

# Lacewings of the Family Osmylidae (Insecta: Neuroptera) from the Upper Jurassic of Asia

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Received April 4, 2013

**Abstract**—Three new genera and five new species of osmylid lacewings are described from the locality Karatau (Kazakhstan, Upper Jurassic): *Jurosmylus parvulus* sp. nov. (Protosmylinae), *Ensiosmylus acutus* gen. et sp. nov. (Spilosmylinae), *Kolbasinella elongata* gen. et sp. nov. (Gumillinae), *Arbusella bella* gen. et sp. nov. and *Jurakempynus arcanus* sp. nov. (Kempyninae). Another new osmylid species (*Jurakempynus sublimis* sp. nov.) is described from the Upper Jurassic of Mongolia (Shar-Teg locality). The quantitative compositions of the osmylid faunas of Karatau and Shar-Teg are discussed.

**Keywords:** Osmylidae, Neuroptera, Karabastau formation, Karatau, Shar-Teg, Upper Jurassic

**DOI:** 10.1134/S0031030114030095

## INTRODUCTION

The family Osmylidae (Neuroptera) is currently distributed worldwide, except in North America, where it is known only from fossils (Carpenter, 1943). At present this family includes about 200 species and eight subfamilies: Protosmylinae, Gumillinae, Spilosmylinae, Kempyninae, Porisminae, Osmylinae, Eidoporisminae, and Stenosmylinae. The earliest osmylids are known from the Lias of Europe and the Lower Jurassic locality Sogyuty in Kyrgyzstan (Bode, 1953; Martynova, 1958; Ansoerge, 1996); they all belong to the extinct subfamily Mesosmylininae (Makarkin et al., 2014). The earliest members of recent subfamilies of Osmylidae have been found in the Middle Jurassic localities Daohugou (China) (Ren and Yin, 2002; Ren and Engel, 2007; Wang et al., 2009a, 2009b, 2010, 2011; Yang et al., 2010) and Kubekovo (Krasnoyarsk Region). *Mesosmylina sibirica* Ponomarenko, 1985 (Mesosmylininae) was described from Kubekovo from fragmentary material; representatives of the subfamily Gumillinae and other osmylids, which remain undescribed, have also been collected in this locality. In Kubekovo, as in Daohugou, osmylids are dominant. In this study, osmylids are described from two Upper Jurassic localities, Shar-Teg and Karatau; they belong to extant subfamilies.

The locality Shar-Teg is situated in southwestern Mongolia; all insects collected in this locality originate from the Lower Shar-Teg Sequence. The age of the Shar-Teg Sequence has not been determined with certainty: Gubin and Sinitza (1996) estimate it as the lower Upper Jurassic; Kurzanov et al. (2003) date the overlying Ulan-Malgait Sequence to the Tithonian. A total of 35 neuropteran impressions have been col-

lected in Shar-Teg (mostly isolated wing fragments). Three neuropteran species have been described from this locality; they belong to the families Grammoling-iidae, Prohemerobiidae, and Osmylidae (Khramov, 2010, 2011). Osmylidae are represented in Shar-Teg by three specimens: *Sogjuta shartegica* Khramov, 2011 (Mesosmylininae); *Jurakempynus sublimis* sp. nov. (Kempyninae), described here; and a forewing fragment of unclear taxonomic placement.

The locality Karatau is represented by several outcrops of the Karabastau Formation situated near the Bol'shoi Karatau Range in South Kazakhstan. The exact age of this formation has not been determined; the majority of specialists (Doludenko et al., 1990; Vršanský, 2007) date it to the early Upper Jurassic (Oxfordian). A total of about 18 000 insect fossils are known from deposits of this formation; 550 of them represent the order Neuroptera. To date, a total of 46 neuropteran species have been described from Karatau, mostly by Panfilov (1968, 1980). Only two of them can be placed in the family Osmylidae: *Jurosmylus atalantus* (Panfilov, 1980) and *Epiosmylus longicornis* Panfilov, 1980.

Osmylids are represented by only 33 specimens (included holotypes) known from Karatau; 32 of them can be identified to subfamily. The abundance of osmylids in Karatau is considerably lower than in Daohugou, where this family is the most abundant group of Neuroptera: of 2000 neuropterans collected in Daohugou (Yang et al., 2012), over 1000 belong to Osmylidae (Makarkin et al., 2014); most of them represent the subfamily Kempyninae. In Karatau Kempyninae are also represented more abundantly than the other subfamilies of Osmylidae. The osmylids col-

lected in Karatau belong to the following subfamilies: Kempyninae, 15 specimens (*Jurakempynus arcanus* sp. nov., 2; *Arbusella bella* gen. et sp. nov., 1; *Arbusella* sp., 2; the generic placement of the remaining 10 specimens is unclear because they are preserved only as fragments); Protosmylinae, 9 (*Jurosmylus atalantus*, 5; and *J. parvulus* sp. nov., 4); Gumillinae, 7 (*Epiosmylus longicornis*, 5; *Kolbasinella elongata* gen. et sp. nov., 1; and 1 unidentified fragment); and Spilosmylinae, 1 (*Ensiosmylus acutus* gen. et sp. nov.).

The osmylid subfamilies known from Karatau and Shar-Teg are briefly characterized below.

