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New mosquitoes from Baltic amber (Diptera: Culicidae)

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ABSTRACT. In addition to the previously known *Culex erikae* from Eocene Baltic amber three new species of fossil mosquitoes are described. They are: *Aedes hoffeinsorum* sp. n., *Aedes damzeni* sp.n. and *Aedes serafini* sp. n. They all belong to the subgenus *Finlaya*. In the extant fauna mosquitoes of that subgenus are most diversified in the Oriental Region. Their larvae live in small water bodies in tree hollows, leaf axils, etc. and usually are not common in their habitats. This may explain why mosquitoes are so rare among inclusions in Baltic amber.

KEY WORDS: Diptera, Culicidae, fossil, amber, Tertiary, Europe.

INTRODUCTION

The Culicidae are a well known family of nematocerous flies. In the extant world fauna over 2, 900 species are known which are frequent parasites of mammals and birds as females feed on their blood. Mosquito larvae and pupae inhabit exclusively shallow stagnant waters.

Despite the fact that the phylogenetic history of mosquitoes is going back to the Mesozoic era they are rarely preserved as fossils. The oldest true mosquito, however still undescribed, is reported from Upper Cretaceous Canadian amber (EVENHUIS 1994). Other records of fossil mosquitoes from the Mesozoic are doubtful. They come from the time when Chaoboridae, Dixidae and Corethrellidae were included in the family Culicidae.

True named fossil mosquitoes are known from the Tertiary of Europe, North America and Africa (EDWARDS 1923, SZADZIEWSKI & SZADZIEWSKA 1985, CAPASSO 1993, EVENHUIS 1994). Some of them are barely preserved and the characters visible indicate only that they are mosquitoes. Mosquitoes are very rare in Eocene Baltic amber, while they are more common in younger Dominican amber (SZADZIEWSKI & GROGAN 1994).

The following determinable fossil mosquitoes are known from Europe:

Mansonia cockerelli (EDWARDS, 1923), **comb. n**. Isle of Wight, England, Oligocene. Compression, female. Proboscis length 2.2 mm, palpus 0.5 mm. Veins of wing with broad scales, vein R_{2+3} short, 2.9 times shorter than R_2. Thorax and abdomen barely preserved. EDWARDS (1923) provisionally placed that fossil in the *Ochlerotatus* which now is treated as a subgenus of *Aedes*. This is the only fossil mosquito with broad wing scales, and it should be member of the genus *Mansonia* BLANCHARD characteristic in having broad scales on wing veins.

Aedes protolepis (COCKERELL, 1916)(=*petrifactellus* COCKERELL, 1916). Isle of Wight, England, Oligocene. Compression, female and male. Male palpi are longer than proboscis with 4th and 5th segments of almost equal length. Male genitalia barely preserved. Gonocoxites with basal lobes which may indicate that this species is a member of the subgenus *Ochlerotatus*. Wing scales slender. Vein R_{2+3} relatively long, only 1.4 times shorter then R_2 (10:7).

Culex erikae SZADZIEWSKI et SZADZIEWSKA, 1985. Baltic amber, Eocene. Inclusion, female. Wing scales slender. Vein R_{2+3} very short, 5.3 times shorter than R_2. Wing scales slender. Claws without teeth, tip od abdomen blunt.

Culex protorhinus COCKERELL, 1916. Isle of Wight, England. Oligocene. Compression, female and male. Length of male proboscis 3.7 mm, palpi 3.3 mm. Palpi probably shorter than proboscis. Vein R_{2+3} about 1.7 times shorter than R_2 in male, and 1.8 times in female (EDWARDS 1923).

Culex vectensis EDWARDS, 1923. Isle of Wight, England, Oligocene. Compression, female. Subcostal vein long, reaching almost level of base of vein R_2. Vein R_2 2.8 times longer than vein R_{2+3}. Wing scales slender. Proboscis and antennae incomplete. Second segment of palpi 1.6 times longer than the first [probably 1+2]. The tip of abdomen missing.

