



40th

Anniversary of the Palaeoentomological Section
of the Polish Entomological Society

International Palaeoentomological Conference

FOSSIL INSECTS
BRIDGING PAST
& PRESENT

BOOK of ABSTRACTS
22-25 May 2025 | Kraków | POLAND





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Institute of Systematics and Evolution of Animals
Polish Academy of Sciences
17, Sławkowska Street, PL31-016 Kraków, Poland

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Monika Michalska – Institute of Paleobiology PAS, Warsaw

Editors: Katarzyna Kopeć, Elżbieta Sontag, Agnieszka Soszyńska, Jacek Szwedo

Typesetting: Elżbieta Sontag; **Cover:** Katarzyna Buss-Nykiel

This volume has been compiled from files supplied by the Authors.

ISBN: 978-83-61358-01-5

Published by: Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, 17,
Sławkowska Street, PL31-016 Kraków, Poland



Ministry of Science and Higher Education
Republic of Poland

Conference Fossil Insects Bridging Past & Present, 40th Anniversary of the Palaeontological Section of the Polish Entomological Society has been financed by the programme “Excellent Science II” of the Ministry of Science and Higher Education of Poland.

WELCOME

The Institute of Systematics and Evolution of Animals Polish Academy of Sciences is pleased to invite you to celebrate 40th anniversary of the Palaeontomological Section and attend the conference *Fossil Insects Bridging Past & Present* which will be held in Kraków, Poland, from 22nd-25th May 2025

The international conference “Fossil Insects – Bridging Past and Present” is being organized to commemorate the 40th anniversary of the Palaeontomological Section of the Polish Entomological Society. This special event celebrates four decades of palaeontomological research in Poland and highlights the important role that Polish scientists play in shaping the global landscape of fossil insect studies.

The conference will serve as a platform to showcase the richness and diversity of palaeontomological discoveries in Poland, with particular emphasis on fossil insects preserved both as impressions and as inclusions in resins – most notably in **Baltic amber**, considered a national treasure. Baltic amber is notable for its remarkably well-preserved inclusions, which offer unparalleled opportunities for the study of extinct insect taxa. This approach facilitates comprehensive morphological analyses, furnishes indispensable data that is crucial to comprehending past ecosystems, and offers insights into evolutionary processes.

The conference is intended for a broad scientific audience, comprising researchers, PhD students, and students with interests in palaeontomology, palaeoecology, and systematics. The opportunity is available for participants to explore the scientific potential of Polish collections and resources, engage with recent advances in palaeontomological methods and technologies, and foster international collaboration in this dynamic and interdisciplinary field.

The conference has been made possible by the financial support of the “Excellent Science II” programme, which is administered by the Ministry of Science and Higher Education of Poland.

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ABSTRACTS

**RUBY JUBILEE OF THE PALAEOENTOMOLOGICAL SECTION
OF THE POLISH ENTOMOLOGICAL SOCIETY
40 YEARS HAVE PASSED AS ONE DAY**

R. Szadziewski* & E. Sontag

²*Museum of Amber Inclusions, Faculty of Biology, University of Gdańsk, Poland;*

● 0000-0002-2899-6861 (R.S.), ● 0000-0002-5966-8334 (E.S.)

**ryszardszadziewski@gmail.com*

Keywords: palaeoentomology, fossil, insect, history, Poland

The Paleontological Section was established during the meeting of Polish entomologists on 19 April 1985 at Regional Museum in Częstochowa. The participants expressed their willingness to collaborate in studies on fossil insects in the group named later as Palaeoentomological Section of the Polish Entomological Society.

The Section was chaired by prof. Jan Koteja (1985-1998), prof. Wiesław Krzemiński (1998-2004), prof. Ryszard Szadziewski (2004-2008) and dr Elżbieta Sontag (since 2008). In the past 40 years once a year, 41 meetings of the Section have been held in Częstochowa (1), Bytom (1), Katowice (3), Mogilany (1), Kraków (12), Warsaw (3), Gdańsk and Gdynia (20). In addition, members of the group each year visited International Fair of Amber Amberif in Gdańsk to hunt for inclusions and to meet friends.

As a research discipline palaeoentomology started to flourish in Poland 40 years ago. It was great time for studies on fossil insects, especially from ambers, good time of close national and international collaboration and developing deep friendships. Polish palaeoentomologists prepared many monographs, books and scientific papers published in prestigious journals. They studied and described many new fossil insects from Baltic amber and from other fossil resins or sediments almost from all continents. The research activity in studies on fossil insects was a major factor in getting the scientific title of professor by Ryszard Szadziewski (1996), Wiesław Krzemiński (2003), Piotr Węgierek (2011) and Iwona Kania-Kłosok (2024). The International Amber Association in recognition of research on inclusions and amber promotion awarded the title of *Amber Personality of the year* to prof. Jan Koteja (2000), dr Elżbieta Sontag (2007), dr hab. Jacek Szwedo (2017) and Ryszard Szadziewski (2018). Also Polish Entomological Society honoured the Section including to the group of honorary members prof. Barbara Kosmowska-Ceranowicz (1989), prof. Ryszard Szadziewski (2008) and prof. Wiesław Krzemiński (2019).

Members of the Section worked in International Amber Association since 1996 and in the World Amber Council (2006-2021). The World Amber Council in Gdańsk proclaimed World Amber Day on 28 June and the Amber Anniversary (44 years of a marriage). New public institutions collecting amber and inclusions were founded: Museum of Amber Inclusions at University of Gdańsk (1998) and Museum of Amber (2000).

The time like a crocodile is merciless. The Section lost eight active members who passed away: mgr Tadeusz Giecwicz (1928-1992), dr Andrzej Skalski (1938-1996), dr Róża Kulicka (1944-1999), prof. Sędzimir M. Klimaszewski (1937-2001), prof. Jan Koteja (1932-2004), dr hab. Antoni Kuśka (1940-2010), Jacek Serafin (1940-2022) and dr. hab. Daniel Kubisz (1957-2025).

In 2001 Wiesław Krzemiński and Ewa Krzemińska invited to Kraków palaeoentomologists from Eastern and Western countries for the congress on fossil insects. During this congress in Kraków the vigorously working International Palaeoentomological Society was founded with own prestigious journal *Palaeoentomology* since 2018 (IF 1.9).

The period of 40 years from 1985 to 2025 (ruby jubilee) was the great time of prosperity of amber promotion and Polish palaeoentomology. We hope that future will still be gracious for fossil insects and their students.



Fig. 1. Participants of the international conference celebrating 25th anniversary of the Museum of Amber Inclusions, 23-26 May 2023, Gdańsk (photo R. Mielczarek).

TINY BEASTS LOST IN TIME: A REVIEW OF FOSSIL MICRO-WASP FAMILIES

S. Álvarez-Parra

State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, China; 0000-0002-0232-1647

**sergio@nigpas.ac.cn*

Keywords: Hymenoptera, Proctotrupomorpha, diversity, parasitoidism, Cretaceous

Hymenoptera are holometabolous insects including wasps, bees, and ants that constitute the fourth most diverse insect order today, with more than 150,000 known species¹. Hymenopterans are widely distributed in terrestrial ecosystems, playing key ecological roles and showing diverse lifestyles, such as herbivory, predation, parasitoidism, pollination, and eusociality¹. The main anatomical characteristic of Hymenoptera is the hamuli, which are tiny hooks on the anterior margin of hind wings that allow their coupling with the forewings and improving their flight dynamics². From a phylogenetic point of view, Hymenoptera represent the sister group to the rest of the holometabolous insects¹. Traditionally, they have been divided into 'Symphyta', 'Parasitica', and Aculeata. However, the two former groupings were found as paraphyletic and the relationships between families are usually unstable in different analyses, hindering the knowledge about the evolutionary history of the group³.

The fossil record of Hymenoptera comprises more than 4,300 described species and the oldest representative of the group dates back to the Late Triassic⁴. The origin of Hymenoptera is estimated in a time range from the end of the Carboniferous to the beginning of the Permian¹, while the first major radiation took place after the Permo-Triassic mass extinction in gymnosperm-dominated ecosystems involving the 'Symphyta'⁴. The parasitoid groups emerged during the Triassic and underwent successive diversification and extinction phases along the Mid-Mesozoic Parasitoid Revolution⁴. The radiation of the angiosperms linked to the Angiosperm Terrestrial Revolution affected the Hymenoptera, triggering the diversification of some groups, like those related to angiosperm-pollination, and causing the extinction of others probably due to competition⁴.

Several families of Hymenoptera are known as micro-wasps in relation to their tiny size, usually a few millimeters and sometimes even less than half a millimeter. Most of the species of micro-wasps are parasitoids of other arthropods, but some of them are known to be herbivorous and/or pollinator. Generally, the term micro-wasps includes the proctotrupomorph groups Platygastridae, Diapriidae, †Serphitidae, Mymarommatoidea, Chalcidoidea, †Chalcidionidae, †Jurapriidae, and †Trupochalcididae (all forming the informal group Microprocta⁵) and the Ceraphronoidea. Here, we present a review of the fossil families belonging to these groups of micro-wasps, commenting their phylogenetic affinities and the known paleobiological information.

The superfamily Platygastridae includes two Cretaceous families, †Caradiophyodidae and †Proterosciopsidae. The †Spathiopterygidae are the only fossil family in Diapriidae. The Mymarommatoidea have a diverse fossil record, including the fossil †Alavarommatidae, †Dipterommatidae, and †Gallorommatidae. The †Serphitidae, divided into †Archaeoserphitidae and †Serphitidae, are known only from Cretaceous ambers. Among the Chalcidoidea, the two Cretaceous families †Diversinitidae and †Protoitidae (Fig. 1) and the Eocene family †Leptoomidae have been described. Finally, the Ceraphronoidea do not include any fossil family, as two families previously assigned to this group (†Radiophronidae and †Stigmaphronidae) probably belong to Aculeata. The study of fossil families is essential to understand the evolutionary history of Hymenoptera and the origin of their modes of life.



Fig. 1. A female micro-wasp preliminarily identified as *Cretaxenomerus* sp. (Chalcidoidea: †Protoitidae) from the Lower Cretaceous amber of Hammana-Mdeyrij, Lebanon.

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EARLY EOCENE INSECTS FROM GREIFSWALDER OIE ISLAND, GERMANY

J. Ansorge

*Institute of Geography and Geology, University of Greifswald, Germany; ☎ 0000-0002-1284-6893**ansorge@uni-greifswald.de***Keywords:** Tertiary, Ypresian, Fur Formation, Moclays, cementstones

The marine Danish Moclays (Moler) of the early Eocene Fur Formation (Ypresian, c. 55.6 Ma) is one of the most productive insect Lagerstätten of the world. Thousands of specimens are housed in Danish and German museum and private collections.

The Moclays of northern Jutland is well exposed in coastal cliffs and open cast mines on the islands Mors and Fur. It consists of laminated marine clayish diatomite with ca. 200 intercalated volcanic ash layers and about 36 levels of limestone concretions (cementstone, *dan.* cementsten, *germ.* Zementsteine) with a rich marine and terrestrial fossil record.^{1,2}

The vast amounts of basaltic ashes originate from rifting processes between Greenland and NW Europe leading to the opening of the North Atlantic Ocean. Most of the ash was windblown to the southeast and deposited on large areas of Fennoscandia and in the Palaeo-North Sea and North German Basin.

During the early Eocene, the climate in the supposed Fennoscandian source mainland of the insects was paratropical. The deposition of the Moclays insects occurred shortly after the Paleocene-Eocene Thermal Maximum (PETM) under calm, often anoxic conditions of the sediment and high productivity of the siliceous phytoplankton.

Rocks, similar to the Danish cementstones are also known as glacial erratic boulders from the small Baltic Sea island Greifswalder Oie and the adjacent Pomeranian mainland (NE-Germany), about 450 km to the SE.³ The lithology of these boulders differs from the Danish ones, in that they contain considerably more clastic material, indicating a shorter distance to the shoreline. Most of the type 2 cementstones contain one or more distinct ash layers with highly bioturbated marly sedimentary background, however no insects. Remains of insects (wings) are rather common in more or less laminated clayey volcanic dust layers of type 1 cementstones with mass occurrences of the giant diatom *Fenestrella antiqua* (Fig. 1A). Early cementation of the fine-grained rock matrix is the reason of the preservation of the wing corrugation. Images of wings in the black basaltic rocks are best taken by steaming the specimens with ammoniumchloride (NH₄Cl) [Fig. 1I-J]. Up to now, about 190 insect remains have been found of which 17.6 % are undetermined. 12 orders have been recorded: Odonata (0.5 %), Saltatoria (0.5 %), Blattodea (2.7 %, Fig. 1A), Isoptera (0.5 %), Neuroptera (15.0 %, Fig. 1I-J), Homoptera-Auchenorrhyncha (21.3 %, Fig. 1B-D), Homoptera-Sternorrhyncha (Aphidina, 4.2 %), Heteroptera (4.2 %), Trichoptera (0.5 %), Lepidoptera (3.2 %), Coleoptera (1.6 %), Hymenoptera (3.7 %, Fig. 1G-H) and Diptera (Nematocera, 18.2 %, Fig. 1E; Brachycera, 9.1 %, Fig. 1F). The faunal composition resembles that of the Danish Fur Formation,⁴ and many species are the same. In contrast, termites (Isoptera), chironomids (Diptera: Chironomidae), sawflies (Hymenoptera: Tenthredinidae) and some still undescribed taxa are known only from NE-German cementstones. The diversity of tropical Nogodinidae like planthoppers (Homoptera: Fulgoromorpha, Fig. 17B, D) with at least five to six recorded species is remarkable, as is the noticeable number of leafhoppers (Cicadellidae). The differences in the composition of the Danish and the NE-German insect taphocoenoses can most probably be explained by the different distances to the mainland rather than by any ecological reasons.

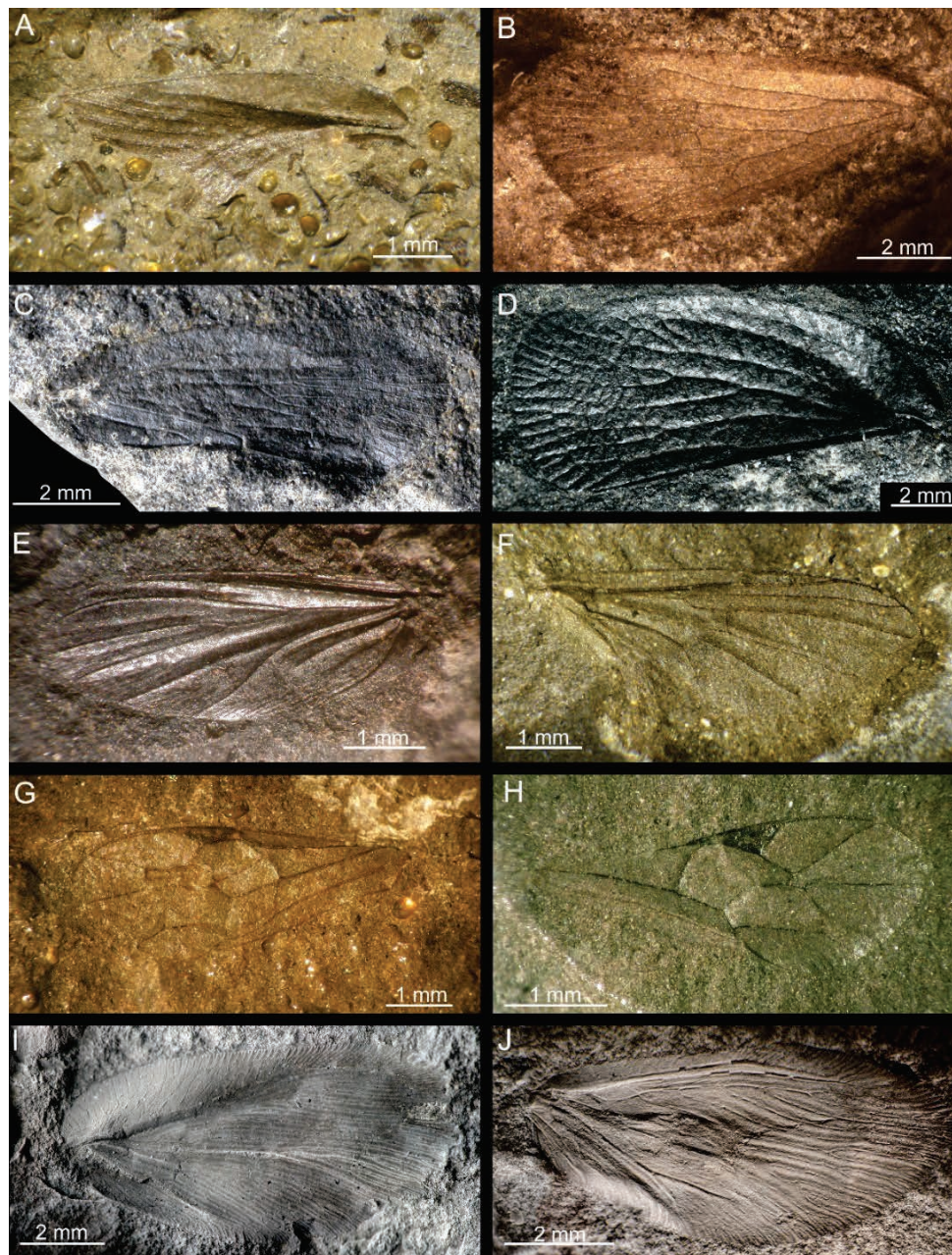


Fig. 1. Early Eocene insects from cementstones of Greifswalder Oie island, Germany. A Blattodea, forewing, B Nogodinidae hindwing (Homoptera, Fulgoromorpha), C Cixiidae forewing (Homoptera, Fulgoromorpha), D Nogodinidae forewing (Homoptera, Fulgoromorpha), E *Garettella* sp. wing (Diptera, Bibionomorpha), F Pipunculidae wing (Brachycera), G Trigonalalydae forewing (Hymenoptera), H Ichneumonidae forewing (Hymenoptera), I *Proneuronema* sp. forewing (Neuroptera, Hemerobiidae), J *Proneuronema* sp. hindwing (Neuroptera, Hemerobiidae).

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ARACHNIDA FROM EL SOPLAO CRETACEOUS AMBER (SPAIN): STATE OF KNOWLEDGE

A. Arillo^{1,*}, E. Peñalver², R. López Del Valle³¹Departamento de Biodiversidad, Ecología y Evolución, Facultad de Biología, Universidad Complutense, Madrid, Spain;

✉ 0000-0002-4878-5797

²Instituto Geológico y Minero de España, CSIC, Valencia, Spain; ✉ 0000-0001-8312-6087³Museo de Ciencias Naturales de Álava, Vitoria-Gasteiz (Álava), Spain; ✉ 0000-0002-7164-9558;

*antonioarillo@gmail.com

Keywords: Albian, Araneae, Acariformes, Parasitiformes, Pseudoscorpionida

Amber, a resin produced by different trees present in the fossil record, is a very important source of information about ancient ecosystems, as it well-preserved organisms. While our understanding of Spanish Cretaceous ambers has developed over 30 years of research, the majority of described species are insects, reflecting their high abundance¹.

Although approximately 140 amber localities have been found on the Iberian Peninsula, only two of them have yielded an important amount of bioinclusions, both located in the Basque-Cantabrian Basin. The El Soplao outcrop, middle Albian in age, has produced more than 1,550 while Peñacerrada I (also known as Moraza) and Peñacerrada II sites, both upper Albian age, have collectively produced more than 3,500 bioinclusions.

In this communication we study the assemblage of arachnid inclusions from El Soplao amber, and we compare it with its assemblage of insect inclusions. From this study we exclude plants, vertebrates, crustaceans, millipedes and ichnofossils as spider webs remains. Arachnids represent around 6% of these inclusions (99 specimens) while 94% of them are insects (1,501 specimens).

Among these 99 fossil specimens we have 42 belonging to Araneae (42.4%), 38 to Acariformes Trombidiformes (38.3%), 15 to Acariformes Oribatida (15.1%), 3 to Pseudoscorpionida (3.0%) and 1 to Parasitiformes Ixodida (1.0%).

In the Peñacerrada (Álava) assemblage, the insect bioinclusions represent 93% of the total while arachnids represent 7% and from them 64 belong to Araneae (25.7%), 163 to Acariformes Trombidiformes (65.4%), 19 to Acariformes Oribatida (7.6%) and 3 to Pseudoscorpionida (1.2%), lacking a record of Ixodida (0%).

Only 5 species have been described from El Soplao amber to date^{2,3,4}: Araneae with *Soplaogonomegops unzuei* Pérez-de la Fuente, Saupe and Selden, 2013 (Lagonomegopidae) and *Orchestina rabagensis* Saupe, Pérez-de la Fuente, Selden, Delclòs, Tafforeau and Soriano, 2012 (Oonopidae); and Acariformes Oribatida with *Afronthrus ornosae* Arillo and Subías, 2016 (Trhypochthoniidae), *Nothrus vazquezae* Arillo and Subías, 2016 (Nothridae) and *Platyliodes sellnicki* Arillo and Subías, 2016 (Neolioididae).

A comparison of the El Soplao and Peñacerrada (I and II) ambers reveals that: 1) despite their age difference, the similar percentages of insects and arachnids suggest comparable environmental conditions, arthropodofauna composition, and taphonomic biases; 2) there is a lack of co-occurrence of genera and species, with the exception of the genus *Orchestina*, which is also found in Peñacerrada I (and San Just amber); and 3) in contrast to the insect record, the scarcity of arachnid bioinclusions in Spanish amber makes meaningful comparisons between different assemblages challenging, highlighting the need for further paleontological excavations and amber preparation.

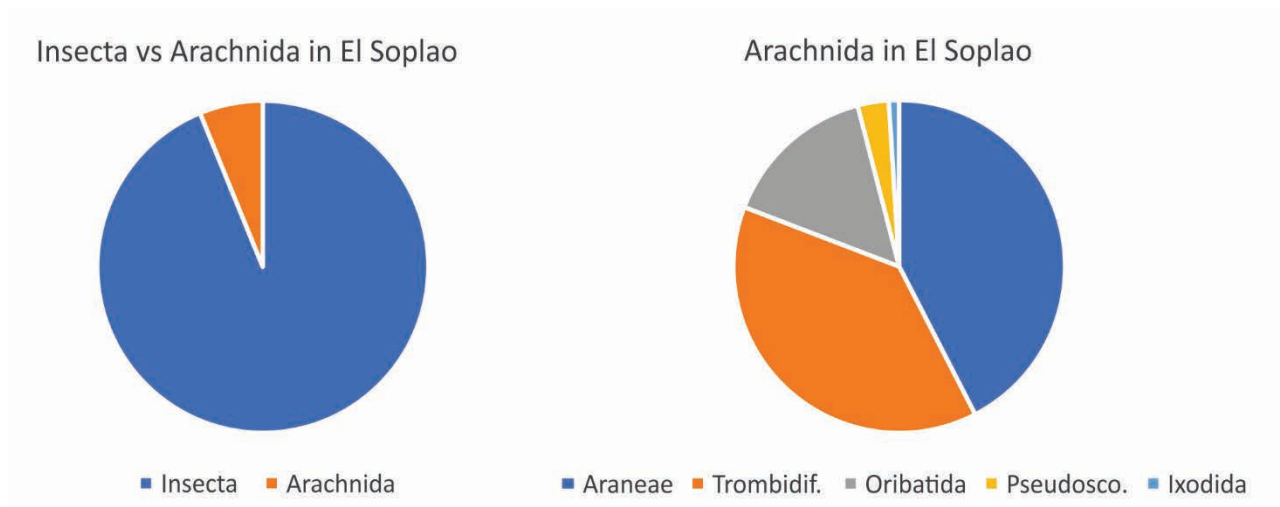


Fig. 1. Percentage of arachnids compared to insects and percentage of each group of arachnids represented in El Soplao Cretaceous amber.

This work is a contribution to the project PID2022-137316NB, funded by MICIU/AEI/10.13039/501100011033 and by ERDF/EU, and to the projects of the *Consejería de Industria, Turismo, Innovación, Transporte y Comercio* of the *Gobierno de Cantabria* through the semi-public enterprise EL SOPLAO S.L. (#20963 with the University of Barcelona and Ref. VAPC 20225428 with the IGME, CSIC).

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**A PRELIMINARY REPORT OF THE EARLY PLEISTOCENE ENTOMOFAUNA OF SHAMB
(SISIAN, ARMENIA)**

A.I. Avrithis^{1,*} & I. Gabrielyan², D. Vasilyan^{3,4}

¹*The Open University, Milton Keynes, United Kingdom; 0000-0001-7813-5843*

²*A.L. Takhtajan Institute of Botany of the Armenian National Academy of Sciences, Yerevan, Armenia;*

0000-0002-5522-4242

³*JURASSICA Museum, Route de Fontenais 21, 2900 Porrentruy, Switzerland; 0000-0001-8712-0678*

⁴*University Fribourg, Chemin de Musée 6, 1700 Fribourg, Switzerland*

**tonyavrithis@gmail.com*

Keywords: Pleistocene, biodiversity, entomofauna, Armenia, steppe

South Armenia is characterised by a rich record of Pleistocene diatomitic deposits, representing lacustrine environments in the volcanically active period. Here, Shamb outcrop contains the longest sequence, which has been dated at late Early Pleistocene (1.7-1.2 Ma) using of absolute and relative dating methods^{1,2}. Palynological and palaeobotanical studies of the outcrop indicated a changing environment from steppe to temperate and humid forested environments³, probably reflecting Pleistocene intense climatic oscillations. Among fossil insects are numerous which, however, except the reference of their presence¹, were not systematically published. This work aims to reinitiate the study of the fossil entomofauna of Shamb, which is particularly rich and diverse. A total of 122 specimens have been examined. The burial in diatomite rock led to the excellent preservation of insects, with some specimens showing the preservation of microtrichia, spurs and color patterns. A possible contamination of water bodies with volcanic ash triggered bloom of diatom algae and probably caused anoxia and an excellent burial⁴.

The identifiable specimens from the Shamb section include Hymenoptera (10), Hemiptera (14), Diptera (14), Coleoptera (78) and Orthoptera (6). Our identification of the material at the family level allowed to confirm the presence of 21 families. Among Hymenoptera we could record Formicidae, Apidae, Megachilidae, and Tenthredinidae families. Hemiptera were represented by Cicadellidae, Aphrophoridae, Cercopidae, Pentatomidae, Corixidae, Coreidae families, whereas Diptera by Mycetophilidae, Bibionidae, and Opomyzidae families. Orthoptera are present by Acrididae and Tettigoniidae. Finally, the most abundant order Coleoptera is present by Curculionidae (making the majority of the group), Carabidae, Buprestidae, Lampyridae (?), Elateridae, and Staphylinidae families. The dominance of Coleoptera in the fossil record of the area may be explained either by taphonomical bias (more resistant cuticle) or due to habitat type (near-shore, shallow water setting).

The Pleistocene record of insects is scarce, with only a few sites from Russia and USA being studied extensively⁵. The further work on this locality will decipher the responses of insects in changing climatic conditions, their range shifts due to glaciation cycles and the interpretation of the modern distribution of several taxa. Finally, a future stratigraphic sampling may allow to trace faunistic changes between different strata, corresponding to different climatic cycles.

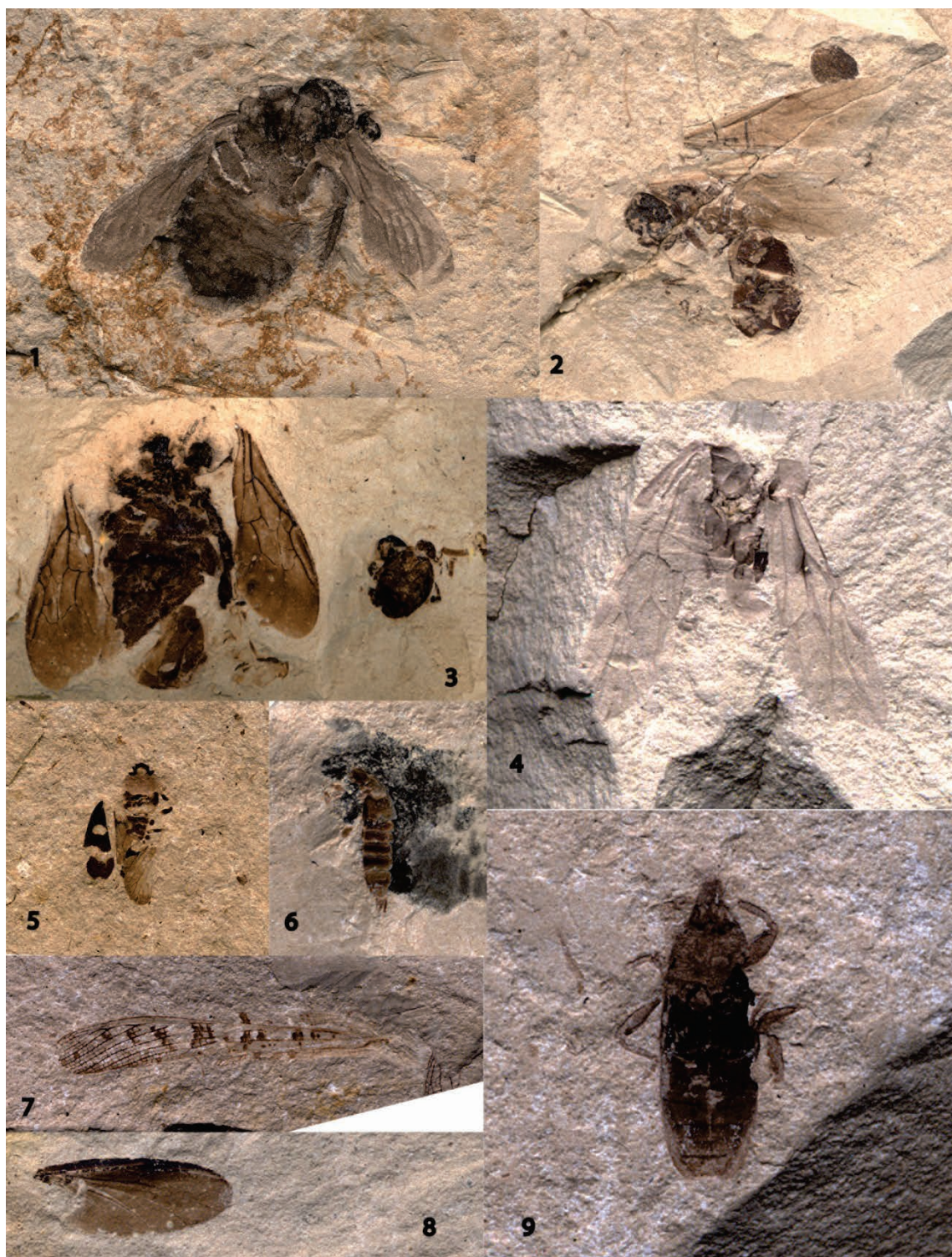


Fig. 1. Examples of nicely preserved specimens: 1. Apidae, 2. Formicidae, 3. Megachilidae (*Chalicodoma* sp.), 4. Tenthredinidae (*Allantus* sp.), 5. Cercopidae (cf. *Cercopis vulnerata*), 6. Staphylinidae, 7. Acrididae, 8. Bibionidae (cf. *Biblio marci*), 9. Curculionidae

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THE LOWER BARREMIAN DYSODILE KONSERVAT-LAGERSTÄTTE OF BKASSINE (SOUTH LEBANON): INSIGHTS ON THE FOSSIL CONTINENTAL ASSEMBLAGES

D. Azar^{1,2,*}, S. Maksoud², N. Robin^{3,4}, L. de Brito⁵, P. Godefroit⁴, S. Olive^{4,6}, L. Cavin⁷,
N. Vallée-Gillette⁴, K. Rey^{8,9} & G. Heneine¹⁰

¹Nanjing Institute of Geology and Palaeontology, CAS, Nanjing, China; [0000-0002-4485-197X](tel:0000-0002-4485-197X)

²Lebanese University, Faculty of Science II, Natural Sciences Department, Fanar, El-Matn, Lebanon;
[0000-0001-7437-7490](tel:0000-0001-7437-7490) (S.M)

³Géosciences Rennes, Univ. Rennes – CNRS, Rennes, France; [0000-0002-1756-3171](tel:0000-0002-1756-3171) (N.R)

⁴Institute of Natural Sciences, Brussels, Belgium; [0000-0002-0922-7872](tel:0000-0002-0922-7872) (P. G.), [0009-0002-7538-6692](tel:0009-0002-7538-6692) (N.V-G)

⁵Centre de recherche en Paléontologie, Muséum national d'Histoire naturelle, Paris, France; [0000-0003-4491-4413](tel:0000-0003-4491-4413)

⁶University of Liège, Liège, Belgium; [0000-0001-9690-7464](tel:0000-0001-9690-7464)

⁷Muséum d'Histoire naturelle de Genève, Geneva, Switzerland; [0000-0001-9666-5864](tel:0000-0001-9666-5864)

⁸Archaeology, Environmental Changes & Geo-Chemistry, Vrije Universiteit Brussel, Brussels, Belgium;
[0000-0002-6788-2453](tel:0000-0002-6788-2453)

⁹Université Claude Bernard Lyon 1, CNRS, ENSL, UJM, LGL-TPE, UMR 5276, Villeurbanne, France;

¹⁰Lebanese Palaeontological and Evolutive Association, Fanar, Lebanon; [0009-0007-1092-2921](tel:0009-0007-1092-2921)

*danyazar@ul.edu.lb

Keywords: Lower Cretaceous, Lebanon, palaeobiodiversity, palaeoenvironment

The Early Cretaceous marks a pivotal phase in the evolution of terrestrial ecosystems, during which many modern biological lineages first emerged – a phenomenon referred to as the Cretaceous Terrestrial Revolution. This interval, characterized by significant global warming, witnessed the early diversification of angiosperms and the concurrent radiation of key insect pollinators, including flies, butterflies, beetles, and bees. Modern-like faunal groups also began to dominate terrestrial and aquatic environments, including the rise of spiny-rayed fishes in marine settings and the persistence of early-diverging ray-finned fishes in freshwater systems. Non-avian dinosaurs and birds underwent extensive diversification, while early placental mammals also appeared.

