

***Heterhelus buzina* sp.n. (Coleoptera: Kateretidae) from Rovno amber: the first proxy for *Sambucus* in the Eocene of Eastern Europe**

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ABSTRACT. *Heterhelus buzina* sp.n. is described from Rovno amber. The new species seems similar to the extant *H. scutellaris* (Heer, 1841), but differs from its by size (length 1.8 mm), relatively small scape, longer elytra exposing two complete abdominal tergites, and confused elytral puncturation. All extant species of *Heterhelus* develop on *Sambucus*; the *Heterhelus* record from Rovno amber is the first indication of *Sambucus* presence in Eocene flora of Eastern Europe.

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***Heterhelus buzina* sp.n. (Coleoptera: Kateretidae) из ровенского янтаря — первый связанный с бузиной вид из эоцена Восточной Европы**

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РЕЗЮМЕ. Описан *Heterhelus buzina* sp.n. из ровенского янтаря. Новый вид похож на современный вид *H. scutellaris* (Heer, 1841), отличается от него меньшей длиной тела (1,8 мм), относительно маленьким скапусом, более длинными надкрыльями, которые оставляют свободными два абдоминальных тергита, смешанной пунктировкой

надкрылий. Все современные виды *Heterhelus* развиваются на *Sambucus*; находка *Heterhelus* в ровненском янтаре — первое указание на присутствие *Sambucus* в эоценовой флоре Восточной Европы.

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КЛЮЧЕВЫЕ СЛОВА: янтаре Уазы, *Heterhelus scutellaris*, приабон, опыление.

Introduction

Beetles from Rovno amber are understudied (Bukejs *et al.*, 2020); only 60 species, 51 genera from 21 families have been reported so far (Bukejs *et al.*, 2020; Bukejs, Legalov, 2020; Sokolov, Perkovsky, 2020; Legalov *et al.*, 2021). In this paper we add to Rovno amber coleopterofauna a new species, genus and family.

Better studied Rovno hymenopteroфаuna includes 135 species, 66 of which are known from Baltic amber (Radchenko, Perkovsky, 2020; Simutnik *et al.*, 2020); for Rovno coleopterofauna the share of Baltic species is only 13% (Bellés, Perkovsky, 2016; Jałoszynski, Perkovsky, 2016, 2019; Nadein *et al.*, 2016; Nazarenko, Perkovsky, 2016; Perkovsky, 2016; Tshernyshev, 2016; Bogri *et al.*, 2018; Bukejs *et al.*, 2018, 2020; Legalov *et al.*, 2018, 2019; Petrov, Perkovsky, 2018; Bukejs, Legalov, 2019a, b, 2020; Kupryjanowicz *et al.*, 2019; Kazantsev, Perkovsky, 2020; Kypke, Solodovnikov, 2020; Lyubarsky, Perkovsky, 2020; Sokolov, Perkovsky, 2020; this paper).

The species is related to the family Kateretidae: truncate elytra with three complete abdominal tergites exposed, antennae with 11 antennomeres, looser 3-segmented club, tarsal formula 5-5-5, tarsomere 4th the shortest, prothoracic and mesothoracic trochantin exposed, prosternal process short, open procoxal cavities, and all coxae widely separated. The modern fauna of the family are not well understood, and only partial revisions exist (Hisamatsu, 2011).

There are nine known fossil species of Kateretidae. The oldest is *Lebanorettes andelmani* Kirejtshuk et Azar, 2008, from Barremian Leb-

anese amber (Kirejtshuk, Azar, 2008). *Furcalabratum burmanicum* Poinar et Brown, 2018, *Cretarettes minimus* Peris et Jelínek, 2020, *Eoceniretes antiquus* Peris et Jelínek, 2020 (Poinar, Brown, 2018; Peris, Jelínek, 2020), *Electrumeretes birmanicus* Peris et Jelínek, 2019 and *Polliniretes penalveri* Peris et Jelínek, 2019 (Peris, Jelínek, 2019) were described from Cenomanian Burmese (Kachin) amber. Two species were described from Ypresian Oise amber: *Eoceniretes yantaricus* Kirejtshuk et Nel, 2008 and *Heterhelus expressus* Kirejtshuk et Nel, 2008 (Kirejtshuk, Nel, 2008) and one species from the late Priabonian: *Amartus petrefactus* Wickham, 1912 (Florissant: Wickham, 1912).

