

A SPLIT-FOOTED LACEWING AND TWO EPIOSMYLINES FROM THE JURASSIC OF CHINA (NEUROPTERA)

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Abstract.— The first Chinese fossil of the family Nymphidae (Neuroptera: Myrmeleontiformia) is briefly described and figured along with two episomyline Osmylidae, a generally plesiomorphic group which can be easily confused with nymphids when only wings are known. Four new species and three new genera are characterized from Jurassic deposits of the Jiulongshan Formation (Daohugou Biota), Inner Mongolia, China. New genera are *Liminympa* (Nymphidae), *Enodinympa* (Osmylidae), and *Nilionympa* (Osmylidae), while the new species are *Liminympa makarkini*, *Enodinympa translucida*, *Nilionympa pulchella*, and *N. imperfecta*.



Key words.— Neuroptera, Myrmeleontiformia, Nymphidae, new genus, new species, Jurassic, Mesozoic, Osmylidae, Epiosmylinae, China.

INTRODUCTION

The neuropteran families Nymphidae and Osmylidae are quite distinctive although generally plesiomorphic for their respective clades and as a result, although not closely related, do share primitive similarities in some wing details making their separation challenging when presented only with fossil fragments (Lambkin 1988). This is all the more difficult when examining Mesozoic fossils as those from the Jurassic represent the earliest representatives of both families and these early, particularly primitive forms coalesce in many traits rendering the separation of Nymphidae, Osmylidae, and other plesiomorphic families from the middle Mesozoic a fascinating challenge (e.g., Lambkin 1988).

Today split-footed lacewings (Nymphidae) comprise 35 species distributed in New Guinea and Australia.

Where known, nymphid larvae prey on termites or caterpillars, those of *Nymphes* occurring in leaf litter or under logs, while those of *Osmylops* and *Myiodactylus* are arboreal. Adults are frequently large, with wingspans reaching 80 mm. Unfortunately, despite the size and showiness of these animals, almost nothing further is known of their biology. In the past the split-footed lacewings enjoyed a much greater diversity and far more extensive distribution. Fossils confidently assigned to Nymphidae are known in middle Eocene Baltic amber (Krüger 1923, MacLeod 1970), the Early Cretaceous of Transbaikalia (Ponomarenko 1992), and the Late Jurassic of Bavaria (Carpenter 1929, 1992) and Kazakhstan (Panfilov 1980, Lambkin 1988).

The Osmylidae are relatively primitive lacewings with their greatest diversity in the Old World, although

two subfamilies do occur in South America. The family is relatively heterogeneous and, like the nymphids, is relatively poorly studied in terms of biology. Where known, species tend to live in damp, terrestrial habitats although it is speculated that their larvae may be aquatic. Fossils of Osmylidae are not uncommon and extend back well into the Early Cretaceous and Jurassic (e.g., Panfilov 1980, Lambkin 1988, Makarkin 1990, Ren and Yin 2003).

Herein we report the discovery of the first fossil of Nymphidae from China as well as two new epiosmyline Osmylidae. The fossils are all from the Jurassic of Inner Mongolia, China and represent four species which we classify into three genera. The fossils were recovered from the Jiulongshan Formation, a section composed of gray tuffaceous sandstone and sandy mudstone exposed near the village of Daohugou, Inner Mongolia, China. The Jiulongshan strata, a lacustrine sedimentary sequence with outcrops in northeastern China, have yielded a diversity of lacewings (e.g., Ren 2002, Ren and Oswald 2002, Ren *et al.* 2002, Ren and Yin 2003), wasps (e.g., Rasnitsyn and Zhang 2004), flies (e.g., Ren and Krzeminski 2002), freshwater conchostracans (e.g., Zhang *et al.* 1987), and vertebrates (e.g., Gao and Shubin 2003, Wang 2004), among others. These fossils, and other data, have been used to estimate a Late Aalenian or Early Bajocian (i.e., Early mid-Jurassic) age for the Jiulongshan Formation (e.g., Shen *et al.* 2003). However, the age of the deposits are of some controversy, with many vertebrate paleontologists favoring a Late Jurassic origin (e.g., Wang *et al.* 2000, Ji and Yuan 2002), which has some support from radiometric dating (e.g., He *et al.* 2004: but see also Liu and Liu 2005, He *et al.* 2005). Until this controversy has been resolved we are considering the age to be approximately middle Jurassic. Material discussed herein is deposited in the Department of Biology, Capital Normal University, Beijing.

SYSTEMATICS

Family Nymphidae Rambur, 1842

Liminympa gen. nov.

Type species. *Liminympa makarkini* sp. nov.

