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First record of the family Ithonidae (Neuroptera) from Baltic amber

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Abstract

Elektrithone expectata **gen. *et* sp. nov.** (Neuroptera: Ithonidae) is described from Eocene Baltic amber and represents the first record of this family from Baltic amber. The forewing venation of the new genus is characterized by a small number of crossveins as found in some 'polystoechotid'-like genera, and by the absence of the distal nygma and the strong reduction of the anal area which are characteristic of 'rapismatid'-like ithonids.

Key words: Neuroptera, Ithonidae, Baltic amber

Introduction

Although Neuroptera in Baltic amber are less than 0.1% of inclusions (Hoffeins & Hoffeins 2004), these include 28 described species of 13 extant families. In terms of numbers of specimens, Nevrorthidae clearly dominate the assemblage (more than 50%; TW, pers. obs.); Coniopterygidae and Hemerobiidae are relatively common; Psychopsidae, Osmylidae, Sisyridae and Berothidae (including Rhachiberothinae) are rather rare; Chrysopidae, Nymphidae and Ascalaphidae are very rare; and only one or two specimens of the families Dilaridae, Mantispidae and Ithonidae (present paper) have been found (MacLeod 1971; Ohm 1995; Weitschat & Wichard 1998; Engel 1999; Archibald *et al.* 2009; Wichard *et al*. 2009, 2010; Makarkin & Kupryjanowicz 2011; Ohl 2011; Makarkin *et al*. 2012; Wedmann *et al*. 2013). Of the extant families of Neuroptera, only confirmed records of Myrmeleontidae and Nemopteridae are as yet absent from Baltic amber.

In this paper, we describe the first ithonid genus from Baltic amber based on a single specimen. At present, the relict family Ithonidae (s.l.) comprises 10 genera (41 species) formerly attributed to Ithonidae (s. str.), Polystoechotidae and Rapismatidae (Winterton & Makarkin 2010; Oswald 2013). The family is distributed in Australia, the mountains of the Oriental Region, southern North America to Meso-America and Chile; an exception is *Polystoechotes punctatus* (Fabricius, 1793), which is widely distributed in America, from southern Canada to Panama.

Thirty-one fossil species (25 of which are named) are known from the Early Jurassic to the late Eocene (Table 1). There are also numerous undescribed taxa from the Jurassic and Cretaceous of China, Kazakhstan and Russia (VM, pers. obs.).

All Cenozoic records of Ithonidae are restricted to the Eocene. Of these, 16 species are known from the early Eocene of western North America (Canada and U.S.A.) and Denmark. They belong to 'polystoechotid-like' genera (Andersen 2001; Archibald & Makarkin 2006) except for one 'rapismatid-like' genus described from Republic, Washington, U.S.A. (Makarkin & Archibald 2009). One poorly preserved species is described from the late Eocene of Florissant, Colorado, U.S.A. (Cockerell 1908; Archibald & Makarkin 2006); and we add another late Eocene species from Baltic amber.

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TABLE 1. A list of fossil species currently assigned to Ithonidae.

