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A new species of *Tipula* LINNAEUS, 1758 (Diptera: Tipulidae) from Green River Formation, USA

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Original article

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Abstract. We describe *Tipula americana* sp. nov., third known species of *Tipula* from the Eocene Green River Formation (USA). Morphological comparison with its closest recent and fossil relatives is provided.

Key words: Tipulomorpha, Eocene, fossil Diptera, new species.

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I. INTRODUCTION

The Eocene locality of the Green River Formation (USA) (Fig. 1) is one of the best known localities of fossil insects on the Northern Hemisphere. The Green River Formation is formed by a complex of terrestrial and spiny lakes in SE Wyoming, NE Utah and NW Colorado. The position is known for oil shales, minerals and fossils (FEBER & WELLS 1995). It was created by the gulping of the Rocky Mountains, where the lakes to which the sand, mud, and mineral salts flowed and filled the bowl of lakes. On the basis of the fossil reptiles, especially crocodiles, found there, the paleoclimate was subtropical (SELF et al. 2010), without frost, a temperature of 15-21ºC, and high equability (FEBER & WELLS 1995). Calcium carbonate, micrite, calcite or aragonite are found in the sediments. Occurrence of different sediments varies depending on the geological level (SELF et al. 2010). Fossil fishes, birds, reptiles, and mammals are frequent in the Green River Formation. The invertebrate fossil fauna of this locality is abundantly represented by arthropods, mainly by insect compressions (BRENES et al. 1999). To that day two fossil species of the genus *Tipula* LINNAEUS, 1785 have been described from this formation (Table 1).

The genus *Tipula* is one of most numerous genera of the Tipulidae LATREILLE, 1802, which are one of the largest extant families of the Diptera, in the infraorder Tipulomorpha ROHDENDORF, 1961. First Tipulidae are supposed to have evolved from the family Limoniidae SPEISER, 1909 in the Jurassic (rendering this last family paraphyletic) (KRZEMIŃSKI 1992a,b, 1996, 2000, 2001; KRZEMIŃSKI & ANSORGE 1995; SHCHERBAKOV et al. 1995;

