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The first trigonotarbid arachnid from Ukraine

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ABSTRACT:

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The extinct arachnid order Trigonotarbida Petrunkevitch, 1949 is reported here for the first time from Ukraine. The material consists of an opisthosoma preserved in ventral view from the upper Carboniferous (lower Moscovian; *Paralegoceras–Eowellerites* ammonoid zone) of the Gorlivka locality in the Donets Basin, eastern Ukraine. Formal assignment to a family or genus is difficult, but the preserved ventral anatomy is consistent with a member of the families Aphantomartidae Petrunkevitch, 1945, Kreischeriidae Haase, 1890 or Eophrynidae Karsch, 1882. It is noteworthy for expanding the known distribution of trigonotarbids in Europe and is only the second Palaeozoic arachnid to be formally described from Ukraine; the other being the carapace of a whip scorpion (Thelyphonida Latreille, 1804) from Lomovatka in the Luhansk Region, also in the Donets Basin.

Key words: Carboniferous; Moscovian; Arachnida; Trigonotarbida; Donets Basin; Ukraine.

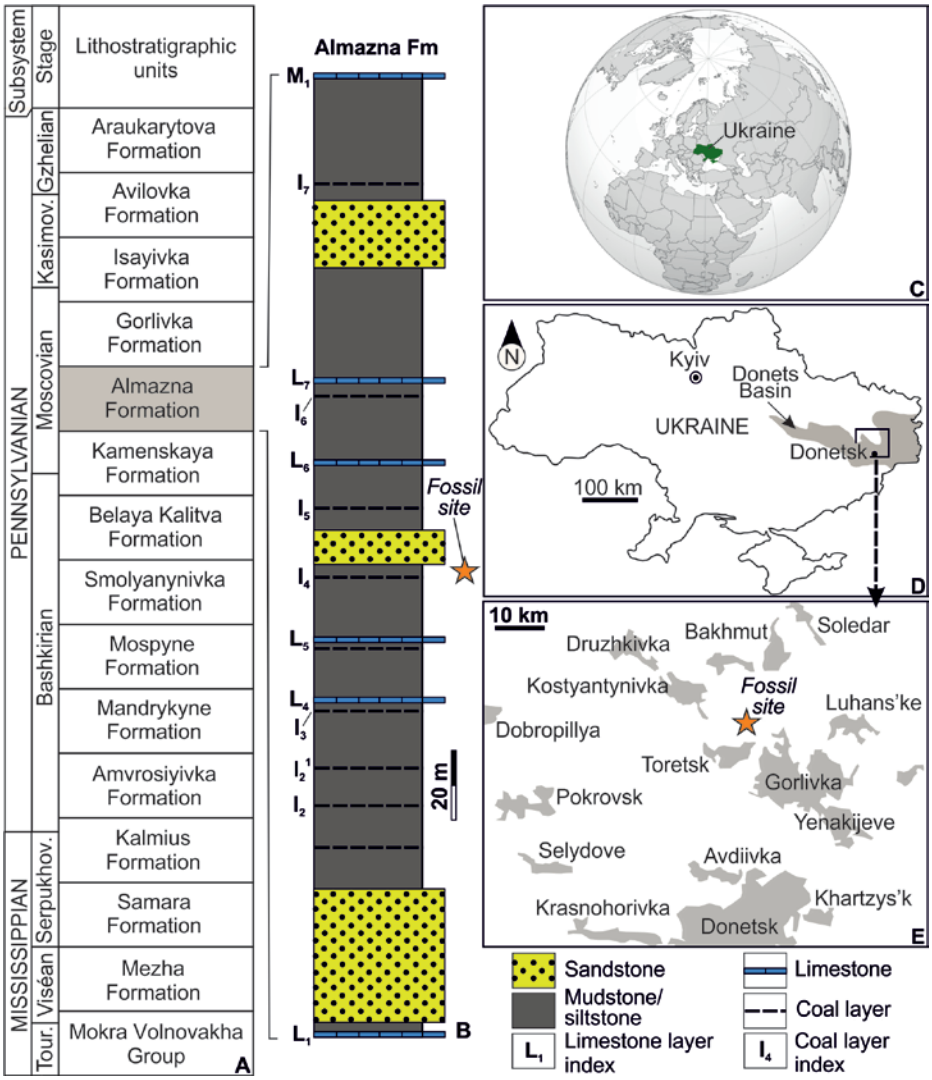
INTRODUCTION

Trigonotarbids (Arachnida Lamarck, 1801) are an extinct order of spider-like arachnids. They belong to an arachnid clade named Pantetrapulmonata Shultz, 2007 sharing several features with spiders and their closest relatives including mouthparts shaped like a clasp-knife, a narrowing of the body between the prosoma and opisthosoma and the presence of two pairs of book lungs in the ground plan. For an overview of these animals see, e.g., Garwood and Dunlop (2010) or Jones *et al*. (2014). Seventy species of trigonotarbids are currently recognised (Dunlop *et al*. 