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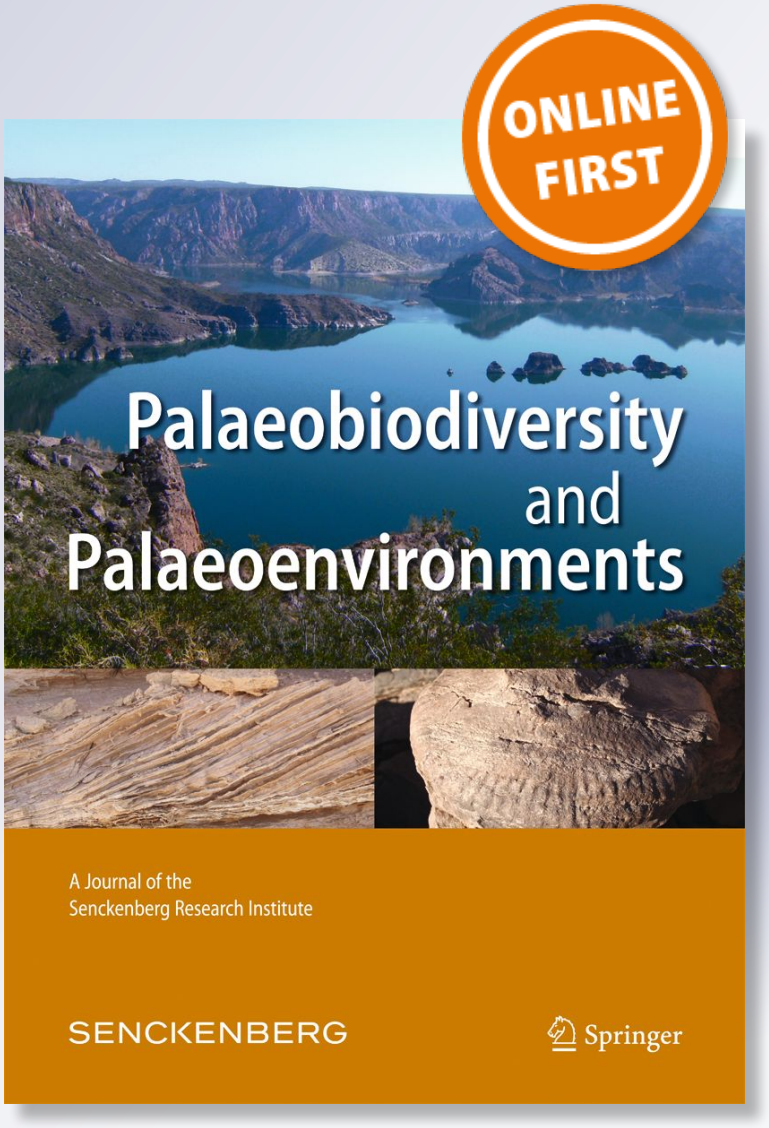
Palaeobiodiversity and Palaeoenvironments

ISSN 1867-1594

Palaeobio Palaeoenv
DOI 10.1007/s12549-018-00369-w



Springer

Palaeobiodiversity and Palaeoenvironments
https://doi.org/10.1007/s12549-018-00369-w

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ORIGINAL PAPER

First record of March flies (Insecta: Diptera: Bibionidae) from the Miocene Gračanica mine (Bugojno, Bosnia-Herzegovina)

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Received: 3 April 2018 / Revised: 26 June 2018 / Accepted: 13 December 2018

Abstract

Two fossil March flies (Insecta, Diptera, Bibionidae) are recorded from open lake deposits of the middle Miocene Gračanica mine near Bugojno in Bosnia and Herzegovina. These two fossils represent the first insects found in this outcrop. One specimen is described as *Plecia* sp. indet, the other as *Bibio* sp. indet. The incomplete preservation does not allow for species descriptions, but the specimens seem not to be conspecific with any known fossil bibionids. The habitus and colouration of the *Bibio* specimen is very similar to the recent species *Bibio hortulanus* (Linnaeus). The presence of the genus *Plecia* is considered to indicate warm climate, while *Bibio* points more to a temperate climate. But for reliable conclusions on the climate, much more records of bibionid fossils would be needed.