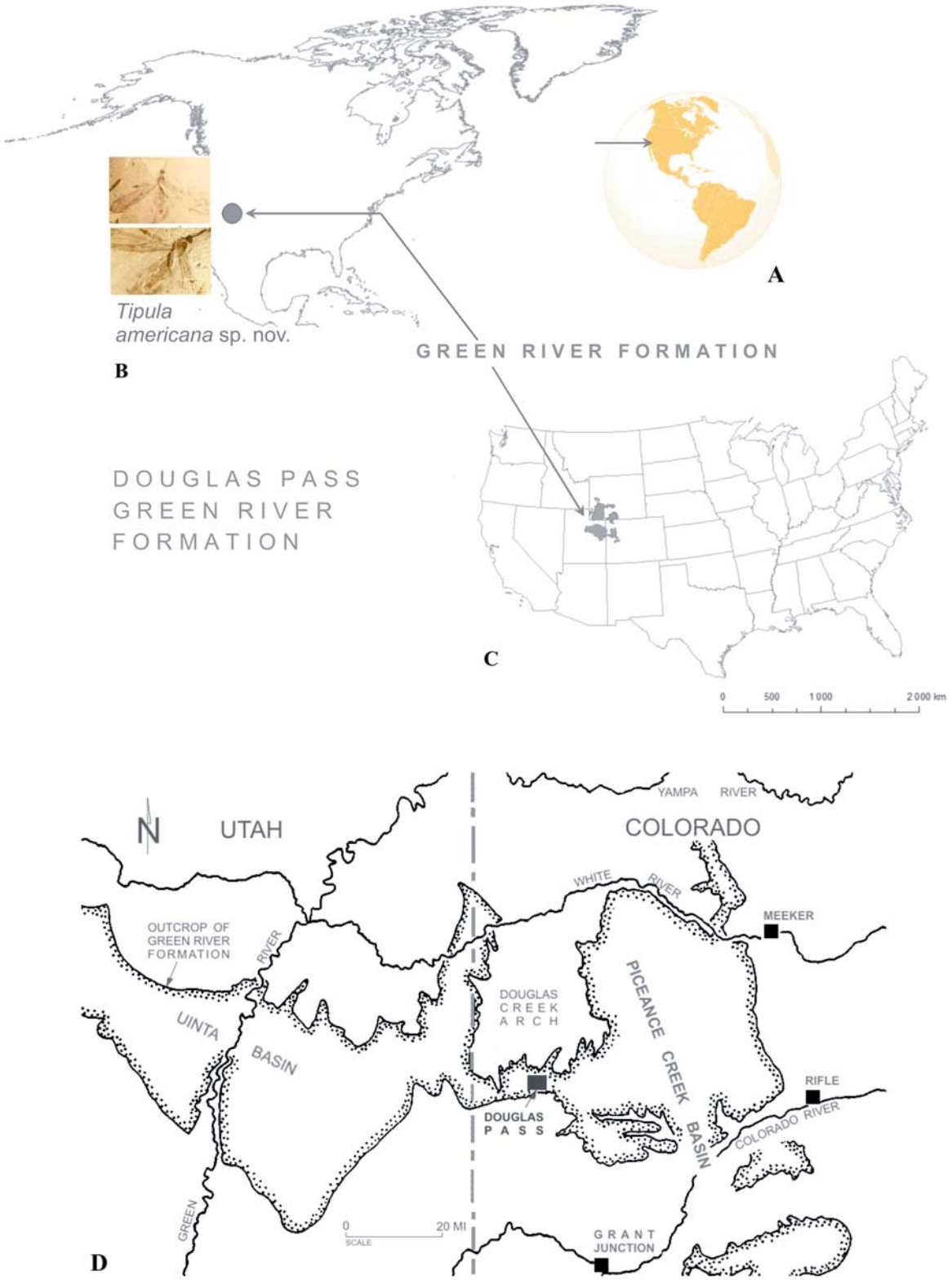

Fig. 1. The locality of fossil new species of Tipulidae preserved in sediments of Douglas Pass, Green River Formation. A – position of Green River Formation on the Earth (after http://www.plecakowcy.pl/ameryka/index.html modified); B – map of North America with the position of Green River Formation; C – map of the United States with the location of the Green River Formation, in the state of Colorado, Utah, Wyoming, using a GPS signal; D – General Index map for the Piceance Creek Basin, Colorado with Douglas Pass locality, and Uinta basin, Utah (after BRADLEY 1931 and COLE 1985, modified).

Table 1

List of fossil species of the genus *Tipula* known from Paleogene of North America (partially after EVENHUIS (1996), modified according to BYERS (2011)