2023), ranging in time from the late Silurian to the early Permian. Most species, and specimens, come from the upper Carboniferous/Pennsylvanian Coal Measures of Europe and North America with particularly strong concentrations in areas associated with coal mining. For a comprehensive list of localities and their stratigraphy see Dunlop and Rößler (2013, table 1 and fig. 6).

Here, we expand the known geographical range of Trigonotarbida by describing the first representative of this arachnid order from Ukraine. The specimen consists of an opisthosoma preserved in ventral view from the upper Carboniferous of the Donets Basin. It also represents only the second example of a Palaeozoic arachnid from Ukraine, the other being the unnamed carapace of a whip scorpion (Thelyphonida Latreille, 1804) described by Selden *et al*. (2014).

MATERIAL AND METHODS

The present fossil was discovered in the collections of the Institute of Geological Sciences of the National Academy of Sciences of Ukraine, Kyiv (IGS NASU). It was found in the core sample of borehole No. 118 drilled near the town of Gorlivka in the Donetsk Region, eastern Ukraine (Text-fig. 1) at a depth of 122.9 m. The single specimen (IGS



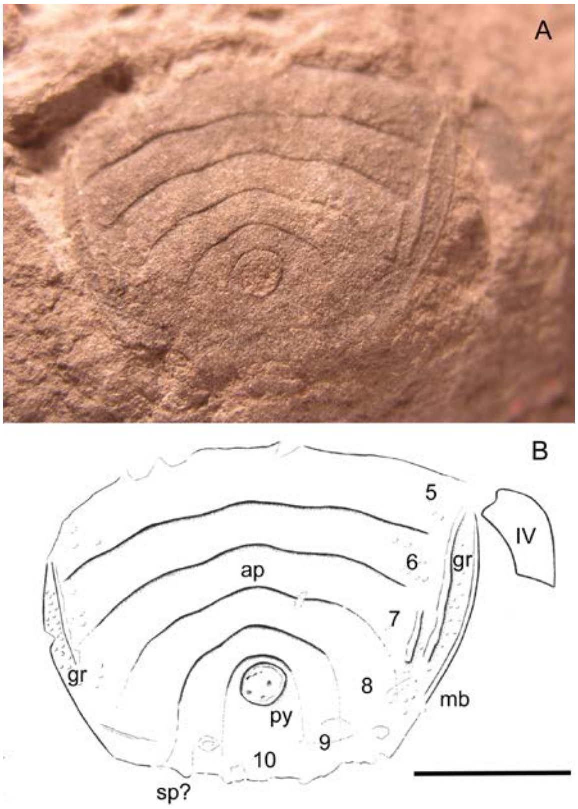
Text-fig. 1. Stratigraphic and geographic location of the trigonotarbid arachnid from Ukraine. A, B – Stratigraphic position of the fossil (orange star) in the Carboniferous succession of the Donets Basin. C–E – Maps indicating the general and detailed position of the locality. Abbreviations: Tour. – Tournaisian, Serpukhov. – Serpukhovian, Kasimov. – Kasimovian. Lithological column in B modified after Belokon (1963).

