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A New Alderfly in Baltic Amber (Megaloptera: Sialidae)

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ABSTRACT

A new species of alderfly (Megaloptera: Sialidae) is described and figured from a rare adult specimen preserved in middle Eocene (Lutetian) Baltic amber. ***Sialis* (*Protosialis*) *voigti***, new species, is distinguished from the two other species of *Protosialis* recorded from Baltic amber. The Megaloptera documented from Baltic amber are briefly overviewed and the geological history of Sialidae summarized.

INTRODUCTION

The Megaloptera (alderflies, dobsonflies, and fishflies) are relatively primitive members of the holometabolan superorder Neuropterida, notable for the plesiomorphic retention of a broad anal region in the hind wing. The order consists of about 275 species distributed throughout the world and segregated into two modern families—the large and robust Corydalidae (dobsonflies, fishflies), and the more diminutive Sialidae (alderflies). Larvae of both families are aquatic and generalist predators of small invertebrates. The final-instar larva emerges from the water and pupates in a chamber dug into soft soil. The adults are relatively short-lived, some living merely a week, and spend almost all of their time in vegetation near water.

Since Megaloptera are essentially aquatic insects, at least in their immature stages, their occurrence in Baltic amber is not common. Indeed, only 15–20 inclusions of adult Megaloptera seem to be known. Remarkably, two mature larvae are also known as amber inclusions, both of the family Sialidae—the first recorded by Weidner (1958; Weitschat and Wichard, 2002), the

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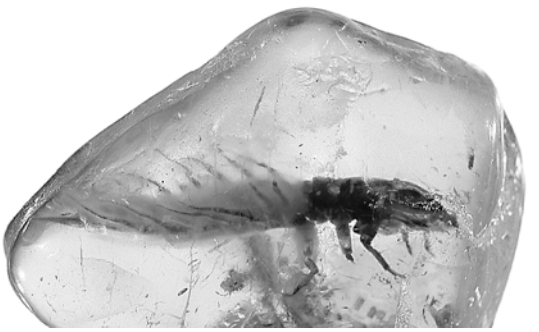


Fig. 1. Photomicrograph of a mature alderfly larva in middle Eocene Baltic amber (private collection of Mr. Jürgen Velten, Idstein).

second nearly a half a century later by Wichard (2005: fig. 1). These larvae were almost assuredly entombed shortly after leaving the water and while attempting to find a suitable location for a pupal chamber. In total the Baltic amber fauna contains seven species of Megaloptera, summarized in table 1.

Herein we provide the description of a new species of alderfly recently recognized in Baltic amber. The new species belongs to the modern genus *Sialis* and the subgenus *Protosialis* in particular, and is known from two adult females. Morphological terminology and venational nomenclature follow that employed elsewhere for Megaloptera (e.g., Wichard, 1997, 2002). The age and origin of Baltic amber has been reviewed by Weitschat and Wichard (2002) and Grimaldi and Engel (2005).

TABLE 1

Baltic Amber Megaloptera

Family CORYDALIDAE Leach 1815
†*Chauliodes prisca* Pictet-Baraban *In* Pictet-Baraban and Hagen 1856
†*Chauliodes carsteni* Wichard 2003
Family †CORYDASIALIDAE Wichard et al. 2005
†*Corydasialis inexpectatus* Wichard et al. 2005
Family SIALIDAE Leach 1815
†*Sialis groehni* Wichard 1997
†*Sialis* (*Protosialis*) *baltica* Wichard 1997
†*Sialis* (*Protosialis*) *herrlingi* Wichard 2002
†*Sialis* (*Protosialis*) *voigti* Wichard and Engel n.sp.

SYSTEMATIC PALEONTOLOGY

Genus *Sialis* Latreille

Sialis Latreille, 1802: 290. Type species: *Hemerobius lutarius* Linnaeus, 1758, by monotypy.

