

DISTRIBUTION OF THE ALIEN SLUG *BOETTGERILLA PALLENS* SIMROTH, 1912 IN BULGARIA AND SERBIA (MOLLUSCA: GASTROPODA: BOETTGERILLIDAE)

IVAYLO K. DEDOV¹, ULRICH E. SCHNEPPAT², VUKAŠIN GOJŠINA³, FABIA
KNECHTLE GLOGGER⁴ & REGULA CORNU⁵

¹Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, 2 Gagarin Street,
1113 Sofia, Bulgaria (e-mail: idedov@gmail.com)

2CH-7074 Churwalden-Malix, Sennereiweg 8, Switzerland (e-mail: u.schneppat@gmail.com)

³Department of Morphology, Systematics and Phylogeny of Animals, University of Belgrade, Faculty
of Biology, Studentski trg 16, 11000, Belgrade, Serbia (mr.gojsinavukasin@gmail.com)

⁴CH-9100 Herisau, Sturzenegg 2147, Switzerland (e-mail: naturmanagement@knechtleglogger.ch)

⁵CH-7000 Chur, Raschärenstrasse 16, Switzerland (e-mail: regula.cornu@bluewin.ch)

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alien slug *Boettgerilla pallens* Simroth, 1912 in Bulgaria and Serbia (Mollusca: Gastropoda: Boettgerillidae). *Nat. Croat.*, Vol. 34, No. 1, 53-67, Zagreb, 2025.

We present the first records of the family Boettgerillidae, and the species *Boettgerilla pallens* Simroth, 1912 in the gastropod fauna of Serbia. The history of the discovery of *B. pallens* in Bulgaria is summarized, and new faunistic records from the country are provided. The anatomy of Bulgarian specimens is described, compared with specimens from Switzerland, and the general details of the habitus and anatomy of the species are discussed. We comment on the habitat preferences and invasive potential of the species.

Keywords: new family and species for the fauna, new records, anatomy, morphology, habitat preferences, invasive potential

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strane vrste puža golača *Boettgerilla pallens* Simroth, 1912 u Bugarskoj i Srbiji (Mollusca: Gastropoda: Boettgerillidae). *Nat. Croat.*, Vol. 34, No. 1, 53-67, Zagreb, 2025.

U radu se predstavljaju prvi nalazi porodice Boettgerillidae i vrste *Boettgerilla pallens* Simroth, 1912 za faunu puževa Srbije. Objedinjena je povijest nalaza *B. pallens* u Bugarskoj, uz nove nalaze za zemlju. Opisana je anatomija bugarskih primjeraka, uspoređena s primjercima iz Švicarske te se raspravljaju opći podaci o izgledu i anatomiji vrste. Komentira se izbor staništa i invazivni potencijal vrste.

Ključne riječi: nova porodica i nova vrsta u fauni, novi nalaz, anatomija, morfologija, odabir staništa, invazivni potencijal

INTRODUCTION

SIMROTH (1912) described *B. pallens* from the Caucasus Mountains, at the south-eastern border of Europe (REISE *et al.*, 2000). Because of the morphological and anatomical differences identified, WIKTOR & LIKHAREV (1979) raised the family Boettgerillidae from the family Milacidae. Their new family included one genus (*Boettgerilla*) and two species – *Boettgerilla pallens* Simroth, 1912 and *Boettgerilla compressa* Simroth, 1910. Currently, *B. compressa* seems to occur in Abkhazia (Verknyaya Tzebelda) only (SYSOEV &

SCHILEYKO, 2009), while *B. pallens* is expanding in Europe (REISE *et al.*, 2000). According to KERNEY & CAMERON (1996), *B. pallens* is widespread in southeastern Europe and is rapidly invading the southwestern part of the continent. REISE *et al.* (2000) summarized the history of the invasion of the species in Europe (i.e., USSR - 1907; West Germany - 1949; Poland - 1956; Czechoslovakia - 1960; East Germany - 1960; Switzerland - 1960; Belgium - 1967; France - 1968; Finland - 1968; Romania - 1969; Austria - 1971; Hungary - 1971; Great Britain - 1972; island of Ireland - 1973; Netherlands - 1973; Sweden - 1974; Turkey - 1985; Andorra - 1991; Luxembourg - 1996; Denmark - 1998; Norway - 1998). Furthermore, in 1987 and 1988, *B. pallens* was found at one natural and three urban sites in Crimea (BALASHOV & BAIDASHNIKOV, 2012), while later ĐATKAUSKIENĖ (2001) reported the species for Lithuania (collected September 2000), and in 2014, the species was reported for the first time from the Canary Islands (MARGRY, 2014).

Based on material collected in 1998, REISE *et al.* (2000) published the first record of the species outside Eurasia – in Vancouver (British Columbia, Canada), in semi-natural habitats. Mc DONNELL *et al.* (2014) published the first information for the species from the United States, from a potted plant in a retail garden center in San Mateo, Northern California. ARAIZA-GÓMEZ *et al.* (2016) reported *B. pallens* for Mexico.