The subfamily Protosmylinae currently comprises three genera living in East Asia (*Heterosmylus* Krüger, 1913 and *Paryphosmylus* Krüger, 1913) and South America (*Gryposmylus* Krüger, 1913). In addition to Karatau (*Jurosmylus*), Protosmylinae are known from fossils from Daohugou (*Juraheterosmylus* Wang et al., 2010), Lower Cretaceous of southern England (*Protosmylina* Jepson et al., 2009), Baltic amber (*Protosmylus* Krüger, 1913), and Eocene deposits of the American locality Florissant (*Osmylidia* Carpenter, 1943). Protosmylinae are similar in the few crossveins and shortened CuP in the forewings and hindwings to the fossil osmylids of the subfamily Mesosmylinae.

Spilosmylinae is the largest subfamily of Osmylidae, including more than half of all known members of this family. The largest genus of the subfamily, *Spilosmylus* Kolbe, 1897, is distributed in Asia, Africa, Australia (New, 1986a) and New Guinea (New, 1986b); the other five genera live in East Asia (Tjeder, 1957). In spite of the abundance of extant Spilosmylinae, this subfamily is almost absent from the fossil record. The only fossil member of this subfamily was recorded from Daohugou (*Palaeothyridosmylus septemaculatus* Wang et al., 2009), but the placement of this species in Spilosmylinae is doubtful because of the well developed pectinate A2 in the forewing and absence of gradate series of crossveins, atypical of this subfamily. Hence, *Ensiosmylus acutus* gen. et sp. nov. is the first true record of Spilosmylinae.

The only recent representative of the relict subfamily Gumillinae (*Gumilla* Navás, 1912) lives in Brazil. Fossil Gumillinae were first recorded by Panfilov (1980) in Karatau and described by him in a separate family, Epiosmylidae. Gumillinae are especially abundant in Daohugou. The following taxa of Gumillinae have been described from Daohugou: *Epiosmylus panfilovi* Ren et Yin, 2002, *Enodinympa* Ren et Engel, 2007, *Nilionympha* Ren et Engel, 2007, *Tenuosmylus* Wang et al., 2009, *Allotriosmylus* Yang et al., 2010. Fossil Gumillinae have also been recorded within their recent range, in Brazil: *Nuddsia longiantennata* Menon et Makarkin, 2008 and *N. repatriata* Martins-Neto, 2010 have been described from the Lower Cretaceous formations Crato and Santana, respectively. In addition, *Stenosmylina* Jepson et al., 2009 and *Mesosmylidus* Jepson et al., 2012 from the Lower Cretaceous deposits Wealden and Purbeck in southern

England, respectively, can also be placed in Gumillinae. The placement of *Mesosmylidus* in Gumillinae is questionable, because the specimen is fragmentary and its CuP is very strongly developed, which is atypical to representatives of this subfamily. Undescribed Gumillinae are also present among materials collected in Kubekovo (Middle Jurassic, Krasnoyarsk Region).

The subfamily Kempyninae, which includes four recent genera (*Australysmus* Kimmins, 1940, *Clydosmylus* New, 1983, *Euosmylus* Krüger, 1913, and *Kempynus* Navás, 1912), has a typical Gondwanan range and is distributed in Australia, New Zealand, and South America (Kimmins, 1940; New, 1983). It is also known from fossils from the Paleocene of Australia (*Euporismites* Tillyard, 1916; Lambkin, 1987) and from Daohugou (*Jurakempynus* Wang et al., 2011). In this study, new species of *Jurakempynus* are described from Shar-Teg and Karatau, suggesting the strong connection of these localities with Daohugou. The genus *Arbusella* gen. nov., described from materials from Karatau, is also represented in Daohugou. Members of *Arbusella* from Daohugou and Bakhar (Mongolia, Middle Jurassic), which remain undescribed, are larger than *Arbusella bella* sp. nov. from Karatau: their wing length is over 30 mm; in addition to the spotted pattern, the coloration of the wings of these neuropterans includes also longitudinal stripes.

Records of Kempyninae from Shar-Teg, Karatau, and Daohugou prove that during the Middle and Upper Jurassic the range of this subfamily considerably differed from its recent range. This is another fact supporting the idea that the Gondwanan range of a number of insect taxa evolved as a result of their extinction in the Northern Hemisphere (Eskov, 2002; Grimaldi, Engel, 2005). Therefore, Kempyninae, as well as Gumillinae, are relicts that had a much wider distribution in the past. This is not true of Protosmylinae and Spilosmylinae, because they were present in Eurasia in the Jurassic and remain present here to this day.

## SYSTEMATIC PALEONTOLOGY

### Family Osmylidae Leach, 1815

#### Subfamily Protosmylinae Krüger, 1913

#### Genus *Jurosmylus* Makarkin et Archibald, 2005

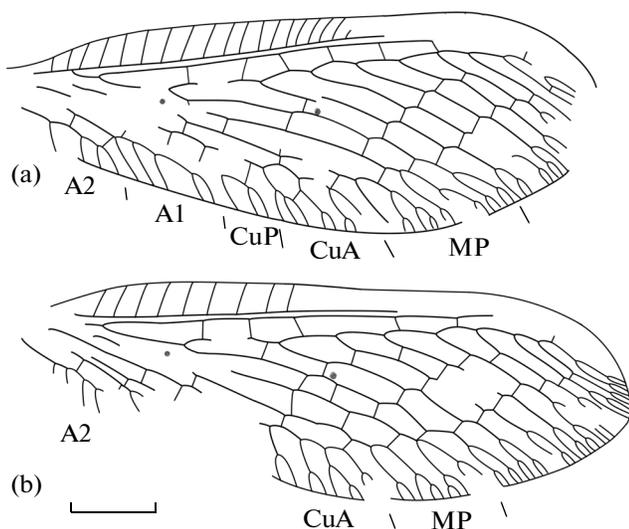
##### *Jurosmylus parvulus* Khramov, sp. nov.