Protosialis van der Weele, 1909: 263. Type species: *Semblis americanus* Rambur, 1842, by original designation. [recognized as a subgenus]

Ilyobius Enderlein, 1910: 381. Type species: *Ilyobius flavicollis* Enderlein, 1910, by original designation. [= *Protosialis*]

Nipponosialis Kuwayama, 1962: 329. Type species: *Sialis jezoensis* Okamoto, 1910, by original designation. [= *Sialis* s.str.]

Protosiails Penny, 1977: 9. *Lapsus calami pro Protosialis*.

DIAGNOSIS: Adult with head prognathous and relatively flattened; compound eyes large, positioned laterally; ocelli absent; antennae filiform; mandibles strong, multidentate. Pronotum broad (width up to twice length), rectangular or trapezoid; meso- and metathorax of equivalent proportions and design. Legs moderately long and stout; tarsi pentamerous, fourth tarsomere bilobed (and heart-shaped), with fifth tarsomere inserted near base. Wings well developed, with complete venation typical of the order; fore- and hind wings with Sc fusing with R_1 before wing apex, R_3 forked in *Sialis* s.str., simple in *Protosialis*, M_{1+2} simple; forewing with M_{3+4} forked (New and Theischinger, 1993). Males with nine, females with seven fully exposed abdominal segments.

COMMENTS: The foundation for the classification and determination of species of Sialidae are the works of Lestage (1927) and Weele (1909, 1910). Weele (1909, 1910) established *Protosialis* as a separate genus. Later, Ross (1937) considered *Protosialis* a synonym of *Sialis*, and Whiting (1994) considered the group to be a basal subgenus. Today some authors prefer to retain *Protosialis* as generically distinct, but we consider it as a subgenus pending a comprehensive cladistic analysis of species in Sialidae. Unlike *Sialis* s.str., *Protosialis* has R_3 simple in both the fore- and hind wings while this vein is forked in the former group (New and Theischinger, 1993).

TABLE 2
Comparison of Baltic Amber *Protosialis*

	baltica	*herrlingi*	*voigti*
R_2 in both wings	simple	simple	forked
M_{3+4} in hind wing	forked	simple	simple

Sialis (Protosialis) voigti, new species
Figures 2–8

DIAGNOSIS: The new species shows the diagnostic combination of features typical of the subgenus *Protosialis*; i.e., R_3 and M_{1+2} are both unforked in the fore- and hind wings and M_{3+4} is forked in the forewing (New and Theischinger, 1993). The new species can most readily be distinguished from the other *Protosialis* species in Baltic amber by the combination of R_2 forked in both fore- and hind wings and by M_{3+4} unforked in the hind wing (table 2). In addition, R_4 and R_5 in both the fore- and hind wings are unforked.