Kateretid beetles are becoming essential for understanding the evolution of early pollination strategies, and also the rapid success of flowering plants during the mid-Cretaceous. Kateretidae showed mutualisms with a variety of gymnosperms and one angiosperm host during the Cretaceous (Peris *et al.*, 2020), thus demonstrating how a gymnosperm-to-angiosperm shift occurred during the Cretaceous amongst the generalist pollen-feeding family of beetles, driving the subsequent success of flowering plants (Peris *et al.*, 2020). The gymnosperm hosts (as pollen) were cycads, ginkgoaleans, and bennettitaleans, whereas the angiosperm host (also as pollen) was a water lily (Nymphaeales: Nymphaeaceae). It seems important to trace the evolution of this family in the further history of the development of pollination.

The new species belongs to the genus *Heterhelus* Jacquelin du Val, 1858. Diagnosis of this genus: body oval, convex dorsally; pronotum transverse, projecting at mid-length or uniformly rounded lateral margins; disc with punctures

smaller than the eye facet; posterior angles obtusely angulate; basal margin nearly straight or with slight curvature; male abdominal tergite VIII externally visible; tarsal claws simple.

Material and Methods

The beetle inclusion is preserved in a polished piece of amber (Fig. 1A), yellowish in colour, without supplementary fixation. The amber piece is elongate. Digital photographs were taken in the Laboratory of Evolutionary Biology and Insect Ecology at the Institute of Biology, University of Białystok (Poland). Images were obtained with an Olympus DSX110 stereomicroscope and a camera with a colour CCD image sensor (1/1.8 inch, 2.01 megapixels), equipped with a DSXPLFL 3.6x lens. The specimen drawings were made using CorelDrawX6.

The holotype will be deposited at the Professor Andrzej Myrcha University Centre of Nature (UCP), University of Białystok (Białystok, Poland).

Taxonomical part

Family Kateretidae Erichson 1843

Genus *Heterhelus* Jacquelin du Val, 1858

Species type. *Cercus sambuci* Erichson 1843 [= *Heterhelus scutellaris* (Heer, 1841)], recent.

Heterhelus (Heterhelus) buzina sp.n.

Figs. 1, 2.

HOLOTYPE. The specimen, in Rovno amber, deposited under accession number UCP No. 287. No syninclusions.

Type-locality: Klesov (Ukraine).

DIAGNOSIS. Length 1.8 mm. Scape relatively small. Elytra exposing two complete abdominal tergites, elytral puncturation confused. Tarsal claws simple, without basal tooth.

DESCRIPTION. Body (Fig. 1: A, B) parallel-sided, convex, reddish-yellow, dully shining, covered with whitish setae. Head transverse

and short, somewhat shorter than the distance between the eyes, densely punctate, punctures on disc smaller than the eye-facet, separated by 1-2 diameters (Fig. 1C). Antennal (Fig. 1E) insertions hidden behind projections of the frons; antennae 11-segmented with an indistinct 3-segmented, loosely articulated club. Antennae 1.1 times longer than the greatest width of the head, including eyes, with club 3-segmented; approximate ratio of segments: 31 : 10 : 7 : 6 : 7 : 5 : 6 : 5 : 9 : 9 : 12. Two apical segments are missing on the left antenna. Scape relatively small, elongated, not very long, 2.18 times longer than its width. Eyes prominent, ocular setae absent. Labrum moderately arcuate (Fig. 1C). Terminal segment of labial palpus elongate-oval (Fig. 1D).

Pronotum (Figs. 1B) convex, transverse, 1.5 times as wide as long; anterior margin slightly convex, anterior corner not prominent; anterior margin unbordered; lateral margin bordered; sides not explanate, not ciliate; basal margin indistinctly bordered, almost straight; punctures on disc similar in size to those on the head; posterior angles slightly obtuse.

Length of prosternum (excluding prosternal process) 1.17 times as long as the length of the mesoventrite, length of mesoventrite 0.5 times as long as the length of the metaventrite; prosternal process slender, subparallel-sided, apex truncate (Fig. 1F). Procoxae transverse, separated. Metaventrite convex, shining, densely covered with whitish or yellowish setae; punctures on disc about the same size as those on the head, separated by one diameter in the middle, becoming denser laterally (Fig. 2A). Mesocoxae and metacoxae widely separated, metacoxae not reaching the elytra at the sides. Inter-mesocoxal distance separated by 2.4 times the width of the inter-procoxal distance. Inter-metacoxal distance separated by 3.6 times the width of the inter-procoxal distance.

