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The first psychodid (Diptera: Psychodidae: Phlebotominae) species from the Lower Eocene amber of Vastan, Gujarat, India

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Abstract

The new genus and species, *Phlebotoiella eoindianensis*, from the Eocene Vastan amber deposits in western India is described and illustrated. This marks the first Psychodidae to be described from Vastan amber. The relationship of this new genus is discussed as well as its biogeographic implications.

Key words: Lower Eocene, systematics, India, Vastan amber, Phlebotominae, new genus

Introduction

Psychodidae is a cosmopolitan and widely distributed family often associated with moist habitats, especially the immature stages. Adults of extant forms can also be found in many habitats. Psychodidae are well represented in the dipteran fossil record. According to Evenhuis (1994) 18 genera and about 52 fossil species were described before 1994. The oldest sand flies have been found in Lebanese amber from the Lower Cretaceous (Azar *et al.* 1999, 2003). The fossil evidence from the Lower Cretaceous and the numerous species in amber, suggests that the family was already diverse during the Tertiary (Evenhuis 1994). The family is now widespread on all continents except Antarctica, suggesting that it has a long history which began in the Mesozoic (Ansorge 1994). Lambrecht (1980) estimated that Psychodidae originated as long ago as the Permian/Triassic boundary.

The Vastan amber has been dated at about 52 Mya. The age implicates that the amber fauna must have existed before the Indian-Asian collision, which occurred at about 49–50 Ma (Bajpai and Gingerich 1998), founded on biostratigraphic and biogeographic data from vertebrates. The Palaeoenvironment has been interpreted by Sahni *et al*. (2006) as a freshwater to brackish water environment. The amber beds are interpreted as a marginal marine to very shallow marine habitat, probably with mangrove vegetation (Bandana & Phadtare 1997, Sahni *et al*. 2006).

The present paper represents the first description of an especially well preserved psychodid species (Phlebotominae) from Indian amber, which opens a window of opportunity for a comparison of the Indian fossil fauna with the extant fauna.

Materials and methods

The amber used for the present study derives from the Vastan lignite mine deposited about 30 km northeast of

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Surat between the rivers Narmada and Tapti in western India (Alimohammadian *et al*. 2005). The type specimen will be deposited in Department of Geology at the Lucknow University, India. (MLGDLU/NS).

The piece of amber with the inclusion described here is very small. The specimen itself appears cleared and the details of some features are not evident, but all the salient characters are clear enough to allow description and comparison with other psychodids. The amber is very brittle, thus preparation in Araldite was required (see Solórzano Kraemer and Evenhuis 2008 for description of method of preservation). Illustrations were made with a Leica MZ12 stereomicroscope and camera lucida. The photographs were taken with digital cameras (KY-F70B JVC70 and Nikon Coolpix 8800 VR) through a Leica MZ16 stereomicroscope. The photographs were edited with Adobe Photoshop©.

***Phlebotoiella eoindianensis* Solórzano Kraemer & Wagner, gen. nov., sp. nov.**
(Fig. 1)

Diagnosis: *Phlebotoiella* (Fig. 1A) can be distinguished from other genera of the Phlebotominae by the following combination of characters: abdominal segments 5 and 6 with dense, erect long setae, oval coxites with several thin setae and with two pairs of three internal strong setae, short parameres with apical patch of short, strong setae, number of ommatidia less than 100, palpi 4-segmented, palpomere 4 reduced.

Type species: ***Phlebotoiella eoindianensis*, by monotypy.**

Description: **Male**. *Head*. Displayed in lateral view, eyes circular, no eye bridge, vertex with a patch of elongate setae. Antenna demolished, with seven flagellomeres left (Fig 1C). Scape vaguely visible, pedicel almost spherical. First flagellomere elongate cylindrical, almost twice the length of the second flagellomere, further distal segments elongate pyriform, at least flagellomeres 5, 6, and 7 markedly recessed into the basal bulbs. In the distal third of flagellomere 1 a single short ascoid is apparent, whereas ascoids in pairs occur towards the bases of some median flagellomeres, others are probably lost. Length of the preserved flagellum: 0.15 mm. Mouthparts elongate, although the specimen is a male, it is seemingly of the biting type; proboscis length about 0.1 mm; labium with distinct labellum, and two stylets. Palpi 5-segmented, segments 1 and 2 longer than the others, segment 4 shorter than segment 3 (Fig. 1D).