Plate 13, fig. 1

**E t y m o l o g y.** From the Latin *parvulus* (tiny).

**H o l o t y p e.** PIN, no. 2554/765, impressions of forewings, head, and fragments of thorax; Kazakhstan, South Kazakhstan Province, Karatau locality; Upper Jurassic.

**D e s c r i p t i o n** (Figs. 1a, 1b). The proximal and distal nygmae are well developed; trichosors are poorly discernible; wings in the costal space do not branch and are sparsely situated closer to the base of the wing; Rs is eight-branched; two long parallel gradate series of crossveins and one short row running slightly prox-



**Fig. 1.** (a, b) *Jurosmylus parvulus* sp. nov., holotype PIN, no. 2554/765, forewings. Scale bar, 2 mm.

imal to the distal nygma are present; MP branches at the level of MA diverging from Rs; CuA has four to five branches and branches more strongly than CuP; A1 and A2 are pectinate.

**Measurements, mm.** Wing length, 14; wing width, 5.

**Comparison.** The new species differs from *J. atalantus* (wing length, 28 mm) in the smaller size, half as great number of branches of Rs, and short cells between second and third rows of crossveins in the distal half of the wing. Otherwise these two species are very similar.

**Material.** In addition to the holotype, three specimens (PIN, nos. 2997/4951, 2384/849, and 2997/2756) that probably belong to this species.

#### Subfamily Spilosmylinae Krüger, 1913

##### Genus *Ensiosmylus* Khramov, gen. nov.

**Etymology.** The Latin *ensis* (sword) and generic name *Osmylus*. Gender masculine.

**Type species.** *E. acutus* sp. nov.

**Diagnosis.** Elongate wings with concave posterior margin at distal end; branches of CuA and CuP simple, without terminal bifurcations; A1 dichotomizing once near wing margin; A2 pectinate.

**Species composition.** Type species.

**Comparison.** The placement of *Ensiosmylus* in Spilosmylinae is suggested by the structure of the anal veins, very similar to those found in extant members of

the subfamily. Thus, A1 (CuP in the terminology of Tjeder, 1957) in the hindwings of Spilosmylinae either is a simple non-branching vein or, as in *Spilosmylus majalis* Navás, 1924, ends in a single bifurcation, as found also in *Ensiosmylus*. A2 either has one or two branches or is slightly pectinate, as in *S. leletensis* New, 1986 and *Thyridosmylus perspicillaris* (Gerstaecker, 1885), as found also in *Ensiosmylus*. *Ensiosmylus* also resembles members of Spilosmylinae in the position of crossveins, concentrated in the proximal part of the wing more sparsely than in Kempyninae and Gumillinae, and forming one pronounced gradate series at the end of the wing. *Ensiosmylus* is distinguished from the other genera of the subfamily in the absence of bifurcations at the ends of the branches of CuA and CuP.

##### *Ensiosmylus acutus* Khramov, sp. nov.

Plate 13, fig. 2

**Etymology.** From the Latin *acutus* (acute).

**Holotype.** PIN, no. 2784/1020, impressions of hindwings; Kazakhstan, South Kazakhstan Province, Karatau locality; Upper Jurassic.

**Description** (Figs. 2a, 2b). The nygmae and trichosors are indiscernible; Rs is 16-branched; clearly discernible oblique vein b (=base of MA fused with Rs in the terminology of Martynov, 1928) joins the base of Rs; one gradate series of crossveins is present, parallel to the posterior margin of the wing. The pectinate CuA, CuP, and A2 bear six, 11, and four branches, respectively. A3 has a bifurcation at the end.

**Measurements, mm.** Wing length, 20.5; width, 4.3.

**Material.** Holotype.

#### Subfamily Gumillinae Navás, 1912

##### Genus *Kolbasinella* Khramov, gen. nov.

**Etymology.** From the Russian *kolbasa* (minced meat packed in gut or artificial film). Gender feminine.

**Type species.** *K. elongata* sp. nov.

**Diagnosis.** Elongated narrow wings (ratio of length and width 1 : 5); hindwing with branches of CuA and MP simple, short, clinging to wing margin, not ending in bifurcation and not joined with crossveins; MP pectinate, with more branches than CuP.