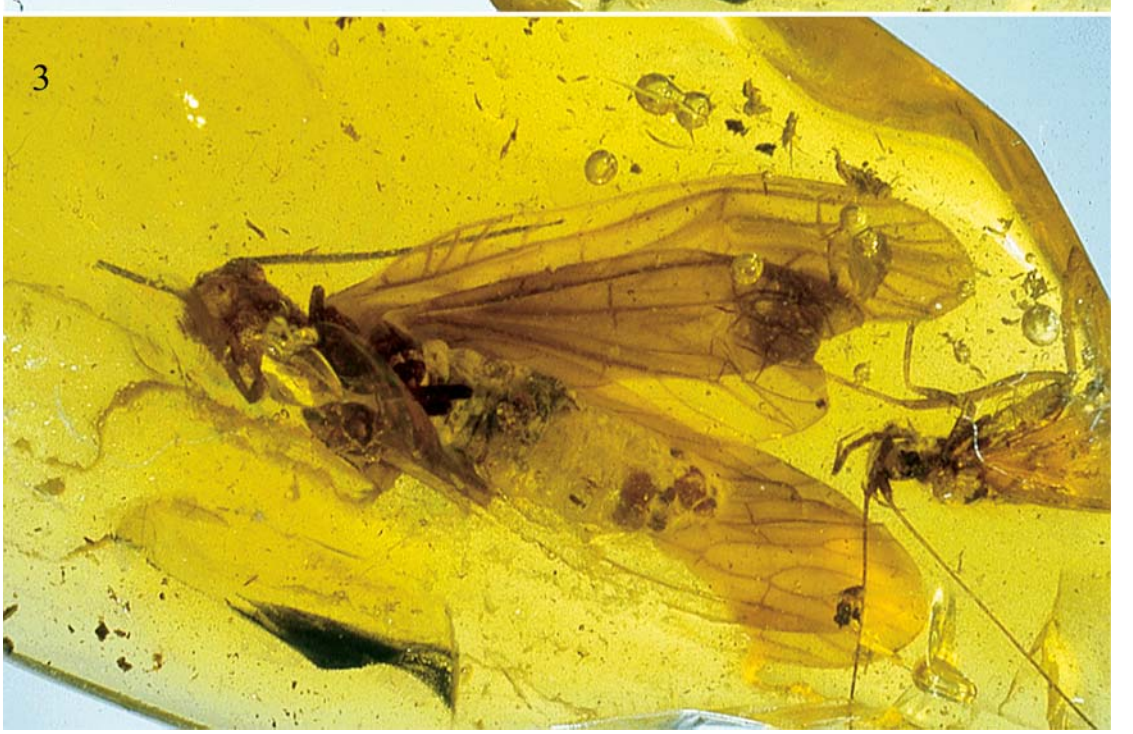
DESCRIPTION: **Female.** Total body length approximately 11.5 mm. Integument imbricate and dark brown where evident; wing veins dark brown, membrane hyaline. Head about as long as wide, with large compound eyes positioned laterally on anterior half of head. Mandibles stout; maxillary palpi 5-segmented; labial palpi 3-segmented; other mouthpart structures not discernable. Left antenna with 28 antennomeres (i.e., including scape and pedicel), right antenna partial; flagellomeres of roughly equal size, each slightly longer than wide. Ocelli absent. Tarsi of typical pentamerous construction, with fourth tarsomere bilobed and heart-shaped (distinguishing feature of Sialidae, along with the absence of ocelli). Forewing approximately 14 mm in length; costal field weakly arched, giving wing a slender form; seven c-sc crossveins present before termination of Sc; R_1 running parallel with Sc (with narrow subcostal cell between them) before veins merge near wing midpoint; R_2 forked near wing apex; R_3, R_4, and R_5 simple at wing apex; M_{1+2} simple; M_{3+4} forked near wing apex. Hind wing with R_2 forked near wing apex; R_3, R_4, R_5, M_{1+2}, and M_{3+4} simple (the last vein is easily seen in the right hind wing but challenging to discern in the left hind wing). Female terminalic sclerites as depicted in figure 6; sternite VIII with two, well-differentiated, lateral calli.

HOLOTYPE: Adult female in middle Eocene Baltic amber (figs. 2, 3); accession number KU-NHM-ENT, B-003; located in the Fossil Insect Collection, Division of Entomology, University of Kansas Natural History Museum, Lawrence, Kansas.

