ISSN 0031-0301, Paleontological Journal, 2006, Vol. 40, No. 5, pp. 553–559. © Pleiades Publishing, Inc., 2006.
Original Russian Text © J.-f. Zhang, 2006, published in Paleontologicheskii Zhurnal, 2006, No. 5, pp. 80–86.

New Mayfly Nymphs from the Jurassic of Northern and Northeastern China (Insecta: Ephemeroptera)

J.-f. Zhang

Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, 39 East Beijing Road, Nanjing, 210008 China
e-mail: jfzhang@nigpas.ac.cn

Received July 8, 2005

Abstract—Four new species of mayfly nymphs, *Furvoneta relicta* sp. nov., *Clavineta eximia* sp. nov. (originally *Mesoneta antiqua*), *Mesobaetis latifilamentacea* sp. nov., and *Stackelbergisca cylindrata* sp. nov. are described from the Jurassic of China. All these species may have inhabited lakes rather than flowing water. The geological age and stratigraphical correlation of the nymph-bearing strata are briefly reviewed.

DOI: 10.1134/S0031030106050091

Key words: Insecta, Ephemeroptera, nymphs, Jurassic, China.

INTRODUCTION

The majority of Mesozoic aquatic insect assemblages of China are of lacustrine origin; they typically contain nymphs of Ephemeroptera, larval Odonata, larval and adult Heteroptera (within Hemiptera), larval and adult Coleoptera, and larval and pupal Diptera. Thousands of specimens of aquatic insects have been collected by Chinese researchers from the Jurassic and Lower Cretaceous fossil sites in China. Among them, the mayflies are rather rare, and only a few remnants of nymphs have been described from the Shiti, Jiulongshan, Haifanggou, Sanjianfang, and Yixian formations, respectively (Lin, 1986; Lin and Huang, 2001; Hong, 1983; Hong et al., 1995; Wang, 1980, 1987). Contrary to this, a large number of nymph specimens have recently been discovered in the Daohugou Formation. Only some of them have so far been described taxonomically, although some specimens are assigned to species known from Russia, i.e., *Mesoneta antiqua* Brauer, Redtenbacher et Ganglbauer, 1889 and *Mesobaetis sibirica* Brauer, Redtenbacher et Ganglbauer, 1889 (Ren et al., 2002). Unfortunately, the placements of all these taxa may be incorrect (Kluge and Sinitshenkova, 2002; Kluge, 2004).

Four new species of four known genera are established and depicted in this paper: *Furvoneta relicta* sp. nov.; *Clavineta eximia* sp. nov., which was previously placed in *Mesoneta antiqua* sensu auct., Hong, 1983 (non Brauer, Redtenbacher et Ganglbauer, 1889); *Mesobaetis latifilamentacea* sp. nov.; and *Stackelbergisca cylindrata* sp. nov.; they come respectively from the Haifanggou, Jiulongshan, and Daohugou formations of the Liaoning and Hebei provinces, and Inner Mongolia. Each species is described based on a single nymph.

It is difficult to classify fossil mayfly nymphs based only on the outline characters preserved, because they are not the main features used in the modern phylogenetic classification of Recent Ephemeroptera. For this reason, the erection of some extinct genera and families may be insufficient, and their taxonomic positions are debatable. Thus, the four new species described herein may be temporarily placed in known genera within known extinct or extant families, although their attribution needs to be further studied. This is also true of many fossil taxa established based on mayfly nymphs.

The age of the nymph-bearing strata mentioned above has been the focus of much discussion among geologists and paleontologists, and is estimated in a range from the early Middle Jurassic to the Early Cretaceous (Hong, 1983; Wang et al., 2000, 2002; Wang 2000, 2004; Lin and Huang, 2001; Ji and Yuan, 2002; Ren et al., 2002; Gao and Shubin, 2003; Shen et al., 2003; Chen et al., 2004; Rasnitsyn and Zhang, 2004a, 2004b). According to new biostratigraphical data and isotope dating, the entomofaunas from the Daohugou, Haifanggou, and Karabastau formations (Karatau, Kazakhstan) can be correlated and, consequently, are contemporaneous or almost contemporaneous, being Callovian or Oxfordian of the latest Middle Jurassic–earliest Late Jurassic. The Jiulongshan Formation (especially at the fossil site of the village of Zhouyingzi in Luanping, Hebei, China) is older than the Daohugou or Haifanggou formations and is dated Middle Jurassic (Zhang and Zhang, 2003; Zhang, 2004).

