *Cronicus* Eaton, 1871), Germany, Bavaria (*Olgisca* Demoulin, 1970), Brazil (*Siphgondwanus* McCafferty, 1990, *Costalimella* Martins-Neto, 1996), Australia, Victoria (*Promirara* Jell et Duncan, 1986, *Australurus* Jell et Duncan, 1986, *Dulcitnanna* Jell et Duncan, 1986), and California, Colorado of America (*Aphelophlebodes* Pierce, 1945, *Siphurites* Cockerell, 1923). But the family Siphonuridae is accepted in a wider sense. Now this taxon is regarded to be paraphyletic assemblage and is rejected by most ephemeropterologists (McCafferty 1991, Kluge *et al.* 1995). We cannot usually observe in fossil mayfly imagines those particular features (genitalia, tarsi and other important characters) which are used in recent taxonomy of the family. The up-to-date knowledge of the fossil mayflies does not permit to choose any of the proposed systems, moreover the ancient mayflies possess

a lot of plesiomorphic features while the taxonomy of living forms based on autapomorphies. The wing venation of fossil mayflies which is often available for studying, turned out to be not enough for determining the real systematic position of the species. So here this is not that family Siphonuridae which is accepted in modern classification of recent mayflies, but a plesiomorphon-family Siphonuridae in a wider sense.

The imago is known only in 7 genera of Mesozoic Siphonuridae *s.l.*: *Cretoneta*, *Proameletus*, *Mogzonurus*, *Costalimella*, *Stackelbergisca*, *Olgisca* and *Mesobaetis*. The genus *Huizhougenia* originally placed to Siphonuridae *s.l.* described by the apical part of wing (Lin 1980), most probably belongs to a dragonfly (Kluge and Sinitshenkova 2002).

At some localities, representatives of the family Siphonuridae *s.l.* were dominant among the mayflies, for example *Stackelbergisca sibirica* Tshernova, 1967 – the Late Jurassic mayfly fauna from Transbaikalia (Sinitshenkova 1989); *Proameletus caudatus* Sinitshenkova, 1976 – the Early Cretaceous sites, also from Transbaikalia; and *Australurus plexus* Jell et Duncan, 1986 – the Early Cretaceous of Victoria, Australia.

A new and unique imago specimen from the Daohugou beds allows us to carry out detailed study because of its excellent preservation. We establish a new genus and species *Multiramificans ovalis* gen. et sp. nov. of the Siphonuridae *s.l.* Morphological terms used here are explained by Kluge (2004).

MATERIAL AND METHODS

The fossil specimen was recently collected from the Middle Jurassic Daohugou beds, Jiulongshan Formation, Ningcheng County, Inner Mongolia in China, about 165 Ma (Ren *et al.* 2002, Chen *et al.* 2004, Gao and Ren 2006).

The specimen was examined with a Leica MZ12.5 dissecting microscope and illustrated with the aid of a drawing tube attached to the microscope. Line drawings were made with CorelDRAW 12 graphic software. Type specimen studied here is housed in the Key Lab of Insect Evolution and Environmental Change, College of Life Sciences, Capital Normal University, Beijing, China.

SYSTEMATICS

Order Ephemeroptera Hyatt et Arms, 1891

Suborder Euplectoptera Tillyard, 1932

Family Siphonuridae Bank, 1900

Multiramificans gen. nov.

Type species. *Multiramificans ovalis* sp. nov.,

Middle Jurassic, Daohugou beds, Ningcheng County, Inner Mongolia in China.

Diagnosis. Imago. Metathorax unusually long, with evident scutum and scutellum; fore wings narrow and triangular; MA forked before its mid-length; cubital area large, CuA straight and connected to hind margin by more than fifteen veinlets; CuP slightly arched, unforked; numerous crossveins and short intercalate veins near the wing margin. Hind wings ovoid, relatively large; C arched, smooth; 8 longitudinal veins connected by cross-veins after medial area.

Composition. The type species only.

Etymology. Latin prefix multus-(many) and ramificans (branched).

