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; Psychopodidae, 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; Wëtschat & 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.
### TABLE 1. A list of fossil species currently assigned to Ithonidae.

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

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**TABLE 1. (Continued)**

<table>
<thead>
<tr>
<th>Species</th>
<th>Age</th>
<th>Locality</th>
<th>References</th>
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<tbody>
<tr>
<td>20 Palaeopsychops setosus</td>
<td>early Eocene</td>
<td>Horsefly River, British Columbia, Canada</td>
<td>Archibald &amp; Makarkin 2006: Figs. 16A,B, 17A–C</td>
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<td>Archibald et Makarkin, 2006</td>
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<tr>
<td>21 Palaeopsychops dodgeorum</td>
<td>early Eocene</td>
<td>Quilchena, British Columbia, Canada</td>
<td>Makarkin &amp; Archibald 2003: Figs. 1–5; Archibald &amp; Makarkin 2006: Figs. 12A, B</td>
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<td>Makarkin et Archibald, 2003</td>
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<tr>
<td>22 Palaeopsychops douglasae</td>
<td>early Eocene</td>
<td>Quilchena, British Columbia, Canada</td>
<td>Archibald &amp; Makarkin 2006: Figs. 18A, B</td>
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<td>Archibald et Makarkin, 2006</td>
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<tr>
<td>23 Polystoechottites sp. A</td>
<td>early Eocene</td>
<td>Quilchena, British Columbia, Canada</td>
<td>Archibald &amp; Makarkin 2006: Figs. 23A–D</td>
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<td>Archibald et Makarkin, 2006</td>
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<td>Makarkin et Archibald, 2009</td>
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<tr>
<td>31 Polystoechottites piperatus</td>
<td>late Eocene</td>
<td>Florissant, Colorado, U.S.A.</td>
<td>Cockerell 1908: Pl. 5, Fig. 2; Archibald &amp; Makarkin 2006: Figs. 19A, B.</td>
</tr>
<tr>
<td>(Cockerell, 1908)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32 Elektrithone expectata gen. et sp. nov.</td>
<td>late Eocene</td>
<td>Baltic amber</td>
<td>This paper</td>
</tr>
</tbody>
</table>

*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.*
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.
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).
**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 possess 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 nygmatas can be detected. The distal nygma is very probably absent and the basal nygma is indiscernible.

The majority of extant Ithonidae have two nygmatas 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 ‘polystochoitid’-like ithonids (e.g., *Palaeopsychops abruptus* Andersen, 2001; *Polystochoitites barksdalae* Archibald et Makarkin, 2006; Archibald & Makarkin 2006: Figs. 9A, 20B), but in most taxa no nygma may be identified due to poor preservation. In the forewings of the Early Cretaceous *Principitala* 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 nygmatas 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

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**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.
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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