



## An important new fossil genus of Berothinae (Neuroptera: Berothidae) from Baltic amber

VLADIMIR N. MAKARKIN<sup>1,3</sup> & MICHAEL OHL<sup>2</sup>

<sup>1</sup>*Institute of Biology and Soil Sciences, Far East Branch of the Russian Academy of Sciences, Vladivostok, 960022, Russia*

<sup>2</sup>*Museum für Naturkunde, Leibniz-Institut für Evolutions- und Biodiversitätsforschung, Invalidenstrasse, 43, D-10115 Berlin, Germany. E-mail: Michael.Ohl@mfn-berlin.de*

<sup>3</sup>*Corresponding author. E-mail: vnmakarkin@mail.ru*

### Abstract

*Elektroberotha groehni* **gen. et sp. nov.** (Neuroptera: Berothidae) is described from Baltic amber. The genus is assigned to Berothinae based on female terminalia that have the following characteristics: long hypocaustae on gonocoxite 9; sternite 7 that is medially divided into a pair of lateral sclerites; and gonocoxite 8 with a medial process that is very similar to that of some extant berothine genera. The new genus is the first described fossil genus of the subfamily Berothinae. It is noteworthy for the possession of a fully-developed CuP in the hind wing, a vein that is strongly reduced in all other species of the subfamily. The genus *Spiroberotha* is considered to belong to the Berothinae.

**Key words:** Baltic amber, Eocene, Berothidae, Berothinae

### Introduction

The Berothidae is a small family (approximately 130 extant species, including Rhachiberothinae) that occurs in most warm-temperate to tropical regions of the world, and very rarely in temperate regions (Oswald 2013). Fossil berothids are numerous (45 named species in 31 genera, excluding *Mesithone* Panfilov, 1980), known from the Middle Jurassic to late Eocene (Makarkin *et al.* 2011, 2012; Azar & Nel 2013; Khramov 2015; Makarkin 2015; Shi *et al.* 2015).

Baltic amber berothids are currently known from only one named species, the rhachiberothine *Whalfera wiszniowskii* Makarkin et Kupryjanowicz, 2010, although five described larvae are thought to belong to at least two (maybe more) species of two different subfamilies (Wedmann *et al.* 2013). *Proberotha prisca* Krüger, 1923 was considered for a long time as a berothid, but recently it was reasonably assumed to be a nevrothid (Wedmann *et al.* 2013; Wichard 2014).

In this paper, a remarkable new berothid genus and species from Baltic amber is described, based on two specimens. The new genus is assigned to the subfamily Berothinae based on female terminalia, although it possesses a fully-developed CuP in the hind wing, a vein that is strongly reduced in all other species of the subfamily.

### Material and methods

This study is based on two specimens from Baltic amber. The amber piece containing the holotype is nearly square, ca. 15 by 14 mm. The piece containing the paratype is broadly rectangular, about 27 by 45 mm.

The photographs of the holotype were taken by Carsten Gröhn using a Zeiss stereomicroscope (modified with variable objectives: Nikon M Plan 5x, 10x, 20x, 40x; Luminar 18 mm, 25 mm, 40 mm) and an attached Canon EOS 450D digital camera. The photographs of the paratype were taken by Lukas Kirschey using a Leica DFC420

(1990), and transferred to Nosybinae by Aspöck & Nemeschkal (1998). The latter authors note, however, that this genus “eidonomically looks very similar to some berothine taxa and shares many characters with this subfamily”, and that *Spiroberotha* is a “conflicting element within the Nosybinae” (p. 61). The females of *Spiroberotha* can hardly be distinguished from those of Berothinae (especially from *Lomamyia*); only male internal genitalia are similar to those of the Nosybinae. The basic structure of the female internal genitalia is rather conservative in Neuroptera (Szíraki 1996). It is quite possible that this may pertain also to female external structures, at least at the subfamily level within the Berothidae. Recently, Aspöck & Randolph (2014) concluded that *Spiroberotha* “might belong to the Berothinae” (p. 169) based on these female structures, although they still considered the genus to belong to the Nosybinae in their cladogram (Aspöck & Randolph 2014: Fig. 56). Therefore, *Elektroberotha* **gen. nov.** might be better considered as a conflicting element within the Berothinae rather than within the Nosybinae.

Superficially, *Elektroberotha* **gen. nov.** most resembles the berothine genus *Lekrugeria*, especially the African species *L. koenigi*, by its general venation, shape (i.e., outer wing margin not excised), and size (see Aspöck & Aspöck 1986a: Fig. 19). However, the new genus easily differs from *Lekrugeria* by its complete hind wing CuP, short scapus, and female terminalia (especially by the structure of gonocoxites 8). In general, its fully-developed hind wing CuP distinguishes *Elektroberotha* **gen. nov.** from all other Berothinae genera.