Diagnosis. Forewing long, narrow, with narrowly rounded apex; trichosors present in apical half of wing; costal space with numerous c-sc crossveins becoming more dense toward wing apex, a few of such veins bifurcating before wing margin in apical half of wing; subcostal cell without crossveins; Sc and R₁ fused apically and thence curving slightly posteriorly to terminate on wing margin beyond apex; 16

r₁-rs crossveins; Rs originating near wing base, with MA separating from radial system at about one-fourth of wing length, first branch of Rs just beyond one-third wing length; Rs field (i.e., space between anteriormost and posteriormost branches of Rs system) with few crossveins, apparently with 17 pectinate branches, those beyond four branch densely packed, first fusing with MA, a few fusing with each other; 2 basal rs-m crossveins; 9 rs-ma crossveins; MP originating near wing base, forking in basal quarter of wing; CuA simple for most of its length, pectinately branched in apical third of wing; CuP with single row of cells posterior to vein; 1A distinct but not elongate, terminating on posterior wing margin in basal quarter of wing length (almost immediately beyond point of forking in MP); 2A and 3A short, not forming closed anal loop. Hind wing with stem of MA absent; anal field occupying an exceedingly small area at wing base.

Etymology. The new genus-group name is a combination of the Latin *limus* (meaning, "mud") and *nympha* (Latin, meaning "young woman"; Greek form, *nymphe*). The name is feminine.

Comments. The venation of *Liminympa* superficially resembles that of the Osmylidae but has Sc+R₁ terminating beyond the wing apex, one of the more distinctive features of Nymphidae. While nymphids also tend to have the forewing with 3A short and in the hind wing the absence of the stem of MA (*vide* Lambkin 1988), these features do occur among some primitive osmylids (e.g., Stenosmylinae, Epiosmylinae). An exceedingly short 3A occurs in both Nymphidae and Osmylidae.

Liminympa makarkini sp. nov. (Figs 1–3)

Diagnosis. As for the genus (*vide supra*).

Description. In accordance with ICZN (1999) Article 13.4 the above diagnosis confers availability on both the generic and specific names. To the generic-specific diagnosis we provide the following metrics and details pertinent to the holotype: forewing length (as preserved) 30 mm, width 9 mm (Fig. 2); hind wing length (preserved portion) 25 mm, width 7 mm (Fig. 2); antennal length at least 29 mm, antenna filiform, preserved portion about as long as forewing (full antenna must have been distinctly longer than forewing). Head, pro- and mesothorax largely not preserved (Figs 1 and 3); first two abdominal segments about as long as wide and of relatively equal proportions; remaining abdominal segments longer than wide and of relatively equal proportions except distalmost segment apparently more like first abdominal segment; abdominal length shorter than that of wings.



Figure 1. *Liminympha makarkini* gen. and sp. nov. Photograph of holotype. No. NN99024-1.

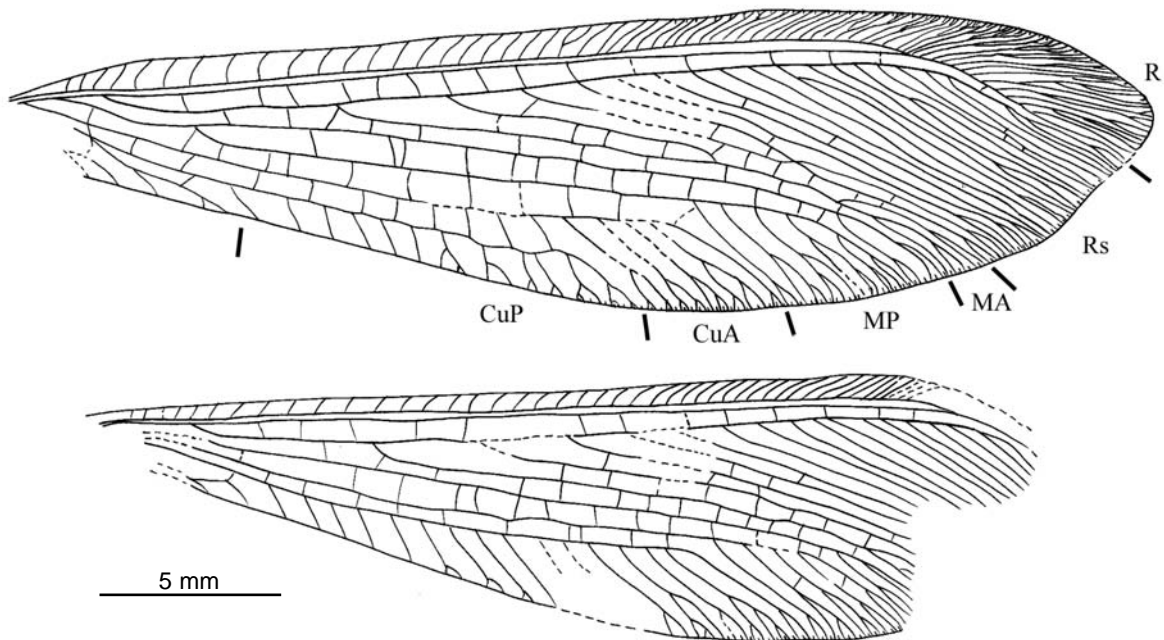


Figure 2. *Liminympha makarkini* gen. and sp. nov. Venation of right fore- and hind wing. No. NN99024-1.

