



## Distribution of the Invasive Land Snail *Eobania vermiculata* (O. F. Müller, 1774) (Gastropoda: Helicidae) in Bulgaria

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**Abstract:** Previous and newly obtained data on the distribution of *Eobania vermiculata* (O. F. Müller, 1774) from Bulgaria are summarised. New localities and new regions of distribution in the country are reported. Photos of live animals, its habitats and the reproductive system of the species are given. Hypothesis for dual origin of specimens in Bulgarian populations, paths for spread and pest potential of the species are discussed.

**Key words:** *Eobania vermiculata*, Helicidae, land snail, genital anatomy, Bulgaria, new chorological data

### Introduction

Originally, *Eobania vermiculata* (O. F. Müller, 1774), popularly known as “chocolate band snail”, is a Circum-Mediterranean species, typical for the coastal areas of Spain, France, Italy, Croatia, Montenegro, Albania, Greece, Turkey, Morocco, Algeria, Tunisia and Libya (YILDIRIM et al. 2004, PUZINA et al. 2013, MUMLADZE & PAPOSHVILI 2016, RONSMANS & VAN DEN NEUCKER 2016). Natural populations are absent in Israel and Egypt (MIENIS et al. 2016). Initially, this species penetrated the Mediterranean countries as well as the neighbouring territories; subsequently, it was introduced and adapted in more

distant countries such as Great Britain, Netherlands, Belgium, Germany, Slovakia, Hungary, Bosnia and Herzegovina, Bulgaria, Romania, Ukraine, Crimea, Russia, Japan, Georgia, Azerbaijan, Iran, Egypt, South Africa, Israel, Jordan, Iraq, Saudi Arabia and Qatar (WOHLBEREDT 1911, KERNEY & CAMERON 1979, PETNEY & HUSSET 1992, HERBERT & SIRGEL 2001, MIENIS 2002, UESHIMA et al. 2004, KARAMAN 2006, EGOROV 2008, ROLL et al. 2009, SON 2009, AL-KHAYAT 2010, HERBERT 2010, DESOUKY & BUSAIS 2012, SOES 2014, AL-KHAFAJI et al. 2016, MIENIS et al. 2016, MUMLADZE & PAPOSHVILI 2016, RONSMANS & VAN DEN NEUCKER 2016, HOLYOAK & HOLYOAK 2017, GURAL-SVERLOVA 2018, AMR et al. 2019, HO-

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LYOAK et al. 2020, PÁLL-GERGELY et al. 2020, GRIGORE 2021). The chocolate band snail was also introduced in Australia (STANISIC et al. 2010, BLACKET et al. 2016) and USA (ROBINSON 1999). Some authors reported *E. vermiculata* as a dangerous pest species to many crops and vegetables, especially when the populations are abundant (ISMAIL 1997, HERBERT & SIRGEL 2001, HUSSEIN & SABRY 2019) and proposed pesticides and pharmaceutical contraceptive drugs to control its populations (ESSAWY et al. 2009, ABD EL-ATTI et al. 2020). In the countries where *E. vermiculata* is widespread, it could be used as food (YILDIRIM et al. 2004).

The successful spreading of this native to the Mediterranean region species in the Palaearctic and worldwide in the past decades, its successful overwintering there, resistance to high temperatures and low humidity and the possibility of being a pest, set the goals of the present work. We aim to update the distribution of chocolate band snail on the territory of Bulgaria by summarising all published and unpublished chorological data and assess its pest potential in the territory of the country. We also present data (including photos) of the shells and anatomy of the Bulgarian specimens to confirm the species identification of the new findings and report our observations on the variations of its characters.

## Materials and Methods

The snails were searched, hand collected or (and) photographed in the following Bulgarian regions (see Fig. 6, Table 1):

1. Black Sea Region – Varna (Fig. 1), Burgas, Sozopol, Kiten, Arapyra camping, Tsarevo, Ahtopol (Fig. 2) and Rezovo;
2. Thracian Lowland – Plovdiv (Fig. 3, 4C), Stara Zagora (Fig. 4 A);
3. Eastern Rhodope Mountains – Haskovo (Fig. 4D), Susam village;
4. Strandza Mountain (Bulgari village);
5. Region of Struma and Mesta valleys – Rupite area (Fig. 4B, 5);
6. Kraishte – Smirov Dol village.

Additional specimens collected by one of the present authors (P. G. Mitov) from the European part of Turkey were checked. They were from the following localities: (1) Black Sea coast, Kıyıköy (Midye) village, on herbaceous vegetation, shrubs and limestone rocks, N41.637517 E028.093255, 13 m a.s.l., 24.05.2011, 8 mature specimens, Malacological collection of P. G. Mitov (MCPM); (2) Pınarhisar (Bunarhisar) village, Pınarhisar castle, N41.629050 E027.514911, 209 m a.s.l.,

22.05.2010, 2 mature specimens, MCPM; (3) Marmara Sea coast, in the region of Tekirdağ, Yeniçiftlik village, near Ünal camping, small beach park, N41.010657 E027.778507, 5 m a.s.l., 27.05.2011, 2 mature specimens, MCPM.

The specimens collected alive were fixed in 75 % or 95 % ethanol. To confirm the species identification, a couple of dissections were provided (the specimens from Plovdiv, Varna and Rupite). The reproductive system of specimens from Rupite is presented in Fig. 7. The species' taxonomy follows HOLYOAK et al. (2020).

## Results

### Chorological data

We summarize the published and newly collected data on *E. vermiculata* in Bulgaria. In total, 15 main localities from six regions were registered (Table 1). Nine localities are new distribution points for the species: Burgas, Kiten, Arapyra, Rezovo, Haskovo (Fig. 4 D), Susam, Bulgari, Rupite (Fig. 4 B, 5) and Smirov Dol. The information for occurrence of the species in the area of Bulgari village, Strandzha Mountain (IRIKOV, personal communication) was not confirmed again after checking the locality. After the first registration of *E. vermiculata* in the region of Kraishte (Smirov Dol village), the species was not found again at the same spot. The finding nearby Rupite was the first one in the region of Struma and Mesta valleys and Southwestern Bulgaria (Fig. 4B, 5 A-C). The species was also registered for first time for Eastern Rhodopes – Haskovo (Fig. 4 D) and Susam village. Within the populations of the species in Bulgaria, variations in the pattern of the shell were observed. Such variations had individual rather than population-specific character (Fig. 4 A-D).

The known altitude range of the species in Bulgaria was from 1 to 290 m above sea level (the locality at the Smirov Dol village, 793 m a. s. l., was excluded). In Smirov Dol village, *E. vermiculata* was accidentally found in cypress pots brought from Greece for replanting. When re-collecting at the site next year, the species was not found again. Due to the extremely cold winters in the area, the locality was probably unsuitable for this Mediterranean species and the specimens had not been able to survive (Table 1).

### Reproductive system

The male part of the reproductive system was characterised by club-shaped penis, long epiphallus and penial retractor attached at the boundary

**Table 1.** Distribution of *Eobania vermiculata* (O. F. Müller, 1774) in Bulgaria.

The localities are arranged geographically. Abbreviations: ad. – adult/s, juv. – juvenile/s, al – alive specimen/s, sh – empty shell/s; Blvd. – boulevard, Str. – street; Coll. ID – identical number in Malacological collection of Institute of Biodiversity and Ecosystem Research (Sofia), MCMNHV – Malacological collection of Museum of Natural History (Varna), MCPM – Malacological collection of Plamen G. Mitov.