The female terminalia of *Elektroberotha* **gen. nov.** appear to be most similar to those of the northern African to southern Asian berothine genus *Nodalla*. The scapus and wing shape in these genera are also configured similarly. However, specimens of *Elektroberotha* **gen. nov.** are larger and have richer venation with some character states differing from those of *Nodalla* (e.g., the crossvein 2r-m connecting RP and MA; three crossveins between RA and RP proximad the distal crossvein scp-ra). Well-developed pseudohypocaudae are absent in *Nodalla*, but the long, dense setae at the elongated ventral part of its tergite 9 + ectoproct are similar to those on the pseudohypocaudae of *Elektroberotha* **gen. nov.**

Interestingly, another Baltic amber berothid genus, *Whalfera* Engel, 2004, is also most similar to an extant African genus, i.e., *Mucroberotha* (Makarkin & Kupryjanowicz 2010).

Two first instar larvae of Berothinae recently described from Baltic amber as “Berothidae indet., larva A” and “Berothidae indet., larva B” (Wedmann *et al.* 2013) may belong to this species.

## Acknowledgements

We thank Carsten Gröhn (Glinde, Germany) for allowing this research on the holotype specimen, performing photography, and answering our numerous questions; Thomas Weiterschan (Höchst Odw., Germany) for helpful information; Lukas Kirschey for help with photography of the paratype S. Bruce Archibald (Simon Fraser University, Burnaby, Canada) for editing of the English. The study is partly supported by a President’s Grant for Government Support of the Leading Scientific Schools of the Russian Federation No.HIII-150.2014.4, and a grant from the Far Eastern Branch of the Russian Academy of Sciences No. 12-I-II30-03 for VM.

## References

- Adams, P.A. (1990) A new genus of Berothidae from tropical America, with two new species. *Psyche*, 96 (for 1989), 187–193. <http://dx.doi.org/10.1155/1989/39647>
- Ardila-Camacho, A. (2013) First record of beaded lacewings (Neuroptera, Berothidae) from Colombia. *Zootaxa*, 3669 (2), 159–164. <http://dx.doi.org/10.11646/zootaxa.3669.2.7>
- Aspöck, U. (1989) *Nyrma kervillea* Navás – eine Berothide! (Neuropteroidea: Planipennia). *Zeitschrift der Arbeitsgemeinschaft Österreichischer Entomologen*, 41, 19–24. Available from: [http://www.landesmuseum.at/pdf\\_frei\\_remote/ZAOE\\_41\\_0019-0024.pdf](http://www.landesmuseum.at/pdf_frei_remote/ZAOE_41_0019-0024.pdf) (accessed on 13 March 2015)
- Aspöck, U. & Aspöck, H. (1981) Weitere Untersuchungen an Berothiden: *Berothera* Walker, *Isoscelipteron* Costa und *Asadeteva* n. g. (Neuropteroidea: Planipennia). *Zeitschrift der Arbeitsgemeinschaft Österreichischer Entomologen*, 33, 1–14. Available from: [http://www.landesmuseum.at/pdf\\_frei\\_remote/ZAOE\\_33\\_0001-0014.pdf](http://www.landesmuseum.at/pdf_frei_remote/ZAOE_33_0001-0014.pdf) (accessed on 13 March 2015)
- Aspöck, U. & Aspöck, H. (1984) Zur Kenntnis des Genus *Sphaeroberotha* Navás, 1930 (Neuropteroidea: Planipennia: Berothidae). *Zeitschrift der Arbeitsgemeinschaft Österreichischer Entomologen*, 35 (for 1983), 65–83. Available from: [http://www.landesmuseum.at/pdf\\_frei\\_remote/ZAOE\\_35\\_0065-0083.pdf](http://www.landesmuseum.at/pdf_frei_remote/ZAOE_35_0065-0083.pdf) (accessed on 13 March 2015)