	Species	Age	Locality	References
1*	*Mesopolystoechus apicalis* Martynov, 1937	Early Jurassic ?Hettangian	Sogyuty, Kyrgyzstan (Dzil [=Dzhil] Fm)	Martynova 1949: Fig. 8
2*	*Mesopolystoechus apicalis* Martynov, 1937	Early/Middle Jurassic	Shurab-1, Tajikistan (Sulyukta Fm)	Martynov 1937: Fig. 18
3	*Mesopolystoechus wangyingziensis* Hong, 1983	Middle Jurassic	Wangyingzi, Hebei Prov., China (Jiulongshan Fm)	Hong 1983: Fig. 88; Pl. 5, Fig. 5
4	*Osmyloides distinctus* Panfilov, 1980	Late Jurassic (Oxfordian/ Kimmeridgian)	Mikhailovka, Karatau, Kazakhstan	Panfilov 1980: Fig. 101
5	*Paleopterocalla superba* (Panfilov, 1980)	Late Jurassic (Oxfordian/ Kimmeridgian)	Mikhailovka, Karatau, Kazakhstan	Panfilov 1980: Fig. 100; Oswald 2007
6	*Panfilovdvia fasciata* (Panfilov, 1980)	Late Jurassic (Oxfordian/ Kimmeridgian)	Mikhailovka, Karatau, Kazakhstan	Panfilov 1980: Fig. 97; Özdikmen 2009
7	*Kirgisella ornata* Martynov, 1925	Late Jurassic (Oxfordian/ Kimmeridgian)	Galkino, Karatau, Kazakhstan	Martynov 1925: Fig. 11; Oswald *et al*. 2010
8	*Principiala rudgwickensis* Jepson *et al*., 2009	Early Cretaceous (Barremian)	Wealden, England (Upper Weald Clay)	Jepson *et al*. 2009: Fig. 2
9	*Lasiosmylus newi* Ren *et* Guo, 1996	Early Cretaceous (Barremian)	Huangbanjigou, China (Yixian Fm)	Ren & Guo 1996: Figs. 5, 10.3, 11.2, 11.4; Makarkin *et al*. 2012
10	*Lasiosmylus* sp.	Early Cretaceous (Barremian)	Huangbanjigou, China (Yixian Fm)	Makarkin *et al*. 2012: Fig. 3G
11	*Principiala* sp.	Early Cretaceous (Barremian)	Huangbanjigou, China (Yixian Fm)	Makarkin *et al*. 2012: Fig. 3F
12	Ithonidae gen. sp.	Early Cretaceous (Barremian)	Huangbanjigou, China (Yixian Fm)	Makarkin *et al*. 2012: Fig. 3E
13	Ithonidae gen. sp.	Early Cretaceous (Barremian/Aptian)	Liutiaogou, Inner Mongolia, China (Yixian Fm)	Makarkin *et al*. 2012: Fig. 3D
14	*Principiala incerta* Makarkin *et* Menon, 2007	Early Cretaceous (late Aptian)	Chapada do Araripe, Brazil (Crato Fm)	Makarkin & Menon 2007: Figs. 1–5
15	*Palaeopsychops abruptus* Andersen, 2001	early Eocene	Mo-Clay, Denmark (Fur Fm)	Andersen 2001: Figs. 4, 9; Archibald & Makarkin 2006: Figs. 4B, 6–9
16	*Palaeopsychops angustifasciatus* Andersen, 2001	early Eocene	Mo-Clay, Denmark (Fur Fm)	Andersen 2001: Figs. 5, 11; Archibald & Makarkin 2006: Figs. 10(A–E)
17	*Palaeopsychops latifasciatus* Andersen, 2001	early Eocene	Mo-Clay, Denmark (Fur Fm)	Andersen 2001: Figs. 3,10; Archibald & Makarkin 2006: Figs. 5A, B
18	*Palaeopsychops maculatus* Andersen, 2001	early Eocene	Mo-Clay, Denmark (Fur Fm)	Andersen 2001: Figs. 6, 12 ; Archibald & Makarkin 2006: Figs. 15A, B
19	*Palaeopsychops quadratus* Archibald *et* Makarkin, 2006	early Eocene	Mo-Clay, Denmark (Fur Fm)	Archibald & Makarkin 2006: Figs. 11A, B

......*continued on the next page*

TABLE 1. (Continued)

	Species	Age	Locality	References
20	*Palaeopsychops setosus* Archibald *et* Makarkin, 2006	early Eocene	Horsefly River, British Columbia, Canada	Archibald & Makarkin 2006: Figs. 16A,B, 17A–C
21	*Palaeopsychops dodgeorum* Makarkin *et* Archibald, 2003	early Eocene	Quilchena, British Columbia, Canada	Makarkin & Archibald 2003: Figs. 1–5; Archibald & Makarkin 2006: Figs. 12A, B
22	*Palaeopsychops douglasae* Archibald *et* Makarkin, 2006	early Eocene	Quilchena, British Columbia, Canada	Archibald & Makarkin 2006: Figs. 18A, B
23	*Polystoechotites* sp. A	early Eocene	Quilchena, British Columbia, Canada	Archibald & Makarkin 2006: Figs. 23A–D
24	*Polystoechotites* sp. B	early Eocene	Quilchena, British Columbia, Canada	Archibald & Makarkin 2006: Figs. 24A, B
25	*Palaeopsychops marringerae* Archibald *et* Makarkin, 2006	early Eocene	Republic, Washington, U.S.A.	Archibald & Makarkin 2006: Figs. 13A, B
26	*Palaeopsychops timmi* Archibald *et* Makarkin, 2006	early Eocene	Republic, Washington, U.S.A.	Archibald & Makarkin 2006: Figs. 14A, B
27	*Polystoechotites barksdalae* Archibald *et* Makarkin, 2006	early Eocene	Republic, Washington, U.S.A.	Archibald & Makarkin 2006: Figs. 20A–D
28	*Polystoechotites falcatus* Archibald *et* Makarkin, 2006	early Eocene	Republic, Washington, U.S.A.	Archibald & Makarkin 2006: Figs. 21A, B
29	*Polystoechotites lewisi* Archibald *et* Makarkin, 2006	early Eocene	Republic, Washington, U.S.A.	Archibald & Makarkin 2006: Figs. 22A, B
30	*Allorapisma chuorum* Makarkin *et* Archibald, 2009	early Eocene	Republic, Washington, U.S.A.	Makarkin & Archibald 2009: Figs.2, 3
31	*Polystoechotites piperatus* (Cockerell, 1908)	late Eocene	Florissant, Colorado, U.S.A.	Cockerell 1908: Pl. 5, Fig. 2; Archibald & Makarkin 2006: Figs. 19A,B.
32	*Elektrithone expectata* gen. *et* sp. nov.	late Eocene	Baltic amber	This paper