**Species composition.** Type species.

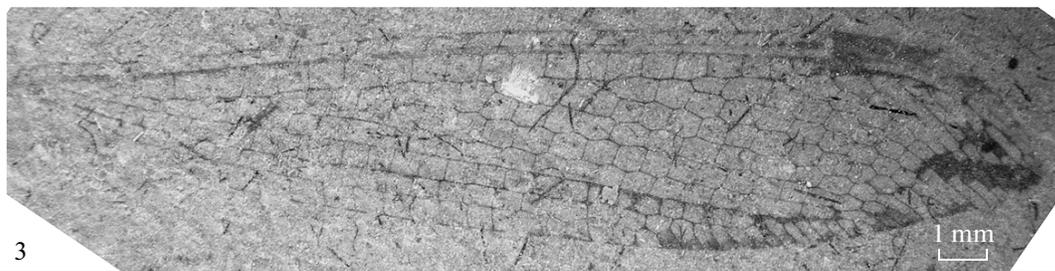
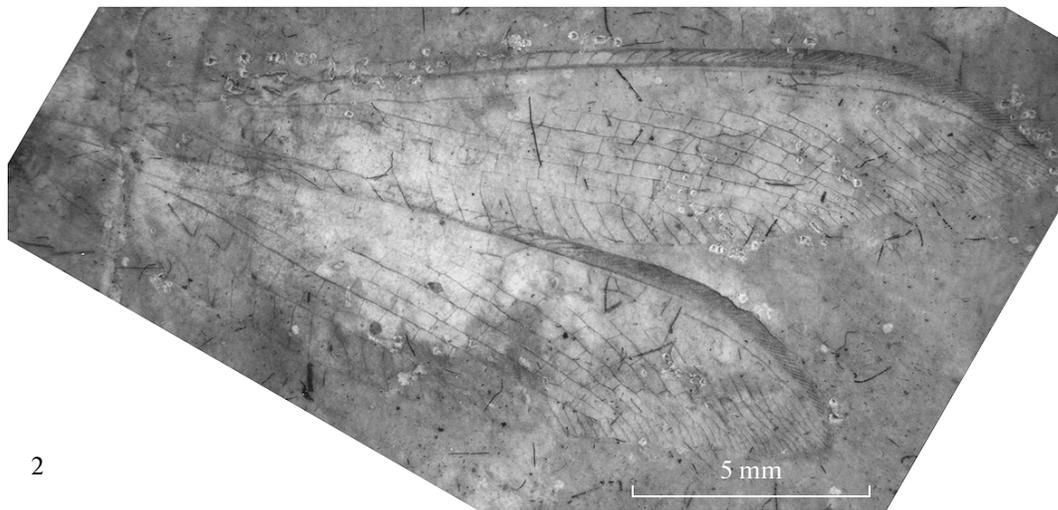
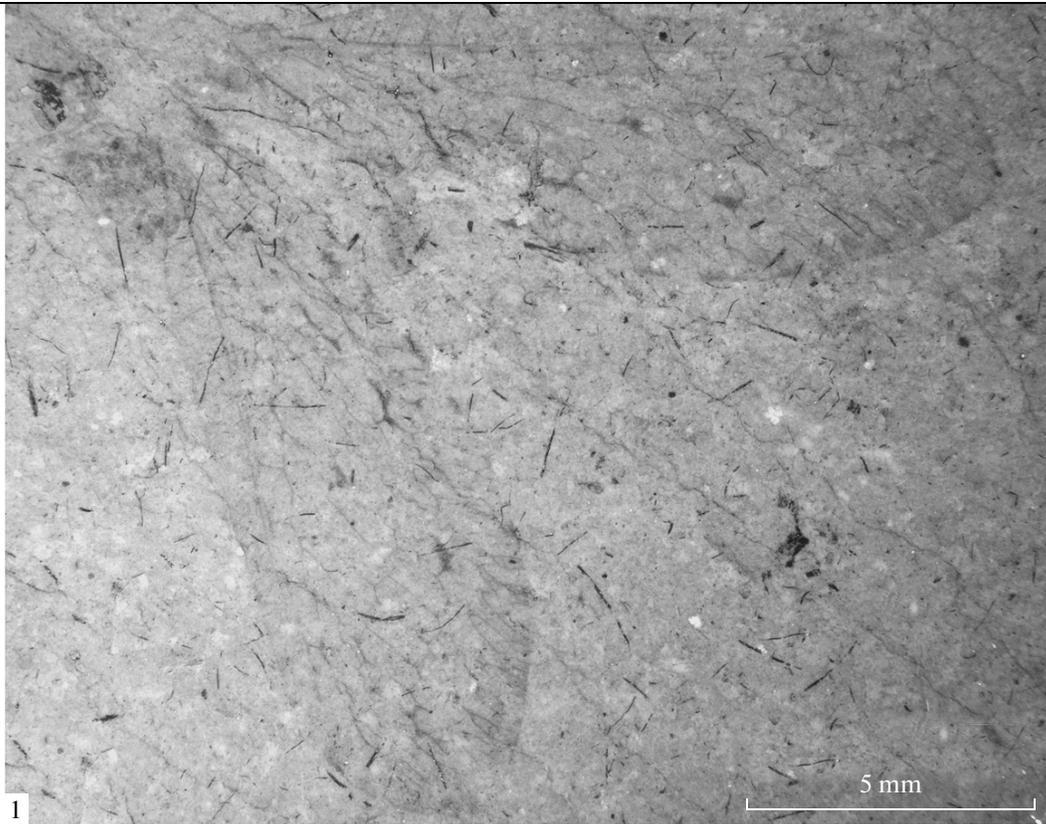
**Comparison.** The placement of *Kolbasinella* in Gumillinae is evidenced by the dense crossveins occupying almost the entire wing and by the absence of trichosors. Elongate wings similar in shape to those of *Kolbasinella* are found only in two species of the sub-

