JHR 77: 219–226 (2020)
doi: 10.3897/jhr.77.53307
http://jhr.pensoft.net

RESEARCH ARTICLE

JOURNAL OF Hymenoptera RESEARCH
A peer-reviewed open-access journal
The International Society of Hymenopterists

Discovery and description of the first known fossil Signiphoridae (Hymenoptera, Chalcidoidea)

Roger A. Burks[1], James B. Woolley[2], Shroq O. Kesbeh[2], Devon S. Eldridge[2,3], Ana Dal Molin[4,5], John M. Heraty[1]

1 *Department of Entomology, University of California, Riverside, CA 92521, USA* **2** *Department of Entomology, Texas A&M University, College Station, TX 77843-2475, USA* **3** *Department of Entomology and Plant Pathology, University of Tennessee, Knoxville, TN 37996, USA* **4** *Departamento de Microbiologia e Parasitologia, Universidade Federal do Rio Grande do Norte, Lagoa Nova, Natal, RN, 59072-970, Brazil* **5** *Instituto Nacional de Ciência e Tecnologia dos Hymenoptera Parasitoides (INCT/HYMPAR)/Laboratório de Biodiversidade de Insetos, DCBIO, Universidade Federal do Espírito Santo, Vitória, Brazil*

Corresponding author: Roger A. Burks (burks.roger@gmail.com)

Academic editor: Mark Shaw | Received 16 April 2020 | Accepted 7 June 2020 | Published 29 June 2020

http://zoobank.org/D28C85B0-D7BB-4F31-9708-3592D2957B28

Citation: Burks RA, Woolley JB, Kesbeh SO, Eldridge DS, Dal Molin A, Heraty JM (2020) Discovery and description of the first known fossil Signiphoridae (Hymenoptera, Chalcidoidea). Journal of Hymenoptera Research 77: 219–226. https://doi.org/10.3897/jhr.77.53307

Abstract

Chartocerus azizae **sp. nov.** is described as the first known fossil from the family Signiphoridae, based on two inclusions in the same piece of Eocene Baltic amber (36.7–48.5 million years ago). Implications of the morphology of *C. azizae* are discussed, indicating that it should be placed in *Chartocerus*.

Keywords

Baltic amber, extinct, new species

Introduction

The family Signiphoridae is a monophyletic group (Heraty et al. 2013) of primary and secondary parasitoids of a variety of hosts, classified into four genera (Woolley 1988, 1997; Woolley and Dal Molin 2017). Although two subfamilies, Signiphorinae (for *Signiphora* Ashmead) and Thysaninae (for *Chartocerus* Motschulsky, *Thysanus* Walker and *Clytina* Erdös), have been proposed in the past, Woolley (1988, 1997) suggested that Thysaninae is paraphyletic with respect to Signiphorinae. Changes resulting in monophyly would have required formation of a weakly justified and plesiomorphic subfamily to contain only *Chartocerus* (Woolley 1988).

Molecular data (28S and 18S ribosomal DNA) indicated that *Clytina giraudi* Erdős rendered *Chartocerus* paraphyletic, thus reinforcing that Thysaninae would be problematic if recognized (Munro et al. 2011). Combined data (Heraty et al. 2013) agreed with these results but did not include enough taxa to test monophyly of *Chartocerus*.

Extant Signiphoridae possess many features that are presumably apomorphic within Chalcidoidea, including long, unsegmented antennal clava, the anelliform shape and size of all preclaval flagellomeres, lack of external indication of notauli, transverse shape of the mesoscutellum, lack of external indication of axillae, lack of or reduced number of fore wing disc setae, presence of a triangular median area defined on the propodeum, presence of internal anterior projections on metasomal sterna 3–6, and presence of a separate epipygium (metasomal tergum 9) in females and most males (Woolley 1997). Some of these features are shared most notably with Azotidae, which is the sister group of Signiphoridae supported by most recent analyses (Woolley 1988, Heraty et al. 2013).

