

To the study of arthropods of Tavrida Cave, Crimea

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ABSTRACT. Preliminary results of studying the biota of the recently discovered Tavrida Cave (Foothill Crimea) are presented. By now, six species of arthropods (Arthropoda) have been identified, i.e. one species of spiders (Aranei), one species of diplura (Diplura), two species of springtails (Collembola) and two species of flies (Diptera). The obtained results indicate the relative youth of the recent fauna of Tavrida Cave, despite Eopleistocene age cave, and have a significant faunal value, since a number of discovered species are specified for the first time for the Crimea and Russia. For the troglobiont diplura *Campodea (Dicampa) taurica*, discovered in Tavrida Cave, a probable scenario of its penetration into the karst cavities of the Crimea in connection with global climate changes in the Late Pleistocene time is presented. However, all other found species are most likely to have entered Tavrida Cave at the present time, after its opening as a result of road construction work.

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KEY WORDS: fauna, Tavrida Cave, troglobiont, troglophile, subroglophile, Crimea.

К изучению членистоногих пещеры Таврида, Крым

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РЕЗЮМЕ. Представлены предварительные результаты изучения биоты недавно открытой пещеры Таврида (Предгорный Крым). На данный момент выявлено шесть видов членистоногих (Arthropoda) — один вид пауков (Aranei), один вид двухвосток (Diplura), два вида коллембол (Collembola) и два вида двукрылых (Diptera). Полученные результаты говорят о сравнительной молодости рецентной фауны пещеры Таврида, несмотря на эоплейстоценовый возраст пещеры, и имеют значительную

фаунистическую ценность, т.к. ряд обнаруженных видов впервые указывается для Крыма и России. Для троглобионтной двухвостки *Campodea (Dicampa) taurica*, обнаруженной в пещере Таврида, представлен вероятный сценарий её проникновения в карстовые полости Крыма в связи с глобальными климатическими изменениями в позднеплейстоценовое время. Однако все остальные обнаруженные виды, вероятнее всего, проникли в пещеру Таврида в настоящее время, после её вскрытия в результате строительных дорожных работ.

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КЛЮЧЕВЫЕ СЛОВА: фауна, пещера Таврида, троглобионт, троглофил, субтроглофил, Крым.

Introduction

Tavrida Cave was opened in June 2018 during the construction of Tavrida highway. It is located near Zuya Village (Belogorsky Distr., Crimea). In accordance with the karstological zoning of the Crimea, Tavrida Cave belongs to the speleological region of the Inner Ridge, Simferopol karst region (Vakhrushev, 2009). The cavity belongs to the labyrinth type, has a length of 1300 m with an amplitude of 18 m. The cave lies in the Eocene limestone. By its genesis Tavrida Cave is a relict hypogenic karst system (Amelichev *et al.*, 2018, 2019).

A rich Eopleistocene taphocenosis of vertebrates was found in Tavrida Cave, the taxonomic composition of which allows us to date the bone deposits of the remains corresponding to the Late Villafrancian of Western Europe (zones MQ18–MQ19) and the Psekup (= Odessa) faunal complex of Russia, and has an age of about 1.8–1.5 million years (Lopatin *et al.*, 2019). At the same time, the formation of the bulk of the karst cavities of the Crimea occurred much later, in the Middle and Late Pleistocene (Klimchouk *et al.*, 2009). The Eopleistocene age and significant geological isolation of Tavrida Cave suggest the presence of relict elements of pre-Glacial times in its fauna. This hypothesis prompted us to conduct biospeleological studies in the cave under discussion.

On September 25, 2018, we made an inspection of Tavrida Cave in order to collect and

study its biota. However, long-term visual searching of animals did not bring results. Our colleague, G.A. Prokopov (Simferopol), examined the cave in early July 2018 and also found no animals (personal communication). This case forced us to make temporary stations with baits to attract cave animals.

