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FIRST RECORD OF *TANDONIA BUDAPESTENSIS* (HAZAY, 1880) (GASTROPODA: STYLOMMATOPHORA: MILACIDAE) FROM BOSNIA & HERZEGOVINA WITH ADDITIONAL NOTES ON THE OCCURRENCE OF *TANDONIA KUSCERI* (H. WAGNER, 1931)

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Gojšina, V., Stanković, M. & Dedov, I.: First record of *Tandonia budapestensis* (Hazay, 1880) (Gastropoda: Stylommatophora: Milacidae) from Bosnia & Herzegovina with additional notes on the occurrence of *Tandonia kusceri* (H. Wagner, 1931). Nat. Croat., Vol. 32, No. 2, 423-429, Zagreb, 2023.

In this paper, we present the first records of the Budapest slug, *Tandonia budapestensis* (Hazay, 1880), from five localities in Bosnia & Herzegovina. We provide a detailed description of the external morphology and reproductive system of the specimens. We also speculate on the presence of *Tandonia kusceri* (H. Wagner, 1931) in Bosnia & Herzegovina, based on the present distribution and spread of the species and one photo posted on a social media platform.

Keywords: slugs, new findings, morphology, anatomy, distribution, alien species

Gojšina, V., Stanković, M. & Dedov, I.: Prvi nalaz *Tandonia budapestensis* (Hazay, 1880) (Gastropoda: Stylommatophora: Milacidae) iz Bosne i Hercegovine s dodatkom o pojavljivanju *Tandonia kusceri* (H. Wagner, 1931). Nat. Croat., Vol. 32, No. 2, 423-429, Zagreb, 2023.

U ovom radu donosimo prve nalaze budimpeštanskog golaća *Tandonia budapestensis* (Hazay, 1880) s pet lokaliteta u Bosni i Hercegovini. Dajemo detaljni opis vanjske morfologije i reproduktivnog sustava primjeraka. Također, razmatramo prisutnost vrste *Tandonia kusceri* (H. Wagner, 1931) u Bosni i Hercegovini, na temelju sadašnje rasprostranjenosti i širenja vrste te jedne fotografije s društvenih mreža.

Ključne riječi: puževi golaći, novi nalazi, morfologija, anatomija, rasprostranjenost, strane vrste

INTRODUCTION

Tandonia budapestensis (Hazay, 1880) is a medium-sized milacid slug most probably native to the Southern Alps and the northern part of the Balkan peninsula (Wiktor, 1983, 1987). Alongside *Milax gagates* (Draparnaud, 1801), it is one of the most widely spread milacids outside its native range. According to Wiktor (1987), it is native to Austria, Hungary, Switzerland, Romania, Italy and Germany but has also been introduced in the major part of the Balkan peninsula, Belgium, Czech Republic, Poland,

Great Britain and Iceland (see also Dvořák *et al.*, 2003; Reise *et al.*, 2006 and Rowson *et al.*, 2014). Outside Europe, it is known from New Zealand and North America (Wiktor, 1987; Reise *et al.*, 2006). From the countries of the former Yugoslavia, this species is known from North Macedonia (Stankovic *et al.*, 2006), Serbia (Karaman, 2007), Croatia(Štamol, 2010) and Montenegro (Telebak *et al.*, 2013).

Tandonia kusceri (H. Wagner, 1931) was described from the vicinity of Sveta Petka Monastery, near Niš in Serbia. It is native to the Balkan peninsula (southern Serbia, North Macedonia, Bulgaria, Dobrudzha in Romania, and northern Greece) (Wiktor, 1996; Balashov & Markova, 2023). It has also been introduced in many parts of Europe (see Son, 2010; Balashov *et al.*, 2013; Telebak *et al.*, 2013; Korábek *et al.*, 2016; Gural-Sverlova *et al.*, 2019; Čejka *et al.*, 2020; Turóci *et al.*, 2020; Gojšina, 2021; Duda *et al.*, 2022; Balashov & Markova, 2023) as well as in North America (Gerber, 2014).