*The conspecificity of these two specimens represented by different fragmentary wings (the Sogyuty specimen is a hind wing, the Shurab-1 specimen is a forewing) is very problematic.

Material and methods

This study is based on one specimen from Baltic amber. The amber piece is elongate and rounded, about 23 mm x 7 mm; in parts the amber is slightly brittle, and the wing parts are not flatly embedded, but bent. Line drawings were prepared by Thomas Weiterschan, while photographs were taken by Sonja Wedmann and Thomas Weiterschan using a Leica MZ12.5 stereomicroscope and an attached Nikon D300 digital camera. Extension of depth of focus was achieved by stacking several photos using Helicon Focus, version 5.3 X64.

We use the venational terminology of Kukalová-Peck and Lawrence (2004) in the interpretation of Yang *et al.* (2012), except the terminology of the anal veins, in which we in general follow that applied to other Neoptera (e.g., Béthoux 2005; Béthoux & Jarzembowski 2010). Crossveins are designated after the longitudinal veins which they connect and are numbered in sequence from the wing base, e.g., 1scp-r, first (proximal-most) crossvein connecting ScP and R/RA; icu, crossvein between CuA and CuP. Terminology of wing spaces and details of venation (e.g., traces, veinlets) follows Oswald (1993).

Abbreviations: AA1, first anterior anal vein; CuA, anterior cubitus; CuA1, proximal-most branch of CuA; CuP, posterior cubitus; MA and MP, anterior and posterior branches of media; RA, anterior radius; RP, posterior sector; RP1, proximal-most branch of RP; RP2, branch of RP distad RP1; ScA, subcosta anterior; ScP, subcosta posterior.

Systematic paleontology

Order Neuroptera Linnaeus, 1758

Family Ithonidae Newman, 1853 *sensu* Winterton & Makarkin, 2010

Genus *Elektrithone* gen. nov.

Type species. *Elektrithone expectata* sp. nov.

Diagnosis. The new genus is characterized by a combination of the following forewing features: costal space broad; ScA well developed; majority of subcostal veinlets with only very shallow forks; one subcostal crossvein in proximal part of wing; radial crossveins arranged in two gradate series; CuP, AA1 very short; anal area strongly reduced; distal nygma absent.

Etymology. From the Greek *elektro* [ήλεκτρο], amber, and *Ithone*, a genus-group name, in reference to the occurrence of the genus in Baltic amber. Gender feminine.

Species included. Type species only.

Elektrithone expectata sp. nov.

Figs 1–3

Holotype. Specimen SMF Be 2374, deposited in Senckenberg Forschungsinstitut und Naturmuseum Frankfurt (SMF, Frankfurt am Main, Germany); a proximal two thirds and apical fragment of a forewing; a fragment of the anterior portion of a hind wing in the same amber piece; Baltic amber (precise collecting locality is unknown).

Etymology. From the Latin adjective *expectatus*, expected, in reference to the long-expected finding of an ithonid in Baltic amber.

Description. Forewing ca. 19 mm long as preserved (estimated complete length ca. 30 mm); ca. 10 mm wide as preserved (measured at widest part). Trichosors prominent along apical-most portion of wing; weakly developed along costal and posterior margins. Costal space very broad basally. All proximal subcostal veinlets (including branches of humeral veinlets) forked very shallowly, two preserved subcostal veinlets additionally more deeply forked. Humeral veinlet (i.e., basal-most subcostal veinlet) recurrent, branched with three branches (one longest deeply forked, two shorter with only shallow forks). ScA distinct, rather stout, terminated on ScP before humeral veinlet. No costal crossveins present in proximal part of wing. Subcostal space moderately broad; basal subcostal crossvein (1scp-r) oblique, located slightly distad origin of RP; other crossveins absent in proximal part of space. RA space with one crossvein, located distal to RP2 origin. RP originates rather near wing base, with three pectinate branches preserved. M not fused basally with R, forked proximal of RP1 origin. MA deeply dichotomously branched distally. MP pectinately branched, with three long branches, which are shallowly dichotomously forked, and one shorter branch. Cu dividing into CuA and CuP near wing base, proximal to origin of RP. CuA rather long, pectinately branched, with five branches, each dichotomously (some deeply) branched. CuP short, deeply forked; each branch with few branches. AA1 short, deeply forked (its distal part not preserved). AA2, AA3 not preserved. Majority of veins of MP to CuP shallowly forked near hind margin. Crossveins in proximal part of forewing posterior to RP stem scarce: basal crossvein between R and M long, oblique, connecting RP with MA just before origin of RP1; two parallel gradate series in radial to intramedial spaces (five crossveins preserved in inner series anterior to CuA, two in outer series anterior to MP); four crossveins in mediocubital space (including one belonging to inner gradate series); one crossvein in intracubital space connecting Cu with CuP before origin of CuA1. Color pattern not detected; wing probably with uncolored (or faintly colored) membrane.