These new nymph species, like other Mesozoic Chinese nymphs, are limnic rather than fluvial. Sinitshenkova (1984, 1999) discussed in detail the habitats of Mesozoic mayflies. She believes that all Jurassic and Early Cretaceous mayfly nymphs are lacustrine rather than rheophilous (Sinitshenkova, 1984), while the insects that can be connected with flowing water are

almost exclusively represented by flying adults (Sinitshenkova, 1999). This deduction seems correct. The nymphs recorded in China, including *Ephemeropsis trisetalis* Eichwald, 1864, *Mesoneta antiqua* sensu auct. (Hong, 1983; Ren et al., 2002) (non Brauer, Redtenbacher et Ganglbauer, 1889), and *Mesobaetis sibirica* sensu auct. (Hong et al., 1995; Ren et al., 2002) (non Brauer, Redtenbacher et Ganglbauer, 1889), are limnic rather than fluvial, although Ren et al. (1996) was of the opinion that all the above-mentioned species inhabited streams.

The material examined is housed at the Nanjing Institute of Geology and Palaeontology of the Chinese Academy of Sciences (NIGPAS).

SYSTEMATIC PALEONTOLOGY

Family Mesonetidae Tshernova, 1969

Genus *Furvoneta* Sinitshenkova, 1990

Furvoneta relicta sp. nov.

Plate 15, figs. 1–3

Etymology. From the Latin *relictus* (relict).

Holotype. NIGPAS, no. DHG 0515-a, DHG 05015-b, part and counterpart, impression of a well-preserved nymph, nearly dorsoventral aspect; China, Liaoning Province, Beipiao City, Haifeng Township, Yushudonggou locality; uppermost Middle Jurassic–lowermost Upper Jurassic, Haifanggou Formation.

Description (Fig. 1a). Nymph. The head is oval, slightly longer than wide. The clypeus is transversely rectangular. The mandibles are obscure. The eyes are poorly preserved, seemingly oval. The head and thorax are long, while the abdomen (excluding caudalii = tail filaments, caudal filaments) is about 1.7 times as long as the head and thorax (excluding wing buds = wing sheaths, wing pads) combined. The pronotum has straight anterior and posterior margins, 3.8 times wider than long. The anterior pair of wing buds are large, bladelike, and reach the posterior margin of the second abdominal segment; the posterior pair of wing buds are completely covered by anterior buds. The legs are short and thick, with the femora longer than the tibiae and tarsi combined, the tarsi are longer than the tibiae; the claws are well developed. The abdomen is approximately 2.5 times longer than wide, with the basal abdominal segments being the widest, each tergum of the basal abdominal segment is about four times wider than long, the remaining terga taper gradually terminally. The tenth is clearly shorter and narrower than the ninth; the posterolateral projections on abdominal segments 1–8 are long and sharp; on the ninth, the posterolateral projections become very long and sharp, and are nearly as long as the tenth abdominal tergum. Tergalii (= gills) are well developed on abdominal segments 1–7; all tergalii are single, comparatively small (about half as long as the width of the abdominal terga at the middle) and elongated oval (with their tops more or less sharp), with sclerotized anal costae (= inner ribs) and costae (= fore costae, outer ribs) are weakly developed. The caudalii are comparatively thin and short (about half as long as the abdomen, and less than one-third of the body length). The paracercus and inner margins of the cerci are covered with hairs.

Measurements, mm. Length of nymph (including caudalii) 14.1 (head length, 1.5; pronotum length, 1.0; pterothorax length,1.7; abdomen length, 6.7; paracercus length, 3.2; cercus length, 3.2); the width (at the basal abdominal segments), 2.7; middle leg length, 3.0 (femur length, 1.6; tibia length, 0.5; tarsus length, 0.9).

Comparison. The new species is similar to *F. lucida* Sinitshenkova, 2002 from the Middle–Upper Jurassic of the Shar-Teeg (= Shara-Teeg) locality, Adzh-Bogdo Mountain Ridge, south of Shar-Teeg Mountain, Gobi-Altai Aimak, Mongolia, from which it differs in the larger head, which is longer than wide and in the longer posterolateral projections on abdominal segments 1–8. This nymph is distinguished from *F. sobria* Sinitshenkova, 2002 (for locality, see under *F. lucida*) by the shape of its smaller tergalii, in which the anal costae are sclerotized and the costae become weak.

However, the Shar-Teeg locality, which yielded *F. lucida* and *F. sobria*, is a series of outcrops of Mesozoic, most probably Upper Jurassic, lacustrine sediments (Gubin and Sinitza, 1996; Sinitshenkova, 2002).

Material. Holotype.

Genus *Clavineta* Sinitshenkova, 1991

Clavineta eximia sp. nov.

