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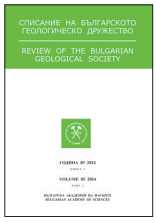

Problematic fossils from the Upper Cretaceous of western Bulgaria might be the first record of Mesozoic insects in the country

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Проблемни фосили от горната креда на Западна България са може би първите находки от мезозойски насекоми в страната

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Abstract. Recent work at the Upper Cretaceous vertebrate locality near the town of Tran, western Bulgaria, brought to light a diverse assemblage of plant mesofossils and other microfossils of uncertain systematic affinities. Here we briefly report on 18 problematic specimens that share a striking morphological similarity to the Late Cretaceous *Knoblochia cretacea*, an ichnotaxon thought to be an insect egg. This material appears to represent the first record of Mesozoic insects from Bulgaria.

Keywords: *Knoblochia cretacea*, fossil insect eggs, upper Santonian–lower Campanian, west Bulgaria.

The Bulgarian fossil record of Insecta is scarce and mostly restricted to the Middle Miocene deposits of the Satovcha Basin, SW Bulgaria, which yielded fossils of dragonflies, March flies, and a jewel beetle (Nel et al., 2016; Simov et al., 2021a, b). The oldest described insect specimen from Bulgaria is currently a fungus gnat of supposed late Eocene to early Oligocene age (Drensky, Stefanoff, 1938).

Plant mesofossils, i.e., seeds and fruits, are common fossils in the Upper Cretaceous continental and marine sedimentary rocks in Europe. Some angiosperm seeds are very similar to insect eggs due to their small size and surface ornamentation, which might lead to the misinterpretation of fossil insect eggs as seeds (Heřmanová et al., 2017). In recent years, the supposed Late Cretaceous plant mesofossil taxa *Palaeoaldrovanda splendens* Knobloch and Mai, 1984 and *Knoblochia cretacea* Heřmanová et al., 2013 have been indeed reinterpreted as insect eggs (Heřmanová, Kvaček, 2010; Heřmanová et al., 2013). The genus *Knoblochia* is diagnosed by an ovoid shape, longitudinal ridges, and projections on both ends of the fossil and is currently known from Central Europe (Heřmanová et al., 2013), Romania

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(Csiki et al, 2008; Bodor et al., 2014), and possibly Spain (Marmi et al., 2016).

Here we report and provide preliminary description of problematic fossils with *Knoblochia*-like morphology from the Upper Cretaceous vertebrate locality near the town of Tran, Western Bulgaria. The studied fossil locality is positioned in the Vrabchov Dol gully, about 4.7 km NE of the town of Tran (Fig. 1a). This area falls within the extent of the Western Srednogorie Tectonic Subzone, part of the Srednogorie Tectonic Zone of the Alpine orogenic belt in Bulgaria (Ivanov, 2017). Here, Turonian to upper Campanian sedimentary and volcano-sedimentary successions (intruded by rare igneous bodies) have been deposited within an arc to back-arc setting (Dabovski et al., 2009). These successions