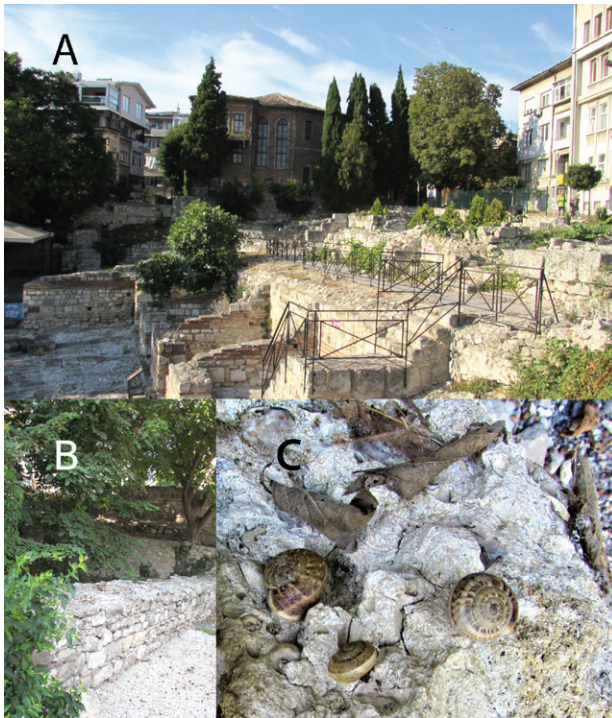
Settlements	Data sources (published and original)	Coordinates, altitude
<b>Bulgarian Black Sea Coast</b>		
<b>1. Varna</b> (=Варна)	WOHLBEREDT (1911): surroundings of Varna; PETRBOK (1941): “Varna”	-
	Greek Quarter: Small (South) thermae of Odessos (=Small Roman Baths), 3rd-6th centuries AD (on a territory of 0.24 ha), vegetation: <i>Opuntia</i> sp., <i>Hedera helix</i> , <i>Yucca</i> sp., <i>Euonymus</i> sp. shrubs, <i>Iris</i> sp., tree of <i>Thuja</i> , <i>Celtis</i> , <i>Juglans</i> , <i>Ficus carica</i> : 07.07.2014, leg. L. Zapryanov – 30 ad. (al), 10 ad. (sh), MCMNHV; 21-24.08.2021, leg. P. Mitov – 19 ad. (al), 7 juv. (al), 149 ad.(sh), 6 juv. (sh), MCPM	N43.198369° E027.917636°, 5 m, N43.198444° E027.917708°, 5 m, N43.198211° E027.917925°, 4 m
	Greek Quarter: On the periphery of the Small Roman Baths, under a stump next to the fence and on the fence, at the corner of 8th of November Str. and Primorski Blvd., 21.08.2021, leg. P. Mitov – 4 ad. (al), MCPM	N43.198000° E027.917678°, 5 m, N43.198253° E027.918189°, 10 m
	Greek Quarter: Backyard close to the Small Roman Baths, the area between Graf Ignatiev Str., Khan Omurtag Str. and Primorski Blvd., under stones and a tree trunk, as well as on a stonewall, vegetation: <i>Geranium</i> sp., <i>Hedera helix</i> , <i>Parthenocissus quinquefolia</i> , <i>Yucca</i> sp., tree of <i>Juglans</i> , <i>Tilia</i> , <i>Celtis</i> , 21.08.2021, leg. P. Mitov – 20 ad. (al), 4 juv. (al), 1 ad. (sh), MCPM	N43.198383° E027.917603°, 5 m, N43.198528° E027.917764°, 9 m, N43.198564° E027.917503°, 8 m
	Greek Quarter: Backyard close to the Small Roman Baths, at 8th of November Str., vegetation: <i>Hedera helix</i> , <i>Yucca</i> sp., <i>Diospyros kaki</i> , <i>Ailanthus altissima</i> , 21.08.2021, leg. P. Mitov – 14 ad. (sh), 1 juv. (sh), MCPM	N43.198328° E027.918297°, 12 m
	Greek Quarter: Garden in front of the Maritime Administration, on the corner of Primorski Blvd. and Graf Ignatiev Street, 21.08.2021, leg. P. Mitov – 12 ad. (sh), MCPM	N43.198097° E027.916733°, 3 m
	Greek Quarter: Backyard of the port of Varna, at the back entrance from Primorski Blvd., opposite the Small Roman Baths, near the fence, 21.08.2021, leg. P. Mitov – 3 ad. (sh), MCPM	N43.197722° E027.918044°, 2 m
	<b>2. Burgas</b> (=Бургас)	Area between Burgas Shipyard Port (=Iliya Boyadjiev Port) and the Poda Nature Preserve (on the left side of the international highway from Burgas to Istanbul), before the port breakwater, under stones and pieces of concrete, among shrubby ( <i>Rubus fruticosus</i> ) and herbaceous vegetation ( <i>Anethum</i> sp., <i>Avena</i> sp., <i>Erigeron</i> sp., <i>Phragmites</i> sp.) with single trees of <i>Elaeagnus angustifolia</i> , 31.08.2021, leg. P. Mitov – 3 ad. (al), 45 ad. (sh), 6 juv. (sh), MCPM
<b>3. Sozopol</b> (=Созопол)	URBANSKI (1960)	-
	30.10.2015, leg. I. Dedov, U. Schnepat, R. Cornu, I. Stoyanov – 1ad. (sh), Coll. ID-1892	N42.42162° E027.6940°, 9 m
<b>4. Kiten</b> (=Китен)	1.10.2015, leg. I. Dedov, U. Schnepat, R. Cornu, I. Stoyanov – 1ad. (sh), Coll. ID-1901	N42.23647° E027.77651°, 28 m new locality
<b>5. Агаруа</b> (=Арапя)	25.05.1996, Collector unknown. 2ad. (sh), Coll. ID-36	N42.1921° E027.8301°, 12 m new locality
<b>6. Тсарево</b> (=Царево)	PETRBOK (1941); URBANSKI (1960)	N42.1677° E027.8503°, 9 m (coordinates restored)
<b>7. Ахтопол</b> (=Ахтопол)	URBANSKI (1960): Ahtopol; DAMJANOV & LIHAREV (1975): Ahtopol; ZAPRYANOV (1993): Ahtopol, the beach	-
	Near the seacoast, on rocks, 13.06.2009, leg. P. Mitov – 3 ad. (al), MCPM	N42.101481° E027.946902°, 3 m
	Near the seacoast, below Kraymorska Street, on the ruins of coastal southern fortress wall of ancient and medieval Ahtopol, 28.05.2011, leg. P. Mitov – 3 ad. (al), MCPM	N42.100790° E027.945865°, 3 m
	On the corner of Chernomore Street and Georgi Kondolov Street, vegetation: fig tree, grassy area and <i>Portulaca oleracea</i> , 29.08.2021, leg. P. Mitov – 8 ad. (sh), 1 juv. (sh), MCPM	N42.100833° E027.941169°, 14 m
	The slope below the Greek House, under stones, among grassy vegetation and fig tree, 29.08.2021, leg. P. Mitov – 17 ad. (al), 28 juv. (al), 5 ad. (sh), 14 juv. (sh), MCPM	N42.100825° E027.946025°, 10 m, N42.101314° E027.946900°, 6 m
	Along the alley Kraymorska Street, above the sea (from the Greek House to the Church Monument “St. Ascension of the Lord”), among grassy vegetation and <i>Yucca</i> sp., 29.08.2021, leg. P. Mitov – 2 ad. (al), 7 ad. (sh), MCPM	N42.100978° E027.945819°, 14 m, N42.102336° E027.946053°, 14 m
	Yard of the Greek school, among grassy vegetation, 29.08.2021, leg. P.	N42.102894° E027.945917°, 12 m

Table 1. Continuation.

