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Mosquitoes (Diptera: Culicidae) in Eocene amber from the Rovno region, Ukraine

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Abstract

Culex ekaterinae **sp. nov.** is described based on an adult male embedded in amber from the Rovno region, northwestern Ukraine. The new species is compared with its presumed closest known relative, i.e. *Culex erikae* Szadziewski *et* Szadziewska, 1985 described from adults in Baltic amber. The two species exhibit distinct differences in the size of the main body parts, including the antenna, maxillary palpus and proboscis, as well as in the venation of the wing, the structure of the ungues and male genitalia—characters crucial in the diagnosis of adult mosquitoes. A redescription of *Culiseta gedanica* Szadziewski *et* Giłka, 2011, to date known from a single adult male, is presented based on a male in amber from Voronki, Rovno region. A tabulation of fossil Culicidae with their geological ages is provided.

Key words: *Culex*, *Culiseta*, fossils, new species, systematics

Introduction

Rovno amber has been dated to the Priabonian Age (33.9–37.8 Mya) of the Eocene Epoch (Sokoloff *et al.* 2018; Radchenko & Perkovsky 2021; Radchenko *et al.* 2021). Most Rovno amber containing nematoceran Diptera, and most other inclusions studied thus far, was mined in Klesov (Sarny district, Rovno region) (Perkovsky *et al*. 2010; Mitov *et al*. 2021). The new findings, including mosquitoes, come from the former Zarechnoye and Vladimirets districts of the northwestern part of the Rovno region (Perkovsky & Nel 2021 and references therein).

The nematoceran Diptera constitute more than half (58%) of all Rovno amber insect inclusions, but only 144 species have been recorded so far (Azar *et al.* 2013; Perkovsky & Fedotova 2016 and references therein; Fedotova & Perkovsky 2017; Sontag & Szadziewski 2011; Zakrzewska & Giłka 2014; Perkovsky & Sukhomlin 2015; Baranov *et al.* 2016; Pielowska *et al.* 2018; Kopeć *et al.* 2019; Wojtoń *et al.* 2019; Skartveit 2021; Wagner 2021), and 110 (76%) of these species are not known from coeval Baltic amber. Fossil representatives of four families of the infraorder Culicomorpha have been described from Rovno amber, including Ceratopogonidae (Sontag & Szadziewski 2011; Perkovsky & Rasnitsyn 2013; Perkovsky 2013, 2017), Chironomidae (Zelentsov *et al.* 2012; Giłka *et al.* 2013; Baranov & Perkovsky 2014; Baranov *et al*. 2014; Zakrzewska & Giłka 2014; Andersen *et al.* 2015; Zakrzewska *et al.* 2016; Dietrich & Perkovsky 2020), Corethrellidae (Baranov *et al*. 2016) and Simuliidae (Perkovsky *et al.* 2013; Perkovsky & Sukhomlin 2015, 2016); however, information on mosquitoes (Culicidae) from this amber has not been published to date.

Twenty-seven extinct fossil species of Culicidae have been described. Three species are representatives of three extinct genera that existed in the Late Cretaceous Epoch or at the turn of the Early and Late Cretaceous (today called the "mid-Cretaceous") of the Mesozoic Era. Twenty-four species of the extant genera *Aedes*, *Anopheles*, *Coquillettidia*, *Culex*, *Culiseta* and *Toxorhynchites*, and three extinct genera are known from the more recent Cenozoic Era.

The 27 species and their geological ages are listed in Table 1 (see also for their authorship, which is not included at first mention in the text).

Material and methods

The specimens studied here are adult male inclusions found in amber from the Rovno region, Ukraine. The new *Culex* species was found in the Veselukha river valley [see Lyubarsky & Perkovsky (2020); Kuchotskaya Volya is the most well-known locality there] in a big piece of amber LKV-102 (27.2 g before primary treatment, length of piece 68 mm, width 44 mm, height 19 mm), and the *Culiseta* species was found in a large piece of amber (174 g after primary treatment, length of piece 128 mm, width 46 mm, height 20 mm) from Voronki, Vladimirets district (local fauna is discussed in Perkovsky *et al*. 2020).

Except for the ungues and genitalia, for which lengths are given in micrometres (μm), measurements are in millimetres (mm) rounded to the first decimal place (total body lengths) or to the second digit after the decimal point (remaining measurements, including calculated ratios). The body and wing lengths were measured from the antennal pedicel to the apex of the genitalia and from the arculus of the wing to the wing tip, respectively. The morphological terminology and abbreviations follow Harbach & Knight (1980, 1982), revised and updated in the Anatomical Glossary of the Mosquito Taxonomic Inventory (http://mosquito-taxonomic-inventory.info/), except for crossveins of the wing which follow the usage of Belkin (1962). Photographs were taken using a PZO Biolar SK14 microscope with a Sony NEX-3N digital camera, a Leica M205A stereomicroscope with a DCF 495 camera (*Culex*) and a Leica Z16 APO stereomicroscope with a DFC 450 camera (*Culiseta*). The images were compiled using the LAS Montage multifocus and the Helicon Focus 6 stacking software. The type specimen of the new species designated here is the property of the I.I. Schmalhausen Institute of Zoology, National Academy of Sciences of the Ukraine, Kiev (SIZK); the specimen L-800 (1DNCCC2021) from the Victor Gusakov collection (Zviozdnyi gorodok, Russia; GVGM) is on long-term loan in the SIZK.

Results

Culex ekaterinae **sp. nov.**
LSID: urn:lsid:zoobank.org:act:74519104-A47C-4A85-98BD-80C2269524A7
Figs 1A–D; 2A, B, D, E, H, I; 3A, B, D

Derivation of the name. The specific name is a feminine patronym commemorating the Russian palaeontologist Ekaterina Alekseevna Sidorchuk (1981–2019).