Holotype. No. NN99024-1 (part), NN99024-2 (counterpart). The holotype consists of a well-preserved and complete impression of the body with all four wings in place, although only those wings of the right side are complete. Deposited in the Department of Biology, Capital Normal University, Beijing.

Occurrence. Daohugou Village, Shantou Township, Ningcheng County, Inner Mongolia, China. Jiulongshan Formation, Jurassic (Aalenian-Bajocian?).

Etymology. The specific epithet is a patronymic honoring Dr. Vladimir N. Makarkin, authority on living and fossil Neuroptera.

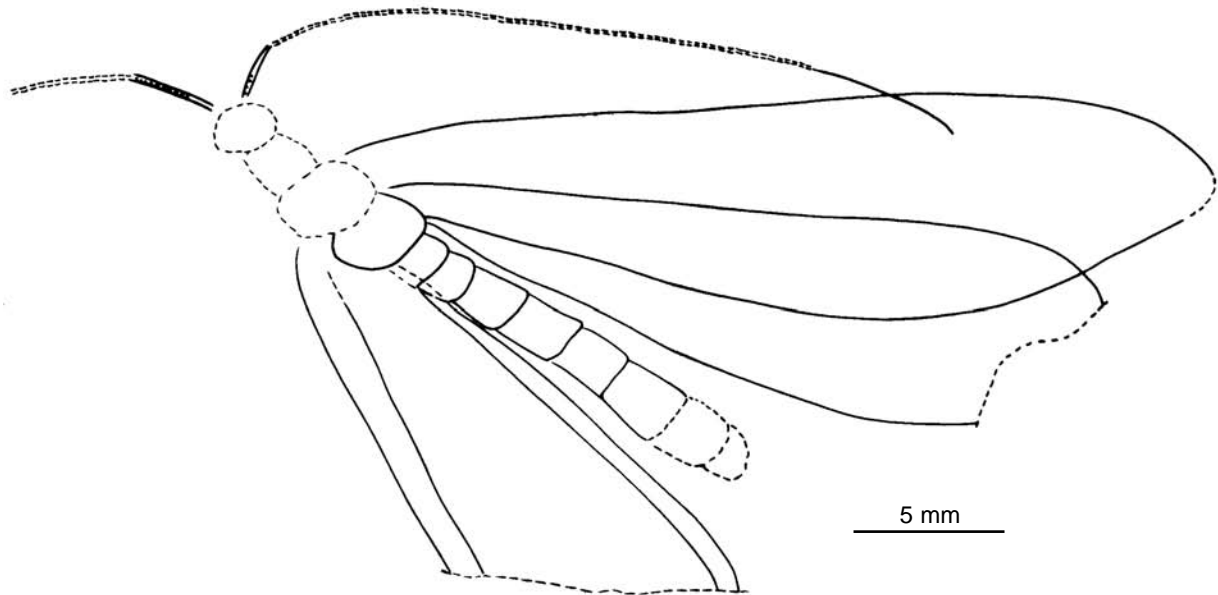


Figure 3. *Liminympha makarkini* gen. and sp. nov. Body with wings omitted. No. NN99024-1.

Family Osmylidae Leach, 1815
Subfamily Epiosmylinae Panfilov, 1980

Two of the genera described herein have some of the same peculiar features of *Epiosmylus* Panfilov, 1980. The species described herein have the very long antennae distinctive of *Epiosmylus* and generally rare among Neuroptera.

Enodinympha gen. nov.

Type species. *Enodinympha translucida* sp. nov.

Diagnosis. Forewing long, narrow, with acute apex; membrane without markings or microtrichiae; a few trichosors present and evident near wing apex; costal space with numerous c-sc crossveins becoming more dense at wing apex, all crossveins simple; subcostal cell without crossveins; Sc and R_1 fused apically and thence arching posteriorly (perhaps terminating on wing margin at apex as indicated by course; however, venation here is incomplete and exact point of termination unknown); at least 20 r_1 -rs crossveins; Rs originating near wing base, with MA separating from radial system at about one-third of wing length, first branch of Rs just before wing midlength; Rs field with numerous crossveins, apparently with 11 pectinate branches; 5 basal rs-m crossveins; 19 rs-ma crossveins; MP originating near wing base, forking in basal quarter of wing; CuA simple for most of its length, pectinately branched beyond wing midlength; CuP with single row of cells posterior to vein; 1A distinct and relatively elongate, with several pectinate branches, terminating

on posterior wing margin in basal third of wing length (well beyond point of forking in MP); 2A and 3A very short, not forming closed anal loop; without markings. Hind wing venation unknown.

