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First fossil blood sucking Psychodidae in South America: a sycoracine moth fly (Insecta: Diptera) in the middle Miocene Amazonian amber

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Abstract

Sycorax peruensis sp.n. is the first blood sucking fossil Psychodidae in South America. The new species mainly differs from all recent Neotropical Sycoracinae in its number of antennal segments. It is described from the middle Miocene Western Amazonian amber, which included an intertropical entomofauna previous to the land connection with Central and North America that occurred in the latest Miocene-Pliocene. Insects from this material are diverse with normal bias for amber inclusions of Diptera and Hymenoptera and small-sized specimens.

Keywords

Sycorax, *S. peruensis* sp.n., amber, Peru.

Introduction

Neogene fossil insects are nearly unknown from South America and there are even no previously reported Miocene deposits (Petrulevičius & Martins-Neto 2000). The recent

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discovery of the first inclusions in amber from South America (Antoine *et al*. 2006) is noteworthy. Arthropods included in fossilized resins in the Northern Hemisphere are reported from many sites from the Cretaceous to the Holocene (Azar 2007; Martínez-Delclòs *et al*. 2003). Pre-quaternary inclusions in amber were unknown in South America (Antoine *et al*. 2006); only the entomofauna from Colombian copal from the Holocene, <1000 years old, of Santander has been briefly described (Azar *et al*. 2009; DuBois & Lapolla 1999). In spite of this, the Colombian copal has potentially an extraordinary high insect diversity to be studied and also the Miocene amber of Western Amazonia is relevant to unveil Early Neogene paleodiversity.

Psychodidae is a cosmopolitan family of nematoceran Diptera comprising six subfamilies (Quate & Brown 2004). Some of its species are blood suckers, such as Phlebotominae (sand flies) and Sycoracinae. Other species feed on terrestrial lower vertebrates as anurans (Bravo & Salazar-Valenzuela 2009). To date the earliest fossil record of Sycoracinae is from the Cretaceous of France (Azar *et al*. 2007).

Geological occurrence

The studied amber is from the Pebas Formation near Iquitos in northeastern Peru at 4° 0’ S 73° 9’ W. The amber-bearing level corresponds to a paleolake in the upper parasequence of the formation (Wesselingh *et al*. 2002). This amber was previously mentioned but not investigated further by Gingras *et al*. (2002). The Miocene Pebas formation was deposited in a fluvio-lacustrine wetland that formed the precursor of the Amazon River system and originated in the Andes (Hoorn 1993, 1994a,b). The Pebas fresh water wetland system was semi-isolated and received sediment input from the Andes and consisted of a system of interconnected, shallow lakes and swamps (Hoorn 2006; Hoorn & Vonhof 2006). This wetland covered over 1 million km^2 (Wesselingh *et al*. 2002), and formed a cradle of speciation for invertebrate taxa (Muñoz-Torres *et al*. 2006; Wesselingh and Macsotay 2006).

The bearing strata of the amber is considered middle Miocene in age (Gingras *et al*. 2002; Hoorn 1993), which predates the connection of South America and Central America. Its situation in the Western Amazonia gives us the record of an intertropical entomofauna previous to the land connection between Central and North America that occurred in the latest Miocene-Pliocene (Coates *et al*. 2004).

The first screening of 28 amber pieces demonstrates a high species diversity with many insects, Acarina, pollen and spores or dispersed organs of cyanobacteria, fungi, and freshwater algae, as well as a few unicellular organisms (Antoine *et al*., 2006). Insects are species-rich with 23 recognized families with a common bias for amber inclusions to the orders Diptera and Hymenoptera and small-sized specimens.

Material and methods

For the description of the vein nomenclature of the wing we follow McAlpine (1981).

Systematic Palaeontology

Fossil Sycoracinae

The Sycoracinae are a relatively small subfamily. They are currently represented by three genera, i.e., *Sycorax* Haliday in Curtis, 1839, *Aposycorax* Duckhouse, 1972, and *Parasycorax* Duckhouse, 1972, even if some authors consider that all members of this subfamily must be placed in a single genus *Sycorax* (Jezek 1999; Bejarano *et al*. 2008). To date, only between 34 and 36 species have been described worldwide (Jezek 1999; Bravo 2003, 2007; Bejarano *et al*. 2008).

The females of recent species of *Sycorax* are hematophagous. *Sycorax silacea* and *S. wampukrum* feed on frogs, which could also be the case for *S. peruensis* (Bravo & Salazar-Valenzuela 2009); the larvae of some species are rheophile in freshwater (Duckhouse 1965). The genus occurs under very diverse climates from cold temperate to warm intertropical.

The oldest record of Sycoracinae comes from the Lower Cretaceous of France (Azar *et al*. 2007) and two unidentified species of *Sycorax* from the Upper Cretaceous amber of Canada (Quate & Vockeroth 1981; Evenhuis 1994). From the Cenozoic, there are two Paleogene species from the Baltic amber (Meunier 1905) and they are also cited from the Pleistocene of Japan (Saigusa 1974).