Settlements	Data sources (published and original)	Coordinates, altitude
	Mitov – 1 juv.(al), 3 ad. (sh), MCPM	
	Parking above the beach, among grassy vegetation ( <i>Cephalaria transilvanica</i> , 29.08.2021, leg. P. Mitov – 1 ad. (sh), MCPM	N42.102939° E027.937850°, 15 m
	The beach, among grassy vegetation along the coast [ <i>Phragmites australis</i> , <i>Ammophila arenaria</i> , <i>Leymus racemosus</i> , <i>Andropogon halepensis</i> , <i>Elymus</i> sp., <i>Melilotus albus</i> , <i>Ononis spinosa</i> , <i>Equisetum arvense</i> ], 29.08.2021, leg. P. Mitov – 3 ad. (al), 6 juv. (al), 5 ad. (sh), 3 juv. (sh), MCPM	N42.103603° E027.936408°, 4 m, N42.103819° E027.936575°, 4 m
<b>8. Rezovo village (=Резово)</b>	Yards of houses, 27.08.2021, leg. P. Mitov – 5 ad. (sh), 1 juv. (sh); near fence of house yard – 1 juv. (sh)	N41.983972° E028.031164°, 20 m, N41.983983° E028.031369°, 24 m, N41.985447° E028.029853°, 34 m new locality
	<b>Thracian Lowland</b>	
<b>9. Plovdiv (=Пловдив)</b>	HESSE (1913): region of Plovdiv; PETRBOK (1941): Plovdiv	-
	<b>Northern District:</b>	
	IRIKOV (2018): “Rogosh Cemetery Park” (=Cemetery Rogoshko Rd.)	-
	<b>Central District:</b>	
	Maritsa River valley: 11.10.2013, leg. U. Schnepat, F. Knetchle, D. Georgiev, I. Dedov – 1 ad. (al), Coll. ID-1638	N42.1529° E024.7341°, 170 m
	IRIKOV (2018): “Maritsa River banks in the city of Plovdiv”, “Under stones, stumps and refuse”; „Adata Island in Maritsa River“	-
	Shesti Septemvri Blvd., on the concrete wall, 5.05.2019, leg. P. Mitov – 1 ad. (al), MCPM	N42.153111° E024.764528°, 157 m
	URBANSKI (1960): “in Plovdiv auf den Syenit-Hügeln” [syenite hills]	-
	ZAPRYANOV (1993): “the hills of the old town”	-
	IRIKOV (2018): “Halm Bunardzhik Hill (Bunardzhik Tepe Hill)”(=Liberators' Hill), “Danov Halm Hill (Sahat Tepe Hill)”, “Mladezhki Halm Hill (Dzhendem Tepe Hill)”, “Trihalmie Hill (includes Nebet Tepe Hill, Dzhambaz Tepe Hill, Taksim Tepe Hill)” (see also below)	-
	Liberators' Hill (Bunardzhik Hill, Bunardzhik Tepe), leg. P. Mitov, MCPM: periphery of Bunardzhika Hill: near the church St. St. Peter and Paul, №2 Nikola Petkov Street, under concrete block, 4.05.2019 – 1 ad. (al); Volga Street, under syenite stones, 2.10.2021 – 1 ad. (sh), 1 juv. (al), 1 juv. (sh)	N42.142010° E024.737960°, 175 m N42.147243° E024.738594°, 184 m
	Close to the Liberators' Hill, in a small city garden near to the Tsar Osoboditel Square, among a shrub of <i>Chamaecyparis</i> sp., 02.10.2021, leg. P. Mitov – 1 ad. (sh), MCPM	N42.147243° E024.741161°, 167 m
	Trihalmie hills (=Ancient Plovdiv) (incl. Nebet Tepe, Dzhambaz Tepe and Taksim Tepe hills): Dzhambaz Tepe (Dzhambaz Tepe Hill), leg. P. Mitov, MCPM: near to the Ancient (Roman) theatre of <i>Philippopolis</i> , 10 Hemus Street, under syenite stones: 6.07.1989 – 11 ad. (al), 3 juv. (al) specimens; 05.05.2019 – 5 ad. (al); 1-2.10.2021 – 1 ad. (al), 3 ad. (sh); 5 Knyaz Tseretelev Street, in a small city garden, close to Puldin Restaurant, 2.10.2021 – 3 ad. (sh); close to Zlatyu Boyadzhiev Gallery, under syenite stone, 2.10.2021 – 1 ad. (sh); at the Early Byzantine fortress walls with a Circular Tower, under syenite stone, 2.10.2021 – 1 ad. (al); 8A Strumna Street, near to the Old Crafts, on the walls, 02.10.2021 – 1 ad. (sh), 1 ad. (al), 2 juv. (al); Nebet Tepe (Nebet Tepe Hill), leg. P. Mitov, MCPM: above Shesti Septemvri Blvd., 5.05.2019, on a syenite rock. – 2 ad. (al); Doctor Stoyan Chomakov Street, close to the Archaeological Complex, under syenite stones, 5.05.2019 – 2 ad. (al)	N42.146856° E024.751899°, 203-208 m N42.148638° E024.753049°, 192 m N42.149112° E024.753063°, 189 m N42.149545° E024.753093°, 184 m N42.150139° E024.753417°, 184 m N42.151762° E024.751681°, 186 m N42.150985° E024.752619°, 200 m
	Danov Hill (=Danov Halm Hill, Sahat Tepe), 02.10.2021, leg. P. Mitov, MCPM: 1 Stefan Karadzha Street, under syenite stones, close to stony wall – 1 ad. (sh), 1 juv.(sh); around the Clock tower, under syenite stones – 1 ad. (sh); 7 Knyaz A. Dondukov-Korsakov Street, on a stony wall – 1 juv. (al), 09.05.2022: near the Open Air Cinema Orpheus, under syenite stones and on a stony wall – 13 ad. (al)	N42.147228° E024.744947°, 182 m N42.146484° E024.747227°, 193 m N42.144199° E024.746727°, 166 m N42.144903° E024.745899°, 172 m
	ZAPRYANOV (1993) and IRIKOV (2018): “Mladezhki hulm” (=Dzhendem tepe)	-
	IRIKOV (2018): “Trimontium Hotel”, “Mikhail Takev Street”	-

Table 1. Continuation.

Settlements	Data sources (published and original)	Coordinates, altitude
	Roman Forum of Philippopolis, close to the Central Post Office, near to Tsar Boris III Obedintel Blvd., under syenite stones and on walls of the Roman forum, leg. P. Mitov: 2.05.2015 – 7 ad. (al), Coll. ID-2051; 3.10.2021 – 62 ad. (al), 20 ad. (sh), 3 juv. (al), MCPM. 12.04.2022 – 7 ad. (al), 1 juv. (al), MCPM	N42.142854° E024.751198°, 162 m N42.142966° E024.750971°, 162 m N42.142362° E024.751300°, 162 m
	In a small garden near to the State Financial Inspection Agency (former Party House), under stones, 3.10.2021, leg. P. Mitov – 2 ad. (al), MCPM	N42.140694° E024.749583°, 164 m
	In the area of Plovdiv University, near to Tsar Boris III Obedintel Blvd., 03.10.2021, leg. P. Mitov, MCPM: under street tiles – 2 ad. (al); among a pile of syenite stones in a small city garden – 15 ad. (al), 4 juv. (al); Kostaki Peev Street, under stones – 3 ad. (al), 2 juv. (al)	N42.137646° E024.751948°, 162 m N42.138113° E024.751822°, 162 m N42.137975° E024.751336°, 163 m
	<b>Eastern District:</b>	
	IRIKOV (2018): “Technical University Near Sankt Petersburg Boulevard“ [63 Sankt Petersburg Blvd.]	-
	Near to the parking of the Technical University, 3.10.2021, leg. P. Mitov – 1 ad. (sh)	N42.138658° E024.772070°, 158 m
	<b>Western District:</b>	
	IRIKOV (2018): “Otdih i Kultura Park by the Rowing Canal”	-
	<b>Thrace District:</b>	
	IRIKOV (2018): “Lauta park”; “Trakia Neighborhood, open space between blocks of flats”	-
	<b>Near the road between Plovdiv and Asenovgrad Town:</b>	
	Terrain near the road, vegetation: <i>Populus x canadensis</i> , <i>Rubus idaeus</i> , <i>Cephalaria transsilvanica</i> , <i>Sorghum halepense</i> , <i>Sambucus ebulus</i> , <i>Equisetum arvense</i> , <i>Artemisia vulgaris</i> , <i>Erigeron canadensis</i> , <i>Chenopodium album</i> , <i>Setaria</i> sp., <i>Xanthium strumarium</i> , leg. P. Mitov, MCPM: 13.08.2022, 7 ad. (sh), 1 juv. (sh); 1.09.2022, 1 ad. (al), 1 ad. (sh).	N42.089096° E24.793743°, 163 m N42.089232° E24.794180°, 163 m N42.089063° E24.793630°, 163 m N42.089090° E24.793753°, 163 m
<b>10. Stara Zagora (=Стара Загора)</b>	GEORGIEV et al. (2020): South part in the Industrial Zone	N42.4149° E025.6402°, 187 m (coordinates restored)
	<b>Eastern Rhodope Mountains</b>	
<b>11. Haskovo (=Хасково)</b>	July 2019, A. S. Stefanov, personal communication	N41.9627° E025.5611°, 188 m (coordinates restored), new locality
<b>12. Susam village (=Сусам)</b>	At the base of the mountain, May 2020, A. S. Stefanov, personal communication	N41.9627° E025.3459°, 234 m (coordinates restored), new locality
	<b>Strandzha Mountain</b>	
<b>13. Bulgari village (=Българи)</b>	A. Irikov (personal communication). The species was not confirmed by searching the locality by I. Dedov (03.10.2015) and P. Mitov (29.08.2021)	N42.08717° E027.73025°, 290 m N42.088611° E027.724278°, 275 m N42.086201° E027.728859°, 277 m N42.084891° E27.734937°, 252 m new locality (?)
	<b>Struma and Mesta rivers' valleys</b>	
<b>14. Rupite (=Рупите)</b>	2 km east of the village of Rupite, at the foot of the volcanic hill Kozhuh, near the thermal springs, around and in the yard of the mineral bath. Vegetation: mix of wild ( <i>Avena</i> sp., <i>Alopecurus</i> sp., <i>Medicago</i> sp., <i>Sonchus</i> sp., <i>Ailanthus altissima</i> ) and garden plants ( <i>Oxalis debilis</i> , <i>Oenothera speciosa</i> , <i>Trachycarpus</i> sp., <i>Platycladus orientalis</i> , <i>Yucca</i> sp., <i>Lonicera caprifolium</i> , <i>Euonymus japonicus</i> , <i>Rosa</i> sp., <i>Rosmarinus officinalis</i> , <i>Punica granatum</i> ): 1-10.10.2016, leg. V. Gashtarov – 5 ad (al), Coll. ID-2047; in the yard of the mineral bath, on ornamental plants <i>Trachycarpus</i> sp. and <i>Rosmarinus officinalis</i> , 19.04.2019, leg. P. Mitov – 6 ad. (al), Coll. ID-2050; around and in the yard of the mineral bath, among the grassy vegetation, on the plants, on the walls, under stones and roof tiles, 17.05.2022, leg. P. Mitov – 42 ad. (al), 20 ad. (sh), 38 juv. (al), 4 juv. (sh), MCPM	N41.458344° E023.262197°, 90 m new locality
	<b>Kraishte</b>	
<b>15. Smirov Dol village (=Смиров дол)</b>	In cypress pots brought from Greece, 6.12.2015, leg. A. Dedov – 5 juv. (al), 1 juv. (sh), Coll. ID-2048	N42.561242° E022.731036°, 793 m New locality; not found again after the first observation