In Lebanon, finely laminated sedimentary rocks known as dysodiles, rich in organic matter and exceptional fossil preservation, provide a unique window into these ecosystems. Although sporadically documented in early 20th-century literature, Lebanese dysodiles – particularly from the Early Barremian – had been largely overlooked until recent geological surveys led to their rediscovery. Our work focuses on the Bkassine locality in southern Lebanon, where dysodiles are embedded within the lower Barremian sandstone formation. These deposits are spatially associated with volcanic material, suggesting a potential link between volcanism and fossil preservation.

We present new data on a diverse fossil assemblage from these layers, including several tetrapods (anurans, chelonians, lizards, and possible archosaur remains), a varied ichthyofauna (coelacanth, putative polypteriforms, and small teleosts), pulmonate gastropods, aquatic insects, plant macroremains and palynomorphs (ferns, algae, spermatophytes), ostracods, and coprolites. Together, this assemblage supports a preliminary palaeoenvironmental reconstruction of a freshwater lake ecosystem located near volcanic edifices and bordered by typical Early Cretaceous flora. This lake likely hosted early-diverging actinopterygians alongside more derived teleosts that would later form the foundation of modern fish diversity.

AMBERART – A JOURNEY BETWEEN SCIENCE AND BEAUTY

E. Bonino

Rue G.Thiriart 74, 4000 Liège, Belgium; ☎ 0000-0002-4590-2759

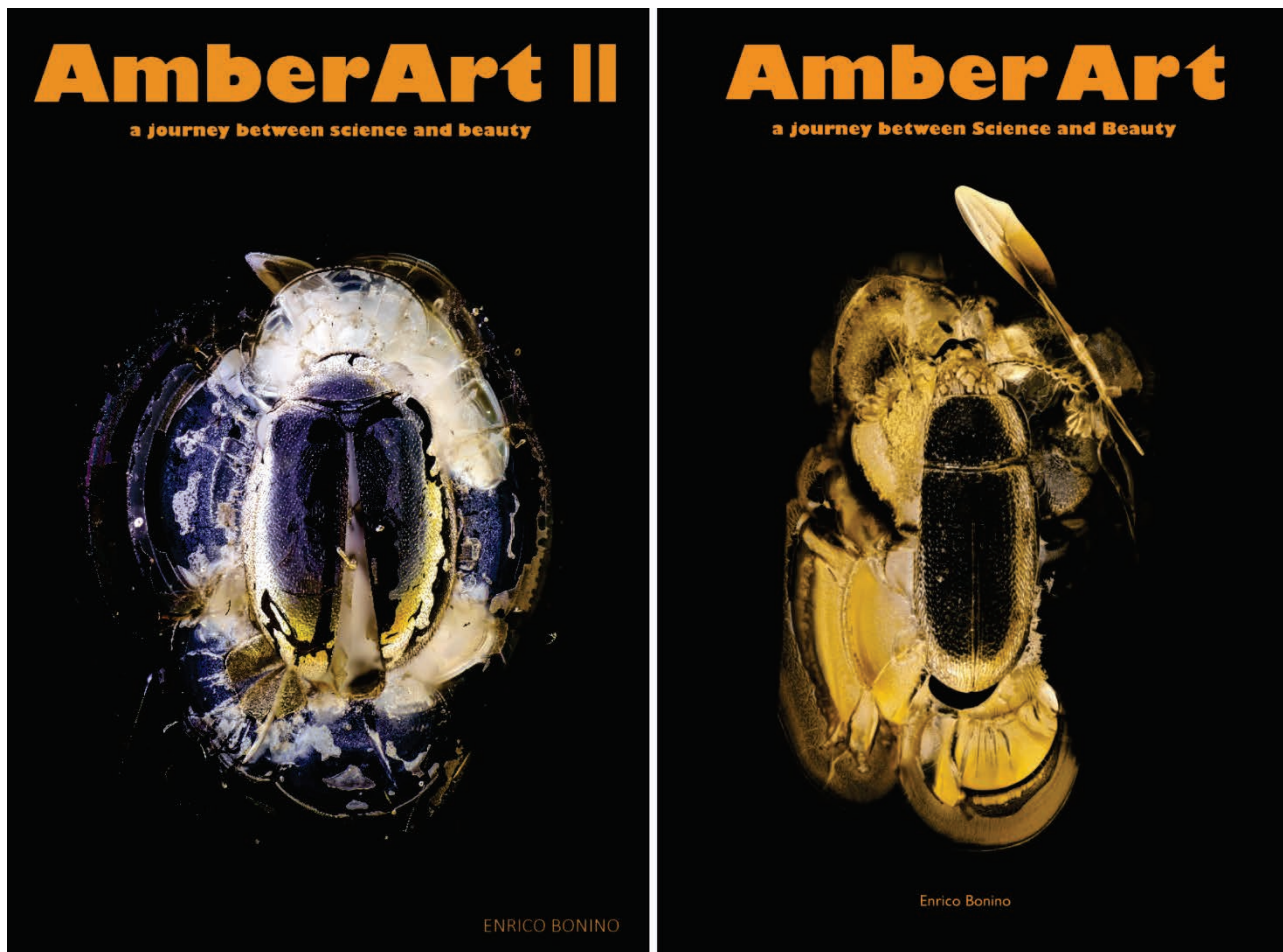
enrico-bonino@outlook.com

Keywords: inclusions, macrophotography, technique, image stacking, art

Fossil resins are found globally and include those classified as ambers. To date, at least 200 sites have been identified where fossil resins contain bioinclusions and inorganic inclusions. Amber, due to its distinctive capacity for preserving fossils, can be regarded as the optimal medium for the preservation of complete fossils, thus constituting ideal Konservat-Lagerstätten, as defined by Adolf Seilacher¹. Inclusions are most often minute objects, thus necessitating specialised and sophisticated photography techniques. *AmberArt – a journey between science and beauty*² combined scientific analysis with aesthetic appreciation, showcasing the beauty of organisms enclosed in amber. The plant and animal inclusions presented originated from diverse geographical regions and span multiple geological eras – Cretaceous Cenomanian amber from Myanmar, Eocene amber from the Baltic Sea region and Ukraine, Miocene amber from the Dominican Republic, and inclusions in subfossil copal, defaunation resin from Madagascar. Approximately 330 photographs of inclusions resulted from extreme macro photography revealed the beauty of nature, allowing for a close encounter with the biodiversity of the past, showing fascinating worlds that once teemed with life. This volume was met with considerable acclaim among professionals, collectors, and enthusiasts of natural science, which subsequently led to the publication of a second volume.

The present volume, just published *AmberArt II – a journey between science and beauty*³, is organised in the same manner as the first volume. The objective is to conserve the taxonomic classification of arthropods, whilst also incorporating other equally intriguing inclusions, such as feathers, plants, vertebrates, and non-biological elements. It focuses particularly on the inclusions found in Cenomanian amber (Upper Cretaceous, ~99 million years ago) from Myanmar, showing inclusions from this extraordinary region of Southeast Asia. Inclusions from other locations are also included, because of their aesthetic value, scientific value, and availability. The aim of this book is to interest readers in the beauty hidden in amber. In addition to the specimens from the author's collection, the volume was also created thanks to the cooperation of collectors and professionals who provided photos and specimens from their private and public collections. Many of the specimens in this volume are very rare, previously undescribed and have great paleontological value. This volume contains about 480 photographs of inclusions captured using the most modern macrophotography techniques and advanced image stacking techniques. The extreme macrophotography, and the entire system, described in the last chapter of the volume, is based basically on a mirrorless camera, microscopic lenses, and all of this is controlled by a micro-stepper motor, which allows for recording frames at intervals of a few microns between each photo. Depending on the lens used, since the depth of field is extremely small (even a few microns), dozens or even hundreds of photos may be needed to cover the entire thickness of the object.

The two *AmberArt* volumes are designed to amaze and intrigue, to give the profound impressions, to reveal inclusions intrinsic, mystical beauty. Now, more than ever, it is important to appreciate this richness of life forms, this incredible microcosm, the beauty and the complexity of the living, and the importance of every single organism on this tiny, wonderful planet.



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DIVERSITY OF COCCIDULINI (COLEOPTERA: COCCINELLIDAE) IN EOCENE BALTIC AMBER

T. Czerwiński* & K. Szawaryn

Museum and Institute of Zoology, PAS, Warszawa, Poland; ☎ 0000-0002-0598-7858 (T.C.),

☎ 0000-0002-9329-4268 (K.S.)

*tczerwinski@miiz.waw.pl

Keywords: Baltic amber, fossil, ladybird beetles, Eocene, evolution

Ladybird beetles (Coccinellidae) are one of the best recognizable groups of insects by the general public. Ladybirds comprise about 6,000 species classified in about 360 genera (Ślipiński and Tomaszewska 2010). Traditional classification, based on morphological features, divided them into six or seven subfamilies and about 40 tribes. Recent investigation using more advanced methods of molecular phylogenetics and broad sampling have recognized only three subfamilies: Microweiseinae, Coccinellinae and Monocoryninae¹. Molecular dating of the age of the origin of ladybirds to date results in varied estimates. Most of them place the origin of this group of beetles in the early Cretaceous: from about 118 Mya to 144 Mya (Zhang et al. 2018, McKenna et al. 2015, Che et al. 2021, Toussaint et al. 2017). However, some estimates suggest even much older period of the group's divergence, namely the late Jurassic, about 150 Mya (Li et al. 2020). Regardless of the estimated divergence time of the whole group, however, the early Cretaceous is considered to be a period of increased speciation of ladybirds, particularly the subfamily Coccinellinae¹.

Currently thirteen species of fossil ladybird beetles are known. The oldest representatives of this family were described from Eocene Oise amber (~53 Mya) from France and classified in genera *Rhyzobius* Stephens, 1832 (2 species) and *Nephus* Mulsant, 1846 (1 species)². Recent studies of Baltic amber inclusions (~37-45 Mya) have revealed a variety of Eocene ladybird beetles representing two subfamilies, Microweiseinae and Coccinellinae, and four extant tribes. The discovered taxa represent two modern genera *Serangium* Blackburn, 1889 (tribe Serangiini – 3 species)³ and *Rhyzobius* (tribe Coccidulini – 3 species)⁴, and two fossil genera *Electrolotis* Szawaryn & Tomaszewska, 2020 (tribe Sticholotidini – 1 species) and *Baltosidis* Szawaryn, 2021 (tribe Microweiseini – 3 species)⁵.

Genus *Rhyzobius* with 5 fossil species (belonging to a single phylogenetic lineage⁴) is the most abundant taxon, that makes the tribe Coccidulini the most diverse group of ladybird beetles in the fossil record. That can potentially suggest that *Rhyzobius* (or Coccidulini in general) were very diverse in the Eocene, and could be one of the first lineages of the subfamily Coccinellinae evolution. However, there are no Cretaceous records of ladybird beetles so far, thus any conclusions about evolution of *Rhyzobius* or Coccinellidae in general, are very limited. In addition, Coccidulini (currently comprising 29 genera and about 200 species) has so called gondwanan pattern of distribution; they are mainly distributed in Southern Hemisphere, in Australian, Neotropic and African regions, with only few species known from Holarctic.

We used MicroCT scanning to reveal detailed morphological structures of two another fossil species belonging to the tribe Coccidulini. To find their phylogenetic position we conducted a cladistic analysis of 54 various Coccidulini representatives, including 4 (out of 5 known) previously described fossil *Rhyzobius* species, and two newly analyzed specimens. Based on this analysis, we confirmed that newly examined specimens belong to two new and independent taxa, and their evolutionary position within coccidulini is proposed and discussed. Our new finding confirm that Coccidulini were the most abundant and most diverse ladybird taxon during the Eocene in Europe.

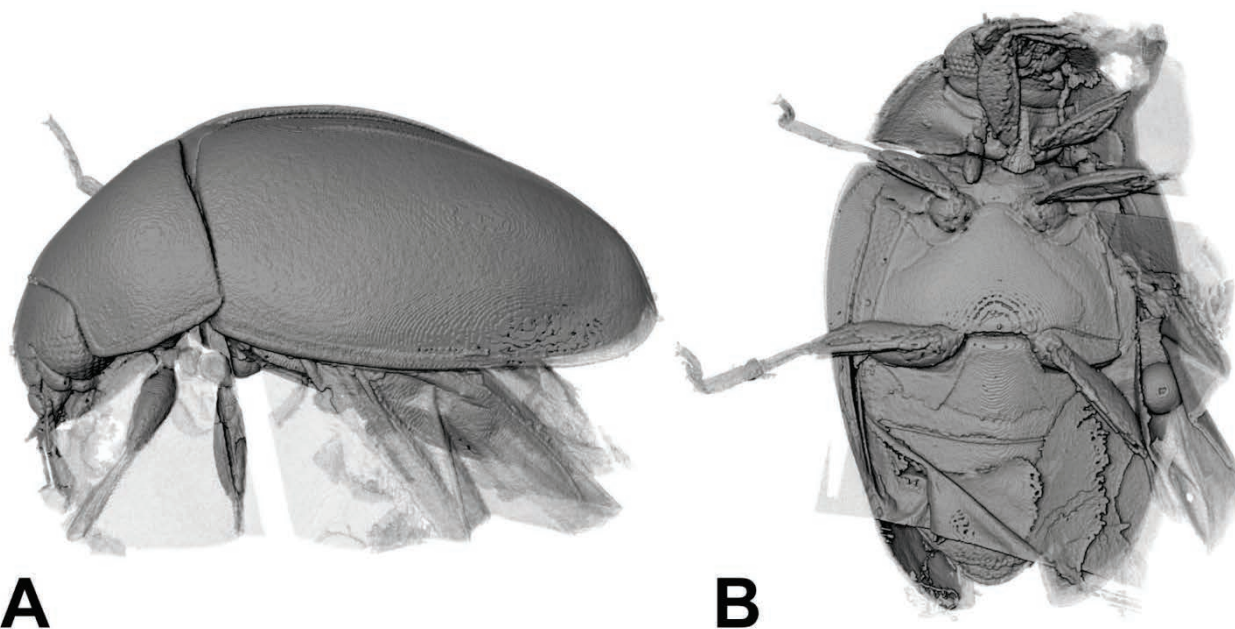


Fig. 1. A new representative of a fossil ladybird beetles (Coccinellidae) from Eocene Baltic amber.

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HOW ACCURATE BATESIAN MIMICRY SURVIVED PREDATOR TURNOVER: FOSSIL EVIDENCE OF EVOLUTIONARY RESILIENCE

K. Daňková^{1,*}, J. Hadrava¹, J. Straka¹, M. Mikát¹, A. Exnerová¹, P. Hulva², V. Nidergas³,
M. Pecharová¹, A. Nel³ & J. Prokop¹

¹Faculty of Science, Charles University, Czech Republic; [ORCID: 0000-0002-5360-0128 \(K.D.\)](#), [ORCID: 0000-0003-3247-6399 \(J.H.\)](#),
[ORCID: 0000-0002-8987-1245 \(J.S.\)](#), [ORCID: 0000-0001-5364-7180 \(M.M.\)](#), [ORCID: 0000-0001-7937-1477 \(A.E.\)](#),
[ORCID: 0000-0001-6996-7832 \(J.P.\)](#)

²Faculty of Science, Charles University and University of Ostrava, Czech Republic; [ORCID: 0000-0002-4968-4859](#)

³Muséum national d'Histoire naturelle, Sorbonne Université, Paris, France; [ORCID: 0000-0002-4314-5619 \(V.N.\)](#),
[ORCID: 0000-0002-4241-7651 \(A.N.\)](#)

*dankova.kla@gmail.com

Keywords: coloration, antipredator defence, Diptera, Syrphidae, Early Oligocene


Batesian mimicry is a widespread strategy that reduces the risk of predation of a harmless mimic by imitating a harmful model. Batesian mimics often vary greatly in how accurately they resemble their models. However, disentangling the causes of evolutionary changes in mimetic accuracy, or lack of them, is challenging. The fossil record provides a powerful tool, although it is constrained by the quality of preservation. In particular, fossil records of accurate mimics are exceptionally rare. Here, we describe the first evidence of highly accurate wasp mimicry, in a fossil belonging to diverse group of Batesian mimics: hoverflies (Diptera, Syrphidae). The hoverfly *Spilomyia kvaceki*¹, from the Early Oligocene (33 mya) deposits in Děčín-Bechlejovice, Czech Republic, exhibits well-preserved color pattern that closely resembles extant wasp mimics. Whether modern wasp genera could have served as its model remains uncertain. However, there is an abundant fossil record of stem-group social wasps (*Palaeovespa* spp.) that we propose as suitable models. Notably, two *Palaeovespa* specimens were found in the same locality as *S. kvaceki*, supporting their co-occurrence. Currently, passerine birds (Passeriformes) are considered the main selecting agent of mimicry of wasps. However, passerines were rare in Europe during the Early Oligocene. Thus, the agents selecting the earliest known highly accurate mimics of wasps were most likely non-passerines of Coraciimorphae and Apodiformes clades. In conclusion, the highly accurate mimicry of wasps originated during or at least persisted through the era of non-passerine dominance in the guild of diurnal flying insectivorous predators in the Northern Hemisphere. The project was supported by Czech Science Foundation grant no. no. 24-11498S.

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**CRETACEOUS AMBER RESEARCH TEAM: BRIDGING SCIENTIFIC DISCOVERIES AND SOCIAL
DISSEMINATION**

X. Delclòs^{1,*}, E. Peñalver², M.M. Solórzano-Kraemer³, R. Pérez-de la Fuente⁴, J.L. Viejo⁵, S. Álvarez-Parra⁶, M. Santer¹, A. Arillo⁷, A. García-Forner⁸ & A. Rodrigo⁹


¹University of Barcelona, Barcelona, Spain;  0000-0002-2233-5480


²Instituto Geológico y Minero de España, CSIC, Valencia, Spain;  0000-0001-8312-6087

³Senckenberg Research Institute and Natural History Museum, Frankfurt, Germany;  0000-0003-3065-119X


⁴Oxford University Museum of Natural History, Oxford, UK;  0000-0002-2830-2639

⁵Autonomous University of Madrid, Cantoblanco, Spain;  0000-0003-3160-6892

⁶Nanjing Institute of Geology and Palaeontology, Nanjing, China;  0000-0002-0232-1647

⁷Universidad Complutense, Madrid, Spain;  0000-0002-4878-5797

⁸Museo de Historia Natural, Universidad de Valencia, Valencia, Spain;  0000-0003-3032-9168

⁹Instituto Geológico y Minero de España, Madrid, Spain;  0000-0001-7201-9286

*xdelclos@ub.edu

Keywords: amber, Cretaceous, science dissemination, palaeontology

Amber, fossil resin that can contain organism remains from the past, is an invaluable source of information on ancient ecosystems, evolutionary processes and environmental changes over millions of years.

The dissemination of scientific results is a fundamental stage in any research, as it allows to share the generated knowledge with the public, the scientific community and other parties. In a society increasingly interested in scientific advances, governmental administrations require researchers to dedicate part of their time to share their discoveries with the public. The Cretaceous Amber Research Team AMBERIA has been committed to this work for years, exploring multiple ways to bring our findings closer to society in an accessible and attractive way.

The AMBERIA Team uses various innovative strategies to disseminate its results:

Realistic reconstructions: We incorporate detailed images and recreations in our scientific publications, improving the understanding of our studies and facilitating their later dissemination in the press, television and digital platforms.

Documentary videos: We produce videos that document our projects, field expeditions, and surprising findings. These materials are shared on platforms such as YouTube and used in educational and outreach activities.

Scientific comics: We create comics that showcase different aspects of our research such as how we work in the field or amber throughout historical times. These comics are published in paper but also reach the general public through our social networks and educational events.

Exhibitions and conferences: We actively participate in interactive exhibitions, school talks, and outreach conferences, bringing the amber world closer to students, teachers, and the general public.

Collaborations with content creators: We work with bloggers, YouTubers, and science communicators to expand the impact of our discoveries and reach new audiences in an entertaining and rigorous way.

Open Science Events: We take part in activities such as the Science Festival (University of Barcelona, UB, Spain), Super Science Saturday (Oxford University Museum of Natural History, OUMNH, UK), or the Aha?!

Forschungswerkstatt (Senckenberg Museum, Germany), where we share our advances through recreational and educational activities.



Fig. 1. A) “Gea and the amber” video. B) Comic: about our fieldwork in Madagascar. C) El Soplao amber exhibition, Santander 2010, Spain. D) Cretaceous Resinous Interval (CREI) scientific project, video_30k views in Spanish version). E) Super Science Saturday at OUMNH, Oxford 2017, UK. F) Science Festival (UB), Barcelona 2019, Spain. G) Our portals in Facebook, X and Instagram. H) Frame from a video by J.A. Peñas showing the pollinator activity of Zangsolvidae dipterans found in El Soplao amber, included in the original publication. I) Half-term children activity based on amber cut-outs at OUMNH, Oxford 2019, UK. J) Our amber research showcased by the youtuber Pakozoico (155k subscribers) about El Soplao amber 2024. K) Amber and science dissemination at the Spanish national radio, Madrid 2025.

Media: We use our public, private, and research group networks, such as Instagram, X, Facebook, and Youtube, to report on our scientific advances, attendance to conferences or field trips. The press offices of our institutions promote publishing articles in newspapers and digital media, as well as facilitating interviews on radio, press, and television to disseminate the most relevant findings.

Disseminating these findings not only fosters general knowledge and appreciation of the natural heritage, but also strengthens interdisciplinary collaboration. In addition, scientific dissemination contributes to the transparency of the research process, allowing society to evaluate and appreciate the importance of investing in scientific research. On the other hand, the dissemination of the scientific results of this project can also impact on the conservation of natural and cultural heritage. By reporting on the scientific value of these fossils, awareness about the need to protect and regulate their extraction, trade, and study is raised, avoiding the loss of valuable scientific specimens.

This contribution was financially supported by the Spanish *Ministerio de Ciencia, Innovación y Universidades* [research agreement PID2022-137316NB, funded by MICIU/AEI/10.13039/501100011033 and by ERDF/EU, and research agreement PID2022-138986OB-I00 funded by MICIU/AEI/10.13039/501100011033], and by the *Consejería de Industria, Turismo, Innovación, Transporte y Comercio* of the *Gobierno de Cantabria* through the semi-public enterprise EL SOPLAO S.L. [research agreement #20963 with *Universitat de Barcelona* and research contract Ref. VAPC 20225428 to *Instituto Geológico y Minero de España, Consejo Superior de Investigaciones Científicas*, both 2022–2025]

FOSSIL WHITEFLIES AS A KEY TO PUPARIAL LOCK OF CLASSIFICATION?

J. Drohojowska^{1,*} & J. Szvedo²

¹*Institute of Biology, Biotechnology and Environmental Protection, Faculty of Natural Sciences, University of Silesia, Katowice, Poland; ☎ 0000-0002-7668-2242*

²*Laboratory of Evolutionary Entomology and Museum of Amber Inclusions, Department of Invertebrate Zoology and Parasitology, Faculty of Biology, University of Gdańsk, Gdańsk, Poland; ☎ 0000-0002-2796-9538*

**jowita.drohojowska@us.edu.pl*

Keywords: fossils, Hemiptera, Sternorrhyncha, Aleyrodidae, morphology

Whiteflies (Hemiptera: Sternorrhyncha: Aleyrodomorpha) constitute a distinctive group within the Hemiptera, with a classification system based on the morphology of the immature stage. Taxonomic levels, ranging from species to subfamilies, could be accurately diagnosed by the morphological characteristics of the fourth instar – the puparium. Despite the identification of the species for an adult specimen, it is extremely difficult, if not impossible, to determine whether a specimen is male or female. It was over a century ago that Quaintance and Baker^{1,2} directed their attention for the first time towards this neglected group of insects. In their seminal work, they presented the classification, relationships within the Aleyrodidae genera and subfamilies, and their placement within Sternorrhyncha. They also provided detailed descriptions of the developmental stages, from egg to adult, in terms of morphology and anatomy. The incorporation of additional imaginal features into the taxonomy of whiteflies has been limited to the wax plates of males and females, which differ in males and females of specific subfamilies. There is currently no identification key available that is based on the morphological features of the adults. This situation is further exacerbated by the fact that for the vast majority of recently recognized genera and species, the imaginal forms are not known. The taxonomic practice concerning whiteflies, their systematics and classification is still 'locked' on puparial characters.

The issue raised was about how fossils, found as inclusions in resins and as imprints, were managed. But, these fossils are mainly found as imagines, which must not be disregarded. This highlights the importance of studying new morphological characteristics of the imagines. These characteristics could be important in identifying and classifying recent whiteflies. Preliminary results suggest that features on the fore and hind wings, the head capsule, antennae, legs and genitals of males and females could be reliably identified.

The Aleyrodidae has four subfamilies: the extinct Bernaeinae (Middle Jurassic/Cretaceous); the Udamoselinae (of uncertain validity); the Aleurodicinae; and the Aleyrodinae. The earliest fossil representatives of Aleurodicinae and Aleyrodinae have been documented in Early Cretaceous Lebanese amber. The remaining Aleyrodidae are known from Cenomanian Burmese amber, Lowermost Eocene Oise amber and Eocene succinite from several European localities. Other members of Aleyrodinae have been reported from Miocene ambers of Ethiopia, China, the Dominican Republic, Mexico and Peru. The only three fossil puparia have been reported from the Miocene of New Zealand (*Miotetraleurodes novaezealandiae* Drohojowska *et al.*, 2024)³ and Pliocene deposits from Germany (*Aleurochiton petri* Rietschel, 1983)⁴ and India (*Praealeurolobus indicus* Drohojowska *et al.*, 2023)⁵. The question of how these many fossil imagines can influence classification and phylogeny remains unresolved. Recent studies are exploring the complex issue of their imaginal characters. We believe that research on adult morphology and taxonomy of fossil whiteflies can significantly contribute to our understanding and the 'pupal lock' can be opened.

This research was funded by the National Science Centre, Poland, grant no. 2022/47/B/NZ8/02113.

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**EVOLUTIONARY INSIGHTS ON SCOLYTINAE (COLEOPTERA: CURCULIONIDAE)
BASED ON FOSSIL AND PHYLOGENETIC DATA**J. Ferreira^{1,2,*}, B.H. Jordal³, F.L. Condamine⁴, and D. Peris¹¹Institut Botànic de Barcelona (CSIC-CMNCB), Barcelona, Spain; ☎ 0000-0003-4074-7400 (D.P.)²Facultat de Ciències de la Terra, Universitat de Barcelona, Barcelona, Spain; ☎ 0009-0006-1919-8979 (J.F.)³University Museum of Bergen, Bergen, Norway; ☎ 0000-0001-6082-443X⁴CNRS, Institut des Sciences de l'Évolution de Montpellier, Université de Montpellier, Montpellier, France;
☎ 0000-0003-1673-9910

*jules.ferreira27@gmail.com

Keywords: Bayesian Brownian Bridge, divergence time estimates, fossil record, Scolytinae, total-evidence dating

Bark beetles (Scolytinae) belong to the weevil family Curculionidae and are well known for their xylophagous or saprophagous lifestyle, as well as for their close relationships with fungi. However, the exact timing of their diversification remains uncertain. It is sometimes estimated to have occurred at 115–100 million years ago (Ma), or more recently around 90, 70 Ma and even 50 Ma in some studies, associated with the rise of flowering plants. The oldest unambiguous fossil of the clade, †*Cylindrobrotus pectinatus* (dating to 125.77–121.4 Ma)¹, described from the Cretaceous Lebanese amber, has consistently been used as a calibration point for the entire subfamily in previous node dating analyses. Because it is the earliest known fossil of the group, authors have assumed it represents a stem lineage of the subfamily². However, its phylogenetic position has never been formally tested through rigorous phylogenetic analysis. Here, we refined the divergence time estimates of Scolytinae by applying total-evidence dating, integrating morphological and molecular data along with 15 well-preserved fossils included as terminal taxa. We additionally used traditional node dating, as well as the Bayesian Brownian Bridge³ model to independently analyse 200 fossil occurrences of Scolytinae and cross-validate our results. Our findings suggest that Scolytinae originated much earlier than previously thought, with divergence occurring in the Late Jurassic to Early Cretaceous (around 160–135 Ma), predating the major diversification of angiosperms⁴. Our results lend renewed consideration to the hypothesis that early Scolytinae may have initially been associated with gymnosperms before transitioning to angiosperms during the Cretaceous, such as some other insect lineages⁵. Furthermore, we discovered that †*Cylindrobrotus pectinatus* is in fact not a stem lineage of the subfamily as traditionally assumed, but nested within Scolytinae. Our study underscores how important fossil placement is in estimating divergence times, as different interpretations can lead to significantly different results. Ultimately, our study demonstrates that by integrating a variety of dating techniques and carefully considering the placement of Scolytinae fossils, we can achieve more accurate and reliable hypotheses about the evolutionary history of this subfamily.

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EPHEMEROPTERA, OLD STONES AND NEW PERSPECTIVES

R.J. Godunko^{1,2}

¹*University of Lodz, Faculty of Biology and Environmental Protection, Department of Invertebrate Zoology and Hydrobiology, Łódź, Poland*

²*Biology Centre of the Czech Academy of Sciences, Institute of Entomology, České Budějovice, Czech Republic;*
☎ 0000-0003-2196-3327

godunko@seznam.cz

Keywords: Ephemeroptera, fossil record, new analytical techniques

The fossil record of Ephemeroptera from Triassic to Cretaceous shows significant morphological diversity, with disparity documented within the sedimentary series and amber resin, based on both larvae and adults. The history of many mayfly lineages is still fragmentarily studied due to the small number and poor preservation of their fossil remains. While **paleolake** deposits contain a rich fauna documented on larvae and adults, presumably rheophilic Ephemeroptera are very rarely preserved as compression fossils due to taphonomic features of sedimentation in lotic paleoecosystems.

Considering the time of origin, the ancient group Ephemeroptera is relatively conservative in its larval distribution in freshwater ecosystems, characterised by very low vagility compared to other insect taxa. The larvae of individual species have varying requirements; however, the majority of mayflies can be described as stenobionts, preferring a narrow range of ecological conditions. On the other hand, their short-living and relatively fragile winged stages are also limited in their distribution. Ecological features mentioned above make mayflies a suitable subject for biogeographical generalizations linked to historical drift patterns of land masses, alongside other freshwater groups that cannot be dispersed by ocean currents. Thus, considering the historical changes in ecosystems at the biome level as a response to global climatic fluctuations under the impact of geological and extraterrestrial collisions, different evolutionary and adaptive potentials of particular taxa, a grounded reconstruction of biogeographic relationships could only be assured by analysing both recent and fossil taxa¹. Recently, Staniczek et al.² and Godunko et al.³ describing extinct taxa from the Mesozoic and Cenozoic, showed the importance of vicariant events, dispersal and extinction associated with the breakup of Pangea, and later East Gondwana for shaping the historical and current distribution patterns of several mayfly families. Therefore, the future research may reveal the more ancient age of many Ephemeroptera lineages, proposing more reliable biogeographical reconstructions.