Six visible abdominal segments; abdominal segment 1 is the longest. Abdominal sternites shining; approximate ratio of length of abdominal sternites I–VI is 36 : 10 : 10 : 23 : 22 : 8 (Fig. 2B); abdominal sternite VI short, the greatest width of the sixth abdominal sternite 5.5

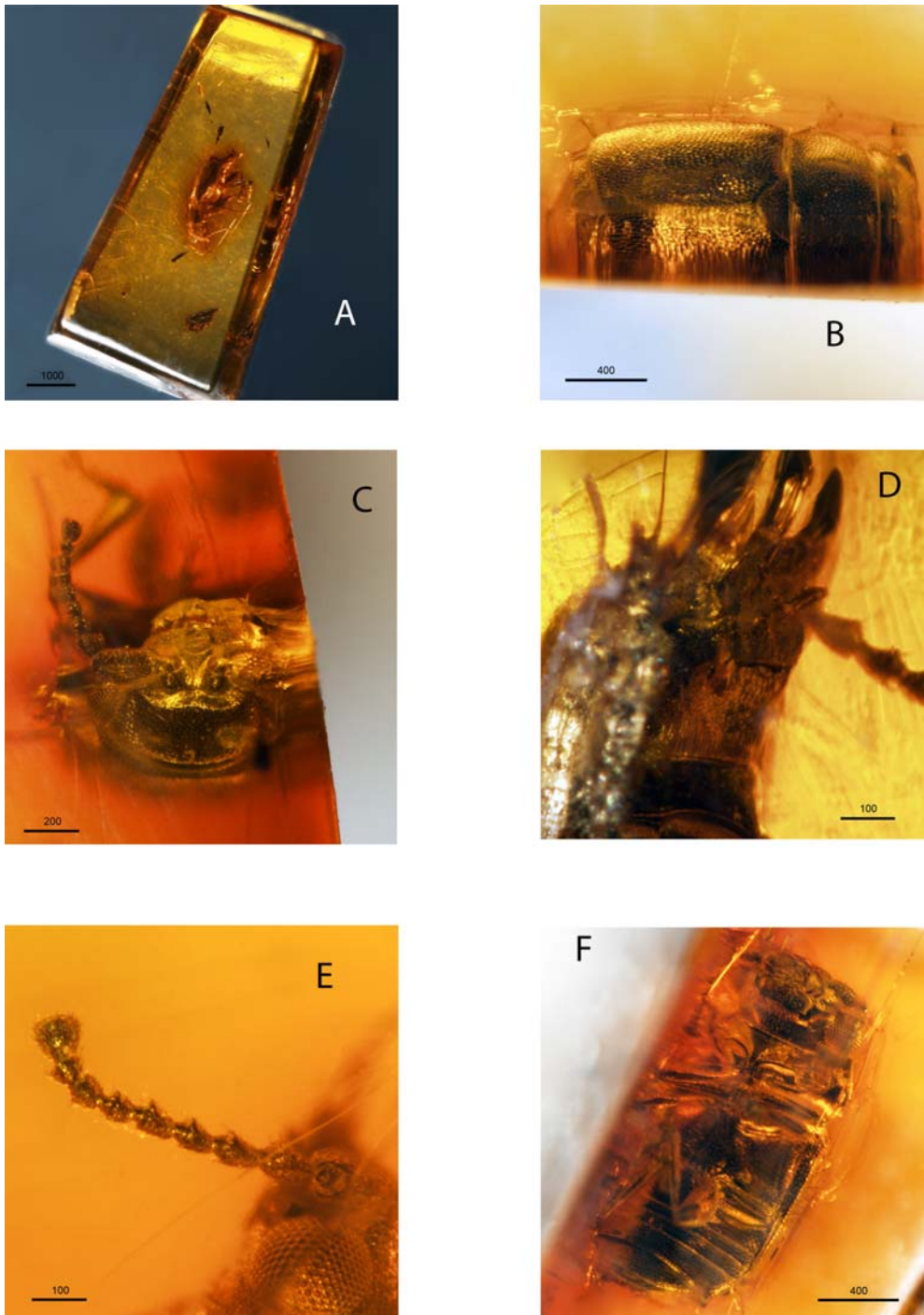


Fig. 1. *Heterhelus buzina* sp.n. (photo): A — total view, amber piece; B — total view, dorsal; C — head, in front; D — head, lateral; E — antenna; F — total view, ventral.