Species	Geological age	Location
Genus *Tipula* LINNAEUS, 1785		
Tipula carolae, LEWIS, 1973	Oligocene	Ruby River Basin, Montana
Tipula decrepita SCUDDER, 1890	Oligocene	White River, Colorado
Tipula rubiensis LEWIS, 1973	Oligocene	Ruby River Basin, Montana
Tipula tecta SCUDDER, 1877	Oligocene	Fossil Canyon, Utah
Tipula bilineata SCUDDER, 1894	Eocene-Oligocene	Florissant, Colorado
Tipula carolinae SCUDDER, 1894	Eocene-Oligocene	Florissant, Colorado
Tipula carpenteri ALEXANDER, 1938	Eocene-Oligocene	Florissant, Colorado
Tipula clauda SCUDDER, 1894	Eocene-Oligocene	Florissant, Colorado
Tipula decorata BROWN, 1985	Eocene-Oligocene	Florissant, Colorado
Tipula consumpta SCUDDER, 1894	Eocene-Oligocene	Florissant, Colorado
Tipula evanitura SCUDDER, 1894	Eocene-Oligocene	Florissant, Colorado
Tipula florissanta SCUDDER, 1894	Eocene-Oligocene	Florissant, Colorado
Tipula fmartinbrowni EVENHUIS, 1994	Eocene-Oligocene	Florissant, Colorado
Tipula heilprini SCUDDER, 1894	Eocene-Oligocene	Florissant, Colorado
Tipula hepiliana COCKERLL, 1909	Eocene-Oligocene	Florissant, Colorado
Tipula internecata SCUDDER, 1894	Eocene-Oligocene	Florissant, Colorado
Tipula lapillescens SCUDDER, 1894	Eocene-Oligocene	Florissant, Colorado
Tipula lethaea SCUDDER, 1894	Eocene-Oligocene	Florissant, Colorado
Tipula limi SCUDDER, 1894	Eocene-Oligocene	Florissant, Colorado
Tipula maclurei SCUDDER, 1894	Eocene-Oligocene	Florissant, Colorado
Tipula magnifica SCUDDER, 1894	Eocene-Oligocene	Florissant, Colorado
Tipula needhami COCKERELL, 1910	Eocene-Oligocene	Florissant, Colorado
Tipula picta SCUDDER, 1894	Eocene-Oligocene	Florissant, Colorado
Tipula reliquiae SCUDDER, 1894	Eocene-Oligocene	Florissant, Colorado
Tipula revivificata SCUDDER, 1894	Eocene-Oligocene	Florissant, Colorado
Tipula rigens SCUDDER, 1894	Eocene-Oligocene	Florissant, Colorado
Tipula subterjacens SCUDDER, 1894	Eocene-Oligocene	Florissant, Colorado
Tipula tartari SCUDDER, 1894	Eocene-Oligocene	Florissant, Colorado
Tipula wilmatteae MELANDER, 1949	Eocene-Oligocene	Florissant, Colorado
Tipula sepulchri SCUDDER, 1890	Eocene	Green River, Wyoming
Tipula spoliata SCUDDER, 1890	Eocene	Green River, Wyoming
Tipula tulameena HANDLIRSH, 1910	Eocene	Tulameena River, British Columbia
Tipula tubifera WIGHTON, 1980	Paleocene	Canada

KRZEMIŃSKI & EVENHUIS 2000; KRZEMIŃSKI & KRZEMIŃSKA 2003; BLAGODEROV et al. 2007; SHIH et al. 2015; KRZEMIŃSKI et al. 2017). Currently the family Tipulidae comprises over 4000 extinct and extant species (EVENHUIS 1994, 1996; OOSTERBROEK 2018), but the knowledge about the origin and early evolution of this group of insects is still relatively scarce. The genus *Tipula* with ca. 2800 described extant species (OOSTERBROEK 2018) comprises medium and large sized insects, with V-shaped mesonotal suture, distinguished by their very long terminal segment of maxillary palpus, distinct nasus and the absence of ocelli (SHIH et al. 2015). Currently they are worldwide distributed, occurring on almost all continents except Antarctica (OOSTERBROEK 2018). Their Paleogene record in North America is represented by 33 species of *Tipula* (Table 1; SCUDDER 1877, 1890, 1894; COCKERELL 1909, 1910; HANDLIRSCH 1910; ALEXANDER 1938; MELANDER 1949; LEWIS 1973; WIGHTON 1980; BROWN 1985; EVENHUIS 1994). The largest number of fossil species of *Tipula* were described from Florissant, Colorado (Eocene-Oligocene). Four species were described from the Oligocene (Ruby River Basin in Montana, Fossil Canyon in Utah, and White River in Colorado). Only two species of *Tipula* were described from the Eocene:

Tipula sepulchri SCUDDER, 1890, and *Tipula spoliata* SCUDDER, 1890. Lastly, a pupa (*Tipula tubifera* WIGHTON, 1980) was described from the Paleocene of Alberta (Table 1). From the Paleogene, over 70 species are known, Palearctic representatives of *Tipula* were described from Denmark (HENRIKSEN 1922; FREIWALD 1990), Turkey (KANIA & NEL 2013), and Baltic Region (LOEW 1850; MEUNIER 1899, 1906; ALEXANDER 1931).

In this paper we describe a new species of *Tipula* from the Douglas Pass in the Green River Formation. This is a third species of this genus known from this locality.

II. MATERIAL AND METHODS

The study was based on material from the Natural History Museum in Paris (MNHN). The study material (one specimen) is an imprint from the Green River Formation, Douglas Pass (Fig. 1) dated on Eocene.