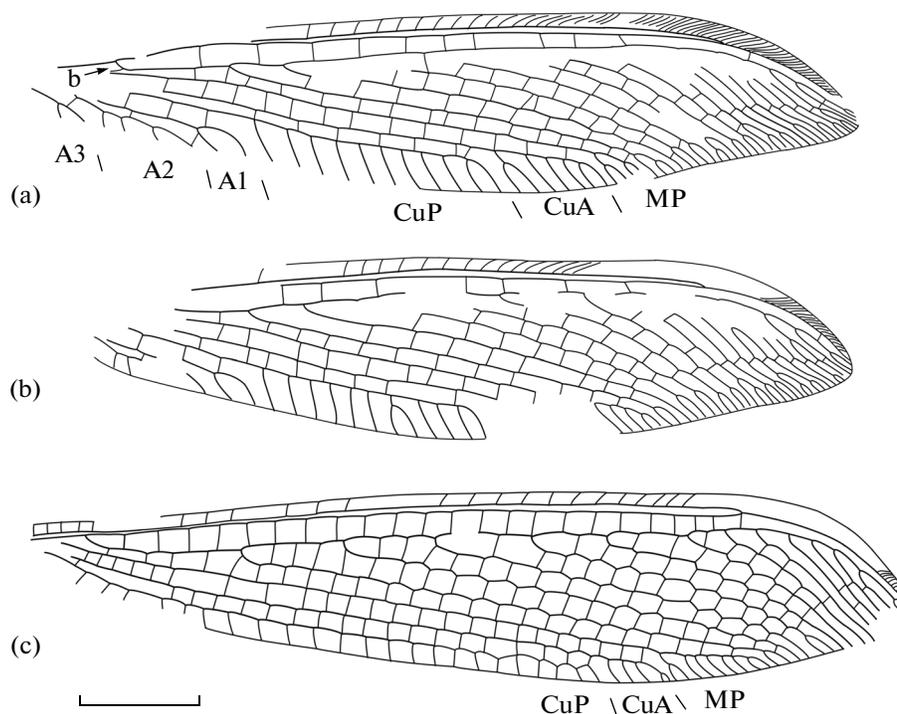
#### Explanation of Plate 13

**Fig. 1.** *Jurosmylus parvulus* sp. nov., holotype PIN, no. 2554/765.

**Fig. 2.** *Ensiosmylus acutus* gen. et sp. nov., holotype PIN, no. 2784/1020.

**Fig. 3.** *Kolbasinella elongata* gen. et sp. nov., holotype PIN, no. 2997/746.





**Fig. 2.** (a, b) *Ensiosmylus acutus* gen. et sp. nov., holotype PIN, no. 2784/1020, hindwings; (c) *Kolbasinella elongata* gen. et sp. nov., holotype PIN, no. 2997/746, hindwing. Scale bar, 3 mm.

family: *Epiosmylus panfilovi* Ren et Yin, 2002 (very different from the type species *E. longicornis*) and *Enodinympha translucida* Ren et Engel, 2007. In *E. panfilovi*, as in *Kolbasinella*, CuA in the hindwing is short and not branching, but MP in *E. panfilovi* has fewer branches than CuA, the Rs has half as many branches as in *Kolbasinella*, and they start diverging from the stem only in the distal half of the wing. In the hindwings of *Enodinympha translucida*, in contrast to *Kolbasinella*, the branches of CuA are longer and do not divide. The hindwings of the other Gumillinae are more rounded and have longer branches of CuA, which do divide (except in *Allotriosmylus uniramosus* Yang et al., 2010, which has strongly reduced venation).

*Kolbasinella elongata* Khramov, sp. nov.

Plate 13, fig. 3

**Etymology.** From the Latin *elongatus* (elongate).

**Holotype.** PIN, no. 2997/746, impression of hindwing; Kazakhstan, South Kazakhstan Province, Karatau locality; Upper Jurassic.

**Description** (Fig. 2c). A dark longitudinal fascia is present at the level of the wing apex. The trichosors are absent almost along the entire length of the wing; nygmae are indiscernible; Rs is 12-branched; crossveins, dense in the proximal part of the wing, disappear between the sixth and seventh branches of Rs, where the single gradate series of crossveins begins; MP has eight branches; CuA has five.

**Measurements,** mm. Wing length, 21.5; width, 4.3.

**Material.** Holotype.

**Subfamily Kempyninae Krüger, 1913**

**Genus *Jurakempynus* Wang et al., 2011**

*Jurakempynus arcanus* Khramov, sp. nov.

Plate 14, fig. 1

**Etymology.** From the Latin *arcanus* (keeper of secrets).

**Holotype.** PIN, no. 2554/775, incomplete impressions of two forewings and one hindwing; Kazakhstan, South Kazakhstan Province, Karatau locality; Upper Jurassic.