- Aspöck, U. & Aspöck, H. (1985) Die Berothiden Australiens (und Neuseelands) II: Die Genera *Trichoma* Tillyard, *Trichoberothena* Handschin, *Protobiella* Tillyard und *Austroberothenella* n. g. (Neuropteroidea: Planipennia: Berothidae). *Zeitschrift der Arbeitsgemeinschaft Österreichischer Entomologen*, 36 (for 1984), 65–85. Available from: [http://www.landmuseum.at/pdf\\_frei\\_remote/ZAOE\\_36\\_0065-0085.pdf](http://www.landmuseum.at/pdf_frei_remote/ZAOE_36_0065-0085.pdf) (accessed on 13 March 2015)
- Aspöck, U. & Aspöck, H. (1986a) Das Genus *Lekrugeria* Navás (Neuropteroidea: Planipennia: Berothidae: Berothinae). *Zeitschrift der Arbeitsgemeinschaft Österreichischer Entomologen*, 37 (for 1985), 85–98. Available from: [http://www.landmuseum.at/pdf\\_frei\\_remote/ZAOE\\_37\\_0085-0098.pdf](http://www.landmuseum.at/pdf_frei_remote/ZAOE_37_0085-0098.pdf) (accessed on 13 March 2015)
- Aspöck, U. & Aspöck, H. (1986b) Die Berothiden Australiens III: Die Genera *Spermophorella* Tillyard und *Quasispermophorella* n. g. (Neuropteroidea: Planipennia: Berothidae). *Zeitschrift der Arbeitsgemeinschaft Österreichischer Entomologen*, 38, 17–34. Available from: [http://www.landmuseum.at/pdf\\_frei\\_remote/ZAOE\\_38\\_0017-0034.pdf](http://www.landmuseum.at/pdf_frei_remote/ZAOE_38_0017-0034.pdf) (accessed on 13 March 2015)
- Aspöck, U. & Aspöck, H. (1988a) Die Subfamilie Cyrenoberotheninae – ein Gondwana-Element? *Manselliberothera neuropterologorum* n.g. et n. sp. aus S.W.A./Namibia (Neuropteroidea: Neuroptera: Berothidae). *Zeitschrift der Arbeitsgemeinschaft Österreichischer Entomologen*, 40, 1–13. Available from: [http://www.landmuseum.at/pdf\\_frei\\_remote/ZAOE\\_40\\_0001-0013.pdf](http://www.landmuseum.at/pdf_frei_remote/ZAOE_40_0001-0013.pdf) (accessed on 13 March 2015)
- Aspöck, U. & Aspöck, H. (1998b) Intra- und interspezifische Differenzierungen im Genus *Nodalla* (Neuroptera: Berothidae) im Eremial der Westpaläarktis. *Entomologia Generalis*, 23, 39–76.
- Aspöck, U. & Aspöck, H. (1996) Revision des Genus *Podallea* Navás, 1936 (Neuroptera: Berothidae: Berothinae). *Mitteilungen der Münchener Entomologischen Gesellschaft*, 86, 99–144.
- Aspöck, U. & Aspöck, H. (1997) Studies on new and poorly-known Rhachiberothidae (Insecta: Neuroptera) from subsaharan Africa. *Annalen des Naturhistorischen Museums in Wien*, 99B, 1–20. Available from: [http://www.landmuseum.at/pdf\\_frei\\_remote/ANNA\\_99B\\_0001-0020.pdf](http://www.landmuseum.at/pdf_frei_remote/ANNA_99B_0001-0020.pdf) (accessed on 13 March 2015)
- Aspöck, U. & Aspöck, H. (2008) Phylogenetic relevance of the genital sclerites of Neuropterida (Insecta: Holometabola). *Systematic Entomology*, 33, 97–127.  
<http://dx.doi.org/10.1111/j.1365-3113.2007.00396.x>
- Aspöck, U. & Mansell, M.W. (1994) A revision of the family Rhachiberothidae Tjeder, 1959, stat. n. (Neuroptera). *Systematic Entomology*, 19, 181–206.  