Рис. 1. *Heterhelus buzina* sp.n., фото: А — общий вид янтаря с включением; В — общий вид, дорзально; С — голова спереди; D — голова сбоку; E — усик; F — общий вид, вентрально.

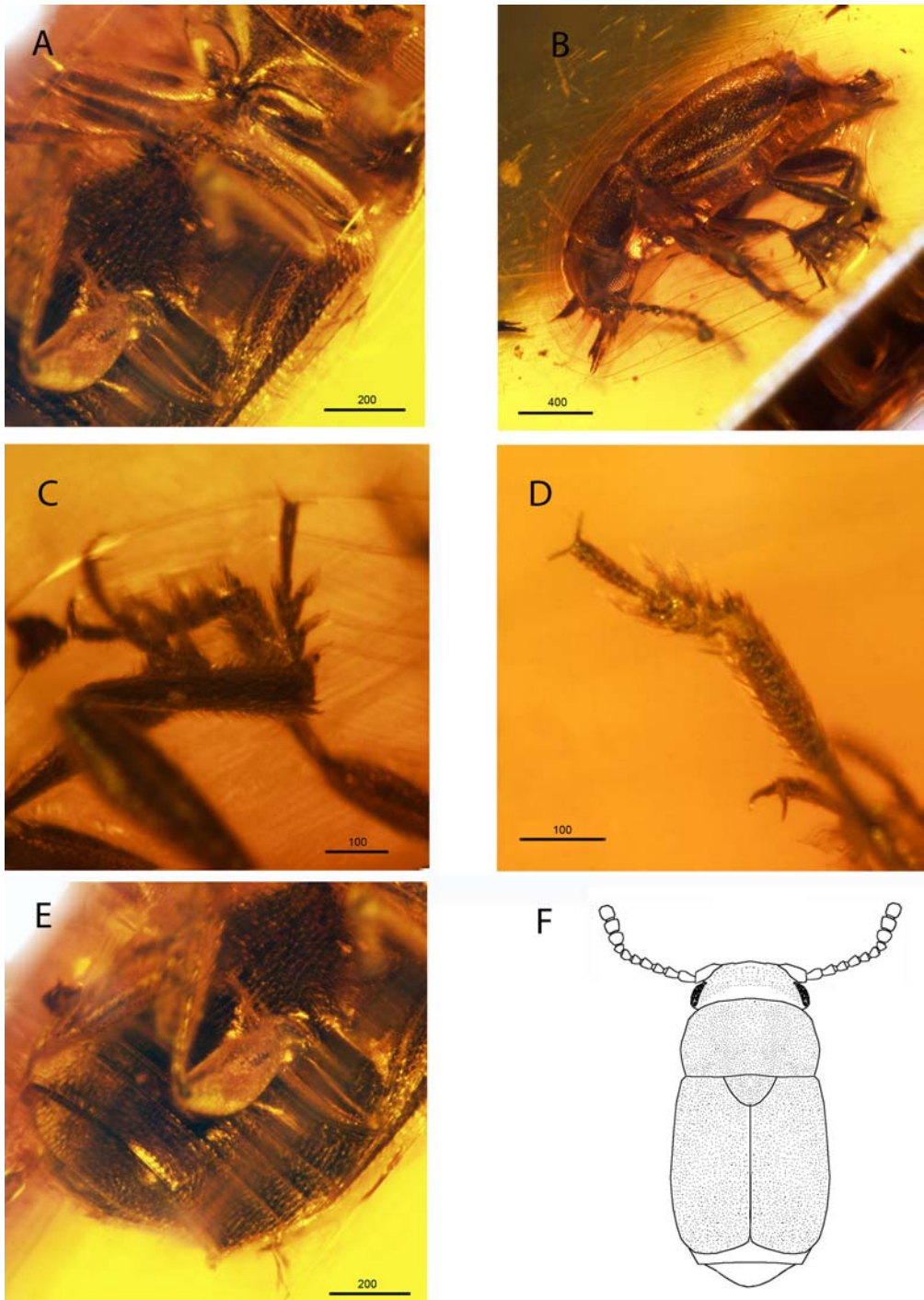


Fig. 2. *Heterhelus buzina* sp.n. (photo and drawing): A — meso- and metathorax, ventral; B — total view, lateral; C — tibia and tarsus II and III; D — claw; E — abdomen; F — total view, dorsal, line drawings.
 Рис. 2. *Heterhelus buzina* sp.n., фото и рисунок: А — средне- и заднегрудь, вентрально; В — общий вид, латерально; С — голени и лапки II и III; D — коготок лапки; E — брюшко; F — общий вид, дорзально.