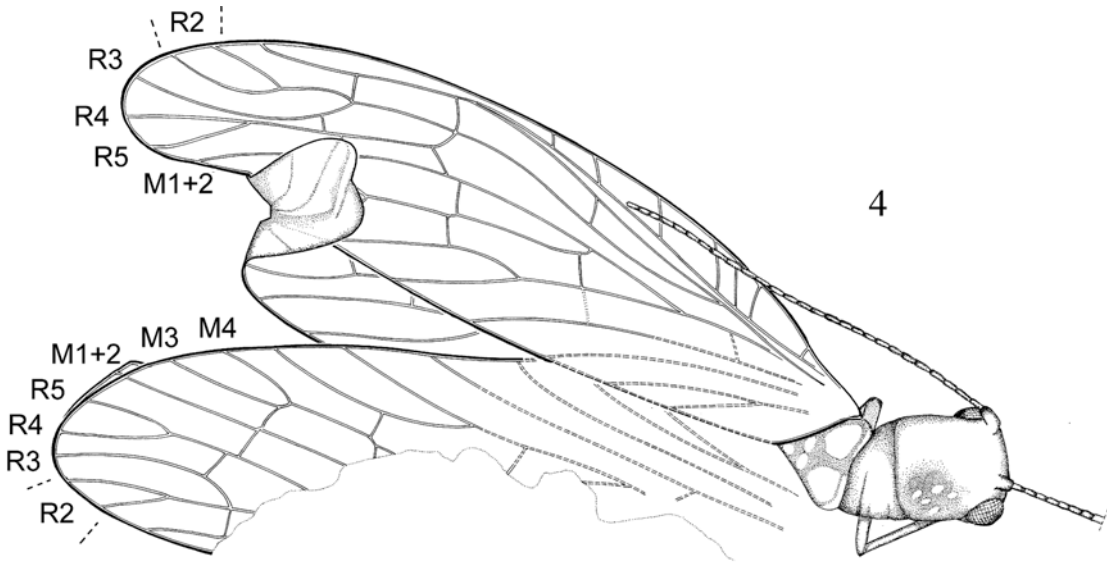
PRESERVATION: The holotype is on one side of a large, oval piece of clear, yellow amber of maximally 39 mm length and 20 mm width, with a mass of 3.3 g. In the immediate vicinity of the alderfly is a partial caddisfly (only the front half of the body preserved, the distal half of the body and the distal third of the wings are cut off) along the amber's edge. The maxillary palps, antennae, and legs permit identification of the caddisfly as a species of Leptoceridae (Trichoptera). The remaining and larger portion of the amber contains fine detritus and numerous stellate trichomes, characteristic of Baltic amber.

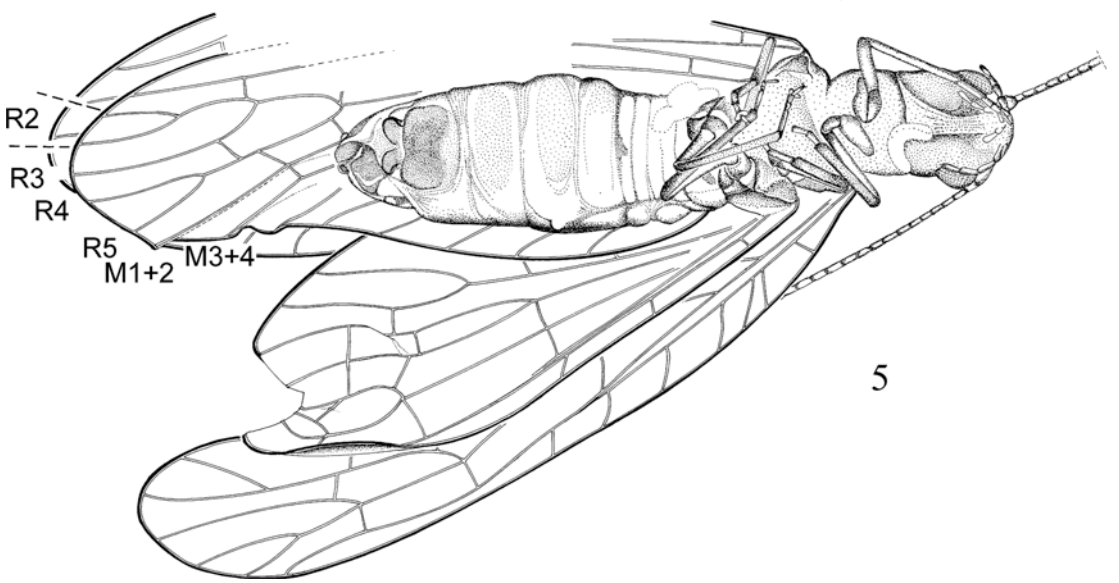
The alderfly is in remarkably good condition and, aside from being rather complete, is also well positioned in the amber, permitting detailed examination. The specimen has some Schimmel (a froth of microscopic bubbles) obscuring the integument in some areas, but none of it prevents identification. The right forewing is rather extensively damaged along its leading edge while the left forewing is complete, only slightly obscured near the apex of its posterior margin by the left hind wing being partly folded forward (figs. 4, 5). Both hind wings can be seen in ventral aspect and, despite a few minor folds and some obscuring by the abdomen, the venation can be easily discerned (figs. 4, 5). The legs are complete and preserved folded beneath the body. The right antenna is incomplete, but the left antenna is well preserved. The mouthparts are not easily viewed, except for the palpomeres of the labium and maxilla, which can be distinguished. The venter of the abdomen is easily examined, and the female genital sclerites can be sufficiently discerned (fig. 6).