Hind wing only very fragmentarily preserved; costal space relatively broad, with rather long, closely spaced subcostal veinlets, partly forked; trichosores weakly developed.

Remarks. The forewing is preserved in two parts. The basal two thirds are well preserved with the venation clearly visible; a deep rupture separates it from the wing tip. This apical part is small and strongly folded. Its probable connection to the basal part cannot be traced entirely, therefore its venation can not be determined with certainty.

FIGURE 1. *Elektrithone expectata* **gen.** ***et*** **sp. nov.** Photograph of the holotype SMF Be 2374. Scale bar = 5 mm.

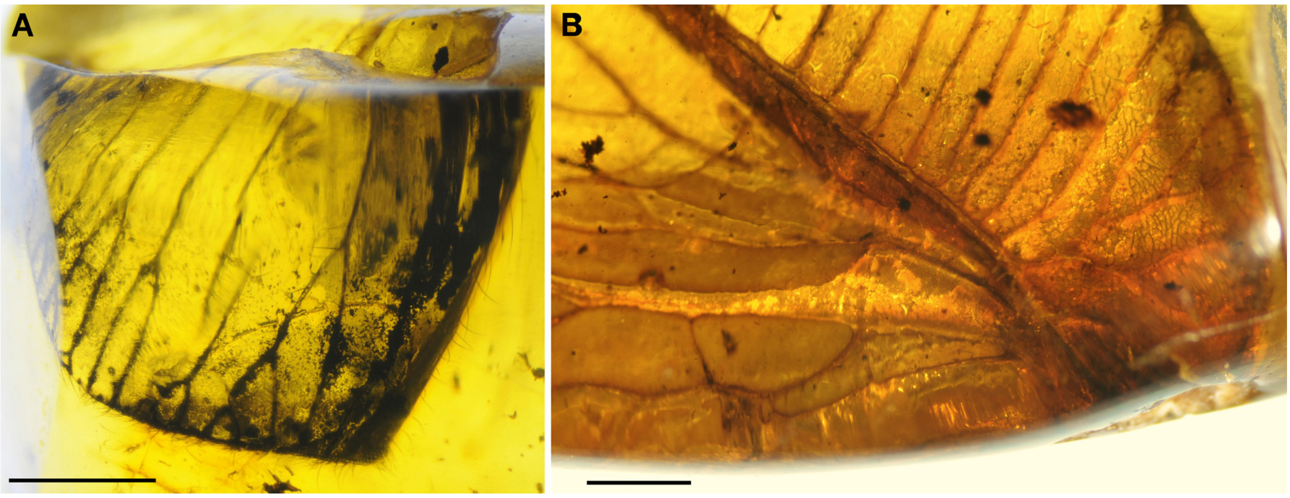

FIGURE 2. *Elektrithone expectata* **gen.** ***et*** **sp. nov.**, holotype SMF Be 2374. A, apical portion of the forewing. B, basal portion of the forewing. Scale bar = 1 mm.

The small hind wing fragment is located in its original place showing that the specimen became embedded into the resin with an intact thorax, possibly alive.

Discussion

The ithonid affinity of this new genus is not obvious because of the absence of autapomorphic character states in the Ithonidae forewing (Winterton & Makarkin 2010). Based on the venation, *Elektrithone* **gen. nov.** may theoretically be considered as belonging to two clades of Neuroptera, the psychopsoid and ithonoid (see Makarkin *et al*. 2013: Fig. 7). A psychopsoid affinity is very unlikely. The only families of this clade to which the genus may be theoretically assigned are Brongniartiellidae and Osmylopsychopidae whose CuP might be relatively short and not pectinate (see e.g., Makarkin 2010: Fig. 3A), i.e., more or less comparable to that of *Elektrithone* **gen. nov.** The anal area in both these families, however, is very well developed, with one or two of the anal veins being long and profusely branched, in contrast to this new genus. The ithonid affinity of this genus is supported by its venation, i.e., the broad costal space, the strongly recurrent humeral veinlet, the presence of only one subcostal crossvein in the proximal part of the wing, pectinate MP and CuA, dichotomous CuP and the arrangement of the radial crossveins into two gradate series. Parakseneuridae, another family of the ithonoid clade, has a distinctly different venation, e.g., CuA and AA1 are long and dichotomously branched (see Yang *et al*. 2012).