The great potential of modern methods for studying and visualising the structure of fossil insects is now widely employed in palaeontology but remains very limited in application to Ephemeroptera⁴. Therefore, for the first time, we shall apply a combined set of innovative equipment (e.g., 3D techniques such as high-resolution micro-CT, ESEM, and SEM). Additionally, for a series of mayfly fossils comprising numerous specimens (e.g., hundreds of morphologically similar adults and larvae of “*Protoligoneuria*” from the Crato Formation), intraspecific differences will be statistically analysed, and data will be summarised using morphological and Elliptical Fourier analysis.

In early 2023, a pilot study at the Karlsruhe Institute of Technology (KIT) used Synchrotron Radiation-Computed Laminography (SRCL) for the first time on a Crato Formation larva from Brazil, originally catalogued by Staniczek et al.⁵ and housed at SMNS. Digital reconstruction revealed previously hidden morphological features within the matrix. This confirmed structures such as double tarsal claws in Coxoptera and larval penes, underlining the value of innovative imaging for reassessing phylogenetic relationships within

Ephemera. These methods also provide new insights into the functional morphology and biology of extinct mayflies.

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FOSSIL EVIDENCE OF CRETACEOUS PSOCODEA: DIVERSITY, PALAEODISTRIBUTION AND BEHAVIOUR

M. Hakim

*State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology,
Chinese Academy of Sciences, Nanjing, China; ☎ 0000-0003-4398-6140*

**marina@nigpas.ac.cn*

Keywords: Psocoptera, amber, Mesozoic, biodiversity; palaeoecology, palaeobiogeography

The order Psocodea encompasses both the true lice (Phthiraptera) and their non-parasitic relatives ('Psocoptera'), comprising approximately 10,800 extant species. Barklice and booklice are typically herbivorous or detritivorous, feeding on microflora and organic detritus. They live in warm and humid environments or occasionally as pests within human dwellings¹. In contrast, the parasitic lice are highly specialized ectoparasites of birds and mammals, feeding on the blood, oily secretions and keratin of their hosts. Psocodea are recognized as the least derived group within the Acercaria in terms of their more primitive chewing-type mouthparts, with the exception of the blood sucking lice.

Psocodea are commonly preserved as bioinclusions in Mesozoic and Cenozoic amber, but they are very scarce in rock compressions. They are well represented in the Cretaceous with 81 described species to date. Their Cretaceous fossil record is exclusively known from bioinclusions in amber, and reported mainly from seven amber deposits, i.e., Canada, France, Lebanon, Myanmar, Spain, Russia, and the USA². These deposits have yielded exceptionally diverse and well-preserved psocodean inclusions, thus collectively providing an invaluable record of the evolutionary history, classification and palaeoecology of the order.

Fossil representatives of all three suborders have been discovered and described from the Cretaceous. Interestingly, the Trogiomorpha exhibit the highest diversity at species level, while they are the least diverse in current ecosystems. The Troctomorpha display the highest diversity at family level. In contrast, despite the high number of Psocomorpha species today, they are rare in the Cretaceous fossil record². Probably, the shift on diversity between these suborders took place during the Eocene due to niche competition. Burmese amber is currently the richest deposit in terms of psocodean biodiversity, followed by Lebanese amber.

Due to the restriction of the Cretaceous psocodean fossil record to amber bioinclusions, their palaeodistribution matches the distribution of amber deposits, mainly located in the Northern Hemisphere. The co-occurrences of several barklice genera in different ambers have been reported, the most significant being the co-occurrences in Burmese, Lebanese, and Spanish amber. This fact might be the result of similar palaeoenvironmental conditions, palaeogeographic connections, or other factors such as oceanic or wind currents facilitating displacement through long distances.

Amber inclusions have allowed the inference of behavioural traits in Psocodea due to their great degree of preservation. Instances of camouflage in immatures have been observed in both Burmese and Lebanese amber³. Reproductive behaviour has also been examined and deduced from interactions of specimens preserved in Burmese amber⁴. The majority of Cretaceous fossils are barklice and booklice, however, the discovery of at least lice eggs on enantiornithine feathers and one described phthirapteran species from Burmese amber indicates that parasitism had already emerged in Psocodea by that time⁵.

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AMATEUR MEETS PROFESSOR.

THE IMPACT OF AMBER ENTHUSIASTS IN AMBER PALAEOENTOMOLOGY IN THE PAST DECADES

C. Hoffeins

Arbeitskreis Bernstein: Hamburg, Germany; 📍 0000-0001-6815-0871

The year 1997 and the amber fair "Amberif" in Gdańsk is marking the beginning of a fruitful cooperation between amber enthusiasts from Hamburg, Germany and palaeoentomologists from Poland. As a connecting person we see Jacek Serafin. Serafin, bursztynnik and cosmopolitan, as amber dealer was in contact with members of the workshop "AK Bernstein" in Hamburg and entomologists at the universities of Gdańsk and Cracow. Thanks to his contacts a first meeting with Ryszard Szadziewski was arranged in May 1997. At Amberif 1998 firstly present was Jan Koteja well known by his journal "WrosteK – Inclusion" and somewhen later Wiesław Krzemiński, both from Cracow. We met Jonas Damzen from Lithuania firstly at the amber fair in 1998. This assemblage of amber enthusiasts – collectors, dealers and scientists is symbolic for a continuous progress in the international amber research.

AMBER RESEARCH IN CHINA

D. Huang

Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, China;

☎ 0000-0002-5637-4867

dyhuang@nigpas.ac.cn

Keywords: Cenozoic, Mesozoic, biological inclusions, paleoclimate, paleoenvironment



Amber research in China began in the 1970s with Professor Youchong Hong's studies on Eocene Fushun amber in Liaoning, leading to several monographs. Since the 21st century, significant progress has been made in the research on Fushun amber and Miocene Zhangpu amber in Fujian. In recent years, detailed studies have reported amber from the mid-Triassic Qingyan biota in Guiyang, Guizhou; Lower Cretaceous Damoguaihe-Yimin Formation amber in Hulunbuir, Inner Mongolia; Late Cretaceous Xixia amber in Henan; Late Cretaceous Guangzhou and Xingning amber in Guangdong; Paleocene amber from the Buxin Formation in Foshan, Guangdong (reported for the first time); Eocene amber in Maoming, Guangdong; Oligocene amber in Nanning, Guangxi; and Miocene amber in Taiwan.

Chinese amber research holds immense potential. Our research group has recently discovered new Cretaceous amber, as well as Eocene, Oligocene, and Miocene ambers from various regions. Notably, some of these amber deposits contain numerous biological inclusions, some of which are significant for global comparisons, while others reveal the characters and comparative relationships of amber biotas in different regions of China. These discoveries will be crucial for filling gaps in Chinese amber research, enabling global comparisons of amber biotas, and increasing understanding of paleoclimates and paleoenvironments.

X-RAY MICROTOMOGRAPHY IN PALEOBIOLOGY – A SHORT GUIDE FOR BEGINNERS

K. Janiszewska^{1,*}, M. Michalska²

¹*Institute of Paleobiology, Polish Academy of Sciences, Warsaw, Poland;*

 0000-0002-7094-1821 (K.J.),  0009-0004-1505-5618 (M.M.)

*k.janiszewska@twarda.pan.pl

Keywords: microCT, 3D visualisation

X-ray microtomography (micro-CT) enables three-dimensional imaging of the morphology of even the smallest objects. It provides data on the internal structure of samples, e.g., the fine surface details of inclusions in amber, the incremental layers in scales or the thickness and spatial relations of the layers forming the teeth. Such data reveal information about the rate and pattern of growth of the examined structures, enabling further paleobiological interpretations.

The most spectacular micro-CT results are animations created in synchrotrons, where the highest resolution is achieved for a wide range of sample sizes. However, in recent years, laboratory micro-CT has developed significantly, is more easily accessible to researchers and allows for achieving excellent results.

X-ray microtomography is based on the difference in the absorption of radiation by materials of different densities. The higher the density of the material, the greater the absorption. In addition to density, the absorption of radiation is also influenced by the thickness of the sample – i.e. the path that the radiation must travel through the sample. During scanning, the object is placed on a rotating table (360°). The radiation beam passes through the sample (some of it is absorbed) and hits a scintillator-detector, which "converts" X-ray radiation into visible light. Information about the absorption of radiation by the object in a given position is recorded. Then, the sample is rotated by a given angle and another image is created. During scanning, hundreds of such two-dimensional X-ray absorption images – i.e. projections – are created. The next step is the process of the reconstruction of the interior of the sample as a superposition of those two-dimensional projections. Then we obtain a three-dimensional image of the sample and a series of cross-sections in any plane. The next step is visualization. Based on those micro-CT data, we can create a virtual model and perform morphometric analysis. We can also process information about the sample's porosity, volume or surface area.

Microtomography replaces destructive preparation for fossils whose remains are dispersed in the rock. (e.g., skeletal plates, spicules, teeth). The spatial arrangement of individual elements can be preserved, allowing for drawing conclusions about their function and original position within the creature's body. The non-destructive nature of the technique is particularly important when studying priceless paleontological collections. Holotypes can be made available in virtual form or as a 3D print.

The Laboratory at the Institute of Paleobiology, PAS is equipped with a Zeiss XRadia 200 microtomograph with an X-ray source with an adjustable voltage in the range of 20-90 keV. With sample sizes of several millimeters, the microtomograph can achieve very high contrast and image resolution <2 µm. Micro-CT is equipped with a source operating in relatively low energy ranges which gives a good contrast in imaging not only skeletons but also various types of soft tissues and fossil resins. The design of the XRadia micro-CT system enables experiments using phase contrast. This technique, taken from synchrotrons, allows imaging and separating structures of similar density, including fossils preserved in amber.

FOSSIL RECORD OF ELATERIFORMIA (INSECTA: COLEOPTERA)

D. Jetelina¹, G. Pačková², K. Třísková³ & R. Kundrata^{4,*}*Department of Zoology, Faculty of Science, Palacky University, Olomouc, Czech Republic*

ORCID: 0009-0002-1212-0651 (D.J.), 0000-0001-7949-619X (G.P.),

ORCID: 0000-0003-2385-5557 (K.T.), 0000-0001-9397-1030 (R.K.)

*robin.kundrata@upol.cz

Keywords: evolution, extinct families, Mesozoic, origin, palaeodiversity

The series Elateriformia, a major polyphagan beetle clade comprising over 50,000 described species classified in five superfamilies (Buprestoidea, Byrrhoidea, Dascilloidea, Dryopoidea, and Elateroidea), contains remarkable morphological and ecological diversity¹. Apparently, there are multiple shifts from the well-sclerotized body (e.g., Buprestoidea, clicking Elateroidea) to the soft-bodied forms in Elateriformia, often connected with pedomorphosis (e.g., soft-bodied Elateroidea, Dascilloidea pars). While most elateriform beetles are terrestrial, especially Dryopoidea contain many lineages connected to aquatic or semiaquatic environments. Although Elateriformia may have originated before the Mesozoic as suggested by some dated phylogenies, the first fossil evidence comes from the Triassic². The Mesozoic fossil record is of a special importance as it contributes to our understanding of the early diversification of the group. Numerous Mesozoic adpression fossils are known for Elateriformia, especially from rich Asian deposits. Recently, many discoveries of amber inclusions, especially those from the mid-Cretaceous amber of northern Myanmar (i.e., Burmese amber), further contributed to our understanding of the palaeodiversity of Elateriformia in the Mesozoic Era. Several new elateriform families were proposed recently based on the specimens deposited in Burmese amber, including Mysteriomorphidae (originally as Elateriformia incertae sedis but later confirmed as belonging to Elateroidea³), Cretophengodidae (putative bioluminescent lineage close to elateroid Phengodidae and Rhagophthalmidae⁴), and Mastigocoleidae (belonging to Dryopoidea, probably related to Dryopidae⁵). Interestingly, these lineages are not known from younger deposits. The Cenozoic fossil record of Elateriformia contains many species which are classified in extant genera and families. The elateroid family Berendtimiridae is known only from the Eocene Baltic amber.

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**PORTION OF BLOODY MYSTERIES – OVERVIEW OF FOSSIL SAND FLIES
(PSYCHODIDAE: PHLEBOTOMINAE) INCLUDING NEW DATA**

S. Kaczmarek¹, A. Soszyńska¹ & W. Krzemiński²

¹*University of Lodz, Faculty of Biology and Environmental Protection, Department of Invertebrate Zoology and Hydrobiology, Lodz, Poland; ☎ 0009-0002-7544-1938 (S.K.), ☎ 0000-0002-2661-6685 (A.S.)*

²*Institute of Systematics and Evolution of Animals, PAS, Krakow, Poland;*

☎ 0000-0001-5685-891X

**szymon.kaczmarek@edu.uni.lodz.pl*

Keywords: Sand flies, evolution, amber, fossil record, diversity

Sand flies (Diptera: Psychodidae, Phlebotominae) are best known for their blood-feeding (hematophagous) behaviour. They represent a medically important group of flies, as they serve as vectors for several serious diseases, including leishmaniasis, bartonellosis, and Pappataci fever, contributing to death of tens of thousands of people and animals every year. Their distribution is primarily limited to tropical, subtropical, and southern Palaearctic regions. However, due to rapid climate change, these insects are gradually expanding their geographic range. While females are mostly blood-sucking, males feed on nectar and other plant secretions and are easily distinguishable from females by large, spinous genitalia and lack of working mandibles. Typical habitats of sand flies are quite similar to those occupied by other subfamilies of Psychodidae – they prefer moist, shaded environments rich in organic matter, which provide suitable conditions for breeding and development, regardless of whether these habitats are natural or anthropogenically modified.

To date, over 1000 species/subspecies of sand flies have been described. Nonetheless, their fossil record remains poorly understood, with only 30 known fossil species, despite the relatively abundant material preserved as amber inclusions. Material from the Cretaceous is remarkably diverse – probably even more than in the modern fauna. Numerous undescribed Phlebotominae taxa from Burmese amber are housed in museum collections. These fossils are of exceptional importance, as they illustrate the beginnings of this group evolution and show numerous plesiomorphic features. In contrast, Phlebotominae inclusions in Baltic amber (Eocene) are extremely rare, what is likely caused by the less tropical, and rather subtropical or warm-temperate climate of the Eocene amber forests. Miocene Dominican amber contains large numbers of Phlebotominae inclusions; however, these specimens represent extant genera, with extinct species. Meanwhile, sand flies found in Colombian copal, which is approximately 10,000 years old, are rather reflecting only the present-day species. Examining fossil material can be crucial to re-evaluate the evolutionary history, past biogeographic distribution, morphological homologies, and overall diversity of these flies, both in the past and in modern times.

The aim of our poster is to summarise knowledge on the diversity of sand flies from the fossil record and present new data from various amber deposits, highlighting their evolutionary significance and associated implications on further research of this group.

FROM FOSSILS TO DNA: HOW CLOSE ARE WE TO A REAL JURASSIC PARK?

M.J. Kamiński

Zoological Museum, Museum and Institute of Zoology, Polish Academy of Sciences, Warszawa, Poland;

0000-0002-2915-0614

kaminskientomo@gmail.com

Keywords: ancient DNA, Next-Generation Sequencing, midden, desert, Tenebrionidae

The study of ancient DNA has transformed our understanding of human evolution. With the rapid advancement of Next-Generation Sequencing (NGS) technologies, researchers can now access high-resolution genetic data from extinct species and populations. However, despite their ecological importance and overwhelming diversity, insects remain largely underrepresented in ancient DNA research¹. In this presentation, findings from the first insect-focused study using ancient DNA will be presented, based on specimens recovered from subfossilised pack rat middens dated to as far back as 34,000 years before present (Fig. 1). These results not only demonstrate the potential of insects as genetic archives of past ecosystems but also highlight the methodological challenges specific to working with degraded insect DNA. Both the opportunities and limitations of incorporating insects into the broader narrative of reconstructing Earth's biological history from ancient DNA will be discussed.

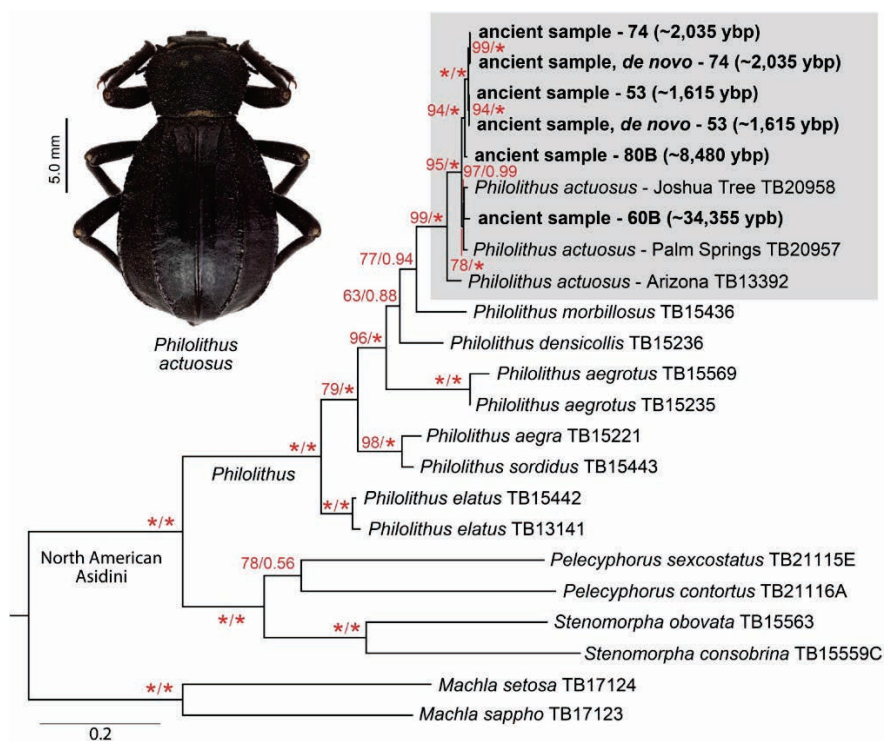



Fig. 1. Phylogenetic placement of recovered ancient samples of *Philolithus actuosus* (Coleoptera Tenebrionidae) ranging from 1,615 to 34,355 years before present. Maximum likelihood tree generated by analysis of a concatenated dataset of 13,926 bp (16 s, 28 s, 12 s, atp6, atp8, cob, COI-III, NAD1-6) in IQ-Tree with ancient midden samples assembled de novo or using *Philolithus actuosus* (TB20958) as the reference. Posterior probabilities from Bayesian analyses are displayed on the right, bootstrap values from IQ-Tree on the left. An asterisk indicates either PP of 1.0 or bootstrap value of 100%.


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A NEW SPECIES OF THE GENUS *STYRINGOMYIA* (DIPTERA: LIMONIIDAE) FROM MIOCENE DOMINICAN AMBER

I. Kania-Kłosok^{1,*}, W. Krzemiński², A. Ross³, P. Wąsacz¹, A. Soszyńska⁴ & K. Kopeć²

¹Faculty of Biology and Nature Protection, University of Rzeszów, Poland;  0000-0002-2325-4308 (I.K-K.);

 0009-0001-1316-7008 (P.W.)

²Institute of Systematics and Evolution of Animals, PAS, Kraków, Poland;

 0000-0001-5685-891X (W.K.),  0000-0001-6449-3412 (K.K.)

³Department of Natural Sciences, National Museums Scotland, Edinburgh, UK;  0000-0003-2751-9091

⁴University of Lodz, Faculty of Biology and Environmental Protection, Department of Invertebrate Zoology and Hydrobiology, Łódź, Poland;  0000-0002-2661-6685

*ikania@ur.edu.pl

Keywords: fossils, Chioneinae, Cenozoic, new species, taxonomy, evolution

The genus *Styringomyia* Loew belongs to the family Limoniidae in the infraorder Tipulomorpha, and the order Diptera. Morphologically, the genus *Styringomyia* is particularly distinctive differing significantly from most other Limoniidae in wing venation, the structure of the male hypopygium, and the female copulatory organs. The genus comprises 176 described extant species distributed across the Neotropical, Ethiopian, Australian, and Palearctic regions, but it has not been recorded in the Nearctic region. The first fossil representatives of this genus were discovered by Loew and preserved in East African copal and Baltic amber^{1,2}. The first extant species, *Styringomyia didyma* Grimshaw, was described half a century later from Hawaii.

A total of six fossil species have been described so far, although one was subsequently synonymized: *Styringomyia venusta* Loew from East African copal, *S. gracilis* Loew from Baltic amber, *S. concinna* (Cockerell) (= *S. extensa* Cockerell and Haines) from the Bembridge Marls of the Isle of Wight, *S. dominicana* Podenas and Poinar and *S. optiva* Podenas and Poinar from Dominican amber. The new discoveries increase the total number of fossil-recorded species to eight.

The hypopygial features of the Dominican amber representatives of genus resemble those of certain extant species of *Styringomyia* found in Australia. Notably, despite the abundance of *Styringomyia* fossil in Dominican amber, the genus is not known to inhabit the island of Hispaniola today.

These findings contribute to our broader understanding of crane fly diversity and significantly enhance our knowledge of Miocene *Styringomyia*.

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**FOSSILS SUPPORT IN CONSTRUCTING PHYLOGENY: A CASE STUDY IN ISOMETOPINAE
(HEMIPTERA: CIMICOMORPHA: MIRIDAE)**

J. Kim¹, A. Tazsakowski^{2,*}, T.S. Keetapithchayakul¹ & S. Jung^{3,*}

¹*The Center for Entomology & Parasitology Research, College of Medicine and Pharmacy, Duy Tan University, Da Nang, Vietnam; ☎ 0000-0003-0594-7618 (J.K.); ☎ 0000-0001-7565-4701 (T.S.K.)*

²*Institute of Biology, Biotechnology and Environmental Protection, Faculty of Natural Sciences, University of Silesia in Katowice, Katowice, Poland; ☎ 0000-0002-0885-353X*

³*Laboratory of Systematic Entomology, Department of Applied Biology, College of Agriculture and Life Sciences, Chungnam National University, Daejeon, Korea; ☎ 0000-0001-6086-0326*

**artur.tazsakowski@us.edu.pl, jung@cnu.ac.kr*

Keywords: Heteroptera, plant bugs, jumping tree bugs, phylogeny, cladistics

Isometopinae, jumping tree bugs (Hemiptera: Heteroptera: Cimicomorpha), is one of the small groups in the large family Miridae, with six tribes and 280 described species worldwide¹. This subfamily is monophyletic², and is considered a sister-group to the remaining groups of Miridae, characterized by autapomorphic characters, such as possessing paired ocelli³.

Most phylogenetic analyses rely heavily on extant taxa, as fossil records are often rare, fragmentary, or lack sufficient morphological resolution for character coding. Consequently, few studies have explicitly assessed the role of fossils in shaping phylogenetic hypotheses, and to date, no one has systematically explored this issue within Heteroptera.

The plant bug subfamily Isometopinae offers a rare opportunity for such an evaluation, as it includes a relatively large number of fossil taxa^{1, 4, 5} – many of which are remarkably well-preserved amber inclusions described over several decades by our research group – and the formally recognized fossil tribe Electromyiommini. Leveraging this long-standing accumulation of high-quality fossil material, we conducted comparative phylogenetic analyses based on 105 morphological characters. Three approaches were employed: (i) a single most parsimonious tree including both extant and fossil taxa, (ii) a Bayesian inference tree with both data sets, and (iii) parsimonious analyses of extant taxa alone under the different weighting schemes.

The results revealed notable topological discrepancies, particularly in earlier relationships and tribal placements, highlighting the critical influence of fossil taxa on tree structure. Our findings demonstrate the value of integrating well-characterized fossil specimens in reconstructing deeper phylogenetic relationships. We further discuss the implications for the monophyly of Isometopinae and the tribal relationships based on the preferred topology.

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Fig. 1. *Metoisops popovi* Kim, Tazsakowski & Jung, 2023 (Baltic amber, mid-Eocene).

LEBIINI (COLEOPTERA: CARABIDAE) FOSSIL GROUND BEETLES: THE HISTORY OF RESEARCHES

M.B. Kirichenko-Babko^{1,*}, R.V. Babko^{1,2}¹Schmalhausen Institute of Zoology NAS of Ukraine, Kyiv, Ukraine; ☎ 0000-0002-6234-2896 (M.K-B.)²Lublin University of Technology, Lublin, Poland; ☎ 0000-0002-3292-5580 (R.B.)

*kirichenko@izan.kiev.ua

Keywords: carabid beetle, compressed, amber, palaeodiversity

The family Carabidae Latreille, 1802 is a very diverse group among Coleoptera, comprising ca. 40,000 species¹. The fossil record of this family is relatively rich, with compression fossils known since the Triassic². Most compression fossil carabids are known from the Mesozoic. The oldest ground beetle (Trechinae) in amber was found in the Lower Cretaceous Lebanese amber³. Over the last decade, adult ground beetles have been described from the mid-Cretaceous Burmese amber – *Oodes kachinensis* Liu, 2015 (Harpalinae), *Kryzhanovskiana olegi* Kataev et Kirejtshuk, 2019 (Paussinae), *Burmapseudomorphus planus* Beutel, Liu, Pang, Fikáček et Ślipiński, 2019 (Harpalinae), as well as a larva of two species – *Cretomigadops bidentatus* Liu, Beutel, Makarov et Luo, 2023 (Migadopinae) and *Cretomophron mutilus* Rosova, Prokop et Beutel, 2023 (Omophroninae). The greatest diversity of ground beetles is known from the Cenozoic, where beetles from two subfamilies, Paussinae and Lebiinae, predominate in Baltic amber⁴.

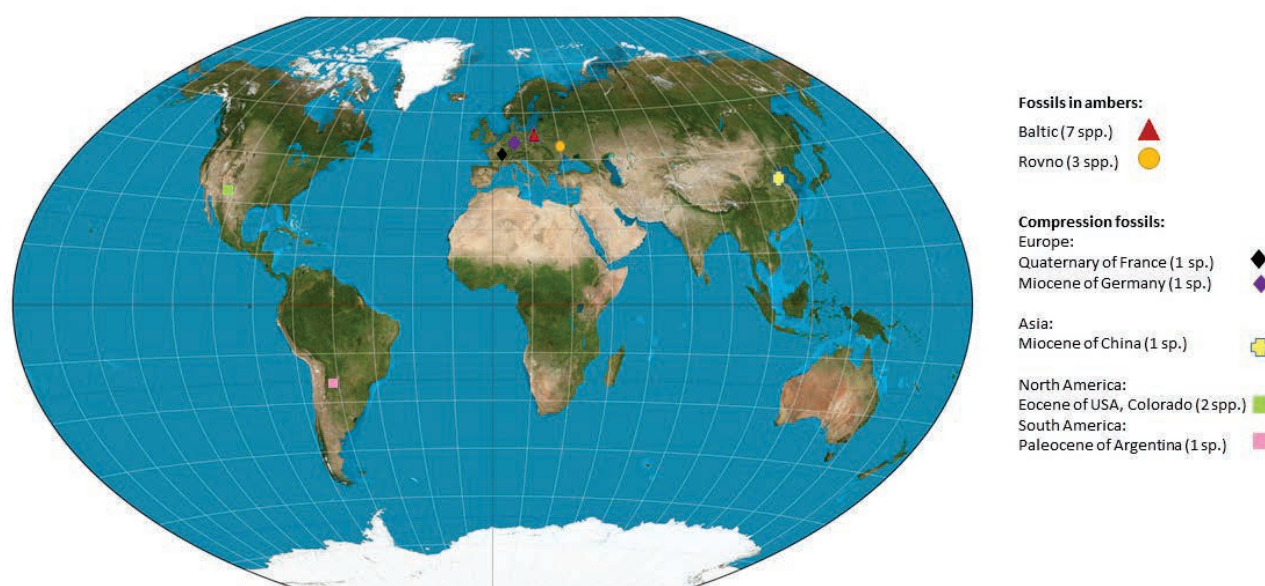
The tribe Lebiini Bonelli, 1810 (Lebiinae) is a very diverse carabid group, including more than 4800 extant species that are distributed across all continents¹. To date, only 16 fossil species of Lebiini are known, belonging to nine genera (Table 1). Five genera are fossils – *Agatoides* Motschulsky, 1856, *Cymindoides* Motschulsky, 1856, *Protoscalidion* Schaufuss, 1888, *Miolebidia* Zhang, 1989, and *Antepphilorhizus* Kirichenko-Babko et Perkovsky, 2021; and four extant genera – *Coptodera* Dejean, 1825, *Dromius* Hope, 1838, *Lebia* Latreille, 1802, and *Plochionus* Latreille et Dejean, 1824.

Of the 16 described fossil species, 10 are known from the late Eocene Baltic and Rovno ambers (Fig. 1): *Agatoides carinulatus* Motschulsky, 1856, *Cymindoides sculptipennis* Motschulsky, 1856, *Protoscalidion rugiae* Schaufuss 1889, *Dromius resinatus* (Germar, 1813), *D. backeri* Abdullah, 1969, *Coptodera elektra* Gamboa et Ortuño, 2009, *Antepphilorhizus pripiatiensis* Kirichenko-Babko, Perkovsky et Vasilenko, 2021, *A. zerovae* Kirichenko-Babko et Perkovsky, 2021, *Lebia baehri* Kirichenko-Babko et Perkovsky, 2024 and *L. akinobuella* Kirichenko-Babko, Kopeć et Krzemiński, 2024. The remaining six species were preserved as compression fossils; four of them belong to the genus *Lebia*. They are known from the different parts of the world (Fig. 1): *Lebia harrelli* Cockerell, 1936 from the late Paleocene of Argentina, *L. minuscula* Piton, 1936 from the Gelasian of France, *L. amissa* Heyden et Heyden, 1865 from the Miocene of Germany, *L. protospiloptera* Cockerell, 1921 and *Plochionus lesquereuxi* Scudder, 1900 from the latest Eocene of Colorado (Florissant), and *Miolebidia gaura* Zhang, 1989 from the Miocene of China.

Today, there is a significant number of unidentified fossils taxa among compressions and inclusions in amber, the description of which will significantly expand our understanding of extinct fauna, including Carabidae. Further accumulation of information about fossil species will significantly deepen our understanding of the evolution of the family Carabidae and establish phylogenetic relationships between taxa of different ranks within the family.

Table 1. Fossil record of *Lebiini*.

Taxon	Occurrence
<i>Agatoides carinulatus</i> Motschulsky, 1856	Eocene Baltic amber
<i>Cymindoides sculptipennis</i> Motschulsky, 1856	Eocene Baltic amber
<i>Dromius resinatus</i> (Germar, 1813)	Eocene Baltic amber
<i>D. backeri</i> Abdullah, 1969	Eocene Baltic amber
<i>Coptodera elektra</i> Gamboa et Ortuño, 2009	Eocene Baltic amber
<i>Antephilorhizus pripiatiensis</i> Kirichenko-Babko, Perkovsky et Vasilenko 2021	Eocene Rovno amber, Ukraine
<i>A. zerovae</i> Kirichenko-Babko et Perkovsky, 2021	Eocene Rovno amber, Ukraine
<i>Protoscalidion rugiae</i> Schaufuss, 1889	Eocene Baltic amber
<i>Lebia akinobuella</i> Kirichenko-Babko, Kopeć et Krzemiński, 2024	Eocene Baltic amber
<i>L. baehri</i> Kirichenko-Babko et Perkovsky, 2024	Eocene Rovno amber, Ukraine
<i>L. harrelli</i> Cockerell, 1936	Paleocene of Argentina
<i>L. protospiloptera</i> Cockerell, 1921	Eocene of Colorado, USA
<i>L. minuscula</i> Piton, 1936	Quaternary of France
<i>L. amissa</i> Heyden et Heyden, 1865	Miocene of Germany
<i>Plochionus lesquereuxi</i> Scudder, 1900	Eocene of Colorado, USA
<i>Miolebidia gaura</i> Zhang, 1989	Miocene of China

Fig. 1. The map of the distributions of the fossil *Lebiini* species (Carabidae).

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RESEARCH POSSIBILITIES AT NATIONAL SYNCHROTRON RADIATION CENTRE SOLARIS

T. Kołodziej

Jagiellonian University/NSRC SOLARIS, Kraków, Poland; ☎ 0000-0002-1543-7868

**t.kolodziej@uj.edu.pl*

Keywords: synchrotron radiation, large scale facilities, spectroscopy, imaging, structural studies

Polish National Synchrotron Radiation Centre SOLARIS¹ is a modern tool for multiscale and multidisciplinary research. Open to external users since 2018, it offers unique capabilities across a broad variety of research fields in Central and Eastern Europe.

It is one of the so-called large-scale facilities, in which many subsystems work simultaneously to always keep the infrastructure operational and useful for users. From another point of view, it is an accelerator-based radiation source, in which relativistic particles emit very intense radiation with unique properties, spanning a broad spectral range of electromagnetic radiation. This synchrotron radiation beam is received by a physical system called a beamline, which shapes the beam both spectrally and geometrically, adapting it for a particular type of experiment. Each beamline is a separate laboratory, in which the properties of matter can be studied using different experimental techniques and various types of radiation. The properties and technical aspects of a particular beamline – and the experiments performed there – depend strongly on the type of radiation used.