No fossil Signiphoridae have been previously described, but similarly small-bodied Chalcidoidea such as Aphelinidae and Trichogrammatidae are known from Eocene Baltic amber (Burks et al. 2015). The discovery of a Baltic amber signiphorid establishes the minimum age of Signiphoridae in the Eocene, but does not pinpoint that age with great accuracy because of uncertainty over which stratum the fossils came from (Ritzkowski 1997). Therefore, we choose a cautious estimate of 36.7–48.5 million years ago for this species.

Methods

The holotype belongs to the American Museum of Natural History (AMNH B-JWJ-73, UCRCENT00237907). Stereoscope photographs were taken using Leica Imaging System Software with a Z16 APO A microscope, a Keyence VHX-6000 digital microscope equipped with NHZ20R 20–200× zoom lens and VH-250R/W/T 250–2500× zoom lens, and a Macropod Pro macrophotography system (https://macroscopicsolutions.com) using Mitutoyo planapochromat objectives. Serially focused images were focus-stacked using Zerene Stacker (Build T2019-10-07-1410 or earlier versions) using the PMax algorithm, and subsequently processed in Adobe Lightroom to adjust brightness and contrast and to bring out image details, and Adobe Photoshop to add scale bars. In some cases, backgrounds were removed using Topaz ReMask. Images were annotated in Adobe InDesign. Terminology follows that of Woolley (1988), with some additional terms following Gibson (1997) and sculptural terms following Eady (1968). For the Macropod images, the amber piece was submerged in glycerin in an optical cuvette, with the surface closest to the specimen placed as close as possible to the crystal optical surface. Illumination was entirely indirect: twin Yognou flashes were directed not at the specimen but at a white plastic diffuser on the front of the microscope objective. For the Keyence images, specimens were submerged in glycerin in a small petri dish, and lighting was performed using diffusers on the Keyence lenses. Best results with the Keyence were generally obtained with the Depth Up/Fine Depth Composition algorithm.