ADDITIONAL MATERIAL: An adult female in middle Eocene Baltic amber (figs. 7, 8); specimen in the collection of Jürgen Velten, Idstein, Germany.



Figs. 2–3. Photomicrographs of the holotype female of ***Sialis* (*Protosialis*) *voigti***, n.sp. **2**. Dorsal aspect. **3**. Ventral aspect.





Figs. 4–5. Line illustration of the holotype female of ***Sialis* (*Protosialis*) *voigti***, n.sp. **4**. Dorsal aspect. **5**. Ventral aspect.

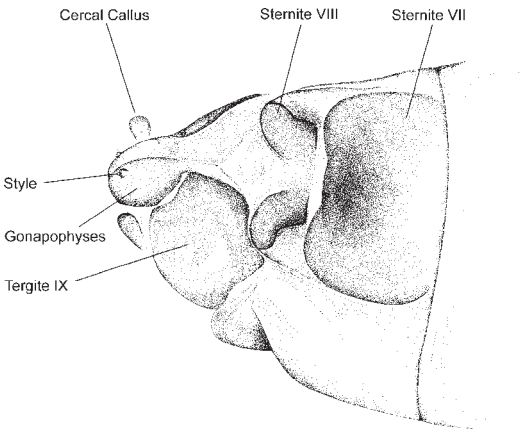


Fig. 6. Ventral aspect of the terminalia of the female holotype of ***Sialis* (*Protosialis*) *voigti***, n.sp.

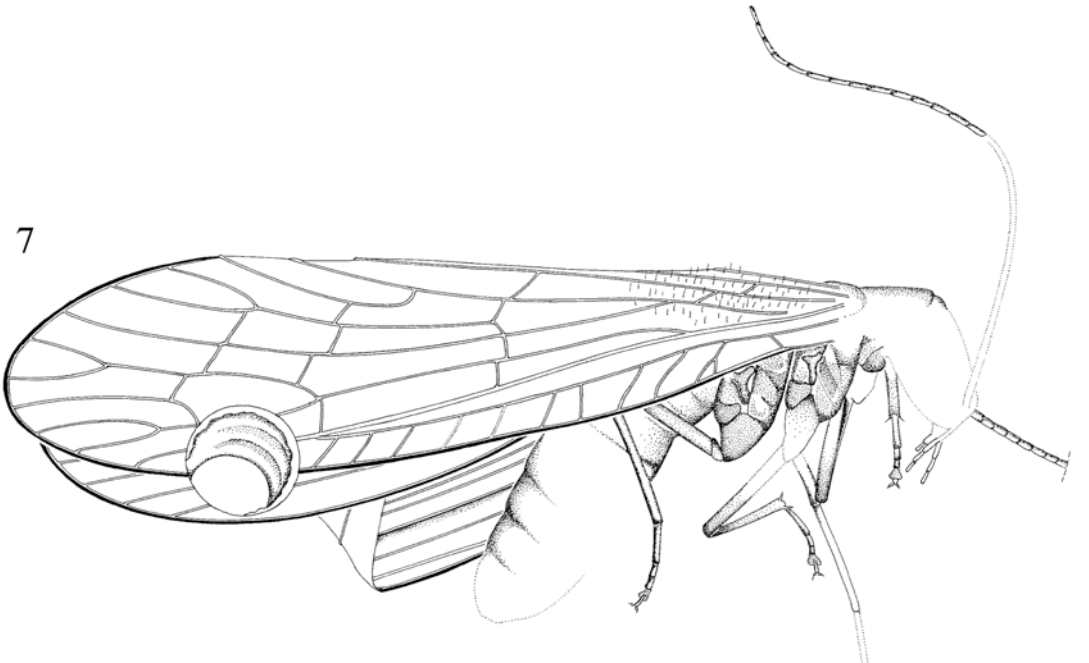
ETYMOLOGY: The specific epithet honors the late Peter C. Voigt (July 22, 1930–November 25, 2004). Peter was the heart and soul of the *Bernstein Arbeitskreis* (based in Hamburg), maintaining strong contact with each member and sharing with all his great enthusiasm for every aspect of amber and its study. He is greatly missed.