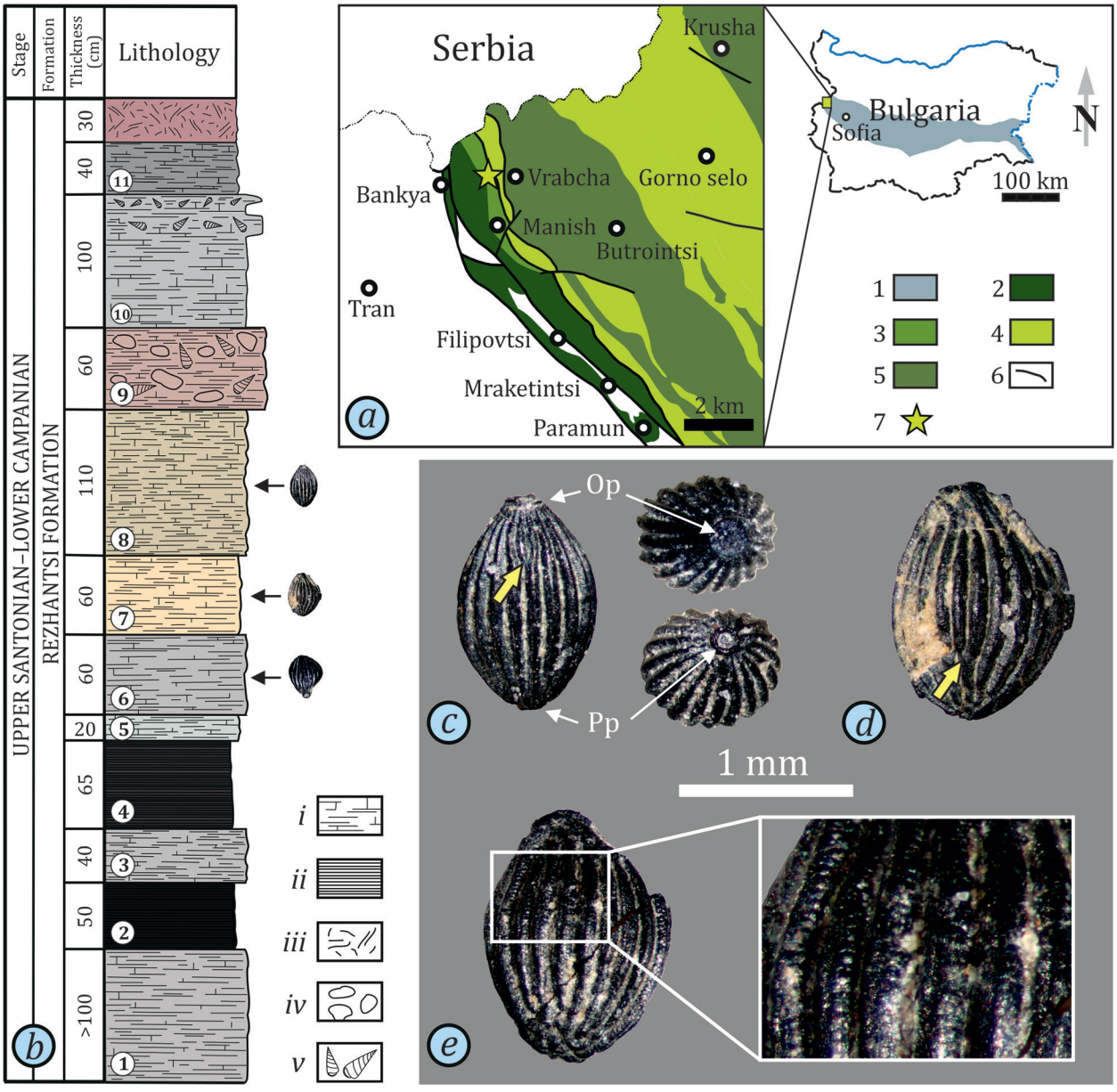

Fig. 1. ***a***, Geographical position of the fossil locality and simplified sketch map of the studied area (after Sinnyovsky et al., 2012): 1, geographic extent of the Srednogorie Tectonic Zone; 2, lower Turonian to Santonian strata (i.e., Paramun, Izvor, Golesh, and Melove formations); 3, Rezhantsi Formation; 4, lower to upper Campanian sediments (i.e., Nedelkovo, Dolniromantsi, Tsrancha, and Zavala formations); 5, Coniacian to lower Campanian volcanic rocks (i.e., Delyan, Babski, and Vidritsa volcanic complexes); 6, fault; 7, fossil locality; ***b***, Lithological column of the sedimentary succession at the Vrabchov Dol locality (after Pavlishina et al., 2019) with the position of sediment samples yielding fossil material: *i*, marlstone; *ii*, coaly shale/shaly coal; *iii*, soil; *iv*, silicified zone; *v*, mollusk abundance; ***c***, specimen F31801 (yellow arrow indicates the point of rib bifurcation); ***d***, specimen F31799 (yellow arrow indicates the point of rib bifurcation); ***e***, specimen F31806 (enlarged area illustrates the fine ornamentation of transverse ridges on the main ribs). Abbreviations: Op, operculum; Pp, posterior projection/mound.

are preserved as NW-SE elongated strips (Fig. 1a). The vertebrate-bearing deposits cropping out at the Vrabchov Dol locality are part of the Rezhantsi Formation (Sinnyovsky et al., 2013) and are palynologically dated as uppermost Santonian–lowermost Campanian (Pavlishina et al., 2019). The studied section is part of a small, isolated block comprised of soft marlstones and coaly shales, whose lower and upper boundaries cannot be observed. A total of 11 beds are recognized, of which seven contain vertebrate remains (Fig. 1b). A palynofacies analysis suggests that the fossil-bearing sediments were deposited in lagoonal to foreshore marine environment, while the composition of the examined palynoflora reveals a warm, seasonally dry climate during the time of deposition (Pavlishina et al., 2019).