Results

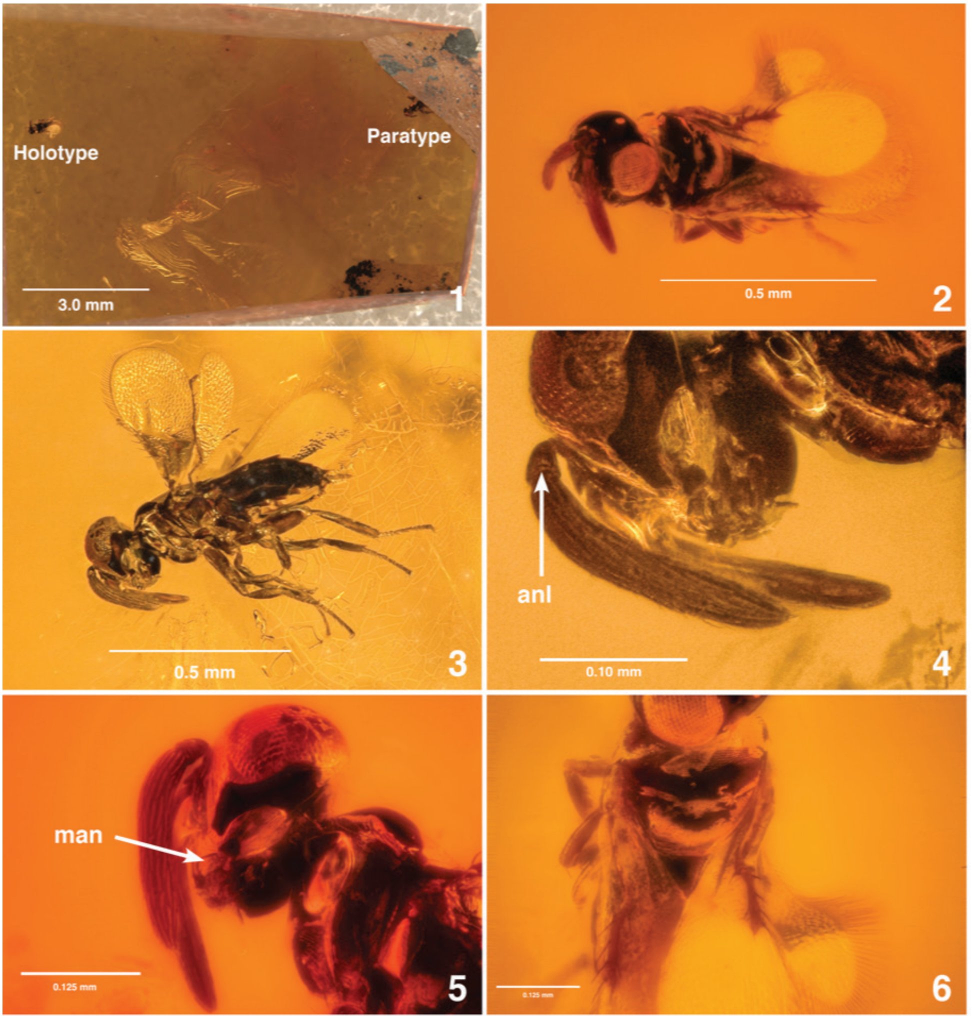
Generic placement

Chartocerus is defined by features that are presumably plesiomorphic in Signiphoridae (Woolley 1988), including a narrowly rounded occipital margin of the head (instead of broadly rounded or sharp), presence of 4 anelli in females (instead of 3 or fewer in other genera) and 3 anelli in males, presence of five dorsal setae on the anterior edge of the marginal vein (instead of four), a rounded posterior hind wing margin (instead of nearly straight), lack of a comb of setae on the protibial spur, three or four long mesofemoral spines (instead of one), lack of a lamelliform process on the median elevation of the propodeum, and the lack of an epipygium in males (Woolley 1988). *Chartocerus azizae* possesses most characters used by Woolley (1988) and Woolley and Dal Molin (2017) to define *Chartocerus*, including a curved and bifid foretibial spur, without a comb of fine setae (Fig. 10), and metasomal terga 8 and 9 combined to form a syntergum (Fig. 13: syn). However, *C. azizae* has two mesofemoral spines instead of three or four (Fig. 13), and one anellus in males instead of three (Fig. 4). The median area of the propodeum could not be assessed. *Chartocerus azizae* also possesses a posteriorly emarginate subgenital plate, but its exact shape is also not clearly discernable in these specimens (Fig. 11: Ms_8). The fore wing venation setae in *C. azizae* correspond to that those in extant *Chartocerus* (Fig. 7). The raised surface sculpture of the fore wing (Fig. 7) is much stronger and more conspicuous than the hardly visible fore wing sculpture of other Chalcidoidea. Recently, an unusual new species has been described in *Chartocerus*, *C. kartiniae* Polaszek and Schmidt (Schmidt et al. 2019). This species has two anelli in females, a large discal seta in the fore wing, and light coloration on the mesosoma (both previously unknown in *Chartocerus*).

Description

***Chartocerus azizae* Burks, Woolley, Kesbeh, Eldridge & Dal Molin, sp. nov.**
http://zoobank.org/0A161559-185B-44CB-AC7D-53EF17055711
Figs 1–13

Male (n = 2). Body length 0.67–0.75 mm.



Figures 1–6. 1 Whole fossil showing the holotype and paratype (Leica Z16 Apo A) **2** holotype, dorsal habitus (Macropod) **3** paratype, lateral habitus (Keyence) **4** paratype, head and antennae (anl: anellus) (Keyence) **5** holotype, head and antennae (man: mandible) (Macropod) **6** holotype, mesosoma (Macropod).

Type material. The Baltic amber piece containing the holotype and paratype contains two inclusions, both males of this species [AMNH B-JWJ-73, UCRCENT00237907]. The amber was not cut to separate the specimens, because fractures in the piece would endanger the inclusions (Fig. 1). The holotype (Fig. 1: Holotype, Figs 2, 5–7, 9, 11, 12) is the specimen with one wing folded over the body. The paratype (Fig. 1: Paratype, Figs 3, 4, 8, 10, 13) is the specimen with both wings raised, near a fractured edge in the amber. Types deposited in AMNH.

