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A new species of the booklouse genus *Embidopsocus* in Baltic amber (Psocoptera: Liposcelididae)

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Abstract. The first representative of the booklouse genus *Embidopsocus* Hagen (Nanopsocetae: Liposcelididae) is documented from the *blaue Erde* of northern Europe. ***Embidopsocus pankowskiorum*** Engel, new species, is similar to the related *E. saxonicus* Günther from the Bitterfeld deposits (so-called 'Saxonian amber') and *E. eocenicus* Nel *et al*. from Oise amber, but differs in details of antennal structure, setation, wing venation, and size. The species is described and comments made regarding its character affinities to other fossil liposcelidids.

INTRODUCTION

Booklice of the family Liposcelididae hold an auspicious position among Psocodea as the closest extant relatives of the true lice, Phthiraptera (Lyal, 1985; Yoshizawa & Johnson, 2003; Grimaldi & Engel, 2005, 2006; Yoshizawa & Lienhard, 2010). Liposcelidids are tiny and free-living detritivores, unlike their lice relatives, and have diverse habits ranging from troglobitic to epizoic species. Individuals are generally dorsoventrally compressed with particularly enlarged metafemora, and while females may be either fully winged or apterous, males universally lack wings. There are about 200 species distributed throughout the world, and these are arranged into two subfamilies.

The subfamily Liposcelidinae comprises the genera *Liposcelis* Motschulsky, the most familiar group sometimes associated with humans and with over 125 species scattered throughout the world (Yoshizawa & Lienhard, 2010), and *Troglotroctes* Lien-

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Table 1. Described fossil Liposcelididae (Nanopsocetae).

CRETACEOUS	
Cretoscelis burmiticus Grimaldi & Engel, 2006	Myanmar: Cenomanian
PALEOGENE	
EOCENE	
Embidopsocus eocenicus Nel *et al*., 2004	Paris Basin (Oise): Ypresian
Embidopsocus pankowskiorum, n. sp.	Baltic: Lutetian
Embidopsocus saxonicus Günther, 1989	Baltic (Bitterfeld): Lutetian
Liposcelis atavus Enderlein, 1911	Baltic: Lutetian
Liposcelis sp. (Nel *et al*., 2005)	Paris Basin (Oise): Ypresian
NEOGENE	
MIOCENE	
Belaphopsocus dominicus Grimaldi & Engel, 2006	Dominican Republic: Burdigalian
Belaphotroctes similis Mockford, 1969	Chiapas (Mexico): Burdigalian
Liposcelis sp. (Mockford, 1969)	Chiapas (Mexico): Burdigalian
PLEISTOCENE	
Liposcelis resinatus (Hagen, 1865)	East African copal: Pleistocene

hard, represented by a singular troglobitic species from Ascension Island (Lienhard, 1996). Liposcelidines are assuredly monophyletic and are united by a number of traits, most notably their wholly apterous females, loss of the metatibial spur, and the presence of a distinct, metafemoral tubercle (Grimaldi & Engel, 2006; Yoshizawa & Lienhard, 2010).

The remainder of the family is grouped into the subfamily Embidopsocinae. Embidopsocinae are rather problematic and evidence for their monophyly has been lacking. A clade comprising the genera *Belaphotroctes* Roesler (19 species), *Belapha* Enderlein (two species), *Belaphopsocus* Badonnel (four species), and *Troctulus* Badonnel (a single species from Angola) has repeatedly been recovered in cladistic treatments (Grimaldi & Engel, 2006; Yoshizawa & Lienhard, 2010), but the remaining genera have remained unresolved and usually fall within a basal polytomy. These genera comprise the Brazilian *Embidopsocopsis* Badonnel and *Chaetotroctes* Badonnel, both monotypic, and the extinct genus *Cretoscelis* Grimaldi & Engel, the latter representing the sole Mesozoic and earliest occurrence for the family.

The family has a sparse but temporally extensive fossil record, with seven described fossil species, and two further occurrences known only to the level of genus, as well as a putatively subfossil species in Pleistocene copal (Table 1). All of the fossil records are based on inclusions in amber or copal, with a single Cretaceous species present in the earliest Cenomanian amber of northern Myanmar (Grimaldi & Engel, 2006). All of the Cenozoic fossils represent extant genera, and most of those are of embidopsocine taxa. Although Lewis (1989) attributed the fragmentary Pliocene fossil *Miotroctes rousei* Pierce (1960) to Liposcelididae, there is no support for such an attribution and the species is best considered as *incertae sedis* among Psocoptera (Nel *et al*., 2004).