In general, synchrotron radiation research can be divided into three main fields: imaging, spectroscopy, and structural studies. Among other capabilities, the SOLARIS Centre supports experiments using the following techniques:

- X-ray absorption spectroscopy in soft and hard X-rays, which provides information on the chemical state of atoms in a sample and their nearest surroundings;
- Photoemission spectroscopy, which probes electronic structure properties;
- Imaging techniques such as radiography, microtomography, and X-ray microscopy, which allow observation of objects on various scales from micrometers down to nanometers;
- Fluorescence mapping, which reveals the spatial distribution of chemical elements in a sample;
- Microscopy and spectroscopy in the infrared regime, which are sensitive to molecular vibrations in matter;
- Cryogenic transmission electron microscopy, used for refining biomacromolecular structures;
- Beamlines currently under construction for small-angle X-ray scattering and macromolecular crystallography in hard X-rays, which will support studies of molecular structures in biological materials, among other applications.

In the presentation, a general overview of the facility is given. In an accessible way, the basic physical principles on which the facility's operation is based will be explained. Additionally, with reference to specific beamlines, examples of research that can be conducted will be presented, with particular emphasis on life sciences where applicable. The practical steps involved in the proposal submission procedure will be briefly explained.

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**IN MEMORY OF DR HAB. DANIEL KUBISZ (1957-2025) – EXCELLENT COLEOPTEROLOGIST
AND PALEONTOLOGIST, GREAT COLLEAGUE**

S. Konwerski^{1,*} & K. Szawaryn²

¹Natural History Collections, Faculty of Biology, Adam Mickiewicz University, Poznań, Poland; ☎ 0000-0002-6438-8759

²Muzeum and Institute of Zoology, Polish Academy of Sciences, Warszawa, Poland; ☎ 0000-0002-9329-4268

*szymkonw@amu.edu.pl

Keywords: Daniel Kubisz, Coleoptera

On January 21, 2025, Daniel Kubisz – one of the best Polish coleopterologists, died suddenly and prematurely. He gained the recognition and respect of his colleagues not only for his impressive knowledge but also for his numerous qualities of character, among which stood out his readiness to help novice students of coleopterology.

For most of his time he was associated with the Museum of Natural History of the Institute of Systematics and Evolution of Animals of the Polish Academy of Sciences in Kraków.

As a coleopterologist, he focused mainly on the biodiversity, faunistics and zoogeography of beetles of the superfamily Tenebrionoidea in Central and Eastern Europe, including forest entomology (the impact of the use of pheromone traps for bark beetles on other forest Coleoptera and the succession and biodiversity of beetles in large forest complexes of Poland – including Białowieża Primeval Forest). Daniel devoted much attention to the protection of biodiversity of Polish beetles (elaborated red lists of Coleoptera both locally and nationwide, species for the “Polish Red Data Book of Animals. Invertebrates” and to the Natura 2000 habitats and species conservation guides. He also elaborated chapters in “Alien species in the fauna of Poland”. He conducted interdisciplinary research on the ecology, phylogeography and conservation genetics of beetles in Central Europe (in cooperation with Polish and foreign scientists), for which material was collected during numerous scientific expeditions (to Bulgaria, Czech Republic, Romania, Slovakia, Ukraine, Hungary). The object of research were beetles inhabiting steppe environments (mostly Buprestidae, Chrysomelidae, Curculionoidea). Daniel Kubisz was the author and co-author of about 150 publications, including “Keys for the Identification of Polish Insects” and “Faunistic Monographs” series, and three volumes of “Coleoptera Poloniae” devoted to Tenebrionoidea, which significantly influenced the intensification of coleopterological research in Poland.

As part of his paleoentomological interests, he described three genera and 14 species of extinct beetles belonging to five families:

Melyridae

Malachiinae

Colotes sambicus Kubisz, 2001

Mordellidae

Falsomordellistena eocenica Kubisz 2003

Succimorda Kubisz, 2001

Succimorda rubromaculata Kubisz, 2001

Oedemeridae

Oedemera girulskii Szawaryn, Sontag et Kubisz, 2022

Trogossitidae (Lophocateridae)

Promanodes Kolibac, Schmied, Wappler & Kubisz, 2010

Promanodes serafini Kolibac, Schmied, Wappler & Kubisz, 2010

Staphylinidae

Paederinae

Lathrobium ambricum Paśnik & Kubisz, 2002

Lathrobium balticum Paśnik & Kubisz, 2002

Lathrobium jantarticum Paśnik & Kubisz, 2002

Lathrobium succini Paśnik & Kubisz, 2002

Tachyporinae

Palaeosepedophilus Paśnik & Kubisz, 2002

Palaeosepedophilus succinicus Paśnik & Kubisz, 2002

Sepedophilus balticus Paśnik & Kubisz, 2002

Aleocharinae

Aleochara baltica Paśnik & Kubisz, 2002

Dictyon antiquus Paśnik & Kubisz, 2002

Phymatura electrica Paśnik & Kubisz, 2002

He also dealt with the possibility of using the elytra microsculpture of Dytyscidae in identification of subfossil materials.



Fig. 1. Daniel Kubisz (1957-2025) (photo S. Konwerski)

FOSSIL RESINS AS A SOURCE OF PALEONTOLOGICAL DATA: MUSEUM COLLECTIONS IN POLAND

K. Kopec^{1,*}, E. Sontag² & K. Kwiatkowska³

¹*Institute of Systematics and Evolution of Animals PAS, Krakow, Poland; ☎ 0000-0001-6449-3412*

²*Museum of Amber Inclusions, Faculty of Biology, University of Gdańsk, Poland; ☎ 0000-0002-5966-8334*

³*PAS Museum of the Earth, Warsaw, Poland; ☎ 0009-0008-3924-2724*

**kopec@muzeum.pan.krakow.pl*

Keywords: amber, insects, inclusions, evolution, biodiversity

Inclusions in amber represent a unique source of palaeontological data, enabling the reconstruction of ancient ecosystems, the analysis of past climates, and studies on the evolution and biodiversity of organisms. The distribution and diversity of the age of fossil resins (e.g., Baltic amber 40–50 million years old, Dominican amber approx. 18 million years old, Burmese amber approx. 100 million years old, or Lebanese amber approx. 145 million years old) will enable multi-level paleontological research. The preservation of fossils in fossilized resins enables the study of microscopic details of morphological and, in some cases, anatomical structure. This places amber at the forefront of palaeontological research.

In Poland, three major institutions curate scientific collections of fossil resins. The most extensive and venerable assemblage of amber in Poland is held by the **Museum of the Earth of the Polish Academy of Sciences (PAN)** in Warsaw, which boasts a collection of over 30,000 pieces. These contain inclusions of diverse organismal groups, including rare ones such as crustaceans (Crustacea) and twisted-wing parasites (Strepsiptera), as well as unique mammalian hair. The Warsaw collection comprises 156 holotypes and a substantial comparative material of animal and plant inclusions.

The second oldest inclusions collection is that of the **Natural History Museum of the Institute of Systematics and Evolution of Animals, Polish Academy of Sciences (PAN)** in Kraków. This collection was assembled since approximately 1985 and currently holds around 5,000 amber pieces, which contain over 20,000 organic inclusions. It is a vital resource for studies on insect evolution and biodiversity changes. The collection was largely established through donations from collectors and scientists from Poland and abroad, significantly enriching its diversity and scientific value. Currently, it comprises 100 type specimens (77 holotypes and 23 paratypes), representing numerous invertebrate groups, including arachnids (Acari, Araneae), insects (Coleoptera, Diptera, Hemiptera, Hymenoptera, Mecoptera, Neuroptera, Odonata), and gastropods (Gastropoda: Vertiginidae). These holdings are subject to continuous updating and are available for consultation in the RCIN database. The museum also houses a laboratory for amber processing and imaging, which is fully equipped for the preparation of amber specimens for scientific research. The laboratory is also equipped with a photospectrometer, which is utilised for the analysis of infrared spectra of fossil resins, with the objective of identifying their types.

The youngest, but arguably the most diverse, is the scientific collection of the University of Gdańsk. The **Museum of Amber Inclusions** houses a collection of over 7,000 amber pieces, accompanied by more than 18,000 inclusions and fossil traces. The collection was made possible by the generous contributions of donors, whose list has already surpassed 100 individuals. This list is available for viewing on the Internet. The collection is predominantly composed of Baltic amber, but also encompasses fossil resins from various regions worldwide, including distinctive fossil resin from Ethiopia. The collection is notable for housing the only bivalves preserved in Mexican amber, and the only one in the world fossil barnacle in Mexican amber. The collection is distinguished by the presence of previously unselected materials, and it is housing 176 type specimens (141 types and 35 paratypes), among which are ichnotypes, described for the first time from fossil

resins. The university collection is equipped with unique facilities, including a fully equipped palaeontological laboratory (the Palaeontological Laboratory of Fossil Resins) for the preparation of amber for scientific research.

These collections provide essential data for systematic, palaeobiological, and palaeoenvironmental research, significantly contributing to our understanding of the history of life on Earth.

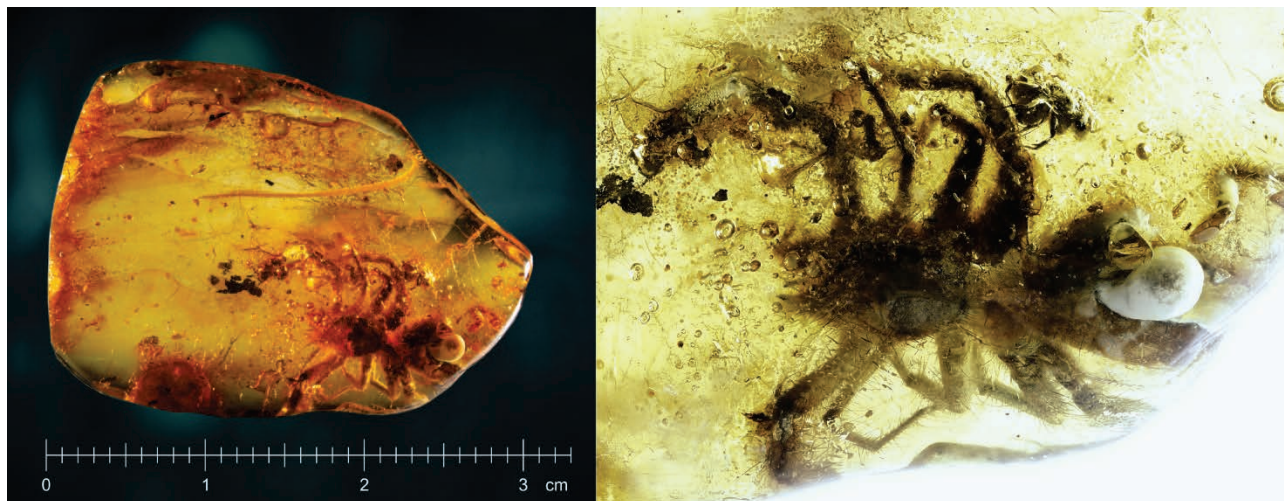









Fig. 1. *Eognosippus fahrenheitiana* Dunlop, Erdek & Bartel, 2023. There are three solifuges preserved in Baltic amber worldwide, but only two described species. One of them in the collection of the University of Gdansk, in the Museum of Amber Inclusions; Baltic amber, age ca. 45 million years, inv. no.: MAIG 7000. photo R. Mielczarek

**DEVELOPMENT OF ECOLOGICAL ADAPTATIONS
IN THE CRETACEOUS DEUTEROPHLEBIIDAE (DIPTERA)**

E. Krzemińska^{1,*}, A. Soszyńska², I. Kania-Kłosok³, K. Skibińska¹, K. Kopeć¹, J. Sternalski¹
& W. Krzemiński¹

¹*Institute of Systematics and Evolution of Animals, PAS, Kraków, Poland;  0000-0002-3431-9963 (E.K.),  0000-0001-6449-3412 (K.K.),  0000-0002-5971-9373 (K.S.),  0000-0002-7560-0970 (J.S.),  0000-0001-5685-891X (W.K.)*

²*Faculty of Biology and Environmental Protection, Department of Invertebrate Zoology and Hydrobiology, University of Łódź, Poland;  0000-0002-2661-6685*

³*Faculty of Biology and Nature Protection, University of Rzeszów, Rzeszów, Poland;  0000-0002-2325-4308*

**ekrzeminska9@gmail.com*

Keywords: Burmese amber, paleoecology, false veins, rheophile



Recent juvenile Deuterophlebiidae are rheophiles, i.e., adapted to life in swift-running, cold streams. Adults have an exceptionally brief lifespan (2-6 hrs) devoted to mating on flight over turbulent water, and to egg laying. Their adaptations to these extreme conditions include several unique features. Mouthparts are completely reduced; the adults do not feed during their short life. Very long antennae (in males) and tarsi ending with large empodia enable bouncing back from the water surface in case of accidental falls¹. Wings are probably largest among the Diptera (considering the body/wing proportions) and supported by a dense net of false veins. This distinctive venation probably allows for a quick spreading of wings after emergence. Here we present early stages of these adaptations in two extinct genera of Deuterophlebiidae from Burmese amber². In particular, we will concentrate on venation and the structure of false veins in fossil and recent specimens.

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FOSSIL RECORD OF DIPTERA: NEMATOCERA – THE POLISH CONTRIBUTION TO GLOBAL RESEARCH

W. Krzemiński¹, E. Krzemińska¹, A. Soszyńska², I. Kania-Kłosok³, M. Syratt^{1,4} & K. Kopec^{1,*}

¹*Institute of Systematics and Evolution of Animals PAS, Kraków, Poland;  0000-0001-5685-891X (W.K.), 0000-0002-3431-9963 (E.K.),  0000-0001-6449-3412 (K.K.)*

²*University of Lodz, Faculty of Biology and Environmental Protection, Department of Invertebrate Zoology and Hydrobiology, Łódź, Poland;  0000-0002-2661-6685*

³*Faculty of Biology and Nature Protection, University of Rzeszów, Poland;  0000-0002-2325-4308*

⁴*Faculty of Biology, Jagiellonian University, Kraków, Poland;  0000-0003-4795-2634*

*kopec@muzeum.pan.krakow.pl

Keywords: palaeoentomology, fossil flies, Limoniidae, evolution

Within the Polish Section of Fossil Insects, an active palaeoentomological research group conducts extensive studies on fossil flies belonging to the group Diptera, Nematocera. The scope of research encompasses representatives of Tipulomorpha, Psychodomorpha, Ptychopteromorpha, Anisopodomorpha, Culicomorpha, and selected families within the superfamily Sciaroidea.

Since the establishment of the Section in 1985, its members have developed wide collaborations with researchers from around the world and have visited most of the major fossil insects collections. These efforts have enabled numerous significant scientific discoveries, resulting in many publications, including:

- identification of Triassic fly assemblages from the early Middle Triassic France (approx. 245 Ma) including the description of the most primitive wing venation (in *Grauvogelia*);
- description of the Upper Triassic dipteran assemblage from North America (approx. 208 Ma)
- description of the first fossil representatives of the family Deuterophlebiidae,
- confirmation of a close relationship between the families Tanyderidae and Psychodidae based on fossil evidence, a hypothesis that had previously been contested,
- revision of numerous fossil taxa from historic collections, including those of Bode, Rohdendorf, and Alexander,
- analysis of wing vein homologies between the orders Mecoptera and Diptera, as well as within selected families of Nematocera,
- demonstration that fossil taxa are comparable to extant forms, and that excluding of fossil data precludes an inaccurate reconstruction of phylogenetic relationships within Diptera,
- documentation of evolutionary changes in Diptera over a period of approximately 250 million years, and the use of fossil evidence to calibrate the molecular clock,
- publication of a monograph of fossil Trichoceridae.

In total, approximately six new families, three subfamilies, 38 genera, and 260 species have been described. Additionally, several hundred taxa originally described by various authors have been revised.

Research on fossil flies from the family Limoniidae (infraorder *Tipulomorpha*) has been particularly intensive. To date, one new subfamily, six genera, 12 subgenera, and 113 species have been described. Currently, work is underway on a comprehensive catalogue of fossil *Tipulomorpha*, coordinated by Piotr Oosterbroek.

ELATEROID IMMATURE STAGES IN THE FOSSIL RECORD (COLEOPTERA: POLYPHAGA)R. Kunderata^{1,*}, K. Třísková¹, S.P. Rosa², J. Hoffmannová¹, D. Jetelina¹, E. Bonino³ & G. Pačková¹

¹Department of Zoology, Faculty of Science, Palacky University, Olomouc, Czech Republic;
● 0000-0001-9397-1030 (R.K.), ● 0000-0003-2385-5557 (K.T.), ● 0000-0003-0216-6031 (J.H.),
● 0009-0002-1212-0651 (D.J.), ● 0000-0001-7949-619X (G.P.)

²Universidade Federal de Itajubá, Instituto de Recursos Naturais, Itajubá-MG, Brazil; ● 0000-0002-7499-9158

³Back to the Past Museum, Puerto Morelos, Quintana Roo, Mexico; ● 0000-0002-4590-2759

*robin.kunderata@upol.cz

Keywords: amber, diversity, Elateroidea, larva

The superfamily Elateroidea (click beetles, fireflies, soldier beetles and relatives) constitutes a morphologically diverse group of polyphagan beetles with a long evolutionary history. More than 30,000 described species are currently classified in 18 families. The morphological diversity of Elateroidea includes a continuum from well-sclerotized forms with interlocking mechanisms (e.g., Elateridae and Eucnemidae) to lineages with the incomplete sclerotization of the cuticle (e.g., Lampyridae and Cantharidae)¹. Elateroid larvae have mouthparts specialized for liquid feeding. Many elateroid larvae are saproxylic. Larvae of soft-bodied groups prefer microhabitats with high relative humidity, i.e., in leaf litter, under stones, in soil, or in decaying wood. This is probably due to their feebly sclerotized integument in combination with their food preferences. Immature stages in Elateroidea are insufficiently studied despite the fact that they may bear diagnostic morphological characters crucial for separating taxa at various levels, and that these characters may also play an important role in phylogenetic reconstruction. For example, two large subfamilies of Elateridae, i.e., Elaterinae and Dendrometrinae (=Denticollinae), are difficult to separate based on adult morphology but are easily distinguishable based on larval characters. On the other hand, some only distantly related taxa might have similar morphology due to similar ecological requirements². Within Elateroidea, immature stages are completely unknown for Omethidae and the recently discovered Sinopyrophoridae. Although the fossil record of Elateroidea is quite well studied, it is almost entirely based on adult specimens. The fossil record of larval elateroids is very scarce³. So far, only fossil larvae of Brachypsectridae, Eucnemidae, Elateridae, Lampyridae, Cantharidae, and Lycidae have been reported³⁻⁵. Interestingly, fossil larvae were reported for some elateroid families for the first time in recent years⁴. Although the fossil record of Elateridae (click beetles) includes almost 300 described species, there are only three described fossil larvae of this group, all from the mid-Cretaceous amber of northern Myanmar⁵.

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**SINOAGETOPANORPIDAE, THE FIRST CHINESE MECOPTERAN FAMILY (INSECTA, MECOPTERA)
FROM THE GUADALUPIAN OF SOUTH CHINA**

X. Lian¹, C. Cai², Z. Feng¹ & D. Huang^{2*}

¹*Institute of Palaeontology, Yunnan University, Kunming, China;*

• 0000-0001-6680-1781(X.L.), • 0000-0001-9635-1144 (Z.F.)

²*State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, China; • 0000-0002-9283-8323 (C.C.), • 0000-0002-5637-4867 (D.H.)*

*dyhuang@nigpas.ac.cn

Keywords: diversity; Capitanian; Yangtze Platform; Permochoristidae

Mecoptera, one of the most ancient holometabolic insect orders, can be traced back to the Early Permian. While Mecoptera thrived during the Permian period, little is known in China, with only one species previously reported. Herein, we describe and illustrate the first Chinese mecopteran family, Sinoagetopanorpidae Lian, Cai and Huang, 2023, based on 57 new specimens from the upper Guadalupian Yinping Formation at Yinping Mountain, Chaohu City, Anhui Province, China.

Sinoagetopanorpidae are characterized by several characters: wing well oval, pigmented with dark color spots; Sc space notably broad, typically with 3 (sometimes 4) evenly developed branches; Rs with 5 branches, Rs₄ dividing into 2 branches; M typically with 6 branches (sometimes 5). This family can be distinguished from the others by its varied forked patterns of the 3-branched M: M₃ forked and M₄ single, M₃ single and M₄ forked, or the convergence of all 3 branches of M at one point.

Due to the stable number of wing venation within this family, it can serve as a primary classification feature at the genus level. For instance, fossils with Sc 3 branches are assigned to the genus *Sinoagetopanorpa*, those with Sc 4 branches are classified under the genus *Permoagetopanorpa*, and those with M 5 branches belong to the genus *Raragetopanorpa*. Species-level classification is based on variations in size, shape, the position of longitudinal vein forks, particularly the colored patterns, of which 3 distinct types have been observed.

Previously attributed to Permochoristidae, *Sinoagetopanorpa permiana* Lin, Nel, and Huang, 2010, has now been reclassified as the type species of Sinoagetopanorpidae. In total, 3 genera and 11 new species of this family are described and illustrated. Additionally, some isolated hind wings are described and illustrated, although assigning them to specific species proves challenging.

These new findings significantly enhance the palaeodiversity of Chinese Permian mecopterans and providing insights into their early evolution and palaeogeographical distribution. As a notable mecopteran lineage within the Yinping Formation, Sinoagetopanorpidae represent an endemic group that potentially underwent independent evolution on the Yangtze Platform.

**THE NEW MIDDLE TRIASSIC INSECT LAGERSTÄTTE OF MONTE SAN GIORGIO (SWITZERLAND):
EXCEPTIONAL PRESERVATION AND DIVERSITY**

F. Magnani^{1*}, M. Montagna² & G. Magoga³

¹Museo cantonale di storia naturale, Lugano, Switzerland; ☎ 0000-0002-5982-7278

²Department of Agricultural Sciences, Naples, Italy; ☎ 0000-0003-4465-7146

³Department of Agricultural Sciences, Naples, Italy; ☎ 0000-0002-0662-5840

*fabio.magnani@ti.ch

Keywords: Monte San Giorgio, UNESCO, Late Ladinian, diverse paleocommunity, Fossil deposit

Monte San Giorgio, located on the border between Switzerland and Italy, is a UNESCO World Heritage site known for its exceptionally well-preserved fossil fishes and marine reptiles from the Middle Triassic period. The sedimentary conditions that facilitated these remarkable fossil discoveries resulted from long-term transgression and dysoxic to anoxic bottom waters. During the Middle Triassic, Monte San Giorgio was positioned at a latitude of 15-18°N and was influenced by monsoonal circulation, which contributed to seasonal variations and density stratification in the lagoon. Insect fossils were collected during excavations led by the Museo cantonale di storia naturale in 2020 and 2023 at the Val Mara VM 12 site, near the village of Meride in Switzerland. These fossils were found in strata dating to the late Ladinian, specifically in the upper “Kalkschieferzone”. The fossil-bearing strata consist of thin-bedded laminated limestones and marly limestones, indicating a shallow lagoon environment with seasonal salinity fluctuations.

A new collection of approximately 300 insect fossils discovered in VM 12 site, representing 15 major insect groups, exhibits exceptional preservation and small size. The fauna recovered includes both freshwater species (e.g. Odonata, Ephemeroptera, Thripidae and Trichoptera) and terrestrial insects (e.g., Hymenoptera, Diptera and Heteroptera), suggesting the presence of complex ecosystems that supported a diverse palaeocommunity.

The preliminary palaeoentomofaunal studies conducted at site VM 12 have led to several significant discoveries, including the youngest and most complete specimen of †Permithonidae (*Merithone laetitia*), the hymenopteran *Magnicapitixyela dilettae*, the oldest sawfly found in European deposits, and a new species of roachoid from the Subioblattidae family, *Samaroblattella valmarensis*. Additionally, *Dasyleptus triassicus*, previously described from another site at Monte San Giorgio, was also found in large quantities at the earlier VM 12 site, with specimens ranging from 1 to 29 millimeters in length, indicating different developmental stages.

PALAEOENTOMOLOGICAL OUTCROPS IN LEBANON

S. Maksoud^{1,*} & D. Azar^{1,2}

¹*Lebanese University, Faculty of Sciences II, Department of Natural Sciences, Fanar, Lebanon;*

☎ 0000-0001-7437-7490

²*Nanjing Institute of Geology and Palaeontology, CAS, Nanjing, China;*

☎ 0000-0002-4485-197X

**sibelle.maksoud@ul.edu.lb*

Keywords: Amber, Mesozoic, adpressions, fossil insects

Lebanon is globally well known for its numerous and diverse palaeontological sites. Before the seventies of the last century, Lebanon was internationally known for its richness in its Mesozoic and Cenozoic marine fossil outcrops (mainly Cenomanian fossil fishes' ones). In the recent two decades, with the massive discovery of Jurassic and Lower Cretaceous amber outcrops in its lands, Lebanon gained a universal primary place in its richness in very important palaeontological sites. To date, 38 Mesozoic outcrops yielding fossil insects, either in amber or as rock (marls, limestones, cinerite, or dysodile) impressions-compressions (adpressions), were found in Lebanon. Compared to its small surface area, this country can be considered among the richest in fossil insect outcrops. All these outcrops are from Upper Jurassic (Kimmeridgian) but mainly from the Cretaceous Period, most of them from the Lower Cretaceous (lower Barremian and Albian) whilst remainder from the 'mid-Cretaceous' (Cenomanian). The Cretaceous is undoubtedly one of the most interesting and important geological periods in the history of the Earth. It is when the origin and radiation of the angiosperms took place, and most of the extant insect families first appeared.

During the Lower Cretaceous the palaeoenvironment was a forest, fluvial – lacustrine tropical and a proximal marine tropical and subtropical receptively during the Late Jurassic and the "Middle Cretaceous". We present, an exhaustive review of all outcrops with insects in Lebanon. The recent discoveries of new and very diverse outcrops of fossiliferous amber in Lebanon help to meet the challenge of considerably enriching our knowledge of the Past.

LATE JURASSIC INSECTS FROM THE OWADÓW-BRZEZINKI SITE, POLAND

M. Michalska^{1,*}, B. Błazejowski^{1,2}

¹*Institute of Paleobiology, PAS, Warsaw, Poland; ☎ 0009-0004-1505-5618*

²*Museum of the Earth of the PAS, Warsaw, Poland; ☎ 0000-0001-6320-9870*

**m.michalska@twarda.pan.pl*

Keywords: fossil, limestone, palaeoenvironment

The Owadów-Brzezinki palaeontological site located in the NW margin of the Holy Cross Mountains is one of the most important palaeontological discoveries from Poland¹. For over a decade, numerous fossils of both marine and terrestrial organisms of Late Jurassic (Tithonian) age have been collected from this quarry.

The exposed carbonate sequence belongs to 2 formations: the Kcynia Formation and Pałuki Formation. The Kcynia Formation is divided into four successive units (I, II, III and IV) of limestones, with all fossil insects having been found in the lowermost, highly fossiliferous part of unit III. In general, first three units appear to represent a continuous transition from offshore to nearshore, perhaps lagoonal settings, whereas unit IV shows evidence of a return to more open marine conditions².

The current collection of fossil insects consists of 45 specimens and is continually expanding through regular excavations. Initial research has confirmed the presence of 3 insect orders: Coleoptera, Odonata and Orthoptera³. The state of preservation is typical for sites containing palaeoentomofauna – where relatively decay-resistant elements are found, i.e. the wings of dragonflies and orthopterans (with clearly visible venation and sometimes traces of their original colouration), as well as the abdomens and elytra of beetles, which are characterised by more thick cuticle.

Insect assemblages preserved in carbonate rocks are often dominated by species that rely on water for various reasons, such as feeding, habitation, or egg-laying⁴. The slight prevalence of beetles observed among the Owadów-Brzezinki specimens may be a result of their robustness and ability for easy transport, rather than implying their dominance in the environment. Isolated elytra are not a reliable indicator of the mode of life of the beetle. However, the state of preservation may perhaps be indicative of the beetles' allochthonous origin – as greater disarticulation and fragmentation may be associated with longer way of transport to the deposition place, which could entail additional external destructive factors on the lagoon's shores, water surface and in the water column. The presence of orthopterans, in turn, clearly indicates the proximity of dry land in the area, presumably an island archipelago. Dragonflies are known for their ability to travel long distances, so they may have flown to the lagoon shore for hunting. The absence of fossilised dragonfly larvae may indicate the proximity of a freshwater reservoir where they developed, as recent dragonfly larvae rarely inhabit lagoons. Alternatively, such larvae may have been part of the lagoon ecosystem but have not been preserved. It should be noted that despite the importance of taphonomy, searching for fossil insects in rocks is subject to certain biases; as such, dragonfly larvae, other delicate body parts or even another order of insects may simply not have been discovered yet.

These findings highlight close relationship between Owadów-Brzezinki and similar Late Jurassic faunal assemblages from Great Britain⁵.

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THE CONTRIBUTION OF THE MONTE SAN GIORGIO FOSSIL DEPOSIT TO INSECT EVOLUTION

M. Montagna^{1*}, G. Magoga² & F. Magnani³

¹*Department of Agricultural Sciences, Naples, Italy; ☎ 0000-0003-4465-7146*

²*Department of Agricultural Sciences, Naples, Italy; ☎ 0000-0002-0662-5840*

³*Museo cantonale di storia naturale, Lugano, Switzerland; ☎ 0000-0002-5982-7278*

**matteo.montagna@unina.it*

Keywords: Middle Triassic, end Permian crisis, insect fossil Lagerstätte, exceptionally preserved fossils

The Middle Triassic deposit of Monte San Giorgio, located on the border between Switzerland and Italy, has recently been recognized as a significant site for insect fossils. The site has yielded numerous insect specimens (273 fossils belonging to 19 major insect lineages), which greatly contribute to our understanding of insect evolution, both due to their conservation status and systematic placement. Specifically, some of these fossils exhibit remarkable preservation, including soft tissues and internal organs such as components of the central nervous system, muscles, and tendons. Moreover, some fossils represent the oldest known specimens of their taxonomic group, while others mark taxa last known occurrence of certain taxa.

Notably, phylogenomic and molecular clock analyses, using a selection of the most relevant Monte San Giorgio fossils as calibration points, have revealed that many insect lineages originated much earlier than previously thought. For instance, the origins of over 30 major hexapod lineages have been backdated by more than 50 million years, suggesting that key innovations, such as flight and metamorphosis, evolved significantly earlier than previously believed. This includes insect lineages (e.g. Hymenoptera, Heteroptera and Diptera) which were once thought to have originated after the end of the Permian but are now understood to have emerged before it. Conversely, some of the fossils discovered at Monte San Giorgio (†Permithonidae and †Monura), which were previously thought to have gone extinct after the end of the Permian, were still present during the Middle Triassic.

Together, these pieces of evidence challenge earlier theories that the end-Permian events had a major impact on insect lineage survival. In conclusion, Monte San Giorgio fossil deposit has made an invaluable contribution to the study of insect evolution, providing key specimens that reshape our understanding of the Triassic period. These fossils not only reveal previously unknown taxonomic and ecological diversity but also provide critical insights into the early evolution of major insect lineages, the emergence of key innovations, and the resilience of insect life through one of Earth's most catastrophic extinction events.

FOSSIL FAUNA OF SAKHALINIAN AMBER WITH PARTICULAR EMPHASIS ON APHIDS; HISTORY AND STATE OF RESEARCH

B. Ogłaza^{1,*}, M. Kalandyk-Kołodziejczyk¹, E.E. Perkovsky^{2,3} & P. Węgierek¹

¹*Institute of Biology, Biotechnology and Environmental Protection, University of Silesia, Katowice, Poland;*

ORCID: 0000-0002-5553-0813 (B.O.), ORCID: 0000-0003-0007-7457 (M.K-K.), ORCID: 0000-0001-9960-0433 (P.W.)