Keywords Insecta · Diptera · Bibionidae · Miocene · Gračanica

Introduction

The Gračanica mine is situated in the Bugojno Basin in central Bosnia and Herzegovina (Mandic et al. 2016; papers in this special issue). It is a large opencast mine from which mammalian remains and molluscs have been reported earlier. Based on earlier geological investigations (Mandic et al. 2011, 2016) and on gastropods (Harzhauser et al. in press, this issue), the age of the deposits was dated as middle Miocene, early Langhian and was interpreted to range between 15.4 and 15.0 Ma, correlating to MN5. Ongoing stratigraphic analyses currently indicate a slightly younger date, somewhere in the range between 15.2 and 14.0 Ma (pers. comm. O. Mandic), correlating with MN5 and early MN6. For a final integrative biostratigraphic and magnetostratigraphic dating of the Gračanica section, see Mandic et al. (in prep., this issue).

In 2017, excavations were conducted in the Gračanica mine by the JURASSICA Museum, Porrentruy (Switzerland) and by the Geological Paleontological Department of the Natural History Museum Vienna (Austria) in cooperation with the Federal Geological Survey of Bosnia and Herzegovina and the mine authorities. During these excavations, the first macroscopic arthropod fossils from this locality have been found, which comprise two insects and a crab. In this paper we report on the two insects.

The two fly fossils (and also the only other arthropod found until now, a crab) were found in the upper half of the section cropping out in the Gračanica coal mine. The upper half of the section (about 20 m in height) are clear light-coloured, laminated sediments (marls, silts, sands), whereas the lower half of the section (also about 20 m) is dominated by interlayers of coaly sediments and lignites (this is where all mammalian remains come from) (see also Mandic et al. 2016, fig. 28, personal communication Ursula Göhlich 2018). These two parts represent different habitats, and the March flies were found in what corresponds to the "littoral" or the "profundal" part of an open lake (personal communication Davit Vasilyan 2017 and 2018). This fits well with other records of fossil bibionid flies which are mostly found in deposits of former lakes.

This article is a contribution to the special issue "The drowning swamp of Gračanica (Bosnia-Herzegovina)—a diversity hotspot from the middle Miocene in the Bugojno Basin"

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Published online: 04 March 2019

Material and methods

This study is based on two specimens of fossil flies (coll-No. MJSN GRC-126.1 (part A)-126.2 (counterpart B) and MJSN GRC-127.1 (part A)-127.2 (counterpart B).

The fossils are deposited in the JURASSICA Museum (former Musée jurassien des sciences naturelles, MJSN), Porrentruy, Switzerland.

The bibionid specimens were examined under a Leica MZ12.5 stereomicroscope with an attached Camera lucida for making