Described herein is the first species of *Embidopsocus* from Baltic amber, based on an exceptionally well-preserved female (Figs. 1, 2). The genus has been documented previously from the coeval amber from Bitterfeld (Günther, 1989), and the present species does have similarities to *Embidopsocus saxonicus* Günther. In addition, there are similarities with the slightly older *E. eocenicus* Nel *et al*. (2004) in the Oise amber from the Paris Basin. Collectively, these three species represent the only fossil records for the genus, and the earliest Cenozoic occurrences for the Embidopsocinae.

Figure 1. Photograph of holotype (SEMC F000384) in dorsal view, *Embidopsocus pankowskiorum*, new species, in middle Eocene Baltic amber.

MATERIAL AND METHODS

A single female was located in middle Eocene Baltic amber by Michael Pankowski (Fig. 1). The individual is preserved in a small, teardrop-shaped, light yellow piece of amber. The piece was polished flat on both sides parallel to the dorsal and ventral surfaces of the inclusion, resulting in in an amber piece with final dimensions of about 12 mm in maximum length, 8 mm in maximum width, and 2 mm in depth. The inclusion is finely preserved, and although there are some internal fractures and small bubbles (Figs. 1, 2), there is no real defect preventing optimal viewing of the fossil aside from patches of microscopic froth along some body surfaces. Due to interactions between the body and the surrounding resin, the individual is partially cleared as preserved (Figs. 1, 2).

The format and terminology for the description loosely follow those used in previous works on fossil Liposcelididae (*e.g.*, Grimaldi & Engel, 2006). The specimen was examined using reflected and transmitted light with both an Olympus SZX-12 stereomicroscope and a BX-41 compound microscope. Line drawings were prepared with the aid of camera lucida attached to the stereomicroscope, and photographs were taken with a Canon 7D digital camera and Infinity K-2 long-distance microscope lens. The specimen is deposited in the amber fossil collection of the Division of Entomology, University of Kansas Natural History Museum, Lawrence.

Figure 2. Photograph of holotype (SEMC F000384) in ventral view, *Embidopsocus pankowskiorum*, new species, in middle Eocene Baltic amber.

SYSTEMATIC PALEONTOLOGY

Family Liposcelididae Enderlein
Subfamily Embidopsocinae Broadhead
Genus *Embidopsocus* Hagen

Embidopsocus pankowskiorum Engel, new species
ZooBank: urn:lsid:zoobank.org:act:6A5251B0-9AB6-4717-ABA1-6B94FC7E7E78
(Figs. 1–5)

DIFFERENTIAL DIAGNOSIS: Head with sparse setation, entirely lacking on vertex and posterior to compound eyes; all flagellomeres with annulation, albeit finer on first flagellomere (as in *E. saxonicus*; in *E. eocenicus* the first two flagellomeres lack annuli); flagellomeres more elongate, longer than scape and pedicel combined (as in *E. saxonicus*; in *E. eocenicus* the flagellomeres are shorter, with the basal flagellomeres shorter than the scape and pedicel combined); profemur without prominent, medioventral seta (such a seta present in both *E. saxonicus* and *E. eocenicus*); protibia with row of minute denticles on inner apical half (as in both *E. eocenicus* and *E. saxonicus*); mesosternum without sclerotized bands; forewing with R and Rs distinct (either Rs absent or without distinct kink demarcating separation between R and Rs in both *E. saxonicus* and *E. eocenicus*); forewing Rs weakly arched anteriorly (R straight toward apex in *E. saxonicus* and apically curved in *E. eocenicus*); forewing M elongate, straight, and largely parallel with R and Rs; forewing Sc short; traces of Cu and A present; hind

wing with R extending nearly through wing length, with slight curve in apical half; hind wing with traces of Sc and M present; abdominal terga largely devoid of setation except apical two segments; abdominal terga without sclerotized bands.