²*Natural History Museum of Denmark, Universitetsparken 15, Copenhagen, Denmark; ORCID: 0000-0002-7959-4379*

³*Schmalhausen Institute of Zoology, National Academy of Sciences of Ukraine, Kiev, Ukraine*

*bartosz.oglaza@us.edu.pl

Keywords: Sakhalin, fossil insects, fossil resin, bioinclusions

Amber, the fossilised resin of trees, has unique properties that allow the preservation of organic matter. They are a window into the past. The inclusion provides information not only about the taxonomic diversity and phylogenesis of individual groups but also about palaeoecology, palaeogeography and animal behaviour. However, this knowledge is related only to the time when amber was formed. One of the most intriguing gaps in the amber inclusions records is the Eocene Amber Bioinclusion Gap. It occurred between 50 and 42 million years ago¹. The results of preliminary studies indicate that bioinclusions from the Far East Asian amber from Sakhalin Island may partially fill this gap (43–47 million years ago). Sakhalinian amber is an Eocene fossil resin containing numerous animal inclusions, the deposits of which are located in the southern part of Sakhalin Island, near the Naiba River.






During an expedition to Sakhalin in 1972 by the Paleontological Institute RAS, numerous amber insects were collected. The amber was found on the beaches of the Okhotsk Sea (South Sakhalin). In situ fossil resin of the same composition was also found near the Naiba River, embedded in coal of the Naibuchi Formation². Sakhalinian amber is supposed to belong to rumanite. Initially, only 838 inclusions were reported but the number has increased to 1250 now and new ones are still being found. Up till now, 25 studies have been published. A total of only 85 inclusions have been examined and described. Phytostratigraphy indicated that in the southern part of South Sakhalin, the Naibuchi flora occupied vast stretches of alluvial lowlands along the seashores, with a dense net of rivers and large areas of wetlands. Small lakes and swamps were the dominating type of water body. The age of Sakhalinian amber has remained disputable. Zherikhin³ estimated the age in a broad range, from the Paleocene (56–59 Ma) to the middle Eocene (42–47 Ma). However, Kodrul² suggested the middle Eocene age of the Naibuchi Formation, in which Sakhalinian amber was found in situ.

In addition to the insects already described, aphid inclusions may provide a lot of information about this period of time. Chironomids and aphids are the most frequently found insects in Sakhalinian amber, and aphid parasitoids are the commonest hymenopterans in the Lagerstätte.

The goal of our current aphid focused research is not only to study and describe the Eocene biocenosis of the Sakhalin amber forest but also to conduct a comprehensive biological comparative analysis of many other Eocene sites with the occurrence of fossil insects. The results should provide information on the evolution of terrestrial ecosystems during the Eocene Amber Bioinclusion Gap [EAGB, 50 – 42 Ma].

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FOSSIL RECORD OF BIOLUMINESCENT AND PAEDOMORPHIC ELATEROID BEETLES (COLEOPTERA: ELATERIFORMIA)G. Pačková¹, K. Třísková¹, V. S. Ferreira², E. Bonino³ & R. Kunderata^{1,*}¹*Department of Zoology, Faculty of Science, Palacky University, Olomouc, Czech Republic;  0000-0001-7949-619X (G.P.),  0000-0003-2385-5557 (K.T.),  0000-0001-9397-1030 (R.K.)*²*Senckenberg Deutsches Entomologisches Institut, Müncheberg, Germany;  0000-0001-8748-0358*³*Back to the Past Museum, Puerto Morelos, Quintana Roo, Mexico;  0000-0002-4590-2759***robin.kunderata@upol.cz***Keywords:** Burmese amber, Elateroidea, fireflies, luminescence, neoteny

The Elateroidea, with over 30,000 described species, form a substantial part of the polyphagan beetle series Elateriformia, with an ancient evolutionary history and worldwide distribution. Elateroid beetles are interesting from an evolutionary point of view due to the presence of bioluminescence (i.e., ability to emit visible light) and paedomorphosis (i.e., retention of immature characters into adulthood) in often distantly related lineages. Elateroidea are morphologically very diverse, spanning well-sclerotized lineages with a functional clicking mechanism through various intermediate stages to soft-bodied groups¹. More than 3,000 species classified in elateroid families Elateridae (click beetles), Sinopyrophoridae, Lampyridae (fireflies), Phengodidae, and Rhagophthalmidae are bioluminescent. All these families except for Elateridae form the so-called 'lampyroid clade'². Origin and evolution of light production in elateroid beetles has been a widely debated topic over the last decades^{2,3}. The bioluminescence in Elateroidea most probably originated not later than in the Jurassic. According to recent studies, the common ancestor of luminescent groups was non-luminescent, and luciferase evolved independently in Elateridae, Sinopyrophoridae, and the 'lampyroid clade'³. Bioluminescent Cretophengodidae, Phengodidae, and Lampyridae have been recently reported from the mid-Cretaceous amber of northern Myanmar (Burmese amber, ~99 Mya). Paedomorphosis in Elateroidea usually more affect females than their male counterparts, and some lineages contain almost completely larviform females⁴. Interestingly, the soft-bodiedness can be interpreted as the first step of gradual paedomorphic transformations leading to highly larviform forms. Multiple origins of paedomorphosis have been repeatedly found not only at the superfamily level¹ but also within the individual families Elateridae, Lampyridae, and Lycidae. Although the presumably paedomorphic representatives of Phengodidae, Cretophengodidae, and Lampyridae were reported from the Mesozoic, there is no fossil evidence of paedomorphic Lycidae from that Era. The monotypic genus *Anouema* Li *et al.* from the Burmese amber, currently without a family attribution in Elateroidea, was also considered presumably paedomorphic by the original authors⁵.

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**ARTHROPODS ASSOCIATED WITH PLANT REMAINS FROM THE UPPER TRIASSIC PORĘBA LOCALITY
(UPPER SILESIA, POLAND)**

G. Pacyna

*Jagiellonian University, Faculty of Biology, Institute of Botany, Department of Taxonomy, Phytogeography and
Paleobotany, Kraków, Poland; 0000-0003-4365-3549*

grzegorz.pacyna@uj.edu.pl

Keywords: isolated cuticles, beetle elytra, scorpions, plant-arthropods interactions

Poręba is a significant Upper Silesian Late Triassic fossil locality, providing numerous well-preserved micro- and macroplant, invertebrate and vertebrate remains¹. Beds exposed at Poręba contain interdigitated conglomerates, bone-bearing breccias, grey to yellowish sandstones, and grey to bluish claystones and siltstones. The strata belong to the upper part of the Patoka Member of the Grabowa Formation and represent a braided river system. Sporomorphs found in fossil-bearing levels are typical for the local miospore zone *Classopollis meyeriana* subzone b, pointing to middle–late Norian age.

The claystones and siltstones with plant remains were soaked in water with detergent for a few days and next washed on sieves. The identifiable plant remains were manually picked out by small brush from the remaining organic residue. Some arthropod remains were identified during this process. They were separated from the plant cuticles, cleaned in HF from the remaining sediment particles, and examined under a stereoscopic microscope. Some specimens were gold-coated for SEM.

Among the arthropod remains are small disarticulated body parts and isolated cuticle fragments. Cuticle fragments (mainly with torn edges, about 1–5 mm in diameter) possess characteristic tuberculation and hair-like setae allowing attribution to arthropods, but closer determination is not possible. There are several well-preserved leg segments. Some cuticle fragments and leg segments have tubercles and hair bases strongly resembling those described for isolated and articulated fossil scorpion cuticles^{2,3,4}. Only beetles can be recognized with higher probability. They are represented by small elytra similar to so-far undescribed beetle material from the neighboring Carnian locality Krasiejów⁵.

Additionally, numerous traces of plant–arthropod interactions were found; they include leaf mining (tunnels filled with coprolites inside leaf cuticles), leaf piercing (small round holes in leaves), and enigmatic cuticle micromorphology modifications.

Funding provided by the National Science Centre, Poland (Grant no 2021/43/B/ST10/00941).

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CHECKLIST OF SPANISH AMBER TAXA: 30 YEARS OF RESEARCH SINCE THE DISCOVERY OF THE FIRST BIOINCLUSION

E. Peñalver^{1,*}, A. Arillo², R. López Del Valle³ & X. Delclòs⁴

¹*Instituto Geológico y Minero de España, CSIC, Valencia, Spain; ☎ 0000-0001-8312-6087*

²*Departamento de Biodiversidad, Ecología y Evolución, Facultad de Biología, Universidad Complutense, Madrid, Spain; ☎ 0000-0002-4878-5797*

³*Museo de Ciencias Naturales de Álava, Vitoria-Gasteiz (Álava), Spain; ☎ 000-0002-7164-9558*

⁴*Departament de Dinàmica de la Terra i de l'Oceà, Facultat de Ciències de la Terra, Universitat de Barcelona, Barcelona, Spain; ☎ 0000-0002-2233-5480*

**e.penalver@igme.es*

Keywords: type localities, holotypes, taxonomy, Cretaceous

Spanish Cretaceous amber has been known since the 18th century, but the first amber containing bioinclusions was discovered in 1994. Since then, numerous outcrops have been found in Spain, with five being exceptionally rich in bioinclusions and nine are type localities. The bioinclusions from these sites are primarily Albian in age (approximately 110–102 Ma), with a few exceptions that are Cenomanian in age. The first publication describing species from Spanish amber (Fig. 1A) appeared in a Polish journal in 1998¹. The majority of described taxa as new are insects, but also include non-insect hexapods, arachnids, and crustaceans.

Here we present a checklist that focuses on taxa described from Spanish Cretaceous amber bioinclusions, including a few plant remains (though none are new taxa based on Spanish holotypes). For each taxon, it provides key data such as the amber locality (mostly type localities), the specimen collection number (mostly holotypes), and taxonomic changes. To date, more than 100 taxonomic papers have been published, with a significant increase since 2005. Based on 184 holotypes from Spanish amber (Fig. 1C), eight families, 104 genera (representing 104 type species), and 184 species have been described.

Peñacerrada I amber has yielded the most holotypes. Hymenoptera is the best-represented arthropod group, followed by Diptera and Coleoptera. Hymenoptera and Diptera also show the highest family diversity, followed by Coleoptera and Acariformes/Oribatida. These two orders (Hymenoptera and Diptera) also contain the most diverse families in terms of genera and the most diverse genera in terms of species. Notably, all families within Coleoptera, one of the most represented orders, are extant.

A comparison with other Cretaceous ambers shows that Spanish amber has the most extensive taxonomic lists for Tanaidacea (Malacostraca) and Acariformes. Notably, three-quarters of all mites described from Cretaceous ambers are from Spain, a distinction likely due to the Spanish research team's focus on this group of arachnids.

This checklist of taxa has been compiled 30 years after the first bioinclusion discovery in Spain. It reflects three decades of research by the Spanish AMBERIA team, supported by various Spanish scientific public institutions and semi-public enterprises. Updated to May 2025, the checklist includes the most recently described species, *Tethysthrips attenboroughi*² (Fig. 1B), and was recently published in the New Zealand journal *Palaeoentomology*³. This compilation has also allowed for the detection and correction of several errors in the original descriptions, such as incorrect type localities and holotype collection numbers.

This research is a contribution of the project PID2022-137316NB, funded by MICIU/AEI/10.13039/501100011033 and by ERDF/EU, and a project of the *Gobierno de Cantabria* through the semi-public enterprise *EL SOPLAO S.L.* (research agreements #20963 and VAPC 20225428).

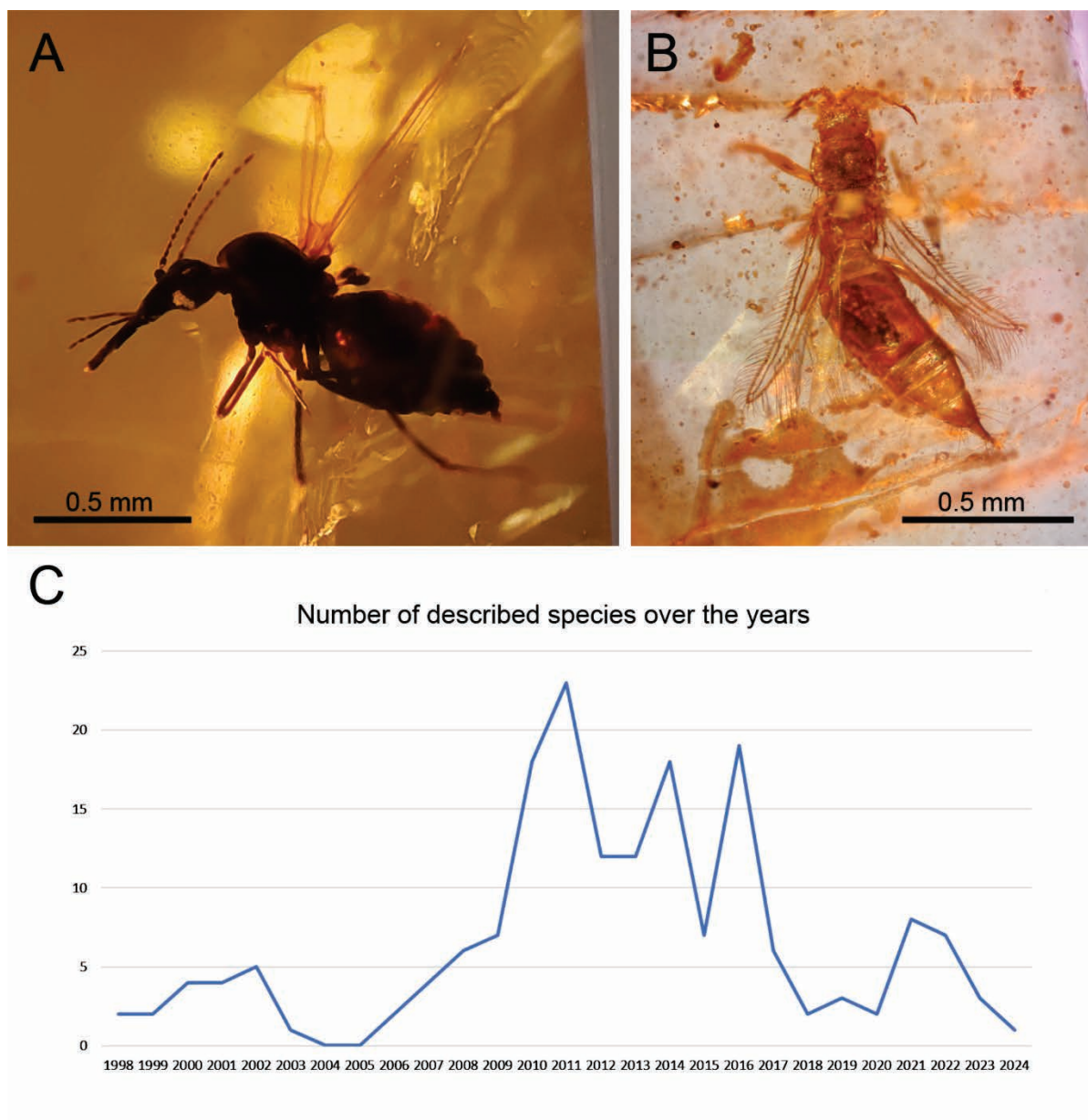


Fig. 1: A) *Gerontodacus skalskii* (Szadziwski & Arillo, 1998) of the family Ceratopogonidae¹ from Peñacerrada I outcrop; this specimen corresponds to the first holotype that was established from Spanish amber, B) *Tethysthrips attenboroughi* Peñalver, Peña-Kairath, P. Nel & A. Nel, 2025 of the family Thripidae², from the same amber outcrop; this is the last holotype established. C) Graph of described species based on bioinclusions (holotypes) in Spanish amber.

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PALAEOZOIC EVIDENCE FOR THE TRANSITION FROM NON-FLYING (APTERYGOTE) TO FLYING (PTERYGOTE) INSECTS

J. Prokop^{1,*}, K. Rosová¹, P. Sroka² & T. Ohde³

¹*Faculty of Science, Charles University, Czech Republic;  0000-0001-6996-7832 (J.P.),  0000-0002-1358-3052 (K.R.)*

²*Institute of Entomology, Biology Centre of the Czech Academy of Sciences, Czech Republic;  0000-0003-4367-6564*

³*Faculty Department of Applied Biosciences, Division of Applied Biosciences, Kyoto University, Japan;*

 0000-0002-0870-9175

**jprokop@natur.cuni.cz*

Keywords: Hexapoda, Pterygota, wing origin, metamorphosis, fossil record

Insects are the only arthropod group to have achieved powered flight, which facilitated their rapid radiation on land. Understanding the evolutionary transition from non-flying (apterygote) to flying (pterygote) insects remains a major challenge due to the large gap in the fossil record. The evolution of wings is also closely linked to the emergence of the metamorphic life cycle.

Recent evo-devo studies support and refine a paleontology-based classical hypothesis that an ancestral exite incorporated into the body wall contributed to the origin of insect wings. The modern hypothesis locates an ancestral precoxa leg segment with an exite within the hexapod lateral tergum, reframing the longstanding debate on the insect wing origin. A current focus is on the contributions of the incorporated exite homolog and surrounding tissues, such as the pleuron and the medial bona fide tergum, to wing evolution¹.

In parallel, recent analyses of Paleozoic fossils have confirmed thoracic and abdominal lateral body outgrowths as transitional wing precursors and suggested their possible role as respiratory organs in aquatic or semiaquatic environments, resembling a protopterygote model². These recent studies have revised our understanding of the transition to flying insects.

The participation of JP on FossilBPP was supported by the Grant Agency of the Czech Republic 24-11498S.

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FOSSIL LEPIDOPTERA – GENERAL REMARKS AND TWO CASE STUDIES

Ł. Przybyłowicz

Institute of Systematics and Evolution of Animals Polish Academy of Sciences; Kraków, Poland;

☎ 0000-0001-5456-9479;

lukasz@isez.pan.krakow.pl

Keywords: moths, butterflies, fossil calibration, amber inclusion, copal

Lepidopterans, compared to other larger insect orders, are rare in the fossil record. What is more, most of these fossils have only superficial original descriptions, have never been critically re-examined, and hence have very uncertain taxonomic assignments at present. Much of what is known about lepidopteran fossils resides in difficult-to-access publications or unpublished sources. Lepidopteran fossils are especially scarce in Mesozoic strata and are known mainly from the Cenozoic.

The summarizing, critical catalogue of all of them has been published¹. The publication includes descriptions of 131 fossil genera and 229 fossil species, as well as 72 extant genera and 21 extant species to which some of these fossils supposedly belong or show superficial similarity.

The majority of fossil Lepidoptera are amber inclusions, but nearly all of these are small moths². Large moths are extremely rare as amber inclusions, and a reason may be that scales are relatively easily lost, and doing so prevents big moths from getting trapped in amber. Large dead moths are also an attractive food source to scavengers and so may get spotted and eaten before they can be fossilized.

The oldest Lepidoptera fossils come from the Late Triassic (ca 212 Ma) and are the numerous but single scales preserved in shales and claystone sediments (Lower Saxony, Germany)³. However, despite the fact that one of the most recent Lepidoptera studies uses these fossils for calibrating the phylogenetic tree⁴, their affiliation with Lepidoptera is still debatable.

It should also be mentioned that one of the well-known Polish scientists studying fossilized Lepidoptera was Dr. Andrzej Skalski. For over 20 years of his scientific career, he published 41 articles devoted to fossilized moths. He described 15 species of lepidopterans, mostly from the Baltic amber, but also based on imprints in rocks. It is worth mentioning that he is also the author of a description of a single fossilized Diptera and a single Hymenoptera. Most of the species described by him represent so-called Microlepidoptera – leaf-rollers (Tortricidae), clothes-moths (Tineidae), and concealer-moths (Oecophoridae). He also described one tiger-moth (Arctiinae). His papers are constantly cited by various studies dealing with the evolution and phylogeny of moths and butterflies. Studying inclusions in copal, special attention should be paid to evaluate if the studied samples, containing the contemporary fauna, are real pieces of fossilized resin. A good example of the growing market of false copal is the one from Madagascar. The real origin of the samples containing specimens belonging to various insect groups (but always contemporary taxa) was traced and it was evidenced⁵ that most of what is known as “Madagascar copal” originated from the leguminous tree *Hymenaea verrucosa*. Therefore, the real age of every sample of copal originated from this island, containing any inclusion should be very critically verified before undertaking any taxonomic study.

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THE EARLIEST EOCENE INSECT FAUNA OF MORS AND FUR, DENMARK – RECENT DISCOVERIES

J.A. Rasmussen^{1,2,*}, R.L. Sylvestersen³, H. Madsen¹, K. Olsen⁴ & T.J. Simonsen⁴¹Museum Mors, Nykøbing Mors, Denmark; [☎ 0000-0003-0520-9148](tel:0000-0003-0520-9148) (J.A.R)²Natural History Museum of Denmark, Copenhagen, Denmark³Fur Museum, Museum Salling, Fur, Denmark; [☎ 0000-0002-1946-4716](tel:0000-0002-1946-4716)⁴Natural History Museum Aarhus, Aarhus, Denmark; [☎ 0000-0002-5624-128X](tel:0000-0002-5624-128X) (K.O.), [☎ 0000-0001-9857-9564](tel:0000-0001-9857-9564) (T.J.S)

*jan.rasmussen@museummors.dk

Keywords: Eocene, Insecta, Fur Formation, Stolleklint Clay, Denmark

With nearly 30,000 insect specimens recorded in collections held by Museum Mors, Museum Salling, and the Natural History Museum of Denmark, insects represent the most prevalent group of macrofossils, primarily derived from the calcareous concretions of the early Ypresian Fur Formation¹ of Denmark, though some originate from the underlying Stolleklint Clay, which was deposited during the Paleocene-Eocene Thermal Maximum (PETM). The occurrence of approximately 200 insect species from the two units have been reported^{2,3}. As of November 2024, around 99 species across 13 insect orders had been formally described. Preservation is frequently excellent, retaining original patterns and colouration.

The siliciclastic Stolleklint Clay and the succeeding fossil-rich, early Eocene clayey diatomites of the Fur Formation are exposed on the islands of Mors and Fur and adjacent areas. At the time of deposition (c. 56–54.6 Ma⁴), Denmark was entirely submerged, with Mors and Fur believed to have been under at least 200 meters of water. The climate was warm and rather humid. Beyond the billions of fossilized microscopic algae, the deposits contain exceptionally preserved marine fossils of fishes, reptiles and rare benthic invertebrates. Terrestrial organisms like insects, plants, and birds originated from nearby landmasses and were transported to the sea by wind, rivers, currents, or their own flight.

Previous studies^{2,3} indicated that the orders Hemiptera (especially Heteroptera and Auchenorrhyncha) and Diptera dominated the early Eocene insect fauna of the Western Limfjord Area, Denmark, and made up 35.4 % and 27 % of the insect fauna, respectively. Our recent counting and calculations (2024), which is based on over 27,000 insect fossils identified to at least the order level, largely confirm these findings, with slightly higher proportions of Hemiptera (40.8%) and slightly fewer Diptera (26.2%).

The fossil insects provide a detailed picture of coastal terrestrial faunas, thought to be mainly from southern and southwestern Scandinavia. The assemblage is dominated by large, winged forms; smaller or weakly flying insects are rarer, and wingless types are absent⁵.

Some of the most remarkable insect findings from the Fur Formation and the Stolleklint Clay are listed here: 1) The oldest known butterfly on Earth, *Protoeliades kristenseni*, a skipper (superfamily Papilionoidea, family Hesperidae) was described by de Jong; 2) The oldest known spider wasp *Cryptocheilus leleji* (order Hymenoptera, family Pompilidae) was recorded by Waichert and colleagues; 3) New species classified as the oldest representatives of the subfamily Pimplinae (pimpline parasitoid wasps, order Hymenoptera, family Ichneumonidae) known so far were described by Klopstein; 4) The new moth species *Eopyralis morsae* (order Lepidoptera) was recorded as the oldest known species of the superfamily Pyraloidea by Heikkilä and colleagues; 5) The oldest record of the subfamily Spondylidinae of the longhorn beetles (order Coleoptera, family Cerambycidae, longhorn beetles) was described by Legalov and colleagues, and 6) The only known fossil representative of the extant earwig family Apachyidae on a global scale, *Apachyus madseni*, was described by Simonsen and colleagues.

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THE DIVERSITY OF PALAEODICTYOPTERIDA FROM THE PENNSYLVANIAN OF PIESBERG

K. Rosová^{1,*}, A. Leipner², M. Heising³, M. Pecharová⁴, J. Prokop⁵

¹Faculty of Science, Charles University, Prague, Czech Republic; [ORCID: 0000-0002-1358-3052](https://orcid.org/0000-0002-1358-3052) (K.R.), [ORCID: 0000-0003-4611-1868](https://orcid.org/0000-0003-4611-1868) (M.P.), [ORCID: 0000-0001-6996-7832](https://orcid.org/0000-0001-6996-7832) (J.P.)

²Museum Am Schölerberg, Osnabrück, Germany; ORCID: 0000-0001-8501-3174

³LWL-Museum of Natural History, Münster, Germany; ORCID: 0009-0006-0950-1962

*katerina.rosova@natur.cuni.cz

Keywords: Palaeodictyoptera, Carboniferous, wing venation, thoracic morphology

The appearance of wings over 400 million years ago was a pivotal moment in insect evolution. The ability to fly allowed insects to occupy diverse ecological niches, efficiently search for food sources, evade predators, or migrate over long distances. The wings display a wide range of forms reflecting different flight patterns and other life history traits. As the most frequently fossilised body parts of insects, particularly from the Palaeozoic era, wings provide crucial evidence of insect diversity in the past¹.

The superorder Palaeodictyoptera was one of the earliest lineages of winged insects, emerging in the Late Carboniferous, and is generally considered an early diverging group of Pterygota. The group roamed the Palaeozoic skies from the Late Carboniferous until their extinction at the end of the Permian. Their wings were noticeably corrugated, which contributed to the wing stiffness. The largest representatives of the superorder reached enormous sizes with wingspans up to 56 cm, while the smallest forms had wingspans around 1 cm. The palaeodictyopteridans were probably herbivores that used their unique prolonged piercing-sucking mouthparts to suck liquids from plant tissues. The suborder contained four orders, the Megasecoptera, Palaeodictyoptera, Dicliptera, and Diaphanopteroidea, which differed by number of wing pairs, the mode of wing flexion, patterns of venation, and wing shapes^{2,3}.

The representatives of three palaeodictyopterid groups, the Diaphanopteroidea, Megasecoptera and Palaeodictyoptera, are known from the still active geological site of Piesberg quarry near Osnabrück (Lower Saxony, Germany), one of the most important Moscovian (Late Carboniferous) localities in Europe. The continuous sampling has uncovered many fossil Palaeodictyoptera, containing not only isolated wings of adults, but also larval stages and specimens with other preserved body parts. Our findings expand the knowledge about the morphological disparity of the wing shapes and venation patterns of Palaeodictyoptera and Megasecoptera⁴. We also studied the morphological structure of alinota and wing base elements in the family Archaemegaptilidae (Palaeodictyoptera: Eugereonoidea). The preserved thoracic segments of *Haseneura jarmilae* Rosová et al., 2024 bear outstretched pairs of fore- and hindwings, allowing the identification of structural details⁵. Studies of the fossil record of insects from the Piesberg quarry significantly enrich the knowledge of the diversity of Palaeodictyoptera in the Palaeozoic era.

The work was supported by the Grantová Agentura České Republiky [No. 24-11498S].

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A CRITICAL REVIEW OF THE AGE OF BALTIC AMBER

A.J. Ross^{1,*}, B. Bojarski² & J. Szewo²

¹*Department of Natural Sciences, National Museum of Scotland, Edinburgh, Scotland; 0000-0003-2751-9091*

²*Laboratory of Evolutionary Entomology and Museum of Amber Inclusions, Department of Invertebrate Zoology and Parasitology, University of Gdańsk, Gdańsk, Poland; 0000-0001-6301-7959 (B.B.), 0000-0002-2796-9538 (J.S.)*

**a.ross@nms.ac.uk*

Keywords: Stratigraphy, Eocene, glauconite, dinocysts, palynomorphs

Baltic amber is the best known of all the inclusion-bearing ambers and is often washed up on the shores around the Baltic Sea. Its age has been a subject of controversy for many years, it can only be dated from the bed it came from and dating by different techniques has produced different results.

Most Baltic amber has come from the Upper Blue Earth Member of the Prussian Formation, which has the highest concentration and has been commercially mined since the middle of the 19th Century on the Samland (Sambian) Peninsula, Kaliningrad Oblast, Russia. However, Baltic amber has been recorded from other stratigraphic units in the Prussian Formation, the underlying Alka and Sambian formations and the overlying Palvé Formation in the same area, as well as being re-worked into Quaternary deposits.

Absolute dating has been provided by two studies using Potassium-Argon (K-Ar) dating of the mineral glauconite, but they yielded different results. The second study¹, which has been widely accepted, provided older dates than those suggested by biostratigraphical studies. Unfortunately glauconite dating is unreliable as it can be thermally altered and re-worked, also any contamination by illite produces an incorrect older result². Thus the previous results can only be regarded as unreliable and re-dating of the Upper Blue Earth is required using pure glauconite samples and reproducibility tested by independent labs.

There have been three detailed studies of the biostratigraphy using dinoflagellate cysts from a borehole and exposures³ but unfortunately the results are inconsistent. They recorded some species from different levels, or some species were not recorded in all three studies and the resulting biostratigraphies are open to interpretation. Also none of these studies have been compared with the new dinocyst zonation scheme for the North Sea which was adopted for the *Geologic Time Scale 2020*⁴, so they have been compared, combined and correlated here. A recent study of the palynomorphs from Primorsky opencast amber mine provided results consistent with the results of the latest dinocyst study⁵.

Figure 1 shows the most likely stratigraphy and ages of the amber-bearing horizons on the Samland Peninsula based on this critical review of current evidence. The lithostratigraphy and unit thicknesses have been taken from the published studies of the P-1 borehole and Primorsky mine. The chronostratigraphy was taken from the latest International Chronostratigraphic Chart, v2024/12. The dinocyst zones have been taken from the *Geologic Time Scale 2020* and correlated based on the first or last occurrences of zonal marker species as published in the biostratigraphical studies of the P-1 borehole and Primorsky mine.

From the results it can be seen that the Prussian and Palvé formations are Priabonian in age, so even if the precise horizon for a piece of Baltic amber is not known it can be said that it is probably Priabonian in age. For those pieces where it is known that they came from the Upper Blue Earth, it can be said that they are early Priabonian in age, 35-36 Ma.

Thickness	Formation	Member	Dinocyst zones	Stage	Age (Ma)
1.5+m	Kurshskaya		DO1 DE20b	Rupelian	33.9
5.7m	Palvé	Green Wall		Priabonian	35
5.1m	Prussian	White Wall	DE20a		
3.3m		Upper Quicksand			
5.5m		Upper Blue Earth	DE19		
3.7m		Upper Wild Earth			
18.7m	Alka	Lower Quicksand	DE18 DE15	Bartonian	37.71 41.03
3.4m		Lower Blue Earth	DE13 DE12 DE2b	Lutetian	47
1.3m		Lower Wild Earth	DE2a DE1 DP12	early Ypresian	55 Hiatus 56.0
14.5m	Sambian			Thanetian	
				?	

Fig. 1. Revised stratigraphy of the Baltic amber-bearing beds on the Samland Peninsula. The coloured units contain amber, with the highest concentration in the Upper Blue Earth.

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**NEW FOSSIL INSECT DISCOVERIES FROM THE BEMBRIDGE MARLS
(EOCENE) OF THE ISLE OF WIGHT, UK**

A.J. Ross

National Museum of Scotland, Edinburgh, Scotland;  0000-0003-2751-9091

a.ross@nms.ac.uk

Keywords: Priabonian, Diptera, Odonata, Hemiptera, Plecoptera

In 2004 I organised a major project involving many multi-national collaborators to study the fauna and flora of the Insect Limestone from the Bembridge Marls (late Priabonian) of the Isle of Wight, England¹. This resulted in two thematic sets of papers published by the *Earth and Environmental Science Transactions of the Royal Society of Edinburgh* in 2014 and 2019 (volumes 104(3-4) and 110(3-4)), in which many new species of insect were described. Although many specimens from the Natural History Museum (London), Booth Museum of Natural History (Brighton), Maidstone Museum and Isle of Wight museums were studied for the project, not everything was studied so there are still some taxa that are waiting to be described.

In 2020 I was invited to join a project being led by Prof. Wiesław Krzemiński entitled *The influence of environmental and climate conditions in Eocene Europe on the contemporary fauna of nematoceran Diptera*, funded by National Science Centre, Poland (project no. UMO-2020/37/B/NZ8/03042). This enabled me to visit the Isle of Wight and Oxford in 2022 to study recently collected specimens by local collector Andy Yule, as well as additional material in the Dinosaur Isle Museum and Oxford University Museum of Natural History that had not been studied previously. Although my main aim was to look for unstudied specimens of Nematocera, while doing so I also took the opportunity to look for other new insect records. I borrowed the new Nematocera (mostly Limoniidae) and any other interesting specimens that I considered would be worth studying further and had the potential for scientific papers. Some of the specimens have been studied and published on, others are currently being studied and the remainder have yet to be studied.