<http://dx.doi.org/10.1111/j.1365-3113.1994.tb00587.x>
- Aspöck, U. & Nemeschkal, H.L. (1998) A cladistic analysis of the Berothidae (Neuroptera). *Acta Zoologica Fennica*, 209, 45–63.
- Aspöck, U. & Randolph, S. (2014) Beaded lacewings – a pictorial identification key to the genera, their biogeographics and a phylogenetic analysis (Insecta: Neuroptera: Berothidae). *Deutsche Entomologische Zeitschrift*, 61, 155–172.
- Azar, D. & Nel, A. (2013) A new beaded lacewing from a new Lower Cretaceous amber outcrop in Lebanon (Neuroptera: Berothidae). In: Azar, D., Engel, M.S., Jarzembowski, E., Krogmann, L., Nel, A. & Jorge Santiago-Blay, J. (Eds.), *Insect Evolution in an Amberiferous and Stone Alphabet. Proceedings of the 6th International Congress on Fossil Insects, Arthropods and Amber*. Brill, Leiden, Boston, pp. 111–130.
- Bachofen-Echt, A. (1949) *Der Bernstein und seine Einschlüsse*. Springer Verlag, Wien, 204 pp.
- Banks, N. (1905) A revision of the Nearctic Hemerobiidae. *Transactions of the American Entomological Society*, 32, 21–51.
- Blanchard, C.É. (1851) Mirmeleonianos. Rafidianos. In: Gay, C. (Ed.), *Historia Fisica y Politica de Chile. Zoologia. Vol. 6*. Claudio Gay & Museo de Historia Naturel de Santiago, Paris & Santiago, pp. 119–135.
- Costa, A. (1863) Nuovi studii sulla entomologia della Calabria ulteriore. *Atti della Accademia delle Scienze Fisiche e Matematiche di Napoli*, (1), 1 (2), 1–80.
- Engel, M.S. (2004) Thorny lacewings (Neuroptera: Rhachiberothidae) in Cretaceous amber from Myanmar. *Journal of Systematic Palaeontology*, 2, 137–140.  
<http://dx.doi.org/10.1017/S1477201904001208>
- Esben-Petersen, P. (1915) Neuropteren und Embiiden aus Ober-Aegypten und dem Aegypt. Sudan. *Entomologische Mitteilungen*, 4, 79–88.
- Faulkner, D.K. (1992) *A revision of the genus Lomamyia Banks (Planipennia: Berothidae) with an emphasis on the western United States species*. Unpublished Master thesis. California State University, Long Beach, CA, USA, xii + 119 pp.
- Handlirsch, A. (1906–1908) *Die fossilen Insekten und die Phylogenie der rezenten Formen. Ein Handbuch für Palaeontologen und Zoologen*. W. Engelmann, Leipzig, ix + 1430 pp. [Issued in 1906 (pp. 1–640); 1907 (pp. 641–1140); 1908 (pp. 1120–1430)]
- Khramov, A.V. (2015) Jurassic beaded lacewings (Insecta: Neuroptera: Berothidae) from Kazakhstan and Mongolia. *Paleontologicheskii Zhurnal*, 2015 (1), 26–34. [in Russian; English translation: *Paleontological Journal*, 49, 26–35]
- Krüger, L. (1923) Neuroptera succinica baltica. Die im baltischen Bernstein eingeschlossenen Neuroptera des Westpreussischen Provinzial-Museums (heute Museum für Naturkunde und Vorgeschichte) in Danzig. *Stettiner Entomologische Zeitung*, 84, 68–92.
- Kukulová-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.
- Linnaeus, C. (1758) *Systema naturae per regna tria naturae secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis, 10th ed., vol. 1*. Salvii, Holmiae, 824 pp.