COMMENTS: The genital sclerites are typical for species of *Sialis* (e.g., Ross, 1937; New and Theischinger, 1993; Engel, 2004). Sternite VII is large and sclerotized but is otherwise little modified. Structural modifications are predominantly located on sternite VIII. Typically in Sialidae, sternite VIII forms a narrow, transverse strip with various, species-specific modifications. In *S. voigti* sternite VIII consists of two calli that are well separated medially (fig. 6). The calli are particularly strong apicolaterally and their form reinforced by a strong medial depression. Tergite IX is enlarged and extends ventrally to the sides such that it can be seen in ventral aspect, the apicolateral margins bordering the gonapophyses of the ovipositor (fig. 6). Subapically on the ventral margin of each gonapophysis is positioned a minute stylus. Cercal calli can be seen lateral to the ovipositor.

DISCUSSION

With the discovery of *S. voigti*, the number of alderflies in Baltic amber has risen to four and the number of Megaloptera to seven (table 1). Alderflies are exceptionally rare in amber, with only two larval and six adult (including the four holotypes) specimens documented. The two additional adult specimens are recorded as a paratype of *S. herrlingi* Wichard (2002) and the other as a putative *S. voigti* (herein, vide supra). The putative specimen of *S. voigti* has only the right forewing recognizable in which it depicts the forked R_2 and unforked R_3, R_4, and R_5, unforked M_{1+2}, and forked M_{3+4} typical for the species. The hind wings, however, are entirely covered, and the rear of the body is damaged and cleared (figs. 7, 8). Thus, definitive placement is not possible, but the evidence from the forewing is strongly suggestive.

Almost all fossil records of sialids are from the Tertiary and almost exclusively from Europe, with single records from Asia Minor and Australia (table 3). The earliest record of an alderfly is *Dobbertinia reticulata* (Handlirsch, 1925) (Sialidae: Dobbertiniinae) from the Liassic of Germany (Ansorge, 2001). *Dobbertinia* is plesiomorphic in almost all details for Sialidae but exhibits the characteristic partial desclerotization of MA in the forewing. Unfortunately, an approximately 120 million year gap exists until the next record of a fossil alderfly, a wing fragment of an unnamed *Austrosialis* from the Paleocene of Queensland, Australia (Lambkin, 1992). A real diversity of sialids is first observed in the Eocene, particularly the fauna recorded from Baltic amber. However, given the extreme paucity of specimens it is impossible to ascertain the true diversity of sialids in the Late Mesozoic or Early Tertiary and whether the family was already well established in during the Cretaceous or, like some other insect groups such as ants, bees, termites, chrysidoid wasps (Grimaldi and Engel, 2005; Engel, 2005), they were present but did not diversify until later in their evolution. Given the low diversity of Megaloptera today it is most likely that they have always been relatively species-poor and in moderate abundance. It is greatly hoped that more complete and extensive material of fossil Sialidae, particularly from the Cretaceous, will eventually be discovered and



Figs. 7–8. A putative specimen of ***Sialis* (*Protosialis*) *voigti***, n.sp. **7**. Illustration of the specimen. **8**. Photomicrograph of the specimen.