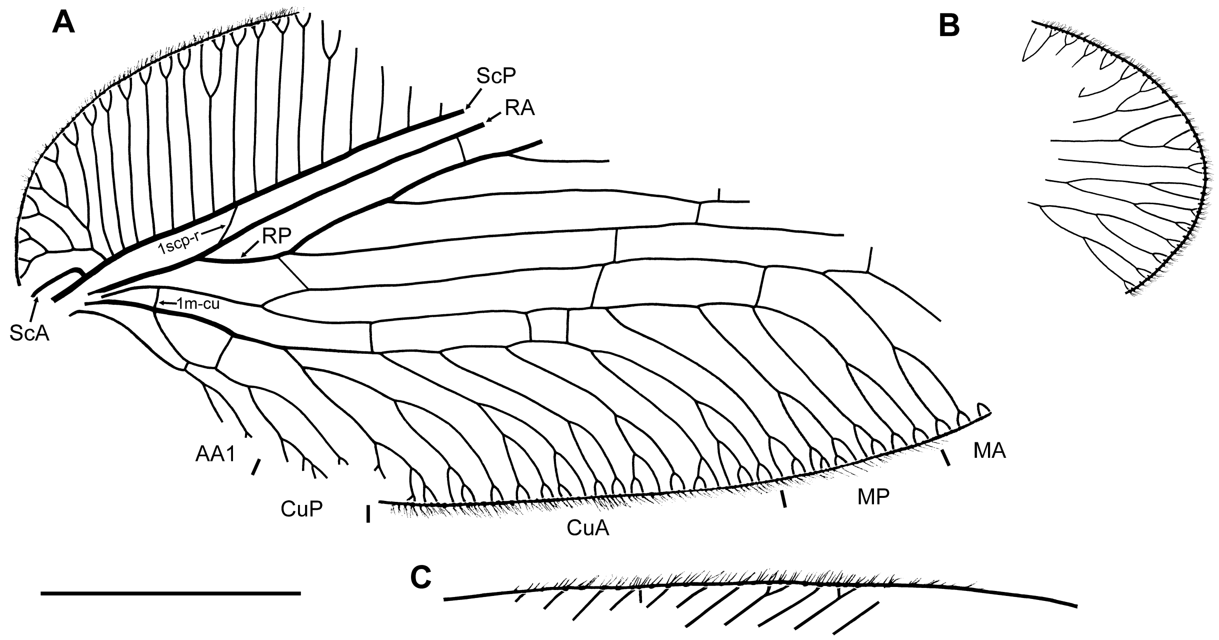

FIGURE 3. *Elektrithone expectata* **gen. *et* sp. nov.** Drawing of the preserved venation of the holotype SMF Be 2374 (converted to standard right view). A, proximal portion of the forewing. B, apical portion of the forewing (reconstructed wing shape). C, preserved fragment of the costal space of the hind wing. Scale bar = 5 mm.

Elektrithone **gen. nov.** has no close relatives in the Ithonidae. Oddly enough, such a short AA1 as found in this genus is characteristic of some species of the extant *Rapisma* McLachlan, 1866, which possess numerous and sporadically arranged crossveins, including crossveins between ScP and RA, in contrast to the new genus. *Elektrithone* **gen. nov.** shares with *Rapisma* not only the strong reduction of the anal area, but also the absence at least of the distal nygma.

On the other hand, *Elektrithone* **gen. nov.** is characterized by a small number of crossveins. Of the extant genera of Ithonidae, a comparable number of crossveins (arranged in two gradate series in the radial space) is found only in the genus *Polystoechotes* Burmeister, 1839. The forewings of *Oliarces* also possesses a rather small number of crossveins but these do not form regular gradate series in the radial space. Within fossil ithonids, a group of taxa (mostly undescribed) similar to *Lasiosmylus* Ren *et* Guo, 1996 from the Early Cretaceous Yixian Formation of China has even fewer crossveins (see Makarkin *et al*. 2012: Fig. 3G).

In the forewing of *Elektrithone* **gen. nov.**, no nygmata can be detected. The distal nygma is very probably absent and the basal nygma is indiscernible.