A detailed analysis of the specimen was performed using standard methods used in paleoentomology studies. The specimen was studied using a Nikon SMZ 1500 stereomicroscope. The microphotographs were taken with a Nikon DSFi1 camera equipped with a stereomicroscope. The drawings were made on the basis of specimen and photographs. The measurements were taken with NIS Elements D 3.0 software. Maps were made using a computer program to create ArcGIS geographic maps, based on databases obtained by the GPS signal.

III. SYSTEMATIC PALAEONTOLOGY

Order: **Diptera** LINNAEUS, 1758

Family: **Tipulidae** LATREILLE, 1802

Subfamily: **Tipulinae** LATREILLE, 1802

Genus: ***Tipula*** LINNAEUS, 1758

Type species: *Tipula oleracea* LINNAEUS, 1758; by subsequent designation of LATREILLE, 1810: 379.

Tipula americana sp. nov.

(Figs 2-4)

D i a g n o s i s. Sc ending opposite 1/3 the length of Rs; Rs slightly longer than m-cu, m-cu twice longer than R_3 and slightly longer than R_4; d-cell positioned in one fifth of wing length, rather small, pentagonal, 2/3 longer than petiole; R_1 ending just beyond bifurcation of R_{2+3+4}; R_{2+3} as long as m-cu; M_1 and M_2 very short, as long as d-cell; M_3 twice longer than petiole; M_4 separating from M_{3+4} in 1/4 of d-cell.

C o m p a r i s o n. The new species *T. americana* sp. nov. differs from other species known from the Paleogene of USA by its wing venation, especially the very short M_1 and M_2, as long as d-cell. The two species of *Tipula* described by SCUDDER (1890) from the Green River (Wyoming) differ from this newly described species as follows: in *Tipula sepulchri* SCUDDER, 1890 vein Rs is longer than m-cu, M_1 and M_2 are distinctly longer than

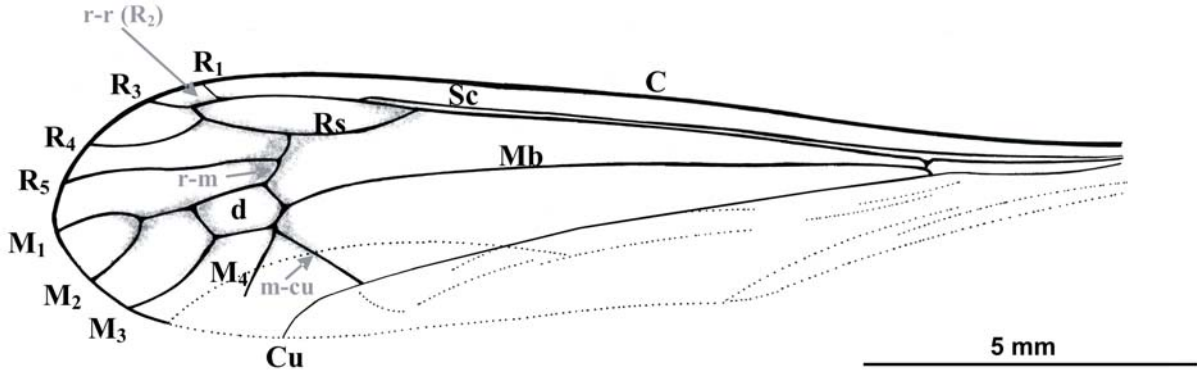

Fig. 2. *Tipula* (*Tipula*) *americana* sp. nov., holotype, MNHN.F.A70573, drawing of wing. Abbreviations: C – costal vein; Cu – cubital vein; d – discal cell (d-cell); m-cu – medio-cubital cross-vein; Mb – medio-basal vein; M_1-M_4– medial veins; Rs – sector radii; R_1-R_5 – radial veins; Sc – subcostal vein.

Fig. 3. *Tipula* (*Tipula*) *americana* sp. nov., holotype, MNHN.F.A70573: photograph of habitus, dorsal view.