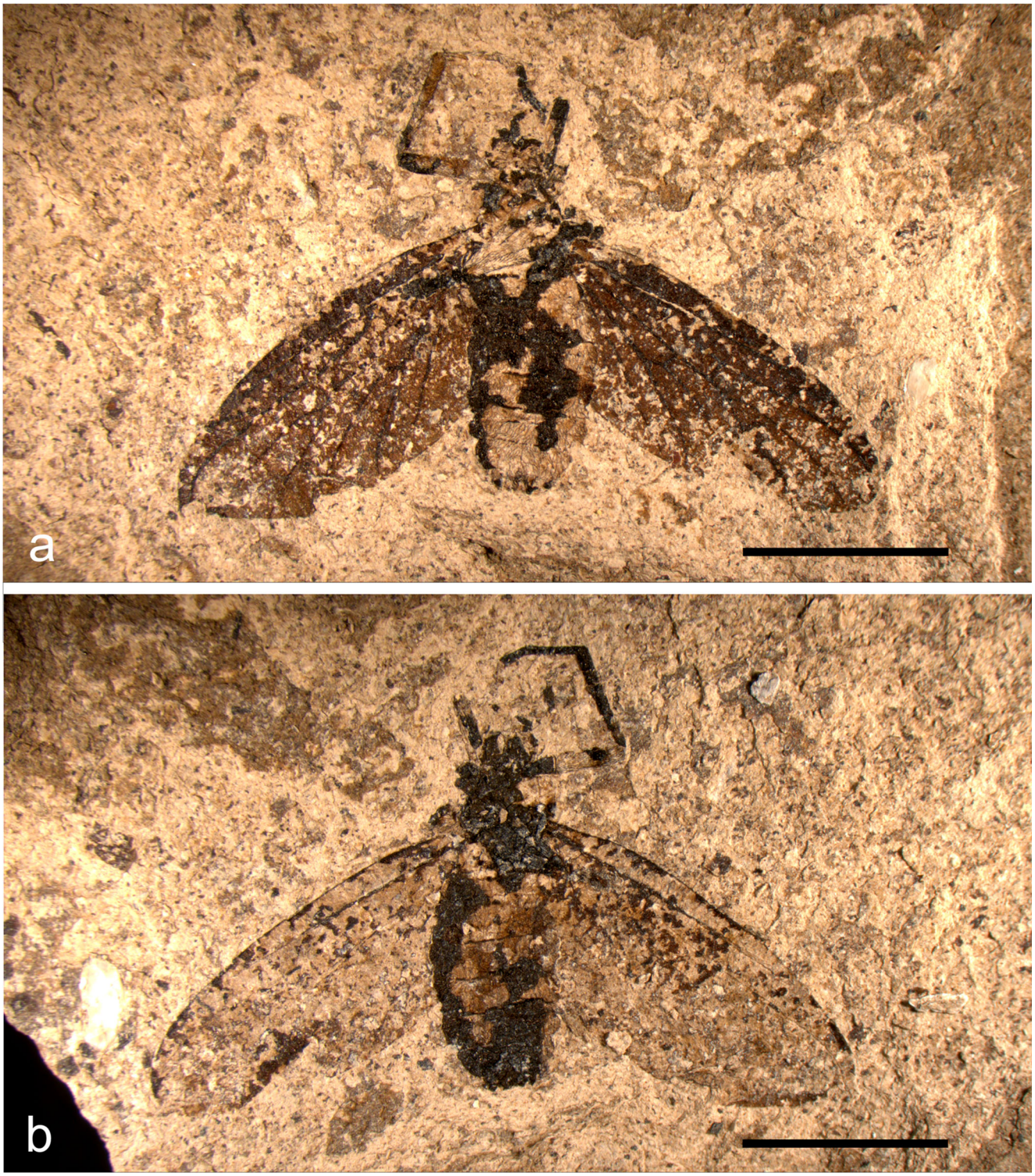

Fig. 1 *Plecia* sp. indet. (Bibionide), **a** MJSN GRC-127.1, **b** MJSN GRC-127.2. Scale = 5 mm

drawings. Photographs were taken either using a Leica MZ12.5 stereomicroscope and an attached Nikon D300 digital camera or with a Leica M165C stereomicroscope with an attached digital camera PROGRES GRYPHAX® ARKTUR (Jenoptik Optical Systems). Terminology follows Merz and Haenni (2000).

Systematic palaeontology

Insecta, Diptera, Bibionidae
Plecia Wiedemann, 1828

Plecia sp. indet.
(Figs. 1, 2)

Material: MJSN GRC-127.1 (part A) and MJSN GRC-127.2 (counterpart B).

Locality and horizon: Gračanica mine, collected in 2017 from the surface; exact horizon not clear, originating from the range between 23 and 27 m of the Gračanica profile in Mandic et al. 2016, fig. 28, corresponding to the littoral or profundal facies of the open lake (personal communication Davit Vasilyan 2017 and 2018).

Description and preservation: Female. Total body length 7.4 mm, dorsoventrally embedded, strongly compressed. Body entirely black.

Head length not visible, head width ca. 1 mm. Antenna incompletely preserved, seven characteristic flagellomeres preserved.

Thorax length and width not visible.

Wing length ca. 8 mm, width 3.6 mm, length/width = 2.2. Rather short and wide wing, membrane dark brown, all veins black. Pterostigma indistinctive. Costa not well preserved. Humeral cross vein not visible. Distal part of subcosta preserved, relatively long, terminates on Costa

Fig. 2 *Plecia* sp. indet. (Bibionide), wing venation. **a** Microphotograph of left wing of MJSN GRC-127.1. **b** Reconstruction of wing venation of specimen MJSN GRC-127, wing venation from left and right wing combined. Scale 1 mm

much nearer to origin of R_{2+3} than to crossvein r-m. Vein R_{2+3} slightly curved, R_{4+5} distally distinctively curved.

