Online ISSN: 2588-3526
Journal of Wildlife and Biodiversity

Volume 7 (3): 10-16 (2023) (http://www.wildlife-biodiversity.com/)

Short communication

Oxidus gracilis (C. L. Koch, 1847), an alien millipede in the fauna of Turkey (Diplopoda, Polydesmida, Paradoxosomatidae)

Kadir Boğaç Kunt[1*], Mert Elverici[2], Dragan Antić[3, 4]

[1]Cyprus Wildlife Research Institute, Taşkent, Kyrenia, Cyprus

[2]Department of Biology, Faculty of Science and Arts, Erzincan Binali Yıldırım University, TR–24100, Erzincan, Turkey

[3]University of Belgrade – Faculty of Biology, Institute of Zoology, Studentski Trg 16, 11000 Belgrade, Serbia

[4]Serbian Biospeleological Society, Trg Dositeja Obradovića 2, 21000 Novi Sad, Serbia.

*Email: chaetopelma@gmail.com

Received: 21 May 2022 / Revised: 20 June 2022 / Accepted: 04 July 2022/ Published online: 04 July 2022. Ministry of Sciences, Research, and Technology, Arak University, Iran.

How to cite: Kunt, K.B., Elverici, M., Antić, D. (2023). *Oxidus gracilis* (C. L. Koch, 1847), an alien millipede in the fauna of Turkey (Diplopoda, Polydesmida, Paradoxosomatidae), 7(3), 10-16. **DOI**: https://doi.org/10.5281/zenodo.6795795

Abstract

A millipede species originating from South Asia and distributed throughout Europe, *Oxidus gracilis* is recorded for the second time in Turkey, with the first definite locality record, an altered cave environment (Koçköy cave, Düzce province, West Blacksea coast).

Keywords: Anatolia, infestation, pest, biospeleology, caves

Introduction

Habitat loss and degradation caused by mining or urbanization has been recognized as one of the most significant global threats to subterranean biodiversity (Mammola et al., 2019) and a direct driving factor promoting alien species colonization and invasion (Pyšek et al., 2020). However, it is unknown whether degradation promotes invasions in subterranean ecosystems. Alien species invading the subterranean habitats and their ways of colonization have been rarely documented worldwide. On the other hand, it has been shown that they can establish abundant populations and threaten the native subterranean fauna through direct or indirect effects (Reeves, 1999a; Taylor et al., 2003). Since indigenous subterranean life is characterized by restricted distributions, low diversity, and slow population growth, it is prone to instability and low redundancy at the population and community levels, respectively (Mammola et al., 2019). Consequently, new interactions inflicted by aliens, such as competition or predation, may threaten species in their entire ranges or

communities as a whole; therefore, it is crucial to reveal such invasions and collect data to develop a better understanding.

The proliferation of global trade and cross-continental travel contributes to the spread of invasive species, including alien invertebrates mainly translocated through unintentional pathways, difficult to track or prevent (Saul et al., 2017). Numerous invertebrate species are considered invasive in Europe, yet our knowledge is limited compared to other groups like plants or vertebrates, mainly because of taxonomic impediments or lack of ecological research (Roques et al., 2009). One of the poorly known groups is Diplopoda, represented by 20+ known alien species across Europe (Stoev et al., 2010; Decker et al., 2016), and one of them is the globally widespread *Oxidus gracilis* (C. L. Koch, 1847).

Oxidus gracilis is an alien species known in Europe since the 19th century and regarded as a pest due to its plant damaging feeding habits and mass occurrence in greenhouses; and one of the few alien millipede species that can colonize natural habitats (Stoev et al., 2010). It is now common in many regions, including the Caucasus and the rest of the Black Sea coast (Stoev & Korsós, 2010; Kokhia & Golovatch, 2020). Not surprisingly, Enghoff and Kebapçı (2008) reported this species from Rize in the Caucasian part of Turkey. This species can also colonize subterranean habitats (Strasser, 1974; Vicente & Enghoff, 1999), and reports emphasize the high abundances it can attain as an alien subterranean element (Reeves, 1999b), indicating its troglophilic nature.