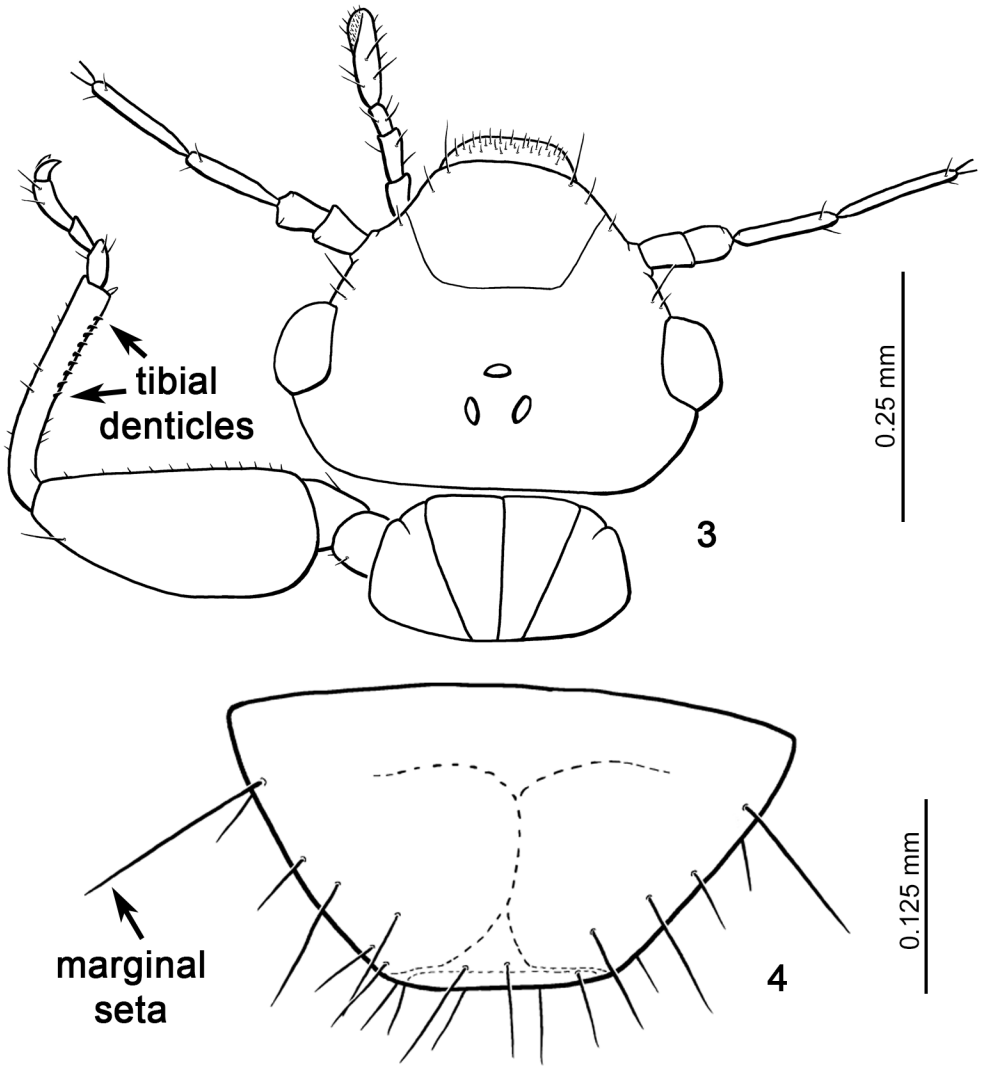
Description: ♀: Total body length 1.85 mm; generally dorsoventrally compressed; integument throughout faintly and finely imbricate; color as preserved, light yellow brown except brown on head, mesoscutellum, and portions of legs (Fig. 1).

Head wider than long, length 0.33 mm, width across compound eyes 0.44, width immediately posterior to compound eyes 0.40 mm, interocular distance 0.32 mm; compound eye well-developed, of moderate size, diameter 0.08 mm, with over 30 ommatidia; ocelli present, arranged in close triangle on top of vertex, separated by about one ocellar diameter, not situated on a slight swelling. Epicranial scar lacking. Head with sparse setae, most prominent setae anterior to compound eyes and apicolaterally on clypeus; labrum with numerous minute, fine setae. Antenna with scape and pedicel shorter and thicker than flagellomeres; scape length 0.049 mm, width 0.028 mm; pedicel length 0.42 mm, width 0.028 mm; flagellum with at least 10 flagellomeres (both antennae are incomplete as preserved: 10 flagellomeres preserved in left antenna, 7 in right antenna); each flagellomere with fine annulations and 2–3 short apical setae, flagellomeres about 6–9 times longer than wide, individual flagellomeres longer than combined lengths of scape and pedicel (Fig. 3). Maxillary palpus with four palpomeres; palpomere lengths (P_1, P_2, P_3, P_4) 0.035, 0.049, 0.027, 0.076 mm, respectively; apical palpomere (P_4) scarcely broader than preceding palpomeres, with fine preapical sensory area, without stout conical sensilla. Labial palpus short, with two palpomeres (largely obscured as preserved).