Type material. Holotype, adult male, right hindleg broken, tarsomeres incomplete or missing, preserved in a subtriangular piece of amber 28.5 × 20.5 × 7.5 mm (SIZK LKV-178, Fig. 1A), Veselukha river valley, Rovno region, Ukraine; Eocene, Priabonian (33.9–37.8 Mya). Syninclusions: LKV-178/I, Sciaridae; SIZK LKV-179, Dolichopodidae.

Description. Adult male (holotype). *Colour*: Dark brown to black, with proximal abdominal segments slightly lighter (Fig. 1B). *Size*: Body length 5.2 mm (excluding proboscis), body + proboscis 7.0 mm, thorax + abdomen 4.7 mm (Fig. 1B). *Antenna* (Fig. 1C): Length including pedicel 1.97 mm, flagellum 1.85 mm; flagellomeres 12 and 13 longest (0.44 and 0.47 mm, respectively), their combined length slightly less than total length of preceding flagellomeres (ratio 0.97); whorls well developed, flagellomeres 1–12 each with whorl of many long setae, flagellomere 13 with whorl of few shorter setae and short conical apical prolongation; antenna about 1.11 x length of proboscis. *Proboscis* (Fig. 1D): Length 1.77 mm, distinctly shorter than maxillary palpus (ratio 0.65), with a distinct constriction 0.67 from base; labella with well-defined proximal and distal sclerites; forefemur/proboscis ratio 0.84. *Maxillary palpus* (Fig. 1D): Length 2.72 mm, much longer than proboscis (ratio 1.54); palpomeres 1–3 ankylosed (combined length 1.65 mm), about 0.93 length of proboscis; palpomere 4 (0.57 mm) longer than palpomere 5 (0.50 mm), ratio 1.14; palpomeres 1–3 slender, broadening toward apex of palpomere 3; palpomere 4 broadest, palpomere 5 tapering toward narrow apex (cf. *Culex erikae*: Fig. 1E). *Wing* (Fig. 2A, B): Length 2.90 mm; veins R_2 and R_3 distinctly longer than vein R_{2+3} ($R_2/R_{2+3} = 3.00$, $R_3/R_{2+3} = 3.16$); arrangement of veins in area of radiomedial and mediocubital crossveins as shown in Fig. 2B; mediocubital crossvein [base of M_{3+4} of Harbach & Knight (1980)] unusually short, with media

Table 1. The 27 extinct species of Culicidae formally described prior to the present paper, known from a male (m), female (f) and/or a leg (l), wing (w); egg (e). For names/nominal species removed from Culicidae see Poinar *et al*. (2000) and Harbach (2021).

Genus	Species	Sex	Period (epoch)	Reference (taxonomy)
Aedes Meigen, 1818 (extant)	*protolepis* (Cockerell, 1916) (originally *Culex*, doubtful combination)	w	Eocene	Cockerell (1916), Krzemiński *et al*. (2019, as species of the genus *Ochlerotatus* Lynch Arribálzaga, 1891)
	serafini Szadziewski, 1998	m	Eocene	Szadziewski (1998), Szadziewski & Giłka (2011)
Aetheapnomyia Harbach *et* Greenwalt, 2012 (extinct)	*hoffeinsorum* (Szadziewski, 1998) (originally *Aedes*)	m f l?	Eocene	Szadziewski (1998), Harbach & Greenwalt (2012)
Anopheles Meigen, 1818 (extant)	*dominicanus* Zavortink *et* Poinar, 2000	f e	Miocene	Zavortink & Poinar (2000)
	rottensis Statz, 1944	m	Oligocene	Statz (1944)
Burmaculex Borkent *et* Grimaldi, 2004 (extinct)	*antiquus* Borkent *et* Grimaldi, 2004	f	mid-Cretaceous	Borkent & Grimaldi (2004)
Coquillettidia Dyar, 1905 (extant)	*adamowiczi* Szadziewski, Sontag *et* Szwedo, 2019	m	Eocene	Szadziewski *et al*. (2019)
	cockerelli (Edwards, 1923) (originally *Taeniorhynchus* Lynch Arribálzaga, 1891)	f	Eocene	Edwards (1923), Poinar *et al*. (2000), Krzemiński *et al*. (2019)
	gedanica Szadziewski, Sontag *et* Szwedo, 2019	m	Eocene	Szadziewski *et al*. (2019)
	martinii (Statz, 1944) (originally *Mansonia* Blanchard, 1901)	f	Oligocene	Statz (1944), Krzemiński *et al*. (2019)
	varivestita (Statz, 1944) (originally *Mansonia*)	f	Oligocene	Statz (1944), Krzemiński *et al*. (2019)
Culex Linnaeus, 1758 (extant)	*damnatorum* Scudder, 1890	f	Eocene	Scudder (1890)
	erikae Szadziewski *et* Szadziewska, 1985	f m	Eocene	Szadziewski & Szadziewska (1985), Szadziewski & Giłka (2011)
	malariager Poinar, 2005	f	Miocene	Poinar (2005)
	protorhinus Cockerell, 1916	m	Eocene	Cockerell (1916)
	vectensis Edwards, 1923	f	Eocene	Edwards (1923)
	winchesteri Cockerell, 1919	f	Eocene	Cockerell (1919)
Culiseta Felt, 1904 (extant)	*gedanica* Szadziewski *et* Giłka, 2011	m	Eocene	Szadziewski & Giłka (2011)
	kishenehn Harbach *et* Greenwalt, 2012	m f	Eocene	Harbach & Greenwalt (2012)
	lemniscata Harbach *et* Greenwalt, 2012	f	Eocene	Harbach & Greenwalt (2012)
Eoaedes Harbach *et* Greenwalt, 2012 (extinct)	*damzeni* (Szadziewski, 1998) (originally *Aedes*)	m	Eocene	Szadziewski (1998), Harbach & Greenwalt (2012)
Neoculicites Evenhuis, 1994 (extinct)	*arvernensis* (Piton, 1936) (originally *Culicites*)	f	Pleistocene	Piton (1936), Evenhuis (1994)
	ceyx (von Heyden, 1870) (originally *Culex*)	f	Oligocene	von Heyden (1870), Meunier (1915), Evenhuis (1994)
	depereti (Meunier, 1915) (originally *Culicites*)	f	Oligocene	Meunier (1915), Evenhuis (1994)
Paleoculicis Poinar, Zavortink, Pike *et* Johnston, 2000 (extinct)	*minutus* Poinar, Zavortink, Pike *et* Johnston, 2000	m	Late Cretaceous	Poinar *et al*. (2000)
Priscoculex Poinar, Zavortink *et* Brown, 2019 (extinct)	*burmanicus* Poinar, Zavortink *et* Brown, 2019	f	mid-Cretaceous	Poinar *et al*. (2020)
Toxorhynchites Theobald, 1901 (extant)	*mexicanus* Zavortink *et* Poinar, 2008	f	Miocene	Zavortink & Poinar (2008)