In this paper, we report a new record of the alien *O. gracilis* discovered in an altered cave environment, aiming to provide new data on Turkey's poorly known millipede fauna and draw attention to a subterranean colonization event that possibly occurred following the degradation of a cave.

Material and methods

Koçköy (= Yenimahalle) cave is located 1,5 km south of Akçakoca, and 38,5 km north of Düzce city centers on the western Black Sea coast of Turkey. It is a horizontally developed, semi-active, doline-type cave with 360 m planimetric length and -13 m depth. Previous studies reported its original dimensions at the entrance as 5 m wide and 4.4 m high and the surrounding surface habitat as a dense forest (MTA, 2002). Today, the entrance and the surrounding habitat have been entirely altered due to excavation and construction activities that took place recently (ASPEG, 2008). The formerly large cave entrance is buried, leaving the sole possible access to the cave through a reinforced concrete pipe system installed in an upright position (Fig. 1). Buildings, roads, backyards, and anthropogenic shrub vegetation surround its environs, which replaced the formerly dense forest habitat.

We visited Koçköy Cave on 24 October 2020 to sample terrestrial arthropods. A direct intuitive search methodology was adopted (Wynne et al., 2019) to sample the cave's entrance and twilight zones. Unfortunately, exhaustive sampling was not possible in the dark zone due to low oxygen levels, which triggered the immediate evacuation of the cave upon detection. Live specimens were photographed in the field using a Nikon D7000 camera attached with a 105 mm macro lens; specimens were directly taken into 70% ethanol and transferred to the laboratory.

Figure 1. Entrance of Koçköy Cave.

Results and discussion

***Oxidus gracilis* (C. L. Koch, 1947)** (Fig. 2)

Material examined: 7 ♂♂, 8 ♀♀, Turkey, Düzce Province, Akçakoca District, Koçköy Cave (41°4'40.48"N, 31°7'20.96"E), asl 40 m, 20 Oct 2020, leg. M. Elverici.

Numerous individuals were observed foraging in high density on the walls of the concrete pipe and cave and on allochthonous organic material accumulated on the ground during the twilight and dark zones, with 15 specimens collected by hand. Specimens were aggregated mainly in the twilight zone, but individuals were also observed in the examined portion of the dark zone.

The presence of *O. gracilis* in Turkey (Enghoff & Kebapçı, 2008) was mentioned in a sentence in the paper that authors dedicated initially to an invasion event by *Calyptophyllum longiventre* (Verhoeff, 1941). It was based on specimens observed in the indoor environment of houses at night in Rize, on the Black Sea coast of northeastern Anatolia. Unfortunately, this significant report recording *O. gracilis* in Turkey has been overlooked in the subsequent literature.

With our record from Northwestern Anatolia, the species is now known from two localities on the Black Sea coast of Turkey, both from altered or anthropogenic habitats. These two localities correspond to two distinct ecological regions (İyigün et al., 2013); regardless, *O. gracilis* has been recorded from every country on the Black Sea coast, as well as from territories neighboring Turkey in the west and east: Bulgaria, Georgia, and Iran (Enghoff & Moravvej, 2005; Stoev, 2007; Kokhia & Golovatch, 2020). Even though expanding trade and greenhouse cultivation of tropical plants has been regarded as the main reason for this species' expansion in Europe, it shows a continuous distribution pattern around the Black Sea coast, implying colonization through natural ways like dispersal.

The record we are presenting is the first from a subterranean environment in Turkey. The fact that the new locality is a severely altered cave is not very surprising, given that *O. gracilis* is mainly associated with altered or modified ecosystems as a result of anthropogenic causes (Nguyen & Sierwald, 2013; Nguyen et al., 2017). It is currently unknown how widespread this species actually is in Turkey. However, a survey of 59 caves around Anatolia during the 2019–2021 period, 27 from the Black Sea coast, indicates it is not common, at least in caves. All 59 caves have been sampled via state-funded projects, in which a similar sampling methodology was carried out by the second author, enabling the production of comparable invertebrate inventories. These efforts yielded a single locality for *O. gracilis*, the Koçköy (Yenimahalle) cave.