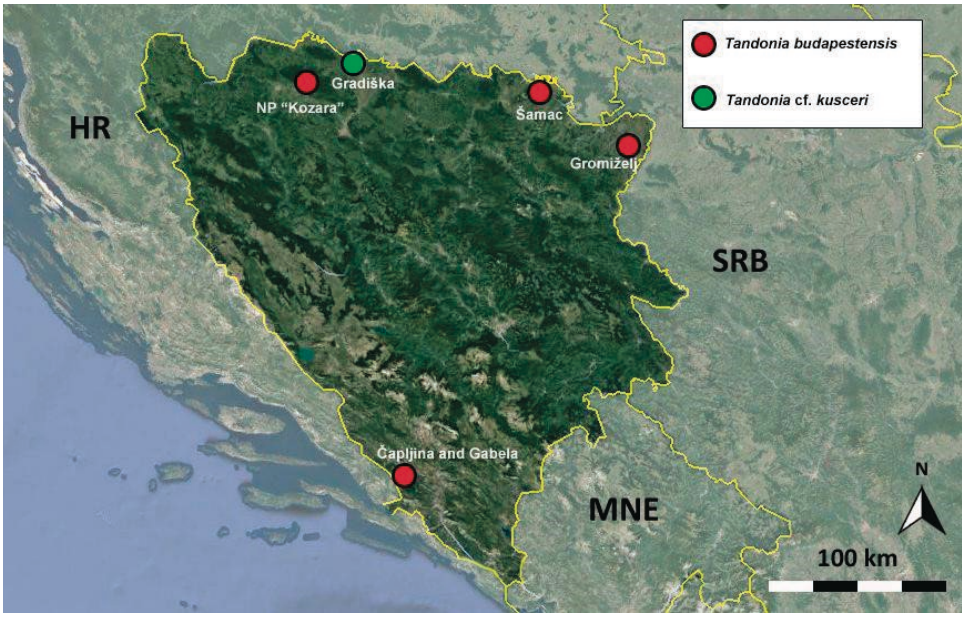

Fig. 1. Distribution map of *T. budapestensis* and *T. cf kusceri* in Bosnia & Herzegovina.

In this paper, we report the first finding of *T. budapestensis* from Bosnia & Herzegovina (BiH) and speculate on the presence of *Tandonia kusceri* (H. Wagner, 1931) (Fig. 1) based on the present distribution of the species and a photo posted on the social media platform Facebook.

MATERIAL AND METHODS

Slugs were collected by hand and fixed in 70% ethanol. Slugs were dissected and photographed with Zeiss SteReo Discovery.v12 stereomicroscope with a Leica Flexacam C3 camera. Distribution maps were made using Google Earth Pro. All specimens are stored at the Institute of Zoology, Faculty of Biology, Belgrade, Serbia.

Abbreviations

IZOO – Institute of Zoology, Faculty of Biology, Belgrade, Serbia

BL – body length

BiH – Bosnia & Herzegovina

ML – mantle length

RESULTS

Superfamily Parmacelloidea P. Fischer, 1856 (1855)

Family Milacidae Ellis, 1926

Tandonia budapestensis (Hazay, 1880)

Material examined: Bosnia & Herzegovina: Šamac, Tišina, swampy area near the Sava river, 45°02′30.90″N 18°28′33.31″E, x.2020., leg. M. Stanković, 1 specimen (IZOO-MG-010); Gabela, a swampy field with *Phragmites communis*, *Bolboschoenus maritimus* and several *Salix* spp. 43°04′34.023′′N, 17°40′11.123′′E, 16.viii.2022., leg. M. Stanković, 1 dissected specimen (IZOO-MG-012,012A); Čapljina, bank of the Neretva river, under rotting bark and among *Amorpha fruticosa*, 43°06′21.87″N, 17°42′21.99″E, 15. viii.2022., leg. M. Stanković, 1 specimen (IZOO-MG-008); Gromiželj, Laketića vir, among *Thelypteris palustris* and *Salix cinerea*, 44°52′00.81″N, 19°18′31.54″E, 09.ix.2016., leg. M. Stanković, 2 specimens (IZOO-MG-011); Kozara, National Park under tree bark and near a beech forest, 45°03′03.45″N, 16°52′43.58″ E, 22.viii.2022., leg. M. Stanković, 1 specimen (IZOO-MG-009).

Measurements (preserved specimens): BL= 20–35 mm; ML= 8–9 mm.