There are only 11 described modern species of Neotropical Sycoracinae, with no record from Peru, while there are some from Amazonian Brazil and from Colombia. This situation shows that this group is clearly still poorly investigated in this area. Very curiously, the Sycoracinae remain unknown in North America, while the subfamily is known from the Modern Neotropical, Afrotropical, Palaearctic, Oriental and Australasian regions.

Concerning the fossil record of Psychodidae in the Americas, up to now only representatives have been described from Central America in the Miocene Dominican Republic amber (Wagner 2001, 2002; Andrade Filho 2003; Andrade Filho *et al*. 2004, 2006a,b, 2007a,b; Poinar 2008), from the Simojovel deposit of Mexican Miocene amber (Quate 1961, 1963), one unidentified specimen of *Sycorax* from the Upper Cretaceous of Canada (Quate & Vockeroth 1981: 298), and material from the Upper Triassic of Virginia (USA) (Blagoderov *et al*. 2007). We describe herein a new species of fossil psychodoid fly referable to the genus *Sycorax* from the Middle Miocene amber of Amazonian Peru. The new species represents the first fossil record of the family Psychodidae in South America.

***Sycorax* Haliday *in* Curtis 1839**

Type species

Sycorax silacea Haliday *in* Curtis 1839, pp. 745.

***Sycorax peruensis* sp.n.** (Figs 1-3)

Diagnosis

Sycorax-like wing venation; antenna with 12 flagellomeres; first flagellomere 1.7 times as long as second.

Description

Mandibles elongate, slightly shorter than palpi, probably hematophagous; eyes rounded, 0.1 mm of diameter; antenna 1.0 mm long, with 12 flagellomeres; first flagellomere 1.7 times as long as second, an apical drop-like pseudo-flagellomere; antennal scape nearly cylindrical, about 0.01 mm long and 0.01 mm wide; antennal pedicel

Fig. 1. *Sycorax peruensis* sp.n., holotype IQ26IA1-10, photograph of general habitus (scale bar represents 0.2 mm). This figure is published in colour in the online version of this journal, which can be accessed *via* http://www.brill.nl/ise

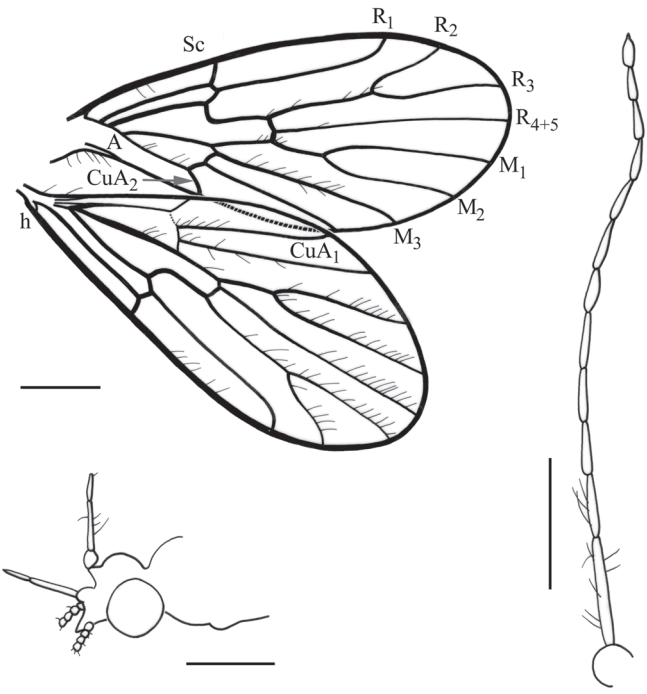

Fig. 2. *Sycorax peruensis* sp.n., holotype IQ26IA1-10, drawings. (A) Wings; (B) head; (C). 13 distal antennomeres (scale bars=0.2 mm).

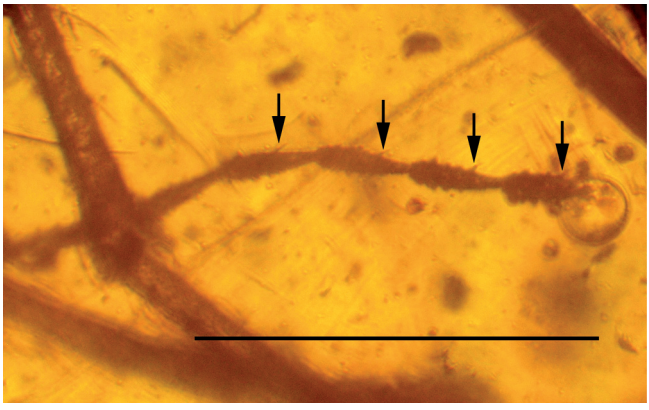

Fig. 3. *Sycorax peruensis* sp.n., holotype IQ26IA1-10, photograph of last flagellomeres, arrows showing ascoids (scale bar=0.2 mm). This figure is published in colour in the online version of this journal, which can be accessed *via* http://www.brill.nl/ise