Plate 15, fig. 4

Mesoneta antiqua: Hong, 1983, pl. I, figs. 6–8; fig. 7 (non Brauer et al., 1889).

Etymology. From the Latin *eximius* (eximious, select, excellent).

Holotype. NIGPAS, no. DHG 0516, impression of a well-preserved nymph, dorsoventral aspect; China,

Explanation of Plate 15

Figs. 1–3. *Furvoneta relicta* sp. nov., nymph, holotype: (1) part, NIGPAS, no. DHG 0515-a; (2) The same as 1 but wet with glycerol; and (3) counterpart, fragment, NIGPAS, no. DHG 0515-b.

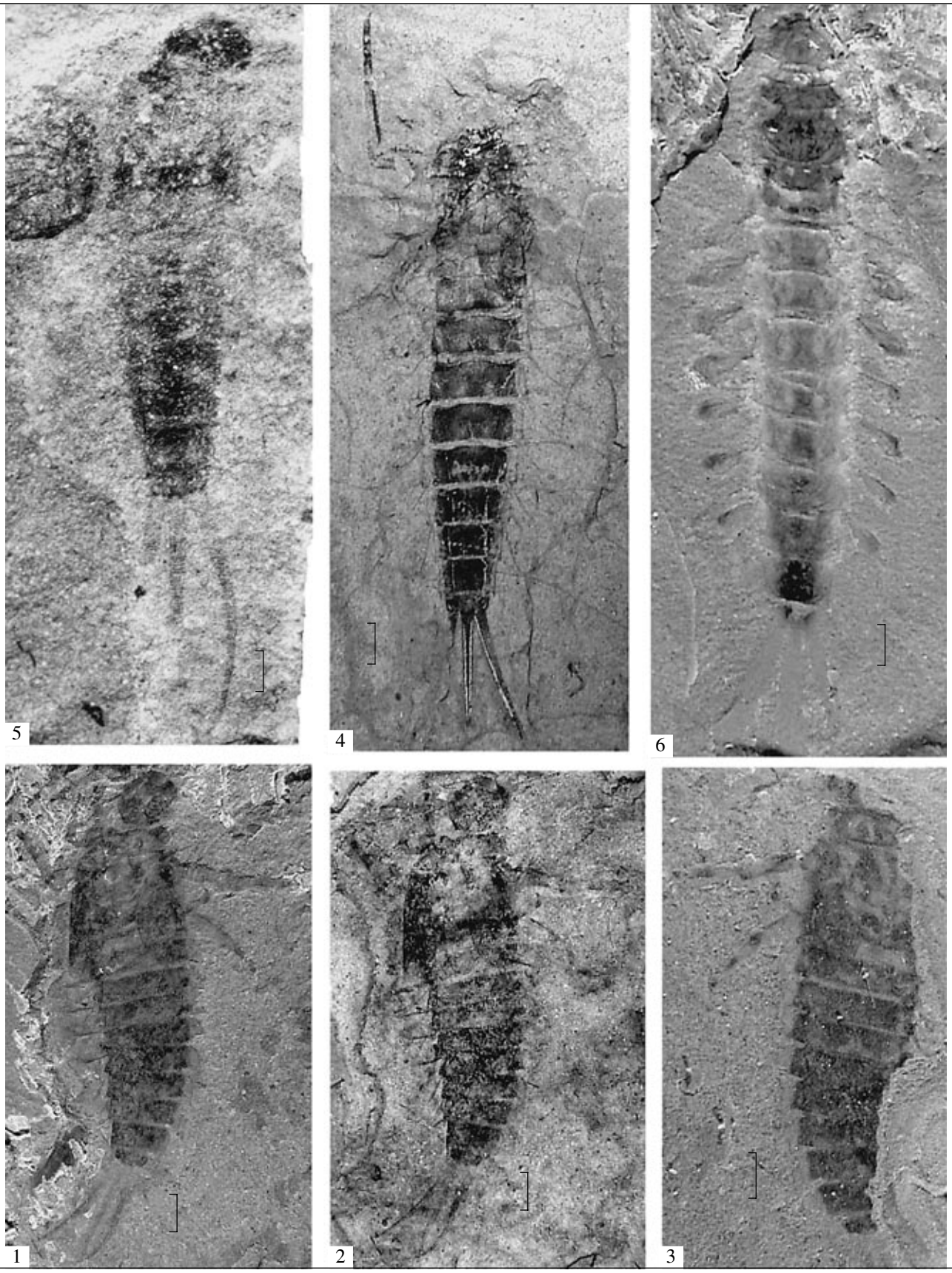
Fig. 4. *Clavineta eximia* sp. nov., nymph, holotype NIGPAS, no. DHG 0516.