Diagnosis. Fore wing venation with setae M1, M2b, and M6 present, thus fore wing venation with a total of 10 dorsal setae, with 7 on the marginal vein (Fig. 7). Male antenna with one anellus (Fig. 4: anl). Mesofemur with 2 stout ventral setae subapically (Fig. 13: mfs). Fore wing with strong raised surface sculpture (Fig. 7).

Color and sculpture. Head and antenna. Head dark brown, pedicel, funicle and clava brown.

Body. Mesosoma and metasoma uniformly as dark brown as head; patchy light areas are visible on the holotype, however these appear to be artifacts of preservation in amber. Fore wings hyaline except for infuscate area below marginal vein and at wing base, hind wings hyaline. Profemur dark with light areas at apex, protibia dark; mesofemur and mesotibia dark, mesobasitarsus light, metafemur and metatibia dark.

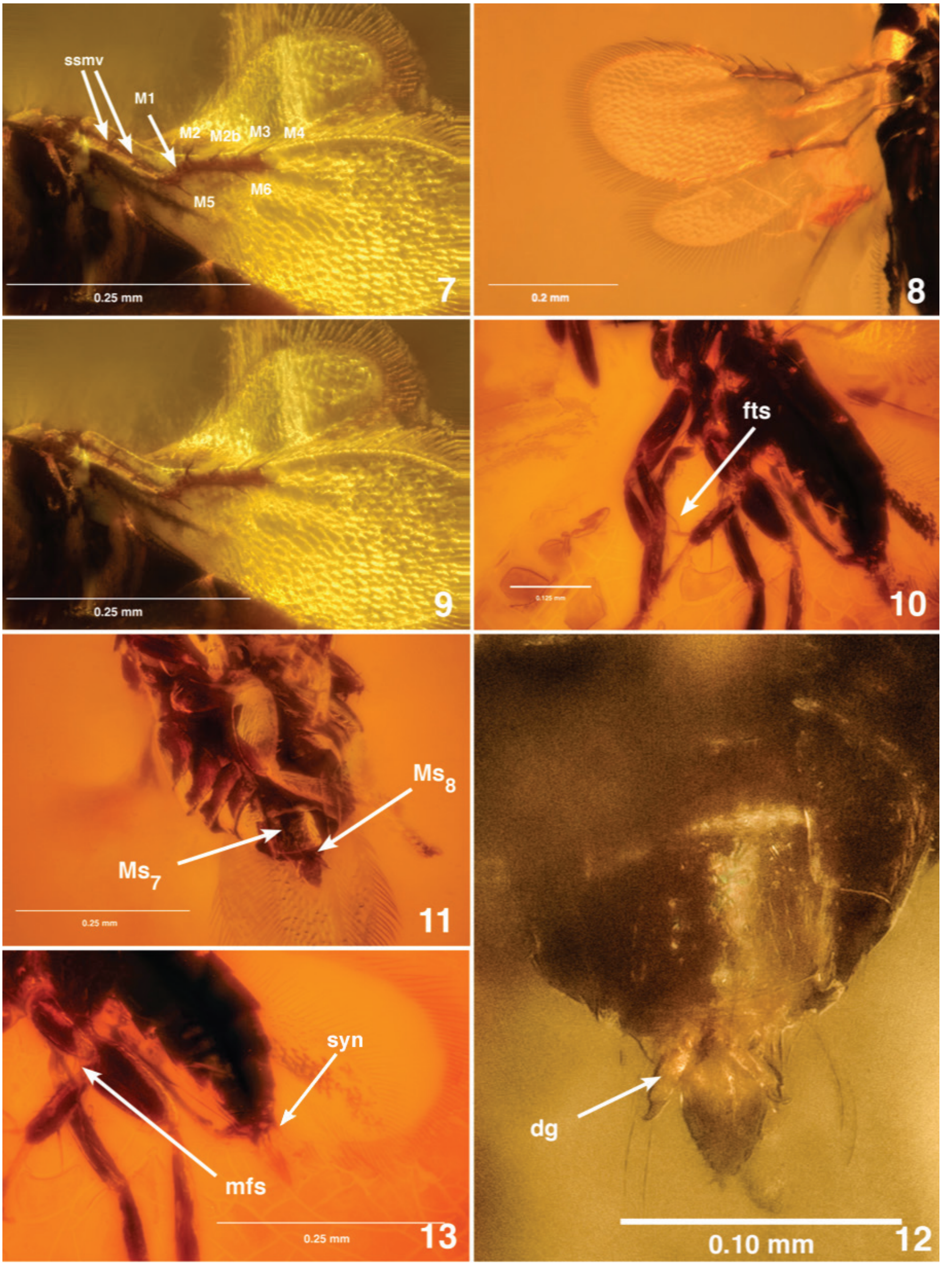
Head (Figs 4, 5). Clava about 5× as long as broad, with about 40 MPS (Fig. 4); one anellus present (Fig. 4: anl). Scape inserted slightly ventral to lower eye margin, about 0.55× clava length; pedicel 0.3× clava length. Mandible small, with two short teeth (Fig. 5: man) of equal length. Face with shallow coriaceous sculpture; antennal scrobe distinctly margined dorsally, rounded interantennal elevation present. Vertex narrowly rounded. Postgenae posteriorly separated (therefore subforaminal bridge similar to that in Burks and Heraty. 2015: fig. 6h).