Etymology. The new genus-group name is a combination of the Latin *enodis* (meaning, "plain") and *nympha* (Latin, meaning "young woman"; Greek, *nymphē*). The name is feminine.

Enodinympha translucida sp. nov.
(Figs 4–6)

Diagnosis. As for the genus (*vide supra*).

Description. In accordance with ICZN (1999) Article 13.4 the above diagnosis confers availability on both the generic and specific names. To the generic-specific diagnosis we provide the following metrics and details pertinent to the holotype: forewing length (as preserved) 25.5 mm, width 7 mm (Fig. 5); antennal length at least 30 mm, antenna filiform, distinctly longer than forewing, scape prominent large and robust, pedicel of proportions like flagellomeres. Head and abdomen largely not preserved (Figs 4 and 6).

Holotype. No. NN99020. The holotype consists of a poorly preserved and incomplete body impression and three of the four wings. Unfortunately, among the wings preserved the venation is only discernable in the right forewing. Deposited in the Department of Biology, Capital Normal University, Beijing.

Occurrence. Daohugou Village, Shantou Township, Ningcheng County, Inner Mongolia, China. Jiulongshan Formation, Jurassic (Aalenian-Bajocian?).

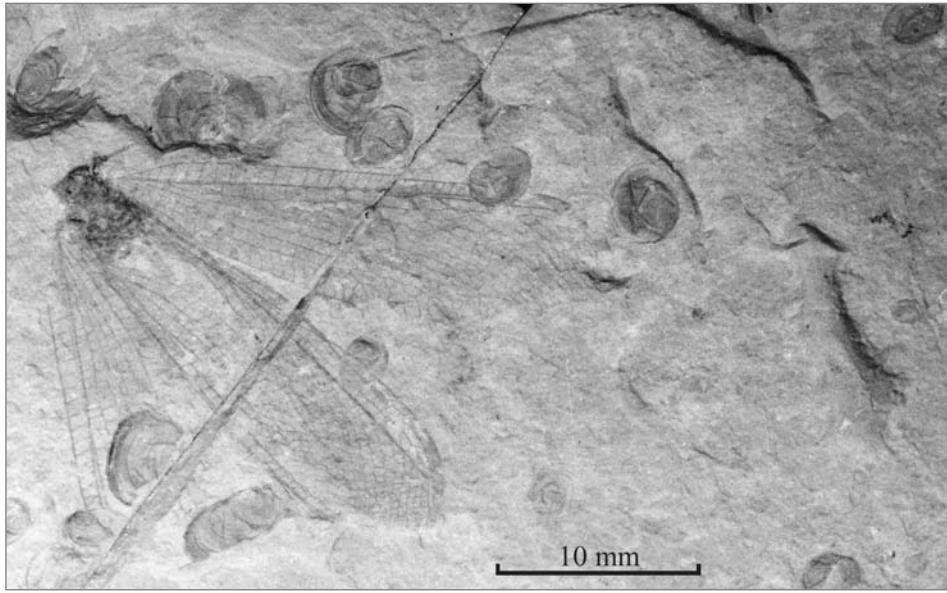


Figure 4. *Enodinympha translucida* gen. and sp. nov. Photograph of holotype. No. NN99020.

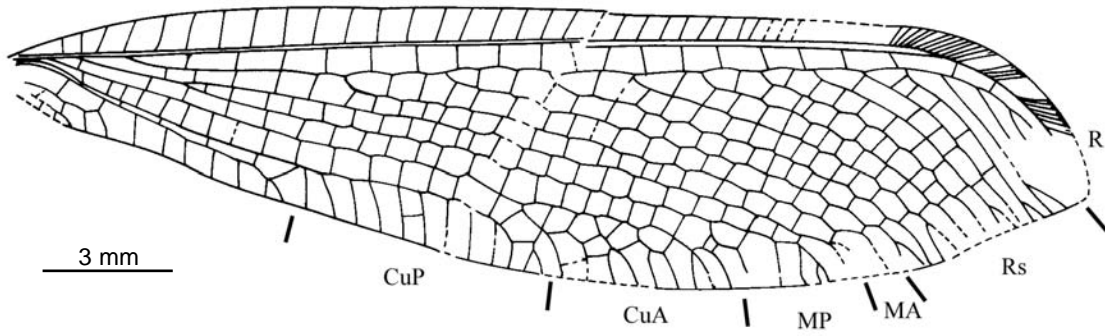


Figure 5. *Enodinympha translucida* gen. and sp. nov. Venation of forewing. No. NN99020).