**Fig. 1.** The area of the Small Roman Thermae of Odessos, Varna (A), where the species *Eobania vermiculata* (O. F. Müller, 1774) was found; a stony wall (B) with alive specimens (C). Photographs by P. Mitov (24.08.2021).

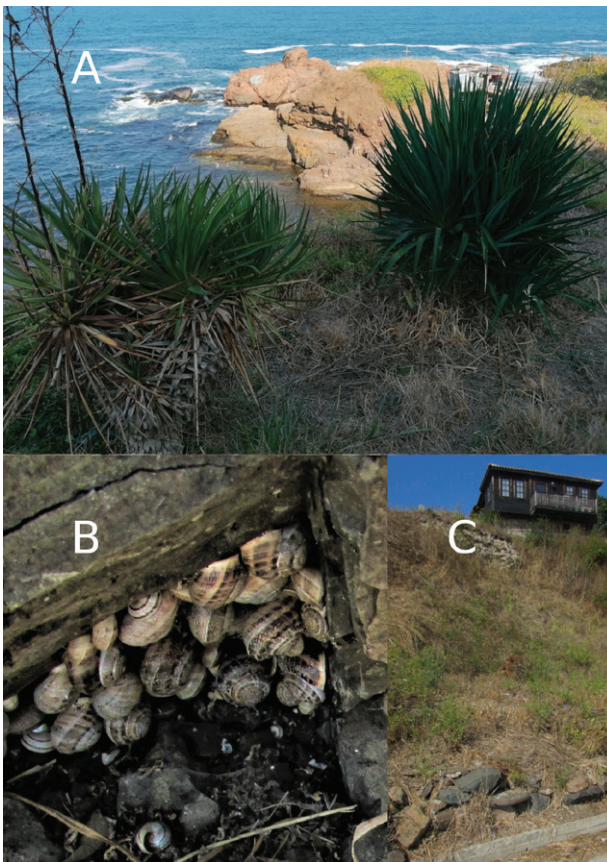
of penis and epiphallus. At female part, the dart sac was opening laterally into the short vagina. The mucous glandulae were with two main stems, branched in numerous subsequent branches; diverticulum of bursa copulatrix (DIV) was longer than duct of bursa copulatrix (BCD) (see DAMJANOV & LIKHAREV 1975: fig. 320, ZAPRYANOV 1993: fig. 1, NEUBERT & BANK 2006: fig. 4; BOUAZIZ-YAHIA-TENE et al. 2017, HOLYOAK & HOLYOAK 2017: fig. 7 C) (Fig. 7A). The inside of penial structure corresponded with the description given by ZAPRYANOV (1993) (see Fig. 7B). Corpusculum irritans (CI) had a conic form and a pear-shaped distal end. The inner wall of the penis (P) formed the aperture of the canal (=glans (G)). On the borderline between the atrium (AT) and the penis, there was a crest-like body (colliculus penialis (CP)) (Fig. 7B) (for more details, see ZAPRYANOV 1993).

## Discussion

### Distribution

For the first time, *E. vermiculata* has been reported for Bulgaria by WOHLBEREDT (1911) from the Varna surroundings. Later, PETRBOK (1941) reported the species from Plovdiv, Varna (as recent) and Tsarevo (quaternary deposits). Then URBANSKI

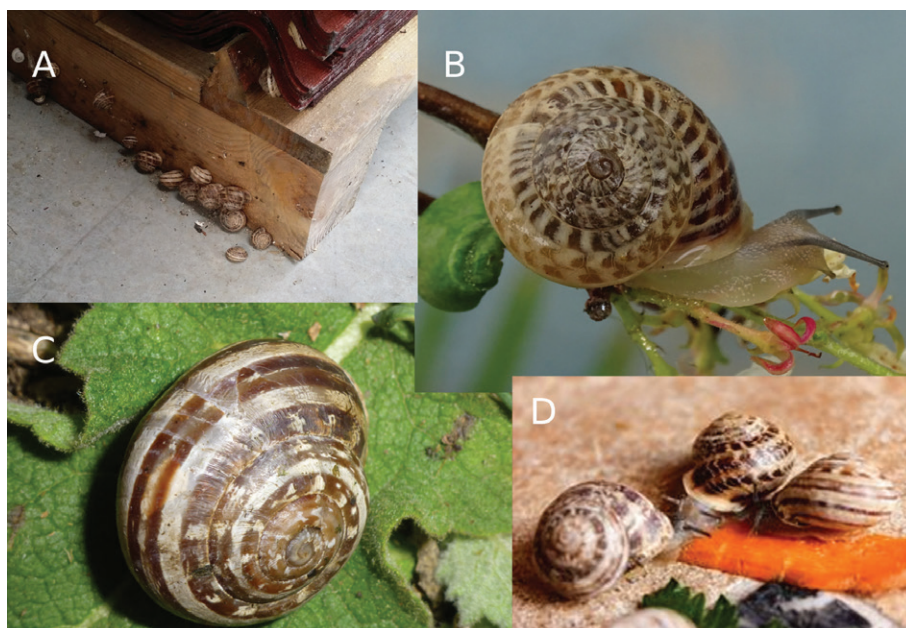
(1960) found *E. vermiculata* for Plovdiv, Sozopol, Tsarevo and Ahtopol. ZAPRYANOV (1993) and IRIKOV (2018) reported again the species from the city of Plovdiv. The most recently published new locality for the snail is the town of Stara Zagora (GEORGIEV et al. 2020). Historically, all findings of *E. vermiculata* in Bulgaria are in or around human settlements (WOHLBEREDT 1911, PETRBOK 1941, URBANSKI 1960, present study). In the Tsarevo locality, the shells of *E. vermiculata* were found in Holocene deposits (PETRBOK 1940, 1941, URBANSKI 1960). Presumably, the Bulgarian population of the species has a dual origin. According to URBANSKI (1960), the coastal area of Southern Black Sea probably is a part of the natural distribution range of the species. This assumption is also supported by the works of PETRBOK (1940) as well as the new findings of recent populations of the species in the European part of Turkey, Eastern Thrace (present study), near to the Black Sea coast. URBANSKI (1960) pointed out that the anthropogenic introduction is the other way for the species to penetrate Bulgaria. Probably, the initial stage of the species' introduction (the end of the XIX and the beginning of the XX century) concerns the localities in Plovdiv and Varna, while the recent introductions occurred at the localities in Burgas, Haskovo, Susam and Rupite. A possible reason for the first appearance of *E. vermiculata* in Northern Black Sea seashore could be streets reconstructions in Varna. At the early 20th century, Maria Luisa Boulevard in the city was covered with granite paving-stones, imported from Bandırma city in northwestern Turkey (N40.2912626 E027.9717606) (THEN THOUSAND STEPS ("10,000 STEPS") on BNT2, 2019). According to our observations, *Eobania* specimens often prefer to hide under stones. Presumably, adhered to the granite paving-stones, the specimens of *Eobania* were imported in Varna (see Fig. 3 B and Table 1). The active spread of *E. vermiculata* in Bulgaria may have been facilitated by the refugee migration in 1903 and 1913. In those years, many Bulgarians emigrated from the Aegean (Western Thrace) and Eastern Thrace, where this snail was found. A large part of the refugees headed towards and settled in the cities of Plovdiv, Burgas and its region, as well as in other regions on the territory of Bulgaria, where *E. vermiculata* has been found. After numerous archaeological excavations in the areas where the species recently occurs, no shell materials from *E. vermiculata* have been recorded among the animal remains found (Neolithic-Middle Ages) (compare with RIBAROV 1990, RIBAROV & BOEV 1990, SPASOV et al. 2001, GEORGIEV et al. 2009,