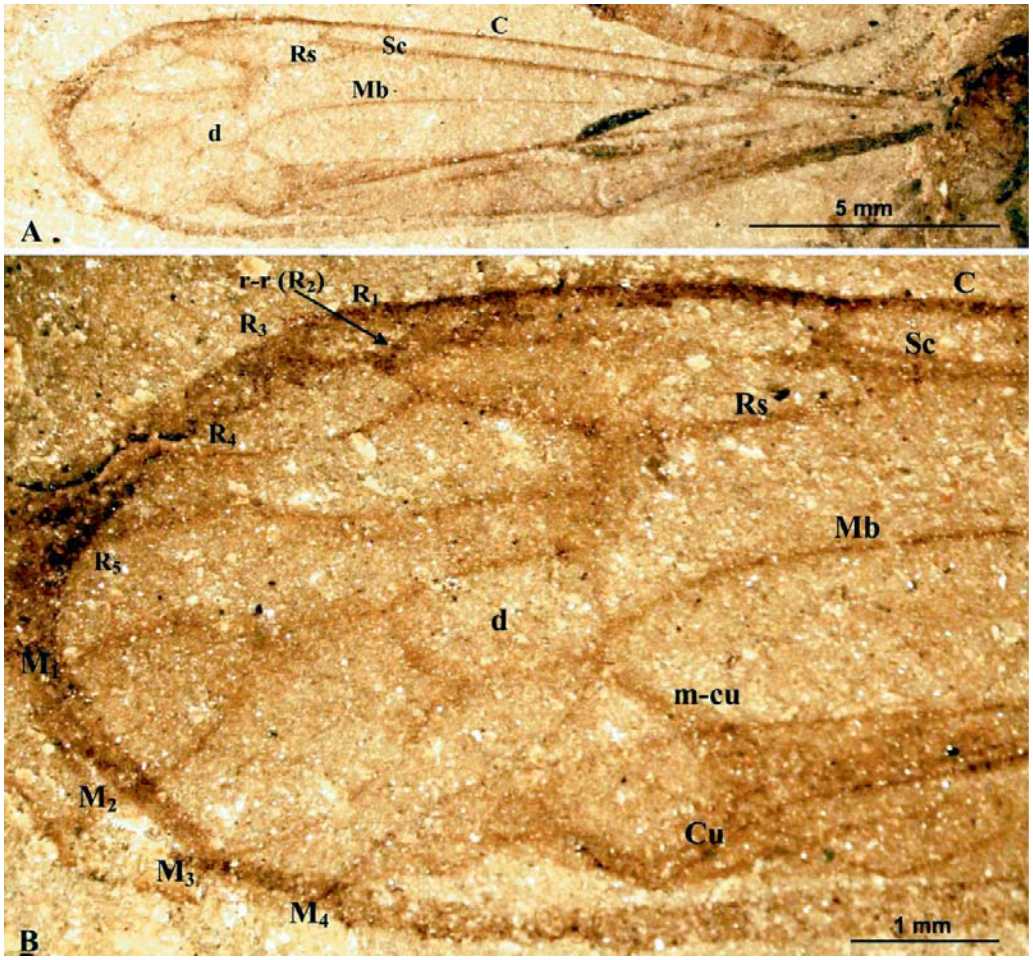

Fig. 4. *Tipula* (*Tipula*) *americana* sp. nov., holotype, MNHN.F.A70573. A – photograph of wing venation; B – enlarged photograph of apex of wing with d-cell visible. Abbreviations: C – costal vein; Cu – cubital vein; d – discal cell (d-cell); m-cu – medio-cubital cross-vein; Mb – medio-basal vein; M_1-M_4– medial veins; Rs – sector radii; R_1-R_5 – radial veins; Sc – subcostal vein.

d-cell, d-cell is positioned in 2/3 of wing length, d-cell is longer than wide, about half as long as broad (SCUDDER 1890). In *Tipula spoliata* SCUDDER, 1890, the vein Rs is rather short, approximately as long as cross vein m-cu (SCUDDER 1890). In *T. americana* Rs is short, only slightly longer than m-cu, similarly to that in *T. spoliata*, but in *T. spoliata* d-cell is short, longer than wide and is rather less than half as long as broad, veins M_1 and M_2 are longer than d-cell (SCUDDER 1890). In *T. americana* sp. nov., in contrast to *T. sepulchri*, the cross vein m-cu is elongated and only slightly shorter than Rs. Moreover, in *T. sepulchri* and *T. spoliata* M_1 is longer than d-cell. In *T. spoliata*, M_1 is twice as long as petiole, while in *T. sepulchri* the petiole is about 1/3 of M_1. In the newly described species, M_1 is shorter than d-cell, and as long as petiole, and d-cell is twice as long as broad.