Materials and methods

In order to attract invertebrates, we have made some temporary biospeleological stations in Tavrida Cave, consisting of baits laid out in the cave, i.e. pieces of hard cheese and dried sausage, peeled boiled chicken eggs. The use of such baits makes it possible to attract invertebrates under conditions of limited trophic resources and almost complete absence of allochthonous organic matter. The exposure time of the baits was 31 days — from September 28 to October 29, 2018. In total, seven points (stations) with baits were placed within the cave, the scheme of their location is shown in Fig. 1.

The collection of material at temporary biospeleological stations was carried out manually, directly from the baits (with tweezers) and fixed in 96% alcohol. The smallest and most delicate invertebrates (Collembola, Diplura) were collected using an exhauster (suction device), also with subsequent fixation in 96% ethyl alcohol. The photos of living arthropods in the cave were taken with a digital camera Ricoh WG-4 (Ricoh Company Ltd, Japan).

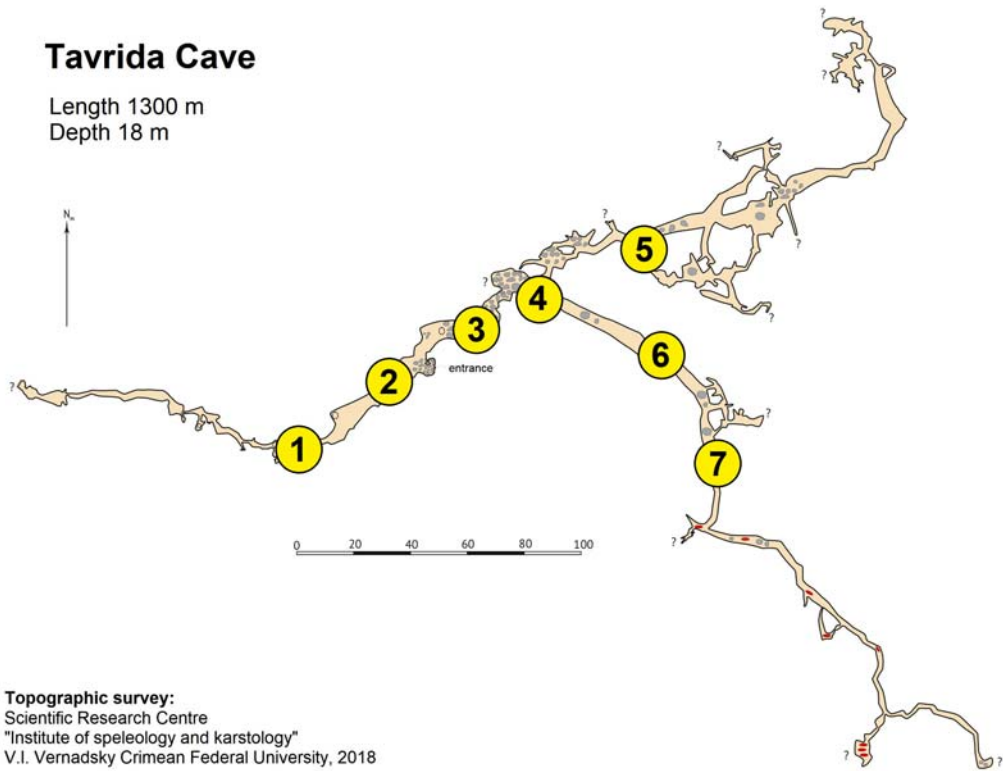


Fig. 1. The layout of biospeleological stations (yellow circles) with baits in Tavrida Cave in the period from September 28 to October 29, 2018. Topographic basis — the plan of Tavrida Cave (Amelichev *et al.*, 2019); processing, additions and changes by I.S. Turbanov.

Рис. 1. Схема расположения биоспелеологических стационаров (желтые круги) с приманками в пещере Таврида в период с 28 сентября по 29 октября 2018 г. Топографическая основа — план пещеры Таврида (Амеличев и др., 2019); обработка, дополнения и изменения И.С. Турбанов.