Wing vein measurements (curves are neglected in the measurements, measured on reconstructed wing venation, Fig. 2b): length Rs basal to r-m 1.8 mm; length Rs distal to r-m 1.4 mm; length R_{2+3} 1.2 mm; length R_{4+5} 2.6 mm; length M distal to r-m 0.5 mm; length mm; length M1 3.1 mm; length M2 2.9 mm; length r-m 0.4 mm; length m-cu 0.4 mm; length CuA1 3.3 mm; length CuA2 2.3 mm.

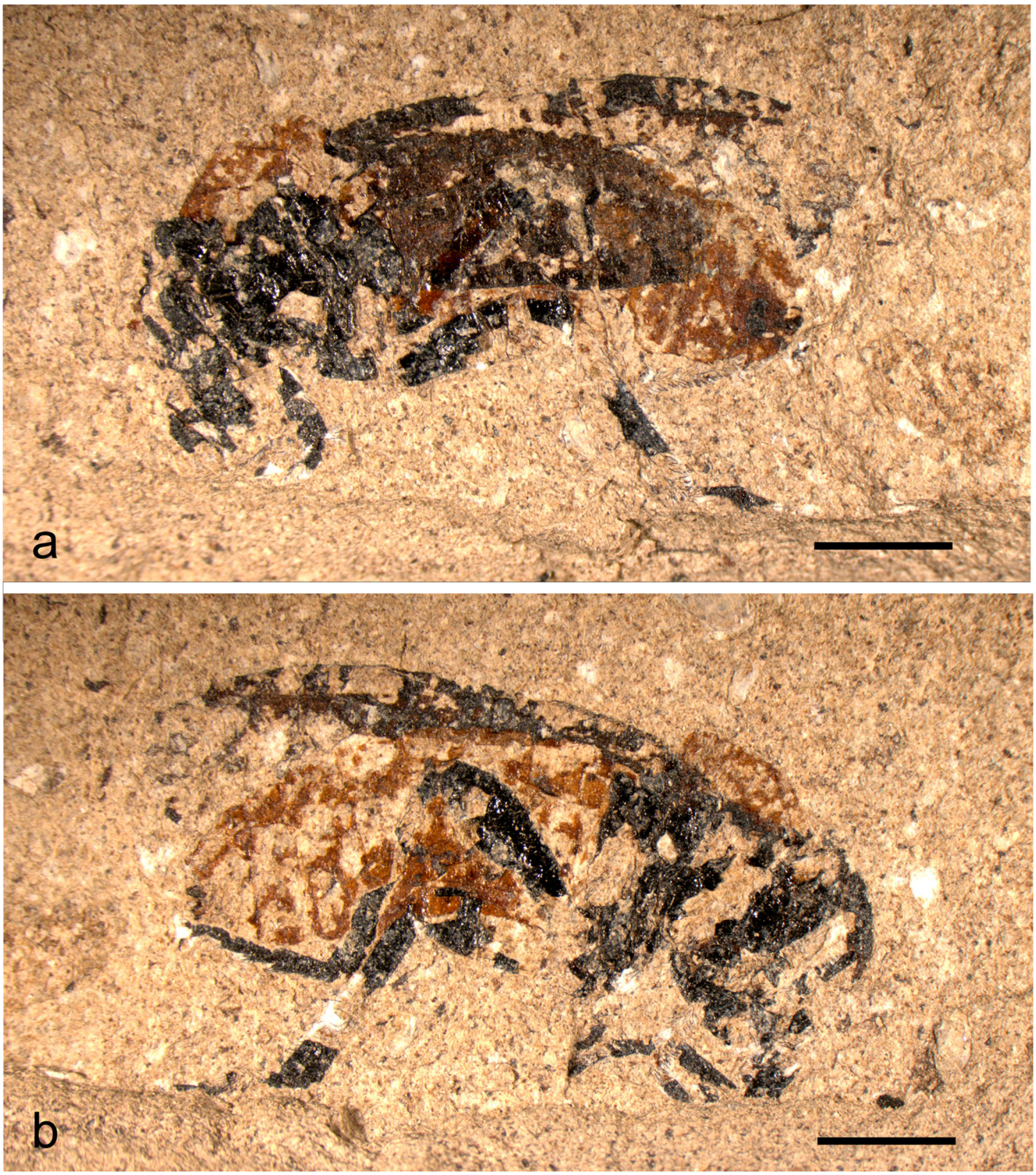

Fig. 3 *Bibio* sp. indet. (Bibionide), **a** MJSN GRC-126.1, **b** MJSN GRC-126.2. Scale = 2 mm