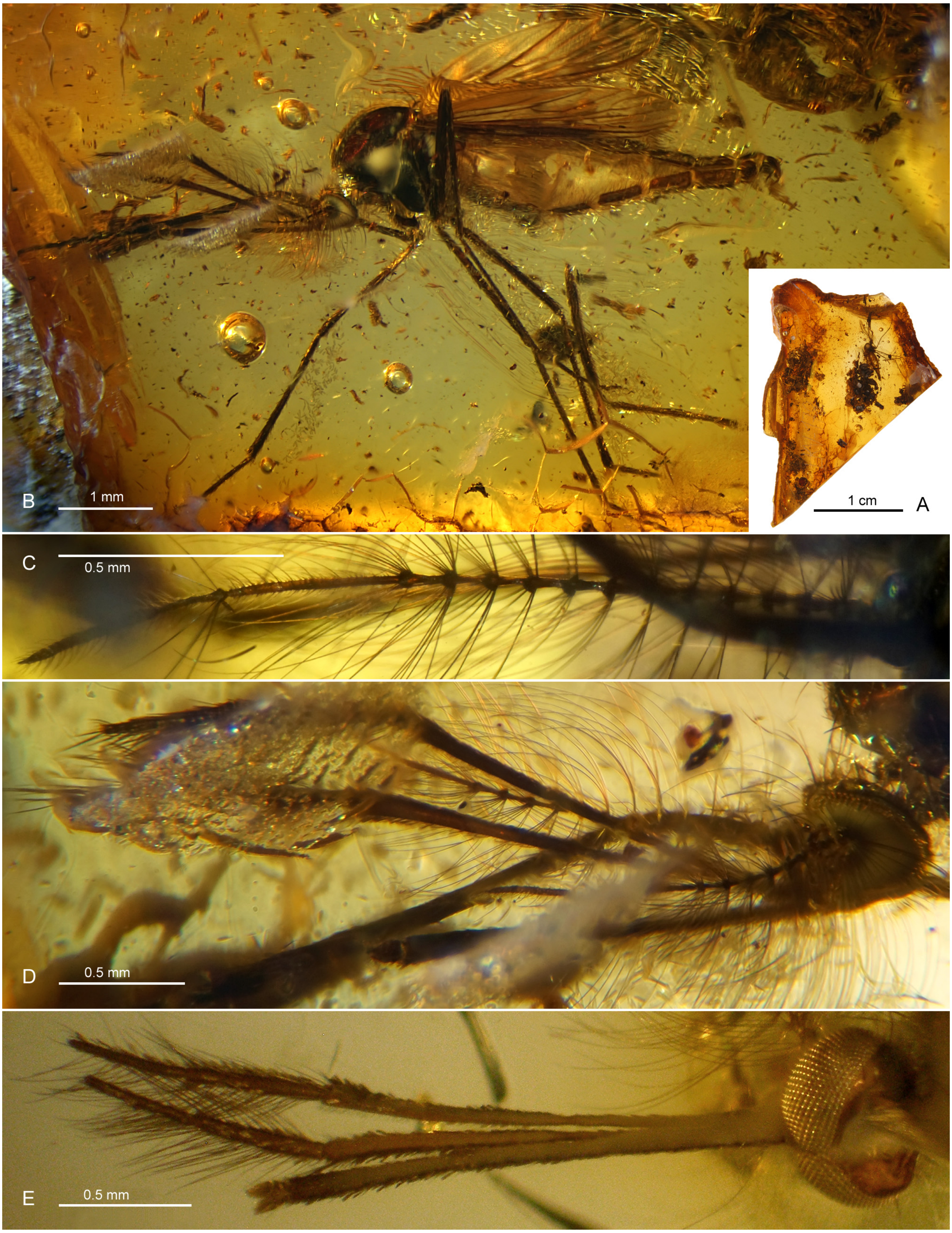

FIGURE 1. Males of *Culex ekaterinae* **sp. nov.** (**A**–**D**) and *Culex erikae* Szadziewski *et* Szadziewska, 1985 (**E**). **A**, Inclusion in amber; **B**, habitus; **C**, antenna; **D**, **E**, head.