There are twelve interesting specimens of Diptera: eight specimens belong to Limoniidae, including three potential new species; one specimen constitutes the first record for the fauna of Anisopodidae: Mycetobiinae and is a potential new species; another constitutes the first record of Bombyliidae: Lomatiinae and is a potential new species; another constitutes the first fossil record of Psilidae: Chylizinae, recently described as a new species, *Chyliza colenutti*²; and the last is an unstudied specimen of Ulidiidae.

Three Odonata wings: one constitutes the first record of Libellulidae: Pantalinae but is too incomplete to name; the other two have added to our knowledge of *Aeschnophlebia andreasi* (Aeshnidae) and *Anglogomphaeschna eocenica* (Gomphaeschnidae)³.

Three Hemiptera wings: one is the second record of Ricaniidae from the fauna and was described as a new genus and species, *Worako yule*⁴; the other two are unstudied specimens of Cercopoidea.

One Plecoptera wing: this is the second record of this order from the fauna and belongs to a different family from the first record, though has not yet been studied.

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FOSSIL RECORD OF MARSH BEETLES (COLEOPTERA: SCIRTOIDEA)

R. Ruta

Department of Biodiversity and Evolutionary Taxonomy, Faculty of Biological Sciences, University of Wrocław,
Wrocław, Poland; ☎ 0000-0001-8515-2385

rafal.ruta@uwr.edu.pl

Keywords: Scirtidae, Kachin amber, Baltic amber

The beetle superfamily Scirtoidea represents a pivotal lineage at the base of Polyphaga diversification, yet its evolutionary history remains incompletely resolved. This group comprises two extant families: Scirtidae (c. 1,900 species) and Decliniidae (2 species). The extinct Upper Jurassic Mesocinetidae shares morphological affinities with Scirtidae, although its precise phylogenetic placement remains contentious¹. Several phylogenomic studies have confirmed the sister-group relationship between Scirtoidea and the remaining Polyphaga². Scirtidae, while difficult to define based on adult synapomorphies, can be readily identified at the larval stage by their complex mouthparts and multisegmented antennae; immature stages of Decliniidae, however, remain unknown.

The fossil record of Scirtoidea appears markedly younger than molecular estimates suggest. The oldest unambiguous and well-described fossils of Scirtidae are known from the Lower Cretaceous (118–115 Ma) Koonwarra Fossil Bed in Australia³, while another species has been reported but not formally described from Lower Cretaceous Lebanese amber. By contrast, mid-Cretaceous (c. 99 Ma) Kachin amber from northern Myanmar has yielded more informative specimens⁴, although Scirtidae are relatively scarce in this deposit. Notably, one species closely resembling extant forms has been described in detail using micro-CT and 3D reconstructions⁴.

The majority of fossil Scirtidae, however, are known from Eocene resins, including Fushun, Oise, Baltic, and Rovno ambers. Scirtidae dominate Baltic amber deposits, accounting for up to 20% of all Coleopteran inclusions. Consequently, they are among the best-studied beetle groups from this fossil resin, with over 20 species described to date. Nevertheless, species-level taxonomy remains challenging, as key diagnostic characters are found in the internal genital structures of both sexes – features rarely observable in amber inclusions. However, the sheer abundance of material has yielded specimens with exposed male genitalia, enabling confident placement within extant genera such as *Contacyphon* Gozis, *Elodes* Latreille, *Microcara* Thomson, and *Scirtes* Illiger. In contrast, several taxa described from Baltic amber were assigned to four newly erected genera by Iablokoff-Khnzorian, whose descriptions lack critical morphological data. A comprehensive re-examination of these genera will be essential to refine Scirtidae taxonomy and elucidate broader evolutionary patterns within the group. The youngest fossil representative of Scirtidae was described from late Oligocene (27–25 Ma) New Zealand amber⁵.

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**FIRST JURASSIC AMBER FROM IBERIA: FOSSIL SAP IN THE OXFORDIAN
OF CABO MONDEGO (PORTUGAL)**

A. Sánchez-García^{1,*}, G. Silvério², R. Pérez-de la Fuente³, E. Peñalver⁴, X. Delclòs⁵, E. Barrón⁴
& R.P. Lozano⁴

¹*Universitat de València, Burjassot, Spain; 0000-0003-0911-2001*

²*Instituto de Ciências da Terra, Évora, Portugal; 0000-0002-3587-7553*

³*Oxford University Museum of Natural History, Oxford, UK; 0000-0002-2830-2639*

⁴*Instituto Geológico y Minero de España, CSIC, València and Madrid, Spain; 0000-0001-8312-6087 (E.P.),
0000-0003-4979-1117 (E.B.), 0000-0002-1022-3860 (R.P.L.)*

⁵*Universitat de Barcelona, Barcelona, Spain; 0000-0002-2233-5480*

**alba.sanchez@uv.es*

Keywords: Mesozoic, amber, fossil sap, Iberia.

A newly discovered amber deposit from the Oxfordian (Late Jurassic) of Cabo Mondego (Figueira da Foz, Portugal) offers rare insight into resin production and preservation during the Jurassic. This site represents the first known occurrence of Jurassic amber on the Iberian Peninsula and adds to the small number of amber-bearing localities known globally from this period. The amber occurs as abundant, mostly submillimetric, transparent yellow particles in coal-rich levels. Although no macroinclusions have been found, the amber contains numerous microscopic, dark, vacuolated structures – known as pseudoinclusions – now understood to be fossilized resin-sap emulsions resulting from the immiscibility of both components during simultaneous exudation.

Amber from Jurassic and older amber deposits is extremely rare¹, usually occurs in small fragments, and generally lack bioinclusions. While the earliest fossil resins date back to the Carboniferous, significant bioinclusions of terrestrial organisms come from Barremian-aged resins (Early Cretaceous), coinciding with the onset of the Cretaceous Resin Interval². The discovery of pseudoinclusions in older ambers, as well as in those from the Early Cretaceous of Spain, has prompted a reevaluation of these structures once thought to be fossilized protists. Recent geochemical and morphological studies have demonstrated that these pseudoinclusions consist of fossilized resin-in-sap-in-resin emulsions, and have further identified their dark-coloured content in the El Soplao amber as phloem sap, based on the presence of several elements and compounds found in this substance³. The Cabo Mondego amber shows similar features **in this respect to** Spanish Cretaceous ambers and adds a new data point to this growing body of evidence.

Analyses using Fourier-transform infrared spectroscopy (FTIR) and Laser-Scanning Confocal Microscopy (LSCM) have been applied to chemically characterize the Cabo Mondego amber and its pseudoinclusions. This supports the idea that resin production and secretion involving complex biochemical interactions were already in place well before the Cretaceous. In this context, the Cabo Mondego site provides not only a palaeogeographically significant record but also a valuable taphonomic window into resin dynamics during the Jurassic. Its discovery highlights the potential of Iberian Jurassic strata to yield further insights into early resin-producing ecosystems and the chemical evolution of plant exudates across deep time, and perhaps even the future discovery of a site preserving bioinclusions. The discovery contributes to the sparse but growing record of Jurassic amber enhancing our understanding of the ecological and chemical conditions that allowed for resin fossilization in pre-Cretaceous settings.

Acknowledgements:

This work is a contribution to the project CIGE/2023/86 funded by GE2024 programme of the *Conselleria de Educació, Cultura, Universidades y Empleo, Generalitat Valenciana*; and to the project PID2022-137316NB, funded by MICIU/AEI/10.13039/501100011033 and by ERDF/EU.

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SIMILARITIES AND COMMON SPECIES OF CERATOPOGONIDAE BETWEEN THE SPANISH AMBERS OF EL SOPLAO, PEÑACERRADA I AND SAN JUST

M. Santer^{1,*}, X. Delclòs¹ & E. Peñalver²

¹*Departament de Dinàmica de la Terra i de l'Oceà, Facultat de Ciències de la Terra, Universitat de Barcelona, Barcelona, Spain & Institut de Recerca de la Biodiversitat (IRBio), Universitat de Barcelona, Barcelona, Spain;*

✉ 0000-0002-3685-4716 (M.S.), ✉ 0000-0002-2233-5480 (X.D.)

²*Instituto Geológico y Minero de España, CSIC, Valencia, Spain; ✉ 0000-0001-8312-6087*

*msantes13@alumnes.ub.edu

Keywords: haematophagy, diversity, taxonomy, Spain

Biting midges, family Ceratopogonidae (infraorder Culicomorpha), are dipterans that originated during the early Cretaceous and still exist in extant ecosystems. Some extant adult females are anautogenous and need to feed on blood to lay eggs, a feeding behaviour known as haematophagy. This behaviour is likely to be ancestral to the family, as all known Lower Cretaceous biting midges display haematophagy-related anatomical features and might also be ancestral to Culicomorpha. Extant biting midges are found all around the world except Antarctica, and are found as fossils in diverse outcrops, notably in amber outcrops. Biting midges from middle Albian El Soplao (Spain) amber were first studied in 2011 and several new species were described¹. One species, *Gerontodacus skalskii*, was found in El Soplao amber while being already known from upper Albian Peñacerrada I and San Just ambers (Spain). Here we present preliminary results based on the identification of more than 100 new specimens of biting midges found in El Soplao amber. Notably, the species *Archiaustroconops alavensis* and *Leptoconops zherikhini*, identified from the new set of specimens, were previously identified in Peñacerrada I amber, while *Leptoconops zherikhini* was also found in San Just amber. Similitude between species from these outcrops despite their age difference is discussed. Three new species will be described, within the genera *Leptoconops*, *Austroconops* and *Lebanoculicoides*, and new specimens from species previously known from El Soplao were also found, including male specimens of species only described based on females.

This research is a contribution of the project PID2022-137316NB, funded by MICIU/AEI/10.13039/501100011033 and by ERDF/EU, and a project of the Gobierno de Cantabria through the semi-public enterprise EL SOPLAO S.L. (research agreements #20963 and VAPC 20225428). M.S. has benefited from a “Joan Oró” grant for the recruitment of pre-doctoral research staff in training (FI-2023), Generalitat de Catalunya.

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CRETACEOUS MITE-TERMITE ASSOCIATION IN AMBER REVEALS EVIDENCE FOR LONG-TERM COMMUNITY AND THE EVOLUTIONARY SIGNIFICANCE OF PHORESY

H. Sendi^{1*}, P.B. Klimov², J. Káčerová³, E. Bonino⁴, D. Azar^{5,6} & N. Robin^{7,8}

¹*Institute of Zoology, Slovak Academy of Sciences, Bratislava, Slovakia; 0000-0003-2389-4580*

²*Dpt of Biological Sciences, Purdue University, West Lafayette, IN, USA; 0000-0002-9966-969X*

³*Department of Sculpture, Object and Installation, Academy of Fine Arts and Design, Bratislava, Slovakia*

⁴*Rue G. Thiriart 74, Belgium; 0000-0002-4590-2759*

⁵*Nanjing Institute of Geology and Palaeontology, CAS, Nanjing, China; 0000-0002-4485-197X*

⁶*Faculty of Science II, Natural Sciences Department, Lebanese University, Fanar, EL-Matn, Lebanon*

⁷*Géosciences Rennes – UMR 6118, Univ Rennes, CNRS, Rennes, France; 0000-0002-1756-3171*

⁸*Directorate Earth and History of Life, Royal Belgian Institute of Natural Sciences, Brussels, Belgium*

**hemen.sendi@savba.sk*

Keywords: Isoptera, Lebanese amber, Mites, Biotic interactions, Social insects

Phoresy, a temporary commensalistic relationship facilitating dispersal, often arises in response to resource scarcity in patchy, ephemeral environments among mites of Astigmata. Astigmatid mites exemplify this through the production of heteromorphic phoretic nymphs (tritonymphs) equipped with specialized attachment structures. Here, we present the oldest known continuous biotic interaction involving phoretic mites, preserved in ~130-million-year-old Lebanese amber. Our discovery reveals 16 heteromorphic astigmatid tritonymphs of *Plesioglyphus lebanotermi* attached primarily to the hindwing membranes of an alate termite via their pretarsal claws and tarsal setae. The study highlights a key aspect bridging past and present: these ancient mites belong to an early-diverging Astigmata lineage (Schizoglyphidae) whose extant members are also phoretic on termites, showing this association has remained consistent and even retaining a highly conserved phoretic morphology that has persisted since the Early Cretaceous. This ancient interaction provides crucial insights into the evolutionary significance of phoresy and the coevolution of mites and termites. The fossil, representing a stem-group Astigmata, holds significant importance for the precise calibration of acariform mite phylogenies, and thereby contributing to a more comprehensive understanding of their evolutionary history.

Phoresy, a temporary commensalistic relationship facilitating dispersal, often arises in response to resource scarcity in patchy, ephemeral environments among mites of Astigmata. Astigmatid mites exemplify this through the production of heteromorphic phoretic nymphs (tritonymphs) equipped with specialized attachment structures. Here, we present the oldest known continuous biotic interaction involving phoretic mites, preserved in ~130-million-year-old Lebanese amber. Our discovery reveals 16 heteromorphic astigmatid tritonymphs of *Plesioglyphus lebanotermi* attached primarily to the hindwing membranes of an alate termite via their pretarsal claws and tarsal setae. The study highlights a key aspect bridging past and present: these ancient mites belong to an early-diverging Astigmata lineage (Schizoglyphidae) whose extant members are also phoretic on termites, showing this association has remained consistent and even retaining a highly conserved phoretic morphology that has persisted since the Early Cretaceous. This ancient interaction provides crucial insights into the evolutionary significance of phoresy and the coevolution of mites and termites. The fossil, representing a stem-group Astigmata, holds significant importance for the precise calibration of acariform mite phylogenies, and thereby contributing to a more comprehensive understanding of their evolutionary history.

BURMESE AMBER AS A WINDOW TO THE HISTORY OF FUNGUS GNATS (DIPTERA: SCIAROIDEA)

J. Ševčík

University of Ostrava, Faculty of Science, Ostrava, Czech Republic; ☎ 0000-0001-7174-593X

sevcikjan@email.cz

Keywords: Bibionomorpha, Myanmar amber, Mesozoic, review, taxonomy

Fungus gnats (Diptera: Bibionomorpha: Sciaroidea) represent one of the most diverse groups of insects in both recent fauna and fossil record^{1,2,3}. In this contribution, all important published papers dealing with Burmese amber Sciaroidea are summarized and briefly commented on, starting with the paper by Blagoderov & Grimaldi⁴. The superfamily Sciaroidea comprises at least 15 families, some of them entirely fossil (e.g. Antefungivoridae, Archizelmiridae or Pleciofungivoridae), plus a group of genera not assigned to a family, belonging to the group called Sciaroidea *incertae sedis* (formerly *Heterotricha* group). The latter group is well represented also in the mid-Cretaceous amber of Myanmar (Burmese amber), together with members of the families Keroplatidae, Mycetophilidae, Archizelmiridae, Ditomyiidae and Pleciofungivoridae. On the other hand, families Bolitophilidae and Sciaridae have not been reliably recorded from Burmese amber yet. The possible presence of Diadocidiidae is discussed. The family Cecidomyiidae is represented by its more primitive subfamilies, with notable absence of the species-rich subfamily Cecidomyiinae⁵. For each family or a group of genera, an overview of hitherto known Burmese amber fauna is given, including taxonomic notes and estimates of true species richness, based mainly on the extensive private collection, accumulated by the author during the last 6 years and comprising more than 1000 specimens of the Sciaroidea from Burmese amber.

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CLOWN BEETLES (COLEOPTERA: HISTERIDAE) IN AMBER DEPOSITS

J. Simon-Pražák^{1,2,*}, T. Lackner³ & J. Prokop¹

¹ Charles University, Faculty of Science, Department of Zoology, Viničná 7, 12800 Prague 2, Czech Republic;

📍 0000-0001-7438-2548 (J.S-P.); 📍 0000-0001-6996-7832 (J.P.)

² Museum of Eastern Bohemia in Hradec Králové, Eliščíno nábřeží 465, 500 03 Hradec Králové 3, Czech Republic

³ Department of Environmental Systems Science, ETH Zürich, Weinbergstrasse 56, 8092 Zürich, Switzerland;

📍 0000-0002-0108-5785

*prazakja@natur.cuni.cz

Keywords: Baltic amber, Burmese amber, beetles, Histeridae

Clown beetles (Coleoptera: Histeridae) represent a relatively diverse group with over 4800 species and worldwide distribution. Representatives of this family have successfully adapted to a wide range of habitats, including faeces and carrion, forest litter, subcortical spaces of decaying trees, wood-boring insects' tunnels, rotting stems of cacti and other succulents, decomposing plant or fungal material, mammal and bird nests and burrows, ant and termite colonies, subterranean cavities and caves, and sand dunes. Specialisation for a specific habitat typically leads to morphological adaptations, sometimes even radical changes of body morphology and particularly body shape. Understanding the evolution history of this group is greatly enhanced by our knowledge of the fossil record. Up to date, almost 50 species of histerid beetles have been described from various deposits.

In our project we examined several clown beetles' amber inclusions from Burmese and Baltic ambers and described 9 new genera and 17 new species. Biology of some of these species was interpreted and the findings suggest that the significant diversity of Histeridae life strategies is of ancient origin. Multiple lineages were adapted to subcortical lifestyle already in the Cretaceous. Cretaceous Histerids also include some of the earliest known myrmecophiles.

This project is supported by GAČR 24-11498S and GAUK 430825

THE HISTORY OF SYSTEMATICS STUDIES OF PSYCHODOMORPHA AND THE ROLE OF POLISH SCIENTISTS

K. Skibińska^{1, *}, S. Kaczmarek², A. Soszyńska² & W. Krzemiński¹

¹*Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, Krakow, Poland;*

📍 0000-0002-5971-9373 (K.S.) 📍 0000-0001-5685-891X (W.K.)

²*University of Lodz, Faculty of Biology and Environmental Protection, Department of Invertebrate Zoology and Hydrobiology, Lodz, Poland; 📍 0000-0002-2661-6685 (A.S.) 📍 0009-0002-7544-1938 (S.K.)*

*yukisiak@gmail.com

Keywords: fossil, evolution, inclusion, amber, sedimentary rocks

Psychodomorpha, an infraorder within lower Diptera (Nematocera), comprises of four extant families: Psychodidae, Tanyderidae, Blephariceridae, and Deuterophlebiidae and seven extinct families: Grauvogeliidae, Nadipteridae, Hennigmatidae, Kuperwoodiidae, Tilliardipteridae, Rhaetaniidae, and Ansorgidae. It represents one of the earliest-diverging evolutionary lineages of Diptera. The first known representatives are wing imprints preserved in Lower/Middle Triassic sedimentary rocks of France (Anisian/Ladinian, ~245 Mya). This group has since long presented significant challenges to systematists due to their morphological diversity and ecological specializations, and often cryptic life histories.

Early views on the systematics of Psychodomorpha, developed in the 19th century, were based primarily on external adult morphology, such as wing venation and antennal structure. These classifications laid a foundation for understanding the group but left the broader phylogenetic relationships within Diptera largely speculative.

A major advance in the understanding of Psychodomorpha came with the discovery and analysis of fossil representatives from Mesozoic and Cenozoic deposits. Exceptionally preserved specimens in Burmese and Baltic amber provided key insights into the antiquity and morphological conservatism of various lineages. Fossil taxa from the Jurassic period further illuminate early diversification and reveal ancestral traits no longer present in extant species. The integration of paleontological data plays a crucial role in calibrating molecular clocks and reconstructing evolutionary relationships – both within its families (e.g., Tanyderidae, Deuterophlebiidae) and in placing Psychodomorpha within the broader dipteran phylogeny.

Polish researchers have made notable contributions to the systematics of this infraorder. Supported by the National Science Centre project “Examination of extant Psychodomorpha as a primer for reconstructing phylogenetic relationships and understanding evolution among Diptera” (PI: K. Skibińska), they re-examined Baltic amber specimens, including historical material studied by Fernand Meunier¹. Additionally, studies of Burmese amber led to the description of the first fossil representatives of the rare subfamily Horaiellinae², which has been essential in clarifying the relationship between Psychodidae and Tanyderidae.

This research continued under a second grant, “Mesozoic stage of evolution of the nematoceros Diptera in the context of contemporary biogeographical changes; importance of this group to the evolution of the order (PI: W. Krzemiński), focusing on Burmese amber collections. These efforts have expanded our understanding of Cretaceous Psychodomorpha diversity and enabled description of the first fossil Deuterophlebiidae and its phylogenetic placement in other Diptera families³. Furthermore, we provided phylogenetic reconstructions for studied families i.e. Tanyderidae, Bruchomyiinae, which once again highlighted the close relationship between Psychodidae and Tanyderidae⁴⁻⁵.

The Polish team has described one new subfamily, six new genera and 27 new species from the Cretaceous and Eocene, significantly advancing knowledge of extinct Psychodomorpha. The ongoing work will apply

advanced imaging methods such as scanning electron microscopy (SEM) and micro-computed tomography (microCT).

These advances reflect broader trends in dipterology, particularly the growing appreciation of fossil evidence in systematic studies. A deeper understanding of Psychodomorpha evolution is essential for reconstructing early dipteran diversification and serves as a model for integrating different kinds of data in insect phylogenetics.

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THE IMPORTANCE OF ACTUOTAPHONOMIC FIELD EXPERIMENTATION IN AMBER RESEARCH

M.M. Solórzano-Kraemer^{1,*}, X. Delclòs², E. Peñalver³¹Senckenberg Research Institute and Natural History Museum, Frankfurt, Germany; ☎ 0000-0003-3065-119X²University of Barcelona, Barcelona, Spain; ☎ 0000-0002-2233-5480³Instituto Geológico y Minero de España, CSIC, Valencia, Spain; ☎ 0000-0001-8312-6087

*monica.solorzano-kraemer@senckenberg.de

Keywords: actualistic experiments, taphonomy, bioinclusions, sticky traps, arthropods

The German term *Aktuo-Paläontologie* (Actualistic paleontology) is defined as the science of the origin and the present-day mode of formation of future fossils, in the broadest sense. At its core, this field applies the uniformitarian principle – “the present is the key to the past” – to paleontological questions, and is closely aligned with taphonomy, currently being referred to as actuotaphonomy.



Fig. 1. A) Defaunation resin from Madagascar with bioinclusions (millimeter scale). B) *Agathis lanceolata* tree with yellow sticky traps at 0 m, 1 m and 2 m high on its trunk, in New Caledonia. C) Representation of the trunk of a resin-producing tree with insects around it; only some of these insects, particularly those belonging to certain groups, became trapped in the resin.

Amber, copal (a much less ancient fossil resin than amber) and Defaunation resin (resin produced after the start of the Industrial Revolution) (Fig. 1A) provide a unique window into ancient ecosystems, preserving both some organisms or their remains (bioinclusions) and some key aspects of their environmental contexts from millions of years ago to the Recent. However, understanding amber/copal bioinclusions requires detailed analysis of preservation biases. This is where actuotaphonomic studies (Fig. 1B) play a crucial role. By investigating the processes that influence entrapment and preservation in fresh resins in the laboratory or in the field, actuotaphonomic experimentation, we can know the main biases related to the formation of amber assemblages, biostratigraphic decay dynamics and even subsequent fossilization processes¹. Two important biases well-illustrated by the actuotaphonomic experimentation are the selective original entrapment and certain post-entrapment alterations. Thus, the knowledge acquired through actuotaphonomic research refines the way in which we approach the study of fossil/subfossil assemblages in ancient resins, for example,

by introducing the recently proposed terminology of eusyninclusions and parasyninclusions, which aims to understand, from a taphonomic point of view, how diverse sets of syninclusions are related to each other. This knowledge is an important tool for a more accurate reconstruction of past biodiversity and of the dynamics of ancient ecosystems (Fig. 1C).

Trapping methods in field experimentation, such as yellow sticky traps (Fig. 1B) and Malaise traps, have further expanded our understanding of the arthropod communities associated with resiniferous trees and the biases involved in resin trapping (Fig. 1C). These artificial traps have proven effective in capturing arthropod fauna from various parts of a forest, offering valuable data on how these organisms interact with resin-producing trees². By integrating these data into amber research, scientists gain a more comprehensive picture of the biodiversity and behaviours of arthropods in resin-rich environments³⁻⁵.

In this talk, we will demonstrate how actuataphonomic experiments can enhance our understanding of the possibilities and limitations of resin as a natural trap and a medium for preserving organism remains from the past. Furthermore, we will emphasize how these experiments advance our knowledge of taphonomic processes and improve the interpretations used to reconstruct ancient environments, shedding light on the complex interplay between preservation medium and ecological context.

This work is a contribution to the project PID2022-137316NB, funded by MICIU/AEI/10.13039/501100011033 and by ERDF/EU, and to the DFG project 457837041 (SO 894/6-1).

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SYSTEMATICS AND EVOLUTION OF FOSSIL MECOPTERA: A POLISH PERSPECTIVE

A. Soszyńska^{1*}, K. Kopec² & W. Krzemiński²

¹*University of Lodz, Faculty of Biology and Environmental Protection, Department of Invertebrate Zoology and Hydrobiology, Banacha 12/16, 90-237 Lodz, Poland; ☎ 0000-0002-2661-6685;*

²*Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, 31-016 Krakow, Poland; ☎ 0000-0001-6449-3412 (K.K.), ☎ 0000-0001-5685-891X (W.K.)*

**agnieszka.soszynska@biol.uni.lodz.pl*

Keywords: scorpionflies, fossil, Baltic amber, evolution, past diversity

The last common ancestor of the Mecopteroidea group is known from the Permian, from which two phylogenetic lineages emerged: the Aphiesmenoptera (Trichoptera and the much younger Lepidoptera) and the Antliophora (Diptera, Mecoptera and Siphonaptera). Today, there are nine families comprising about 800 species, while the fossil record reveals about 40 families – and this represents only a fraction of the vast diversity of extinct fauna. An analysis of changes in the Mecoptera fauna, from the earliest fossils in the Permian, shows a gradual increase in diversity. During the Mesozoic, scorpionflies were a key component of insects faunas. In the Jurassic (~200–150 Mya), the order experienced its peak radiation. From the Cretaceous period onwards, a gradual decline in Mecoptera began; most families existing at the time became extinct, and their ecological importance decreased drastically. Such a clear pattern of long-term decline is not characteristic of any other order within the Holometabola. Mecoptera are therefore considered to be a relict and partially extinct group. Their evolutionary role within Antliophora makes them a model group for palaeoentomological and phylogenetic research.

Due to their relatively large size and long evolutionary history, Mecoptera are primarily known from impressions in sedimentary rocks. In the context of fossil resins, particularly Baltic and Burmese ambers, the presence of isolated specimens of individual species is a notable feature. An exception is the family Pseudopolycentropodidae, two-winged scorpionflies, similar in size to nematoceran flies, whose representatives are extremely common in Burmese amber. For a considerable number of years, a research group from Poland has been engaged in the study of the taxonomy and evolution of fossil Mecoptera. With funding from the National Science Centre for the project ‘Origins and phylogenetic relationships of fossil and modern Mecoptera’ (PI: W. Krzemiński, 2013/09/B/NZ8/03270), we undertook the task of defining the taxonomic boundaries of the problematic family Orthophlebiidae, which is of crucial importance to understanding the evolution of the modern mecopteran fauna. Our work based on existing type specimen and a Jurassic collection from the Daohugou Formation in China. An extensive examination and verification process was undertaken on the majority of the type specimens described by Tillyard (1933), Riek (1950–1955), Handlirsch (1906–1908), Bode (1953), as well as types from collections in Moscow and Chinese type material held at Capital Normal University in Beijing.

The Polish research group has made significant contributions to the understanding of Eocene Mecoptera from Baltic amber. Of the 13 species described from this resin to date, we described five: two species each from the families Panorpidae and Panorpididae, one from Bittacidae, and the first known larva of Panorpidae. From Lower Cretaceous Spanish amber, we described the first and only from this amber and oldest scorpionfly preserved in fossil resin. The phylogenetic relationships of the relict family Eomeropidae were clarified, based on new material from the Early Jurassic site of Dorset, England, and the relict family Meropeidae were clarified, based on new material from Cretaceous Burmese amber. We revised the Cretaceous and Jurassic Bittacidae and Austropanorpididae, and described several new fossil families: the

Triassic Worcestobiidae, the Jurassic Protorthophlebiidae, the Cretaceous Englathaumatidae, and Australochoristidae. In addition, the Mecoptera fauna from the Große Kley and Wealden localities was studied. Research on the morphology of fossil Mecoptera has resulted in a number of notable publications. These include studies on the functional role of the notal organ in mating behaviour, the morphology of the female of Meropeidae and morphology of the larva of Panorpidae from Baltic amber, studied using modern imaging techniques. Further research is currently underway, and additional publications are being prepared.



Fig. 1. *Baltipanorpa damzeni* Krzemiński & Soszyńska-Maj, 2012

**POLYX@SOLARIS – SYNCHROTRON BEAMLINE FOR X-RAY MICROIMAGING AND
MICROSPECTROSCOPY**

K.M. Sowa^{1,*}, P. Wróbel^{1,2}, T. Kołodziej¹ & P. Korecki^{1,3}

¹*SOLARIS National Synchrotron Radiation Centre, Poland;*

☎ 0000-0001-5259-3213 (K.M.S.), ☎ 0000-0002-1543-7868 (T.K.)

²*Faculty of Physics and Applied Computer Science, AGH University of Krakow, Poland; ☎ 0000-0002-5445-6201*

³*Institute of Physics, Jagiellonian University, Poland; ☎ 0000-0003-0357-5187*

**k.sowa@uj.edu.pl*

Keywords: synchrotron, x-ray microimaging, x-ray microspectroscopy

A synchrotron is a special type of particle accelerator that generates highly intense and focused X-ray radiation. A beamline is an experimental station connected to the synchrotron where scientists from around the world can use this radiation for advanced material analysis.

PolyX is a newly developed beamline at the SOLARIS National Synchrotron Radiation Centre in Kraków, Poland¹. Since March 1st, 2024, the beamline has been available for regular users and is devoted to X-ray microimaging and microspectroscopy techniques that are particularly useful for analyzing the internal structure and chemical composition of complex samples – such as microfossils or geological specimens².

The beamline offers three complementary methods:

- X-ray micro-computed tomography (μ CT) for 3D imaging of internal structures with resolutions down to $\sim 0.72 \mu\text{m}$, e.g. revealing internal structures in micro fossils such as nerve canals, bone morphology, or even remnants of soft tissues preserved under exceptional conditions,
- micro-X-ray fluorescence (μ XRF) for 2D elemental composition mapping of flat or quasi-flat samples, with resolution $\sim 5 \mu\text{m}$, helpful in, for example, identifying minerals replacing original tissues or in detecting environmental signals from the organism's life history.
- micro-X-ray absorption spectroscopy (μ XAS) for studying the chemical state and coordination of elements at given points in the sample, useful in e.g. distinguishing between original biogenic materials and later mineral replacements, as well as providing insights into fossilization processes.

These techniques may be combined in a single experiment to provide a comprehensive picture of a specimen – revealing its internal structure, elemental distribution, and chemical speciation.

The beamline operates in three modes (differing in beam intensity and resolution) and covers the X-ray energy range of 5–15 keV, which is well suited for analyzing both small inorganic specimens and biological materials – commonly found in paleontological studies.

In this presentation, we will demonstrate a model sample where multiple techniques available at PolyX are combined to extract complementary information from a single specimen and also present several real users samples investigated at the beamline to demonstrate the performance of the beamline in a variety of research applications.

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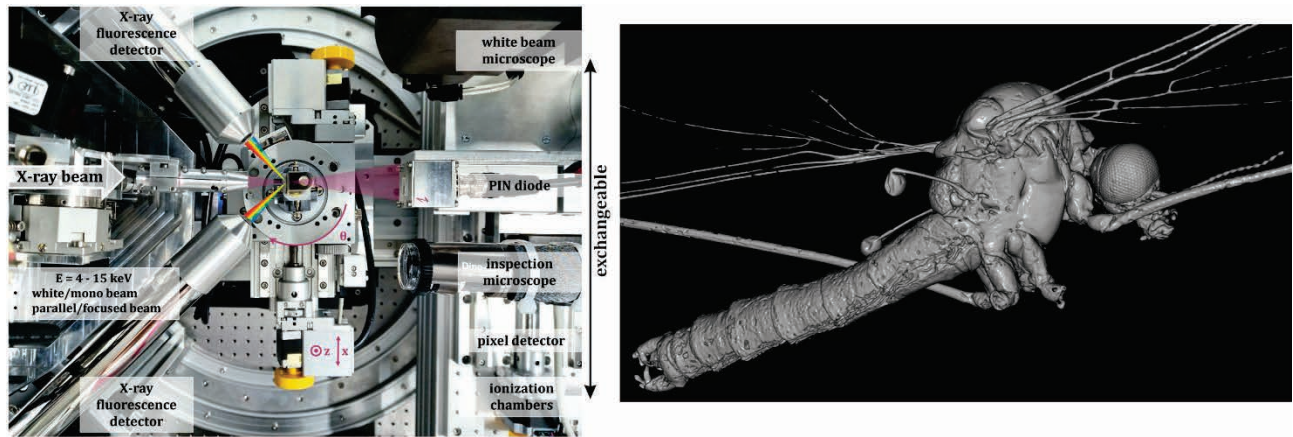


Fig. 1. Left: a top view of the beamline experimental setup. Right: a 3D model of a dipteran inclusion in amber, specimen of *Trichoneura* (courtesy of K. Kopeć Institute of Systematics and Evolution of Animals, Polish Academy of Sciences) obtained with μ CT at PolyX beamline.