Doubtful mosquitoes treated as fossils from Europe are as follows:

Aedes ciliaris (LINNAEUS, 1767). Extant. Probably a senior synonym of extant *Aedes cinereus* MEIGEN, 1818. In 1776 BLOCH determined in copal of unknown origin extant *Culex ciliaris*. Subsequently EDWARDS (1923) listed that name among Quaternary mosquitoes recorded from copal. Finally EVENHUIS (1994) placed it among fossils.

Neoculicites EVENHUIS, 1994 includes 3 names proposed by paleontologists for worthless, barely preserved remnants which were recognized as mosquitoes. The female of the type species *Culicites depereti* MEUNIER, 1915 according to EDWARDS (1923) is barely preserved and showing no more that it is a culicid. The generic name *Culicites* MEUNIER, 1915 was replaced by EVENHUIS because of homonymy. Actually all names included here have no scientific value.

Culex ceyx HEYDEN, 1870. Rott in Siebegebirge, Germany, Lower Miocene. Compression, female. Wing venation not indicated. Palpi short, abdomen pointed. According to EDWARDS (1923) it is possibly a member of *Aedes*.

Lastly among inclusions in Baltic amber intensively collected by enthusiastic private collectors further 3 well preserved mosquitoes are recorded and described in this paper.

DESCRIPTIONS

Subfamily Culicinae
Genus *Aedes* MEIGEN, 1818
Subgenus *Finlaya* THEOBALD, 1903

Finlaya is a subgenus of *Aedes* which include over 190 extant species distributed mostly in the Oriental Region. In the Palaearctic Region there occur 15 species in the Eastern part (Japan, Korea, China, Far East of Russia) while only 3 in the Western part (2 exclusively in the Mediterranean subregion, and 1 more widespread) (MINAŘ 1990). Larvae of mosquitoes included in the subgenus live exclusively in small temporary water bodies in tree hollows, leaf axils, rock pools, etc. In the extant fauna mosquitoes of that subgenus are usually rare and have a mosaic distribution (GUTSEVICH et al. 1970).

Males of *Finlaya* have unusual genitalia armed with characteristic structures called claspettes which are composed of two - proximal and distal elements. The distal one (filament) is mostly blade-like. Claspettes of such a shape are similar to those in the subgenus *Ochlerotatus* LYNCH ARRIBÁLZAGA (=*Taeniorhynchus* LYNCH ARRIBÁLZAGA). However, gonocoxites in *Finlaya* are simple, while in *Ochlerotatus* they are provided with basal and apical lobes on inner surface.

The species described below have simple gonocoxites and claspettes which indicate that they are members of the *Finlaya*.

Aedes (Finlaya) hoffeinsorum sp. n.

Diagnosis

The new species can be distinguished from other fossil species by having very short wing vein R_2 and short male palpi with greatly reduced fifth palpal segment.

Description

Male (Fig. 5a).

Total length 6.2 mm, length of thorax plus abdomen 4.1 mm.

Head typical of Culicinae. Pedicel enlarged. Flagellum composed of 13 units, length 1.98 mm. Proportions of flagellomeres from 1 to 13 as follows: 20-13-13-13-13-13-13-12-12-12.5-12-46 (345 μm)-68 (510 μm). Each flagellomere 1-11 with a ring of long hair-like setae on distal half, flagellomere 12 with a ring of long verticils located at base; flagellomere 13 with some short basal verticils, and with apical stylet-like prolongation (Fig. 1d).

Palpus 5-segmented, total length 1.23 mm, shorter than proboscis (Fig. 1a). Lengths of palpal segments as follows (in μm): 1+2 = 465, 3 = 503, 4 = 203, 5 = 60. Palpus covered with slender scales. Fifth palpal segment very short (Fig. 1c). Proboscis typical of male Culicinae, 1.64 mm long. Proboscis 1.21 times longer than flagellum, and 1.33 times longer than palpus.