Fig. 5. *Mesobaetis latifilamentacea* sp. nov., nymph, holotype NIGPAS, no. DHG 0517.

Fig. 6. *Stackelbergisca cylindrata* Zhang, sp. nov., nymph, holotype NIGPAS, no. DHG 0518.

Scale bars, 1 mm.

Plate 15



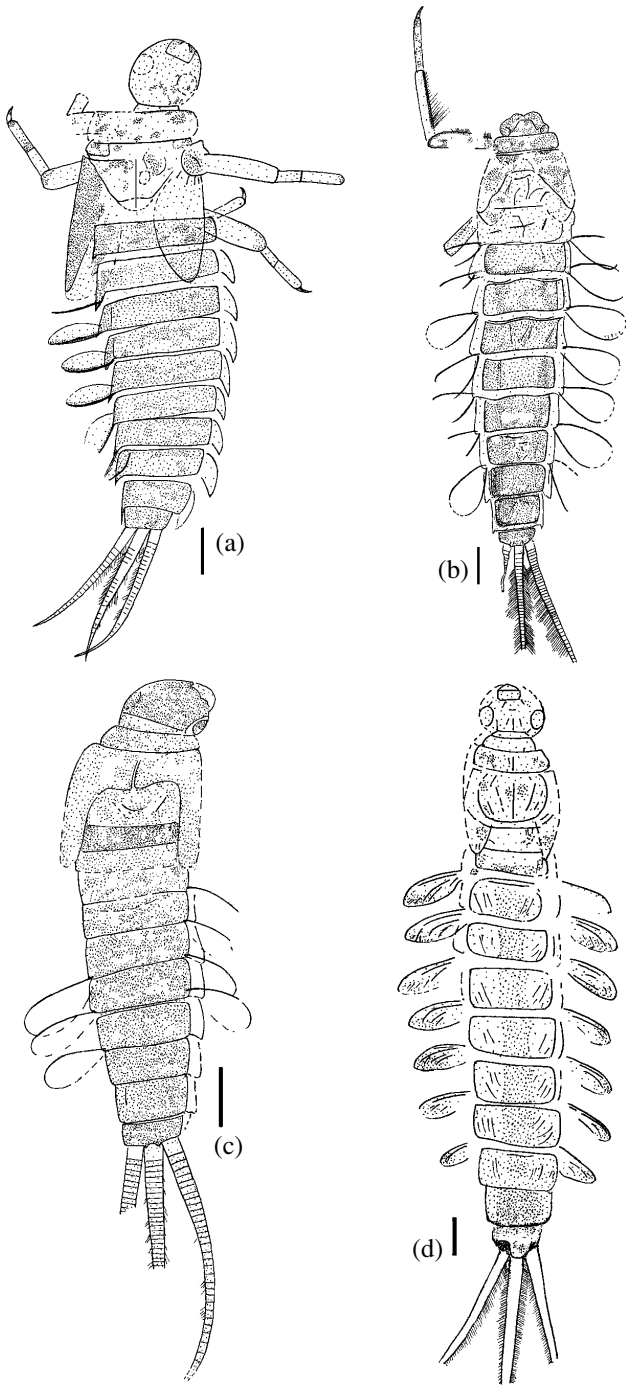


Fig. 1. Mayfly nymphs of the families (a, b) Mesonetidae, (c) Siphlonuridae, and (d) Siphluriscidae: (a) *Furvoneta relicta* sp. nov., holotype NIGPAS, no. DHG 0515-a, nymph; (b) *Clavineta eximia* sp. nov., holotype NIGPAS, no. DHG 0516, nymph; (c) *Mesobaetis latifilamentacea* sp. nov., holotype NIGPAS, no. DHG 0517, nymph; and (d) *Stackelbergisca cylindrata* sp. nov., holotype NIGPAS, no. DHG 0518, nymph. All scale bars, 1 mm.

Hebei Province, Luanping County, Zhouyingzi locality; Middle Jurassic, Jiulongshan Formation.