Description of specimens from Bosnia & Herzegovina: The external morphologyof specimens from BiH corresponds to the usual appearance of this species as previously described in Wiktor, 1987 and 1996. **External morphology:** Body coloration is described based on preserved specimens. To show the appearance of living specimens, a sample collected from Serbia (Belgrade) is provided (Fig. 2). Body is elongated, dark chocolate brown, with a light dull orange keel running from the posterior end of the body all

Fig. 2. Living specimen of *T. budapestensis* from Belgrade (Serbia) Photo: N. Vesović

the way towards the mantle, reaching it. The whole body is "sprinkled" with blackish irregular lines/dots giving the slug a darker appearance. The head and tentacles are slightly darker than the rest of the body. Mantle covering approximately 1/3 of the body length. A characteristic horseshoe groove is well visible on the mantle and the narrow pneumostome in the posterior half. The sole is dark, slightly lighter at the sides than in the middle. When preserved, the brownish/dull orange hue of the body is completely lost, leaving the slug ashen and dark, almost completely black. The keel also loses its dull orange hue, thus becoming more pale. Sole is, after preservation, also almost uniformly dark grey. **Genitalia:** Hermaphroditic gland (ovotestis) is medium-sized, pale and situated among the lobes of the digestive gland. From it, a long pale hermaphroditic duct runs towards the large albuminous gland. The wide spermoviduct branches to a thin and moderately long spermiduct (vas deferens) and a thicker oviduct. The vas deferens opens asymmetrically and apically at the epiphallus. The epiphallus is longer but slightly narrower than the penis. The vagina is short, with two lobated vaginal accessory glands visible at its base. Bursa copulatrix is roughly club-shaped to slightly elongated, with a short duct (Fig. 4). Spermatophores are not analyzed. **Vestigial shell:** The vestigial shell is small, flat and delicate, seed-shaped (Fig. 4).

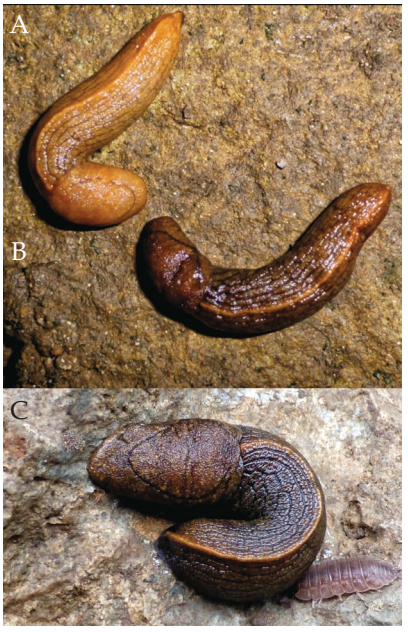

Fig. 3. External appearance variation of *T. budapestensis* from Bulgaria. A. & B. Eastern Bulgaria, Black Sea seashore, Sozopol town; C. Eastern Balkan (=Stara Planina) foothills, Kotel town. All specimens are in resting position. Photo: I. Dedov

Tandonia kusceri (H. Wagner, 1931)

One specimen of what was presumed to be *T. kusceri* was photographed by a citizen scientist from the northern part of BiH (Gradiška). The photo was posted on a Facebook group for insect identification named 'Insekti Srbije'. Unfortunately, we could not find and provide the posted photo, probably due to the fact that the author might have dele-