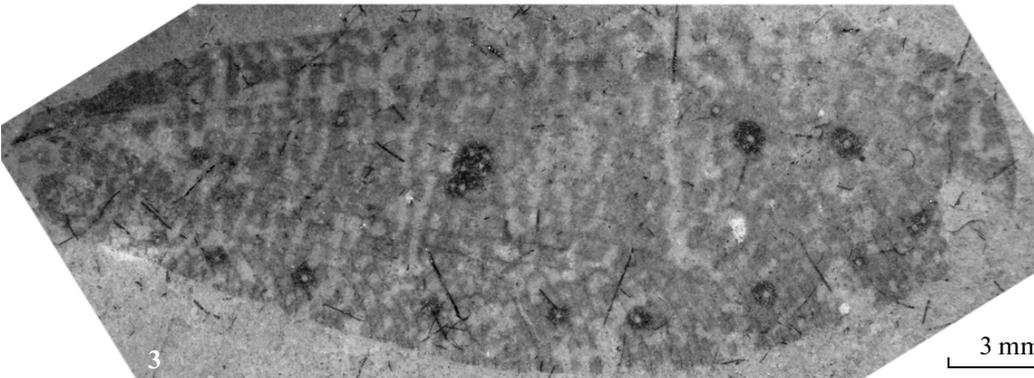
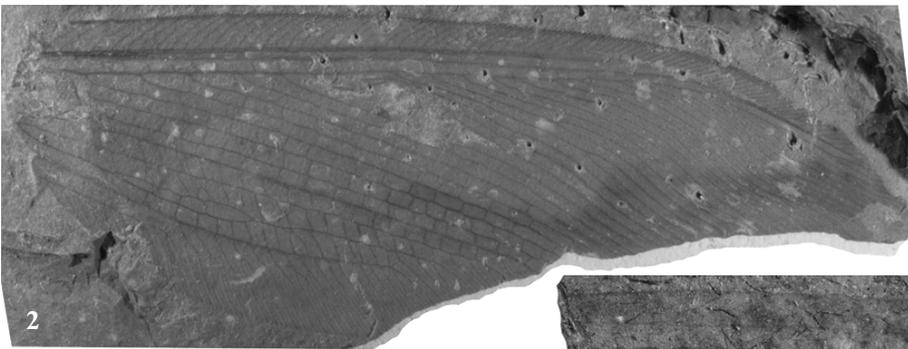
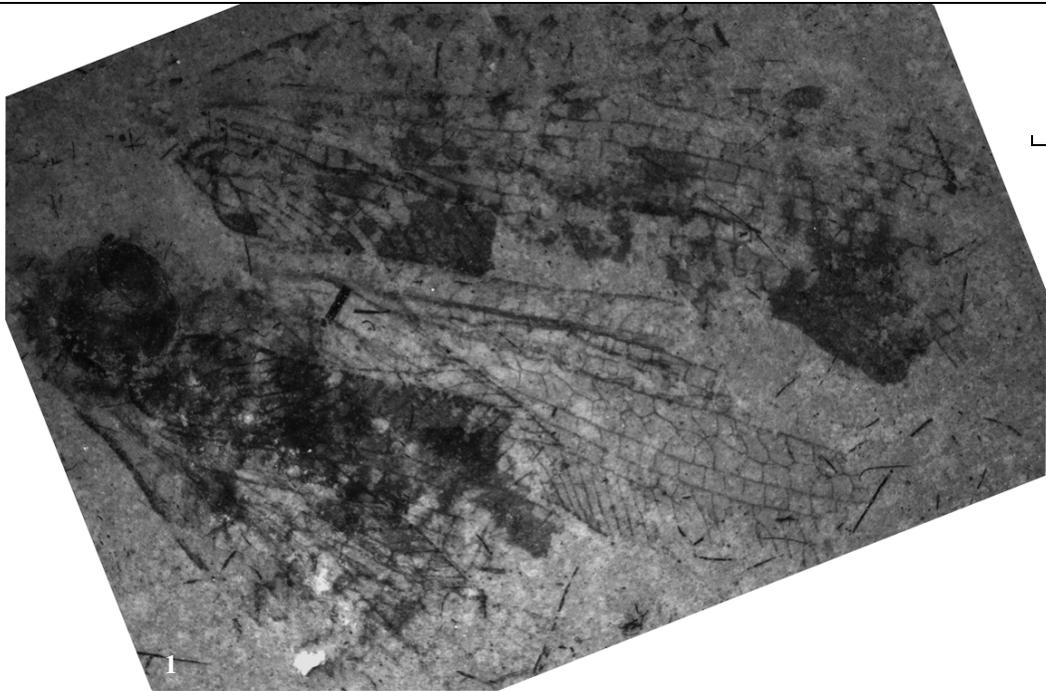
Explanation of Plate 14