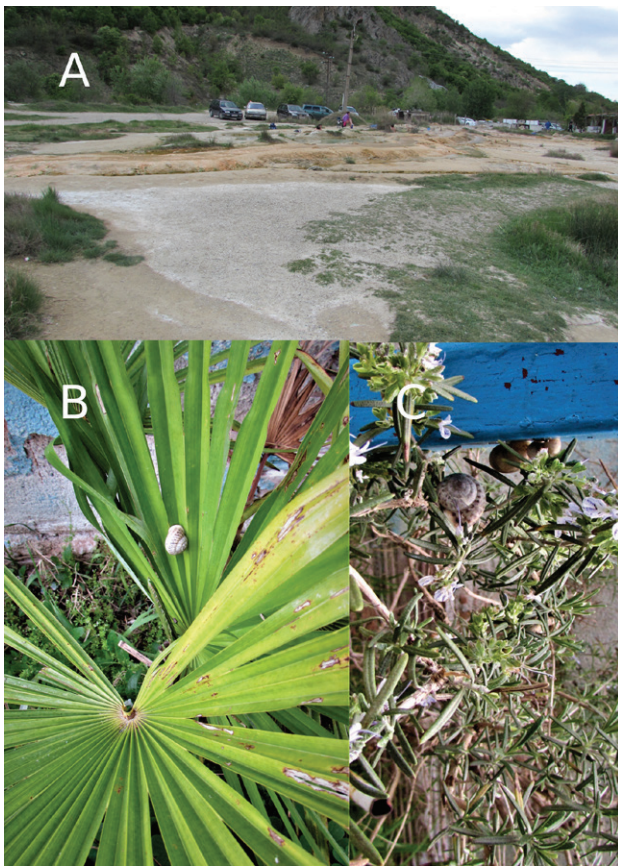
**Fig. 2.** The habitats in the area of Ahtopol, where the species *Eobania vermiculata* (O. F. Müller, 1774) was found: A – sea shore near Ahtopol, B – a cluster of specimens hidden under stones, below „Greek house“, C – locality near „Greek house“. Photographs by P. Mitov (29.08.2021).



**Fig. 3.** Ruins of the Roman Forum of Philippopolis, Plovdiv, where the species *Eobania vermiculata* (O. F. Müller, 1774) was found: (A) area close to the Central post office; alive specimens under syenite stones (B). Photographs by P. Mitov (03.10.2021).



**Fig. 4.** *Eobania vermiculata* (O. F. Müller, 1774), Shells variability of *Eobania vermiculata* (O. F. Müller, 1774) from different localities in Bulgaria. A – Stara Zagora, B – Rupite locality, C – Plovdiv, D – Haskovo. Photographs by V. Ivanova, V. Gashtarov, I. Dedov, S. Stefanov.



**Fig. 5.** The habitat in the area of Rupite locality, where the species *Eobania vermiculata* (O. F. Müller, 1774) was found near the thermal springs, around and in the yard of the mineral bath (A); on ornamental plants: *Trachycarpus* sp. (B) and *Rosmarinus officinalis* L. (C); in the closest to the mineral bath ponds with thermal water (40° C) can be seen many empty shells of fallen in the water and then died *E. vermiculata*. Photographs by P. Mitov: 19.04.2019 (B, C); 17.05.2022 (A).

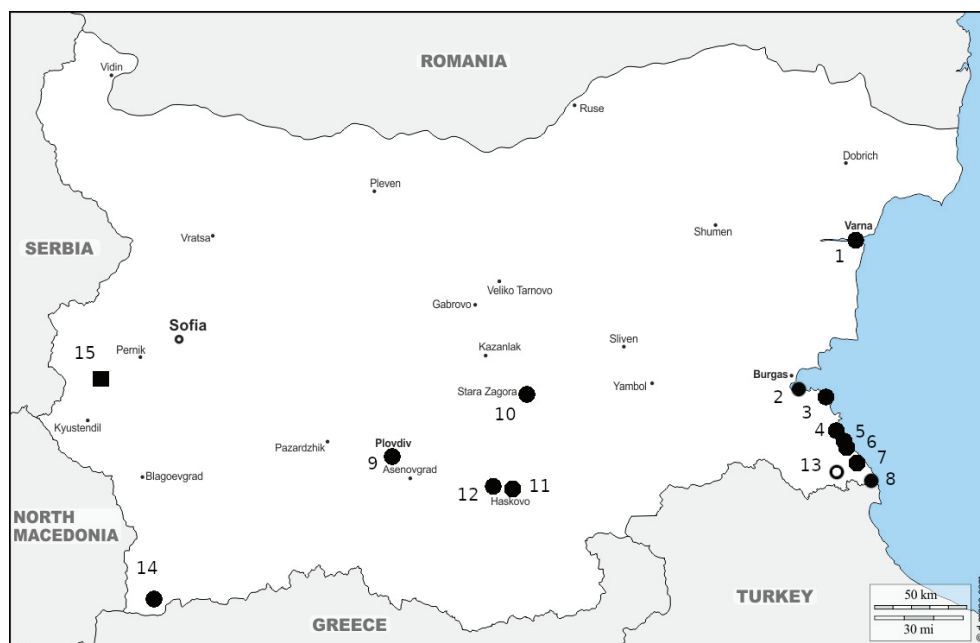
IVANOV & GEORGIEV 2016, VAGALINSKI & CHOLAKOV 2008). One of the present authors (L. Zapryanov) did not find this species in the course of archaeological excavations in the region of Varna. Most probably, the first specimens of *E. vermiculata* in the settlements have been transported with ornamental plants, imported for the city landscaping and creation of the garden and park areas in the end of XIX century (TODOROV 1976, STOYANOVA 2008, STANEV 2017). Presumably, the introduction in Bulgaria of adult specimens or their eggs continues to this day, generally via pots with ornamental plants. Probably it is the case with the specimens found near Rupite, Haskovo and Smirov Dol (Table 1). Multiple introductions have taken place in some of the localities. E.g., in Varna after the first registration, the species has not been found between 1936 and 1959 (URBANSKI 1960). Prob-

ably at that time the snail had not yet acclimatised enough or died during the extremely cold winters in the area in the period 1903–1954 (see IVANOV 1926, BURESCH 1930). Extremely cold winters, which caused the freezing of the Black Sea, were registered three times after the first report of the species' presence in Bulgaria (WOHLBEREDT 1911) – in 1929, 1942 and 1954 (PEYCHEV & DIMITROV 2012, p. 174). Long after WOHLBEREDT (1911), the presence of *E. vermiculata* in the urban fauna of Varna was confirmed again in 2014 as well as again in 2021 (Table 1). The species' appearance here again is probably related to the proximity to the Port Varna and to the opening of the archaeological site *Small Roman Thermae of Odessos* for tourist visits and the re-construction of the area. Here, the favourable climatic conditions (closeness to the sea – 340 m in a straight line, presence of well-heated terrain (Fig. 1), sufficient shelter and food) support abundant population of the species; however, this population is restricted to the area of the Small Roman Thermae only (Table 1). It seems that today, parallel with climate warming and intensive trade, thermophile species as *E. vermiculata* expand their range worldwide (UESHIMA et al. 2004, COWIE et al. 2009, PELTANOVA et al. 2012, PÁLL-GERGELY et al. 2019). Recently, *E. vermiculata* was found for first time in Romania (GRIGORE 2021) not far from the border with Bulgaria. Currently, this finding presents the northernmost locality of the species along the Black Sea coast. It is possible that *E. vermiculata* had been introduced there through the intensive tourist traffic and the trade between Bulgaria and Romania.