Preliminary analysis and determination of the material was performed under laboratory conditions at the I.D. Papanin Institute of Inland Water Biology of the Russian Academy of Sciences (Borok, Yaroslavl Region) using a KONUS CRYSTAL 7x-45x STEREO biological stereomicroscope. For the study, the copulatory organs of the spiders were dissected, boiled in a 10% aqueous solution of potassium hydroxide (KOH), stained with Methylenum coeruleum, and placed in glycerin on a slide with a hole. The photos of copulatory organs and spider habitus were taken at the A.O. Kovalevsky Institute of Biology of the Southern Seas of the Russian Academy of Sciences (Sevastopol) using an MBS-1 and Olympus CX41 microscopes and a

Canon EOS 550D camera attached to them. The images were processed in the Helicon Focus 7.0.2. and CorelDRAW 11 programs. The terminology of copulatory organs is given after Saaristo (1977).

Part of the material collected in Tavrida Cave was given for confirmation and/or clarification of the definition to the specialists in the relevant taxonomic groups, i.e. springtails to A.B. Babenko (A.N. Severtsov Institute of Ecology and Evolution of the Russian Academy of Sciences, Moscow, Russia), diptera to J. Roháček (Silesian Museum, Opava, Czech Republic) and A.A. Przhiboro (Zoological Institute of the Russian Academy of Sciences, St. Petersburg, Russia).



Fig. 2. Female of linyphiid spider *Caviphantes dobrogicus* from Tavrída Cave. A — live specimen photo in the cave (photography by I.S. Turbanov); B — habitus, dorsally, scale 0.5 mm (photography by A.A. Nadolny).

Рис. 2. Самка паука-линифииды *Caviphantes dobrogicus* из пещеры Таврида. А — прижизненная фотография в пещере (фотография И.С. Турбанова); В — габитус, дорсально, масштаб 0,5 мм (фотография А.А. Надольного).

Material examined is deposited in the National Arachnological Collection, Tavrída Academy of V.I. Vernadsky Crimean Federal University, Simferopol (TNU), Zoological Institute of the Russian Academy of Sciences, Saint Petersburg (ZISP), A.N. Severtsov Institute of Ecology and Evolution of the Russian Academy of Sciences, Moscow (IEE), and the private collections I. Turbanov (IT).

Results

On October 29, 2018, 28 individuals of six species of invertebrates (Arthropoda) were collected in Tavrída Cave at biospeleological stations, i.e. one species of spiders (Aranei), one species of diplura (Diplura), two species of springtails (Collembola) and two species of flies (Diptera). Brief study for each of the collected species is given below.

Class Arachnida Cuvier, 1812
Order Aranei Clerck, 1758
Family Linyphiidae Blackwall, 1859

Caviphantes dobrogicus (Dumitrescu
et Miller, 1962)
Figs 2, 3.

MATERIAL. 5 ♀♀ (TNU-10234), Crimean Peninsula, Belogorsk Distr., near Zuya, Tavrída Cave, 29.IX.2018, leg. I.S. Turbanov.

Caviphantes dobrogicus has been recorded in Bulgaria, Romania, Ukraine, Georgia, Azerbaijan, and Kyrgyzstan (Mikhailov, 2013; Polchaninova, Prokopenko, 2013; Nentwig *et al.*, 2021). This species is recorded in the Crimea for the first time. Our discovery of *C. dobrogicus* from Tavrída Cave is the first reliable finding of this spider species in Russia. The species is considered as troglophilic (Mammola *et al.*, 2018: Table S1). In addition to caves, it inhabits sandy steppes, sea coasts and agrocenoses (Polchaninova, Prokopenko, 2013). Since this species is a eurybiont that can enter caves, in our opinion, we characterize it as a subtroglophile.

