Zootaxa 5195 (4): 395–400
https://www.mapress.com/zt/

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ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)
https://doi.org/10.11646/zootaxa.5195.4.8
http://zoobank.org/urn:lsid:zoobank.org:pub:7E53D6B8-67BB-480B-BAC6-ADCF94D13EF2

A brown lacewing pupa (pharate adult) probably belonging to the genus *Sympherobius* (Neuroptera: Hemerobiidae) from Baltic amber

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The larvae of nearly all neuropteran families known from Baltic amber have been described or at least illustrated, *i.e*., Ascalaphidae, Berothidae, Chrysopidae, Coniopterygidae, Hemerobiidae, Mantispidae, Nevrorthidae, Nymphidae, Osmylidae, Psychopsidae and Sysiridae (MacLeod 1971; Weitschat & Wichard 1998: Pl. 53d; Janzen 2002: Fig. 57; Scheven 2004; Weitschat 2009; Wichard *et al*. 2009; Weitschat & Wichard 2010; Ohl 2011; Makarkin *et al.* 2012; Wedmann *et al.* 2013; Haug *et al*. 2020a, b, 2021, 2022a–c). Both early and latest instars are known for some taxa, but nothing is reported about the larvae of Ithonidae, which are extremely rare in Baltic amber.

Pupae of Neuroptera occur rarely in Baltic amber. Hitherto, the only photograph of one was published by Weitschat & Wichard (1998, Pl. 56g), which is probably a member of a different family rather than the pupa described here judging from its morphology.

The pupa of this order is decticous and exarate, *i.e*., it has functional mandibles, and its appendages project freely from the body. At its earlier stage it is unable to move, but in its last stage, *i.e*., the pharate adult, it breaks out of the pupal cocoon, and ultimately moults to an imago (Hinton 1968; Richards & Davies 1977). This stage is probably analogous to the pupa at the pre-emergence stage in Megaloptera (see Cao *et al*. 2018: Fig. 4).

Here, I describe a pharate adult from Baltic amber which can be determined to family and even genus.

Material and methods

This study is based on a single specimen embedded in a very small piece of Baltic amber (*ca*. 6 mm x 5 mm x 3 mm), which was collected at Yantarny (Kaliningrad Region, Russia). Photographs were taken by Carsten Gröhn using a Zeiss stereomicroscope modified with variable objectives (NikonMPlan 5x, 10x, 20x, 40x; ZEISS Luminar 18 mm, 25 mm, 40 mm) and an attached Canon EOS 450D digital camera.

Systematic paleontology

Class Insecta Linnaeus, 1758
Order Neuroptera Linnaeus, 1758
Family Hemerobiidae Leach, 1915
Subfamily Sympherobiinae Comstock, 1918
Sympherobius? sp., pharate adult

(Figs 1, 2)

Material. Specimen no. 7309, deposited in the collection of Mr. Carsten Gröhn, Glinde (Germany). A complete pharate adult. Baltic amber (Yantarny). Late Eocene.

Description. Pharate adult 3.4 mm long as preserved (presumed *ca*. 4.0 mm when extended). Head with large eyes. Maxillary palpus with four visible segments (basal segment not visible): 2nd short, most stout; 3rd and 4th elongate, stout; 5th (terminal) segment elongate, conical (acute apically), with short additional sub-segment ('false apical segment': Killington 1936, p. 17). Labial palpus 3-segmented; first segment relatively short; second segment elongate, stout; terminal segment conical, with very narrow, additional sub-segment. Antennae elongate, 44/46-segmented (difficult to count more precisely). Pronotum elongate, rather flat in lateral view; meso- and metathorax large. Legs slender; tibiae of hind legs

Accepted by X.-Y. Liu: 28 Sept. 2022; published: 13 Oct. 2022

strongly swollen. Wing pads *ca*. 1.6 mm long, *ca*. 0.5 mm wide; venation mostly poorly preserved, only fork of M of forewing clearly determinable. Abdomen: 1st and 8th segments relatively short; 2nd to 7th elongate; dorsal posterior parts of 3th and 4th segments elevated and furnished with two pairs of strongly curved hooks each; structure of apical segments not clear.