NASU-21/01) consists of an opisthosoma preserved in ventral view, plus a limb fragment (Text-fig. 2). The fossil-bearing rock is a dark gray coarse-grained carbonaceous and micaceous siltstone with clusters of carbonized plant debris. This siltstone lies 3.74 m above the l_4 coal layer in the middle part of the Almazna Formation.

The specimen was found in the 1940s or 1950s by Smirnova (forename unknown), a geologist for the 'Uglerazvedka' organization in the town of Artemovsk (now Bakhmut) in the Donetsk Region. The core sample, including the arachnid, was given to Dr. David E. Aisenverg (Institute of Geological Sciences, Academy of Sciences of the Ukrainian SSR, Kyiv), but for reasons unknown he did not complete the study of this material and over time the specimen was misplaced. Only this year, a siltstone slab including the arachnid remains was found in the collection of Carboniferous brachiopods from the Donets Basin, stored in the Department of Palaeontology and Stratigraphy of the Palaeozoic sediments (IGS NASU, Kyiv).

GEOLOGICAL SETTING

The Almazna Formation (Text-fig. 1), also called C_2^6 or L, consists of a paralic succession of sandstones, siltstones, mudstones, coals and limestones. This formation lies on the sediments of the



Text-fig. 2. Trigonotarbida *incertae sedis*. A – IGS NASU-21/01 from the lower Moscovian (upper Carboniferous /Pennsylvanian) of Gorlivka in the Donets Basin, Ukraine. B – Interpretative drawing, opisthosomal segments numbered. Abbreviations: ap – anterior projection of sternites; gr – granular ornament; mb – marginal border; py – pygidium; sp? – possible marginal spines; IV – leg IV fragment (femur?). Scale bar equals 5 mm.

Kamenskaya Formation (also called C_2^5 or K) and is overlain by rocks of the Gorlivka Formation (also called C_2^7 or M). The limestone layer L_1 is a basal layer of the Almazna Formation; the upper boundary of this formation is at the base of the M_1 limestone layer. The thickness of this formation varies from 180 m in the NW part of the Donets Basin to 610 m in the SE part of the Donets Basin (Aisenverg *et al*. 1963; Dunayeva 1969; Nemyrovska and Yefimenko 2013). Near the town of Gorlivka its thickness is 270 m (Feofilova and Levenshtein 1963).

Alluvial sediments (42.8% of the section thickness), as well as sediments of peat and clastic swamps (10.8%), lacustrine (7.4%), lagoonal (26.0%), and shallow marine (13.0%) rocks are present in the section of the Almazna Formation (Feofilova and Levenshtein 1963, table 2). Alluvial sandstones are widespread in the lower part of this formation, in the interval between the L_1 and L_5 limestone layers. The upper part of this formation is dominated by marine and lagoonal deposits, and among the sandstones, a significant portion belongs to deltaic sediments (Feofilova and Levenshtein 1963).

Coal-bearing deposits of the Moscovian strata in the Donets Basin were accumulated mainly in a large alluvial-deltaic plain, which was flooded periodically by the waters of warm epicontinental seas (Feofilova and Levenshtein 1963; Kozitskaya and Schegolev 1993). The Almazna Formation corresponds to the Mar'yivkian Horizon (upper half of the Lozovian Regional Stage) in the Regional stratigraphic scheme of the Dnipro-Donets Depression (Poletaev *et al*. 2011; Nemyrovska and Yefimenko 2013). The absolute age of the claystones (tonsteins in the original paper) from the l_3 coal bed, which lies c. 40 m below the l_4 coal bed, is 312.01±0.08 and 312.18±0.07 Ma (Davydov *et al*. 2010).