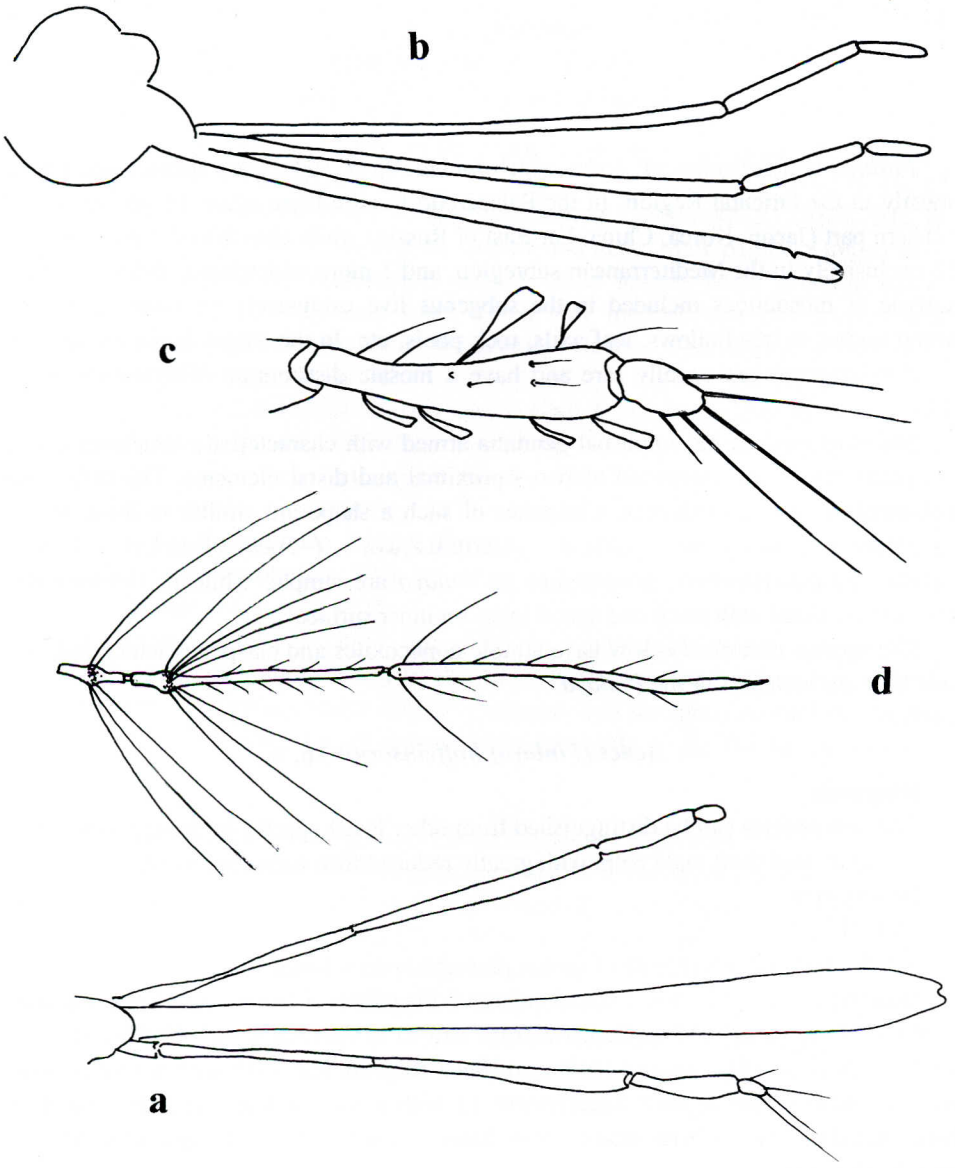

Fig. 1. Male proboscis and palpi (a-c) and terminal flagellomeres (d) of *Aedes hoffeinsorum* sp. n. (a, c, d) and *Aedes damzeni* sp. n (b).