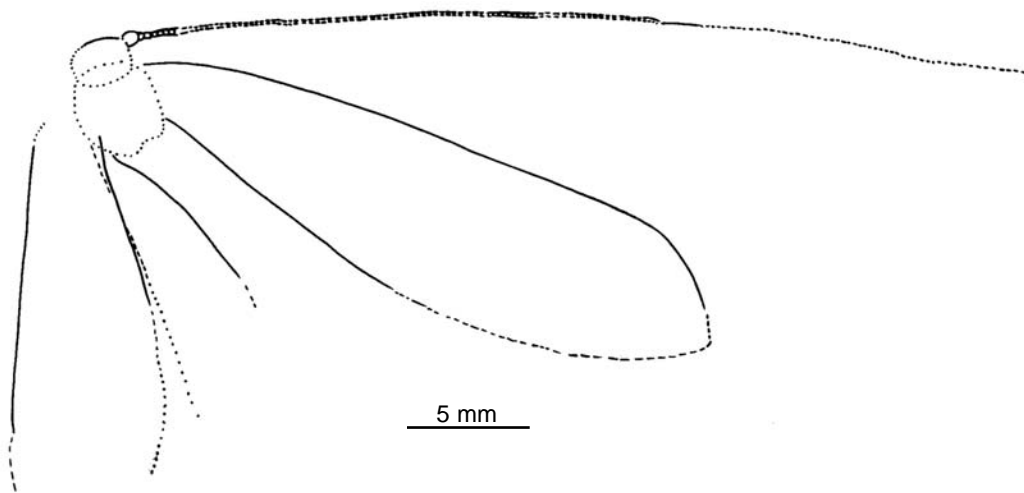


Figure 6. *Enodinympha translucida* gen. and sp. nov. Body with wings omitted. No. NN99020.

Etymology. The specific epithet is a reference to the translucence of the wings.

Nilionympha gen. nov.

Type species. *Nilionympha pulchella* sp. nov.

Diagnosis. Hind wing long, narrow, with somewhat pointed apex; trichosors present; costal space with numerous, simple c-sc crossveins becoming more dense toward wing apex; subcostal cell apparently without crossveins (or basal crossvein not preserved); Sc and R₁ fused apically and thence curving posteriorly to terminate before wing apex; 15 r₁-rs crossveins; Rs originating at wing base, stem of MA absent; MP simple; CuP with single row of cells posterior to vein; 1A distinct and relatively long, simple; anal field relatively small area in basal fifth of wing; wing without markings.

Etymology. The new genus-group name is a combination of *nilius* (Latin, meaning, "precious stone") and *nympha* (Latin, meaning "young woman"; Greek form, *nymphe*). The name is feminine.

Nilionympha pulchella sp. nov.

(Figs 7–9)

Diagnosis. *Nilionympha pulchella* can be discerned from *N. imperfecta* by the relatively narrow space between CuP and 1A and by Cu forking more proximally.

Description. As for the genus, with the following additions pertinent to the holotype: Hind wing length (as preserved) 23 mm, maximal width 7.5 mm (Figs 7–8). Antenna at least 35 mm in length, longer than forewing (Fig. 9), number of antennal articles not discernable; scape prominent, large and robust; pedicel small; flagellum filiform; hind wing with Cu apparently forking very near wing base; 1A running very close to CuP, veins nearly touching without crossveins between them.

Holotype. No. NN99026-1 (part), NN99026-2 (counterpart). The holotype consists of a complete body with all four wings evident (Fig. 7), although only the venation of the right hind wing is discernable (Fig. 8). Deposited in the Department of Biology, Capital Normal University, Beijing.

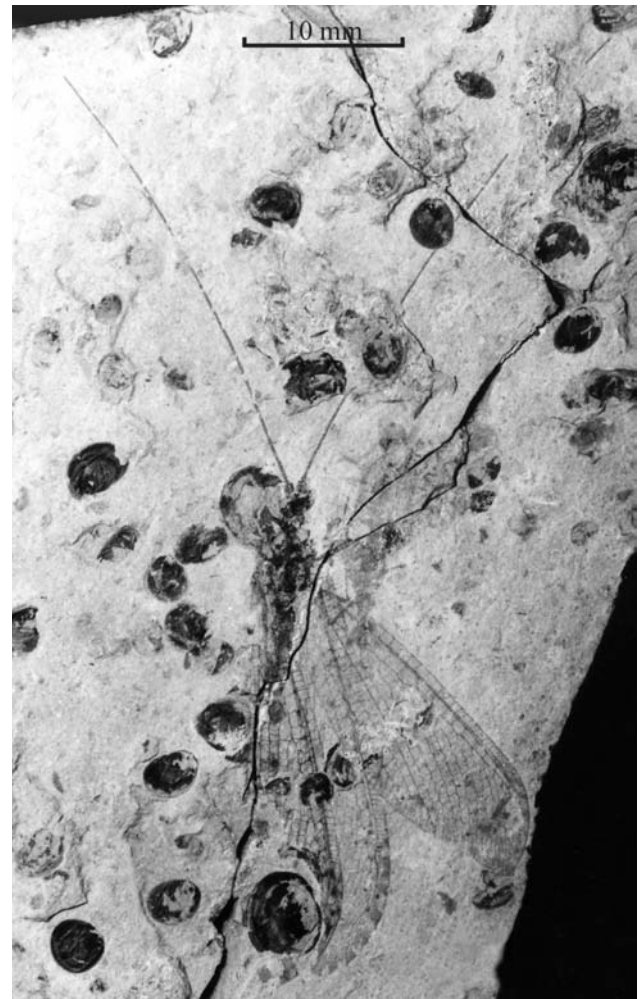


Figure 7. *Nilionympha pulchella* gen. and sp. nov. Photograph of holotype. No. NN99026-1.