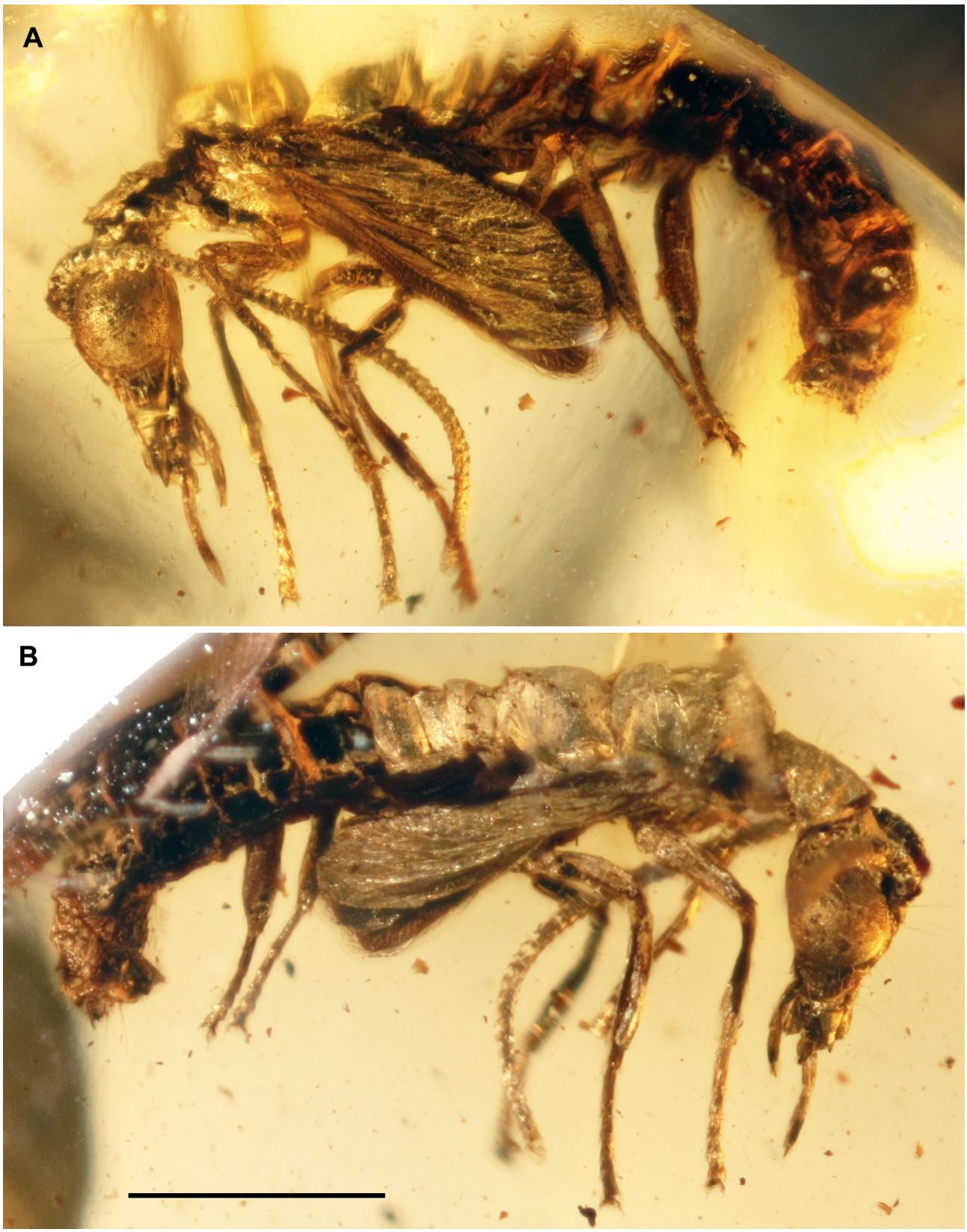

FIGURE 1. *Sympherobius*? sp., specimen no. 7309, pharate adult as preserved. A, left view; B, right view. Scale bar = 1 mm (both to scale).