**THE FIRST MAYFLY (EPHEMEROPTERA) FROM LATE CRETACEOUS AMBER
OF NORTH CAROLINA, USA**

P. Sroka^{1,*} & J-L. Gattolliat^{2,3}

¹*Biology Centre of the Czech Academy of Sciences, Institute of Entomology, České Budějovice, Czech Republic;*

📍 0000-0003-4367-6564

²*Naturéum-State Museum of Natural Sciences, Lausanne, Switzerland; 📍 0000-0001-5873-5083*

³*University of Lausanne (UNIL), Department of Ecology and Evolution, Lausanne, Switzerland*

**pavel.sroka@centrum.cz*

Keywords: amber inclusion, small minnow mayflies, Mesozoic

Compared to the extensively studied insect inclusions in Burmese amber from northern Myanmar, other Cretaceous amber deposits have received much less attention. This is also true for the Late Cretaceous amber from North Carolina, USA, where only a handful of studies have described the insect fauna found there^{1,2}. Yet the importance of this deposit is evident – for example, the youngest known stem ant fossil was described from North Carolina amber². We report the discovery of the first mayfly (Ephemeroptera) in North Carolina amber³, attributable to the family Baetidae. Although this family accounts for a quarter of global mayfly diversity and is currently distributed almost worldwide, its fossil record is extremely limited. Until now, the earliest fossil occurrences of Baetidae originated from the Cretaceous of Asia, found in Burmese and Taimyr ambers^{4,5}. Our new finding provides evidence of nearly contemporaneous occurrences in North America, suggesting a near-global distribution of this family as early as the Cretaceous. Given the fact that the adult lifespan of Baetidae is comparatively short and their reliance on freshwater habitats, it seems reasonable to infer that Baetidae originated before the main continental breakup that began in the Jurassic. This finding is consistent with the most recent phylogenetic analyses of Ephemeroptera, which identify Baetidae as one of the basal lineages. Our results further demonstrate that inclusions in North Carolina amber can substantially contribute to the understanding of the evolutionary history of individual insect lineages and merit greater scientific attention.

PS acknowledges support from the Grant Agency of the Czech Republic (No. 24-11498S).

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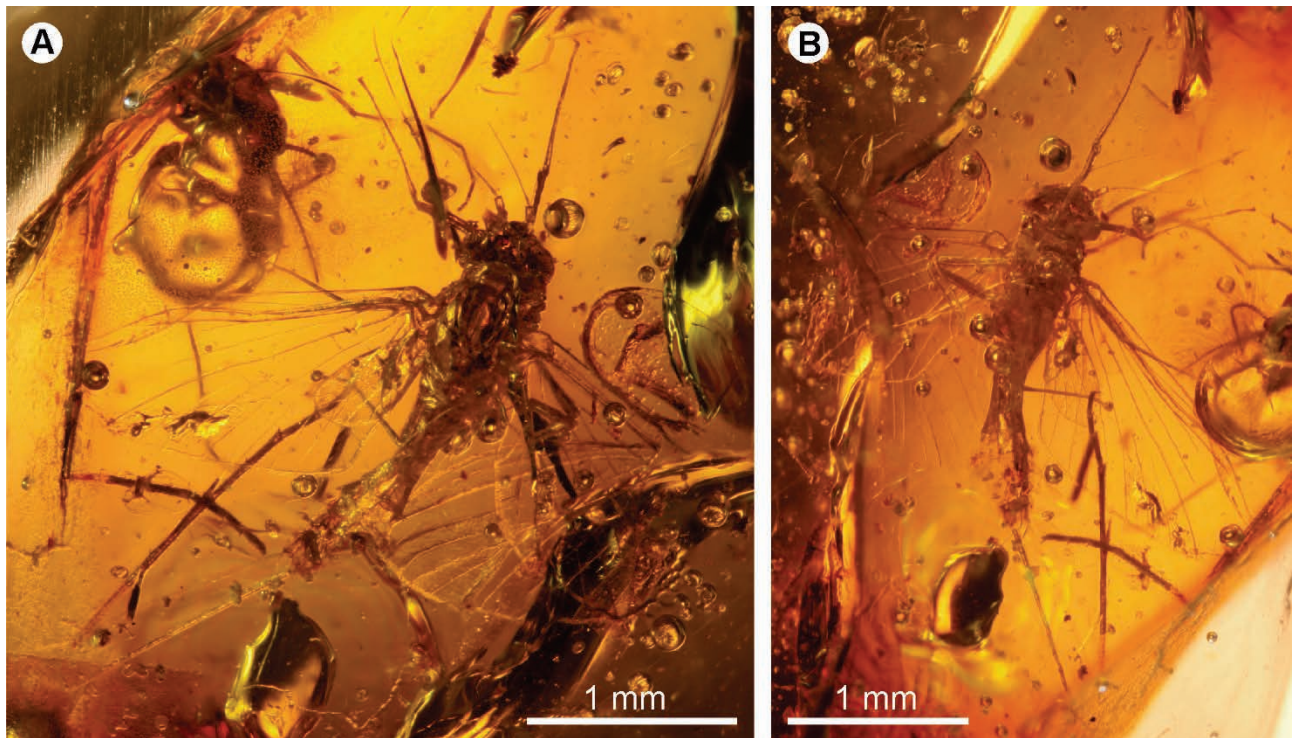


Fig. 1. *Petracloeon carolinensis* Sroka & Gattolliat, 2025 from Cretaceous North Carolina amber, holotype. A dorsal aspect, B ventral aspect.

FOSSIL RICANIIDAE (HEMIPERA: FULGOROMORPHA) – AN OVERVIEW

A. Stroiński^{1,*} & J. Szwedo^{2,*}¹Museum and Institute of Zoology, Polish Academy of Sciences, Warszawa, Poland; ☎ 0000-0003-0876-9263²Laboratory of Evolutionary Entomology and Museum of Amber Inclusions, University of Gdańsk, Gdańsk, Poland;

☎ 0000-0002-2796-9538

*jacek.szwedo@ug.edu.pl



Keywords: Fulgoroidea, planthoppers, fossil record, systematics, relationships

The Hemiptera is an ancient insect order, known since the Carboniferous, divided into six suborders, of which one is the Fulgoromorpha Evans, 1946. According to the most recent interpretation and classification proposals, the Fulgoromorpha are known since the Moscovian with *Aviorrhyncha magnifica* Nel, Bourgoin, Engel & Szwedo, 2013 recently interpreted as the oldest member of the suborder¹. The Ricaniidae Amyot & Audinet-Serville, 1843 is a planthopper family, currently placed in the superfamily Fulgoroidea, comprising 71 (2.78% of the Fulgoromorpha) genera and 444 (3.19% of the Fulgoromorpha) described species, found in almost all the zoogeographic realms, mainly in Afrotropical, Madagascar, Oriental and Oceanian regions². The family Ricaniidae is revealed as a monophyletic lineage from molecular analyses^{3,4}, but there is not a single morphological autapomorphy easily defining the lineage, resulting in internal classification being the subject of discussion, with subfamilies Ricaniinae Amyot & Audinet-Serville, 1843 and Pharsalinae Gnezdilov, 2009 proposed³. Ricaniidae remains defined by a complex of variable characters of body morphology, venation patterns of fore and hind wings, leg structures and genital structures of males and females.

The proposed ages of the family provided by molecular studies and their interpretations, and fossil records are not tightly congruent. A plethora of divergence ages have been proposed: ~116.91 Mya, 98 Mya, 86.49 Mya, 83.5 Mya; the most recent estimation is 96 Mya⁵. The oldest credible fossil record of Ricaniidae was described as *Hammapteryx eocenicus* Piton, 1940 from Paleocene deposits of Menat, France. The majority of fossils assigned to the Ricaniidae require detailed revision because since they were first described, the taxonomic and nomenclatural decisions are not based on a reexamination of the materials, and the definitions and contents of the originally proposed genera are unsatisfactory. From a chronostratigraphic perspective, the fossil record of Ricaniidae in European deposits of Paleocene and Eocene age is the most taxonomically diverse. These occur primarily as adpression fossils, plus some inclusions in fossilised resins. Scarce records are known from the Eocene of North America and Australia; the only (sub)fossils of Ricaniidae from the African continent are from inclusions in copal/defaunation resin from Tanzania of an uncertain age. In addition, new fossils of the Ricaniidae are hereby presented, constituting the first specimens from the Asian continent. The specimens originate from the Niubao Formation, the Qingtao-Tibet Plateau, China (type horizon: Paleocene-early Eocene). These specimens represent one of the most ancient fossil records of Ricaniidae, represented by two new genera, thus bringing the verified fossil record of the family to 15 genera and 14 species. The discovery of the first fossil remains of Ricaniidae in the Asian continent provides a significant contribution to the vibrant discourse on the origins of modern biodiversity. The fossils are of great importance for future phylogenetic analysis of the group, as they provide data on morphological disparity, calibration points and palaeogeographical information. The ongoing discoveries and in-depth study of numerous fossil materials will greatly enhance research on the evolution of the Ricaniidae.

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**THE IMPACT OF PETM AND POST-PETM CLIMATE CHANGE ON EARLY EOCENE INSECT FAUNAS:
PRELIMINARY STUDY FROM THE WESTERN LIMFJORD, DENMARK**R.L. Sylvestersen^{1,*}, T.J. Simonsen² & J.A. Rasmussen³¹*Fur Museum, Denmark;  0000-0002-1946-4716*²*Museum Mors, Denmark;  0000-0003-0520-9148*³*Natural History Museum Aarhus, Denmark;  0000-0001-9857-9564***rlsy@museumsalling.dk***Keywords:** Early Eocene, PETM, Climate change, Denmark

The Early Eocene (Ypresian) Fur Formation and underlying Stolleklint Clay in the western Limfjord, Denmark, offer a unique insight into terrestrial and marine life during a period of significant climate change approximately 56–54.6 million years ago. These formations are globally recognised for their exceptionally well-preserved fossils^{1,2,3}, including a diverse assemblage of insects. This preliminary study examined over 29,000 early Eocene insect fossils from this region. Utilizing the distinct ash layers for tephra stratigraphy allowed for the stratigraphic placement of fossils and correlation with climatic events around the Paleocene-Eocene boundary, specifically the Paleocene-Eocene Thermal Maximum (PETM) and the subsequent gradual cooling period. We compared the distribution of insect fossils across three stratigraphic levels: the warm PETM interval, the recovery phase, and the cooler post-PETM period.

Our analysis revealed significant shifts in the distribution of various insect families across these climatic intervals. Within the Heteroptera, the Lygaeidae family increased from 1.5% during the PETM to 29% in the post-PETM period. More notable shifts were observed within the Orthoptera order. The Tetrigidae family was overwhelmingly dominant during the PETM and Recovery phases, constituting approximately 93% of Orthoptera during the PETM. However, as we transitioned into the post-PETM period, Tetrigidae nearly disappeared, accounting for only about 2.7%, and the Tettigoniidae family became the predominant family, representing 92.5% of all grasshoppers.

The geological setting of the Stolleklint Clay and Fur Formation includes marine clay and diatomite interbedded with over 200 distinct ash layers, providing excellent material for precise correlation and dating. The Stolleklint Clay was deposited during the PETM, a period of rapid global warming. During the PETM, sea surface temperatures (SST) in the Limfjord area are estimated to have increased by 7–10 °C, reaching nearly 30 °C⁴. This extreme warming lasted approximately 150–200 kyr and was followed by a recovery phase where SSTs decreased by over 10 °C within 160 kyr^{4,5}, eventually returning to normal temperatures. The Stolleklint Clay and Fur Formation together span approximately 1.0–1.4 million years⁵.

While a correlation is observed between temperature fluctuations and shifts in insect family distribution during the early Eocene, it is important to note that factors beyond climate may also have influenced these changes. Consequently, temperature alterations cannot be definitively identified as the sole cause at present.

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FOSSIL RESINS AND THEIR INCLUSIONS – SOURCE OF DATA, SOURCE OF CONFUSION

J. Szwedo^{1,*} & B. Bojarski¹

¹Laboratory of Evolutionary Entomology and Museum of Amber Inclusions, Department of Invertebrate Zoology and Parasitology, University of Gdańsk, Gdańsk, Poland; 📍 0000-0002-2796-9538 (J.S.), 📍 0000-0001-6301-7959 (B.B.)

*jacek.szwedo@ug.edu.pl

Keywords: fossil resins, taphonomy, taxonomy

Fossil resins are defined as complex organic mineraloids, that have undergone various post-depositional transformations. While some are collectively recognised as amber, their origins, physical and chemical properties, and depositional and taphonomical histories differ. The earliest documented occurrences of fossil resinite liptobioliths are known from Middle-Late Devonian coals. These phenomena are associated with the evolution of vascular plants and the production of resins during the Devonian period, which were significant for the ecological dynamics, contributing to the development of coal forests and influencing sedimentation processes across various habitats. Fossilised resins that are chemotaxonomically classified as amber of Class Ic¹ have been reported from the Lower Pennsylvanian of the Carboniferous. It is notable that from the Triassic and Jurassic deposits worldwide, there have been several documented cases of amber, which are regarded as the earliest resins to contain bioinclusions. The Cretaceous is characterised by a notable abundance of resins, with some specimens exhibiting a high degree of richness in bioinclusions. The evolution of angiosperms during the Cretaceous has resulted in an increasing number of deposits of fossil angiosperm resins from that botanical source since the beginning of the Cenozoic period². Notwithstanding their importance in palaeontology as a source of bioinclusions, fossil resins themselves have seldom been analysed as taphonomic objects³.

Amber has long been the focus of attention among palaeontologists due to the exceptional preservation of diverse animal and vegetal fossils and ichnofossils it exhibits. Inclusions act as a natural ‘time machine’, linking fossil evidence with molecular data used to build evolutionary trees. This provides a more complete and accurate picture of the evolutionary history of various groups of organisms. Nonetheless, the precision of these calibration points is contingent on accurate estimation of the amber’s age. The present study provides a compelling illustration of the ongoing discussion surrounding the age of the succinite, the resin collectively known as ‘Baltic amber’. A contentious issue that has emerged is the age and provenance of commercially available ‘Myanmar amber’, for which three distinct insectiferous localities of differing age have already been recognised. Moreover, recent discoveries have indicated that ‘Mexican amber’ originates from strata of differing ages. However, it must be noted that the possibility of errors remains constant. The variations in divergence age estimates, major gaps and/or disagreements between the fossil record and available age estimates are routine problems in phylogenetic analyses. These problems can result from the poorly studied fossil record or problematic age estimates, or both. Inclusions in amber have been known to entomb with such rapidity that the process of fossilisation could have occurred within a very brief timespan. The potential for analysis of the possible biological interactions between divergent organisms preserved in the same piece of amber, as well as their relationship with the environment in which they existed, is a conceivable proposition. In the case of two or more organisms being embedded in the same resin flow, it can be deduced that they likely lived and died on the same day. Consequently, there is a possibility that these organisms inhabited the same ecosystem. These associations were termed syninclusions⁴, and their analysis can be approached through the lenses of morphofunctional studies and/or taxonomic analysis. Nonetheless, the direct application of the ethology of extant organisms may prove challenging in the context of

palaeoecology, as extinct organisms may exhibit behavioural tendencies that are divergent from those observed in living beings.

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HOW MANY LINEAGES WITHIN THE PLANTHOPPERS (HEMIPTERA: FULGOROMORPHA) – CONCEPT AND CONTENT OF THE TAXON

J. Szwedo

Laboratory of Evolutionary Entomology and Museum of Amber Inclusions, Department of Invertebrate Zoology and Parasitology, University of Gdańsk, Gdańsk, Poland; ☎ 0000-0002-2796-9538

jacek.szwedo@ug.edu.pl

Keywords: taxonomy, phylogeny, relationships, classification, evolution

The classification of planthoppers is currently undergoing a period of turbulent change. On the one hand, new proposals based on analyses of molecular data; on the other, numerous newly described fossil and modern taxa that do not fit into the accepted classification framework. An additional source of controversy is the current state of knowledge of groups whose morphological definitions are increasingly at odds with the results of molecular studies, and whose fossil taxa are exceeding the limits of recognition of morphological diversity based on modern taxa. Definitions of family-level taxa are still defined by content, only a few are defined by concept, by a set of unambiguous morphological characters.

Currently, the Fulgoromorpha are divided into three extinct superfamilies: Coleoscytoidea Martynov, 1935, Surijokocixioidea Shcherbakov, 2000 and Fulgoridioidea Handlirsch, 1939, three extant superfamilies: Delphacoidea Leach, 1815, Fulgoroidea Latreille, 1807 and Meenoploidea Fieber, 1872, and several other families with no precise superfamilies attribution, viz., Jubisentidae Zhang, Ren et Yao, 2019, Mimarachnidae Shcherbakov, 2007, Neazoniidae Szwedo, 2007 and Perforissidae Shcherbakov, 2007¹⁻³. The extinct Fulgoridioidea are currently containing number of families, attributed there by their venation pattern model⁴, with early and double branching of CuA of the tegmen. This feature seems to be questionable, as resulting in transfer of several taxa to *incertae sedis* position, while the other morphological features clearly place them within recognized families. This results from defining of the families by their content rather (set of taxa included, characterized by subsets of character states), than by the concepts (full set of descriptive characters in a sequential manner). Taxa concept data models conflate properties of circumscription, classification, and nomenclature, resulting in overloaded notions of taxa that quickly become intractable. The presence of fossils has introduced a further layer of complexity to these definitions, thereby expanding the morphological disparity. This has resulted in the description of new higher taxa that are challenging to place within existing phylogenetic frameworks. It has been posited that certain fossil families may be interpreted as evidence of neoteny, with characteristics observed in larval stages being retained in the adult form. Examples of this phenomenon include the preservation of sensory pits observed in the Perforissidae and Jubisentidae. Furthermore, the distinguishing features of the nymphs of Neazoniidae and Dorytocidae include a number of distinctive characters. Notable features include the elongated heads observed in Dorytocidae (akin to those seen in contemporary Dictyopharidae and Fulgoridae) and the reduced size of the hind wings in Inoderbidae: Inoderbinae (resembling the characteristics of modern Derbidae). Ingensalinae (Inoderbidae) display a morphotype that superficially resembles recent Nogodinidae. Mimarachnidae exhibits a combination of characters, some of which are likely to be neotenic (sensory pits, double carinae of the pronotum and mesonotum), in addition to highly derived venation and abdominal terminalia features. Lalacidae exhibits a mixture of features, including a peculiar venational pattern, but the armature of the legs resembles that of modern Meenoploidae. The position of Katlasidae is equivocal; it is similar to extinct Lalacidae: Ancoralini and extant Achilidae: Rhotalini. Yetkhatidae exhibits distinctive features that are more closely aligned with those observed in the families Fulgoridae and Dictyopharidae. New fossils from the Cretaceous of Lebanon and Myanmar are contributing to the complexities surrounding the limits and

definitions of the families, classifications and relationships. It is a matter of some surprise that the Eocene fossils, the vast majority of which have been placed in modern families, may also challenge the classification system and add to the complexity of understanding morphological disparity.

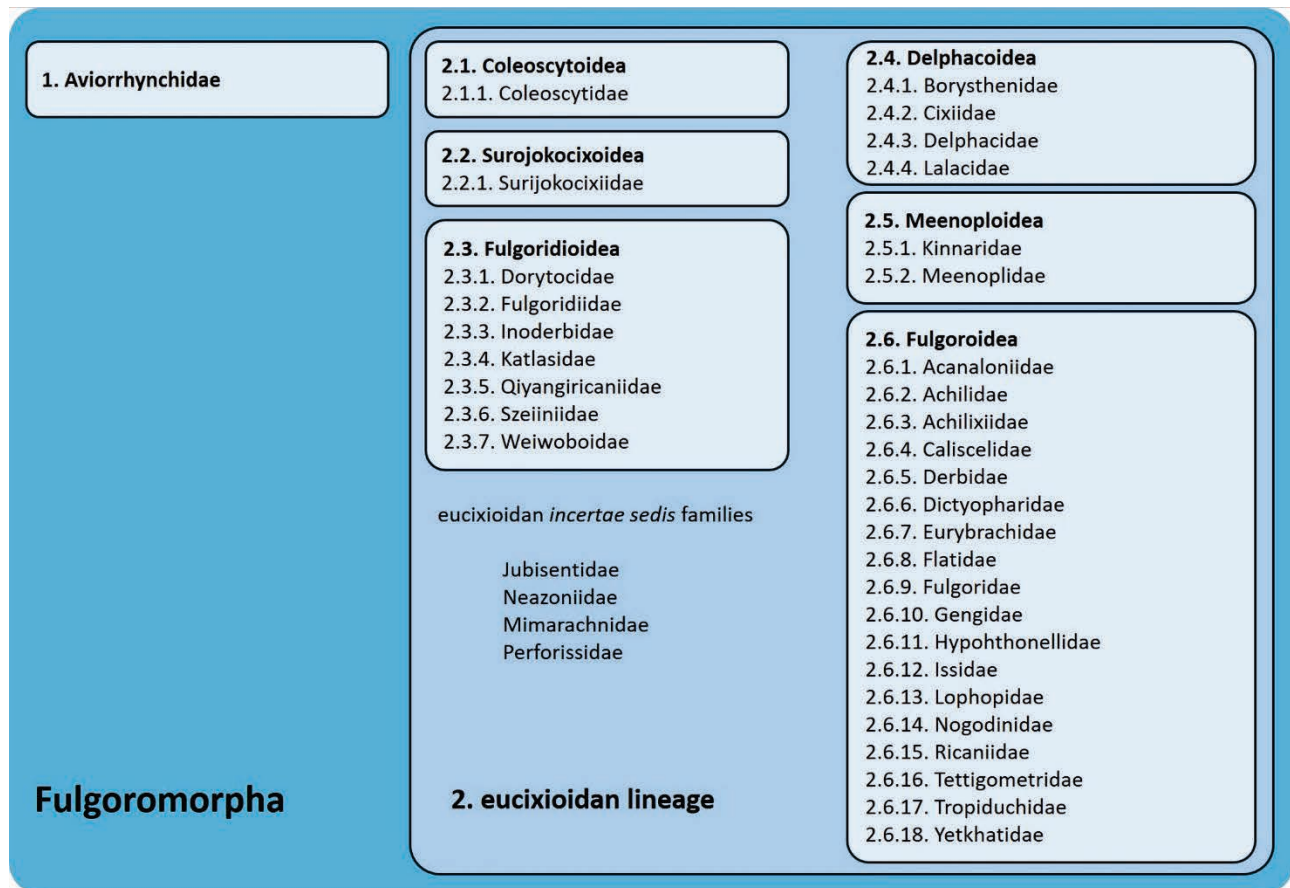


Fig. 1. Current overview of the content and classification of the Fulgoromorpha.

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THE FOSSIL SCALE INSECTS AFTER JAN KOTEJA

J. Szwedo

Laboratory of Evolutionary Entomology and Museum of Amber Inclusions, Department of Invertebrate Zoology and Parasitology, University of Gdańsk, Gdańsk, Poland; ☎ 0000-0002-2796-9538

jacek.szwedo@ug.edu.pl

Keywords: Coccidomorpha, fossil record, contributions to classification, modern research areas

The previous year marked the 20th anniversary of the passing of Professor Jan Koteja (1932–2004), a distinguished Polish coccidologist. As posited by Wegierek¹ (2005), the emergence of the field of palaeontology of scale insects was contingent on Professor Koteja's contributions and expertise. The contributions of the Professor to the field of palaeontology of scale insects are of such significance that it is impossible to overstate them. He described 54 new fossil species, primarily based on the morphology of adult males, which are the most abundant developmental stages in amber deposits. These studies on the scale insects led to the establishment of 15 fossil families. These contributions and accomplishments in the field of fossil scale insect research have been comprehensively outlined by Veá and Grimaldi² (2015).

It has been two decades since the passing of Professor Jan Koteja. What is the current state of knowledge with regard to the fossil record of scale insects? The presence of new fossil resin outcrops has been identified in several locations, with further investigation and utilisation of these sites being undertaken. In the past twenty years, many fossil taxa at diverse levels have been thoroughly documented, encompassing new family classifications. The most ancient scale insect group that has been documented in the fossil record was identified within the Jurassic amber of Lebanon³, and has been included in the updated list. A number of known and new taxa, both fossil and extant ones, have undergone processes of revisions and (re)descriptions. The majority of new fossils were discovered through the examination of inclusions in fossil resins. Furthermore, several documented reports have revealed the presence of fossilised scale remains within sedimentary rocks and on the leaves of their respective host plants. The classification, taxonomic propositions, and phylogenetic relationships of the Coccidomorpha have been subjects of significant debate and development. A discussion has been had regarding the phylogeny and higher classification of scale insects. The establishment of new family-level taxa, in conjunction with a comprehensive reassessment and redefining of extant units, constitutes a substantial augmentation of the existing taxonomy. The nomenclatural and taxonomic issues have been addressed, and the structures of ovaries and the endosymbiotic relationships of scale insects are currently areas of interest. Consequently, the preceding twenty years of research on scale insects has been a period of considerable dynamism, with a multitude of both classical and previously unexplored or underexplored areas being exploited. The research encompassed a broad range of studies, covering morphology, anatomy, physiology, ethology, molecular datasets, and relationships proposals. Additionally, the research extended to include endosymbionts, ecological relationships, the fossil record, and the phylogeny of the Coccidomorpha. The integration of these diverse fields of study served to illuminate novel aspects of the biology and classification of these insects, with the spirit of Professor Koteja's contributions being a prominent feature throughout the research endeavours.

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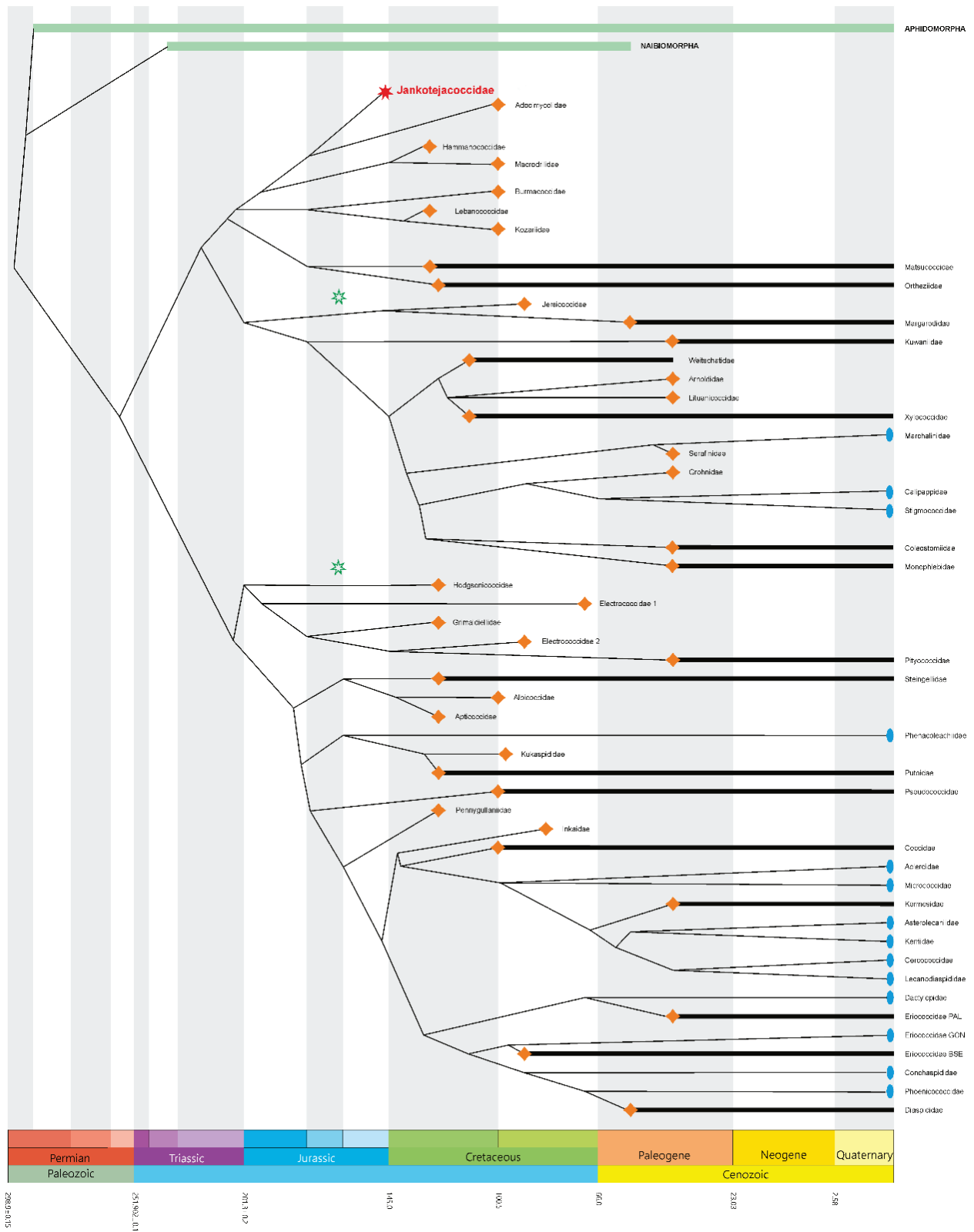


Fig. 1. Chronophylogram of scale insects³.

A PARADIGM SHIFT IN MIRIDAE CLASSIFICATION: A REMARKABLY WELL-PRESERVED EVIDENCE

A. Tazsakowski^{1,*}, J. Kim^{2,*}, Q.T. Phan², E. Bonino³ & S. Jung^{3,*}

¹*Institute of Biology, Biotechnology and Environmental Protection, Faculty of Natural Sciences, University of Silesia in Katowice, Katowice, Poland; ☎ 0000-0002-0885-353X*

²*The Center for Entomology & Parasitology Research, College of Medicine and Pharmacy, Duy Tan University, Da Nang, Vietnam; ☎ 0000-0003-0594-7618 (J.K.), ☎ 0000-0002-3154-6546 (Q.T.P.)*

³*Back to the Past Museum, Carretera Cancún, Puerto Morelos, Quintana Roo, Mexico; ☎ 0000-0002-4590-2759*

⁴*Laboratory of Systematic Entomology, Department of Applied Biology, College of Agriculture and Life Sciences, Chungnam National University, Daejeon, Korea; ☎ 0000-0001-6086-0326*

**artur.tazsakowski@us.edu.pl, jung@cnu.ac.kr*

Keywords: Burmese amber, Hemiptera, Heteroptera, ocelli, plant bugs

The Miridae (plant bugs), belonging to the order Hemiptera and suborder Heteroptera (true bugs), is one of the most species-rich families of insects, with more than 11,300 described species. Also, regarding the number of fossil representatives, plant bugs are the most speciose group within true bugs. However, fossil evidence for the family is limited primarily to Cenozoic amber specimens and a few poorly preserved compression fossils from the Cretaceous period^{1,2}.

The current subfamily classification within Miridae (Hemiptera: Heteroptera: Cimicomorpha) has largely depended on a limited set of morphological characters, among which the presence of ocelli occurs in only one of the eight subfamilies, and is considered a defining autapomorphy of Isometopinae³. However, a remarkably well-preserved fossil mirid from mid-Cretaceous Burmese amber presents an unusual amalgam of traits. The specimen bears clearly defined ocelli while exhibiting a suite of morphological features – an elongate-oval body, fully prognathous head, elongated and prominent first antennal segment, and well-developed maxillary plate, etc. – that closely resemble those of modern Cylapinae, particularly members of the tribe Fulviini.

This unusual combination of traits challenges the long-standing interpretation that ocelli are exclusive to Isometopinae and suggests multiple evolutionary scenarios. For example, ocelli may have been present in the common ancestor of Miridae and subsequently lost in several lineages, or ocelli may represent a trait capable of evolving independently in multiple groups under specific selective pressures. These hypotheses invite a reevaluation of the evolutionary origins of ocelli and suggest that current diagnostic criteria used at the subfamily level may be overly simplified.