Pronotum divided into three distinct lobes (Fig. 3); medial lobe straight anteriorly, with prominent, longitudinal, medial sulcus; lateral lobes narrower; pronotum medial length 0.13 mm, width 0.26 mm. Meso- and metanotum well-divided; mesoscutellum distinctly demarcated from mesoscutum; metascutellum well demarcated, but less so than mesoscutellum. Thoracic sterna broad, flat, without distinct setation; mesosternum without sclerotized bands.

Coxae broadly separated by sterna, mesocoxae at about pterothoracic midlength; femora swollen, particularly pro- and metafemora; tibiae slender, with one apical tibial spur on pro- and metatibiae, mesotibia without apical spurs; all tarsi trimerous; pretarsal claw simple, pulvillus lacking. Profemur length 0.27, maximum width 0.13 mm, without prominent setae medioventrally, with minute, fine setae along length, with more prominent subapical, anterior seta dorsally; protibia length 0.21 mm, with row of 9 minute denticles on inner surface in apical half (Fig. 3), and with sparse, scattered fine setae on all other surfaces. Metafemur length 0.49, maximum width 0.15 mm, lacking tubercle, with exceedingly sparse, minute, fine setae, such setae most noticeable subapically on ventral surface; metatibia length 0.40, maximum width 0.03 mm, with scattered long setae on dorsal surface.

Wings hyaline, diaphanous, membrane finely and irregularly wrinkled, broadly rounded apically, with veins indicated as light brown traces; forewing long, extending beyond abdominal apex, length 1.73 mm, maximum width 0.58 mm; hind wing length 1.23 mm, maximum width 0.31 mm. Forewing (Fig. 5) with trace of Sc scarcely evident along anterior margin in basal sixth of wing length; R extending nearly to wing midlength, without distinct setae at apex of R; Rs arising from R near apex of latter vein, extending to near wing apex and slightly arched anteriorly; M present and straight, extending to near wing apex, terminating slightly before termination of Rs; Cu present as a short, fine trace in basal quarter of wing length; trace of A present



Figures 3–4. Details of *Embidopsocus pankowskiorum*, new species. **3.** Head, pronotum, and foreleg in dorsal view; only basal two flagellomeres are included as well as only the left maxillary palpus. **4.** Abdominal tergum VIII.

posterior to Cu. Hind wing (Fig. 5) with traces of Sc, R, and M [the homology of R and M here is a bit uncertain as these could be R+M and Cu but when comparing the venation to extant species such as *E. angolensis* Badonnel one would conclude that the hind wing venation of *E. pankowskiorum* comprises R and M (*vide* Badonnel, 1955)]; R nearly extending to wing apex, slightly curved anteriorly in apical half; Sc and M exceedingly short, terminating in basal fifth of wing length.

Abdomen length 1.02 mm; terga and sterna well-developed; preclunial terga without bands of sclerotization; terga I–VI without setation, chaetotaxy of tergum VIII as depicted in figure 4, longest marginal seta 0.13 mm.

♂: *Latet*.