Description (Fig. 1b). Nymph. The head is small, obviously wider than long. The eyes are relatively small, oval. The head and thorax are short, and the abdomen (excluding caudalii) is about 3.5 times longer than the head and thorax (excluding wing buds) combined. The pronotum is nearly transversely rectangular, and has straight anterior and posterior margins, nearly four times wider than long. The wing buds are triangular, with the anterior pair of wing buds reaching the posterior margin of the pterothorax, and the posterior pair of wing buds reaching the middle of the first abdominal segment. The foreleg is thin and long, the tibia and tarsus are extended forward; the femur is club-shaped, its inner margin is covered with short hairs. The tibia is cylindrical, slightly shorter than the femur, its inner margin has long hairs. The tarsus is slightly shorter than and as wide as the tibia. The claw is small, simple, about one-fifth of the length of the tarsus. The abdomen is almost 3.6 times longer than wide, with the basal abdominal segments being the widest. Each tergum of the basal abdominal segment is less than three times wider than long, with the W-shaped anterior margin, the posterior margins are straight. Subsequent segments gradually become smaller, the posterior margin of the tenth tergum is more or less rounded. The posterolateral projections on abdominal segments 1–7 are prominent but not extended posterolaterally, while the posterolateral projections on abdominal segments 8 and 9 are long and sharp and clearly extended backward. The tergalii are well developed on abdominal segments 1–7; all tergalii are single, foliaceous (with weak and rounded ends), and comparatively large (at least two-thirds, or more, as long as the width of the abdominal terga); the sixth and seventh pairs of tergalii are nearly as large as the others. The cadalii are comparatively thin; the paracercus and the inner margins of the cerci are covered with long and dense hairs.

Measurements, mm. Length of nymph (including caudalii), 15.3 (with the head length, 0.7; pronotum length, 0.4; pterothorax length, 1.5; abdomen length, 9.2; paracercus length, as preserved, 2.9; cercus length, as preserved, 3.5); the width (at basal abdominal segments), 2.7; foreleg length, 5.9 (femur length, ca. 2.2, tibia length, 1.9, tarsus length, 1.5, claw length, 0.3).

Comparison. The new species is most similar to *C. cantabilis* Sinitshenkova, 1991 from the Upper Jurassic–Lower Cretaceous of the Shar-Teeg locality, Adzh-Bogdo Mountain Ridge, south of Shar-Teeg Mountain, Gobi-Altai Aimak, Mongolia (Sinitshenkova, 1991), but differs in the basal abdominal segments being narrower and longer, and in the larger body. It differs from *C. transbaikalica* Sinitshenkova, 2000, another species from the Upper Jurassic of Chernovskie Kopi (Chita Region, Chita District, Chita–Ingoda Depression, left bank of the Ingoda River, 18–20 km southwest of Chita, Tranbaikalia, Russia), in the shorter and thicker tibia of the foreleg which is nearly as long as the femur, and in the smaller and transverse head.

Remarks. Hong (1983) described three nymph specimens from the Jiulongshan Formation at the village of Zhouyingzi and assigned them to *Mesoneta antiqua*, a species known from the Lower Jurassic Cheremkhovo Formation in Ust'-Bailey, Siberia, Russia (Tshernova, 1962; Kluge and Sinitshenkova, 2002). In 1980, I collected a single nymph impression from the same locality and the same horizon in the vicinity of the village of Zhouyingzi. This specimen shows the same characters as the nymphs provided by Hong (1983, pl. I, figs. 6–8) and can thus be assigned to the same species (*Clavineta eximia* sp. nov. described herein). These nymphs differ sharply from *Mesoneta antiqua* in the structure of foreleg, the body outline (more slender, and not widened at the middle of the abdomen), and in the shape of tergalii.

Material. Holotype.

Family Siphlonuridae Ulmer, 1920

Genus *Mesobaetis* Brauer, Redtenbacher et Ganglbauer, 1889

***Mesobaetis latifilamentacea* Zhang, sp. nov.**

Plate 15, fig. 5

Etymology. From the Latin *latus* (broad) and *filum* (a thread).

Holotype. NIGPAS, no. DHG 0517, impression of a single nymph, almost dorsoventral aspect; China, Hebei Province, Chengde City, Xiabancheng Township, Xiaofanzhangzi locality; Middle Jurassic, Jiulongshan Formation.

Description. (Fig. 1c). Nymph. The head is relatively large, nearly semicircular, markedly wider than long. The eyes are moderately large, suboval. The head and thorax are relatively long, and the abdomen (excluding caudalii) is about 1.8 times longer than the head and thorax (excluding wing buds) combined. The pronotum is 4.4 times wider than long, has a slightly concave anterior margin and a slightly convex posterior margin. The anterior pair of wing buds is large but thin, bladelike, and reach the posterior margin of the second abdominal segment. The posterior pair of buds are completely covered by anterior buds. The abdomen is relatively short and thick, almost 2.8 times longer than wide, with the basal abdominal segments being the widest. Each tergum of the basal abdominal segment is almost 4.5 times wider than long, the other terga gradually narrow terminally. The first tergum is darkish brown in color, the tenth tergum is relatively large, nearly as wide as the posterior margin of the ninth; the posterolateral projections on the abdominal segments are prominent but not extended backward. The tergalii are single, overlapping, comparatively large and elongated foliaceous (with rounded tops) The caudalii are quite thick, the paracercus and inner margins of the cerci are covered with hairs.