Our results demonstrated that the chocolate band snail in Bulgaria is becoming more common along the Black Sea coast, southern of the town Burgas. These territories are the northern borders of the natural distribution range of the species and there local populations exist exchanging specimens with the populations of *E. vermiculata* along the European part of the Turkish Black Sea coast. Confirmation of this are the established small populations of *E. vermiculata* in Eastern Thrace (Turkey) in the regions of Kıyıköy (Midye), Pınarhisar (Bunarhisar) and Yeniçiftlik (see Material and Methods).

### Reproductive system

The investigated reproductive systems of *E. vermiculata* from the new site – Rupite area (Fig. 7 A, B) are typical for the species and fit the descriptions given by ZAPRYANOV (1993) based on specimens from the city of Plovdiv and BOUAZIZ-YAHIAITENE et al. (2017) based on Mediterranean specimens.



**Fig. 6.** The main points of distribution of *Eobania vermiculata* (O. F. Müller, 1774) in Bulgaria. (map source: d-maps.com 2021). Symbols: solid circle – actual spots of distribution, empty circle – unconfirmed locality, square – locality where the species was found once and then disappeared. The numbers of the localities in the map correspond with the numbers of the localities in Table 1.

### Ecological notes

According PUIZINA et al. (2013), the chocolate band snail usually occurs in dry vegetation, in hedge-rows, gardens, vineyards and agricultural fields. In Bulgaria, *E. vermiculata* is distributed in areas with milder climate: Black Sea region, characterised with temperate continental climate (along the Northern Coast) and transitional Mediterranean climate (along the Southern Coast); Upper Thracian lowland, with transitional continental climate and influence of the Mediterranean climate; Eastern Rhodopes Mountains and the region of the valleys of the rivers Struma and Mesta, with transitional Mediterranean climate (GRUEV 1988, GEORGIEV 1991). In Bulgaria, *E. vermiculata* prefers dry, open and warm habitats – gardens, ruderal areas, mineral thermal spring areas, dunes and sea shores, as well as heat-accumulating substrates as limestones, syenite rocks and concrete, and thermophilic vegetation (Figs. 1–5). In Plovdiv and Rupite, *E. vermiculata* often co-occurs with *Helix philibinensis* Rossmässler, 1839. According URBANSKI (1960), on the Plovdiv syenite hills, the chocolate band snail co-occurs with *H. philibinensis*, *Zebrina detrita* (Müller, 1774), *Chondrula microtragus* (Rossmässler, 1839), *Xerolenta obvia* Menke, 1828 and *Monacha cartusiana* (Müller, 1774). In Plovdiv and Varna (The Small Roman Thermae), we found the species occurring together with *Helix lucorum*

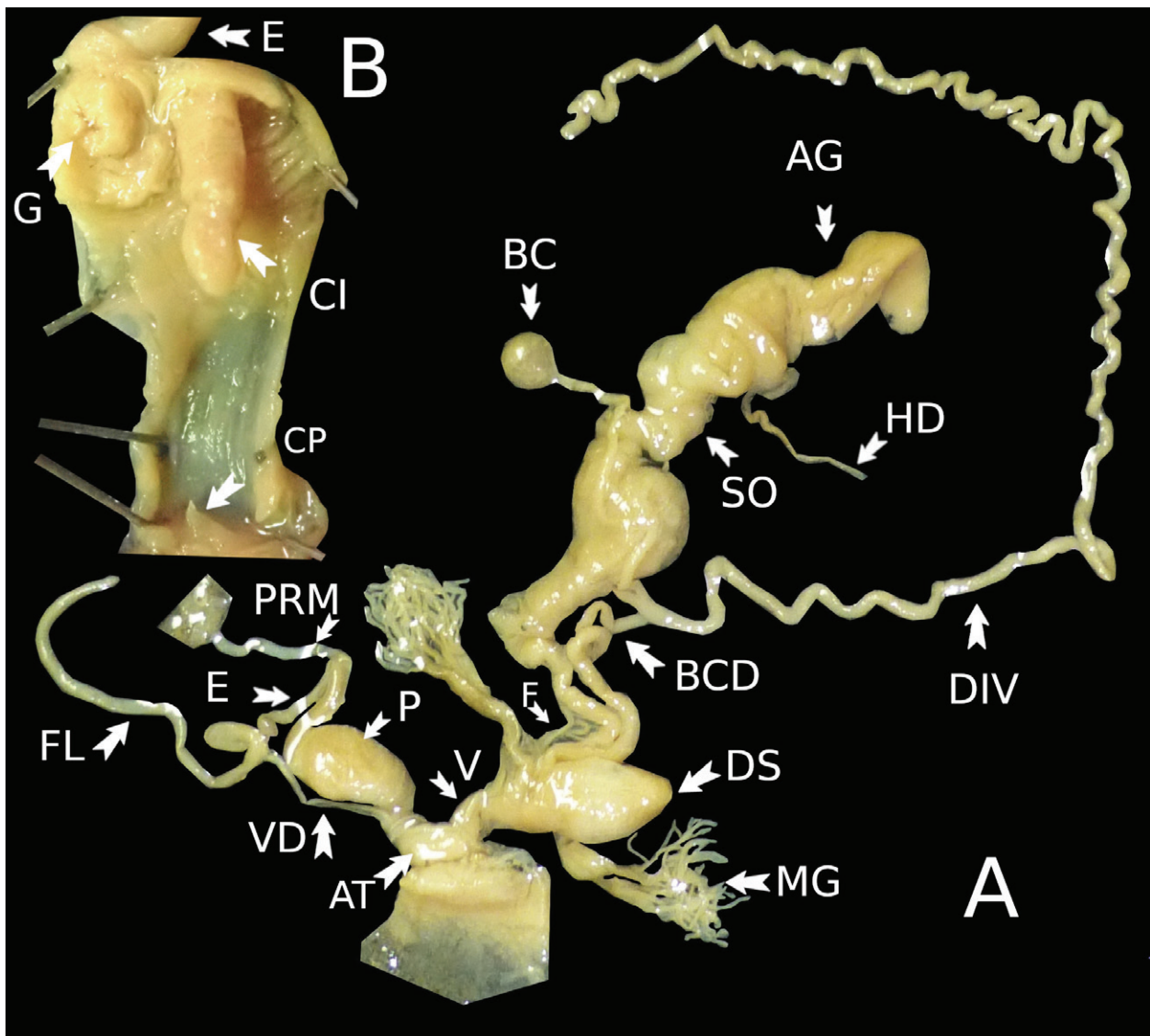
Linnaeus, 1758 (Fig. 3 B). There are no special quantity studies of the Bulgarian populations; however, according to our observations, it seems that they are not as abundant populations as in the Mediterranean countries. With relatively larger numbers, *E. vermiculata* has been found on the syenite hills of Plovdiv (old town), near the sea coast of Ahtopol and Varna (The Small Roman Thermae) as well as at Rupite (URBANSKY 1960, DAMJANOV & LIKHAREV 1975, ZAPRYANOV 1993, present study) (see Table 1). In all of these localities, we found live juvenile specimens, which suggests stable surviving populations.