Legs completely black, slender; fore femur length 2.1 mm, fore tibia length 2.3 mm, length of first tarsomere of fore leg 1.6 mm.

Abdomen length ca. 5 mm, width 2.7 mm.

Discussion of systematic placement: The partly preserved, flattened antennal flagellomeres are typical for Bibionidae. The bibionid genera *Plecia* and *Penthetria* are usually separated using the length of vein R_{2+3}. This works well with the recent species but frequently becomes difficult when trying to identify fossils, since the length of this vein seems to vary in a rather continuous manner (e.g. Rice 1959). In this specimen, the shape of vein R_{2+3} is intermediate between typical *Plecia* and typical *Penthetria*; however, the generally stocky habitus and particularly the short, inconspicuous cerci of this specimen suggest it could be placed in the genus *Plecia* reasonably unambiguously. The incomplete preservation of the specimen does not allow a species description.

Insecta, Diptera, Bibionidae
Bibio Geoffroy, 1762

Bibio sp. indet.
(Fig. 3)

Material: MJSN GRC-126.1 (part A) and MJSN GRC-126.2 (counterpart B).

Locality and horizon: Gračanica mine, collected in 2017 from the surface, in the middle part of the Gračanica profile in Mandic et al. 2016, fig. 28. Exact horizon not clear, originating from the range between 23 and 27 m of the Gračanica profile in Mandic et al. 2016F, fig. 28, corresponding to the littoral or profundal facies of the open lake (personal communication Davit Vasilyan 2017 and 2018).

Description and preservation: Female. Body length from thorax to tip of abdomen 10 mm, laterally embedded, strongly compressed. Body with colouration preserved: the mesonotum, and the abdomen have a reddish-brown colour, the rest of the body including the legs is black.

Head badly preserved. Antenna incompletely preserved, seven characteristic flagellomeres preserved. Thorax length and width not measurable. Wings only partly preserved, membrane dark, veins black.

Legs black, femora of all legs appear to be thickened, length not measurable. Slender; fore femur length 2 mm, fore tibia length 2.2 mm, length of first tarsomere of fore leg 1.5 mm. Abdomen length ca. 6 mm, width less than 3 mm.

Discussion of systematic placement: The partly preserved, flattened antennal flagellomeres are typical for Bibionidae. The habitus and the thickened shape of the fore tibia support an assignment to the genus *Bibio*, because there seem to be no rows of spines, but a strong apical spine. This is characteristic for *Bibio*, but also for the very rare genera *Bibiodes*, *Bibionellus*, and *Enicoscollus*. The incomplete preservation of the specimen does not allow a species description.

The general habitus and the colouration of this specimen are strikingly similar to the recent species *Bibio hortulanus* (Linnaeus). The head, pronotum, pleura and legs are black, mesonotum, and abdomen brownish-orange (likely orange-red in life). The blackish-brown fumose wing is also like in modern *B. hortulanus* females. Apparently, the specimen also has a crossvein R-M a little less than half the length of basal Rs, and a spoon-shaped spur on the hind tibia, though these characters are more difficult to ascertain in the specimen at hand.

We cannot see that this reasonably well-preserved specimen differs from the recent *Bibio hortulanus* in any observable character. This raises the question if it is possible that a species from the Miocene may have survived to the present. There is some evidence for the presence of the same species from localities widely separated in time e.g. the Oligocene sites of Céreste and Aix-en-Provence (both France) (Skartveit and Nel 2017) and also Rott (Oligocene, Germany) and Radoboj (Miocene, Croatia) (Skartveit, pers. obs.), suggesting that it may be possible for a bibionid species to survive for 10 Myr or more; however, because of its insufficient preservation, we cannot be sure if this single specimen could be conspecific with *B. hortulanus.* Finding more specimens, preferably of both sexes is essential if this is to be confirmed. In the literature, there is one record of the recent, oriental species *Bibio flavissimus* Brunetti from the Miocene of China (Zhang 1989).