The species was not reported in earlier summarizing works on the Balkan gastropod fauna (PAVLOVIĆ, 1912; DAMYANOV & LIKHAREV, 1974; WIKTOR, 1983; WIKTOR, 1996). During a collecting trip, related to the preparation of his PhD thesis, the first author (I. Dedov) found a single specimen, belonging to a species completely unknown to him at that time. In his field notebook, he noted that “the specimen probably belongs to the family Milacidae, but has an atypically slender shape, elongated body and an inconspicuous keel”. This particular specimen was collected on July 19, 1999 in Sofia (record #1 in Tab. 1). Between 2013 and 2018, in the course of malacological research into the slug fauna of Bulgaria, additional specimens of the same species were collected from the very same locality, and subsequently identified as *B. pallens*. DEDOV *et al.* (2015) published a short communication on the family, genus, and species, as newly recorded for the Bulgarian malacofauna. In the following years, the species was found in further locations throughout Bulgaria, in both urban, and natural habitats. Quite recently, GEORGIEV *et al.* (2020) reported the species from Sarnena Sredna Gora Mountains, Central Bulgaria. Until now, there were no previous records of *B. pallens* from Serbia. Additional new information on the species from Bulgaria and Serbia is summarized in the present study.

MATERIALS AND METHODS

All specimens from Bulgaria were collected from 1999 to 2018, during our research expeditions across the country. Serbian specimens were collected during two field trips in 2022 and 2023. All the localities studied are listed in Tab. 1 and mapped in Fig. 1. Slugs were hand-collected, then killed and fixed following the recommendations of NITZ *et al.* (2009). Specimens were relaxed in a jar with unchlorinated water and a few drops of the surfactant degreaser SUPRALAN-UF until the animal was completely stretched and dead (usually after 30–60 minutes). Dead slugs were cleaned of mucus in a sieve under cold running water. For preservation, each specimen was injected (using a syringe) with 96% ethanol in the body cavity through the terminal tip of the sole, and was subsequently covered with ethanol (96%) for some hours, and finally stored in 75% ethanol (which was changed at least twice in the following days). All the examined specimens and their age stages are presented in Tab. 1.

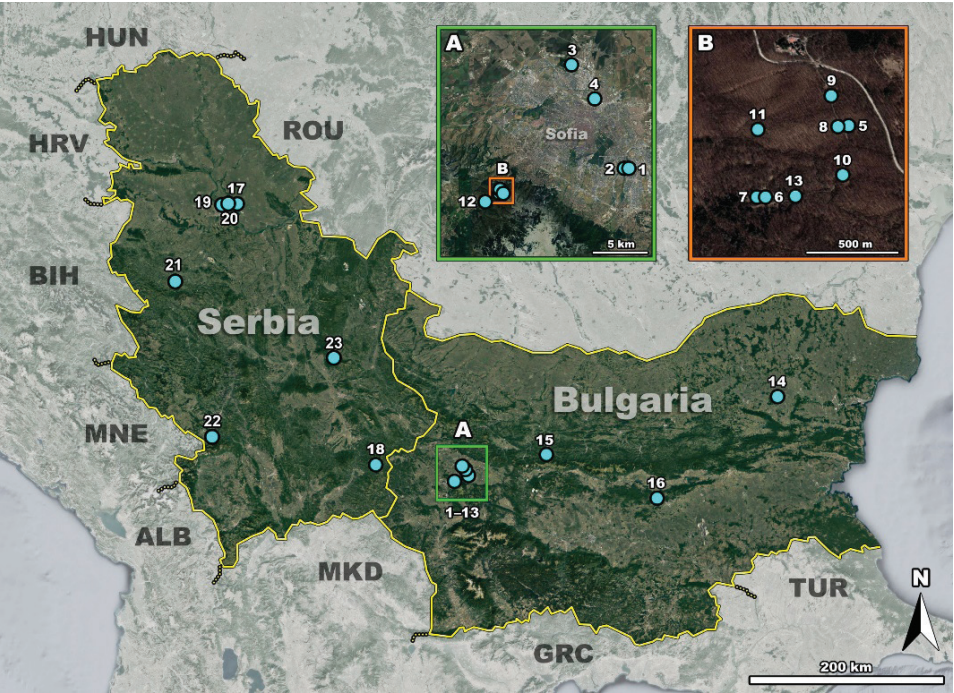


Fig. 1. *Boettgerilla pallens*: new records from Serbia and Bulgaria mapped. Distance between localities 1-13 are as follows: 1&2 - ca. 50 m; 3&4 - ca. 3.8 km; 5-13 are all within an average distance of 434 m (min. 19 m, max. 1224 m).

Tab. 1. Details of the localities from which the *Boettgerilla pallens* examined specimens originated. Abbreviations: BNM = Bündner Naturmuseum, Chur, Switzerland; IBER = Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences; IZOO-MG = Institute of Zoology, University of Belgrade, Faculty of Biology; ad. = adult; ind. = individual; juv. = juvenile; subad. = subadult.

Nº	Geographic Region	Locality	Habitat	Date/collectors/observers/collection/published	GPS coordinates, altitude, remarks
BULGARIA					
1.	Sofia Plain	Sofia city, Mladost 1 district, Rekmaritsa River valley, on the right riverbank	flood-plain forest <i>Corylus avellana</i> L., <i>Acer pseudoplatanus</i> L., <i>Robinia pseudoacacia</i> L., <i>Betula</i> sp., <i>Salix</i> spp., <i>Quercus</i> sp., <i>Fraxinus excelsior</i> L., <i>Ligustrum vulgare</i> L., <i>Urtica dioica</i> L., <i>Geum urbanum</i> L., <i>Hedera helix</i> L., <i>Fallopia japonica</i> (Houtt.), under a fallen trunk of an unidentified broadleaf tree	19 July 1999, leg. I.K. Dedov, 1 ad. (BNM 065469) (Dedov <i>et al.</i> 2015)	N42.663508° E023.369131°, 563 m