times larger than the greatest length of the sixth abdominal sternite (Fig. 2E). Legs flattened; protibiae rather slender and short, shorter than the greatest width of the head, including the eyes. Tibia with a pair of spurs in the inner apical angle. Tarsi 5-5-5, with three basal tarsomeres subequal in length, strongly lobed. Tarsal claws simple, somewhat bulbous, but without a basal tooth (Fig. 2C, D).

Scutellar shield stout, triangular, apically rounded. Elytra truncated, exposing two complete abdominal tergites (Fig. 2B). Elytral disc diffusely punctured. Elytra conjointly 1.2 times as long as wide, 2.2 times as long as the pronotum; punctures on disc larger and shallower than those on the pronotum. Abdominal tergite VI partially obscured by elytra. Abdominal tergite VII fully exposed, apex rounded.

ETYMOLOGY. Buzina is the Russian and Ukrainian name for *Sambucus*.

Discussion

It differs from almost all fossil species by its slightly shortened elytra; in most species, they leave three abdominal segments completely free. Of the many extinct genera and species, the new species is different in size: *Furcalabratum burmanicum* 2.6 mm, elytra with rows of punctures, scapus large; *Cretaretes minimus* very small (1.6 mm), tarsus without lobes, scapus large; *Eoceniretes yantaricus* 2 mm, scutellum with transversal groove; *Lebanoretetes andelmani* very small (1.5 mm) and very shortened elytra, leaving the last three abdominal segments completely exposed, scapus large; *Electrumeretes birmanicus* 1.65 mm, shortened elytra, leaving the last three abdominal segments completely exposed; *Polliniretes penalveri* 2.9 mm, shortened elytra, leaving the two last abdominal segments and part of the third completely exposed, elytra with rows of punctures; *Heterhelus expressus* 3.6 mm, much longer.

Heterhelus differs from the similar genus *Kateretes* in the following characteristics: the points on the pronotum are smaller than the facets of the eye, the posterior angles of the pronotum are not rounded, but angulated. In the

middle of the abdominal sternites there are no areas with dense long hairs.

The genus *Heterhelus* includes seven extant species, zoogeographic characteristics in Hisamatsu (2011); all species are associated with *Sambucus* L., 1753 (Spornraft, 1967; Audisio, 1993; Jelinek, Cline, 2010).

Differences from the closely related species *Heterhelus scutellaris* (Heer, 1841): antenna with 3 segmented club (in *H.scutellaris* the 9th segment is narrower and the club is almost two-segmented); the size of *H.scutellaris* is 2.2–3.1 mm, whereas the new species is 1.8 mm. The punctures on the head of the new species are less frequent, and the distance between them is greater than the diameter of the puncture. Elytra of *H.scutellaris* rounded separately, each elytra independently rounded at the apex; in the new species the elytra are obliquely cut from the outside to the inside. The scutellum in the new species is larger and has the shape of an equilateral triangle, while in *H.scutellaris* it is an isosceles triangle; the new species has a longer scutellum.

Heterhelus scutellaris is related to an ecological type that is oligotrophic, anthophagous and spermatophagous. Perhaps an extinct species similar to it was characterized by similar food preferences. Sibero-European *Heterhelus scutellaris* and *H. solani* are living in mesophilous forests and shady habitats, at the edges of streams; at the larval stage within ripening fruits of *Sambucus* (Adoxaceae), especially on *S. racemosa* L. and *S. nigra* L., and adults mostly on flowers on their host-plants (Audisio *et al.*, 2000).

The new species is easily distinguished from the Ypresian *Heterhelus expressus*: the latter has a larger size (length 3.6 mm) and is reddish brown with a round dark spot at the inner apical angle of each elytron.

Extant species of the genus are distributed in the following regions.

Heterhelus (Boreades) solani (Heer, 1841) is distributed in Europe, Eastern Siberia, the Far East of Russia, Mongolia, S. Korea and Japan (Sibero-European by Audisio *et al.*, 2000). Larval development on *Sambucus racemosa* L and *S. nigra* (Audisio *et al.*, 2000).