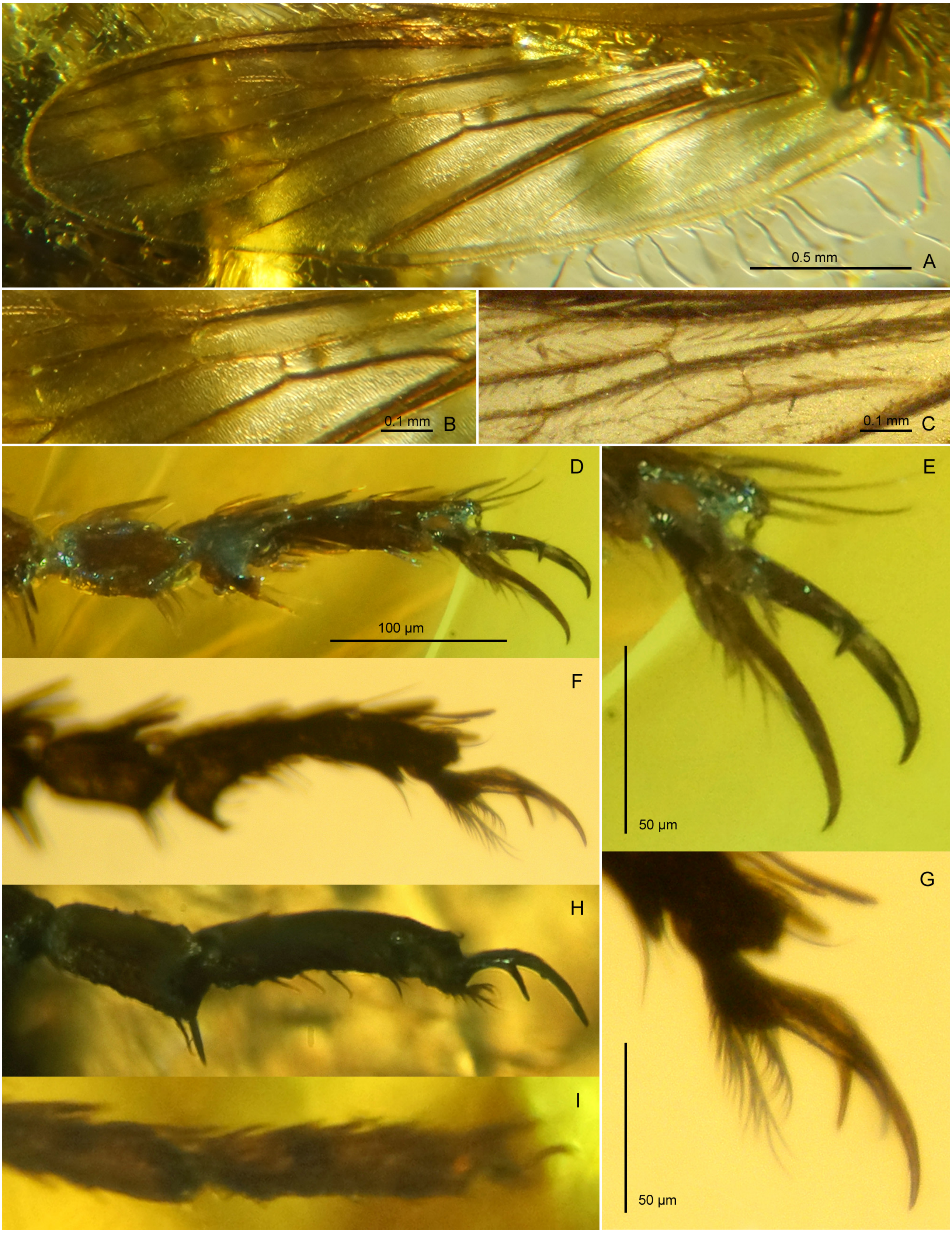

FIGURE 2. Males of *Culex ekaterinae* **sp. nov.** (**A**, **B**, **D**, **E**, **H**, **I**) and *Culex erikae* Szadziewski *et* Szadziewska, 1985 (**C**, **F**, **G**). **A**, Wing; **B**, **C**, area of radiomedial and mediocubital crossveins; **D**–**I**, ultimate tarsomeres with ungues of fore- (**D**–**G**), mid- (**H**) and hindleg (**I**) and ungues magnified (**E**, **G**).