№	Geographic Region	Locality	Habitat	Date/collectors/observers/collection/published	GPS coordinates, altitude, remarks
2.	Sofia Plain			23 October 2013, leg. F. K. Knechtle Glogger, U.E. Schnepapat, I.K. Dedov, 1 subad. (BNM 065461); 03 August 2015, observed by I. K. Dedov, 1 ad. (Dedov et al. 2015)	N42.66356° E023.36966°, 563 m
3.		Sofia city, Severen Park (=Northern Park)	under dead wood and rubbish along a path in a broadleaf mixed forest	05 October 2014, leg. U. E. Schnepapat, F. Knechtle Glogger, I.K. Dedov, 3 ad. (BNM 067106-067108)	N42.74284° E023.30564°, 526 m
4.		Sofia city, Central Sofia cemetery	open terrain, under a broken piece of marble	19 October 2015, leg. I.K. Dedov, U.E. Schnepapat, R. Cornu, 2 juv. (BNM 067985, BNM 067986)	N42.715566° E023.333481°, 533 m
5.	Vitoshka Mts. Vitoshka Mts.	Kiliite, near Tikhiyat kat, along the hiking path Vladaya – Tikhiyat kat – Knyazhevo	mixed forest adjacent to the path, under heavy granite boulders and rotting logs of an unidentified broadleaf tree. <i>Prunus avium</i> L., <i>Acer pseudoplatanus</i> L., <i>Acer platanoides</i> L., <i>Betula spec.</i> , <i>Salix cf. alba</i> L., <i>Populus tremula</i> L., <i>Populus nigra</i> L., <i>Rosa spec.</i> , <i>Euonymus europaeus</i> L., <i>Tanacetum vulgare</i> L., <i>Mentha longifolia</i> (L.) Huds.	21 October 2010, leg. F. K. Knechtle Glogger, U.E. Schnepapat, I.K. Dedov, 4 subad. (BNM 067416-067419)	N42.635861° E023.220583°, 1066 m
6.			edge of a former montane pasture surrounded by mixed broadleaf forest, <i>Corylus avellana</i> L., <i>Prunus avium</i> L., <i>Betula pendula</i> Roth, <i>Asphodelus albus</i> Mill., under a fallen trunk of an unidentified broadleaf tree in white rot	29 September 2012, leg. U. E. Schnepapat, F. Knechtle Glogger, I. K. Dedov, 1 subad. (BNM 064559)	N42.633275° E023.216964°, 1016 m
7.		Kiliite, near Tikhiyat kat, along the hiking path Vladaya – Tikhiyat kat – Knyazhevo	edge of a former montane pasture surrounded by mixed broadleaf forest, <i>Corylus avellana</i> L., <i>Prunus avium</i> L., <i>Betula pendula</i> Roth, <i>Asphodelus albus</i> Mill., under a fallen trunk of an unidentified broadleaf tree in white rot	09 September 2013, leg. I. K. Dedov, 1 subad. (IBER 1633)	N42.63321° E023.21662°, 1014 m

№	Geographic Region	Locality	Habitat	Date/collectors/observers/collection/published	GPS coordinates, altitude, remarks
8.	Vitoshka Mts. Vitoshka Mts.	Kiliite, near Tikhiyat kat, along the hiking path Vladaya – Tikhiyat kat – Knyazhevo	mixed forest adjacent to the path, under heavy granite boulders and rotting logs of unidentified broadleaf trees; <i>Prunus avium</i> L., <i>Acer pseudoplatanus</i> L., <i>Acer platanooides</i> L., <i>Betula spec.</i> , <i>Salix cf. alba</i> L., <i>Populus tremula</i> L., <i>Populus nigra</i> L., <i>Rosa spec.</i> , <i>Euonymus europaeus</i> L., <i>Tanacetum vulgare</i> L., <i>Mentha longifolia</i> (L.) Huds.	08 October 2013, leg. F. K. Knechtle Glogger, U.E. Schnepat, I.K. Dedov, 10 ad. (BNM 065300 - 065309)	N42.635842° E023.220358°, 1055 m
9.		Kiliite, near Tikhiyat kat, along the hiking path Vladaya – Tikhiyat kat – Knyazhevo	edge of a former montane pasture surrounded by a mixed broadleaf forest, <i>Corylus avellana</i> L., <i>Prunus avium</i> L., <i>Betula pendula</i> Roth, <i>Asphodelus albus</i> Mill., under a fallen trunk of an unidentified broadleaf tree in white rot	14 October 2014, observed I.K. Dedov, 1 subad.	N42.63673° E023.22008°, 1063 m
10.		Kiliite, near Tikhiyat kat, along the hiking path Vladaya – Tikhiyat kat – Knyazhevo	forest dominated by <i>Fagus sylvatica</i> L., intermixed with few <i>Acer</i> sp., <i>Carpinus betulus</i> L., <i>Corylus avellana</i> L., under leaf-litter and under a fallen trunk of an unidentified broadleaf tree species	14 October 2014, observed I.K. Dedov, 2 subad.	N42.63430° E023.219921°, 1051 m
11.		Vitoshka Mt., west of the hiking path Vladaya – Tikhiyat kat – Knyazhevo	<i>Fagus sylvatica</i> L. forest, under leaf litter	26 September 2015, observed by I. Dedov, M. Taseva, 1 juv.	N42.63554° E023.21720°, 1011 m
12.		just above Vladaya village	broadleaf forest of <i>Quercus</i> sp., <i>Carpinus betulus</i> L., in leaf litter around a big stone	26 September 2015, observed by I. Dedov, M. Taseva, 1 ad.	N42.63101° E023.20729°, 971 m
13.		Vitoshka Mt., SE of the hiking path Vladaya – Tikhiyat kat – Knyazhevo	broadleaf forest, <i>Carpinus betulus</i> L., <i>Crataegus monogyna</i> Jacq., under a stone	30 September 2015, observed by I. Dedov, M. Taseva, 1 subad.	N42.63333° E023.21807°, 1027 m