Comparison to other Miocene March flies (Bibionidae)

From European Fossil localities, Bibionidae are known from Mókollsdalur in Iceland (Skartveit et al. 2017), from Öhningen in Southern Germany (material revised by Skartveit and Pika 2014), from the Randeck Maar in Germany (no published species, but the material has been studied by JS) and from Radoboj in Croatia (Skartveit and Krizmanić, manuscript in preparation). Recently, a single specimen of *Penthetria* was recorded from Zillerleite in Germany (Beaury et al. 2017). JS has also seen material from the Miocene localities Andance and Sainte-Reine, both in France and from Bellver in Spain. The specimens were also compared to material from the late Oligocene sites of Aix-en-Provence, France (Skartveit and Nel 2017), Rott (Statz 1943) and Enspel (Wedmann 2000), both in Germany, and Bes-Konak in Turkey (Skartveit and Nel 2012).

Concerning MJSN GRC-127, determined as *Plecia* sp. indet., there are a few female specimens from Randeck Maar which may habitually resemble this specimen, but it does not resemble any species known from Öhningen (Skartveit and Pika 2014) nor from Radoboj (Skartveit and Krizmanić, manuscript in preparation). There also do not appear to be any

species closely resembling this species from the late Oligocene localities Aix-en-Provence or Rott.

The specimen MJSN GRC-126, determined as *Bibio* sp. indet, does not resemble any species known from Radoboj (Skartveit and Krizmanić, manuscript in preparation) nor from Mókollsdalur (Skartveit et al. 2017). Heer (1849: 223) stated that the nominal species *Bibio lividus* Heer from Radoboj was coloured like the recent *Bibio hortulanus*; however, this was not confirmed by the examination of the holotype (Skartveit and Krizmanić, manuscript in preparation). Also, *Bibio lividus* is considerably larger than the present specimen with a body length of approximately 15 mm. In the key to species from Öhningen (Skartveit and Pika 2014), this species would key out to *Bibio brevis* Heer, but it differs from this species in numerous characters e.g. the colour of mesonotum and wings. It also does not resemble any species from Randeck Maar (JS unpublished observation). From the Spanish Miocene locality Bellver there are some isolated wings known which appear similar to the present specimen in size and colour (material in Musée National d'Histoire Naturelle, Paris) but no meaningful comparison can be made since the wings of specimen GRA 2017-8 are poorly preserved. There are no species from the late Oligocene sites closely resembling this specimen.

Palaeoecological inferences of the bibionid fossils

Recent species of *Plecia* are widespread in the tropics and are dominating elements of tropical bibionid faunas, while in temperate climates species of *Bibio* dominate the faunas (Hardy 1950, 1981, 1989). For example, in the holarctic region, there are many more species of *Bibio* than of *Plecia*. In Europe today, no species of *Plecia* occur, and there are only two Nearctic species of *Plecia* (Hardy 1965, Krivosheina 1986). And in the Neotropical, Australasian, Oriental and Afrotropical regions species of *Plecia* are much more common than *Bibio* (Fitzgerald 2004).

Based on the distribution of extant genera, fossil March flies have been used to infer temperature changes during the Cenozoic (Gentilini 1991; Wedmann 1998, 2000; Collomb et al. 2008). Especially *Plecia* is considered to be a good indicator of warm conditions (Collomb et al. 2008).

In the Gračanica material, the presence of one *Plecia* and one *Bibio* could point to a rather warm climate, but of course much more specimens are required for reliable conclusions.

Acknowledgements For her help and coordination, we thank Priv.-Doz. Dr. Ursula Göhlich, Natural History Museum Vienna, Austria. For the loan of the fossils and for various information, we thank Dr. Davit Vasilyan, Porrentruy, Switzerland. We sincerely thank Dr. Scott Fitzgerald and Dr. Andre Nel for reviewing the manuscript and Dr. Oleg Mandic for further comments.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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