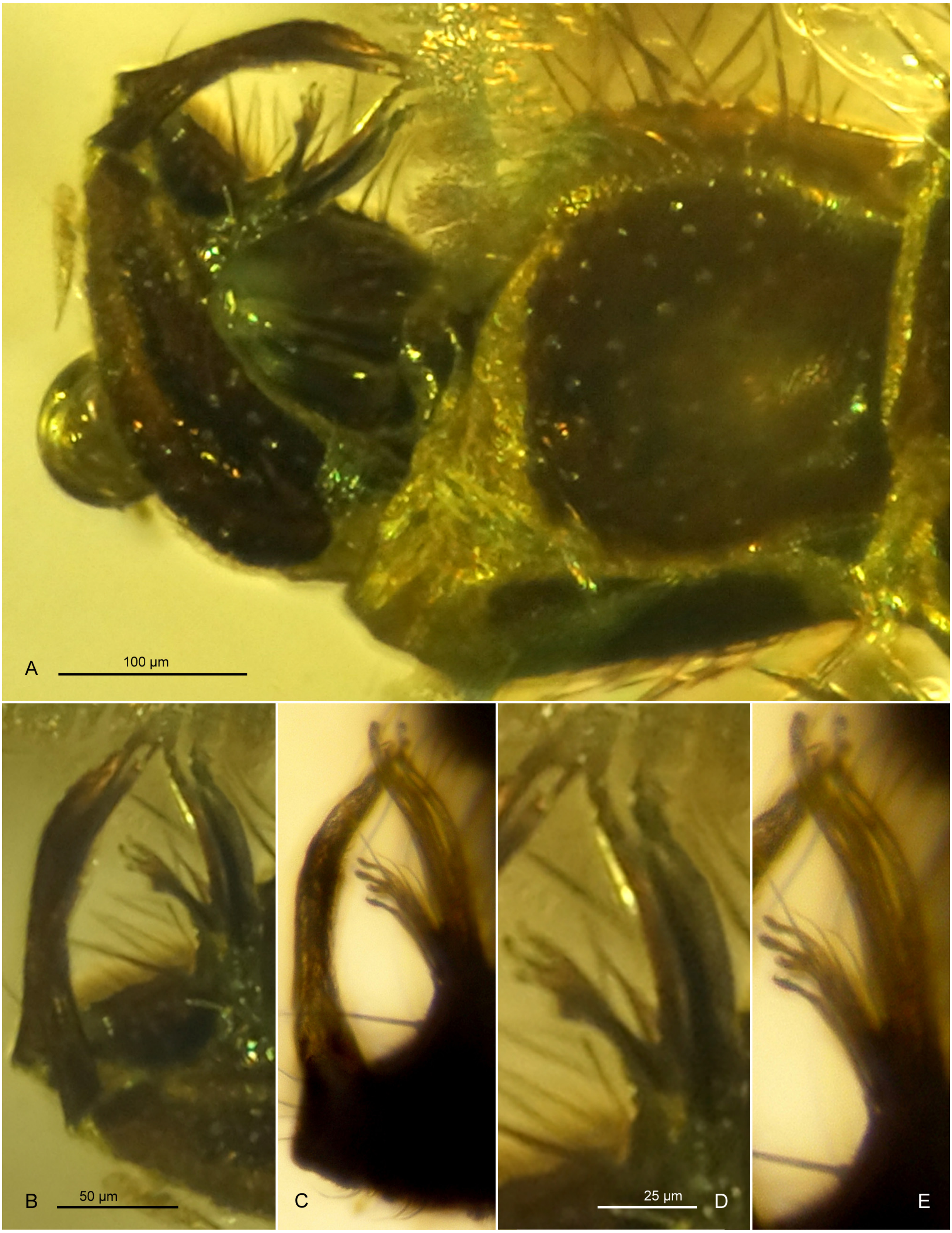

FIGURE 3. Males of *Culex ekaterinae* **sp. nov.** (**A**, **B**, **D**) and *Culex erikae* Szadziewski *et* Szadziewska, 1985 (**C**, **E**). Genitalia in lateral aspect and setae of gonocoxite (C and E magnified proportionally relative to B and D, respectively).

and vein M_{3+4} both indented at point of attachment with the crossvein (cf. *Culex erikae*: Fig. 2C); cubitus posterior [plical vein of Belkin (1962)] developed as strongly as cubitus anterior, with scales on at least proximal part; anal vein (1A) ending 0.67 of distance between intersection of mediocubital crossvein and cubitus and base of M_{3+4} toward wing apex. *Legs* (Fig. 2D, E, H, I; length of segments in Table 2): Entirely dark-scaled; foreleg with ungues strongly curved apically; ungues equally long on foreleg (110 µm), unequal on midleg (90 and 50 µm), equal on hindleg (50 µm); anterior unguis of fore- and midlegs with medial tooth: minute on foreleg (Fig. 2D, E; cf. *Culex erikae*: Fig. 2F, G) and stout on midleg (Fig. 2H), posterior unguis of fore- and midlegs without teeth; ungues of hindleg simple (for length of leg segments see Table 2). *Genitalia* (Fig. 3A, B, D): Observed in lateral view; length of gonocoxite 300 µm, subapical lobe prominent, undivided, with 2 groups of setae: proximal group comprised of 3 long, stout closely appressed setae (setae *a*, *b*, *c*), narrowed distally with retrorse or hooked apices; distal group of partially fused shorter setae (setae *d*–*g*) with spoon-shaped apices (Fig. 3B, D; cf. *Culex erikae*: Fig. 3C, E); length of gonostylus 190 µm, evenly curved, slightly enlarged distally, with long apical gonostylar claw.

TABLE 2. Lengths (mm) of leg segments of the holotype male of *Culex ekaterinae* **sp. nov.**

Leg	Femur	Tibia	Tarsomeres				
			1	2	3	4	5
Foreleg	1.49	1.59	1.03	0.29	0.18	0.09	0.19
Midleg	1.56	1.81	1.54	0.50	0.33	0.09	0.15
Hindleg	1.46	1.90	1.65	0.91	0.71	0.36	0.19

Culiseta gedanica **Szadziewski *et* Giłka, 2011**

Figs 4–6

Material examined. Adult male (left foreleg missing) preserved in a sub-rectangular piece of amber 25.5 × 23 × 13.5 mm (SIZK L-800, Fig. 4A; Voronki, Rovno region, Ukraine; Eocene, Priabonian (33.9–37.8 Mya). Syninclusions. SIZK L-800: stellate hairs, 2 Formicidae [male of *Plagiolepis solitaria* Mayr and worker of *Ctenobethylus goepperti* (Mayr)], Aphidinea (*Germaraphis* sp.), Dolichopodidae, Ceratopogonidae, Aranei; SIZK L-801: Artematopodidae (*Electribius* sp.); SIZK L-802: Acari, mammalian hair; SIZK L-803: *incertae sedis*; SIZK L-804: Aranei; SIZK L-805: Dolichopodidae, Acari, Collembola; SIZK L-806: 3 Dolichopodidae, Sciaridae, 2 Aranei, Acari, *incertae sedis*. Holotype male (cf. Szadziewski & Giłka 2011).