Remarks. Among the Mesozoic Siphonuridae *s.l.* mayflies described by imago, the wing venation is not known for *Mogzonurus* and *Mesobaetis*. *Cretoneta* with several intercalaries in cubital area of fore wing instead of series of veinlets, *Costalimella* with minuscule size (6 mm long) and *Stackelbergisca* with forked veinlets in cubital area of fore wing are obviously distinguished from the new genus *Multiramificans*. By presence of veinlets in cubital area *Multiramificans* resembles *Proameletus* and *Olgisca*, from which it differs well by longer MA fork, in *Olgisca* and *Proameletus* MA fork is 1.5–2 times shorter than MA stem, while in *Multiramificans* gen. nov. MA fork is almost equal to MA stem. In addition, the new genus differs from *Olgisca* by simple A_1 , and from *Proameletus* by a larger number of veinlets in cubital area and relatively larger hind wings.

Multiramificans gen. nov. can be assigned to the family Siphonuridae based on the following features: fore wings narrow and triangular; vein CuA of fore wing connected to hind margin by many veinlets, which are characteristic for Siphonuridae *s.l.*; the branches of MP are almost symmetrical with CuA; MP_2 and CuA don't depart from the base of MP_1 ; hind wing relatively large.

Multiramificans gen. nov. possesses the unique combination of characters: metathorax unusually long, with evident scutum and scutellum; MA fork is almost equal to MA stem; an obviously large cubital area, more than fifteen veinlets on vein CuA of fore wings; large hind wing with eight longitudinal veins behind medial area. These characters allow formal separation of it from other known genera established by mayfly adults, extant or in fossil records. The relatively large hind wing of *Multiramificans* gen. nov., which is longer than half length of fore wing and unusually long metathorax, which has shape of scutum and scutellum more similar to that of mesothorax than in other Euplectoptera, are plesiomorphic features. The mayfly evolution obviously shows the reduction of hind wings and metathorax.

Multiramificans ovalis sp. nov.
(Figs 1–5)

Description (profile). Imago. Body length 18.5mm (excluding the tenth abdomen segment and cerci). Pterothorax well-developed; metathorax unusually long, with evident scutum and scutellum.

Fore wings: narrow and triangular with costal brace; RA and SC almost parallel to the costal margin; RS forming three subordinate triads; MA symmetrically forks before the middle area of wing: MA₁ and MA₂; MP symmetrically forked near wing base: MP₁ and MP₂; cubital area large; vein CuA straight, elongate and connected to wing margin by 18 simple veinlets; CuP short, slightly arched, unforked; in anal region only one A₁ can be seen which connected with CuP through several cross-veins.

Hind wings: ovoid, relatively large; Costal vein smooth, no costal projection; hind wings partly covered by fore wings with venation unclear, only several longitudinal veins can be seen, but behind vein MP, wing veins clear, eight longitudinal veins parallel to wing Tornoapical (out) margin with numerous crossveins among these longitudinal veins; short intercalate veins of different length near wing margin.

Legs: long and slender; forelegs lost, middle legs not completely preserved, only femora, tibia and tarsi with four segments can be seen; Middle tibia evidently longer than hind one; hind legs relatively complete; hind tarsi five-segmented, first segment longest, second one is $\frac{2}{3}$ of first length, third one nearly $\frac{1}{2}$ of second length, fourth one shortest, nearly $\frac{1}{2}$ of third length, fifth longer, subequal to second length; 2 pointed claws, similar.



Figure 1. *Multiramificans ovalis* sp. nov. A photograph of holotype, No. CNU-E-DHG-2006001-1. Scale bar 4 mm.