The majority of extant Ithonidae have two nygmata in the forewing: the basal nygma and the distal nygma. The basal nygma is present in all extant species of Ithonidae, placed between R/RP and M proximad its fork, but is very rarely identified in fossils. The placement and development of the distal nygma varies quite strongly, sometimes even in wings of the same specimen (Riek 1974; Penny 1996; Oswald 1998). Usually, the distal nygma is situated between two proximal branches of RP (RP1, RP2). In *Oliarces* Banks, 1908, however, it is located between MA and RP1 (Carpenter 1951). Sometimes, there is an additional distal nygma located in one of these two places, or between RP2 and RP3 (Riek 1974; Penny 1996). The distal nygma is certainly absent only in *Rapisma* (Barnard 1981). In fossil taxa, this nygma is especially distinct in some 'polystoechotid'-like ithonids (e.g., *Palaeopsychops abruptus* Andersen, 2001; *Polystoechotites barksdalae* Archibald *et* Makarkin, 2006: Archibald & Makarkin 2006: Figs. 9A, 20B), but in most taxa no nygmata may be identified due to poor preservation. In the forewings of the Early Cretaceous *Principiala* Makarkin *et* Menon, 2007, and in the early Eocene *Allorapisma* Makarkin *et* Archibald, 2009 whose venation is similar to each other and to *Rapisma* both nygmata are not detected, and at least the distal nygma is very probably absent (Makarkin & Menon 2007; Makarkin & Archibald 2009).

The structure of the subcosta anterior found in this species is typical for Neuroptera (see Makarkin *et al.* 2013).

Given the incompleteness of the single known holotype of *Elektrithone expectata* **gen. *et* sp. nov.**, it is hard to determine its phylogenetic position within Ithonidae. The genus is remarkable for a mixture of character conditions otherwise found in 'polystoechotid'-like and 'rapismatid'-like genera. Both these groups belong to a clade that is sister to a clade comprising all extant Australian genera (Winterton & Makarkin 2010: Fig. 4), corresponding to the 'ithone'-like genera (e.g., *Ithone* Newman, 1838, *Varnia* Walker, 1860, and *Megalithone* Riek, 1974).

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References

Andersen, S. (2001) Silky lacewings (Neuroptera: Psychopsidae) from the Eocene-Paleocene transition of Denmark with a review of the fossil record and comments on phylogeny and zoogeography. *Insect Systematics & Evolution*, 32, 419–438. http://dx.doi.org/10.1163/187631201X00290

Archibald, S.B. & Makarkin, V.N. (2006) Tertiary giant lacewings (Neuroptera: Polystoechotidae): revision and description of new taxa from western North America and Denmark. *Journal of Systematic Palaeontology*, 4, 119–155, 307 [errata]. http://dx.doi.org/10.1017/S1477201906001945

Banks, N. (1908) A new genus and species of Neuroptera. *Entomological News*, 19, 203–204.

Barnard, P.C. (1981) The Rapismatidae (Neuroptera): montane lacewings of the oriental region. *Systematic Entomology*, 6, 121–136. http://dx.doi.org/10.1111/j.1365-3113.1981.tb00430.x

Béthoux, O. (2005) Wing venation pattern of Plecoptera (Insecta: Neoptera). *Illiesia*, 1(9), 52–81. [Available from: http://www2.pms-lj.si/illiesia/papers/Illiesia01-09.pdf]

Béthoux, O. & Jarzembowski, E.A. (2010) New basal neopterans from Writhlington (UK, Pennsylvanian). *Alavesia*, 3, 87–96.

Burmeister, H.C.C. (1839) *Handbuch der Entomologie. Zweiter Band. Besondere Entomologie. Zweite Abtheilung. Kaukerfe. Gymnognatha. (Zweite Hälfte;vulgo Neuroptera)*. Enslin, Berlin, pp. i–xii + 757–1050.

Carpenter, F.M. (1951) The structure and relationships of *Oliarces* (Neuroptera). *Psyche*, 58, 32–41. http://dx.doi.org/10.1155/1951/28153

Cockerell, T.D.A. (1908) Fossil insects from Florissant, Colorado. *Bulletin of the American Museum of Natural History*, 24, 59–69.

Engel, M.S. (1999) The first fossil of a pleasing lacewing (Neuroptera: Dilaridae). *Proceedings of the Entomological Society of Washington*, 101, 882–826.

Hoffeins, C. & Hoffeins, H.W. (2004) Untersuchungen über die Häufigkeit von Inklusen in Baltischem und Bitterfelder Bernstein (Tertiär, Eozän) aus unselektierten Aufsammlungen unter besonderer Berücksichtigung der Ordnung Diptera. *Studia Dipterologica*, 10 (2), 381–392.