Description. Adult male ($n = 2$, measurements of holotype in boldface). *Colour*: Greyish-brown, with thorax and genitalia slightly darker (Fig. 4B). *Size*: Body length **4.6**–5.0 mm, body + proboscis **6.7**–6.8 mm, thorax + abdomen **4.2**–4.6 mm (Fig. 4B). *Antenna* (Fig. 4B, C): Length including pedicel ~1.75 mm, flagellum 1.68 mm, flagellomeres 12 and 13 0.38 and 0.40 mm, respectively, their combined length less than total length of preceding flagellomeres (ratio 0.87); whorls well developed, flagellomeres 1–11 each with whorl of many long setae, flagellomeres 12 and 13 with whorls of fewer weaker setae; antenna about 0.95 length of proboscis. *Proboscis* (Fig. 4C, D): Length 1.80–**2.06** mm, shorter than maxillary palpus (ratio **0.78**–0.83). *Maxillary palpus* (Fig. 4C, D): Length 2.16–**2.63** mm, longer than proboscis (ratio 1.20–**1.28**); palpomeres 1–3 ankylosed (combined length 1.30 mm), about 0.72 length of proboscis; palpomere 4 (0.50–**0.59** mm), longer than palpomere 5 (0.36–**0.48** mm), ratio **1.23**–1.39; palpomeres 2–4 stout, parallel-sided; palpomere 5 smaller, slightly swollen medially, tapering towards narrow apex. *Thorax* (Fig. 5A, B): Setae as shown in Fig. 5A; mesothoracic prespiracular area with several setae, postspiracular setae not observed. *Wing* (Fig. 5C, D): Length 2.81–**2.88** mm; distal 0.5 of wing with slender lanceolate and spatulate scales on most veins; veins R_2 and R_3 distinctly longer than vein R_{2+3} (R_2/R_{2+3} = 2.25–**2.40**, R_3/R_{2+3} = 2.40–**2.50**); arrangement of veins in area of radiomedial and mediocubital crossveins as shown in Fig. 5D; anal vein (1A) ending 0.5 of distance between intersection of mediocubital crossvein and cubitus and base of M_{3+4} towards wing apex. *Legs* (Fig. 5E–H): Ungues of unequal length on fore- (~120 and 80 µm) and midleg (~120 and 85 µm), equally long on hindleg (~50 µm long); larger anterior unguis of fore- and midleg each with stout proximal and medial teeth, smaller unguis of fore- and midlegs each with proximal tooth, medial tooth absent; hindungues simple (for length of leg segments see Table 3). *Genitalia* (Fig. 5I, J): Gonocoxite long (~360 µm), tapering toward rounded apex; gonostylus slender (~310 µm), hockey-stick-shaped, distinctly curved subapically, with apico-medial lobe and long apical tooth; claspette short, curved, with darkly pigmented, serrate margins and pointed apex (cf. Szadziewski & Giłka 2011: fig. 3).

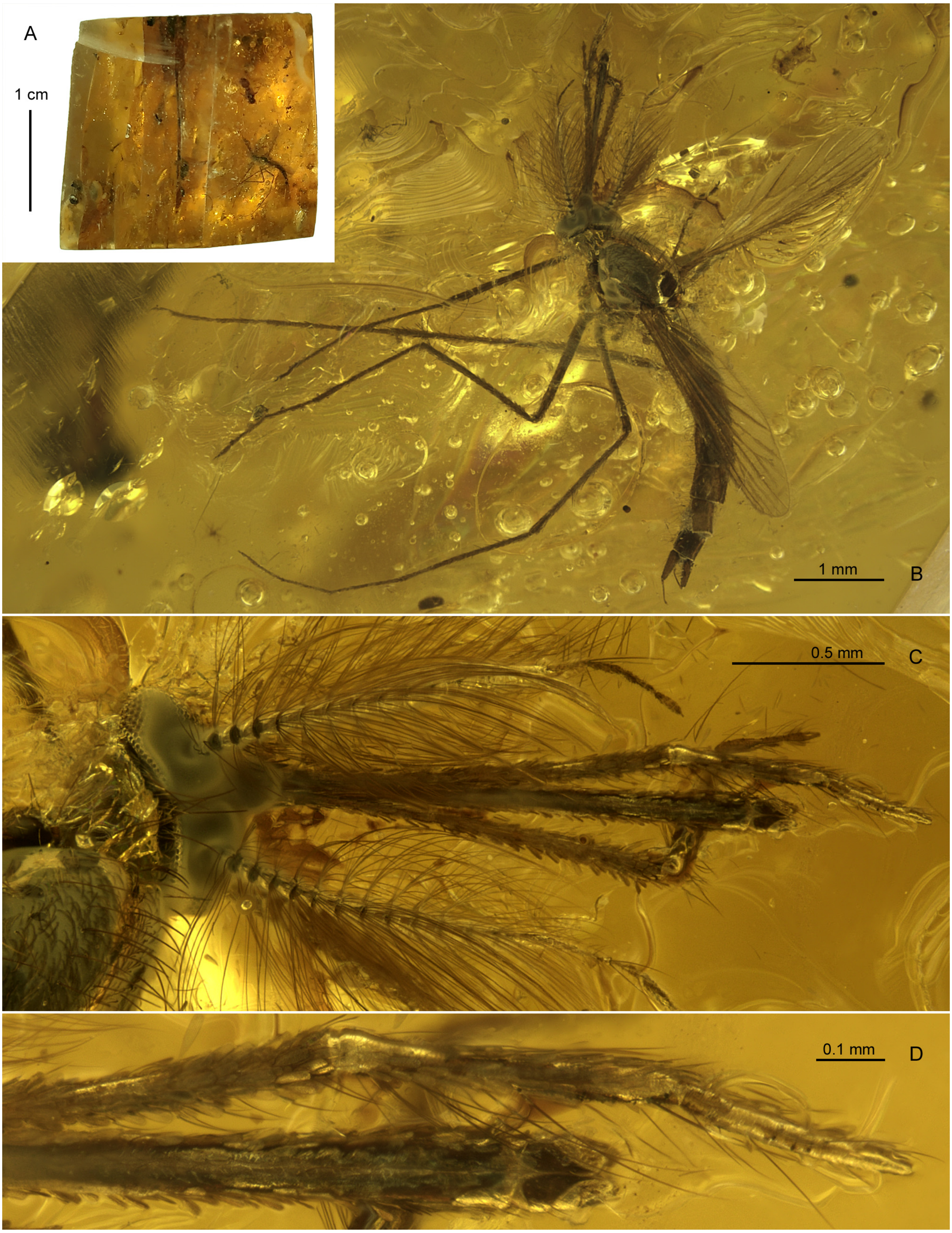

FIGURE 4. Male of *Culiseta gedanica* Szadziewski *et* Giłka, 2011. **A**, Inclusion in amber; **B**, habitus; **C**, head; **D**, maxillary palpus and proboscis.