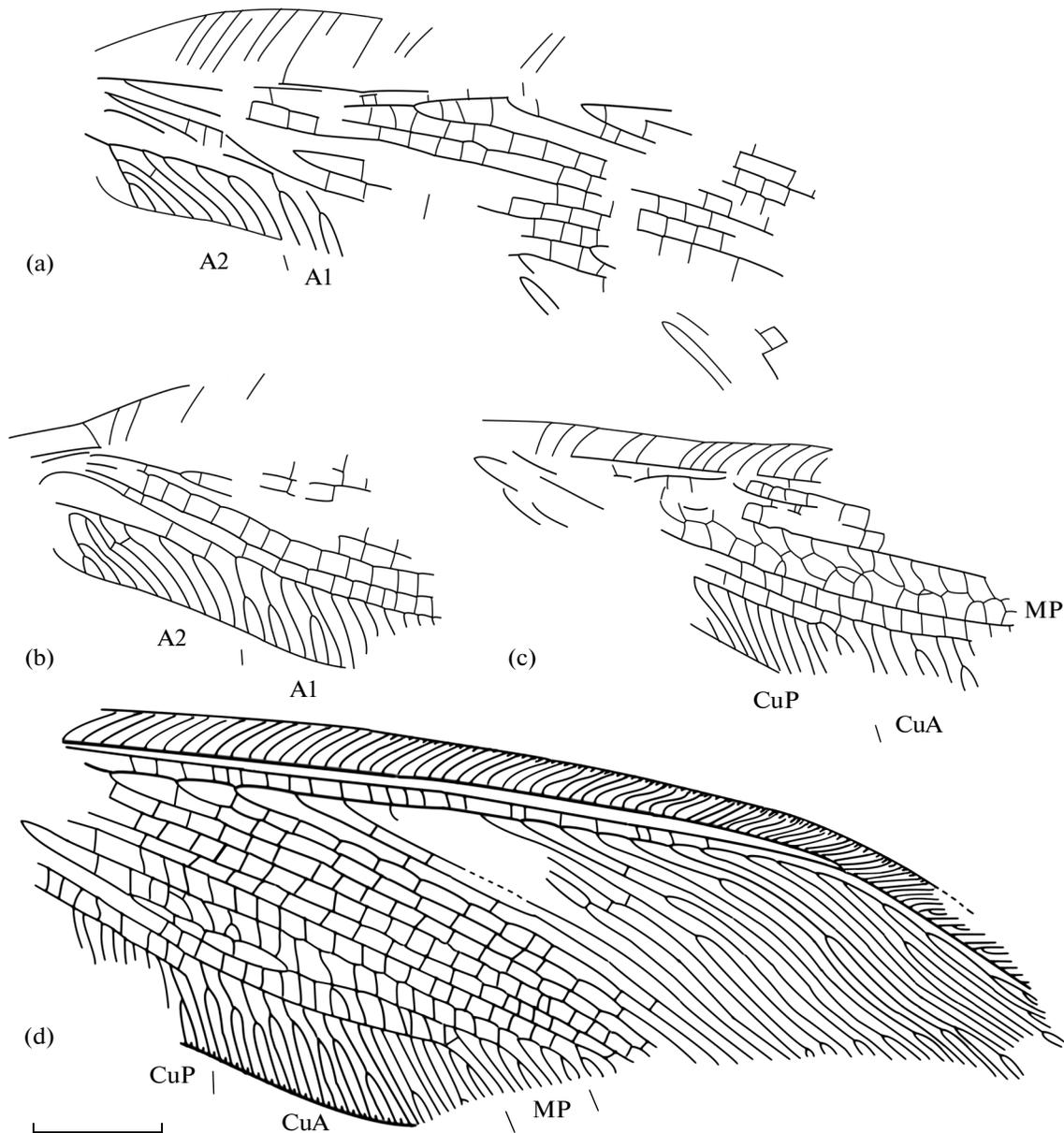
**Fig. 1.** *Jurakempynus arcanus* sp. nov., holotype PIN, no. 2554/775.

**Fig. 2.** *Jurakempynus sublimis* sp. nov., holotype PIN, no. 4270/1522.

**Fig. 3.** *Arbusella* sp., specimen PIN, no. 2904/770.

**Fig. 4.** *Arbusella bella* gen. et sp. nov., holotype PIN, no. 2997/768.





**Fig. 3.** Members of the genus *Jurakempynus*: (a, b, c) *J. arcanus* sp. nov., holotype PIN, no. 2554/775: (a, b) forewings, (c) hindwing; (d) *J. sublimes* sp. nov., holotype PIN, no. 4270/1522, hindwing. Scale bar, 3 mm.

**Description** (Figs. 3a, 3b, 3c). Trichosors and nygmae are indiscernible; in the forewing, A2 is pectinate and has six branches, the first of which, in turn, has three or four branches; in the hindwing, MP over most of its length contains two rows of cells of irregular shape; CuP has at least 11 branches.

**Measurements**, mm. Length of forewing fragment, 16; total forewing length 22–23.

**Comparison.** The new species differs from *J. epunctatus* Wang et al., 2011 and *J. sublimes* sp. nov. in the two rows of cells in the hindwing occupying almost the entire length of MP; it differs from *J. bellatulus* Wang et al., 2011 in the irregular shape of cells in

the MP space and from *J. sinensis* Wang et al., 2011 in the more branches of A2 in the forewing.

**Material.** Holotype.

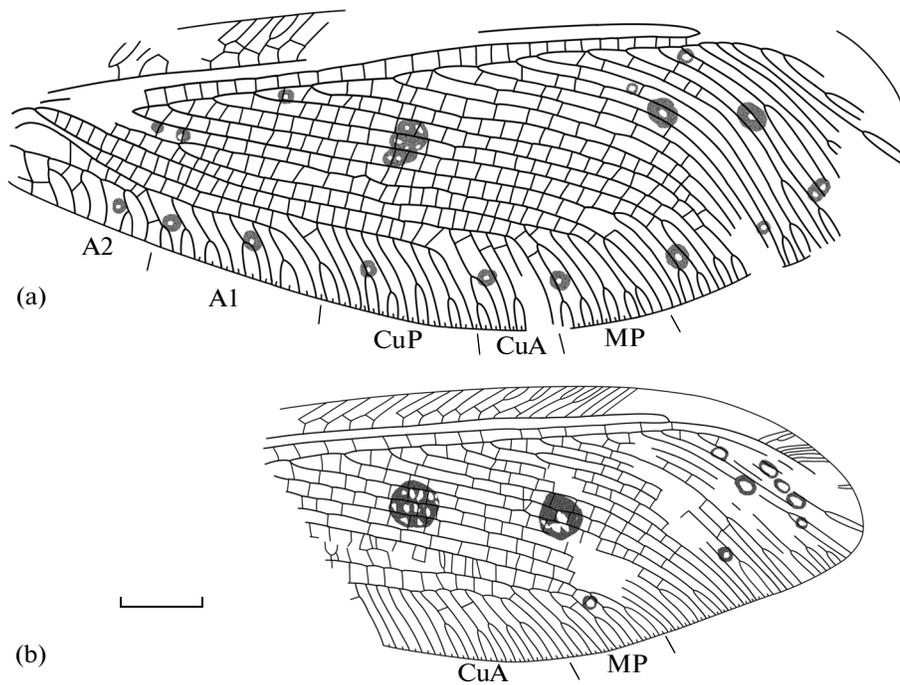
*Jurakempynus sublimes* Khramov, sp. nov.