Hong, Y.C. (1983) *Middle Jurassic fossil insects in North China*. Geological Publishing House, Beijing, 223 pp. [in Chinese, English summary]

Jepson, J.E., Makarkin, V.N. & Jarzembowski, E.A. (2009) New lacewings (Insecta: Neuroptera) from the Lower Cretaceous Wealden Supergroup of southern England. *Cretaceous Research*, 30, 1325–1338.

Kukalová-Peck, J. & Lawrence, J.F. (2004) Relationships among coleopteran suborders and major endoneopteran lineages: evidence from hind wing characters. *European Journal of Entomology*, 101, 95–144. http://dx.doi.org/10.14411/eje.2004.018

Linnaeus, C. (1758) *Systema naturae per regna tria naturae secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Vol. 1. 10th Edition.* Salvii, Holmiae, 824 pp.

MacLeod, E.G. (1971) The Neuroptera of the Baltic Amber. I. Ascalaphidae, Nymphidae, and Psychopsidae. *Psyche*, 77 (for 1970), 147–180. http://dx.doi.org/10.1155/1970/45459

Makarkin, V.N. (2010) New psychopsoid Neuroptera from the Lower Cretaceous of Baissa, Transbaikalia. *Annales de la Société Entomologique de France (N.S.)*, 46, 254–261. http://dx.doi.org/10.1080/00379271.2010.10697666

Makarkin, V.N. & Archibald, S.B. (2009) A new genus and first Cenozoic fossil record of moth lacewings (Neuroptera: Ithonidae) from the Early Eocene of North America. *Zootaxa*, 2063, 55–63.

Makarkin, V.N. & Kupryjanowicz, J. (2010) A new mantispid-like species of Rhachiberothinae from Baltic amber (Neuroptera, Berothidae), with a critical review of the fossil record of the subfamily. *Acta Geologica Sinica*, 84, 655–664. http://dx.doi.org/10.1111/j.1755-6724.2010.00238.x

Makarkin, V.N. & Menon, F. (2007) First record of the fossil 'rapismatid-like' Ithonidae (Insecta, Neuroptera) from the Lower Cretaceous Crato Formation of Brazil. *Cretaceous Research*, 28, 743–753. http://dx.doi.org/10.1016/j.cretres.2006.11.003

Makarkin, V.N., Wedmann, S. & Weiterschan, T. (2012) First record of a fossil larva of Hemerobiidae (Neuroptera) from Baltic amber. *Zootaxa*, 3417, 53–63.

Makarkin, V.N., Yang, Q., Peng, Y.Y. & Ren, D. (2012) A comparative overview of the neuropteran assemblage of the Early Cretaceous Yixian Formation (China), with description of a new genus of Psychopsidae (Insecta: Neuroptera). *Cretaceous Research*, 35, 57–68. http://dx.doi.org/10.1016/j.cretres.2011.11.013

Makarkin, V.N., Yang, Q., Shi, C.F. & Ren, D. (2013) The presence of the recurrent veinlet in the Middle Jurassic Nymphidae (Neuroptera) from China: a unique condition in Myrmeleontoidea. *ZooKeys*, 325, 1–20. http://dx.doi.org/10.3897/zookeys.325.5453

Martynov, A.V. (1925) To the knowledge of fossil insects from Jurassic beds in Turkestan. 2. Raphidioptera (continued), Orthoptera (s.l.), Odonata, Neuroptera. *Izvestia Rossiiskoi Akademii Nauk*, Series 6, 19, 569–598.

Martynov, A.V. (1937) Liassic insects from Shurab and Kisyl-Kiya. *Trudy Paleontologicheskogo Instituta*, 7 (1), 1–232. [in Russian]

Martynova, O.M. (1949) Mesozoic lacewings (Neuroptera) and their bearing on concepts of phylogeny and systematics of the order. *Trudy Paleontologicheskogo Instituta*, 20, 150–170. [in Russian]

McLachlan, R. (1866) A new genus of Hemerobidae, and a new genus of Perlidae. *Transactions of the Entomological Society of London*, Series 3, 5, 353–354.

Newman, E. (1838) Entomological Notes. *Entomological Magazine, London*, 5, 168–181, 372–402, 483–500.

Newman, E. (1853) Proposed division of Neuroptera into two classes. *Zoologist*, 11 (Appendix), clxxxi–cciv.

Ohm, P. (1995) Coniopterygidae in Bernstein-Einschlüssen. Eine vorläufige Übersicht. *Galathea,* Supplement 2, 19–20.