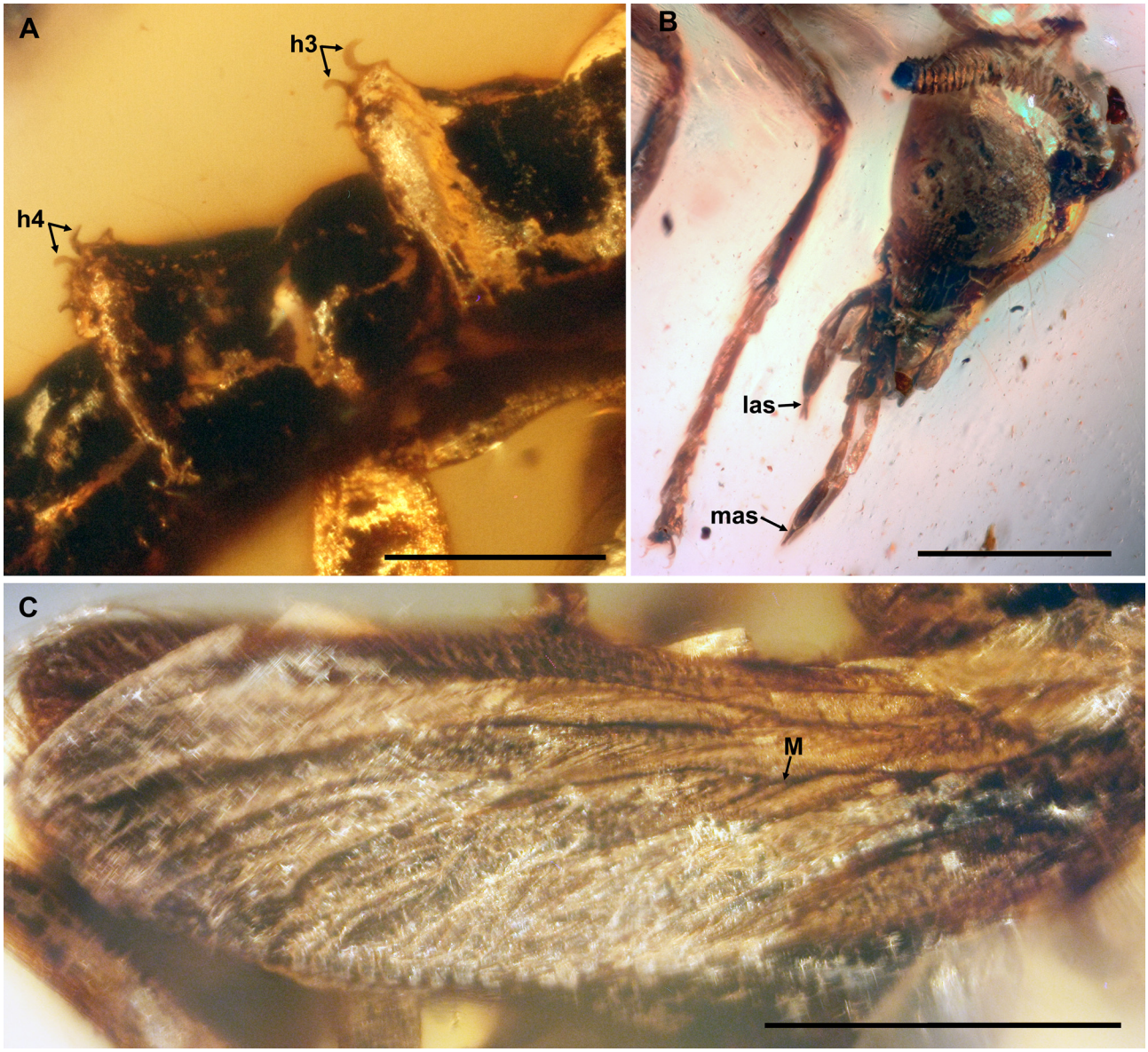

FIGURE 2. *Sympherobius*? sp., specimen no. 7309, details of pharate adult. A, third and fourth abdominal segments, lateral view; B, head, lateral view; C, left wing pads. h3, h4, dorsal hooks on 3th and 4th abdominal segments; las, distal sub-segment of terminal segment of labial palpus; M, media of forewing; mas, distal sub-segment of terminal segment of maxillary palpus. Scale bars = 0.5 mm.