№	Geographic Region	Locality	Habitat	Date/collectors/observers/collection/published	GPS coordinates, altitude, remarks
14.	Stara Planina Mts., N outliers	Shumen, plateau within the W edge of the city, surroundings of Shumen Hospital, Vasil Aprilov street 63	confined green area with broadleaf trees and various shrubs, under a single concrete slab on a lawn	07 October 2014, leg. U. E. Schnepapat, F. Knechtle Glogger, I. K. Dedov, I. Stoyanov, 1 ad. (BNM 067115).	N43.277237° E026.916707°, 253 m in autumn 2017, the habitat was almost completely destroyed through concrete pavement cover, on which a chapel was built. It is currently unknown whether the <i>B. pallens</i> population has survived this intervention
15.	Stara Planina Mts.	Teteven municipality, along road E of village Divchovoto	mixed broadleaf forest in a narrow valley of a creek, under rocks and heavy boulders beside the road. <i>Fagus sylvatica</i> L., <i>Carpinus betulus</i> L., <i>Salix</i> spp., <i>Sambucus ebulus</i> L., <i>Rubus</i> spp., <i>Urtica dioica</i> L., <i>Clematis vitalba</i> L., <i>Petasites</i> sp.	28 October 2017, leg. U. E. Schnepapat, R. Cornu, I. K. Dedov, A. Dedov, I. Stoyanov, 2 ad., 1 subad. (Coll. U. E. Schnepapat BG2017-127 – BG2017-129).	N42.83027° E024.23934°, 708 m
16.	Sredna Gora Mts.	Starozagorski Mineralni Bani Spa & Resort, near the restaurant "Birenata Kashta".	open habitat (meadow) within a built-up area, under a heavy granite boulder and artificial stone slabs	19 October 2018, leg. U. E. Schnepapat, R. Cornu, I. K. Dedov, 3 adult, 1 juvenile (Coll. U. E. Schnepapat, BG2018-51, BG2018-52, BG2018-53, BG2018-58). Published by Georgiev et al. (2020).	N42.453418° E025.497744°, 407 m
SERBIA					
17.	Vojvodina, Pančevo	Pančevo, River Tamiš	swampy area near the river with <i>Salix</i> sp., under a rotten, fallen trunk of an unidentified tree species.	18.05.2022, leg. V. Gojšina, leg. V. Gojšina, 1 juv. (IZOO-MG-020)	N44.87258° E020.620417°, 71 m
18.	SE Serbia	Landscape of outstanding features "Vlasina"	<i>Fagus sylvatica</i> L. forest ecotone, close to ruderal vegetation, roads and houses. Cvetkova river, at the foot of Čemernik mountain, among <i>Fagus</i> wood-debris and under bark.	02.06.2022, leg. V. Gojšina, leg. V. Gojšina, 1 ad. (IZOO-MG-021)	N42.744736° E022.314061°, 1293 m

№	Geographic Region	Locality	Habitat	Date/collectors/observers/collection/published	GPS coordinates, altitude, remarks
19.	Belgrade	Ovča	under bricks near houses and roads	22 April 2023, leg. A. Lazić, 2 ind. (IZOO-MG-022)	N44.8842917° E020.5330333°, 72 m
20.		Krnjača	under bricks near houses and roads	20 April 2023, photo. A. Lazić, 1 ind. (observed)	N44.8982194° E020.4519417°, 72 m
21.	Petnica settlement near Valjevo	Petnica research centre		29 May 2023., leg. M. Vujić, 2 ind. (IZOO-MG-024)	N44.2461472° E019.9301833°, 236 m
22.	Ibar river canyon		under wooden logs	18 July 2023, leg. V. Gojšina & M. Vujić, 4 ind. (IZOO-MG-025)	N42.9341694° E020.4008361°, 750 m
23.	Resnik village	Miloš Obrenović fountain	on wet brick walls	08 November 2023, leg. V. Gojšina & M. Vujić, 5 ind. (IZOO-MG-026)	N43.6573583° E021.8065389°, 273 m
SWITZERLAND					
24.	Switzerland	Grisons, North-Central Grisons	Churwalden, Malix, Sennereiweg 8, private garden, under dead wood	05 October 2008, leg. U. E. Schnepf, 2 ad. (BNM 055655, BNM 055656).	N46.812322° E09.532489°, 1127 m
25.	Switzerland	Appenzell, Ausserrhoden Hinterland of Appenzell	Ausserrhoden, Herisau Sturzenegg 2147, private garden, under an old board near compost heap	09 November 2013, leg. F. Knechtle Glogger, 1 subadult (BNM 065169), 24 January 2014, leg. F. Knechtle Glogger, 1 ad. (BNM 065170)	N47.395700° E09.316931°, 773 m

The anatomical and morphological observations are based mainly on 4 adult specimens: BNM055655 (Switzerland); BNM065300 (Bulgaria, Vitosha Mts.); BNM065469 (Bulgaria, the city of Sofia); BNM067115 (Bulgaria, Shumen town).