Ohl, M. (2011) Aboard a spider – a complex developmental strategy fossilized in amber. *Naturwissenschaften*, 98, 453–456. http://dx.doi.org/10.1007/s00114-011-0783-2

Oswald, J.D. (1993) Revision and cladistic analysis of the world genera of the family Hemerobiidae (Insecta: Neuroptera). *Journal of the New York Entomological Society*, 101, 143–299.

Oswald, J.D. (1998) Rediscovery of *Polystoechotes gazullai* Navas (Neuroptera: Polystoechotidae). *Proceedings of the Entomological Society of Washington*, 100, 389–394.

Oswald, J.D. (2007) A new replacement name for *Pterocalla* Panfilov, 1980 (Neuroptera: Polystoechotidae), a junior homonym of *Pterocalla* Rondani, 1848 (Diptera: Ulidiidae). *Proceedings of the Entomological Society of Washington*, 109, 257–258.

Oswald, J.D. (2013) *Neuropterida Species of the World. Version 3.0.* http://lacewing.tamu.edu/Species-Catalogue/ (accessed 10 November 2013)

Oswald, J.D., Makarkin, V.N., Tyler, S. & Rogozin, A.G. (2010) Resolution of nomenclatural issues stemming from the homonymy of the genera *Kirgisella* Martynov, 1925 (Arthropoda: Insecta: Neuroptera) and *Kirgisella* Beklemishev, 1927 (Platyhelminthes: Rhabditophora: Rhabdocoela). *Proceedings of the Entomological Society of Washington*, 112, 585–587.

Özdikmen, H. (2009) A substitute name for a genus of fossil Neuroptera. *Munis Entomology & Zoology*, 4, 289–290.

Panfilov, D.V. (1980) New representatives of lacewings (Neuroptera) from the Jurassic of Karatau. *In*: Dolin, V.G., Panfilov, D.V., Ponomarenko, A.G. & Pritykina, L.N. (Ed.), *Fossil insects of the Mesozoic*. Naukova Dumka, Kiev, pp. 82–111. [in Russian]

Penny, N.D. (1996) A remarkable new genus and species of Ithonidae from Honduras (Neuroptera). *Journal of the Kansas Entomological Society*, 69, 81–86.

Ren, D., Engel, M.S. & Lu, W. (2002) New giant lacewings from the Middle Jurassic of Inner Mongolia, China (Neuroptera: Polystoechotidae). *Journal of the Kansas Entomological Society*, 75, 188–193.

Ren, D. & Guo, Z.G. (1996) On the new fossil genera and species of Neuroptera (Insecta) from the Late Jurassic of northeast China. *Acta Zootaxonomica Sinica*, 21, 461–479.

Riek, E.F. (1974) The Australian moth-lacewings (Neuroptera: Ithonidae). *Journal of the Australian Entomological Society*, 13, 37–54. http://dx.doi.org/10.1111/j.1440-6055.1974.tb02289.x

Walker, F. (1860) Characters of undescribed Neuroptera in the collection of W.W. Saunders. *Transactions of the Entomological Society of London (N.S.)*, 5, 176–199.

Wedmann, S., Makarkin, V.N., Weiterschan, T. & Hörnschemeyer, T. (2013) First fossil larvae of Berothidae (Neuroptera) from Baltic amber, with notes on the biology and termitophily of the family. *Zootaxa*, 3716 (2), 236–258. http://dx.doi.org/10.11646/zootaxa.3716.2.6

Weitschat, W. & Wichard, W. (1998) *Atlas der Pflanzen und Tiere im Baltischen Bernstein.* Dr. Friedrich Pfeil Verlag, München, 256 pp.

Wichard, W., Buder, T. & Caruso, C. (2010) Aquatic lacewings of family Nevrorthidae (Neuroptera) in Baltic amber. *Denisia*, 29, 445–457.

Wichard, W., Gröhn, C. & Seredszus, F. (2009) *Aquatic insects in Baltic amber. Wasserinsekten im Baltischen Bernstein*. Verlag Kessel, Remagen, 336 pp.

Winterton, S. & Makarkin, V.N. (2010) Phylogeny of moth lacewings and giant lacewings (Neuroptera: Ithonidae, Polystoechotidae) by using DNA sequence data, morphology, and fossils. *Annals of the Entomological Society of America*, 103, 511–522.
http://dx.doi.org/10.1603/AN10026

Yang, Q., Makarkin, V.N., Winterton, S.L., Khramov, A.V. & Ren, D. (2012) A remarkable new family of Jurassic insects (Neuroptera) with primitive wing venation and its phylogenetic position in Neuropterida. *PLoS ONE*, 7 (9), e44762.
http://dx.doi.org/10.1371/journal.pone.0044762