There is only one detailed diagnostic drawing of *C. dobrogicus* epigyne in the literature (Dumitrescu, Miller, 1962). As confirmation of our finding we present photos of *C. dobrogicus* epigyne from Tavrída Cave (Fig. 3). The mor-

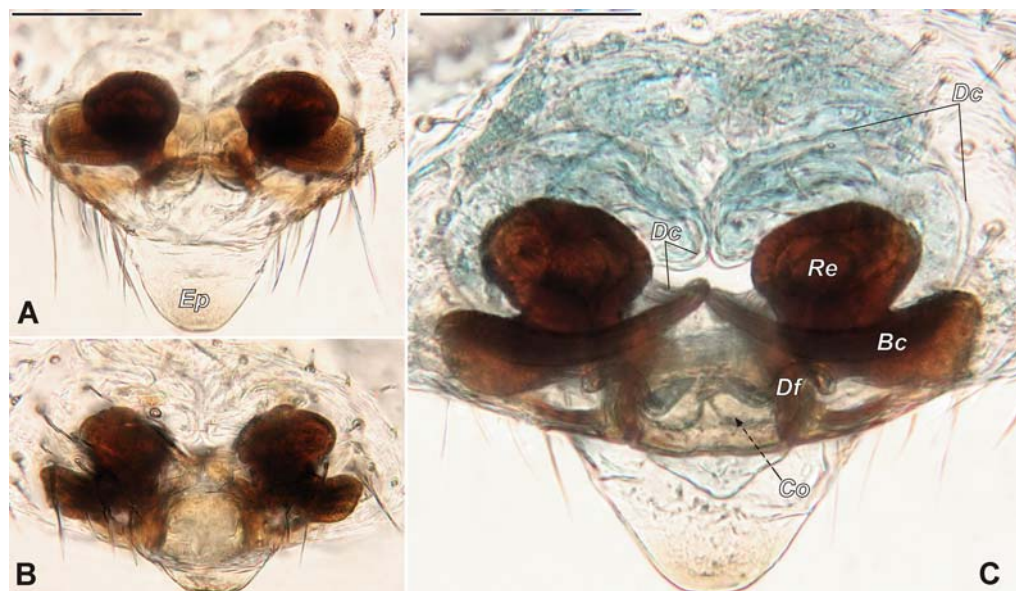


Fig. 3. Epigyne of *Caviphantes dobrogicus* from Tavrida Cave. A — ventral; B — ventral-caudal; C — dorsal.

Abbreviations: *Bc* base of copulatory duct; *Co* — copulatory opening; *Dc* — copulatory duct; *Df* — fertilization duct; *Ep* — epigynal plate; *Re* — receptacle. Scale bars 0.1 mm (photography A.A. Nadolny).

Рис. 3. Эпигина паука *Caviphantes dobrogicus* из пещеры Таврида. А — вентрально; В — вентрально-каудально; С — дорсально.

Обозначения: *Bc* — основание копулятивного канала; *Co* — копулятивное отверстие; *Dc* — копулятивный канал; *Df* — оплодотворительный канал; *Ep* — пластинка эпигины; *Re* — рецептакула. Масштаб 0,1 мм (фотографии А.А. Надольного).

phological features of our specimens correspond to the description of *C. dobrogicus* (Dumitrescu, Miller, 1962): the epigynal plate (*Ep*) has a shape of a tongue; the copulatory openings (*Co*) are located at the base of the epigynal plate; copulatory ducts (*Dc*) are long, convoluted, their walls are thin, membranous, slightly sclerotized, except the base of the copulatory ducts (*Bc*) — thickened and well sclerotized; the receptacles (*Re*) are oval, sclerotized; the receptacula is joined with the copulatory and fertilization ducts posteriorly.