TABLE 3

Described Fossil Sialidae (Records of subfossils, i.e., Pleistocene or younger, are excluded)

Taxa	Deposit	Reference
—Jurassic—		
Dobbertinia reticulata (Handlirsch, 1925)	Germany	Ansorge, 2001
—Paleocene—		
Austrosialis sp.	Australia	Lambkin, 1992
—Eocene—		
Sialis groehni Wichard, 1997	Baltic amber	Wichard, 1997
Sialis (*Protosialis*) *baltica* Wichard, 1997	Baltic amber	Wichard, 1997
Sialis (*P.*) *herrlingi* Wichard, 2002	Baltic amber	Wichard, 2002
Sialis (*P.*) *voigti* Wichard and Engel, n.sp.	Baltic amber	Herein
Eosialis dorisi Nel et al., 2002	Parisian amber	Nel et al., 2002
—Miocene—		
Indosialis beskonakensis Nel, 1988	Turkey	Nel, 1988
Proindosialis cantalensis Nel, 1988	France	Nel, 1988
Sialis muratensis Nel, 1988	France	Nel, 1988
Sialis sp.	France	Nel, 1991
Sialidae indet.	France	Nel, 1991
—Pliocene—		
Sialis strausi Illies, 1967	Germany	Illies, 1967

the evolution of this order more fully understood.

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REFERENCES

Ansorge, J. 2001. *Dobbertinia reticulata* Handlirsch, 1920 from the Lower Jurassic of Dobbertin (Mecklenburg/Germany)—the oldest representative of Sialidae (Megaloptera). Neues Jahrbuch für Geologie und Paläontologie, Monatshefte 2001: 553–564.

Enderlein, G. 1910. Eine neue *Sialis* aus Columbien. Stettiner Entomologische Zeitung 71: 380–381.

Engel, M.S. 2004. The alderflies of Kansas (Megaloptera: Sialidae). Transactions of the Kansas Academy of Science 107(3–4): 119–125.

Engel, M.S. 2005. A dryinine wasp in Burmese amber (Hymenoptera: Dryinidae). Polskie Pismo Entomologiczne 74(4): 485–494.

Grimaldi, D., and M.S. Engel. 2005. Evolution of the insects. Cambridge: Cambridge University Press, xv + 755 pp.

Handlirsch, A. 1925. Palaeontologie. *In* C. Schröder (editor), Handbuch der Entomologie, Band 3: Geschichte, Literatur, Technik, Paläontologie, Phylogenie, Systematik: 117–306. Jena: Fischer, viii + 1201 pp.

Illies, J. 1967. Megaloptera and Plecoptera (Ins.) aus den jungpliozänen Süßwassermergeln von Willershausen. Bericht der Naturhistorischen Gesellschaft zu Hannover 111: 47–55.

Kuwayama, S. 1962. A revisional synopsis of the Neuroptera in Japan. Pacific Insects 4: 325–412.

Lambkin, K.J. 1992. A record of *Austrosialis* Tillyard from the Queensland Paleocene (Insecta: Megaloptera: Sialidae). Queensland Naturalist 31(3–4): 84–86.

Latreille, P.A. 1802. Histoire Naturelle, Générale et Particulière des Crustacés et des Insectes. Ouvrage faisant suite à l'histoire naturelle

générale et particulière, composée par Leclerc de Buffon, et rédigée par C.S. Sonnini, membre de plusieurs sociétés savantes. Tome troisième [3]. Paris: Dufart, xii + 467 pp.

Leach, W.E. 1815. Entomology. *In* D. Brewster (editor), The Edinburgh Encyclopaedia [Vol. 9, part 1]: 57–172. Edinburgh: Blackwood, [2] + 766 pp.

Lestage, J.A. 1927. Le faune entomologique indochinoise, 2: Les Megaloptères. Annales de la Société Entomologique de Belgique 67: 71–90, 93–119.

Linnaeus, C. 1758. Systema Naturae per regna tria natura, secundum classes, ordines, genera, species, cum characteribus, differentiis synonymis, locis [10th ed., revised]. Holmiae [Stockholm]: Laurentii Salvii, 824 pp.

Nel, A. 1988. Les Sialidae (Megaloptera) fossiles des diatomites de Murat (Cantal, France) et des Bes-Konak (Anatolie, Turque). Neuroptera International 5(1): 39–44.