The studied material comprises 18 specimens (catalogue numbers NMNHS F31794–31809, F31811, and F31812) and is stored in the National Museum of Natural History at the Bulgarian Academy of Sciences, Sofia, Bulgaria (NMNHS). All but two of the fossils were obtained from sediment samples collected in 2021. Between 2 and 5 kg of sediment from beds 7 through 11 have been screen-washed on-site. The remaining material has then been brought to the NMNHS for further processing where it was treated with 15% aqueous solution of H_2O_2 for 15 minutes and then rinsed with tap water until the removal of most clay and silt particles. The residual was left to dry at room temperature before being examined for microfossils. Only samples from beds 7 and 8 proved to yield fossils of the type reported here (7 and 9 specimens, respectively). The remaining two specimens were collected on site in 2024, one from bed 6 and another one from eroded sedimentary material from an unknown stratigraphic level.

The specimens were examined and photographed on Zeiss Stemi 2000-C stereomicroscope with mounted Canon EOS 2000D digital camera. The images were further processed with Adobe Photoshop CS5.1. Measurements were taken using ImageJ software.

The fossils are black-colored, preserved 3-dimensionally as charcoal (i.e., they are carbonized), ovoid to rounded in shape, and possess longitudinal ribs (or ridges), which vary in number between 19 and 24 (Fig. 1c–e). These ribs are triangular in cross-section and bear a fine ornamentation of transverse ridges (Fig. 1e), which in most specimens are present along the entire length of the ribs. Some specimens have at least one bifurcating rib (Fig. 1c–d). It is common for the resulting ribs to run only for a short distance before terminating or joining together again (Fig. 1c). The size of the fossils ranges from 0.97 mm to 1.31 mm in length, and from 0.72 mm to 1.06 mm in width. Most specimens are deformed and have poorly preserved apical and basal parts. Specimen F31801, the best preserved in the sample, exhibits projections on both ends, as seen in *Knoblochia*–in this case, an incompletely preserved apical projection (an operculum without capitulum) and a well-developed round collar on the basal side (part of the posterior projection/mound) (Fig. 1c).

The Vrabchov Dol fossils possess the main diagnostic features of the proposed insect egg taxon *Knoblochia cretacea* (Heřmanová et al., 2013), namely: (1) ovoid shape; (2) longitudinal ribs (ridges) with triangular cross-section; (3) rare bifurcating ribs; (4) presence of small transverse ridges; and (5) projections on both ends of the egg. Heřmanová et al. (2013) could not resolve with certainty the taxonomic position of *Knoblochia*, but hypothesized possible affinities to the clades Lepidoptera or Phasmatodea on the basis of morphological similarities to their eggs. Some basal moths lay single eggs of size similar to that of *Knoblochia* directly onto the ground surface, as we consider is the case of the studied fossils due to their isolated nature; however, lepidopteran eggs lack an operculum. Phasmid eggs share several key similarities with *Knoblochia* – they have polar projections, operculum, longitudinal ridges, etc. Furthermore, not only Phasmatodea first appeared in the mid-Cretaceous and their ancestral ovipositional strategy appears to be dropping of or flicking the eggs directly onto the ground (Robertson et al., 2018), but the eggs of many phasmids show convergence with plant seeds in their morphology, possibly as result of similar dispersal strategies (O'Hanlon et al., 2020). On the other hand, one of the unique features of phasmid eggs – the micropylar plate – is not observed in any of the examined specimens. The shape of the area of rib bifurcation in the studied fossils is reminiscent to that of the micropylar plate, but the state of preservation of the fossils and insufficient data do not allow us to confirm the presence of this character. Alternatively, given the depositional environment of the fossil locality and the strong freshwater influence on the formation of the fossil assemblage, as evidenced by the presence of gar, amphibian, crocodylomorph, and turtle remains at Vrabchov Dol, one might speculate about an aquatic insect origin for the eggs. However, the great majority of extant aquatic taxa lay their eggs on clutches, batches, or directly onto the stems of submerged vegetation, while the eggs of taxa that lay these individually exhibit very different chorion structure in comparison to the specimens studied here.

The exact taxonomic affiliations of *Knoblochia cretacea* remain elusive, but this taxon is most similar to the eggs of phasmids. If future evidence confirms the hypothesized Phasmatodea affinities of

the studied material, this would provide additional support for the existence of a warm tropical to subtropical climate in the region during latest Santonian–earliest Campanian times, as already suggested by vegetation pattern data (Pavlishina et al., 2019).

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