Thorax: Metanotum slightly swollen, forming a narrow sclerite. Legs elongate, length of front femur 0.36 mm, coxa with a row of at least five hairs.

Wing: Only the basal 30–40% of the wing are preserved and wrinkled so that vein M_3 is placed above M, and CuA_1 is not visible. Anterior branch of Sc running into C and posterior branch or extension of Sc leads into R_1, stem vein with narrow discontinuity, basal radial cell elongate and broad, Rs uncinate basally. Fork R_{2-4}-R_5 close to wing base as well as fork M_1-M_2. M_3 vaguely visible at base, CuA_1 indistinct as well, probably reduced (Fig. 1B).

Abdomen: Recumbent hairs on tergites II – VI. Abdominal segments 5 and 6 with dense, erect long setae.

Genitalia: male genitalia of the phlebotomid-like inverted type. gonocoxites elongate, oval with several thin setae; each gonocoxite earing three internal strong setae. Gonostyli tubular, rather narrow and a little shorter than the gonocoxites (in dorsal view, appearing longer than in dorsolateral view Figs E,F); each gonostylus with three sharp, elongate spines of about equal length; two apical and one subapical which is in the distal third of the gonostylus Parameres paired, shorter than gonopods and slightly shorter than the surstyli, bearing an apical patch of short, strong setae. Between the parameres lies a distally bipartite structure (aedeagus) with a pair of bent 'hooks'. Surstyli and cerci setose, cercus thin and oval (Fig. 1E, F).

Type: Holotype male from Indian amber: MLGDLU/NS/1001. Housed in the Department of Geology at the Lucknow University, India. The holotype is embedded in a piece of amber 0.3 cm in length, which was embedded in Araldit to preserve the inclusion. In the same piece of amber is another Diptera, however, its preservation is not sufficient to permit identification.