### Pest potential

Some authors reported *E. vermiculata* as a serious pest (HERBERT & SIRGEL 2001, HUSSEIN & SABRY 2019) and suggest chemical control on its population (ESSAWY et al. 2009, ABD EL-ATTI et al. 2020). To date, there is no scientific confirmation that the species causes serious damage to agricultural and cultivated plants in Bulgaria. At the same time, the climate warming could help the expansion of *E. vermiculata* in lowlands of the country (see also GRIGORE 2021), respectively to increase its importance as a pest.

### Utilization

YILDIRIM et al. (2004) listed *E. vermiculata* as an edible snail in Turkey but, in Bulgaria, this snail is



**Fig. 7.** Reproductive system of *Eobania vermiculata* (O. F. Müller, 1774), specimens from Rupite locality, SW Bulgaria. **A.** General view. Abbreviations: Hermaphroditic parts: AT – atrium, HD – hermaphrodite duct, SO – spermoviduct; Male parts: E – epiphallus, FL – flagellum, P – penis, PRM – penis retractor muscle, VD – vas deferens; Female parts: AG – albumen gland, BC – bursa copulatrix, BCD – bursa copulatrix duct, DIV – diverticulum of bursa copulatrix duct, DS – dart sac, F – free oviduct, MG – mucus glands, V – vagina; **B.** Internal structure of the penis. Abbreviations: CI – corpusculum irritans, CP – colliculus penialis, G – glans. Photograph by I. Dedov.

not popular as a food resource. Recent observation in the town of Varna shows that, when the species becomes locally abundant, some of the people collected them for food. With an increase of its population, a popularization of the chocolate band snail as a food could be a prevention against its rapid expansion and potential damages on crops.

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#### References

ABD EL-ATTI M. S., EL-SAYED A. S. A. & SAID R. M. 2020. Usage of pharmaceutical contraceptive drug for controlling *Eobania vermiculata* snails by baits technique. *Heliyon* 6: 1–8. <https://doi.org/10.1016/j.heliyon.2020.e05630>

- AL-KHAYAT J. A. 2010. First record of five terrestrial snails in the State of Qatar. *Turkish Journal of Zoology* 34: 539–545. <https://doi.org/10.3906/zoo-0807-26>
- AL-KHAFAJI K. K. S., ABUD-SAHAB A. M. & AZIZ N. M. 2016. First record of terrestrial snail *Eobania vermiculata* (O.F. Müller, 1774) (Gastropoda: Helicidae) from Basrah areas, Iraq. *Arthropods* 5 (3): 125–129. <https://doi.org/10.5376/ijms.2017.07.0049>
- AMR Z. S., BAKER M. A. & KATBEH-BADER A. 2019. *Massylaea vermiculata* (O. F. Müller, 1774): A Serious Land Snail Pest Introduced to Jordan. *Jordan Journal of Natural History* 6: 60–61.
- BLACKET M. J., SHEA M., SEMERARO L. & MALIPATIL M. B. 2016. Introduced Helicidae Garden Snails in Australia: morphological and molecular diagnostics, species distributions and systematics. *Records of the Australian Museum* 68 (3): 99–116. doi: 10.3853/j.2201-4349.68.2016.1648
- BOUAZIZ-YAHIAENE H., PFARRER B., MEDJDOUB-BENSAAD F. & NEUBERT E. 2017. Revision of *Massylaea* Möllendorff, 1898 (Stylommatophora, Helicidae). *ZooKeys* 694: 109–133. doi: 10.3897/zookeys.694.15001
- BURESCH I. 1930. Zweiter Beitrag zur Schmetterlingsfauna vom Schlosspark Euxinograd, bei der Stadt Varna am Schwarzen Meer. *Bulletin de la Société entomologique de Bulgarie* 5: 207–252. (In Bulgarian).
- COWIE R. H., DILLON J. R. T., ROBINSON D. G. & SMITH J. W. 2009. Alien non-marine snails and slugs of priority quarantine importance in the United States: a preliminary risk assessment. *American Malacological Bulletin* 27: 113–132.
- DAMJANOV S. & LIKHAREV I. 1975. Fauna Bulgarica IV, Gastropoda terrestria. Sofia: Bulgarian Academy of Sciences, 425 p. (In Bulgarian).
- DESOUKY M. M. A. & BUSAIS S. 2012. Phylogenetic relationships of the land snail; *Eobania vermiculata* (Müller, 1774) from Egypt and Saudi Arabia. A combined morphological and molecular analysis. *The Journal of Basic & Applied Zoology* 65: 144–151. doi: 10.1016/j.jobaz.2012.07.009
- EGOROV R. 2008. Illustrated catalogue of the recent terrestrial molluscs of Russia and adjacent regions. *Treasure of Russian Shells, Supplement 5*. Moscow: Colus. 180 p.
- ESSAWY A. E., ABDELMEGUED N. E., RADWAN M. A., HAMED S. S. & HEGAZY A. E. 2009. Neuropathological effect of carbamate molluscicides on the land snail, *Eobania vermiculata*. *Cell Biology and Toxicology* 25 (3): 275–90. doi: 10.1007/s10565-008-9077-7
- GEORGIEV M. 1991. *Physical Geography of Bulgaria*. Sofia: University Publishing House “St. Kliment Ohridski”. 406 p. (In Bulgarian)
- GEORGIEV D., DEDOV I. & SCHNEPPAT U. 2020. The malacofauna (Mollusca: Gastropoda and Bivalvia) of Sarnena Gora Mts – published data and new records. In: GEORGIEV D., BECHEV D. & YANCHEVA V. (Eds.): *Fauna of Sarnena Sredna Gora Mts, Part 1*. *ZooNotes, Supplement 9*: 35–40.
- GEORGIEV D., KOSTOV D. & VLADOVA D. 2009. Molluscs (Mollusca: Gastropoda, Bivalvia) from the Azmashka mound, Upper Trakia Plain, South Bulgaria. *Trakia Journal of Sciences* 7 (2): 74–79.
- GRIGORE S. 2021. First record of *Eobania vermiculata* (O.F. Müller, 1774) (Gastropoda: Eupulmonata: Helicidae) in Romania. *Folia Malacologica* 29 (1): 51–53. <https://doi.org/1012657/folmal.029.003>
- GRUEV B. 1988. *General biogeography*. Sofia: Nauka iizkustvo. 396 p. (In Bulgarian).
- GURAL-SVERLOVA N. V. 2018. Spatial distribution of land molluscs fauna of the steppe zone of Ukraine. *Ruthenica* 28 (4): 131–138.
- HERBERT D. G. 2010. *The introduced terrestrial Mollusca of South Africa*. Pretoria: South African National Biodiversity Institute. SANBI Biodiversity Series 15. 108 p.
- HERBERT D. G. & SIRGEL W. F. 2001. The recent introduction of two potentially pestiferous alien snails into South Africa and the outcomes of different pest management practices: an eradication and a colonization. *South African Journal of Science* 97: 301–304.
- HOLYOAK D. T. & HOLYOAK G. A. 2017. A revision of the land-snail genera *Otala* and *Eobania* (Gastropoda, Helicidae) in Morocco and Algeria. *Journal of Conchology* 40 (6): 419–490.
- HOLYOAK D. T., HOLYOAK G. A., MOLINER B. J. G. & CHUECA L. J. 2020. Phylogeny, species-limits and taxonomic revision of Otalini (Helicidae) from North-West Africa. *Journal of Conchology* 43 (6): 551–611.
- HUSSEIN M. A. & SABRY A. H. 2019. *Bulletin of the National Research Centre* 43: 75 <https://doi.org/10.1186/s42269-019-0118-6>
- IRIKOV A. 2018. *Terrestrial Gastropods (Mollusca: Gastropoda) in the City of Plovdiv*. In: MOLLOV I., GEORGIEV D. & TODOROV O. (Eds.): *Faunistic diversity of the city of Plovdiv (Bulgaria), Volume 1 – Invertebrates*. *Bulletin of the Natural History Museum – Plovdiv* 1: 19–28.
- IVANOV S. N. 1926. *Oceanography*. Phototype edition, Varna: Morsky Sviat. 166 p. (In Bulgarian).
- IVANOV R. & GEORGIEV D. 2016. *Gastropod Shells from Excavations of the “Antic Forum” Complex in the City of Plovdiv (Bulgaria): IV-VI Century*. *Ecologia Balkanica* 8 (1): 111–112.
- ISMAIL S. A. 1997. *Ecology, biology and control of certain terrestrial snails infesting some vegetables and field crops in Sharkia Governorate, Egypt*: Ph.D. Thesis, Faculty Agriculture Zagazig University. p 130.
- KARAMAN B. J. 2006. *Former investigations of the fauna of snails (Mollusca, Gastropoda) in Bosnia & Herzegovina*. *Natura Montenegrina, Podgorica* 5: 55–66.
- KERNEY M. P. & CAMERON R. A. D. 1979. *A field guide to the land snails of Britain and North-West Europe*. United Kingdom, London: Collins. 288 pp.
- MIENIS H. K. 2002. *Eobania vermiculata* in Iran. *Triton* 6: 27.
- MIENIS H. K., RITTNER O. & VAISMAN S. 2016. Information concerning *Eobania vermiculata*, I. On the presence of this exotic species in Israel (Mollusca, Gastropoda, Helicidae). *Triton* 34: 29–36.
- MUMLADZE L. & PAPOSHVILI N. 2016. A New Addition to the Malacofauna of Georgia – *Eobania vermiculata* is Replenishing its Range. *Proceedings of the Institute of Zoology* 25: 153–155.
- NEUBERT E. & BANK R. A. 2006. Notes on the species of *Causotachea* C. Boettger 1909 and *Lindholmia* P. Hesse 1919, with annotations to the Helicidae (Gastropoda: Stylommatophora: Helicidae). *Archiv für Molluskenkunde* 135 (1): 101–132. doi: 10.1127/arch.moll/0003-9284/135/101-132
- PÁLL-GERGELY B., MAJOROS G., DOMOKOS T., JUHÁSZ A., TURÓCI A., BADACSONYI L., FEKETE J. & ASAMI T. 2019. Realtime Social Networking Service rapidly reveals distributions of