Sediments of the Almazna Formation contain conodonts of two zones: the '*Streptognathodus*' *transitivus–Neognathodus atokaensis* Zone (stratigraphic interval between the K_6 and L_5 limestone layers) and the younger *Idiognathodus izwaricus* Zone (L_5–M_1 limestone layers) (Fohrer *et al*. 2007; Nemyrovska 2017). According to conodont studies (Nemyrovska 2017, text-fig. 2), the Mar'yivkian Horizon of the Donets Basin corresponds to the Kashirian Regional Stage of the stratotype of the Moscovian Global Stage (Moscow Syneclise, Russia).

The Almazna Formation also contains remains of typical Bolsovian (= Westphalian C) terrestrial plants such as *Paripteris linguaefolia* (Bertrand) Laveine, 1967, *Eusphenopteris striata* (Gothan) Novik, 1952, *Mariopteris nervosa* (Brongniart) Zeiller, 1879, *Macroneuropteris scheuchzeri* (Hoffmann) Cleal, Shute and Zodrow, 1990, *Laveineopteris rarinervis* (Bunbury) Cleal, Shute and Zodrow, 1990, *Sphenophyllum emarginatum* Brongniart, 1822, etc. (Novik 1952, 1974; Fissunenko 1991, 2000; Boyarina 2016), as well as the nonmarine bivalves *Anthraconaia stobbsi* (Dix and Trueman, 1931), *A. oblonga* (Wright, 1929), *A.* aff. *pulchra* Hind, 1895, *Naiadites daviesi* (Dix and Trueman, 1931), *N. obliquus* Dix and Trueman, 1931, etc. (Sergeyeva 1981, 1984) and the ammonoids *Wiedeyoceras* cf. *cambriense* (Bisat, 1930); see also Dernov (in press). Additionally, Popov (1979) reported the Bolsovian ammonoid species *Wiedeyoceras cambriense* and *Politoceras* cf. *politum* (Shumard, 1858) from the lower part of the Gorlivka Formation. Other marine and terrestrial biota are also present in the Almazna Formation, including calcareous algae, miospores, foraminiferans, worms, corals, bryozoans, brachiopods, scaphopods, gastropods, horseshoe crabs, barnacles and ostracodes.

SYSTEMATIC PALEONTOLOGY

Order Trigonotarbida Petrunkevitch, 1949
Family *incertae sedis*
(Text-fig. 2)

MATERIAL: IGS NASU-21/01 from the lower Moscovian (upper Carboniferous /Pennsylvanian) of the Donets Basin, eastern Ukraine. Carbonaceous siltstones (Almazna Formation, 3.74 m above the l_4 coal layer) at a depth of 122.9 m of borehole No. 118 drilled near the town of Gorlivka (Donetsk Region, Ukraine); leg. Smirnova.

DESCRIPTION: Posterior half of a rounded to oval opisthosoma in ventral view (Text-fig. 2). Preserved length c. 12 mm; maximum width 14.8 mm. Sternites 5–10 visible, plus the two circular segments forming the pygidium. Sternites strongly procurved, all with a slight anterior projection close to the midline giving them a distinctive outline. Hints of light granulation towards the lateral margins, but sternites otherwise smooth. Opisthosoma with narrow (c. 0.2 mm) marginal border. Posterior margin broken in places; weak hints of posterior spines preserved, but their precise presence and form is equivocal. Pygidium forms two small concentric rings, diameter 1.6 mm, positioned towards anterior end of sternite 10. Limb fragment to the right of opisthosoma probably represents the femur of leg IV.