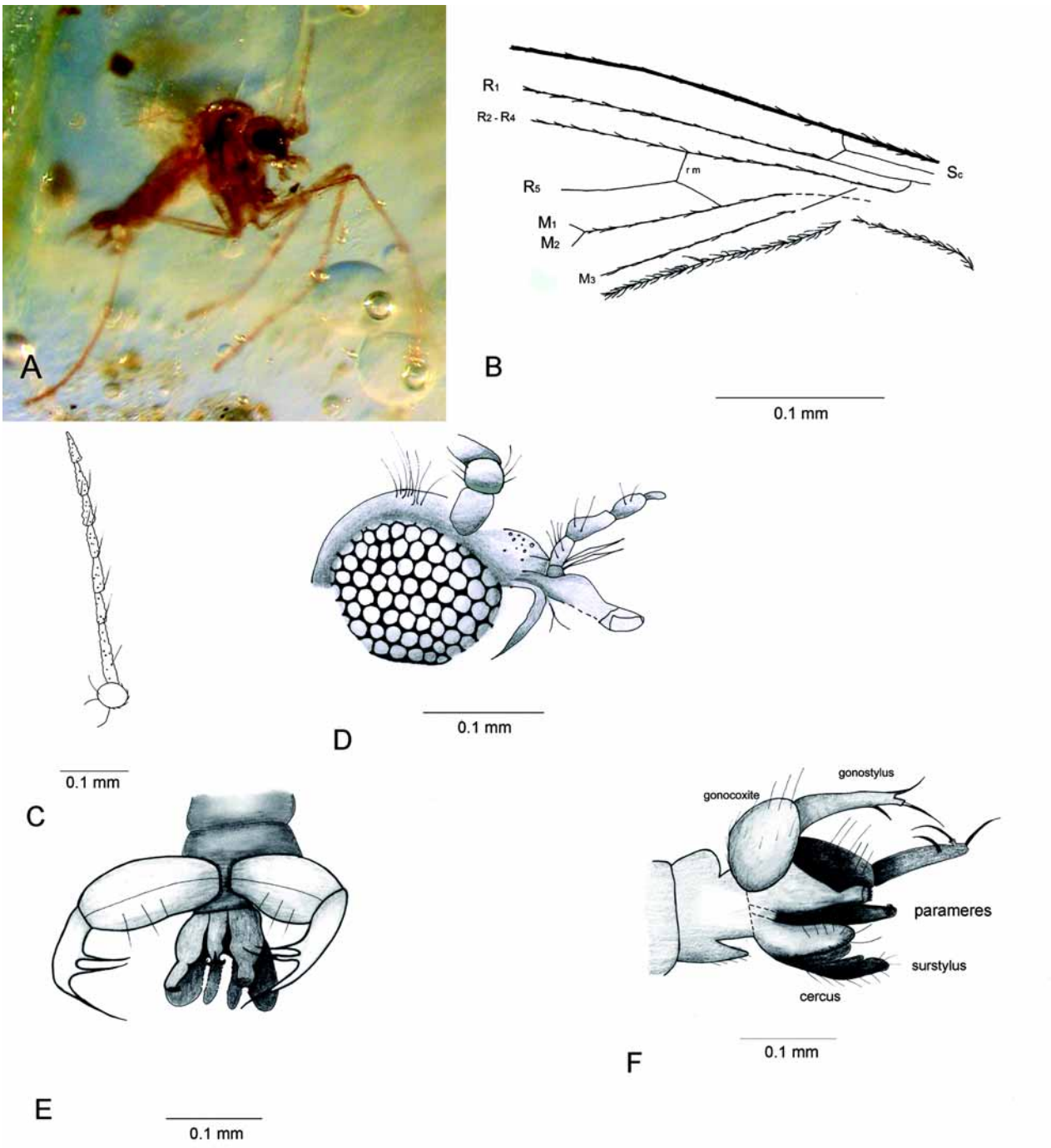

FIGURE 1. A. habitus, lateral view. **B** basal part of the wing. **C**. Left antenna. **D**. Head showing the eye and the mouthparts, **E**. male genitalia dorsal view. **F**. male genitalia dorsolateral view.

Etymology: The generic name derives from the combination of *Phlebotomus* and *Horaiella*, with respect to their similarities with the Vastan specimen. The specific epithet refers to the age and origin of the Indian amber harbouring the inclusion.

Discussion: *Phlebotoiella* belongs to the subfamily Phlebotominae because of the absence of an eye bridge, flagellomeres of antenna pyriform, palpi 5-segmented, Rs four branched, two longitudinal veins present between radial and medial forks, mouthparts longer than height of head (Quate and Vockeroth 1981), and male with a paired elongated penis (Wagner 1997).

The Vastan specimen shares several similarities with the genus *Phlebotomus* Rondani and Berte, 1840. For this reason it has been compared with the 11 subgenera of *Phlebotomus* proposed by Lewis (1982), however, the Vastan genus does not belong to any of them.

A detailed analysis of *Phlebotoiella* shows that it also shares some characters with the genus *Horaiella* Tonnoir, 1933. According to Wagner (pers. com. 2007) members of the subfamily Horaiellinae are actually aquatic Psychodidae related to Phlebotominae. Extant species of the only genus of the subfamily Horaiellinae live in highlands in the Teesta Valley of Northern India, in Fukien, China, and in the Khao Yai National Park from Central Thailand (Tonnoir 1933, Curler *et al.* 2006). Species of the genus *Phlebotomus* are distributed in almost all tropical and subtropical regions and some species are important vectors of Leishmania producing leishmaniasis.

The systematic relationship of the amber specimen can be considered close to *Phlebotomus* with some affinities to the Horaiellinae subfamily. A notable similar character of the genus *Horaiella* with *Phlebotoiella* is the number of ommatidia. *Phlebotoiella* has much fewer ommatidia per eye than *Phlebotomus* and *Horaiella* has less ommatidia than *Phlebotoiella*. Thus, by this character, the new genus seems to be in an intermediate phase between both recent genera. According to the description of Tonnoir (1933) *Horaiella* shares other characters with *Phlebotoiella*, such as: almost bare body and wing, and palpus 4-segmented. Although, in *Phlebotoiella* the last palpal segment is shorter than the others and the palpus of one species of *Horaiella*, *H. iota* Curler, is already 3 segmented. The short parameres without a row of long spines of *Phlebotoiella* are more similar to *Horaiella*, however the shape of the gonostylus is phlebotomid-like. Finally, although the wing is incomplete and the basal portion is very difficult to observe, the venation is clearly close to *Phlebotomus.*

The fossil genera described from Burmese and Lebanese ambers (see Table 1) have also been compared with *Phlebotoiella.*

TABLE 1. Data from: Andrade Filho et al (2003), Azar *et al.* (1999, 2003), Declòs *et al.* (2007), Duckhouse (2000), Grimaldi *et al.* (2000), Perrichot *et al.* (2007), Peçanha Brazil and Andrade Filho (2002) Poinar (2004), and Solórzano Kraemer (2007).