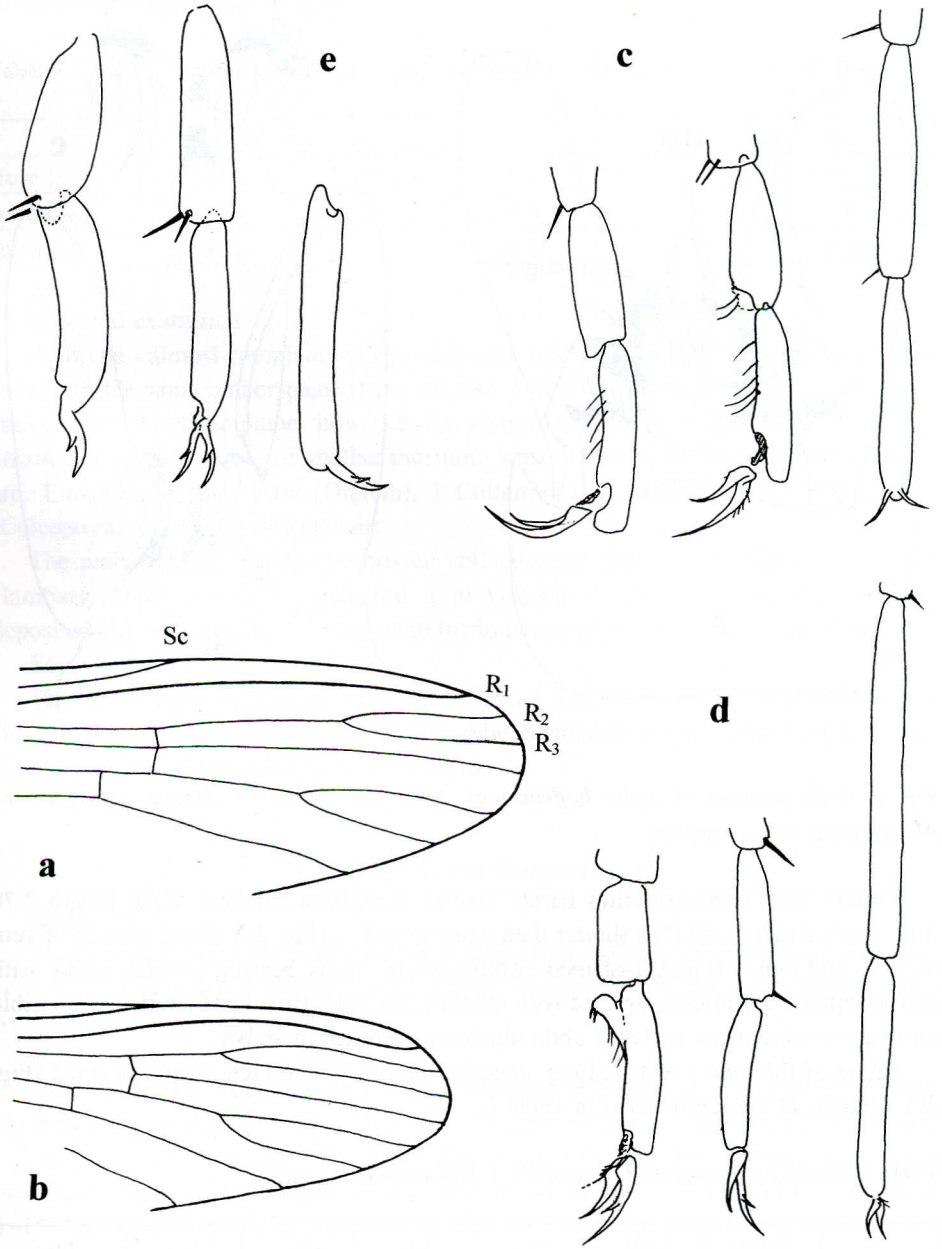

Fig. 2. Wing venation (a, b) and distal tarsomeres of male (c, d) and female (e) of *Aedes hoffeinsorum* sp. n. (a, c, e) and *Aedes damzeni* sp. n. (d).