HOLOTYPE: ♀, SEMC F000384; amber, middle Eocene (Lutetian), '*blaue Erde*', Baltic

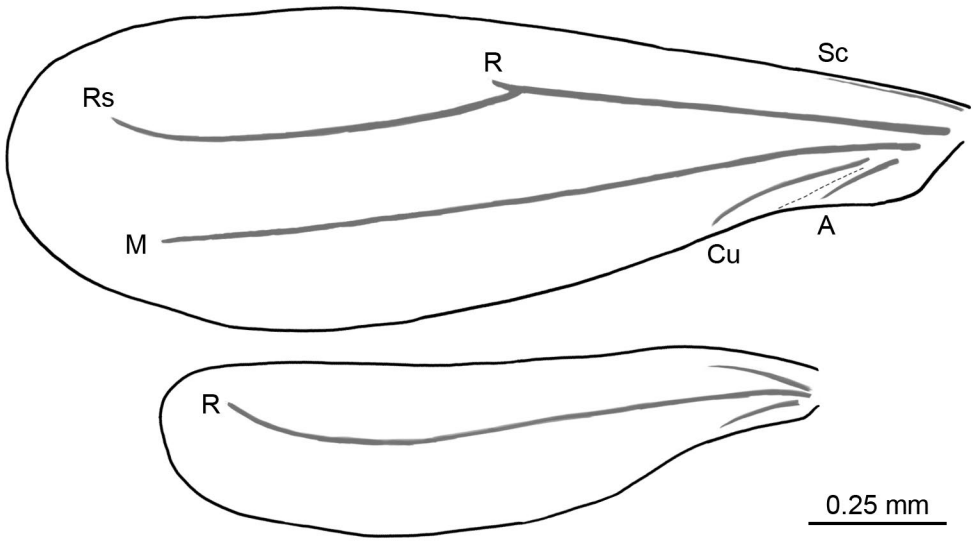


Figure 5. Wing venation of *Embidopsocus pankowskiorum*, new species; forewing above, hind wing below.

region; deposited in the Division of Entomology, Natural History Museum, University of Kansas, Lawrence, Kansas, USA.

Etymology: The specific epithet honors the family of Mark Pankowski (Mark and Karen Pankowski, and their children Mark, Michael, Mary, Maximilian, and Madeline), intrepid explorers in the world of paleontology.

DISCUSSION

The new species is most similar to *E. saxonicus* in the contemporaneous amber from deposits in Bitterfeld, Germany (Günther, 1989). Bitterfeld amber is coeval with the more northern deposits of Baltic amber, but has a distinct source and likely represents a southern portion of the region during the middle Eocene and therefore shares many faunal elements (Wolfe *et al*., 2016), while maintaining rather broad overlap in terms of their generic and even species composition (*e.g*., the same species of bees can be found in both deposits: Engel, 2001). In fact, there is a similar faunal overlap between Baltic, Bitterfeld, and Rovno ambers, the latter of which is also of Eocene age but like the Saxonian amber, represents a geographically distinct region of the Eocene European forests.

As noted in the diagnosis, there are also similarities with *E. eocenicus* in Oise amber. These species differ in numerous wing venation details as the French and Bitterfeld species apparently lack several veins, particularly in the hind wing (Günther, 1989; Nel *et al*., 2004). The purported absence of veins in the hind wing of *E. eocenicus* may be the result of clearing during preservation, rendering the already faint traces indistinguishable on the membrane surface, otherwise this would be a further difference from *E. pankowskiorum*.

Naturally, it is presently not possible to determine whether or not *Embidopsocus* inclusive of these fossil species are monophyletic, and there has not yet been a true test whether the living diversity comprises a natural group in and of itself. Accord-

ingly, it remains unknown to what modern species the fossils are most closely related. Using superficial characteristics, they are all similar to "Group III" (Badonnel, 1955; Mockford, 1987, 1993) and *E. femoralis* (Badonnel) owing to the lack of mesosternal sclerotized bands and the comparatively simple claws. However, these features are likely not indicative of close relationship between *E. femoralis*, *E. saxonicus*, *E. eocenicus*, and *E. pankowskiorum*, and a fuller treatment of cladistic affinities across the genus are needed before the fossils can be properly placed.

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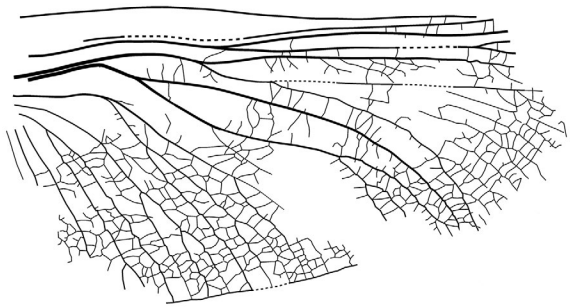

Pharciphyzelus lacefieldi Beckemeyer & Engel, 2011

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