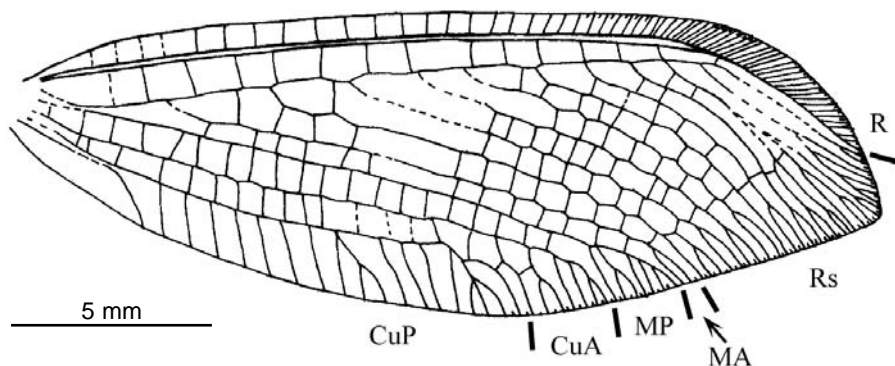


Figure 8. *Nilionympha pulchella* gen. and sp. nov. Venation of right hind wing. No. NN99026-1.

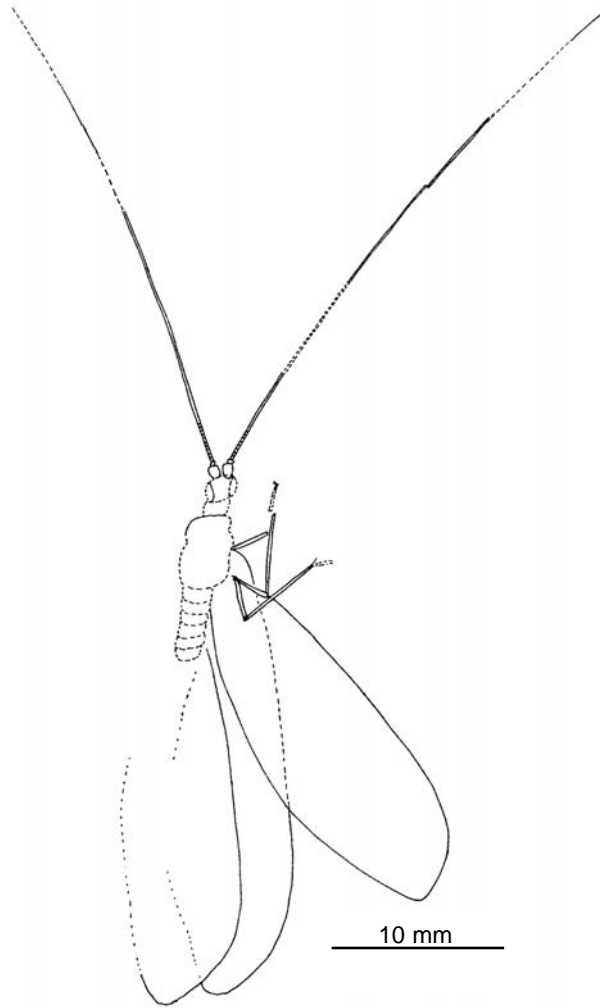


Figure 9. *Nilionympha pulchella* gen. and sp. nov. Body with wings omitted. No. NN99026-1.

Occurrence. Daohugou Village, Shantou Township, Ningcheng County, Inner Mongolia, China. Jiulongshan Formation, Jurassic (Aalenian-Bajocian?).

Etymology. The specific epithet is taken from a diminutive form of *pulchra* (Latin, meaning “beautiful”) and is a reference to the aesthetically pleasing wings.

***Nilionympha imperfecta* sp. nov.**
(Figs 10–11)

Diagnosis. *Nilionympha imperfecta* can be distinguished from its congener, *N. pulchella*, by the relatively wide space between CuP and 1A and by Cu forking more distally (Figs 10–11).