Family affinity of the pharate adult

The specimen is small (approximately 4 mm long), and may reasonably belong to a family of small neuropterans. Eight families include at least a few small-sized species which may theoretically occur in Baltic amber, *i.e.*, Hemerobiidae, Berothidae, Sysiridae, Mantispidae, Dilaridae, Chrysopidae, Coniopterygidae, and Nevrorthidae. Other Baltic amber neuropteran adults are markedly larger, *i.e.*, Nymphidae, Psychopsidae, Ascalaphidae, Osmylidae, and Ithonidae.

A pharate adult is morphologically similar to an imago in most characters, but some of the pharate adult characters are lost in the imago, *e.g.*, dorsal hooks on its abdominal segments.

The pupa is known in many Hemerobiidae (*e.g.*, Killington 1936: Pl. 5, Fig. 5; Nakahara 1954: Pl. 4, Fig. 7, Pl. 5, Fig. 9; Pl. 6, Fig. 4; Agekyan, 1973: Fig. 3; Monserrat *et al*. 2001: Fig. 4.13). In all of them, two dorsal pairs of strongly curved hooks are present on the third and fourth abdominal segments.

In extant Berothidae, the pupa is known only in the North American *Lomamyia hamata* (Walker, 1853) (Brushwein 1987). In this species, "two pairs of short hooks were located dorsally on either side of the midline of the third and fourth

abdominal segment" (p. 675). Unfortunately, these hooks are poorly visible on Brushwein's photograph (1987: Fig. 5), but judging to his description, these hooks appear to be similar to those of the pharate adult described here.

Paired hooks on the pupa's 3rd and 4th abdominal segments are also present in all known Mantispidae, but they have raptorial forelegs (Bissett & Moran 1967; Gilbert & Rayor 1983; Hoffmann & Brushwein 1992; Dorey & Merritt 2017; Marquez-López & Contreras-Ramos 2018). The structure of hooks in Mantispidae is similar to those of our pharate adult (see Bissett & Moran 1967: Fig. 3; Hoffmann & Brushwein 1992: Figs 14, 20a, 26a).

In Sysiridae, there are numerous (24) small hooks on the third and fourth abdominal segments; these are also present on other segments (fifth to seventh), but their number is fewer (see Killington 1936; Parfin & Gurney 1956: Figs 6A, D).

In Osmylidae, 12 strong curved hooks are present on the 3rd to 5th segments (Killington 1936).

Abdominal hooks are not known in Dilaridae (*e.g.*, Gurney 1947: Fig. 16), Nevrorthidae (*e.g.*, Malicky 1984: Figs 5E, G), Chrysopidae (Killington 1936), and Coniopterygidae (*e.g.*, Monserrat *et al*. 2001: Figs 4.7c, d).

Therefore, the hooks of this pharate adult are similar in number, location and structure to those of Hemerobiidae, Berothidae, and Mantispidae. The presence of the additional sub-segment in the terminal segments of the maxillary and labial palpi is also important for determination of the family (Fig. 2B). This is characteristic of some Hemerobiidae, and not detected in Berothidae and Mantispidae.

Therefore, this pharate adult certainly belongs to Hemerobiidae.

Subfamily and genus affinities of the pharate adult

All or at least some genera of the four hemerobiid subfamilies possess an additional sub-segment of the terminal segments of the maxillary and labial palpi, *i.e*., Hemerobiinae, Sympherobiinae, Notiobiellinae and Drepanacrinae, according to the classification of Garzón-Orduña *et al*. (2016) (see Oswald 1993, appendix 5).

Sympherobiinae and Drepanepteryginae are represented in Baltic and contemporaneous Rovno ambers. The former includes two or three genera, *i.e*., *Sympherobius* Banks, 1904, *Prolachlanius* Krüger, 1923, and probably *Prospadobius* Krüger, 1923. Two other genera (*i.e.*, *Drepanepteryx* Leach, 1815 and *Proneuronema* Makarkin *et al*., 2016) belong to Drepanepteryginae; the terminal segments of their maxillary and labial palpi are whole (the additional sub-segment is absent) (Oswald 1993; Makarkin *et al*. 2016). Therefore, it is highly likely that the pharate adult belongs to Sympherobiinae.