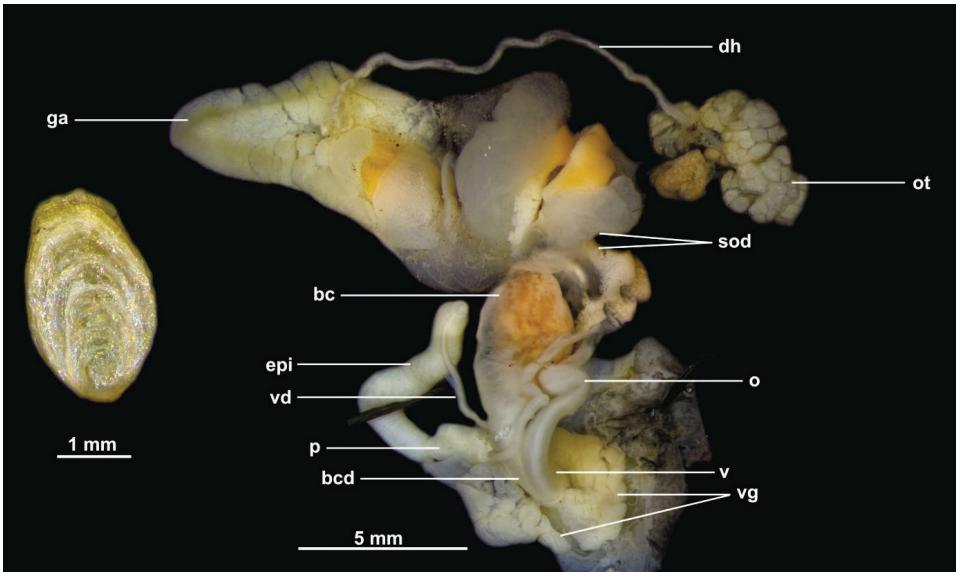

Fig. 4. Genitalia of *T. budapestensis* from Bosnia & Herzegovina (IZOO-MG-012). bc, bursa copulatrix; bcd, bursa copulatrix ductus; dh, ductus hermaphroditicus; epi, epiphallus; ga, glandula albuminalis; o, oviduct; ot, ovotestis; p, penis; sod, spermoviductus; v, vagina; vag, vaginal glandulae; vd, vas deferens. Photo: V. Gojšina

ted the account or the post itself. The photographed specimen clearly showed a light dorsal keel running from the posterior end of the body towards the mantle, reaching the mantle, which made it clear that it was *Tandonia*. Furthermore, the specimens showed pinkish-orangish-brownish coloration of the body, which is characteristic of *T. kusceri* but also several more species from the same genus (e.g. *T. serbica* (H. Wagner, 1931), *T. rustica* (Millet, 1843), see Wiktor, 1987). It would be impossible to unambiguously conclude that the photographed specimen was indeed *T. kusceri*, so the presence of this species in BiH is herein only hypothesized. This matter is further discussed below.

DISCUSSION

The record of *T. budapestensis* from BiH is unsurprising given that it is well-known in neighboring countries (see Karaman, 2007; Štamol, 2010 and Telebak *et al*., 2013). The localities in these five new records are the only mentions to date in BiH. Three of them are located in the northern part of the country, near the border with Serbia and Croatia, while the other two are closer to the Adriatic Sea. Based on the distribution in other countries, these findings in BiH are quite disjunctive, and we can say that it is probably continuous throughout the whole area. In Serbia, based on the unpublished data of the senior author, this species is widespread especially in the northern, lowland part of the country and near Belgrade.

The coloration of specimens is typical for the species and with a stable pattern for all findings. In the more eastern part of the Balkan peninsula (Bulgaria), 3 color varia-

tions are found (Fig. 3). The specimens of Bosnia and Herzegovina probably belong to medium-dark form, known for the species.

When it comes to the presence of *T. kusceri* in BiH, we find it very likely to be present because it was recorded in neighboring Croatia (Štamol, 2010) and Montenegro (Telebak *et al*., 2013), and it is already widespread in Serbia. The recent work of Balashov & Markova, 2023 summarized the present knowledge on this species and emphasized its fast spread. The approximately northernmost point of the native range of *T. kusceri* is in Dobrudzha in Romania (Balashov & Markova, 2023). It was additionally found as probably introduced in western Romania (city park in Timisoara) by the senior author (unpublished data), which suggests that the distribution might be continuous across the whole country. Given the fast spread of the species, we believe that it is only a matter of time before this slug is confirmed from BiH. Until then, we hypothesize its presence based on a photo provided.

Karaman (2006) summarised the previous publications from the territory of BiH and listed 5 species of *Tandonia* (*bosnensis* Wiktor, 1986; *cavicola* (Simroth, 1916); *reuleauxi* (Clessin, 1887); *robici* (Simroth, 1885); *sowerbyi* (A. Férussac, 1823)). With our new findings, this number is increased to 7. Relying on the distribution maps and additional information provided by Wiktor (1987, 1996), we consider both *T. budapestensis* and *T. kusceri* alien in BiH and expect their further spread.

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REFERENCES

Balashov, I. A., Son, M. O., Coadă, V. & Welter-Schultes, F., 2013: An updated annotated checklist of the molluscs of the Republic of Moldova. Folia Malacologica **21,** 175–181.

Balashov, I. & Markova, A., 2023: Expansion of the invasive Balkan slug *Tandonia kusceri* (Stylommatophora: Milacidae): A new frontier in northern Ukraine and other new records. Folia Malacologica **31**, 24–31.