Description. As for the genus, with the following additions pertinent to the holotype: Preserved section

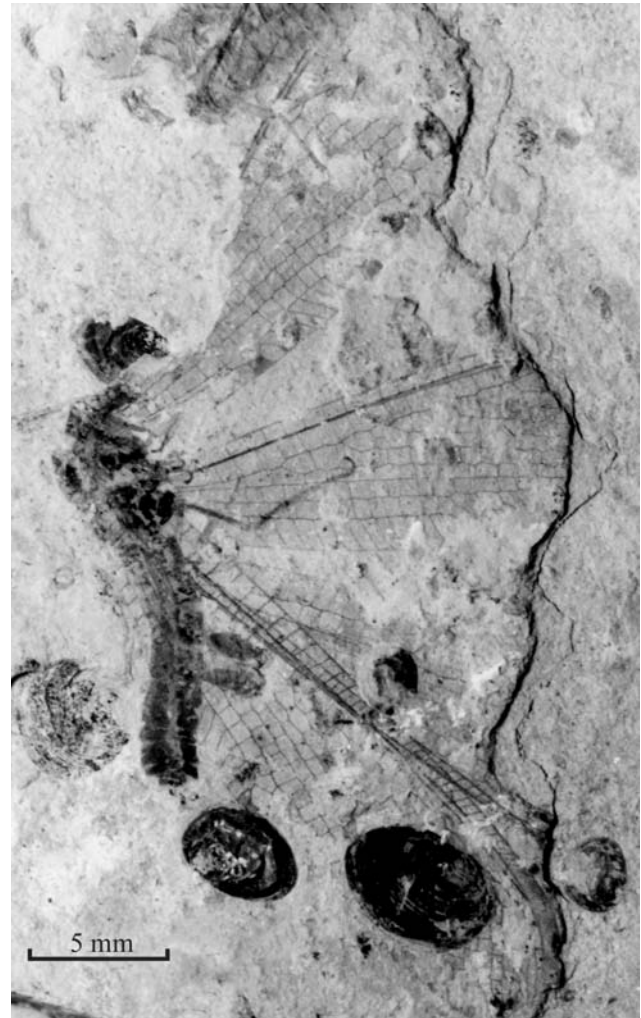


Figure 10. *Nilionympha imperfecta* gen. and sp. nov. Photograph of holotype. No. NN99028.

of hind wing 19 mm in length, maximal width 7 mm; hind wing with Cu forking beyond origin of MP, about at origin of Rs; 1A and CuP well separated, veins with distinct space and at least three crossveins between them.

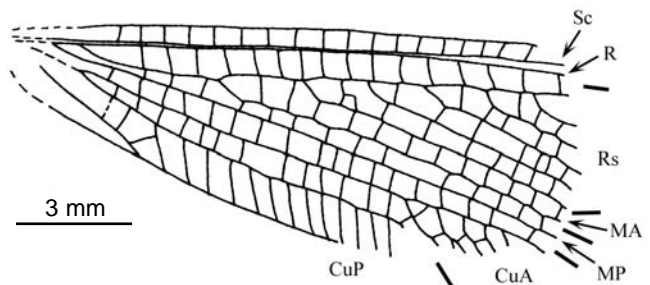


Figure 11. *Nilionympha imperfecta* gen. and sp. nov. Venation of right hind wing. No. NN99028.

Holotype. No. NN99028. The holotype consists of a body with four incompletely preserved wings (Fig. 10). Only the base of the right hind wing can be discerned while the other wings are obscured. Deposited in the Department of Biology, Capital Normal University, Beijing.

Occurrence. Daohugou Village, Shantou Township, Ningcheng County, Inner Mongolia, China. Jiulongshan Formation, Jurassic (Aalenian-Bajocian?).

Etymology. The specific epithet is a reference to the incomplete preservation of the wings.