Abbreviations: BNM = Bündner Naturmuseum, Chur, Switzerland; IBER = Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences; IZOO-MG = Institute of Zoology, University of Belgrade, Faculty of Biology.

RESULTS

Distribution

Between 1999 and 2018, a total of 44 specimens were collected, observed, and documented: 38 specimens from Bulgaria, 16 from Serbia, and 4 from Switzerland (for comparative purposes). *Boetgerilla pallens* was recorded from 4 regions of Bulgaria: the Sofia plain (526–563 m a.s.l.), Vitosha Mountains (971–1066 m a.s.l.), Stara Planina Mountains and its foothills (2 sites, 253–708 m a.s.l.), and Sredna Gora Mountains (1 site, 407 m a.s.l.) (Tab. 1, Fig. 1). Thus, the known altitudinal distribution in Bulgaria ranges from 253 to 1066 m a.s.l. Several of the localities on Mt. Vitosha in which the species was found, are relatively close together (Fig. 1). Most of the known localities of *B. pallens* are clearly synanthropic – in, and around cities and settlements, but at least some on Mt. Vitosha and one from Stara Planina Mountains (east of Divchovoto village) could be considered rather remote areas, from which other potentially introduced species of slugs have not been recorded. How the species could have reached these areas remains unknown.

The first record from Serbia comes from a swampy area in Vojvodina near the Tamiš River (Pančevo), a habitat located near a road and, therefore, under high anthropogenic pressure. Further specimens were found at two sampling sites in the suburbs of Belgrade. All these findings are currently the only records from the northern part of Serbia. *Boettgerilla pallens* was also found twice in W and SW Serbia: the record from W Serbia comes from the vicinity of the town of Valjevo, and the one from SW Serbia – from the banks of the Ibar River. In eastern Serbia, this species was found near a well on the road in the vicinity of the village of Resnik. A further find of this species in Serbia was located further south (SE Serbia), in the region of the Vlasina Landscape of Outstanding Features, where a single adult specimen was found near the Cvetkova River at the foot of Čemernik Mountain (Fig. 2F).

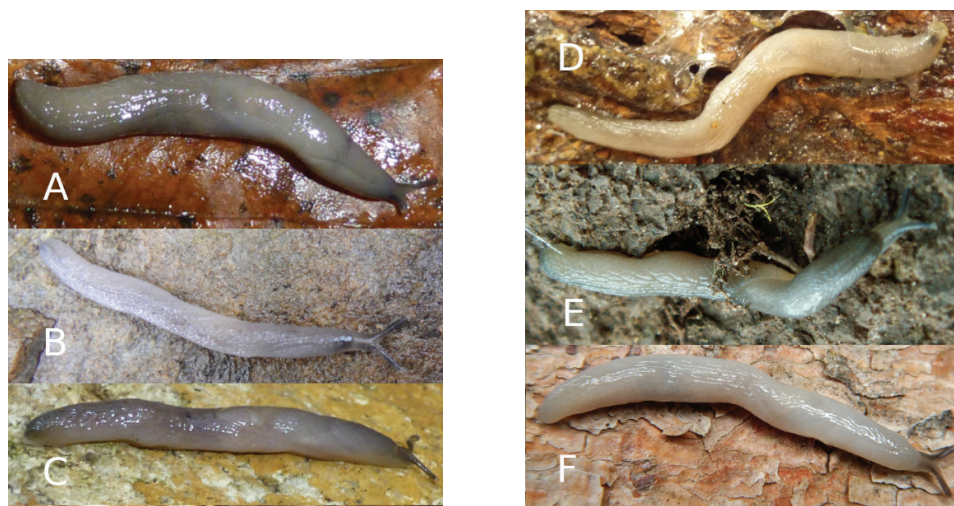


Fig. 2. The specimens of *Boettgerilla pallens* from different localities. A-E Bulgaria: A. Sumen town; B. Stara Planina Mts., Divchovoto village; C. Sredna Gora Mts., Starozagorski Mineralni bani resort; D. The City of Sofia, Mladost 1, Rekmaritsa river; E. Vitosha Mts., up to Vladaya village; F. Serbia, Vlasina, Cvetkova reka. The difference in the color of the different specimens is due to subjective reasons - different times of day in which the photos were taken (including sometimes at night), respectively different type of lighting (weak, strong, natural, artificial), as well as the use of different cameras (in some of the cases).

Morphology

Shape, coloration, mucus

In all known *B. pallens* populations from Bulgaria and Serbia, the specimens had a stable whitish-gray coloration when subadult, almost white/unpigmented (except for the ommatophores) when juvenile. In adults, the pigmentation of the integument turns markedly darker gray. The body is slender, more or less “worm-shaped”, unlike any other slug species in Europe (Figs. 2A-F). The mucus is completely translucent and colorless, the dorsal keel is not particularly pronounced, but in any case, it extends from the posterior tip of the dorsum (“tail”) to the posterior end of the mantle.