Nel, A. 1991. Nouveaux insectes neuroptéroïdes fossiles de l'Oligocène de France (Neuroptera et Megaloptera). Bulletin du Muséum National d'Histoire Naturelle, Série 4, Section C (Sciences de la Terre Paléontologie, Géologie, Minéralogie) 12(3–4): 327–349.

Nel, A., J.-J. Menier, G. de Ploëg, G. Hodebart, and L. Danvin. 2002. *Eosialis*, a new alderfly genus in French lowermost Eocene amber (Insecta, Megaloptera, Sialidae). Geobios 35 (3): 313–319.

New, T.R., and G. Theischinger. 1993. Megaloptera: Alderflies, Dobsonflies. *In* M. Fischer (editor), Handbuch der Zoologie: Ein Naturgeschichte der Stämme des Tierreiches, Band IV Arthropoda: Insecta, Teilband 33: 1–97. Berlin: Walter de Gruyter, 102 pp.

Okamoto, H. 1910. Die Sialiden Japans. Wiener Entomologische Zeitung 29: 255–263.

Penny, N.D. 1977. Lista de Megaloptera, Neuroptera e Raphidioptera do México, América Central, ilhas Caraíbas e América do Sul. Acta Amazônica, suplemento 7: 1–61.

Pictet-Baraban, F.J., and H. Hagen. 1856. Die im Bernstein befindlichen Neuropteran der Vorwelt. *In* G.C. Berendt (editor), Die im Berstein befindlichen organischen Reste der Vorwelt [Vol. 2]: 41–126. Berlin: Nicolaischen Buchhandlung, [2] + 126 pp.

Rambur, J.P. 1842. Histoire naturelle des insectes, Néuroptères. Paris: Fain et Thunot, xvii + 534 pp.

Ross, H.H. 1937. Nearctic alder flies of the genus *Sialis* (Megaloptera, Sialidae). Illinois Natural History Survey Bulletin 21: 57–78.

Weele, H.W., van der. 1909. New genera and species of Megaloptera Latr. Notes from the Leyden Museum 30: 249–264.

Weele, H.W., van der. 1910. Megaloptera. Collections Zoologiques du Baron Edm. de Selys Longchamps, Catalogue Systématique et Descriptif 5: 1–93.

Weidner, H. 1958. Einige interessante Insektenlarven aus der Bernsteininklusen-Sammlung des Geologischen Staatsinstituts Hamburg (Odonata, Coleoptera, Megaloptera, Planipennia). Mitteilungen des Geologischen Staatsinstituts Hamburg 27: 50–68.

Weitschat, W., and W. Wichard. 2002. Atlas of Plants and Animals in Baltic Amber. Munich: Friedrich Pfeil Verlag, 256 pp.

Whiting, M.F. 1994. Cladistic analysis of the alderflies of American north of Mexico (Megaloptera: Sialidae). Systematic Entomology 19(1): 77–91.

Wichard, W. 1997. Schlammfliegen aus baltischen Bernstein (Megaloptera, Sialidae). Mitteilungen aus dem Geologisch-Paläontologischen Institut der Universität Hamburg 80: 197–211.

Wichard, W. 2002. Eine neue Schlammfliege aus dem baltischen Bernstein (Megaloptera, Sialidae). Mitteilungen aus dem Geologisch-Paläontologischen Institut der Universität Hamburg 86: 253–261.

Wichard, W. 2003. *Chauliodes*, ein Großflügler im baltischen Bernstein (Megaloptera, Corydalidae). Mitteilungen aus dem Geologisch-Paläontologischen Institut der Universität Hamburg 87: 147–158.

Wichard, W. 2005. Wasserinsekten im baltischen Bernstein—Zeitzeugen eines alttertiären Waldes. Biologie in unserer Zeit 35(2): 83–89.

Wichard, W., C. Chatterton, and A.J. Ross. 2005. Corydasialidae fam. n. (Megaloptera) from Baltic amber. Insect Systematics and Evolution 36(3): 279–283.

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