The fossil's exceptional preservation enables detailed morphological analysis, offering rare insights into early morphological diversity within Miridae. This discovery not only contributes to our understanding of mirid evolution but also highlights the value of amber inclusions in revealing hidden diversity and evolutionary complexity in Heteroptera.

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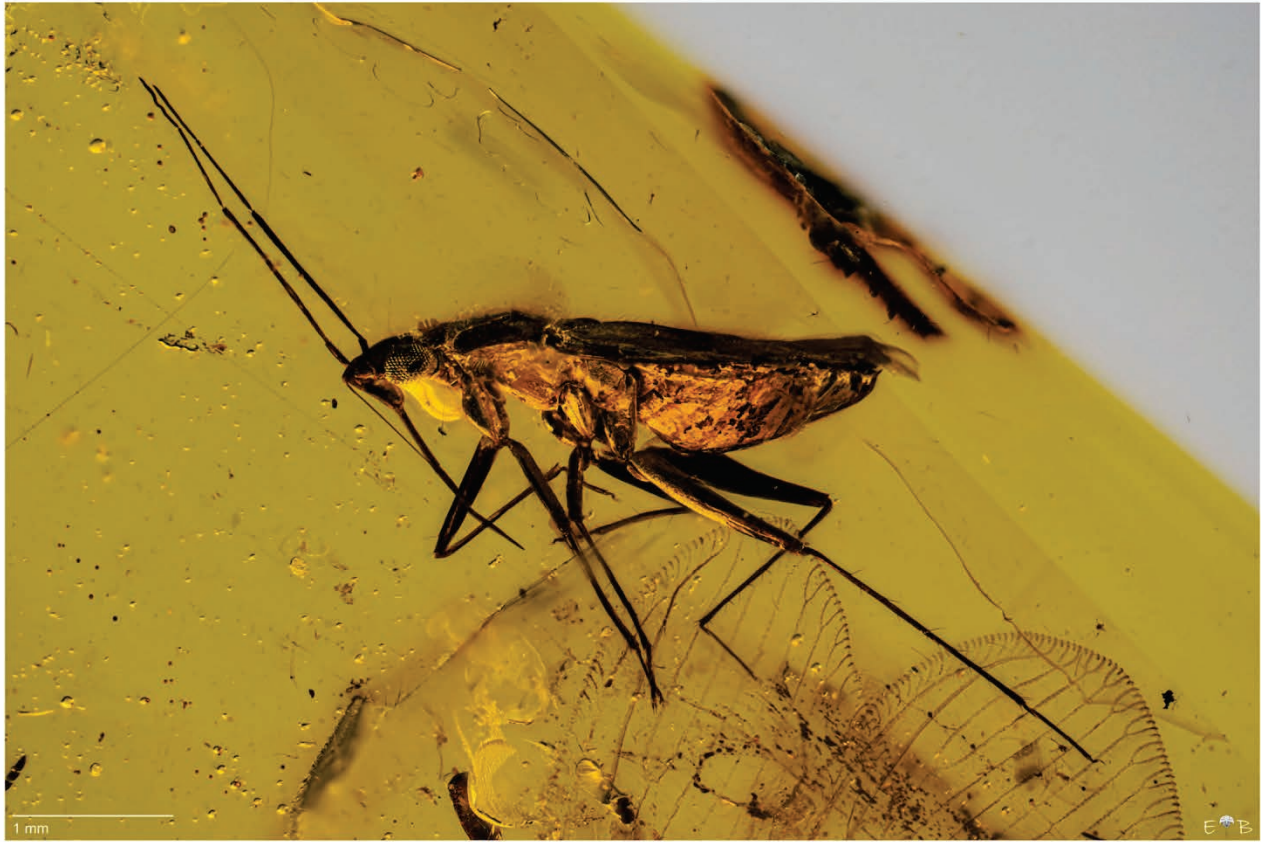


Fig. 1. Well-preserved fossil mirid from mid-Cretaceous Burmese amber.

DIVERSITY OF FOSSIL CLICK BEETLES (COLEOPTERA: ELATEROIDEA)

K. Třísková¹, G. Pačková² & R. Kundrata^{3,*}

Department of Zoology, Faculty of Science, Palacky University, Olomouc, Czech Republic;

ORCID: 0000-0003-2385-5557 (K.T.), 0000-0001-7949-619X (G.P.), 0000-0001-9397-1030 (R.K.)

**robin.kundrata@upol.cz*

Keywords: Burmese amber, Elateridae, Mesozoic, palaeodiversity

The click beetles (Elateridae) represent one of the major clades in the polyphagan series Elateriformia. More than 11,000 described extant and extinct species from all zoogeographic realms are currently classified in 18 subfamilies^{1,2}. Elateridae are famous for both scientists and non-scientists due to the presence of a clicking mechanism in most species, and also because they contain several important economic pests, bioluminescent species, and morphologically modified lineages affected by the paedomorphosis. Elateridae might have originated in the Triassic; however, the click-beetle fossil record from that period is limited to several species of which all but one are isolated elytra of highly doubtful family attribution³. However, the Triassic origin of the group cannot be ruled out since Elateridae are very well represented in the fossil record of the Jurassic, especially from Asian deposits. Elateridae rapidly diversified during the Jurassic; more than 100 species in approximately 40 genera representing five subfamilies have been described. Altogether, the fossil Elateridae are represented by 269 described species, of which more than half are Mesozoic⁴. Those species are classified into 105 genera, of which 77 are extinct. Almost 100 species are placed in the extinct Mesozoic subfamily Protagyrypninae, and more than 50 species are incertae sedis, i.e., without a subfamily attribution. The subfamilies with more than 30 fossil species each include Agrypninae, Dendrometrinae, and Elaterinae. This is not surprising as these three are the most species-rich subfamilies in regard to extant diversity. There are no fossil species known for subfamilies Hapatesinae, Hemiopinae, Morostominae, Oestodinae, Omalisinae, Physodactylinae, Subprotelaterinae, Tetralobinae, and Thylacosterninae⁴. Although the click beetle fauna is well represented in currently very popular mid-Cretaceous Burmese amber, only several species have been formally described to date⁵.

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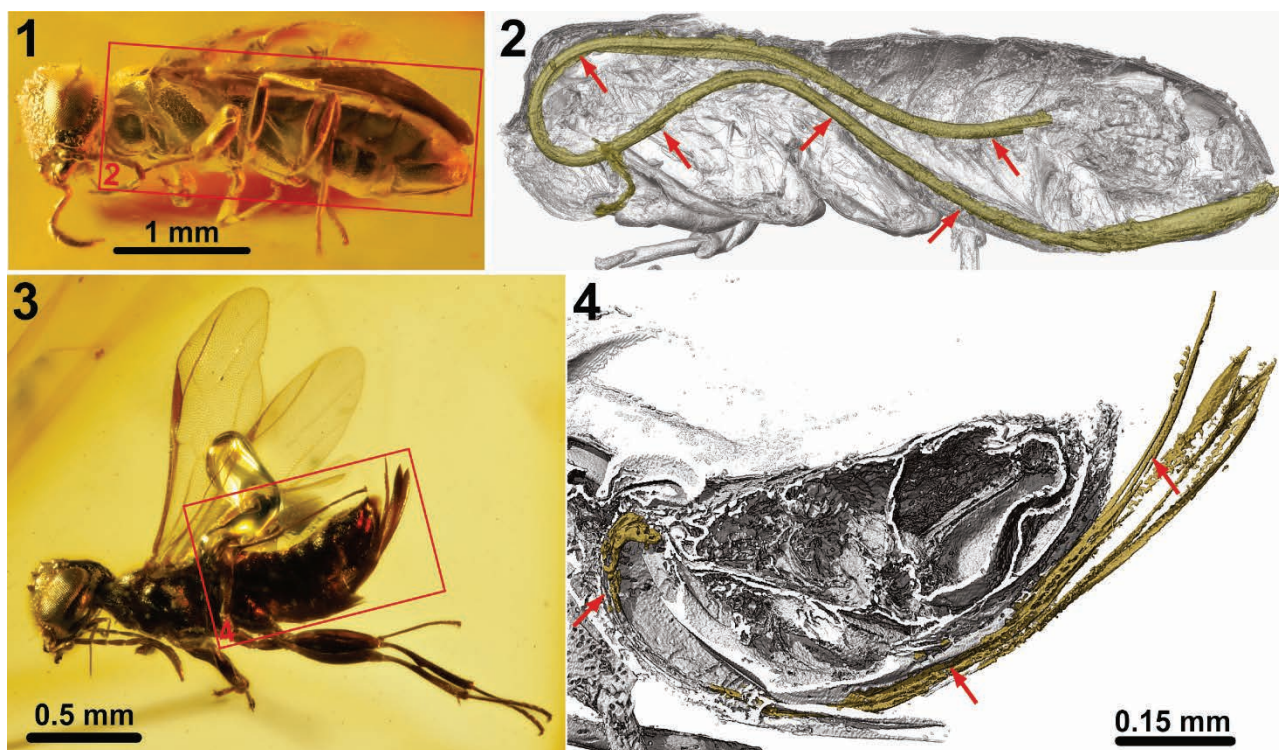
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UNVEILING PARASITOID WASP EVOLUTION IN AMBER

L. Vilhelmsen

*Natural History Museum Denmark, University of Copenhagen; 0000-0002-5593-5722**lvilhelmsen@snm.ku.dk***Keywords:** Orussoidea, Cretaceous amber, Eocene amber, synchrotron scanning, ‘missing link’

Orussoidea are a small group of parasitoid wasps targeting wood-living beetle larvae. They are the sister group of the highly diverse Apocrita, and their lifestyle are possibly reminiscent of that of the common ancestor of all parasitoid wasps in a number of ways. However, extant females of the Orussidae also possess unique highly derived features in their antennae and fore legs associated with detecting hosts by vibrational sounding deep inside wood, and an internalized ovipositor for reaching the host (1). These features are shared by all extant members of the family and have also been demonstrated for crown group Eocene fossils (Fig. 1) from Baltic amber (2) employing synchrotron scanning (Fig. 2).



Figs. 1-4. 1-2. Female holotype of †*Orussus juttagroehnae*, a crown group orussid from Eocene Baltic amber [2]. 3-4. Female holotype of †*Cretovelona orussopteryx*, a stemgroup orussoid from Cretaceous Kachin amber [3]. 1, 3 are brightfield habitus images, 2, 4 are renderings from synchrotron scans. Notice looped, fully internalized ovipositor extending all the way into the thorax in 2 (red arrows) and curved, partly internalized ovipositor extending only to anterior part of abdomen in 4 (red arrows).

Until recently, no stem group fossil orussoids displaying intermediate stages of these specialized features were known. However, recent discoveries from Kachin amber have dramatically increased understanding of how these features might have evolved. A partially preserved female has antennae with very few modifications for vibrational sounding and the fore legs also are not as advanced as in the crown group [4]. A minute female stem group orussoid [3] (Fig. 3) on the other hand has features in the antennae and fore

legs intermediate between other stem group fossils and the crown group, and synchrotron scanning revealed the ovipositor apparatus to be partly internalized (Fig. 4), but not as extensively as in modern orussoids (Fig. 2). This new fossil forms a vital ‘missing link’ in understanding the evolution of these specialized wasps.

The combination of an increasingly diverse fossil record with state-of-the-art investigative techniques has elucidated the evolution in deep time of highly complex morphological features in a level of detail previously mostly known from vertebrates.

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THE EVOLUTION OF DIPLURANS

Y. Wang¹, C. Cai¹ & D. Huang^{1,*}

¹*Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, China*

✉ 0000-0002-4638-974X (Y.W.); ✉ 0000-0002-9283-8323 (C.C.); ✉ 0000-0002-5637-4867 (D.H.)

**dyhuang@nigpas.ac.cn*

Keywords: Mesozoic, morphology, palaeoecology, mouthparts, cerci, molecular clock

Hexapods, the most speciose clade among extant animals, represent a cornerstone for deciphering the origins and evolutionary dynamics of terrestrial ecosystems, particularly through the investigation of their early-diverging lineages. Nevertheless, the sparse fossil record of non-insect hexapods limits our understanding of their evolutionary history. Here we report a giant japygoid dipluran (two-pronged bristletail) from the Middle Jurassic of China, whose mouthparts exhibits an ectognathous configuration, elucidating the ancestral groundplan of hexapod mouthparts. In contrast to extant japygoids, its cerci and associated abdominal segments show plesiomorphic traits, providing critical insights into the evolutionary history of the grasping apparatus. Furthermore, we discovered the earliest fossil records of some lineages of Diplura from Burmese amber. Through integrated phylogenomic and molecular clock analyses, we show that crown hexapods conquered the land by the Middle Ordovician (~470 Ma), with crown Entognatha and Diplura approximately emerging during the early Silurian (~442 Ma) and Early Devonian (~398 Ma), respectively. Our study represents a comprehensive synthesis of palaeontological, morphological, and genomic data, offering new insights into hexapod evolution and the timeline of their terrestrialization.

THE EARLY EVOLUTION OF MODERN PATTERN OF INSECT HERBIVORY

L. Xiao^{1,*}, Y. Wang¹, C. Labandeira² & D. Ren³¹Institute of Zoology, Guangdong Academy of Sciences, Guangzhou, People's Republic of China;

● 0000-0002-6940-1473 (L.X.), 0000-0003-1397-8481 (Y.W.)

²Department of Paleobiology, National Museum of Natural History, Washington, DC, USA. ● 0000-0002-4838-5099³College of Life Science, Capital Normal University, Beijing, People's Republic of China; ● 0000-0001-8660-0901

*xiaolifangxau@163.com

Keywords: beta diversity analysis; insect herbivory; Mesozoic terrestrial shifting; Middle Jurassic; plant-insect associations

The evolution of plant-insect associations has recently attracted significant attention from entomologists and ecologists¹. Fossil evidence of insect herbivory offers valuable insights into how insects responded to long-term environmental changes²⁻⁴. Moreover, insect herbivory plays a crucial role in the energy flow within terrestrial ecosystems and significantly influences the dynamics of plant communities⁵. Understanding the evolutionary development of insect herbivory patterns typically requires a series of fossil records spanning deep time or extensive geological timescales.

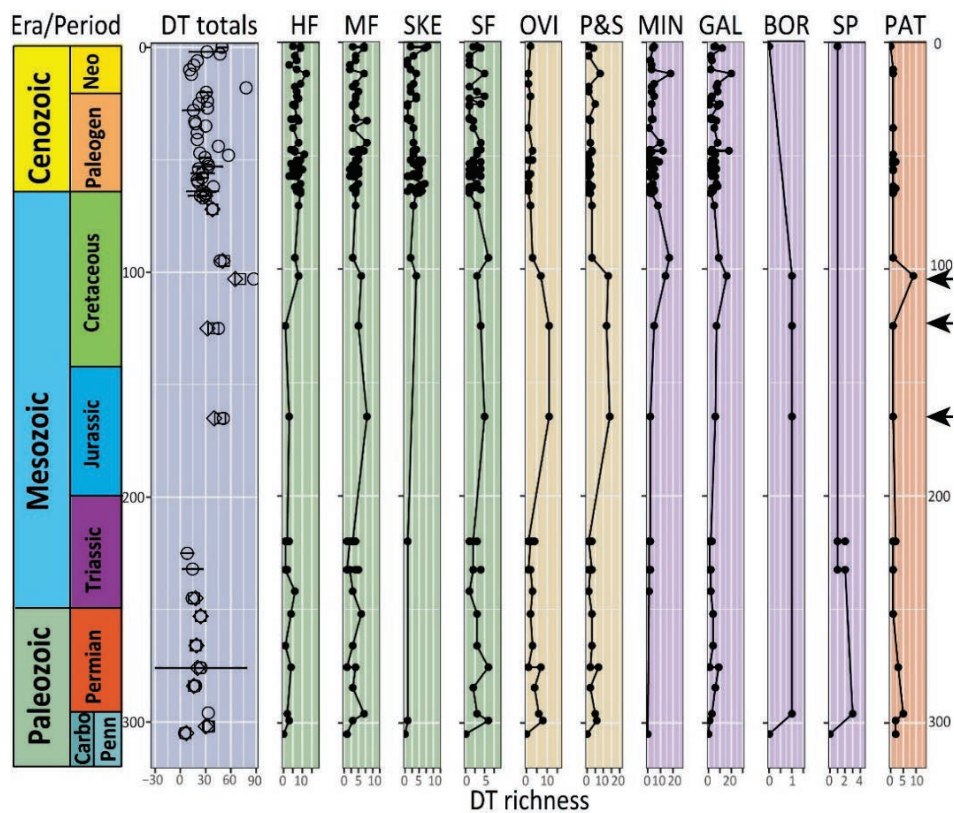


Fig. 1. The richness of DTs and FFGs for 131 fossil plant assemblages and three modern plant assemblages.

To understand the origins of the modern pattern of terrestrial arthropod (mainly insect) herbivory, we used functional feeding group–damage type (FFG-DT) data to perform several analyses covering from the Late Pennsylvanian to the present (305 My interval). Using a beta diversity approach, we assessed turnover and nestedness through pairwise comparisons of damage types (DTs) for 131 fossil and three modern plant assemblages. Well-sampled functional feeding groups (FFGs) show an increase in DT richness over this

period, with a mid-Mesozoic uptick, a decline in the late Cretaceous, and a fluctuating rise throughout the Cenozoic. Our analyses revealed that the current, distinctive pattern of beta diversity extends back to the Middle Jurassic, significantly differing from the patterns of the late Paleozoic and Triassic. Turnover and nestedness patterns were mixed among the three most herbivorized plant-host species per assemblage during this interval. Additional analyses implied that plant assemblages, and their associated FFGs display the overlap pattern among Middle Jurassic to modern plant assemblages, but not with those of the late Paleozoic and Triassic. Host plant specificity analysis shows that gymnosperms exhibited higher DT functional breadth than ferns and angiosperms during the Mesozoic. Overall, beta diversity and related results suggest that turnover in associations between plant groups and functional feeding groups was relatively low from the late Paleozoic through the Cenozoic, while nestedness showed a general high level. A major inflection point observed in a gymnosperm-dominated, late Middle Jurassic (~165 My) plant assemblage suggests that the earliest expression of modern insect herbivory patterns can be traced back to Middle Jurassic.

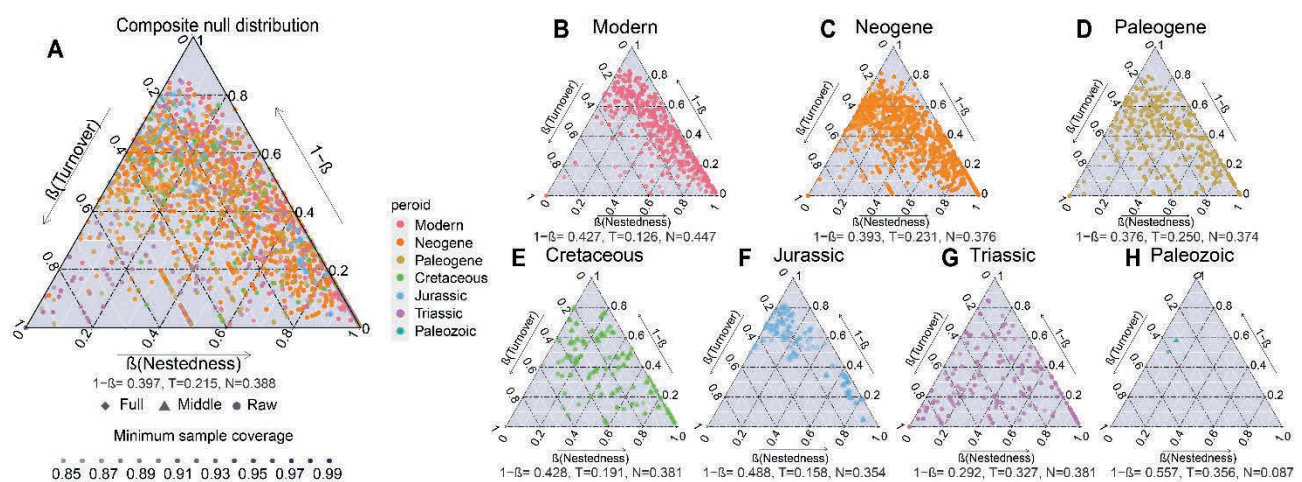


Fig. 2. A composite null distribution of pairwise comparisons of damage types seen in 131 fossil and three modern plant assemblages.

These findings suggest that the previously accepted hypothesis requires reconsideration. That hypothesis proposed that the complex pattern of associations between plants and insects in modern terrestrial ecosystems was established during the initial diversification of flowering angiosperms in the Early Cretaceous Period (125–90 My). However, our updated results indicate that the later (and modern) diversification of arthropod herbivores on angiosperms was a continuation of a pattern that began 60 million years earlier on gymnosperms. Furthermore, the emergence of modern insect herbivory patterns probably driven by the diversification of natural enemies, which regulated herbivorous insects in a top-down effect, rather than by bottom-up effect through plant food sources. A more detailed explanation of the mechanisms by which insect herbivory evolved to its current form still requires further studies.

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**A NEW FOSSIL INSECT (DIPTERA, PROTOBRACHYCERIDAE) FROM LOWER JURASSIC OF GRIMMEN,
GERMANY**

W. Zessin

Lange Str. 9, 19230 Picher OT Jasnitz, Germany;

**wolfgangzessinjasnitz@gmail.com*

Keywords: Diptera, Protobracheridae, Lower Jurassic, Toarcium, Grimmen

Lehmhagenia ansorgei Zessin, 2025, a new genus and new species of the family Protobracheridae (Diptera: Brachycera), is newly described from Grimmen in Mecklenburg-Vorpommern (Lower Jurassic of Germany). The Grimmen Liassic has provided numerous insects, including Diptera, which are among the most common insects in Grimmen and account for almost 25% of the insect material¹. Naturally, my private collection of Liassic insects, comprising approximately 6,000 specimens, also includes numerous Diptera from the Klein Lehmhagen Liassic clay pit near Grimmen (Western Pomerania), but also from Schwinz near Dobbertin (Mecklenburg), and Schandelah (Lower Saxony), of which only a few have been published². The excellently preserved Diptera wing presented here was discovered by me in 2021 while opening small calcareous concretions that I had collected years ago in the clay pit of the former Grimmen porous sinter works near the village of Klein Lehmhagen.

The first Liassic insects of northern Germany were discovered by Geinitz from the clay pit near Dobbertin. In his seminal masterpiece "Die Fossilen Insekten..." and subsequent works, Handlirsch described, among others, Liassic Diptera from Dobbertin, and later Bode from the Lower Saxon sites around Braunschweig (e.g., Schandelah, Grassel, Hondelage). More recently, Ansorge, Horst (Germany), Krzemiński, Kraków (Poland) and Zessin, Jasnitz (Germany), have focused on the Diptera from Dobbertin, Grimmen and Schandelah^{2,3,5}.

The small leftwing specimen (3.2 mm long) of *Lehmhagenia ansorgei*, gen. et sp. nov., is available from the Zessin Collection, Jasnitz (SZJ LG 1999/1-2), later Natureum at Ludwigslust Castle, Museum of the Mecklenburg Natural History Society. The genus is named after the type locality Lehmhagen near Grimmen, the species after my friend Dr. Jörg Ansorge, Horst, who made a significant contribution to the research of the Liassic entomofauna of Lehmhagen near Grimmen.

For better knowledge some other Jurassic dipteran insects are figured in: *Protobracheron sinensis* Zhang et al., 2008⁴, *Protobracheron liasinum* Handlirsch, 1920 and *Liassobracheron kotejai* Krzemiński & Ansorge, 2005³.

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Fig. *Lehmhagenia ansorgei* Zessin, 2025 (5), isolated left wing, liassic-clay pit by Klein Lehmhagen near Grimmen, Mecklenburg-Vorpommern, Germany, Collection Zessin Jasnitz, SZJ LG 1999/1

Participants of International Palaeontological Conference

FOSSIL INSECTS – BRIDGING PAST & PRESENT

Sergio Álvarez-Parra, State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, China

Jörg Ansoerge, Institute of Geography and Geology, University of Greifswald, Germany

Antonio Arillo, Departamento de Biodiversidad, Ecología y Evolución, Facultad de Biología, Universidad Complutense, Madrid, Spain

Antonios Isidoros Avrithis, The Open University, Milton Keynes, United Kingdom

Dany Azar, 1) Nanjing Institute of Geology and Palaeontology, CAS, Nanjing, China; 2) Lebanese University, Faculty of Science II, Natural Sciences Department, Fanar, El-Matn, Lebanon

Tomasz Czerwiński, Museum and Institute of Zoology, PAS, Warszawa, Poland

Klára Daňková, Charles University, Prague

Xavier Delclos, University of Barcelona, Barcelona, Spain

Jowita Drohojowska, Institute of Biology, Biotechnology and Environmental Protection, Faculty of Natural Sciences, University of Silesia, Katowice, Poland

Jules Ferreira, 1) Institut Botànic de Barcelona (CSIC-CMNCB), Barcelona, Spain; 2) Facultat de Ciències de la Terra, Universitat de Barcelona, Barcelona, Spain

Roman Godunko, 1) University of Lodz, Faculty of Biology and Environmental Protection, Department of Invertebrate Zoology and Hydrobiology, Łódź, Poland; 2) Biology Centre of the Czech Academy of Sciences, Institute of Entomology, České Budějovice, Czech Republic Biology Centre of the Czech Academy of Sciences, Institute of Entomology

Marina Hakim, State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, China

Christel Hoffeins, Arbeitskreis Bernstein: Hamburg, Germany

Hans Werner Hoffeins, Arbeitskreis Bernstein: Hamburg, Germany

Diyang Huang, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, China

Kamil Humański, Institute of Paleobiology, Polish Academy of Sciences, Warsaw, Poland

Katarzyna Janiszewska, Institute of Paleobiology, Polish Academy of Sciences, Warsaw, Poland

David Jetelina, Department of Zoology, Faculty of Science, Palacky University, Olomouc, Czech Republic

Szymon Kaczmarek, University of Lodz, Faculty of Biology and Environmental Protection, Department of Invertebrate Zoology and Hydrobiology, Lodz, Poland

Marcin Kamiński, Zoological Museum, Museum and Institute of Zoology, Polish Academy of Sciences, Warszawa, Poland

Iwona Kania-Kłosok, Faculty of Biology and Nature Protection, University of Rzeszów, Poland

Maryna Kirychenko-Babko, Schmalhausen Institute of Zoology NAS of Ukraine, Kyiv, Ukraine

Tomasz Kołodziej, Jagiellonian University/NSRC SOLARIS, Kraków, Poland

Szymon Konwerski, Natural History Collections, Faculty of Biology, Adam Mickiewicz University,
Poznań

Katarzyna Kopeć, Institute of Systematics and Evolution of Animals, Polish Academy of Sciences,
Krakow, Poland

Paweł Koteja, Jagiellonian University

Hubert Kowalski, University of Warsaw Museum, Poland

Ewa Krzemińska, Institute of Systematics and Evolution of Animals, Polish Academy of Sciences,
Krakow, Poland

Wiesław Krzemiński, Institute of Systematics and Evolution of Animals, Polish Academy of Sciences,
Krakow, Poland

Robin Kunderata, Department of Zoology, Faculty of Science, Palacky University, Olomouc, Czech
Republic

Xinneng Lian, Institute of Palaeontology, Yunnan University, Kunming, China

Doug Lundberg, University of Colorado, United States (US)

Fabio Magnani, Museo cantonale di storia naturale, Lugano, Switzerland

Monika Michalska, Institute of Paleobiology, PAS, Warsaw, Poland

Matteo Montagna, Department of Agricultural Sciences, Naples, Italy

Bartosz Ogłaza, Institute of Biology, Biotechnology and Environmental Protection, University of Silesia,
Katowice, Poland

Gabriela Pačková, Department of Zoology, Faculty of Science, Palacky University, Olomouc, Czech
Republic

Grzegorz Pacyna, Jagiellonian University, Faculty of Biology, Institute of Botany, Department of
Taxonomy, Phytogeography and Paleobotany, Kraków, Poland

Enrique Peñalver, Instituto Geológico y Minero de España, CSIC, Valencia, Spain

Jakub Prokop, Faculty of Science, Charles University, Czech Republic

Lukasz Przybyłowicz, Institute of Systematics and Evolution of Animals Polish Academy of Sciences;
Kraków, Poland

Jan Audun Rasmussen, 1) Museum Mors, Nykøbing Mors, Denmark; 2) Natural History Museum of
Denmark, Copenhagen, Denmark

Katerina Rosova, Faculty of Science, Charles University, Czech Republic

Andrew Ross, Department of Natural Sciences, National Museums Scotland, Edinburgh

Rafał Ruta, Department of Biodiversity and Evolutionary Taxonomy, Faculty of Biological Sciences,
University of Wrocław, Wrocław, Poland

Robert Rutkowski, Museum and Institute of Zoology PAS, Warsaw, Poland

Grzegorz Salwa, Wojewódzki Szpital Podkarpacki im. Jana Pawła II w Krośnie

Alba Sánchez-García, Universitat de València, Burjassot, Spain

Maxime Santer, Departament de Dinàmica de la Terra i de l'Oceà, Facultat de Ciències de la Terra, Universitat de Barcelona, Barcelona, Spain & Institut de Recerca de la Biodiversitat (IRBio), Universitat de Barcelona, Barcelona, Spain

Hemen Sendi, Institute of Zoology, Slovak Academy of Sciences, Bratislava, Slovakia

Jan Ševčík, University of Ostrava, Faculty of Science, Ostrava, Czech Republic

Maksoud Sibelle, Lebanese University, Faculty of Sciences II, Department of Natural Sciences, Fanar, Lebanon

Jan Simon-Pražák, 1) Charles University, Faculty of Science, Department of Zoology, Viničná 7, 12800 Prague, Czech Republic; 2) Museum of Eastern Bohemia in Hradec Králové, Eliščíno nábřeží 465, 500 03 Hradec Králové, Czech Republic

Kornelia Skibińska, Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, Krakow, Poland

Wojciech Solarz, Institute of Nature Conservation, Polish Academy of Sciences, Kraków, Poland

Mónica M. Solórzano Kraemer, Senckenberg Research Institute and Natural History Museum, Frankfurt, Germany

Elżbieta Sontag, 1) Museum of Amber Inclusions; 2) Faculty of Biology, University of Gdańsk, Poland

Agnieszka Soszyńska, University of Lodz, Faculty of Biology and Environmental Protection, Department of Invertebrate Zoology and Hydrobiology, Lodz, Poland

Katarzyna Sowa, SOLARIS National Synchrotron Radiation Centre, Poland

Pavel Sroka, Biology Centre of the Czech Academy of Sciences, Institute of Entomology, České Budějovice, Czech Republic

Adam Stroński, Museum and Institute of Zoology, Polish Academy of Sciences, Warszawa, Poland

René Lyng Sylvestersen, Fur Museum, Museum Salling, Fur, Denmark

Maksymilian Syratt, 1) Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, Krakow, Poland; 2) Faculty of Biology, Jagiellonian University, Kraków, Poland

Maria Małgorzata Szadziewska,

Ryszard Szadziewski, 1) Museum of Amber Inclusions, Gdańsk, Poland; 2) Faculty of Biology, University of Gdańsk, Poland

Karol Szawaryn, Muzeum and Institute of Zoology, Polish Academy of Sciences, Warszawa, Poland

Jacek Szwedo, Laboratory of Evolutionary Entomology and Museum of Amber Inclusions, Department of Invertebrate Zoology and Parasitology, Faculty of Biology, University of Gdańsk, Poland

Artur Tazakowski, Institute of Biology, Biotechnology and Environmental Protection, Faculty of Natural Sciences, University of Silesia in Katowice, Katowice, Poland

Kateřina Třísková, Department of Zoology, Faculty of Science, Palacky University, Olomouc, Czech Republic

Lars Vilhelmsen, Natural History Museum Denmark, University of Copenhagen, Denmark

Yehao Wang, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, China

Piotr Węgierek, Institute of Biology, Biotechnology and Environmental Protection, University of Silesia, Katowice, Poland

Lifang Xiao, Institute of Zoology, Guangdong Academy of Sciences, Guangzhou, People's Republic of China

Sigrid Zessin, Naturforschende Gesellschaft Mecklenburg, Germany

Wolfgang Zessin, Jasnitz, Germany





ISBN 978-83-61358-01-5

**Institute of Systematics and Evolution of Animals
Polish Academy of Sciences.
Natural History Museum**

fossilbpp@gmail.com

ul. św. Sebastiana 9
31-049 Kraków