- non-indigenous land snails in a European capital. *Bioinvasions Records* 8 (4): 782–792. <https://doi.org/10.3391/bir.2019.8.4.06>
- PÁLL-GERGELY B., FEHÉR Z. & ČEJKA T. 2020. New records of the Mediterranean land snail *Eobania vermiculata* (O. F. Müller, 1774) in Hungary and Slovakia. *Folia Malacologica* 28 (4): 337–341. <https://doi.org/10.12657/folmal.028.021>
- PELTANOVÁ A., PETRUSEK A., KMENT P. & JUŘIČKOVÁ L. 2012. A fast snail's pace: colonization of Central Europe by Mediterranean gastropods. *Biological Invasions* 14: 759–764. <https://doi.org/10.1007/s10530-011-0121-9>
- PETNEY T. N. & HUSET H. C. 1992. A species and distribution list of landsnails of Jordan. *Argamon, Israel Journal of Malacology* 10: 1–14.
- PETRBOK J. 1940. Zur Kenntnis der quartären Mollusken von Bulgarien. *Archiv für Molluskenkunde* 72: 151–157.
- PETRBOK J. 1941. Posttertiaria nonmarina mollusca bulgarica. *Věstník Královské České Společnosti Nauk. Třída matematicko-přírodovědecká. Ročník*: 1–39.
- PEYCHEV V. D. & DIMITROV D. P. 2012. *Oceanology*. Varna: Ongul 476 p. (In Bulgarian).
- PUIZINA J., FREDOTOVIĆ Ž., ŠAMANIĆ I., ŠUŠNJARA T., KEKEZ L., CUKROV D. & PLESLIĆ G. 2013. Phylogeography of the Land Snail *Eobania vermiculata* (O.F. Müller, 1774) (Gastropoda: Pulmonata) along the Croatian Coast and Islands. *Journal of Entomology and Zoology Studies* 1 (4): 23–31.
- RIBAROV G. 1990. Study of the mollusks remains from archeological sites in Southeastern Bulgaria. *Interdisciplinary Research* 17: 66–82. (In Bulgarian).
- RIBAROV G. & BOEV Z. 1990. Investigation of the animal remains from the Late Iron Age Yassa-Tepe near Yambol. *Interdisciplinary research, Archaeological Institute and Museum, BAS* 17: 83–90. (In Bulgarian, English summary).
- ROBINSON D. G. 1999. Alien invasions: The effects of the global economy on non-marine gastropod introductions into the United States. *Malacologia* 41 (2): 413–438.
- ROLL U., DAYAN T., SIMBERLOFF D. & MIENIS H. K. 2009. Non-indigenous land and freshwater gastropods in Israel. *Biological Invasions* 11: 1963–1972. doi: 10.1007/s10530-008-9373-4
- RONSMANS J. & VAN DEN NEUCKER T. 2016. A persistent population of the chocolate-band snail *Eobania vermiculata* (Gastropoda: Helicidae) in Belgium. *Belgian Journal of Zoology* 146 (1): 66–68. <https://doi.org/10.26496/bjz.2016.41>
- SOES D. M. 2014. Een vondst van *Eobania vermiculata* in Wageningen. *Spirula* 398: 84–85.
- SON M. O. 2009. Mollusks-invaders in the Ukraine territory: the sources and directions of invasion. *Russian Journal of Biological Invasions* 2: 37–48. (In Russian).
- SPASSOV N, ILIEV N. & BOEV Z. 2001. Animal remains from the Eneolithic site near the village of Dolnoslav, Plovdiv District, South Bulgaria. *Historia naturalis bulgarica* 13: 159–179.
- STANEV S. 2017. The green world of Plovdiv: Paisii Hilendarski University Publishing House. 205 p. (In Bulgarian).
- STANISIC J., SHEA M., POTTER D. & GRIFFITHS O. 2010. Australian Land Snails. A Field Guide to Eastern Australian Species. Volume 1. *Reviere des Anguilles, Mauritius: Bioculture Press*. 591 p.
- STOYANOVA I. 2008. Structure and development of the palace park “Evksinograd”, 27–37. In: Peneva M. (Ed.) “The Period of Tsar Ferdinand I”, Scientific Conference dedicated to Bulgaria and laying the foundations of Bulgarian park art, natural sciences, palace and urban architecture. *Euxinograd. Reports. Women’s Liberal Network, Sofia*. 116 p. (In Bulgarian).
- THEN THOUSAND STEPS (“10,000 STEPS”) 2019. Maria Luisa Boulevard in Varna, documentary, broadcast on BNT2, 15.10.2019, Dimitar Urumov Director, Petya Ivanova Script, Hristian Oblakov local historian, video duration: 7’23”, Available at: <https://bnt.bg/bg/a/bulevard-mariya-luiza-vv-varna-16102019>
- TODOROV D. 1976. The landscaping of the city of Varna. Departmental edition, Varna. 87 p. (In Bulgarian).
- UESHIMA R., OKAMOTO M. & SAITO Y. 2004. *Eobania vermiculata*, a land snail newly introduced into Japan. *Chiribotan* 35: 71–74.
- URBANSKI J. 1960. Beiträge zur Molluskenfauna Bulgariens (excl. Clausiliidae), (Systematische, zoogeographische und ökologische Studien über die Mollusken der Balkan-Halbinsel. V.). *Bulletin de la Société des amis des sciences et des lettres de Poznań. Série D. Sciences biologiques* 1: 69–110.
- VAGALINSKI L. & CHOLAKOV I. D. 2008. Archaeological excavations at the site “Ancient city” near the village of Rupite, Petrich municipality. *Archaeological discoveries and excavations in 2007, Sofia*: 384–386. (In Bulgarian.)
- WOHLBEREDT O. 1911. Zur Molluskenfauna von Bulgarien. *Abhandlungen der Naturforschenden Gesellschaft zu Görlitz* 27: 167–234.
- YILDIRIM M. Z., KEBAPÇI Ü. & GÜMÜS B. A. 2004. Edible snails (terrestrial) of Turkey. *Turkish Journal of Zoology* 28: 329–335. <http://journals.tubitak.gov.tr/zoology/issues/zoo-04-28-4/zoo-28-4-8-0305-6.pdf>
- ZAPRYANOV L. 1993. Morphological characteristics of the land snail *Eobania vermiculata* (Müller, 1774) (Gastropoda, Helicidae) from Bulgaria. *Bulletin of Natural History Museum (Varna)* 29 (44): 254–259.

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