- MacLeod, E.G. & Adams, P.A. (1968) A review of the taxonomy and morphology of the Berothidae, with the description of a new subfamily from Chile (Neuroptera). *Psyche*, 74 (3) (for 1967), 237–265.
- Makarkin, V.N. (1999) Fossil Neuroptera of the Lower Cretaceous of Baisa, East Siberia. Part 6. Mesithonidae (Insecta). *Neues Jahrbuch für Geologie und Paläontologie, Monatshefte*, 1999 (12), 705–712.
- Makarkin, V.N. (2015) A remarkable new genus of Mantispidae (Insecta, Neuroptera) from Cretaceous amber of Myanmar and its implications on raptorial foreleg evolution in Mantispidae: A comment. *Cretaceous Research*, 52 (B), 423–424. <http://dx.doi.org/10.1016/j.cretres.2014.06.012>
- 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., Ren, D. & Yang, Q. (2011) Two new species of *Sinosmylites* Hong (Neuroptera: Berothidae) from the Middle Jurassic of China, with notes on Mesoberothidae. *ZooKeys*, 130, 199–215. <http://dx.doi.org/10.3897/zookeys.130.1418>
- 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>
- Monserat, V.J. & Deretsky, Z. (1999) New faunistic, taxonomic and systematic data on brown lacewings (Neuroptera: Hemerobiidae). *Journal of Neuropterology*, 2, 45–66.
- Navás, L. (1910) Hemeróbidos (Ins. Neur.) nuevos con la clave de las tribus y géneros de la familia. *Brotéria (Zoológica)*, 9, 69–90.
- Navás, L. (1919) Algunos insectos Neurópteros de la República Argentina. Serie tercera [III]. *Revista de la Real Academia de Ciencias exactas, físicas y naturales de Madrid*, 17, 287–305.
- Navás, L. (1926) Névroptères d’Égypte et de Palestine. 3me partie. *Bulletin de la Société Royale Entomologique d’Égypte*, 10, 192–216.
- Navas, L. (1936) Mission Scientifique de l’Omo. Tome III. Fascicule 19. Neuroptera, Embioptera, Plecoptera, Ephemeroptera et Trichoptera. *Memoires du Museum Nationale d’Histoire Naturelle, Paris (N.S.)*, 4, 101–128.
- Oswald, J.D. (1993) Revision and cladistic analysis of the world genera of the family Hemerobiidae (Insecta: Neuroptera). *Journal of New York Entomological Society*, 101, 143–299.
- Oswald, J.D. (2013) Neuropterida Species of the World. Version 3.0. Available from: <http://lacewing.tamu.edu/Species-Catalogue/> (accessed 20 October 2014)
- 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. *Fossil insects of the Mesozoic*. Naukova Dumka, Kiev, pp. 82–111. [in Russian]
- Penny, N.D. (1985) Neuroptera of the Amazon Basin. Part 8. Berothidae. *Acta Amazonica*, 13 (for 1983), 689–695.
- Penny, N.D. & Winterton, S. (2007) Rediscovery of the unusual genus *Ormiscocerus* (Neuroptera: Berothidae: Cyrenoberothinae). *Proceedings of the California Academy of Sciences*, 58 (4), 1–6.
- Scheven, J. (2004) *Bernstein-Einschlüsse: Eine untergegangene Welt bezeugt die Schöpfung. Erinnerungen an die Welt vor der Sintflut*. Kuratorium Lebendige Vorwelt, Hofheim a.T., 160 pp.
- Shi, C.F., Ohl, M., Wunderlich, J. & Ren, D. (2015) A remarkable new genus of Mantispidae (Insecta, Neuroptera) from Cretaceous amber of Myanmar and its implications on raptorial foreleg evolution in Mantispidae. *Cretaceous Research*, 52 (B), 416–422. <http://dx.doi.org/10.1016/j.cretres.2014.04.003>
- Sziráki, G. (1996) Female internal genitalia of *Megalithone tillyardi* Riek, 1974 with comments on the systematic position of the neuropterous families (Neuroptera: Ithonidae). *Folia Entomologica Hungarica (N.S.)*, 57, 277–284.
- Tillyard, R.J. (1916) Studies in Australian Neuroptera. No. iv. The families Ithonidae, Hemerobiidae, Sisyridae, Berothidae, and the new family Trichomatidae; with a discussion of their characters and relationships, and descriptions of new and little-known genera and species. *Proceedings of the Linnean Society of New South Wales*, 41, 269–332.
- Tillyard, R.J. (1923) Descriptions of new species and varieties of lacewings (Order Neuroptera Planipennia) from New Zealand, belonging to the families Berothidae and Hemerobiidae. *Transactions and Proceedings of the New Zealand Institute*, 54, 217–225.
- Tjeder, B. (1959) Neuroptera-Planipennia. The Lace-wings of Southern Africa. 2. Family Berothidae. In: Hanström, B., Brinck, P. & Rudebec, G. (Eds.), *South African Animal Life. Results of the Lund University Expedition in 1950–1951, vol. 6*. Almqvist & Wiksell, Stockholm, pp. 256–314.
- Wedmann, S. & Makarkin, V.N. (2007) A new genus of Mantispidae (Insecta: Neuroptera) from the Eocene of Germany, with a review of the fossil record and palaeobiogeography of the family. *Zoological Journal of the Linnean Society*, 149, 701–716.
- Wedmann, S., Makarkin, V.N., Weiterschan, T. & Hörschemeyer, 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., 92 pls. [English Edition: (2002) *Atlas of plants and animals in Baltic amber*. Dr. Friedrich Pfeil Verlag, München, 256 pp. [92 plates]

- Whalley, P.E.S. (1980) Neuroptera (Insecta) in amber from the Lower Cretaceous of Lebanon. *Bulletin of the British Museum of Natural History (Geology)*, 33, 157–164.
- Wichard, W. (2014) Aquatische Neuropteren im Baltischen Bernstein. *DGaaE-Nachrichten*, 28 (1), 1–5.
- Yang, Q., Makarkin, V.N. & Ren, D. (2012a) New fossil Mesochrysopidae (Neuroptera) from the Mesozoic of China. *Zootaxa*, 3597, 1–14.
- Yang, Q., Makarkin, V.N., Winterton, S.L., Khramov, A.V. & Ren, D. (2012b) 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>
- Yang, Q., Makarkin, V.N. & Ren, D. (2014) Two new species of *Kalligramma* Walther (Neuroptera: Kalligrammatidae) from the Middle Jurassic of China. *Annals of the Entomological Society of America*, 107, 917–925. <http://dx.doi.org/10.1603/AN14032>