nearly globular, about 0.01 mm long and 0.01 mm wide; all flagellomeres are setose, with simple long digitate ascoid (Fig 3); palpus 0.07 mm long, with four hairy palpomeres of nearly equal length; wing 1.1 mm long, 0.5 mm wide, hyaline; humeral vein (h) at 0.07 mm from wing base; subcostal vein (Sc) distally fused with R_1 in a

strong angle, 0.4 mm from wing base, and with a cross-vein reaching costal margin; R_1 reaching costal margin 0.9 mm from wing base; Rs separated from R1 0.4 mm from wing base, at same level of fork of M into M_{1+2} and M_3; Rs three-branched, with all its branches extending to wing margin; R_2 and R_3 separated 0.4 mm distally; R_4 and R_5 fused forming R_{4+5}, 0.6 mm long, straight; cross-vein r-m 0.5 mm distal of wing base; fork of M into M_{1+2} and M_3 0.3 mm distal of arculus; fork of M_{1+2} into M_1 and M_2 0.3 mm distal of base of M_{1+2}; M_1 straight; M_2 slightly shorter than M_1; M_3 reaching wing margin at 0.9 mm from wing base; CuA_1 separating from CuA 0.4 mm distal of wing base; CuA_2 short, 0.05 mm long; All main veins and wing margin bearing long macrotrichiae; thorax 0.4 mm long, 0.2 mm high; pronotum gibbous; legs long, longer than whole body; abdomen 0.4 mm long excluding genital appendages, 0.2 mm wide; dorsal surfaces of all abdominal segments bearing few setae; female genital appendages present but hardly visible and useless.

Etymology

Named after Peru.

Type material

Holotype IQ26IA1-10 (female), stored in the Paleontology Department of the Museo de Historia Natural de la Universidad Nacional Mayor San Marcos, Lima, Peru (MUSM).

Age and outcrop

Pebas Formation, Middle Miocene, Tamshiyacu locality, eastern bank of Amazon River, circa 30 km upstream of Iquitos, northeastern Peru (Antoine *et al*., 2006).

Discussion

Sycorax peruensis sp.n. has a wing venation typical of the Sycoracinae Jung, 1954, the eyes without bridge, flagellomeres of antenna subcylindrical, Rs three-branched, with only one longitudinal vein between radial and median forks, and short CuA_2. In *Parasycorax* (*P. stachelli* Barretto, 1956 and *P. filipinae* Quate, 1965) and in *Sycorax utriensis* Bejarano *et al*., 2008, the radial and median forks are almost at the same level and the fourth palpomere is elongate, unlike in *S. peruensis* (Barretto 1956; Duckhouse 1972; Bejarano *et al*. 2008).

Bravo (2003, 2007) listed and separated the Neotropical *Sycorax* species on the basis of the male genitalia, unavailable in our fossil (see also Young 1979; Bejarano 2006). Nevertheless, *S. peruensis* differs from *Aposycorax chilensis* (Tonnoir 1929) in the presence of 14 antennomeres, instead of 15, and third antennomere is comparatively shorter than in *Aposycorax* (ratio third antennomere/fourth antennomere less than 2 in *S. peruensis*, instead of 2.2 in *A. chilensis*). *S. peruensis* also differs from *S. cariacicaensis*

Santos & Bravo, 2009, *S. bahiensis* Bravo, 2003 and *S. assimilis* Barretto, 1956 in the same characters (Barretto 1956; Bravo 2003; Santos & Bravo 2009). The number of antennomeres is unknown in *Sycorax longispinosa* Bravo, 2007 and the ratio third antennomere/fourth antennomere equals 1.5, while it is 1.7 in *S. peruensis*, but the cross-vein between Sc and C is not reaching C in *S. longispinosa*, unlike in *S. peruensis*. The number of flagellomeres is also unknown in *Sycorax espiritosantensis* Santos & Bravo, 2009 but the ratio third antennomere/fourth antennomere=2.0 in this species (Santos & Bravo 2009). Young (1979) indicated for the four Colombian species *S. andicola* Young, 1979, *S. colombiensis* Young, 1979, *S. fairchildi* Young, 1979, and *S. trispinosa* Young, 1979 the presence of 16 antennomeres (with the last one reduced in size and terminating in a cone). This last segment is the terminal 'pseudo-segments' of the other authors; thus, they have 15 'true' antennomeres. *Sycorax wampukrum* Bravo and Salazar-Valenzuela, 2009 from the Andean Ecuador has also 15 antennomeres (Bravo & Salazar-Valenzuela 2009). Thus *S. peruensis* differs from all these species in having only 14 true antennomeres, instead of 15.

The Lower Cretaceous *S. neli* Azar *et al.*, 2007 and the two Eocene Baltic amber species *S. prompta* Meunier, 1905 and *S. tumultuosa* Meunier, 1905 have also 15-segmented antennomeres (Meunier 1905).

Sycorax peruensis appears as a very particular species in this genus. Field investigations for a better knowledge of the recent Peruvian Psychodidae are needed to determine if some recent *Sycorax* species from this area could be related to *S. peruensis*. It is impossible to establish if *S. peruensis* represents a very particular, extinct subclade within the genus *Sycorax*, characterized by having only 14 antennomeres because of the lack of male and information concerning some recent species.

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