Mesosoma (Figs 2, 6–10). Pronotum short. Mesoscutum shallowly sculptured (transversely coriaceous), with sparse, scattered, minute setae, only slightly longer than mesoscutellum. Mesoscutum:mesoscutellum 1.43, number of setae on mesoscutum not visible. Mesoscutellar sculpture nearly isodiametric. Metascutellum with transverse sculpture with meshes longer than those on the mesoscutum. One pair of setae visible on mesoscutellum, mesoscutellum:metascutum 2.33.

Prosternum and lower mesepisternum transversely sculptured. Prepectus dorsally short, shallowly sculptured. Mesepisternum short, with sulcus-like mesodiscrimen, with mesofurcal pit near mesocoxal insertions. Mesopleural sulcus indicated. Foretibial spur curved and bifid, without a comb of fine setae (Fig. 10: fls). Mesotibia expanded apically, with two stout dorsal spines; mesotibial spur stout, setose. Mesobasitarsus:mesofemur 0.36, mesotibial spur:mesobasitarsus 0.88, 6 spines on mesotibial spur. Metafemur stout, less than twice as long as broad.

Fore wing length:width 1.82, with long marginal fringe, the longest fringe setae slightly longer than parastigma, longest fringe:width of fore wing 0.23; parastigma strongly sinuate (Fig. 7), discal seta absent; linea calva not present, but a smooth unsculptured area on fore wing extends basally from stigmal vein almost to posterior margin (Figs 7, 8). Fore wing and hind wing with raised surface sculpture (Figs 7, 8); fore wing with two setae on submarginal vein and with setae M1, M2b, and M6 present. A small seta appears to be present in the basal area of the wing, but the location is different from the discal seta in other Signiphoridae. Posterior margin of hind wing rounded (not nearly parallel with anterior margin, Fig. 8). Hind wing with sculpture like that of fore wing, fringe slightly longer than that of fore wing, hind wing length:width 4.00, marginal setae:width hind wing 0.67, discal seta present on hind wing below apex of marginal vein.

Metasoma (Figs 11–13). Metasomal terga 8 and 9 combined to form a syntergum (Fig. 13: syn). Terga and sterna with coriaceous sculpture. Male genitalia with diver-



Figures 7–13. 7 Holotype, wings showing surface sculpture (ssmv: setae submarginal vein, setae M1–M6). (Macropod) **8** paratype, fore wing and hind wing (Leica Z16 Apo A) **9** holotype, wing venation (Macropod) **10** paratype, legs (fts: foretibial spur) (Macropod) **11** holotype, dorsal metasoma and genitalia (Ms_7: metasomal sternum 7, Ms_8: metasomal sternum 8) (Macropod) **12** Holotype, ventral metasoma and subgenital plate (dg: digitus) (Keyence) **13** Paratype, apex of metasoma, lateral (mfs: mesofemoral spines) (Macropod).

gent digiti, each with 1 apical digital spine (Fig. 12), and possibly a pair of median denticles (one median denticle visible in 2010). Subgenital plate (Ms_8) deeply emarginate medially (Fig. 11, Ms_8). Metasomal sternum 7 broadly truncate (Fig. 11, Ms_7).