Measurements, mm. Length of nymph (including caudalii), 18.9 (head length, 1.9; pronotum length, 0.6; pterothorax length, 1.9; abdomen length, 7.9; paracercus length, as preserved, 2.0; cercus length, as preserved, 6.6), width (at basal abdominal segments) 2.8.

Comparison. Ponomarenko and Schultz (1988) designated a lectotype of *Mesobaetis sibirica,* which is housed in the Naturhistorischen Museum in Vienna. Judging from the photograph (Ponomarenko and Schultz, 1988, fig. 2), this specimen is a young nymph about 9 mm long (instead of 14.4 mm in the original description), with an especially large head (as wide as the thorax) and very short caudalii (about one-quarter of the body length). These characters differ strongly from those of specimens that have previously been assigned to *M. sibirica.* The new species is distinct from the lectotype of *M. sibirica* in having stouter and longer caudalii.

On the other hand, in the presence of the elongated foliaceous tergalii and narrow anterior pair of wing buds by which the posterior pair of wing buds is completely covered, *Mesobaetis latifilamentacea* sp. nov. is similar to nymphs of *M. sibirica*, which was redescribed by Sinitshenkova (1985) from the Lower Jurassic Cheremkhovo, Zhalgalant, and Ichetuy formations in Siberia and to *M. allata* Sinitshenkova, 1985 from the Cheremkhovo Formation in the Ust'-Bailey locality, Siberia, Russia. It may be easily distinguished from them in having the first abdominal segment darkish brown, that is, obviously darker in color than the other abdominal segments, and very thick caudalii.

Remarks. Three species from the Jurassic of China have been assigned to *Mesobaetis: M. sibirica* sensu auct. (Hong et al., 1995; Ren et al., 2002; non Brauer, Redtenbacher et Ganglbauer, 1889); *M. maculata* Hong, Liang et Hu, 1995; and *M. sanjianfangensis* Hong, Liang et Hu, 1995 [originally *Mesobaetis sibirica* sensu Hong, 1983 (non Brauer, Redtenbacher et Ganglbauer, 1889)] based mainly on the absence of hairs on the caudalii. However, the diagnosis for *Mesobaetis* used by the Chinese researchers is questionable. The placements of the three Chinese species are incorrect. Sinitshenkova (1985) developed the diagnosis of the genus in detail, based on new material (735 nymphs) and showed with confidence the presence of long and dense hairs on the caudalii (Sinitshenkova, 1985, p. 13, fig. 1e). In those specimens without hairs on the caudalii, they are most likely secondarily missing, e.g., due to poor preservation. Nevertheless, until those Chinese specimens are reinvestigated, their generic placement is uncertain, although they do not belong to *Mesobaetis.*

Material. Holotype.

Family Siphluriscidae Zhou et Peters, 2003

Genus *Stackelbergisca* Tshernova, 1967

***Stackelbergisca cylindrata* Zhang, sp. nov.**

Plate 15, fig. 6

Etymology. From the Latin *cylindricus* (cylindrical).

Holotype. NIGPAS, no. DHG 0518, impression of a well-preserved nymph, dorsoventral aspect; China, Inner Mongolia, Chifeng City, Ningcheng County, Daohugou locality; uppermost Middle–lowermost Upper Jurassic, Daohugou Formation.

Description. (Fig. 1d). Nymph. The body is slender, long, and cylindrical. The head is moderately large, subcircular, somewhat wider than long. The eyes are moderately large, oval. The head and thorax are relatively long, and the abdomen (excluding caudalii) is about 2.4 times longer than the head and thorax (excluding wing buds) combined. The pronotum has a slightly concave anterior margin and a slightly convex posterior margin, nearly 3.8 times wider than long. The wing buds are subtriangular, with the anterior pair of wing buds overreaching the posterior margin of the metathorax. The abdomen is almost 3.9 times longer than wide, with the first abdominal tergum being the shortest, three times wider than long. The other terga are almost twice as wide as long, with their anterior and posterior margins straight, except for the tenth tergum in which the posterior margin becomes strongly convex medially. The posterolateral projections on abdominal segments 1–7 are not prominent. The tergalii are well developed on abdominal segments 1–7; all tergalii are single, foliaceous (with pointed ends). The costae is seen in all tergalii, the "tracheae" are pigmented and form a partially netlike structure. The caudalii are comparatively thin, pale in color; the paracercus and the inner margins of the cerci are covered with long and dense hairs.