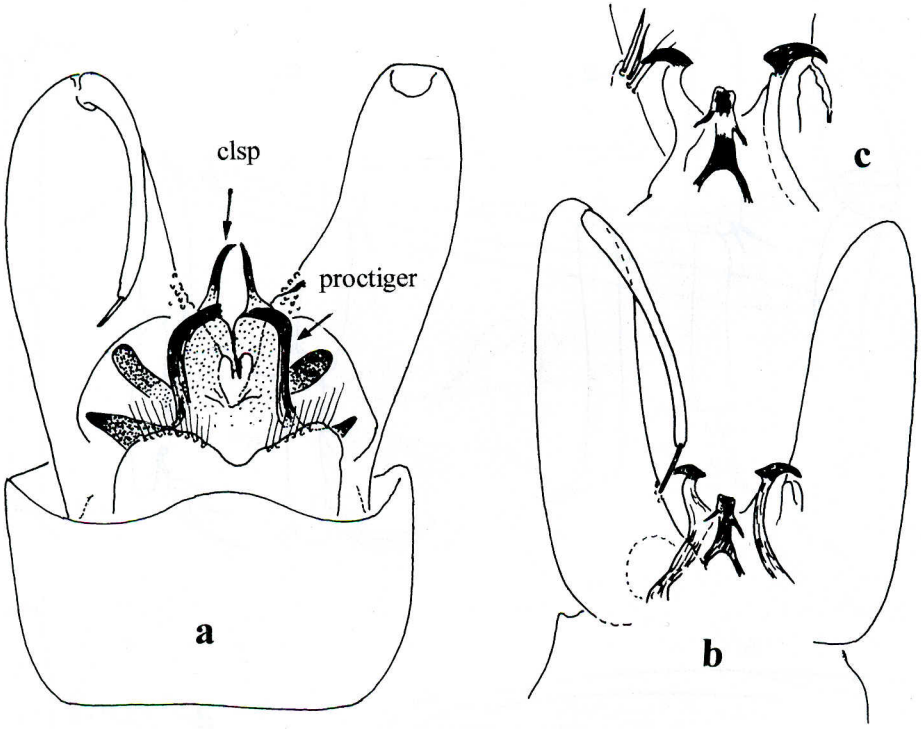

Fig. 3. Male genitalia of *Aedes hoffeinsorum* sp. n. (a) and *Aedes damzeni* sp. n. (b, c). Abbreviation: clsp – claspette.

Thorax with lateral sclerites barely visible. Scutellum trilobed. Wing length 2.78 mm. Second radial cell (R_2) shorter than wing vein R_{2+3} (Fig. 2a). Basal portion of vein of R_{4+5} and r-m forming T-shaped configuration. Veins bearing slender scales with convex apices, membrane covered with microtrichia only. Broad and short scales visible on wing membrane are probably abdominal scales shifted in amber.

Claws of fore and mid legs long, unequal, simple, of hind leg short and equal (Fig. 2c). Lengths of leg segments as in Table 1.

Table 1. Lengths of leg segments of male of *A. hoffeinsorum* (in μm).

	femur	tibia	ta_1	ta_2	ta_3	ta_4	ta_5
fore leg	1482	-	1014	343	218	156	187
mid leg	1654	1856	1248	515	312	156	187
hind leg	-	1919	1295	624	421	-	-

Female. Only tarsi preserved. Each claw armed with a tooth (Fig. 2e). Lengths of tarsomeres are presented in Table 2.

Table 2. Lengths of tarsal segments of female of *A. hoffeinsorum* (in μm).

	ta_1	ta_2	ta_3	ta_4	ta_5
fore leg	1250	480	260	190	200
mid leg	1520	670	410	190	200
hind leg	1810	900	610	400	280

Material examined

Holotype - almost complete male preserved in a relatively large, transparent piece of amber. In the same amber piece there are also 4 tarsi of a female mosquito described above under the same name, however not designated as a paratype. There are also 2 uncomplete tarsi probably of another mosquito with short 4th tarsomere. Moreover, there are: 1 male of Pipunculidae (Diptera), 1 Collembola, 1 small, probably beetle larva (Coleoptera), numerous stellate hairs.

The amber piece is from the private collection of Christel and Hans Hoffeins of Hamburg, Germany. They purchased it in Gdańsk in 1997. The holotype will be deposited in Deutsches Entomologischen Institute und Museum, Eberswalde, Germany.