It is unknown precisely when the construction activities that altered the entrance and the surrounding habitat for Koçköy (Yenimahalle) occurred. However, it is possible to approximate it by considering the existing reports published by public institutions or amateur caving groups. Two reports provide descriptions of the cave based on field studies performed in 1999 and 2008, prior to our visit in 2020. The oldest historical report was based on a 1999 field survey, reporting the original state of the cave prior to construction (MTA, 2002). The following report by ASPEG (2008) quoted a denunciation from October 2007 on the debris depositing and recorded dramatic alterations of the entrance and its environs due to a nearby excavation caused by road construction (ASPEG, 2008). Nevertheless, this condition persisted and was confirmed during our visit in 2020.

Figure 2. Female specimen of *Oxidus gracilis* (C. L. Koch, 1947) *in situ*.

According to Stoev and Korsós (2010), *O. gracilis* is regarded as a pest, damaging plants mainly in greenhouses in many European countries, and capable of reaching high densities (>2500 individuals per m^2). This species is also called the "greenhouse millipede" for these attributes. It is currently only known from altered habitats in Northern Turkey. However, upon finding its way to the South, it might become a severe issue for the greenhouse farmers on the Mediterranean coast.

Acknowledgments

This study is a part of the project "Research Project for Some Caves in the Western and Eastern Black Sea Regions and Central Anatolia Region," supported by the Republic of Turkey, Ministry of Environment, Urbanization, and Climate Change.

We thank our caver friends who enabled access to the cave for sampling, members of the Turkish Caving Federation: Barış Kaymaz, Hilmi Umut Demiriz, Burak, and Murat Gezer.

We also thank Gökhan Eren Çankaya, Ertuğrul Kulaksızoğlu (Kaşif Consulting, Reporting, Organization Company), and Mustafa Uzun (the Republic of Turkey, Ministry of Environment,

Urbanization and Climate Change, Directorate General of Protection of Natural Assets) for their bits of help during field trips and project process.

References

Anatolian Speleology Group (ASPEG). (2008). Koçköy Cave, Yenimahalle, Akçakoca, Düzce, Excursion Report. İstanbul. 4 p. (in Turkish).

Decker, P., Voigtländer, K., Spelda, J., Reip, H. S., Lindner, E. N. (2016). Rote Liste und Gesamtartenliste der Hundertfüßer (Myriapoda: Chilopoda) Deutschlands. In H. Gruttke et al. (Eds.), Rote Liste der gefährdeten Tiere, Pflanzen und Pilze Deutschlands. Band 4: Wirbellose Tiere (Teil 2). Bonn (Bundesamt für Naturschutz). Naturschutz und Biologische Vielfalt, 70(4), 327-346.

Enghoff, H., Moravvej, S. A. (2005). A review of the millipede fauna of Iran (Diplopoda). Zoology in the Middle East, 35(1), 61–72. https://doi.org/10.1080/09397140.2005.10638104

Enghoff, H., Kebapcı, Ü. (2008). *Calyptophyllum longiventre* (Verhoeff, 1941) invading houses in Turkey, with the first description of the male (Diplopoda: Julida: Julidae). Journal of Natural History, 42(31–32), 2143–2150. https://doi.org/10.1080/00222930802196055

İyigün, C., Türkeş, M., Batmaz, İ., Yozgatlıgil, C., Purutçuoğlu, V., Koç, E. K., Öztürk, M. Z. (2013). Clustering current climate regions of Turkey by using a multivariate statistical method. Theoretical and Applied Climatology, 114(1), 95–106.