Measurements, mm. Length of nymph (including caudalii), 17.9 (head length, 1.0; pronotum length, 0.6; pterothorax length, 2.1; abdomen length, 10.8; paracercus length, as preserved, 3.4; cercus length, as preserved, 3.5); the width (at the basal abdominal segments), 2.6.

Comparison. The new nymph closely resembles in body structure that of *S. shaburensis* Sinitshenkova, 1991 from the Ichetuy Formation of Transbaikalia, Russia, but can be differentiated by its specialized tergalii on which the "tracheae" are pigmented, and form a netlike structure, the pale caudalii covered with pale, long and dense hairs, and by the larger-sized body.

Remarks. Zhou and Peters (2003) established a new extant family Siphluriscidae (with the type genus *Siphluriscus* Ulmer, 1920) and provisionally transferred *Stackelbergisca* into this new family. Kluge (2004) believes that *Stackelbergisca* can be subdivided into at least two different taxa and assigned to Anteritorna. The characters of the claw of this new nymph are unknown since its legs are missing. Therefore, further detailed comparison between *S. cylindrata* sp. nov., *S. sibirica* Tshernova, 1967, and *S. shaburensis* is difficult. Until new material can be gained, the new species should be provisionally placed in the *Stackelbergisca.* Meanwhile, the familial placement for *Stackelbergisca* needs to be further studied.

Material. Holotype.

ACKNOWLEDGMENTS

I am grateful to Prof. Nina D. Sinitshenkova (Palaentological Institute, Russian Academy of Sciences) for critical reading the manuscript.

This work was supported by the Pilot Project of Knowledge Innovation Program of the Chinese Academy of Sciences (no. KZCX2-SW-129), the National Science Foundation of China (no. 40372008), and the Major Basic Research Projects of Ministry of Science and Technology, China (no. G2000077700).

REFERENCES

1. F. Brauer, J. Redtenbacher, and L. Ganglbauer, "Fossile Insecten aus der Jura-Formation Ost-Sibiriens," Mem. Acad. Imper. Sci. St. Petersbourg, Ser **36** (15), 1–22 (1889).
2. P. Chen, Q. Wang, H. Zhang, et al., "Jianshangou Bed of the Yixian Formation in West Liaoning, China," Sci. China, Ser. D Earth Sci. **34** (10), 883–895 (2004).
3. K. Gao and N. H. Shubin, "Earliest Known Crown-Group Salamanders," Nature, No. 422, 424–428 (2003).
4. Y. M. Gubin and S. M. Sinitza, "Shar Teg: A Unique Mesozoic Locality of Asia," Bull. Mus. North Arizona **60**, 311–318 (1996).
5. Y. Hong, *Middle Jurassic Fossil Insects in North China* (Geol. Publ. House, Beijing, 1983).
6. Y. Hong, S. Liang, and T. Hu, "Study on Geology and Paleontological Assemblage from Tuha Basin of Xinjiang, China," Geosciences **9**, 426–440 (1995).
7. Q. Ji and C. Yuan, "Discovery of Two Kinds of Protofeathered Pterosaurs in the Mesozoic Daohugou Biota in the Ningcheng Region and Its Stratigraphic and Biologic Significances," Geol. Rev. **48** (2), 221–224 (2002).
8. N. J. Kluge, *The Phylogenetic System of Ephemeroptera* (Kluwer Acad. Publ., Dordrecht, 2004).
9. N. J. Kluge and N. D. Sinitshenkova, "Order Ephemerida Latreille, 1810: The True Mayflies (= Ephemeroptera Hyatt Et Arms 1892 (S. L.); = Euephemeroptera Kluge, 2000," in *History of Insects* (Kluwer Acad. Publ., Dordrecht, 2002), pp. 89–97.
10. Q. Lin, "Early Mesozoic Fossil Insects from South China," Palaeontol. Sin., New Ser. B, No. 170, 1–121 (1986).
11. Q. Lin and D. Huang, "Description of *Caenoephemera shangyuanensis*, gen. nov., sp. nov. (Ephemeroptera), from the Yixian Formation," Canad. Entomol. **133**, 747–754 (2001).
12. A. G. Ponomarenko and O. Schultz, "Typen der Geologisch-Paläontologischen Abteilung: Fossile Insecten," Kataloge wiss. Sammlung Naturhist. Mus. Wien **6** (1), 1–40 (1988).
13. A. P. Rasnitsyn and H. Zhang, "A New Family, Daohugoidae fam. n., of Siricomorph Hymenopteran (Hymenoptera = Vespida) from the Middle Jurassic of Daohugou in Inner Mongolia (China)," Proc. Russ. Entomol. Soc. **75** (1), 12–16 (2004a).
14. A. P. Rasnitsyn and H. Zhang, "Composition and Age of the Daohugou Hymenopteran (Insecta, Hymenoptera =

Vespida) Assemblage from Inner Mongolia, China," Palaeontology **47** (6), 1507–1517 (2004b).