Plate 14, fig. 2

**Etymology.** The Latin *sublimis* (lofty).

**Holotype.** PIN, no. 4270/1522, impression of hindwing; Mongolia, Gobi-Altai Province, Shar-Teg locality; Upper Jurassic, Shar-Teg Sequence.

**Description** (Fig. 3d). The trichosors are present in the distal area of the forewing and on the posterior margin of the wing; nygmae are not visible;



**Fig. 4.** (a) *Arbusella bella* gen. et sp. nov., holotype PIN, no. 2997/768, forewing; (b) *Arbusella* sp., specimen PIN, no. 2904/770, hindwing. Scale bar, 2 mm.

veins in the costal space do not branch; Rs is 24-branched; the branching point of MP is equidistant from the anterior and posterior margins of the wing; the first quarter of the MP space lacks crossveins; the second quarter contains a small narrow intercalary row of four branches that is adjacent to MP2; CuA is well developed and has 17 branches; CuP has nine branches.

**Measurements**, mm. Hindwing length, 24; width, 9.

**Comparison.** The new species differs from the other species of *Jurakempynus* in the structure of MP. The branching point of MP is situated less basally than in the other species and is shifted closer to the posterior margin of the wing; the MP space is narrower; and the additional row of cells is short and narrow.

**Material.** Holotype.

#### **Genus *Arbusella* Khramov, gen. nov.**

**Etymology.** From the Russian *arbus* (water melon). Gender feminine.

**Type species.** *A. bella* sp. nov.

**Diagnosis.** Costal space of forewing and hindwing with row of crossveins; wings spotted.

**Species composition.** Type species.

**Comparison.** The new genus differs from all other genera of Osmylidae in the presence of a row of

crossveins in the costal space of the forewing and hindwing and in the spotted coloration of the wings. In some osmylids (e.g., in *Osmylus hyalinatus* McLachlan, 1875), the costal space of the forewing may display several crossveins, but in no member of the family except *Arbusella* are these crossveins organized in a regular row: in all other genera they are scattered chaotically. The series of crossveins in the costal space of the hindwings typical of *Arbusella* is also unique among osmylids. The placement of *Arbusella* in Kempyninae is evidenced by the dense crossveins in the proximal halves of the wings, well developed CuA in the hindwing, and two rows of cells between MP1 and MP2, which are also typical to the hindwings of *Jurakempynus*.

#### *Arbusella bella* Khramov, sp. nov.

Plate 14, figs. 3–4.

**Etymology.** Feminine form of the Latin *bellus* (pretty).

**Holotype.** PIN, no. 2997/768, impression of forewing; Kazakhstan, South Kazakhstan Province, Karatau locality; Upper Jurassic.

**Description** (Fig. 4a). The proximal part of the costal space of the forewing contains additional crossveins. Trichosors are present. Rs is 18-branched; beginning with branch 10, crossveins between branches are scant. Last branches of Rs are strongly

curved and reach the posterior margin of the wing almost at right angle. MP2 is pectinate and has four branches; CuA has five branches; CuP has ten; A1, eight; A2, six. In the hindwing, two rows of cells are present between MP1 and MP2. The wing coloration consists of spots of two types: numerous rather small rounded spots with a lumen between them and scant large spots with several lumina.

**Measurements**, mm. Wing length, 22.5; width, 8.

**Material**. In addition to the holotype, the genus *Arbusella* is also represented in Karatau by a well preserved distal half of a hindwing (PIN, no. 2904/770, Fig. 4b) and by another, rather small wing fragment (PIN, no. 2554/798). These fossils cannot be identified with certainty as *A. bella*, but the coloration and size of the hindwing PIN, no. 2904/770 are identical to those of the holotype: the length of the fragment is 15 mm; width, 7 mm; total wing length, 22–23 mm.

#### ACKNOWLEDGMENTS

I am grateful to Prof. Zhang Haichun, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, for the chance to study the collection of fossil neuropterans from the Daohugou locality and to Qiang Yang and Prof. Dong Ren, Capital Normal University, Beijing, China, for sending the photographs of the holotype of *Enodinympa translucida*.

This study was supported by the Russian Foundation for Basic Research, project no. 13-04-01839-a, and program of the Presidium of the Russian Academy of Sciences “Problems of the Origin of Life and Formation of the Biosphere.”

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*Translated by P. Petrov*