Etymology

The new species is dedicated to Mrs. Christel and Mr. Hans Werner Hoffeins of Hamburg, outstanding inclusion collectors, who decided to deposit their extremely rare inclusion of a mosquito in the public museum.

Aedes (Finlaya) damzeni sp. n.

Diagnosis

The new species can be distinguished among fossil mosquitoes by having long radial vein R_2, and male palpi longer than proboscis, as well as one claw of mid leg armed with a tooth. Female unknown.

Description

Male (Fig. 5b). Total length 6.3 mm. Length of thorax plus abdomen 4.0 mm. Flagellum longer than proboscis, 1934 μm. Lengths of distal flagellomeres as follows: 13th 420 μm, 12th 390 μm, 11th 83 μm. Proboscis 1.84 mm long. Palpus longer than proboscis (Fig. 1b). Lengths of palpal segments as follows: 1-3 - 1326 μm, 4 - 406 μm, 5 -156 μm. Fifth palpal segment almost 2.6 times shorter than preceding one.

Wing length 3.02 mm. Scales on wing veins slender. Vein R_{2+3} about 2.4 times shorter than R_2 (Fig. 2b). Lengths of leg segments as in Table 3. Claws of fore and middle legs long, unequal, longer one armed with a tooth (Fig. 2d). Hind claws short, simple, equal. Fifth tarsomere of fore leg bearing basal ventral tubercle.

Table 3. Lengths of leg segments of male of *A. damzeni* sp. n. (in μm).

	femur	tibia	ta_1	ta_2	ta_3	ta_4	ta_5 (without claws)
fore leg	1638	1825	1342	546	328	109	172
mid leg	1747	1856	1420	608	359	156	156
hind leg	1638	1872	1732	920	624	359	234

Genitalia (Fig. 3b) typical of the genus *Aedes*. Gonocoxite slender. Gonostylus slender and bearing long apical spine. Claspettes with distinct, blade-shaped distal portion (Fig. 3c). Proctiger barely visible.

Female. Unknown.

Material examined

Holotype male in a large transparent amber piece without stellate hairs. In the same amber piece one specimen of Dolichopodidae is embedded. The holotype will be deposited in the Geological-Palaeontological Institute and Museum, University of Hamburg, Bundesstrasse 55, 20146 Hamburg, Germany.

Etymology

The species is named in honour of Mr. Jonas Damzen of Vilnius (Lithuania) the collector of the holotype.

Aedes (Finlaya) serafini sp. n.

(Figs. 4a, b)

Diagnosis

Males of this species can be readily determined among fossils by the following combination of characters: palpi longer than proboscis, fourth palpal segment broad and almost as long and fifth one, wing vein R_2 about 1.5 times shorter than R_{2+3}, claws of mid legs unequal and simple, claws of fore leg subequal and one with a tooth at midlength.

Description

Male. Total length about 7 mm. Length of thorax plus abdomen 4.7 mm.

Proboscis shorter than palpi (Fig. 4a), length 1.75 mm. Palpi longer than proboscis, length 2.26 mm; fifth palpal segment slender, 374 μm long; fourth palpal segment broad and bearing long setae, length 359 μm.

Pospiracular sclerite behind anterior spiracle with some well visible long setae.

Claws of fore leg almost equal, one simple, another with inner tooth at midlength (Fig. 4b). Claws of midleg greatly unequal, simple. Claws of hind leg short, equal, simple (Fig. 4b).

Lengths of tarsomeres of fore leg as follows: ta_1 1045 μm, ta_2 312 μm, ta_3 171μm, ta_4 78 μm, ta_5 (without claws) 156 μm. Lengths of tarsomeres of middle leg as follows

(in µm): ta_1 1404, ta_2 546, ta_3 328, ta_4 125, ta_5 (without claws) 156. Lengths of tarsomeres of hind leg as follows (in µm): ta_1 1638, ta_2 824, ta_3 546, ta_4 281, ta_5 (without claws) 234. Length of hind tibia 1.763 mm.