15. D. Ren, K. Gao, Z. Guo, et al., "Stratigraphic Division of the Jurassic in the Daohugou Area, Ningcheng, Inner Mongolia," Geol. Bull. China **21**, 584–591 (2002).
16. D. Ren, L. Lu, S. Ji, et al., "Late Mesozoic Fauna Assemblages of Yanliao Area, North China, and Its Paleoecological and Paleogeographical Significance," Acta Geosci. Sin. **17** (Suppl.), 148–154 (1996).
17. Y. Shen, P. Chen, and D. Huang, "Age of the Fossil Conchostracans from Daohugou of Ningcheng, Inner Mongolia," J. Stratigr. **27** (4), 311–313 (2003).
18. N. D. Sinitshenkova, "The Mesozoic Mayflies (Ephemeroptera) with Special Reference to Their Ecology," in *Proceedings of the 4th International Conference on Ephemeroptera* (Czechoslovak Acad. Sci., Prague, 1984), pp. 61–66.
19. N. D. Sinitshenkova, "Jurassic Mayflies (Ephemerida = Ephemeroptera) of Southern Siberia and Western Mongolia," Tr. Paleontol. Inst. Akad. Nauk SSSR **211** (Jurassic Insects of Siberia and Mongolia), 11–23 (1985) [in Russian].
20. N. D. Sinitshenkova, "New Mesozoic Mayflies from Transbaikalia and Mongolia," Paleontol. Zh., No. 1, pp. 120–123 (1991).
21. N. D. Sinitshenkova, "The Mesozoic Aquatic Assemblages of Transbaikalia, Russia," in *Proceedings of the First Palaeoentomological Conference, Moscow, 1998* (AMBA Projects, Bratislava, 1999), pp. 149–154.
22. N. D. Sinitshenkova, "New Late Mesozoic Mayflies from the Shar-Teeg Locality, Mongolia (Insecta, Ephemerida = Ephemeroptera)," Paleontol. J. **36** (3), 270–276 (2002).
23. O. A. Tshernova, "Order Ephemeroptera, Mayflies," in *Fundamentals of Paleontology: Arthropoda, Tracheata, and Chelicerata* (Acad. Nauk SSSR, Moscow, 1962), pp. 55–64 [in Russian].
24. W. Wang, "Insecta," in *Paleontological Atlas of Northeast China: 2. Mesozoic and Cenozoic* (Mineral Geol. Publ. House, Peking, 1980), pp. 130–153.
25. W. Wang, "Early Mesozoic Insect Fossils of Western Liaoning," in *Mesozoic Stratigraphy and Palaeontology of Western Liaoning 3* (Geol. Publ. House, Beijing, 1987), pp. 202–219.
26. X. Wang, Y. Wang, F. Zhang, et al., "Vertebrate Biostratigraphy of the Lower Cretaceous Yixian Formation in Lingyuan, Western Liaoning and Its Neighboring Southern Nei Mongol (Inner Mongolia), China," Vertebr. Palasiat. **38**, 81–99 (2000).
27. X. Wang, Z. Zhou, and F. Zhang, "Discovery of the Feathered Pterosaur from Jehol Biota," Chi. Sci. Bull. **47** (1), 54–58 (2002).
28. Y. Wang, "A New Salamander (Amphibia: Caudata) from the Early Cretaceous Jehol Biota," Vertebr. Palasiat. **38**, 100–103 (2000).
29. Y. Wang, "A New Mesozoic Caudate (*Liaoxitriton daohugouensis* sp. nov.) from Inner Mongolia, China," Chi. Sci. Bull. **49** (8), 858–860 (2004).
30. J. Zhang, "First Description of Axymyiid Fossils (Insecta: Diptera: Axymyiidae)," Geobios **37** (5), 797–805 (2004).
31. J. Zhang and H. Zhang, "*Kalligramma jurarchegonium* sp. nov. (Neuroptera: Kalligrammatidae) from the Middle Jurassic of Northeastern China," Oriental Insects **37**, 301–308 (2003).
32. C. Zhou and J. G. Peters, "The Nymph of *Siphluriscus chinensis* and Additional Imaginal Description: A Living Mayfly with Jurassic Origins (Siphluriscidae New Family: Ephemeroptera)," Florida Entomol. **86**, 345–352 (2003).