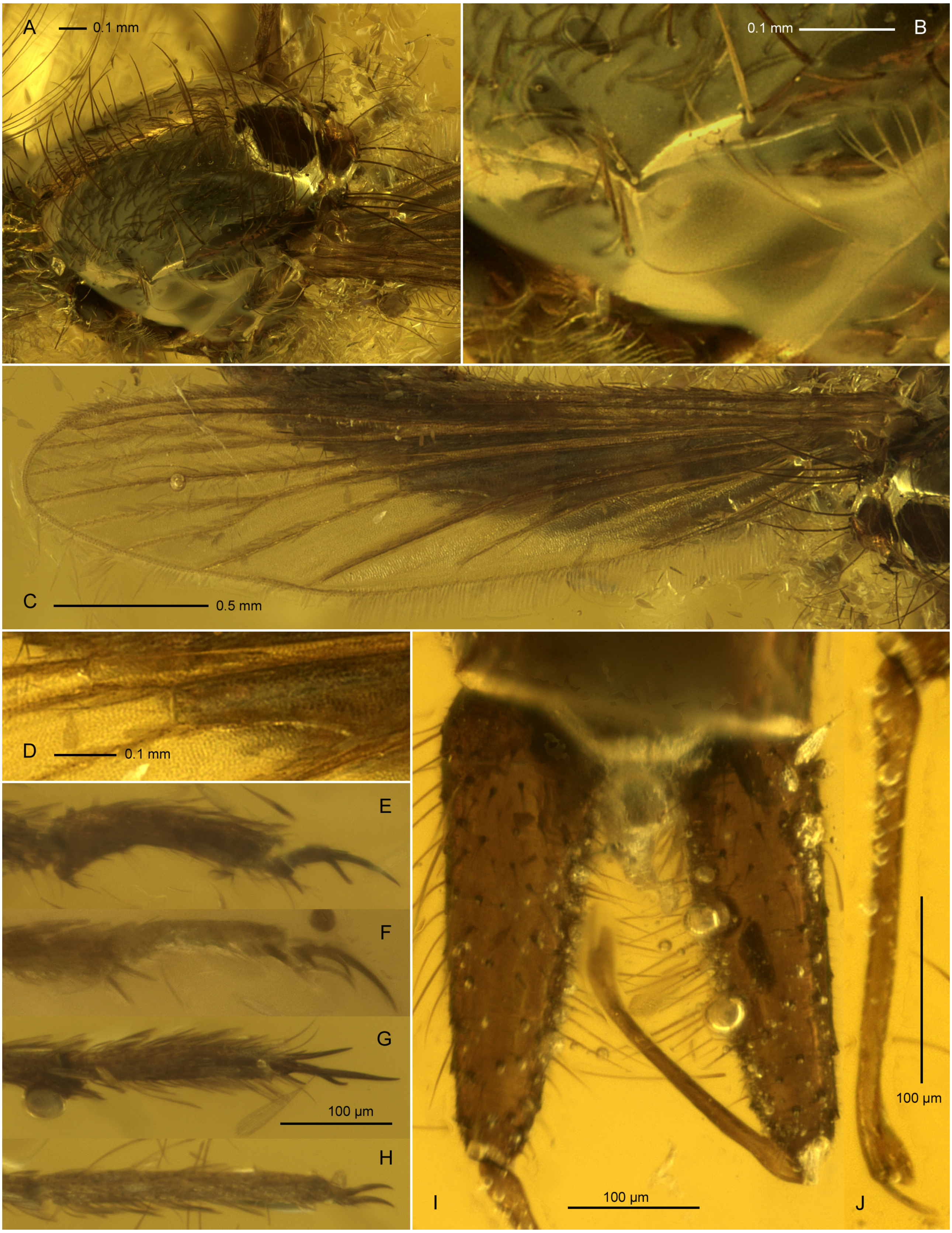

FIGURE 5. Male of *Culiseta gedanica* Szadziewski *et* Giłka, 2011. **A**, Thorax in dorsolateral aspect; **B**, area of mesothoracic spiracle; **C**, wing; **D**, area of radiomedial and mediocubital crossveins; **E**–**H**, ultimate tarsomeres with ungues of fore- (**E**), mid- (**F**, **G**) and hindleg (**H**); **I**, genitalia; **J**, gonostylus.

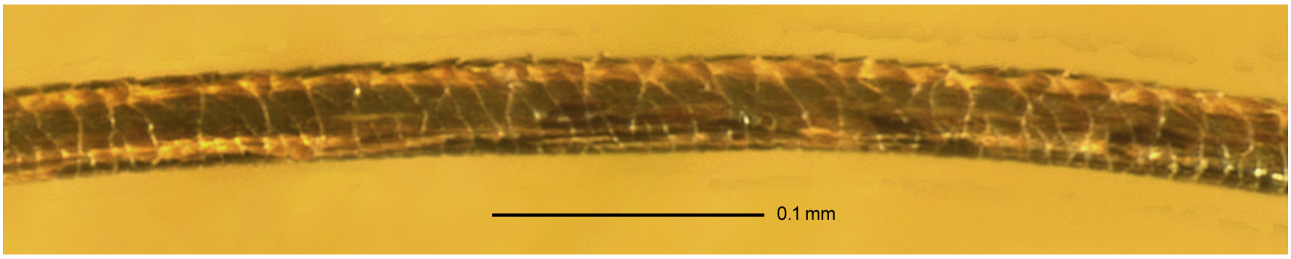

FIGURE 6. The mammalian hair—the syninclusion of the examined specimen of *Culiseta gedanica*.

TABLE 3. Lengths (mm) of leg segments of the male of *Culiseta gedanica* Szadziewski *et* Giłka, 2011. ? Unobservable; measurements of holotype in boldface.