Čejka T., Beran, L., Korábek, O., Hlaváč, J. Č., Horáčková, J., Coufal, R., Drvotová, M., Maňas, M., Horsáková, V. & Horsák, M., 2020: Malacological news from the Czech and Slovak Republics in 2015–2019. Malacologica Bohemoslovaca **19,** 71–106.

Duda M., Schubert, H., Schindelar, J. & Haringe, 2022: Four new records of invasive gastropods in Vienna. Arianta **9,** 37.

Dvořák, L., Čejka, T. & Horsák, M., 2003: Present knowledge of distribution of *Tandonia budapestensis* (Hazay, 1881) in the Czech and Slovak Republics (Gastropoda: Milacidae). Malakológiai Tájékoztató **21**, 37–43.

Gerber, J., 2014: First American record of the exotic slug *Tandonia kusceri* (Gastropoda: Milacidae). The Nautilus **128**, 59–63.

Gojšina, V. Z., 2021: New Serbian records of the slug *Tandonia kusceri* (H. Wagner, 1931) (Gastropoda: Eupulmonata: Milacidae) suggest its continuous dispersal to the north. Folia Malacologica **29**, 229–233.

Gural-Sverlova, N., Gleba, V. & Gural, R., 2019: Einschleppung von *Tandonia kusceri* (Pulmonata: Milacidae) nach Transkarpatien und Verbreitung von *Tandonia*-Arten in der Ukraine. Malacologica Bohemoslovaca **18**, 19–26.

Karaman, B., 2007: Checklist of snails (Mollusca, Gastropoda) of Serbia. Glasnik Republičkog Zavoda Zaštite Prirode Podgorica **29–30**, 131–148.

Karaman, B. J., 2006: Former investigations of the fauna of snails (Mollusca, Gastropoda) in Bosnia & Herzegovina. Natura Montenegrina **5**, 55–66.

Korábek, O., Čejka, T. & Vá, L. J., 2016: *Tandonia kusceri* (Pulmonata: Milacidae), a slug new for Slovakia. Malacologica Bohemoslovaca **15**, 3–8.

Reise, H., Hutchinson, J. M. & Robinson, D. G., 2006: Two introduced pest slugs: *Tandonia budapestensis* new to the Americas, and *Deroceras panormitanum* new to the eastern USA. Veliger **48**, 110–115.

Rowson, B., Turner, J., Anderson, R. & Symondson, B., 2014: Slugs of Britain and Ireland. Telford: FSC Publications, 60 p.

Son, M. O., 2010: Alien mollusks within the territory of Ukraine: Sources and directions of invasions. Russian Journal of Biological Invasions **1**, 37–44.

Štamol, V., 2010: A list of the land snails (Mollusca: Gastropoda) of Croatia, with recommendations for their Croatian names. Natura Croatica **19**, 1–76.

Stankovic, S. V., Stojkoska, E. & Norris, A., 2006: Annotated Checklist of the Terrestrial Gastropods (Gastropoda) of the Republic of Macedonia. Anniversary Proceedings (1926–2006). Eighty years of achievement by the Macedonian Museum of Natural History 43–55.

Telebak, B., Brajković, M. & Ćurčić S., 2013: Contribution to the knowledge of the slugs (Gastropoda: Stylommatophora: Limacidae and Milacidae) from Montenegro. Bulletin of the Natural History Museum **6**, 55–64.

Turóci, Á., Fehér, Z., Krízsik, V. & Páll-Gergely, B., 2020: Two new alien slugs, *Krynickillus melanocephalus* Kaleniczenko, 1851 and *Tandonia kusceri* (H. Wagner, 1931), are already widespread in Hungary. Acta Zoologica Academiae Scientiarum Hungaricae **66**, 265–282.

Wiktor, A., 1983: The slugs of Bulgaria (Arionidae, Milacidae, Limacidae, Agriolimacidae – Gastropoda, Stylommatophora). Annales Zoologici **37**, 71–206.

Wiktor, A., 1987: Milacidae (Gastropoda, Pulmonata) - systematic monograph. In Annales Zoologici **3**.

Wiktor, A., 1996: The slugs of the former Yugoslavia (Gastropoda terrestria nuda–Arionidae, Milacidae, Limacidae, Agriolimacidae). *Annales zoologici* **46**, 1–110.