The Sympherobiinae affinity is supported by the size of adult specimens found in Baltic amber, and by, *e.g*., its strongly swollen metatibia, and the number of its antennomeres. *Sympherobius completus* Makarkin & Wedmann, 2009 is 4 mm long, and *Prolachlanius resinatus* Hagen in Pictet-Baraban et Hagen, 1856 is slightly longer than 4–5 mm (pers. obs.), and so approximately the same length as the pharate adult. Also, the imagoes of Sympherobiinae are most abundant among hemerobiids of Baltic amber (*ca*. 72% of total known hemerobiid specimens, pers. data).

Genus affinity based on a pharate adult is generally hard to determine with certainty, but not in this case. Earlier, it was assumed that a larva described from Baltic amber may belong to *Prolachlanius resinatus* based on larval morphology and that this is the most abundant hemerobiid species here (Makarkin *et al.* 2012). However, this pharate adult highly likely belongs to another genus of Sympherobiinae, *i.e*., a species of *Sympherobius* based on relatively long antennae (44/45 segments), which are 44/47-segmented in three species of this genus from Baltic and Rovno ambers (Makarkin & Wedmann 2009; Jepson *et al*. 2010; Perkovsky & Makarkin 2020), while 35–39-segmented in *Prolachlanius resinatus* (Makarkin *et al*. 2019), and 38-segmented in *Prospadobius moestus* (Hagen in Pictet & Hagen, 1856) according to the original description of the only known but lost holotype.

It may be concluded, therefore, that this pharate adult certainly belongs to the hemerobiid subfamily Sympherobiinae, and highly likely to a species of *Sympherobius*.

Acknowledgements

I thank Carsten Gröhn (Glinde, Germany) for allowing this research on the specimen, performing photography, and answering my questions; Marius Veta (Palanga, Lithuanian) for information on the amber piece; S. Bruce Archibald (Simon Fraser University, Canada) for editing of the English.

References

Agekyan, N.G. (1973) Neuroptera feeding on bamboo aphids in Adzharia and their parasites *Entomologicheskoe Obozrenie*, 52, 549–564. [in Russian]

Banks, N. (1904) A list of neuropteroid insects, exclusive of Odonata, from the vicinity of Washington, D.C. *Proceedings of the Entomological Society of Washington*, 6, 201–217.

Bissett, J L. & Moran, V.C. (1967) The life history and coccon spinning behaviour of a South African mantispid (Neuroptera: Mantispidae). *Journal of the Entomological Society of Southern Africa*, 30, 82–95.

Brushwein, J.R. (1987) Bionomics of *Lomamyia hamata* (Neuroptera: Berothidae). *Annals of the Entomological Society of America*, 80, 671–679.

Cao, C.Q., Liu, F.Q., Tong, C., Fang, Y.Q., Xu, H.M. & Li, X. & Liu, X.Y. (2018) Description of the final-instar larva and pupa of *Neoneuromus ignobilis* Navás, 1932 (Megaloptera: Corydalidae). *Zootaxa*, 4378 (4), 581–588. https://doi.org/10.11646/zootaxa.4378.4.9

Comstock, J.H. (1918) *The wings of insects*. Comstock Publication Company, Ithaca, New York, 430 pp.

Dorey, J.B. & Merritt, D.J. (2017) First observations on the life cycle and mass eclosion events in a mantis fly (Family Mantispidae) in the subfamily Drepanicinae. *Biodiversity Data Journal*, 5, e21206 https://doi.org/10.3897/BDJ.5.e21206

Garzón-Orduña, I.J., Menchaca-Armenta, I., Contreras-Ramos, A., Liu, X.Y. & Winterton, S.L. (2016) The phylogeny of brown lacewings (Neuroptera: Hemerobiidae) reveals multiple reductions in wing venation. *BMC Evolutionary Biology*, 16, 192. https://doi.org/10.1186/s12862-016-0746-5

Gilbert, C. & Rayor, L.S. (1983) First record of mantisfly (Neuroptera: Mantispidae) parasitizing a spitting spider (Scytodidae). *Journal of the Kansas Entomological Society*, 56, 578–580.