However, the proportions of some parts of the epigyne of the spiders from Tavrida Cave differ from those in the original description of *C. dobrogicus*. In particular, the epigynal plate of the spiders from Tavrida Cave is narrower but the distance between the lateral edges of the base of the copulatory ducts and the receptacula is greater. We believe that such differences

should not be interpreted as sufficient to describe a new species. To clarify this case, we need males from the cave, as well as comparative material from different parts of the range of *C. dobrogicus*.

Class Entognatha Stummer-Traunfels, 1891
Order Diplura Börner, 1904
Family Campodeidae Meinert, 1865

Campodea (Dicampa) taurica Silvestri, 1949
Fig. 4.

MATERIAL. 1 ♂, 1 ♀ (IT), Crimean Peninsula, Belogorsk Distr., near Zuya, Tavrida Cave, 29.IX.2018, leg. I.S. Turbanov.

Campodea (Dicampa) taurica troglobiont diplura, endemic to caves of the Crimea. For the first time it was presented in the work of V.G. Pliginsky (1927) from the Kizil-Koba (=Kras-



Fig. 4. Live specimen photo diplura *Campodea (Dicampa) taurica* in Tavrida Cave (photography by I.S. Turbanov).

Рис. 4. Прижизненная фотография диплоры *Campodea (Dicampa) taurica* в пещере Таврида (фотография И.С. Турбанова).

naya) Cave (Dolgorukovsky karst massif) but the species itself was described much later (Silvestri, 1949). There is a record of *C. (D.)* cf. *taurica* in Mangupskaya I Cave (Bakhchisarai karst massif) (Turbanov, 2018). In addition, our collections contain material from a number of caves in the Ai-Petri and Karabi karst massifs (unpublished data).

Class Collembola Lubbock, 1870
Order Entomobryomorpha Börner, 1916,
sensu Soto-Adames *et al.*, 2008
Family Entomobryidae Schäffer, 1896,
sensu Zhang *et al.*, 2015

Pseudosinella aff. *immaculata*
(Lie-Petersen, 1896)

MATERIAL. 1 ex. (IEE), 10 exx. (IT), Crimean Peninsula, Belogorsk Distr., near Zuya, Tavrida Cave, 29.IX.2018, leg. I.S. Turbanov.

A Western Palearctic species, widely spread in Europe and North Africa. It inhabits nemoral

forests and meadow-to-steppe biotopes. It lives in the soil, litter, under rocks, in rodent burrows and in caves (Kaprus' *et al.*, 2006).

We consider this species to be subtrogliphilic. In the literature, we have not found reliable indications for the detection of *Pseudosinella* aff. *immaculata* on the territory of the Crimean Peninsula.

Order Poduromorpha Burner, 1913,
sensu D'Haese, 2002
Family Hypogastruridae Börner, 1906

Schoettella ununguiculata (Tullberg, 1869)

MATERIAL. 1 ♂, 1 ♀, 1 juv. (IEE), Crimean Peninsula, Belogorsk Distr., near Zuya, Tavrida Cave, 29.IX.2018, leg. I.S. Turbanov.

A widespread Holarctic species of Collembola (Babenko, 1994). Specimens from Tavrida Cave, as well as previously recorded for the Crimean Mountains (Babenko, 1994), have characteristic large three-lobed apical papillae on

the antennae and longer and coarser dorsal chaetes.

This species belongs to the eurybionts which inhabits different forest, meadow, steppe and near-water biotops, penetrates into caves, anthropogenic environments (Kaprus' *et al.*, 2006). We consider this species to be subtroglophilic.

Class Insecta Linnaeus, 1758

Order Diptera Linnaeus, 1758

Family Sphaeroceridae Macquart, 1835

Terrilimosina racovitzai (Bezzi, 1911)

MATERIAL. 5 ♂♂ (ZISP), Crimean Peninsula, Belogorsk Distr., near Zuya, Tavrida Cave, 29.IX.2018, leg. I.S. Turbanov.

A widespread Holarctic species, i.e. Canada, Afghanistan, most of Europe, and southern Russia (Marshall *et al.*, 2011). In the literature, we have not found any reliable indications of the presence of *Terrilimosina racovitzai* on the territory of the Crimean Peninsula.