Wing barely visible. Veins with slender scales. Vein R_2 (0.624 mm) 1.5 times longer than vein R_{2+3} (0.406 mm).

Genitalia hardly visible, black. Claspettes with long, bladelike, distal portion.

Female unknown.

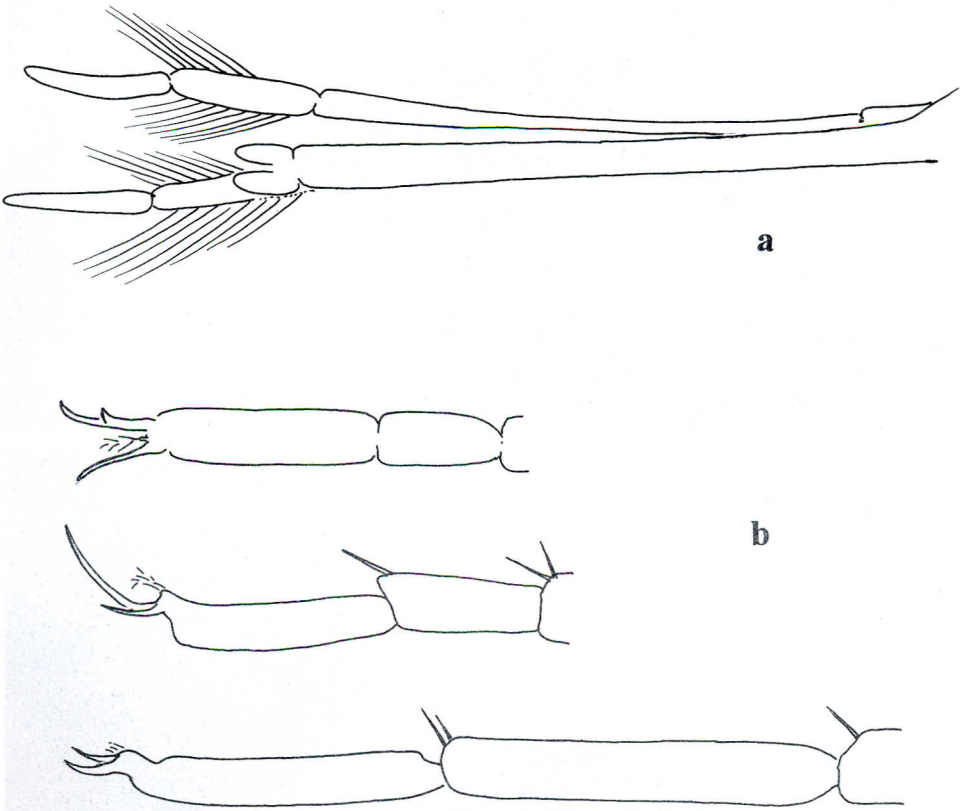

Fig. 4. *Aedes serafini*, sp. n., male; a - proboscis and palpi, b - distal tarsomeres of fore, mid and hind leg.

Material examined

Holotype male in a transparent amber piece. Wings twisted in amber and genitalia totally black, barely visible. Together with the holotype some stellate hairs and a female of Chironomidae embedded. This mosquito was purchased by Jacek Serafin of Kasparus from Russian dealers. It is deposited in the Museum of Amber Inclusions, University of Gdańsk. Inventory number 112.

Fig. 5. Lateral view of male of *Aedes hoffeinsorum* sp. n. (a) and *Aedes damzeni* sp.n. (b).

Etymology

The species is named for Jacek Serafin (Kasparus, Poland), generous collector of inclusions in amber, who purchased this expensive mosquito inclusion and donated it for the Museum of Amber Inclusions, University of Gdańsk.

Discussion

The holotype has barely visible genitalia. However, blade-shaped distal portion of claspettes in the genitalia and the presence of hairs on the postspiracular sclerite evidently show that it is a typical member of the genus *Aedes*.