Heterhelus (Boreades) abdominalis (Erichson, 1843) is distributed in Canada from New Brunswick to Manitoba, in USA south to Georgia, and west to Texas, Arkansas, Missouri, Nebraska, Kansas, and Iowa (Majka *et al.*, 2008 and references therein). Larval development, probably, on *Sambucus canadensis* L.

Heterhelus (Heterhelus) morio (Reitter, 1878) is distributed in Japan. Larval development on *Sambucus racemosa* L.

Heterhelus (Heterhelus) satoi Hisamatsu et Lee, 2007 is distributed in Taiwan. Larval development, probably, on *Sambucus javanica* Blume (syn. *Sambucus formosana* Nakai).

Heterhelus (Heterhelus) scutellaris (Heer, 1841) is distributed in Europe, Eastern Siberia, the Far East of Russia, Mongolia and Japan (Sibero-European by Audisio *et al.*, 2000). Larval development on *Sambucus racemosa* L. and *S. nigra* (Audisio *et al.*, 2000).

Heterhelus (Heterhelus) sericans (LeConte, 1869) is distributed in Canada from Newfoundland to British Columbia, in USA south to North Carolina and Tennessee, and west to Kansas and Wisconsin. (Majka *et al.*, 2008 and references therein). Larval development, probably, on *Sambucus pubens* Michaux, and *Sambucus canadensis* L.

Heterhelus (Taiwanoheterhelus) nigricans Hisamatsu et Lee, 2007 is distributed in Taiwan. Larval development, probably, on *Sambucus javanica* Blume.

It should be noted that in Taiwan only one specimen of almost 1900 specimens of Taiwanese *Heterhelus* was reliably collected below 1800 m. Almost all specimens were collected at an altitude of 1800 to 2600 m (Hisamatsu, Lee, 2007), i.e. they originate from subtropical cloud mountain forests.

Thus, all extant species of *Heterhelus* develop on *Sambucus*; subfossil *Heterhelus* records were used as a proxy for *Sambucus* (Young, 1984).

Heterhelus is divided into subgenera mainly according to the structure of the antennae club and terminal segment of the labial palpus (Hisamatsu, Lee, 2007). The labrum of subgenus *Heterhelus* is deeply notched and has antenna

with an indistinct 3-segmented club. Subgenera *Boreades* and *Taiwanoheterhelus* have a shallow notched labrum and antenna with a distinct 3-segmented club. Subgenus *Boreades* differs from subgenus *Taiwanoheterhelus* by its terminal segment of the labial palpus; not slender — *Boreades*, slender — *Taiwanoheterhelus*. The club of the new species is indistinct. The new species belongs to the subgenus *Heterhelus*.

Before the Oligocene *Sambucus* was known in Europe from the thermophile biotas of Reading Beds and Cliff End Beds (corresponding to the Paleocene/Eocene boundary and the Bartonian, England), and Eckfeld (Lutetian, Germany). Priabonian records belong to equable biotas of Florissant (USA, Colorado) (Allen *et al.*, 2020) and Novosibirsk Region (Western Siberia). From the whole of Eastern Europe (including Russoscandia) Paleogene records of *Sambucus* are not known.

Heterhelus was not found in the huge Klebs collection, although the genus was well known to Edmund Reitter, who determined the beetles (Klebs, 1910); ‘*Sambucus*’ species from Baltic amber have too many petals to belong to *Sambucus* (Cockerell, 1910), so this record is the first indication of *Sambucus* presence in Priabonian amber forests. Based on the modern and Eocene distribution of *Sambucus* and *Heterhelus*, it can be assumed that *Heterhelus* adapted to feeding on *Sambucus* in regions with an equable climate, in which both genera are found in the late Eocene, which prevents *Heterhelus* from spreading further towards south, to regions with hotter summers, included in the modern range of *Sambucus*.

As only *Sambucus* endocarps provide highly reliable generic diagnostic characteristics (Huang *et al.*, 2012), *Heterhelus* fossil records (except the questionable Oise one) can be used as a proxy for *Sambucus*, e.g. *H. buzina* for the oldest *Sambucus* record for Eastern Europe.

Compliance with ethical standards

CONFLICTS OF INTEREST: The authors declare that they have no conflicts of interest.

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