Within its range, *T. racovitzai* has been recorded in a number of terrestrial ecosystems as well as in burrows and caves. Trogliphilic species (Roháček, 1982).

Sphaeroceridae sp. indet.

MATERIAL. 2 puparia (ZISP), Crimean Peninsula, Belogorsk Distr., near Zuya, Tavrida Cave, 29.IX.2018, leg. I.S. Turbanov.

Near the baits (hard cheese pieces), we found two puparia (larval skin (exuvium) of an adult larva, containing a pupa), not identified to the species of diptera of the family Sphaeroceridae Macquart, 1835. Regarding the identification of the species, we received the comments from dipterologist J. Roháček. In his opinion, the puparia found together with the imago *Terrilimosina racovitzai* certainly do not belong to the latter species, since they are too large. Because of their short, fingered forelimb and size, they may have belonged to other species of family Sphaeroceridae, such as *Herniosina* Roháček, 1983, or *Limosina* Macquart, 1835, or even to some smaller species of subfamily Copromyziinae Stenhammar, 1855.

There is no doubt that puparia belong to a species that is not a specialized cave inhabitant (trogllobiont), since its imago (adults) were attracted to bait (cheese) near the entrance part at station No. 2 (see Fig. 1), where they laid eggs, and subsequently the larvae completed development and pupated.

Discussion

The preliminary results show young age of recent fauna of Tavrida Cave (despite its Eopleistocene age) with no ancient trogllobiont forms. However, the trogllobiont diptera *Camptopoda* (*Dicampa*) *taurica*, whose origin is associated with the Late Pleistocene time, should be discussed closer.

Wide distribution of trogllobiont diptera *C. (D.) taurica* in Tavrida Cave and a number of other unrelated karst cavities of the Mountainous and Foothill Crimea, is most likely associated with the geological history of the peninsula. In the Pliocene-Early Pleistocene period, as the Mountain-Crimean Karst Region (Main Ridge) was freed from the Cretaceous-Paleogene cover (Vakhrushev, 2001; Lysenko, 2002) and the orographic separation of the Foothill-Crimean Karst Region (Inner and Outer Ridges) in the Middle and Late Pleistocene (Vakhrushev, 2001; Klimchouk *et al.*, 2013), the caves got inhabited by the ancestral soil form of this species. At the same time, there was no subsequent allopatric speciation in isolated populations. This point of view is consistent with the ideas about the geological history and age of the karst of the Crimean Peninsula (Vakhrushev, 2001, 2010; Muratov, 1960) and could confirm the opinion expressed about the Pleistocene age of the trogllobiont fauna (Prokopov, Turbanov, 2017).

All the other above-mentioned species are not specialized inhabitants of Tavrida Cave, most likely they are geobionts or inhabitants of MSS-biotopes (near-surface cavernous zone), but at the same time they successfully penetrate into caves. The trogliphilic species, namely linyphiid spider *C. dobrogicus*, springtails *Pseudosinella* aff. *immaculata*, *Schoettella unun-*

guiculata, and flies *Terrilimosina racovitzai*, Sphaeroceridae sp. indet., most likely occupied this karst cavity through an artificial entrance.

Despite the small amount of data obtained on the biota of Tavrida Cave, these results have a significant faunal value. For the first time, such species as springtail *P. aff. immaculata*, fly *T. racovitzai* and spider *C. dobrogicus* are recorded in the fauna of the Crimea; the latter species is listed for the first time in the fauna of Russia. For the first time, *C. dobrogicus*, *P. aff. immaculata*, *S. ununguiculata*, and *T. racovitzai* are found in the caves of the Crimea. The finding of troglobiont diplura *C. (D.) taurica* in Tavrida Cave add to the knowledge about its range in the Crimea.

Compliance with ethical standards

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

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