DISCUSSION

The European named mosquitoes from Tertiary deposits can be determined using keys presented below. In the key doubtful names (*Culicites* and *Culex ceyx*) are not included. At present it is impossible to present determination key to all fossil mosquitoes including those described from North America and Africa. The African fossil mosquito *Culex tanzaniae* CAPASSO from Pliocene copal is a female without wings. It could not be determined below the generic level. Actually, it is not certain whether this female represents fossil or extant species. The situation of *Culex flavus* GISTL, 1831 and *Culex loewi* GIEBEL, 1862 reported from the Quaternary copals is similar. North American mosquitoes named as *Culex damnatorum* SCUDDER, 1890 and *Culex winchesteri* COCKERELL, 1920 common in Eocene deposits as compression fossils need further studies. At present they are only mosquitoes without specific or generic features (EDWARDS 1923, CAPASSO 1993).

Key to European fossil mosquitoes

1. Wing veins with broad scales .... ***Mansonia cockerelli*** (EDWARDS, 1923)(female, compression, Oligocene, England
-. Wing veins with slender scales 2
2. Vein R_{2+3} longer than R_2 (Fig. 2a) .... ***Aedes hoffeinsorum*** sp. n. (male, female, Eocene Baltic amber)
-. Vein R_{2+3} shorter than R_2 (Fig. 2b) 3
3. Vein R_{2+3} very short, 5.3 times shorter than R_2 .... ***Culex erikae*** SZADZIEWSKI et SZADZIEWSKA, 1985 (female, Eocene Baltic amber)
-. Vein R_{2+3} long, 1.4-2.8 times shorter than R_2 4
4. Vein R_{2+3} 1.4-1.8 times shorter than R_2 5
-. Vein R_{2+3} 2.4-2.8 times shorter than R_2 6
5. Male palpi longer than proboscis (Fig. 1b). Small species, male proboscis length 1.75 mm. ..... ***Aedes serafini*** sp. n. (male, Eocene Baltic amber)
-. Male palpi shorter than proboscis. Large species, male proboscis length 3.7 mm ..... ***Culex protorhinus*** COCKERELL, 1916 (male, female, compression, Oligocene, England)

6. Subcostal vein long reaching level of base of vein R_2 ..... ***Culex vectensis*** EDWARDS, 1923 (female, compression, Oligocene, England)
-. Subcostal vein short (Fig. 2b) reaching level of vein R_{4+5} ..... ***Aedes damzeni*** sp. n. (male, Eocene Baltic amber)

Key to mosquitoes from Baltic amber

1. Postspiracular sclerite without setae. Wing vein R_{2+3} very short, 5.3 times shorter than vein R_2. Female claws simple ..... ***Culex erikae*** SZADZIEWSKI et SZADZIEWSKA, 1985
-. Postspiracular sclerite with some long setae. Wing vein R_{2+3} long, longer than R_2, or only 1.5-2.4 times shorter than R_2. Female claws armed with teeth 2
2. Vein R_{2+3} longer than vein R_2 (Fig. 2a). Male palpus shorter than proboscis (Fig. 1a) ..... ***Aedes hoffeinsorum*** sp. n.
-. Vein R_{2+3} shorter than vein R_2 (Fig. 2b). Male palpus longer than proboscis (Fig. 1b) 3
3. Male. Fourth palpal segment slender, fifth palpal segment short (Fig. 1b). One claw of middle leg armed with a tooth (Fig. 2d) ..... ***Aedes damzeni*** sp. n.
-. Male. Fourth palpal segment stout, fifth palpal segment long (Fig. 4a). Both claws of middle leg simple (Fig. 4b) ..... ***Aedes serafini*** sp. n.

The presently described mosquitoes are included in the subgenus *Finlaya* of *Aedes*. Extant species of that group are mostly diversified in the Oriental Region. Their larvae live exclusively in small temporary water bodies present in tree hollows, leaf exils, rock pools, etc. In the extant fauna mosquitoes of that subgenus are usually rare and have a mosaic distribution (GUTSEVICH et al. 1970). Probably, in the amber bearing forests mostly small water bodies were occupied by mosquitoes and this may explain the fact why mosquitoes are so rare as inclusions in Baltic amber.

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