Etymology. The species name is a noun in genitive case, the gender is feminine. The species is named after SOK's grandmother, Aziza Meetab. Aziza means "precious" in Arabic, recognizing the precious nature of this fossil.

Acknowledgments

We thank David Grimaldi for loan of the specimens, and the Heraty lab for helpful comments on the manuscript. We also thank Lars Krogmann and Tanja Schweizer for preparation of the amber piece. We thank Mark Smith of Macroscopic Solutions for his help with imaging using the Macropod system. This research was funded by grant NSF-DEB 1555808 to JMH and NSF-DEB 1555790 to JBW.

References

Burks RA, Heraty JM (2015) Subforaminal bridges in Hymenoptera (Insecta), with a focus on Chalcidoidea. Arthropod Structure and Development 44: 173–194. https://doi.org/10.1016/j.asd.2014.12.003

Burks RA, Heraty JM, Pinto JD, Grimaldi D (2015) Small but not ephemeral: newly discovered species of Aphelinidae and Trichogrammatidae (Insecta: Hymenoptera: Chalcidoidea) from Eocene amber. Systematic Entomology 40: 592–605. https://doi.org/10.1111/syen.12124

Eady RD (1968) Some illustrations of microsculpture in the Hymenoptera. Proceedings of the Royal Entomology Society of London (A)43: 66–72. https://doi.org/10.1111/j.1365-3032.1968.tb01029.x

Gibson GAP (1997) Chapter 2, Morphology and terminology. In: Gibson GAP, Huber JT, Woolley JB (Eds) Annotated Keys to the Genera of Nearctic Chalcidoidea (Hymenoptera). NRC Research Press, Ottawa, 16–44.

Heraty JM, Burks RA, Cruaud A, Gibson GA, Liljeblad J, Munro J, Rasplus J-Y, Delvare G, Janšta P, Gumovsky A, et al. (2013) A phylogenetic analysis of the megadiverse Chalcidoidea (Hymenoptera). Cladistics 29: 466–542. https://doi.org/10.1111/cla.12006

Munro JB, Heraty JM, Burks RA, Hawks D, Mottern J, Cruaud A, Rasplus J-Y, Janšta P (2011) A molecular phylogeny of the Chalcidoidea (Hymenoptera). PLoS One 6: 1–27. https://doi.org/10.1371/journal.pone.0027023

Ritzkowski S (1997) K-Ar-altersbestimmungen der bernsteinführenden sedimente des Samlandes (Paläogen, Bezirk Kaliningrad). Metalla (Sonderheft) 66: 19–23.

Schmidt S, Hamid H, Ubaidillah R, Ward S, Polaszek A (2019) A review of the Indonesian species of the family Signiphoridae (Hymenoptera: Chalcidoidea), with description of three new species. Zookeys 897: 29–47. https://doi.org/10.3897/zookeys.897.38148

Woolley JB (1988) Phylogeny and classification of the Signiphoridae (Hymenoptera: Chalcidoidea). Systematic Entomology 13: 465–501. https://doi.org/10.1111/j.1365-3113.1988.tb00256.x

Woolley JB (1997) Chapter 18, Signiphoridae. In: Gibson GAP, Huber JT, Woolley JB (Eds) Annotated Keys to the Genera of Nearctic Chalcidoidea (Hymenoptera). NRC Research Press, Ottawa, 693–699.

Woolley JB, Dal Molin A (2017) Taxonomic revision of the *flavopalliata* species group of *Signiphora* (Hymenoptera: Signiphoridae). Zootaxa 4315: 1–150. https://doi.org/10.11646/zootaxa.4315.1.1