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REFERENCES

- Carpenter, F. M. 1929. A Jurassic neuropteran from the lithographic limestone of Bavaria. *Psyche*, 36: 190–194.
- Carpenter, F. M. 1992. Superclass Hexapoda, pp. 1–655. [Vol. 3: xxi + 1–277 pp., Vol. 4: ii + 279–655 pp.]. *In*: R. L. Kaesler (ed.). *Treatise on Invertebrate Paleontology, Part R, Arthropoda 4* [vols. 3 & 4]. Geological Society of America & University of Kansas Press. Boulder & Lawrence, USA.
- Gao, K.-Q. and N. H. Shubin. 2003. Earliest known crown-group salamanders. *Nature*, 422(6930): 424–428.
- He, H.-Y., Wang, X.-L., Zhou, Z.-H., Zhu, R.-X., Wang, F., Ding, X. and A. Boven. 2004. $^{40}\text{Ar}/^{39}\text{Ar}$ dating of ignimbrite from Inner Mongolia, northeastern China, indicates a post-middle Jurassic age for the overlying Daohugou bed. *Geophysical Research Letters*, 31(20): 206–209.
- He, H.-Y., Wang, X.-L., Zhou, Z.-H., Zhu, R.-X., Wang, F., Ding, X. and A. Boven. 2005. Reply to comment by Liu and Liu on “ $^{40}\text{Ar}/^{39}\text{Ar}$ dating of ignimbrite from Inner Mongolia, northeastern China, indicates a post-middle Jurassic age for the overlying Daohugou bed.” *Geophysical Research Letters*, 32(12): 123–125.
- International Commission on Zoological Nomenclature. 1999. *International Code of Zoological Nomenclature* [Fourth Edition]. International Trust for Zoological Nomenclature. London, UK.
- Ji, Q. and C.-X. Yuan. 2002. Discovery of two kinds of pro tofeathered pterosaurs in the Mesozoic Daohugou Biota in the Ningcheng region and its stratigraphic and biologic significances. *Geological Review*, 48: 221–224. (In Chinese)
- Krüger, L. 1923. *Neuroptera succinica baltica*. Die im baltischen Bernstein eingeschlossenen Neuropteren des Westpreußischen Provinzial-Museums (heute Museum für Naturkunde und Vorgeschichte) in Danzig. *Stettiner Entomologische Zeitung*, 84: 68–92.
- Lambkin, K. J. 1988. A re-examination of *Lithosmylidia* Riek from the Triassic of Queensland with notes on Mesozoic ‘osmylid-like’ fossil Neuroptera (Insecta: Neuroptera). *Memoirs of the Queensland Museum*, 25(2): 445–458.
- Liu, Y. and Y. Liu. 2005. Comment on “ $^{40}\text{Ar}/^{39}\text{Ar}$ dating of ignimbrite from Inner Mongolia, northeastern China, indicates a post-middle Jurassic age for the overlying Daohugou bed” by H. Y., He *et al.* *Geophysical Research Letters*, 32(12): 123–124.
- MacLeod, E. G. 1970. The Neuroptera of the Baltic amber. I. Ascalaphidae, Nymphidae, and Psychopsidae. *Psyche*, 77: 147–180.
- Makarkin, V. N. 1990. A new fossil genus and species of Osmylidae from the Lower Cretaceous of East Siberia (Neuroptera). *Deutsche Entomologische Zeitschrift*, 37(1–3): 101–103.
- Panfilov, D. V. 1980. New representatives of lacewings (Neuroptera) from the Jurassic of Karatau, pp. 82–111. *In*: V. G. Dolin, Panfilov, D. V., Ponomarenko, A. G. and L. N. Pritykina (eds.). *Fossil Insects of the Mesozoic*. Naukova Dumka. Kiev, Ukraine. (In Russian).
- Ponomarenko, A. G. 1992. Neuroptera (Insecta) from the Lower Cretaceous of Transbaikalia. *Paleontologicheskii Zhurnal*, 1992(3): 43–50. (In Russian with English summary).
- Rasnitsyn, A. P., and H.-C. Zhang. 2004. Composition and age of the Daohugou hymenopteran (Insecta, Hymenoptera = Vespida) assemblage from Inner Mongolia, China. *Palaeontology*, 47(6): 1507–1517.
- Ren, D. 2002. A new lacewing family (Neuroptera) from the Middle Jurassic of Inner Mongolia, China. *Entomologica Sinica*, 9(4): 53–67.
- Ren, D. and J. D. Oswald. 2002. A new genus of kalligrammatid lacewings from the middle Jurassic of China (Neuroptera: Kalligrammatidae). *Stuttgarter Beiträge zur Naturkunde, Serie B, Geologie und Paläontologie*, 317: 1–8.
- Ren, D. and W. Krzemiński. 2002. Eoptychopteridae (Diptera) from the Middle Jurassic of China. *Annales Zoologici*, 52(2): 207–210.
- Ren, D. and J.-C. Yin. 2003. New ‘osmylid-like’ fossil Neuroptera from the middle Jurassic of Inner Mongolia, China. *Journal of the New York Entomological Society*, 111(1): 1–11.
- Ren, D., Engel, M. S. and W. Lü. 2002. New giant lacewings from the middle Jurassic of Inner Mongolia, China (Neuroptera: Polystoechotidae). *Journal of the Kansas Entomological Society*, 75(3): 188–193.
- Shen, Y.-B., Chen, P.-J. and D.-Y. Huang. 2003. Age of the fossil conchostracans from Daohugou of Ningcheng, Inner Mongolia. *Journal of Stratigraphy*, 27(4): 311–313. (In Chinese with English summary).
- Wang, Y. 2004. A new Mesozoic caudate (*Liaoxitriton daohugouensis* sp. nov.) from Inner Mongolia, China. *Chinese Science Bulletin*, 49(8): 858–860.

- Wang, X.-L., Zhou, Z., Zhang, F. and X. Xu. 2002. A nearly completely articulated rhamphorhynchoid pterosaur with exceptionally well-preserved wing membranes and "hairs" from Inner Mongolia, northeast China. *Chinese Science Bulletin*, 47: 226–230.
- Zhang, W.-T., Shen, Y.-B. and S.-W. Niu. 1987. Discovery of Jurassic conchostracans with well-preserved soft parts and notes on its biological significance. *Acta Palaeontologica Sinica*, 26(2): 111–129. (In Chinese with English summary).

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