Vestigial shell

The vestigial shell (BNM 067115), in comparison to its minute size, is massive from center towards the edges, slightly humped dorsally near the apical edge, a distinguishable apex is not developed, the surface is uneven with a shallow cavity ventrally, visibly crystallized almost translucent with only a few whitish opaque spots. The highest point of the shell is in approximately the anterior 1/3 of its length. Growth lines are partly visible, but barely distinguishable all around the shell. A distinct periostracum, and a membranous seam were not observed. Length of vestigial shell is 1.8 mm, width 0.6 mm, thickness 0.4 mm at highest point. There is some variation in adult specimens (n =4) in length (1.1 - 2.0mm) and width (0.6 - 1.0mm). Outline and structure of the vestigial shell in *B. pallens* differs from all its other congeners within Limacoidea (Fig. 3A).

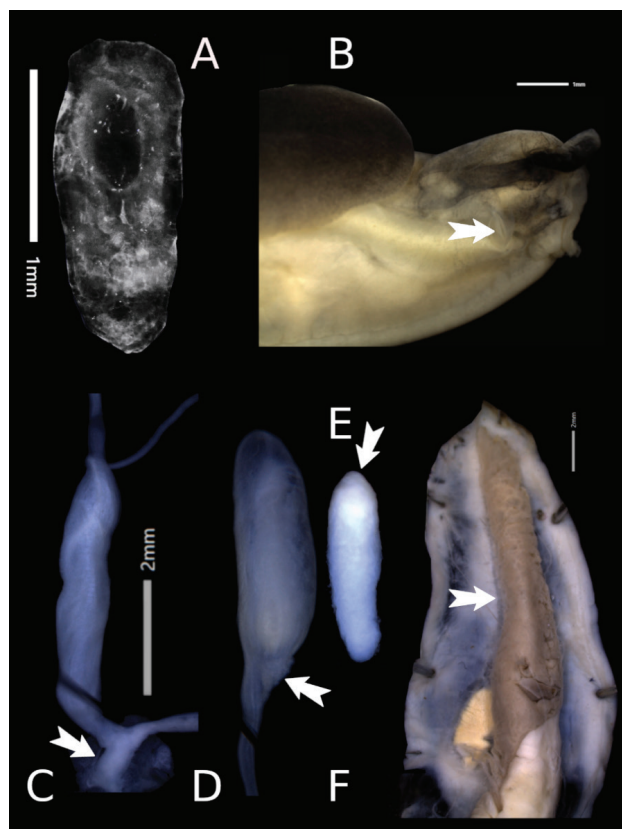


Fig. 3. Morphological and anatomical details of *Boettgerilla pallens*. A. Vestigial shell, Bulgaria, Shumen (BNM 067115); B. Genital pore, Bulgaria, Vitosha Mountains (BNM065300); C. Short atrium, Switzerland, Churwalden, Malix (BNM055655); D. Bursa copulatrix, the pedunculus entering the bursa laterally and the whitish unpigmented gland, Switzerland, Churwalden, Malix (BNM055655); E. Sperm, Switzerland, Churwalden, Malix (BNM055655); F. Huge digestive gland covering the hermaphroditic gland (not visible), Bulgaria, Vitosha Mountains (BNM 065300).

Anatomy

In general, the anatomy of dissected specimens fits that already known from previously published sources (WIKTOR, 1961; BALASHOV & BAIKASHNIKOV, 2012) (Fig. 4). However, we observed some interesting details, described below.