Kokhia M.S., Golovatch S.I. 2020. Diversity and distribution of the millipedes (Diplopoda) of Georgia, Caucasus. In Z. Korsós & L. Dányi (Eds.), Proceedings of the 18th International Congress of Myriapodology, Budapest, Hungary. ZooKeys, 930, 199–219. https://doi.org/10.3897/zookeys.930.47490

Mammola, S., Cardoso, P., Culver, D. C., Deharveng, L., Ferreira, R. L., Fišer, C., ..., Zagmajster, M. (2019). Scientists' warning on the conservation of subterranean ecosystems. BioScience, 69(8), 641–650. https://doi.org/10.1093/biosci/biz064

Nguyen, A. D., Sierwald, P. (2013). A worldwide catalog of the family Paradoxosomatidae Daday, 1889 (Diplopoda: Polydesmida). CheckList, 9, 1132–1353. https://doi.org/10.15560/9.6.1132

Nguyen, A. D., Korsós, Z., Jang, K. H., Hwang, U. W. (2017). A revision and phylogenetic analysis of the millipede genus *Oxidus* Cook, 1911 (Polydesmida, Paradoxosomatidae). European Journal of Taxonomy, 293, 1–22. https://doi.org/10.5852/ejt.2017.293

General Directorate of Mineral Research and Exploration (MTA). 2002. Natural Caves of the Lower Sakarya River Basin (Bolu, Düzce and Sakarya). Ankara.166 p. (in Turkish).

Pyšek, P., Hulme, P. E., Simberloff, D., Bacher, S., Blackburn, T. M., Carlton, J. T., ..., Richardson, D. M. (2020). Scientists' warning on invasive alien species. Biological Reviews, 95(6), 1511–1534. https://doi.org/10.1111/brv.12627

Reeves, W. K. (1999a). Exotic species in North American caves. In G.T. Rea (Ed.), Proceedings of the 1999 National Cave and Karst Management Symposium. Southeastern Cave Conservancy, 164–166.

Reeves, W. K. (1999b). Ecology of Invertebrate Necrophages in Caves of Northwestern Georgia. M.S. Thesis. Clemson University. South Carolina: Clemson.

Roques, A., Rabitsch, W., Rasplus, J. Y., Lopez–Vaamonde, C., Nentwig, W., Kenis, M. (2009). Alien terrestrial invertebrates of Europe. In: Handbook of alien species in Europe (pp. 63–79). Springer Dordrecht. https://doi.org/10.1007/978-1-4020-8280-1_5

Saul, W. C., Roy, H. E., Booy, O., Carnevali, L., Chen, H. J., Genovesi, P., ..., Jeschke, J. M. (2017). Assessing patterns in introduction pathways of alien species by linking major invasion data bases. Journal of Applied Ecology, 54(2), 657–669. https://doi.org/10.1111/1365-2664.12819

Strasser, K. (1974). I diplopodi chilognati della Sardegna. Fragmenta Entomologica, 10, 231–293.

Stoev, P. (2007). Fauna and Zoogeography of Myriapoda in Bulgaria. In V. Fet & A. Popov (Eds.), Biogeography and Ecology of Bulgaria (pp. 379–404). Springer Netherlands. https://doi.org/10.1007/978-1-4020-5781-6_11

Stoev, P., Zapparoli, M., Golovatch, S., Enghoff, H., Akkari, N., Barber, A. (2010). Myriapods (Myriapoda). Chapter 7.2. In A. Roques et al. (Eds.), Alien terrestrial arthropods of Europe. BioRisk, 4(1), 97–130. https://doi.org/10.3897/biorisk.4.51

Stoev, P., Korsós, Z. (2010). 14.2 – *Oxidus gracilis* (C.L. Koch, 1847) (Diplopoda, Polydesmida, Paradoxosomatidae). Chapter 14. Factsheets for 80 representative alien species. In A. Roques & D. Lees (Eds.), Arthropod invasions in Europe. BioRisk, 4(2), 864–865. https://doi.org/10.3897/biorisk.4.69

Taylor, S. J., Krejca, J. K., Smith, J. E., Block, V. R., Hutto, F. R. (2003). Investigation of the potential for red imported fire ant (*Solenopsis invicta*) impacts on rare karst invertebrates at Fort Hood, Texas: A field study. Illinois Natural History Survey. Illinois: Champaign.

Vicente, M., Enghoff, H. (1999). The millipedes of the Canary Islands. Vieraea, 27, 183–204.

Wynne, J. J., Howarth, F. G., Sommer, S., Dickson, B. G. (2019). Fifty years of cave arthropod sampling: techniques and best practices. International Journal of Speleology, 48(1), 33-48. https://doi.org/10.5038/1827-806X.48.1.2231