Leg	Femur	Tibia	Tarsomeres				
			1	2	3	4	5
Foreleg	?	1.45	**1.03**–1.09	**0.37**–0.41	0.22–**0.24**	**0.12**–0.14	**0.20**–0.21
Midleg	1.37–**1.77**	1.55–**1.89**	1.39–**1.42**	0.59–**0.63**	0.37–**0.40**	0.14–**0.15**	0.19–**0.21**
Hindleg	1.28	1.59–**1.89**	1.57	0.82	0.58	0.33	0.25

Discussion

Culex

Culex ekaterinae is the seventh extinct species of the genus *Culex* described to date. Three of the seven species are known from inclusions in amber (*Cx*. *erikae*, *Cx*. *ekaterinae* and *Cx*. *malariager*) and four are known from compressions/impressions in sedimentary rock (*Cx*. *damnatorum*, *Cx*. *protorhinus*, *Cx*. *vectensis* and *Cx*. *winchesteri*). The geological ages of the six previously described species are given in Table 1. Three of the fossils are known from North America: *Cx*. *damnatorum* from deposits in Wyoming, *Cx*. *malariager* from Dominican amber (Dominican Republic) and *Cx*. *winchesteri* from deposits in Colorado. The other four species are known from Europe: *Cx*. *protorhinus* and *Cx*. *vectensis* from deposits in England, *Cx*. *erikae* from Baltic amber (Gulf of Gdańsk) and *Cx*. *ekaterinae* from Rovno amber of Ukraine. The four compression fossils and the inclusion fossil *Cx*. *malariager* are all females, all of which are morphologically distinct from and obviously not conspecific with the males of *Cx*. *erikae* and *Cx*. *ekaterinae*.

Szadziewski & Szadziewska (1985) described *Cx*. *erikae* as a species of the nominate subgenus. However, the placement of *Cx*. *ekaterinae*, and also *Cx*. *erikae* due to close similarity, in the subgenus *Culex* is doubtful in view of the following unique anatomical features: the distinct constriction beyond mid-length of the proboscis, the very short mediocubital crossvein with the adjoining veins distinctly indented and the strongly developed posterior cubitus. It is also noted that the agglutination of setae on the subapical lobe of the male gonocoxite is unusual, and seta *g*, which is most often foliform in species of the subgenus *Culex*, is not leaf-like in *Cx*. *ekaterinae*. These features may justify the recognition of a new subgenus, but until the phylogenetic relationships among extant species of the subgenus *Culex* are better understood, we refrain from introducing a new genus-group taxon at this time.

The adult males of *Cx*. *ekaterinae* and *Cx*. *erikae*, compared here, are presumably the most closely related fossil species known so far. They distinctly differ, however, in characters of the head, wing, legs and genitalia. Detailed character comparisons are shown in Figs 1–3 and listed in Table 4.

Culiseta

Interestingly, among a number of arthropod syninclusions in the large piece of amber with the specimen of *Culiseta gedanica*, a mammalian hair was found (Fig. 6). The presence of adults of both sexes of the studied mosquito, including a hematophagous female in the same place and time seems to be highly probable, as does the co-occurrence of the mosquito with the hair of a mammal, the potential host. Although the structure of the hair is not sufficiently specific to determine a particular mammal (being similar to that known from different systematic groups of these animals), the shape of the scales and their arrangement are the characters that may be interpreted as advanced, typical of several extant taxa (J. N. Izdebska, pers. comm.).

TABLE 4. Comparison of diagnostic characters of the males of *Culex ekaterinae* **sp. nov.** and *Culex erikae* Szadziewski *et* Szadziewska, 1985. [1]Present data, [2]Szadziewski & Giłka (2011); a, body without proboscis; b, proboscis; c, thorax + abdomen.

Character	***Culex ekaterinae***[1]	***Culex erikae***[1,2]
Colour	Dark brown to black	Yellowish brown to dark brown
Main body parts (a, b, c)	5.2, 1.77, 4.7 mm	5.0, 2.06, 4.5 mm
Antennal flagellum	1.85 mm	1.77 mm
Flagellomeres 12 and 13	0.44 and 0.47 mm	0.48 and 0.48 mm
Flagellomeres 12+13 / 1–11 ratio	0.97	1.19
Maxillary palpus	2.72 mm	2.74 mm
Palpomeres 4 and 5	0.57 and 0.50 mm	0.53 and 0.45 mm
Palpomeres 4+5 / 1–3 ratio	0.65	0.56
Antennal flagellum/proboscis ratio	1.05	0.86
Proboscis/maxillary palpus ratio	0.65	0.75
Wing	2.90 mm	2.98 mm
Veins R_2/R_{2+3} and R_3/R_{2+3} ratios	3.00 and 3.16	3.1 and 3.2
Base of M_{3+4}/rm ratio	< 1	> 1
Foreungues	Equally long, apically curved	Unequal, evenly curved
Teeth of foreungues (anterior | posterior)	Proximal absent, medial minute | proximal absent, medial absent	Proximal absent, medial stout | proximal small, medial absent
Teeth of midungues (anterior | posterior)	Proximal absent, medial stout | proximal absent, medial absent	Proximal absent, medial stout | proximal small, medial absent
Proximal setae *a–c* of subapical lobe of gonocoxite	Closely appressed, stout	Separated, narrow
Distal setae of subapical lobe	Partially fused, apices spoon-shaped	Separated, apices spoon-shaped

Conclusions

Mosquitoes, as hematophagous insects and vectors of pathogens of diseases in humans, have been of special interest to zoologists since the discovery of their involvement in the epidemiology of malaria and yellow fever at the turn of the nineteenth century. At the time of this writing, 3,585 extant species classified in 41 genera have been described. As indicated in the Introduction, prior to the new species described above, the mosquito fossil record consisted of 27 species ascribed to 12 genera (six extinct; six extant); however, the morphology of each new fossil species provides useful information for understanding the phylogeny of the Culicidae. Three of the fossil species lived in the Cretaceous; the others existed in the Cenozoic, with 16 in the Eocene, including *Culex ekaterinae* described here. This indicates that the diversity of mosquitoes in the Mesozoic was still relatively meagre and increased significantly in the Paleogene, concomitant with the evolution of their avian and mammalian hosts.

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