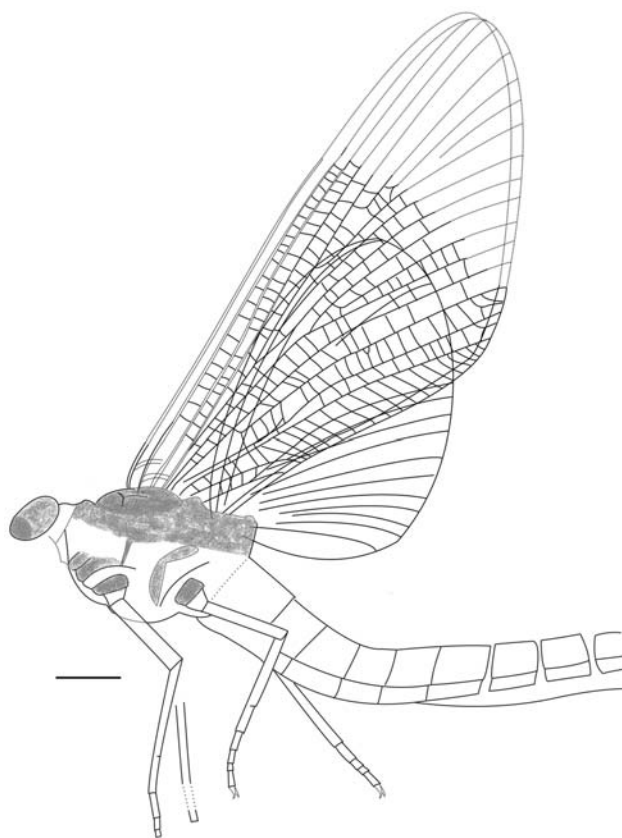


Figure 2. *Multiramificans ovalis* sp. nov. Lateral view, holotype, No. CNU-E-DHG-2006001-1. Scale bar 2 mm.

Abdomen: 9 segments are preserved; the ninth not complete. Cerci and paracercus are not preserved.

Measurements (mm). Imago: body length without the tenth abdominal segment 18.5; length of fore wing fragment 12.5, its total length estimated to be about 18.0, its maximum width 7.1; length of hind wing 9.5, its maximum width 6.0.

Holotype. CNU-E-DHG-2006001-1, CNU-E-DHG-2006001-2. Well preserved part and counterpart of body with fore and hind wings folded, about two-third part of fore wings is preserved; the venation is clear; nine segments of abdomen are preserved; antennae and cerci are not preserved.

Locality and horizon. Daohugou beds, Jiulongshan Formation, Ningcheng County, Inner Mongolia in China, Middle Jurassic.

Etymology. The species name is from the shape of hind wings.

DISCUSSION

The association between nymphs and adults presents an important issue because of the constraints and differences during fossilization. Studying fossil

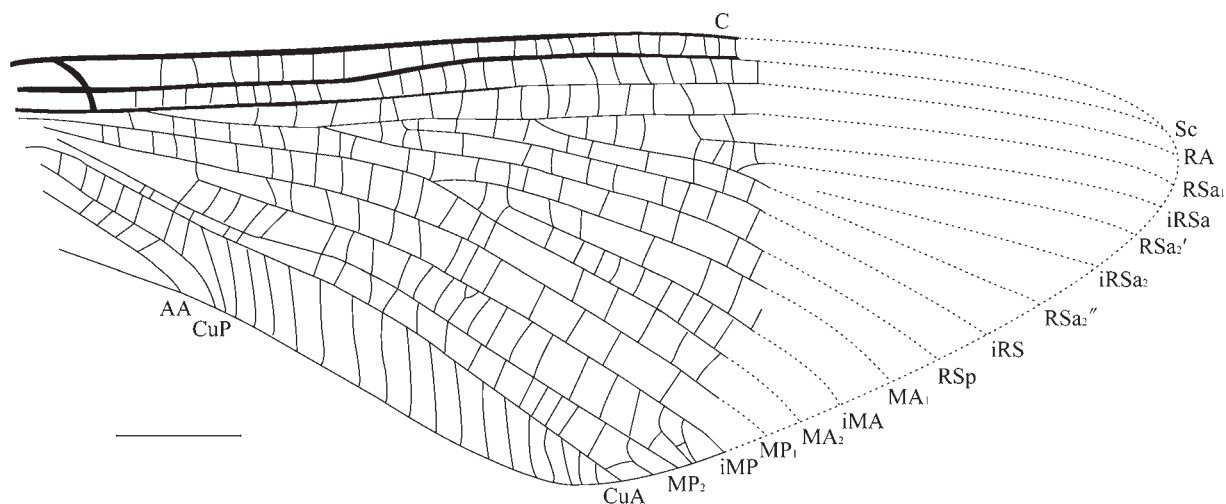


Figure 3. *Multiramificans ovalis* sp. nov. Fore wing, holotype, No. CNU-E-DHG-2006001-1. Scale bar 2 mm.