DISCUSSION

The incomplete nature of the new fossil makes it difficult to assign taxonomically, but it is undoubtedly a member of the extinct arachnid order Trigonotarbida as it has the characteristic ventral anatomy of this group such as the small, rounded segments forming a discrete pygidium on the ventral surface of the opisthosoma (py in Text-fig. 2). Seven trigonotarbid families are currently known from the Carboniferous and several can be excluded from consideration based on their morphology. Anthracomartidae Haase, 1890 usually have sternites which come to a sharp angle on the midline (Garwood and Dunlop 2011, text-figs 1–3) and additionally have a broad sulcus defining a much wider ventral lateral margin. Anthracosironidae Pocock, 1903 have a more elongate, somewhat pear-shaped opisthosoma (Pocock 1903, 1911; Petrunkevitch 1949) and thus presents a quite different habitus. Lissomartidae Dunlop, 1995 and Trigonotarbidae have procurved sternites with smooth borders (Pocock 1911; Dunlop 1995; Jones *et al*. 2014), i.e., they do not show the anterior projection on the midline (ap in Text-fig. 2) preserved in the present fossil.

The best matches to the present specimen thus come from the families Aphantomartidae Petrunkevitch, 1945, Kreischeriidae Haase, 1890 and Eophrynidae Karsch, 1882. In species where the ventral opisthosoma is known, the sternites can also show a projection on the midline. Examples include the Devonian aphantomartid *Alkenia mirabilis* Størmer, 1970 and the Permian species *Aphantomartus ilfeldicus* (Scharf, 1924) as figured by Poschmann and Dunlop (2010, fig. 1d) and Rößler *et al*. (2003, fig. 1), respectively. However, if the observation of posterior spines on the opisthosoma of the new fossil is correct (sp? in Text-fig. 2) this would tend to exclude aphantomartids which do not show such marginal spination and also tend to have a more obviously oval opisthosoma as opposed to a broader and more rounded one; see also figures in Rößler (1998).

Among the kreischeriids this ventral morphology with midline projections is seen in *Kreischeria wiedei* Geinitz, 1882 and *Pseudokreischeria pococki* (Gill, 1924); see especially Rößler and Dunlop (1997, fig. 4) and Dunlop (1998, fig. 4), respectively. This morphology also appears to be present in the kreischeriid *Gondwanarachne argentinensis* Pinto and Hünicken, 1980, the only trigonotarbid currently known from the Southern Hemisphere. Interestingly, the preserved ventral morphology based on Pinto and Hünicken (1980, fig. 3) is quite similar to the new fossil with a narrow marginal border, longitudinal lines towards the margins at an angle and hints of marginal granulation. A median projection of the sternites is also seen, albeit perhaps less strongly, in eophrynids such as *Eophrynus prestvicii* (Buckland, 1837), *Stenotrogulus salmii* (Stur, 1877) and *Pleophrynus verrucosus* (Pocock, 1911). Figured examples for the respective species include Dunlop and Garwood (2014, fig. 2B), Přībyl (1958, figs 1, 2) for a synonym of *S. slamii*, and Dunlop (1994, figs 1b, 2a). Aphantomatidae, Kreischeriidae and Eophrynidae are probably closely related (Jones *et al*. 2014) and are best differentiated in dorsal view based on patterns of tuberculation on the opisthosomal tergites. Since this character is not preserved here, we cannot unequivocally resolve which of these families the new Ukrainian fossil belongs to.

It is nevertheless important for documenting the presence of Trigonotarbida at a locality further east than some of the main concentrations of records in, e.g., the Coal Measures of Silesia in Poland and Bohemia in the Czech Republic. Together with the whip scorpion described by Selden *et al*. (2014) they suggest that the Donets Basin has considerable potential to provide useful comparative data about Carboniferous arachnid faunas across a wider region of the original paleocontinent of Laurasia. We should also reiterate that these two Carboniferous fossils are the oldest arachnids known from Ukraine. The only other source of fossil arachnids from Ukraine is the Paleogene Rovno amber (e.g., Wunderlich 2004; Perkovsky *et al*. 2007; Dunlop *et al*. 2019), which has yielded a rich assemblage of spiders, scorpions, harvestmen and mites; albeit mostly in modern families and/or genera.

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