Etymology. The species name "americana" is derived from North America.

Material examined. Holotype MNHN.F.A70573, Natural History Museum in Paris.

Age and occurrence. Eocene, paleolake of Douglas Pass, Green River Formation, USA.

Description. The body (Fig. 3) pale brown with dark brown pattern on thorax and head, the specimen is rather small, 14.34 mm long.

Head (Fig. 3): 1.64 mm long, 1.54 mm wide, with huge eyes.

Thorax (Fig. 3): wing (Figs 2; 3; 4A, B): 4.18 mm wide; 17.21 mm long; dark spots along veins; venation well preserved, but basal part of wing is not well visible; pterostigma not large, indistinct; Sc ending opposite 1/3 length of Rs, Rs longer than m-cu; R_4 very short, arched, only slightly shorter than Rs; R_5 wavy, d-cell positioned in 1/5 of wing length from wing base, rather short, almost twice as long as wide, pentagonal; cross vein m-cu long, equal in length to R_{2+3+4}, m-cu positioned between M_4 and Cu, just beyond fork of M_{3+4}, fork of M_{3+4} into M_3 and M_4 positioned in 1/4 of d-cell length; M_3 arched.

Abdomen: genitalia not well preserved.

Remarks. Head with palpi and antennae, and right wing of the specimen are not well preserved on imprint. Venation of wing is well preserved, except the anal part of wing which is rolled up which makes the reconstruction of wing shape impossible; but all taxonomic features are visible. Sex of the specimen is unknown because the genitalia are invisible.

IV. DISCUSSION

In recent fauna the genus *Tipula* is worldwide distributed. It is the most numerous in the Holarctic region with over 1800 species, and in the Palearctic region over 1300 species. In the Afrotropical region is represented by less than 200 species, in Australian and Oceanian region no more than 30 species occur. In the Neotropical region the genus *Tipula* is represented by over 400 species (OOSTERBROEK 2018).

The climate on the Earth had changed and some periods are characterized by more or less hot or cold climates. Connected with damp environments; the representatives of *Tipula* are most numerous in the Oligocene (EVENHUIS 1996), when the climate was dynamic with a long term transition from ice-free to glaciated world (SALAMY & ZACHOS 1999). Tipulidae appeared in the Upper Jurassic (KRZEMIŃSKI 1992a,b; KRZEMIŃSKI et al. 2017) and became more numerous in the Lower Cretaceous (LUKASHEVICH & RIBEIRO 2018). All species known from this period belong to the 'basal' genus *Leptotarsus* GUERIN-MENEVILLE, 1831. To this genus belongs also *Leptotarsus* (s. lato) *eva* KRZEMIŃSKI, 1992b which was previously described as the oldest *Tipula* (KRZEMIŃSKI 1992b; RIBEIRO & LUKASHEVICH 2014; RIBEIRO et al. 2015). The first representatives of the genus *Tipula* are known in Paleogene during which a rapid radiation of this group of insects had started. Numerous species are known in Paleogene localities of North America (SCUDDER 1877, 1890, 1894; COCKERELL 1909, 1910; HANDLIRSCH 1910; ALEXANDER 1938; MELANDER 1949; LEWIS 1973; WIGHTON 1980; BROWN 1985; EVENHUIS 1994), Europe (HENRIKSEN 1922; FREIWALD 1990, KANIA & NEL 2013), and also in Baltic amber (LOEW 1850; MEUNIER 1899, 1906; ALEXANDER 1931).

V. CONCLUSION

This new discovery confirms the significant diversity of the genus *Tipula* during the Eocene-Oligocene in North America, and importance of the Paleogene period for radiation of this genus at least in the Northern hemisphere. The relative scarcity of this genus in the southern continents may be related to the more recent colonization of these areas from Eurasia and North America.

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