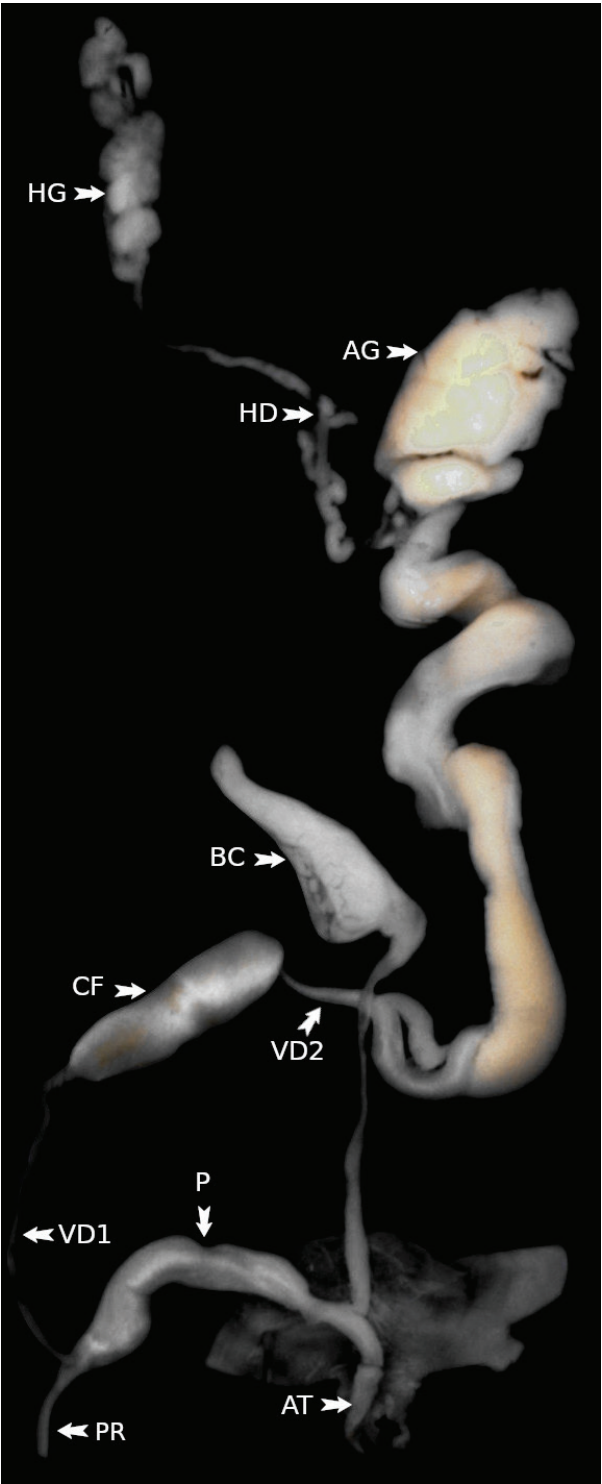


Fig. 4. A general view of the sexual system of *Boettgerilla pallens*. Bulgaria, Sofia, Mladost 1 (BNM 065469). AT – Atrium; P – Penis, PR – Penial Retractor, VD1 – the thin part of Vas Deferens canal before corpus fusiformis, CF - Corpus Fusiformis, VD2 – the thick part of Vas Deferens canal after corpus fusiformis; BC – Bursa Copulatrix, HD – Hermaphrodite Duct, HG – Hermaphrodite Gland (Ovotestis), AG – Albumen Gland.

Genital pore

The opening of the genital pore, situated directly below the base of the right ommatophore, is very small and inconspicuous – about 0,4 x 0,1mm in size. The hole is like a vertical slit, opening directly forwards (i.e., towards the mouth) (Fig. 3B).

Atrium

Judging by the drawings of the genital apparatus of *B. pallens* that have been made (WIKTOR, 1961; BALASHOV & BAIDASHNIKOV, 2012) we know an atrium to be present, but it has not been described in detail. In the specimens examined, an atrium is clearly visible, but it is much shorter – more as described in VALOVIRTA & NIKKINEN (1970) than in the drawings by WIKTOR (1961) and BALASHOV & BAIDASHNIKOV (2012). In the dissected specimen (adult in late male stage/early female stage) the atrium is only 0.6 mm in length and 0.5 mm in width (Figs. 3C, 4).

Vas deferens and corpus fusiformis

The corpus fusiformis is an integral part of vas deferens, and it is a structure unique to the genus *Boettgerilla*. No similar structure is known in any other slugs. In *B. pallens* the vas deferens, from where it leaves the penis to where it joins the corpus fusiformis, is of the usual structure: narrow, almost translucent, whitish, of almost the same diameter throughout its entire length. From the point where the vas deferens leaves the corpus fusiformis, it changes its appearance: it gets thicker in diameter, and its surface becomes the same as that of the corpus fusiformis, i.e. much smoother and shiny (Fig. 4). The shiny appearance comes from fasciae, covering a strong muscular apparatus.

Bursa copulatrix

The pedunculus of bursa copulatrix does not insert centrally, but laterally into the bursa itself (Fig. 3D). In the “ankle” between bursa and pedunculus, there is a small, unpigmented, whitish gland. This gland is of a clearly grape-like structure, and attaches to the bursa and pedunculus through many thin mesenchymal fibers or very thin muscles (impossible to distinguish these two under 80x magnification) (Fig. 3D, indicated by an arrow). No duct(s) branching from this gland could be observed under a magnification of 80x.

Hermaphroditic gland

The hermaphroditic gland is deeply embedded inside the mass of the digestive gland, could not be seen through (Fig. 3F, indicated by an arrow), and is (in the examined specimen) devoid of any pigmentation.

Biology

In Bulgaria, *B. pallens* was found in anthropogenic habitats: the flood area along a river, open terrain, mixed deciduous forests, and mixed forests dominated by deciduous trees. Specimens were found under dead wood and garbage, under broken marble and heavy granite boulders, as well as artificial stone slabs. Furthermore, this slug was collected in semi-natural and natural habitats: edge of a former mountain pasture surrounded by mixed deciduous forests, grasslands with shrubs and individ-

ual deciduous trees, beech forests, oak and hornbeam forests, as well as mixed forests. Here, *B. pallens* was found under heavy granite boulders and rotting logs, and in the leaf-litter around and under stones.

In Serbia, all the records come from habitats under high anthropogenic pressure. The record from the surroundings of the city of Pančevo is from a swampy area near the Tamiš River, where one juvenile specimen was found under a rotten willow tree trunk. In this habitat, *B. pallens* was found sympatrically with numerous specimens of *Arion vulgaris* Moquin-Tandon, 1855. Two additional sampling sites near Belgrade, as well as sites in western (Valjevo city, Petnica village) and eastern Serbia (fountain near Resnik village) were also under high anthropogenic pressure, since specimens were found under bricks along the roadside or on the road itself. In southeastern Serbia (Cvetkova River, foothills of Čemernik mountain, Vlasina plateau), one adult specimen was found under dry beech bark. This habitat is also under high anthropogenic pressure since it is near human settlements and roads, with ruderal vegetation characteristic for the area. The locality from SW Serbia (Ibar river valley) is probably the one that is the least anthropogenically influenced, where four specimens have been found in the surrounding deciduous forest, close to the river-bank, under wet and rotten tree trunks, and were observed to inhabit earthworm tunnels, as was the case in the Vitosha Mountains, Bulgaria (see Fig. 5).