stoneflies, Sinitshenkova (1987) put forward three useful criteria to resolve this issue: first, nymph and adult fossils occur together at the same site; second, both belong to the same high-level taxon basing on the available characters; third, both sizes are compatible. Only when nymph and adult meet *all* the three criteria, they might be conspecific. We think these criteria should be applied to fossil mayflies. Despite many mayfly nymphs and adults being found in the Daohugou beds, according to criteria cited above we could not find relevant nymphs associated with adult *Multiramificans ovalis* gen. and sp. nov. Furthermore, it is very difficult to judge whether this new genus is compatible with other known genera established by nymphs in Siphonuridae *s.l.*, even which were found in neighboring areas such as in Mongolia. As this issue is inevitable in mayfly fossil research, we can only hope that future new fossil findings and more on-going fossil

research will shed light on the association of mayfly nymphs and adults.

Siphonuridae *s.l.* is a relatively ancient cosmopolitan group possessing many primitive characters compared with other groups in the Baetoidea. All nymph species are aquatic, especially preferring cool-water habitats and adults do not move far from water (Gui and Zhou 1999). *Multiramificans ovalis* gen. and sp. nov. and some freshwater conchostracans (Zhang and Shen 1987, Shen *et al.* 2003) were found in the Daohugou beds, Inner Mongolia. This indicates there were lakes with appropriate aquatic environment. Tan and Ren (2002) investigated and studied numerous fossils in the Daohugou, and recognized 3 insect communities: the aquatic insect community, the soil insect community and the forest and vegetation insect community. They conjectured that this area might be a near-shore and shallow lacustrine basin with a humid and warm

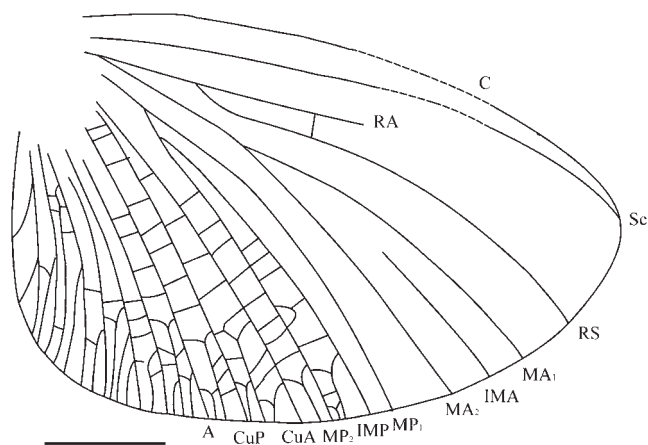


Figure 4. *Multiramificans ovalis* sp. nov. Hind wing, holotype, No. CNU-E-DHG-2006001-1. Scale bar 2 mm.

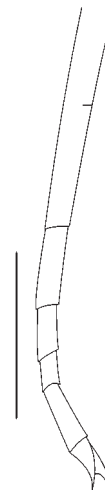


Figure 5. *Multiramificans ovalis* sp. nov. Hind tarsus and claws, holotype, No. CNU-E-DHG-2006001-1. Scale bar 1 mm.

climate, diverse and flourishing vegetation, and plenty of aquiferous soil beneficial to many plants (Tan and Ren 2002). Subsequently, a few Raphidioptera fossils which lived in mountains (Ren 2003) and a salamander (Wang 2004) which preferred mountain streams were found in the same location. Therefore, there might be mountains with streams near the lake or there was a mountain lacustrine basin in the Daohugou beds.

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