Mexican amber	Middle Miocene	*Lutzomyia*
Dominican amber	Middle Miocene	*Pintomyia, Micropygomyia*
Baltic amber	Late Eocene	*Phlebotomiella*
Vastan amber	Early Eocene	*Phlebotoiella*
Burma amber	Eocene, Miocene, or Cretaceous?	*Eophlebotomus,Palaeomyia (larva)*
Lebanon amber	Cretaceous	*Eophlebotomus, Phlebotomites Mesophlebotomites, Libanophlebotomus*
France amber	Cretaceous	*Eophlebotomus*
Spain amber	Cretaceous	*Eophlebotomus*

Eophlebotomus was first described by Cockerell (1920) and redescribed by Duckhouse (2000). Nowadays, four species are known, one from Burmese amber, two from Lebanese amber, and one from French amber. According to Azar *et al*. (2003) the genus *Eophlebotomus* can be recognized by the 15-segmented antenna, with the 1st flagellomere distinctly longer than the subsequent segments. Further, by well developed mouth parts with five palpomeres, the 2nd and 3rd, longer and the 4th, and 5th reduced. The male genitalia are phlebotomine-like, the gonostylus has two sharp and long apical spines and some long and sharp medial spines. The parameres bears a row of long spines extending from the middle to the distal part, the surstyli are reduced.

Eophlebotomus differs from the Vastan amber specimen by the presence of spines on the long parameres, five palpomeres, and pedicel in the branch of M_3-CuA_1. However, most of the wing characters cannot be discussed because of the poor preservation of the exemplar.

The genera *Mesophlebotomites* and *Libanophlebotomus* were described by Azar *et al.* (1999). *Mesophlebotomites* differs from the Vanstan amber specimen by the presence of five palpomeres and by the shape of the discal cell. *Mesophlebotomites* has a very elongated and narrow discal cell, whereas in *Phlebotoiella* this cell is rather broad. They differ further by the elongate gonopods which are shorter than the submedian lamellae in *Mesophlebotomites*, which has only two apical spines.

Libanophlebotomus differs from *Phlebotoiella* by the following characters: it bears five palpomeres, Sc without or with very weak costal branch, crossvein r-m distal to first bifurcation of Rs, male gonostylus with four long spines, and lateral lobes of the 9th abdominal tergite shorter than the penis.

Compared with *Phlebotomites* described by Hennig (1972) *Phlebotoiella* differs by the following characters: vein Rs springs from R very basally; the basal cell is short and broad compared with elongate and narrow shape in the figures 27–30 provided by Hennig (1972). Due to the position of the medial and cubital veins of the wing the shape and length of the third basal cell cannot be given. The size of the ascoids differs as well. These are large in *Phlebotomites* (Hennig 1972 figs 6 and 7) and smaller in *Phlebotoiella*. The size of the male genitalia is almost the length of the pre-genital part of the abdomen in *Phlebotomites*, but much smaller in *Phlebotoiella*. In general *Phlebotomites* is much more *Phlebotomus*-like than *Phlebotoiella*.

Phlebotoiella eoindianensis appears to be endemic to the Indian subcontinent and may not have ranged further from India. Thus, *Phlebotoiella* would support a biotic ferry model for India in the last 65 my. However, in addition to further studies on the characters shared among other genera, more studies on the extant and fossil biodiversity of insects from India, Africa and Asia are needed before any more conclusive comments can be made about hypothetical origins and ranges of this genus or the fossil Vastan arthropod fauna.

The mouthparts of the male holotype of *Phlebotoiella eoindianensis* are elongate, and probably the female mouthparts were of the biting type. Males of recent *Phlebotomus* also possess elongated mouthparts but only females bite.

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