Fig. 5. *Boettgerilla pallens* burrows in earthworm tunnels, Bulgaria, Vitosha Mountains.

DISCUSSION

Distribution

According to Reise *et al.* (2000), *B. pallens* is distributed throughout most of Europe, while in the Balkans, it is known only from Turkey. The wide distribution of the species in Europe suggests a gradual expansion from the Caucasus to the west, or accidental transportation by humans to one or more European countries, followed by expansion into neighboring territories. A good starting point for reflection may be the chronology of the discovery of the species in different European countries. The apparent, gradual expansion of the species' range in Europe may have taken place via a northern (Russia, Moldova, Ukraine, Poland) and/or southern route (Asian Turkey, European Turkey, Bulgaria, Romania). Currently, Reise's data (REISE *et al.*, 2000) support the northern route as more likely, as the first records in Europe were in countries located mainly in the north. REISE *et al.* (2000) suggest that the human factor is a key to the spread of *B. pallens* in Europe, which supports the hypothesis of accidental transfer of specimens in some European countries. The rapid expansion of *B. pallens* in the whole of Europe assumes complex reasons, including both random spreading by humans and rapid adaptation to the local climatic conditions, and natural expanding of the species' range in Europe. We believe that the recent findings of *B. pallens* in Bulgaria and Serbia are due to the lack of enough research on these slugs notwithstanding the summarizing work of WIKTOR (1983, 1996), as well as misidentification (see BALASHOV & BAIDASHNIKOV, 2012), rather than a recent invasion in these countries.

Regarding the lack of information for *B. pallens* in the works of Wiktor, who was a specialist in slugs and certainly knew the species very well, we assume that he concentrated his collecting efforts primarily in the diverse natural habitats of the Balkans, neglecting the settlements where there are more localities of the species in present study.

At the same time, in Bulgaria, we found *B. pallens* not only in anthropogenic habitats, but also in natural forests on Vitosha and Stara Planina Mountains. This could be an indication of an early introduction or the natural occurrence of *B. pallens* in Bulgaria, and probably also in Turkey and Crimea (BALASHOV & BAIDASHNIKOV, 2012). Also, the presence of the species in the latter countries could be isolated remnants of a wider distribution in the past, covering the Caucasus and the Eastern Balkans, which was probably divided into smaller surviving populations (Caucasus, Crimean Mountains, Transylvania, Carpathians, Bulgarian Mountains, probably the Alps).

Biology

Information on the biology of the species was published by GUNN (1992) and Mc DONNELL *et al.* (2014). According to these authors, *B. pallens* is a burrowing species, often utilizing earthworm tunnels where it has been found at depths of up to 60 cm, but it is thought that a small portion of the population remains at the ground surface under leaves, stones, and wood. The slug feeds on earthworm feces, eggs of other gastropods, carrion, fungal hyphae, roots, decaying vegetation, and detritus (see also FORSYTH, 2004). The discovery of *B. pallens* in Bulgaria and Serbia is the result of untargeted collection of malacological material, and we summarize the data on this species in the current paper. All investigations were carried out during the day, and snails were mostly collected under stones, stumps or litter. As *B. pallens* is a cryptic, subterranean species (Mc DONNELL *et al.*, 2014), we can reliably assume that we have only

touched upon its actual distribution not only in Bulgaria and Serbia, but also in the Balkan Peninsula as a whole.

Reproductive anatomy

The detection of a sperm package (Fig. 3E) inside the bursa copulatrix indicates that there is no spermatophore which might be produced in the so called “corpus fusiformis”. This organ is an integral part of the vas deferens, unique in *Boettgerilla*, but the true function of the “corpus fusiformis” still remains unknown. One possible explanation could be that in this organ, the sperm is concentrated and compacts itself, subsequently, with the muscular effort of the corpus fusiformis, it moves forward for sperm exchange between individuals during copulation. Based on the finding of the sperm-package, we know that the species copulates in Switzerland (at 1128 m altitude) at the end of September – beginning of October. According to GUNN (1992), in Wales *B. pallens* breeds and lays its eggs underground in late summer and early autumn. Rowson *et al.* (2014) consider that the species has a one-year life-cycle and reproduces underground in autumn, laying a small number (1-6) of eggs.

We found that the vas deferens is inserting posteriorly into the penis, near to the point of insertion of the penis retractor muscle (Fig. 4), and following its wall as a distinct structure, also internally. VALOVIRTA & NIKKINEN (1970) (as “*Boettgerilla vermiciformis* Wiktor, 1960”) and BALASHOV & BAIDASHNIKOV (2012) have shown that the vas deferens is inserting into the penis laterally, near the point of insertion of the penis retractor muscle. In cases in which the penis retractor muscle is attached to the interior wall of the integument, we suggest that it must be also attached to another strong structure for the purpose of retraction. This is not the case in *B. pallens*, where penis retractor muscle is attached to the pallial cavity membrane which is only a very weak structure – this situation still has no biological explanation. To our knowledge, mating behavior and copulation in *B. pallens* has never been observed. Moreover, the unusual organization of its sexual system suggests a mating behavior and copulation totally different from other known slug families in the Balkans (Agriolimacidae, Arionidae, Limacidae and Milacidae). One possible explanation for this unusual organization of the sexual system of *B. pallens* could be its adaptation to underground copulation in highly confined spaces (GUNN, 1992; ROWSON *et al.*, 2014). Future observations are necessary to further describe and explain how the reproductive system of *B. pallens* works.

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