Gurney, A.B. (1947) Notes on Dilaridae and Berothidae, with special reference to the immature stages of the Nearctic genera (Neuroptera). *Psyche*, 54, 145–169.

Haug, C., Posada Zuluaga, V., Zippel, A., Braig, F., Müller, P., Gröhn, C., Weiterschan, T., Wunderlich, J., Haug, G.T. & Haug, J.T. (2022a) The morphological diversity of antlion larvae and their closest relatives over 100 million years. *Insects*, 13, 587. https://doi.org/10.3390/insects13070587

Haug, G.T., Haug, C., Pazinato, P.G., Braig, F., Perrichot, V., Gröhn, C., Müller, P. & Haug, J.T. (2020a) The decline of silky lacewings and morphological diversity of long-nosed ant lion larvae through time. *Palaeontologia Electronica*, 23 (2), a39. https://doi.org/10.26879/1029

Haug, J.T., Baranov, V., Schädel, M., Müller, P., Gröhn, C. & Haug, C. (2020b) Challenges for understanding lacewings: how to deal with the incomplete data from extant and fossil larvae of Nevrorthidae? (Neuroptera). *Fragmenta entomologica*, 52 (2), 137–167.

Haug, J.T., Haug, G.T., Zippel, A., van der Wal, S., Müller, P., Gröhn, C., Wunderlich, J., Hoffeins, C., Hoffeins, H.-W. & Haug, C. (2021) Changes in the morphological diversity of larvae of lance lacewings, mantis lacewings and their closer relatives over 100 million years. *Insects*, 12, 860. https://doi.org/10.3390/insects12100860.

Haug, J.T., Kiesmüller, C., Haug, G.T., Haug, C. & Hörnig, M. (2022b) A fossil aphidlion preserved together with its prey in 40 million-year-old Baltic amber. *Palaeobiodiversity and Palaeoenvironments*. [in press] https://doi.org/10.1007/s12549-021-00521-z

Haug, J.T., Linhart, S., Haug, G.T., Gröhn, C., Hoffeins, C., Hoffeins, H.-W., Müller, P., Weiterschan, T., Wunderlich, J. & Haug, C. (2022c) The diversity of aphidlion-like larvae over the last 130 Million Years. *Insects*, 13, 336. https://doi.org/10.3390/insects13040336

Hinton, H.E. (1968) Spiracular gills. *In*: Beament, J.W.L., Treherne, J.E. & Wigglesworth, V.B. (Eds.), *Advances in Insect Physiology. Vol. 5*. Academic Press, London, New York, pp. 65–162.

Hoffman, K.M. & Brushwein, J.R. (1992) Descriptions of the larvae and pupae of some North American Mantispinae (Neuroptera: Mantispidae) and development of a system of larval chaetotaxy for Neuroptera. *Transactions of the American Entomological Society*, 118, 159–196.

Janzen, J.-W. (2002) *Arthropods in Baltic amber*. Ampyx Verlag, Halle, 167 pp.

Jepson, J.E., Penney, D. & Green, D.I. (2010) A new species of brown lacewing (Neuroptera: Hemerobiidae) from Eocene Baltic amber. *Zootaxa*, 2692 (1), 61–68. https://doi.org/10.11646/zootaxa.2692.1.4

Killington, F.J. (1936) *A monograph of the British Neuroptera. Vol. 1*. Ray Society, London, xix + 269 pp.

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.

Leach, W.E. (1815) Entomology. *In*: Brewster, D. (Ed.), *Edinburgh Encyclopaedia. Vol. 9. Pt. 1*. Blackwood, Edinburgh, pp. 57–172.

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.
Malicky, H. (1984) Ein Beitrag zur Autökologie und Bionomie der aquatischen Netzflüglergattung *Neurorthus* (Insecta, Neuroptera, Neurorthidae). *Archiv für Hydrobiologie*, 101, 231–246.
Makarkin, V.N., Perkovsky, E.E.& Gröhn, C. (2019) Neotype designation and re-description of *Prolachlanius resinatus* (Hagen) (Neuroptera, Hemerobiidae) from Baltic amber, with the first record of the species from Rovno amber. *Zootaxa*, 4688 (1), 57–70.
https://doi.org/10.11646/zootaxa.4688.1.2
Makarkin, V.N. & Wedmann, S. (2009) First record of the genus *Sympherobius* (Neuroptera: Hemerobiidae) from Baltic amber. *Zootaxa*, 2078, 55–62.
Makarkin, V.N., Wedmann, S. & Weiterschan, T. (2012) First record of a fossil larva of Hemerobiidae (Neuroptera) from Baltic amber. *Zootaxa*, 3417 (2), 53–63.
https://doi.org/10.11646/zootaxa. 3716.2.6
Makarkin, V.N., Wedmann, S. & Weiterschan, T. (2016) A new genus of Hemerobiidae (Neuroptera) from Baltic amber, with a critical review of the Cenozoic *Megalomus*-like taxa and remarks on the wing venation variability of the family. *Zootaxa*, 4179 (3), 345–370.
https://doi.org/10.11646/zootaxa.4179.3.2
Marquez-López, Y. & Contreras-Ramos, A. (2018) Description of the pupa of *Climaciella brunnea* (Say) (Mantispidae, Mantispinae) and a key to known pupae of mantispids from North America. *Zootaxa*, 4444 (1), 66–72.
https://doi.org/10.11646/zootaxa.4444.1.4
Monserrat, V.J., Oswald, J.D., Tauber, C.A. & Díaz-Aranda, L.M. (2001) Recognition of larval Neuroptera. *In*: McEwen, P. K., New, T.R. & Whittington, A.E. (Eds.), *Lacewings in the crop environment*. Cambridge University Press, Cambridge, pp. 43–81.
Nakahara, W. (1954) Early stages of some Japanese Hemerobiidae including two new species. *Kontyû*, 21, 41–46.
Ohl, M. (2011) Aboard a spider—a complex developmental strategy fossilized in amber. *Naturwissenschaften*, 98, 453–456.
https://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.
Parfin, S.I. & Gurney, A.B. (1956) The spongilla-flies, with special reference to those of the western hemisphere (Sisyridae, Neuroptera). *Proceedings of the United States National Museum*, 105, 421–529.
Perkovsky, E.E. & Makarkin, V.N. (2020) A new species of *Sympherobius* Banks (Neuroptera: Hemerobiidae) from the late Eocene Rovno amber. *Palaeoentomology*, 3, 196–203.
https://doi.org/10.11646/palaeoentomology.3.2.9
Pictet-Baraban, F.J. & Hagen, H.A. (1856) Die im Bernstein befindlichen Neuropteren der Vorwelt. *In*: Berendt, G.C. (Ed.), *Die im Bernstein befindlichen organischen Reste der Vorwelt gesammelt, in Verbindung mit Mehreren bearbeitet und herausgegeben von Dr. Georg Carl Berendt. Band 2. Abteilung 2*. Nicholaische Buchhandlung, Berlin, pp. 41–125.
Richards, O.W. & Davies, R.G. (1977) *Imm's General Textbook of Entomology. Tenth Edition. Vol. 1. Structure, Physiology and Development*. Chapman and Hall, London, viii + 418 pp.
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.
Walker, F. (1853) *List [or Catalogue] of the specimens of neuropterous insects in the collection of the British Museum. Part II*. British Museum [Natural History], London, 284 pp. [pp. 193–476]
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.
https://doi.org/10.11646/zootaxa.3716.2.6
Weitschat, W. (2009) Jäger, Gejagte, Parasiten und Blinde Passagiere – Momentaufnahmen aus dem Bernsteinwald. *Denisia*, 26, 243–256.
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 pls.].
Weitschat, W. & Wichard, W. (2010) Baltic amber. *In*: Penney, D. (Ed.), *Biodiversity of fossils in amber from the major world deposits*. Siri Scientific Press, Manchester, pp. 80–115.
Wichard, W., Gröhn, C. & Seredszus, F. (2009) *Aquatic insects in Baltic amber. Wasserinsekten im Baltischen Bernstein*. Verlag Kessel, Remagen, 336 pp.