

NEW DATA ON THE DISTRIBUTION OF *PERILLUS BIOCULATUS* (HETEROPTERA: PENTATOMIDAE): FIRST RECORDS FROM CROATIA, BOSNIA AND HERZEGOVINA, NORTH MACEDONIA, GEORGIA, AND ARMENIA

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Abstract

Perillus bioculatus, a stink bug native to North America, was occasionally introduced to Europe in the early 20th century as a control agent against the potato pest *Leptinotarsa decemlineata*. Efforts were made to establish it, but it was not observed in the wild or considered naturalized until recent decades. In this paper, *P. bioculatus* is reported for the first time from five countries: Croatia, Bosnia and Herzegovina, North Macedonia, Georgia, and Armenia. Individuals were usually observed in the fall in gardens on potato plants while feasting on Colorado potato beetles, or near houses. Details about the new findings are presented, and the origin and further spread of the species are shortly discussed.

KEY WORDS: *Perillus bioculatus*, Croatia, Bosnia and Herzegovina, North Macedonia, Georgia, Armenia

Introduction

Perillus bioculatus (Fabricius, 1775) (Fig.1) is a predatory stink bug native to North America, with a distribution ranging from Mexico to Canada (Froeschner, 1988). It originated in the Rocky Mountains, and its expansion probably followed the spread of its primary prey, the Colorado potato beetle (Knight, 1923), *Leptinotarsa decemlineata* (Say, 1824).



Figure 1. Characteristic coloration of *Perillus bioculatus* showing the distinct red/orange tones on specific parts and the rest of the body in black. The characteristic Y-shaped marking and two black spots can be clearly seen. Pictures were taken by A. Muradkhanyan, O. Pihlajamaa & M. Doboš.

The predatory behavior of *P. bioculatus* toward *L. decemlineata* is the reason for its introduction into Europe. It was introduced as a biological control agent against the potato beetle at the beginning of the 20th century. Since then, the bionomics of *P. bioculatus* has been thoroughly studied, providing extensive information about its life cycle and ecology (e.g., Knight, 1923; 1952; Jermy, 1962). Efforts were made to introduce it into France during the 1930s, with no success (Franz & Szmidt). Later, a new campaign was launched for its introduction into nine other European countries, but again without success (Jermy, 1980).

Thomas (1994) noted that in Europe, the species was introduced into the former Czechoslovakia, France, Germany, Russia, Hungary, and former Yugoslavia. In former Yugoslavia, attempts to introduce *P. bioculatus* were made by P. Bjegović (1971). Eggs of the species were acquired from Germany and Hungary, reared to adulthood, and then used in research focused on its life ecology, overwintering, and effectiveness as a biological control for the Colorado potato beetle. In the summer of 1965, 300 L2 and L3 *P. bioculatus* nymphs were released on a potato plantation in Zemun (now part of Serbia) infested with Colorado potato beetles, where they were monitored daily. The number of individuals declined once they reached adulthood, as they acquired the ability to fly and began to disperse. The following year a similar situation occurred with another 500 nymphs: they thrived until reaching adulthood, at which point they suddenly dispersed. In the springs following the introduction of *P. bioculatus*, the potato plantations and surrounding areas of up to 200 m were inspected for any overwintered adult specimens. In the spring of 1966, a single adult was found, and the next spring, two adults were found. In the following seasons, the species was not detected in the area. Similar results were obtained in Hungary a decade earlier (Jermy, 1962). After the unsuccessful introductions, it was listed as an alien species for Europe, along with tens of other true bug species (Rabitsch, 2008). While the species was not documented in these countries for some time, sightings began to occur toward the end of the 20th century, with reports coming from different locations across Europe, such as European Turkey, Greece, European Russia, Bulgaria, Greece, Serbia, and several others (Fent & Aktaç, 2007; Rabitsch, 2008; Ismailov & Agesieva, 2010; Simov *et al.*, 2012; Protić & Živić, 2012). Sightings of the species have been consistently reported in some countries, such as Serbia (Protić & Živić, 2012; Protić *et al.*, 2022; Nadaždin & Šeat, 2022), but not in others, with significant gaps between sightings sometimes lasting even decades. One such example of this was discussed in Simov *et al.* (2012), who noted that the species was not recorded in Bulgaria for 34 years.

The current distribution of *P. bioculatus* in Europe includes territories of European Turkey, Greece, Bulgaria, Russia, Serbia, Moldova, Ukraine, Romania, and Hungary (Fig. 2.) (Kivan, 2004; Fent & Aktac; Péricart, 2010; Ismailov & Agesieva, 2010; Simov *et al.*, 2012; Protić & Živić, 2012; Derjanschi *et al.*, 2013; Levchenko & Martynov, 2018; Rădac & Teodorescu, 2021, Kóbor & Brhane, 2024). Outside Europe, the species is naturalized in Turkey, India, and Pakistan (Prasad & Pal, 2015; Dursun & Fent, 2018; Kiyak *et al.*, 2019; Ullah, 2019; Çerçi *et al.*, 2021).

Materials and Methods

In 2023, the first author noted two sightings of *P. bioculatus* in Croatia while browsing the iNaturalist platform (www.inaturalist.org). Upon reviewing the literature and recognizing the value of these records, other observations of this species were examined and compared with those from previous studies. In addition to Croatia, records from North Macedonia, Georgia, and Armenia were also found to be significant as they presented new data about the species' distribution. In early June 2024, new information came from a Croatian gardening group on Facebook called "*Biovr.com - u skladu s prirodom*". The first author noticed *P. bioculatus* in several photos and subsequently made a post in the group, asking members if they had spotted the species in their gardens or cities. Members commented on the post for about a week, sharing pictures of the observed species, which were either *P. bioculatus* or the similarly colored *Graphosoma italicum* (Müller, 1766). After this short campaign ended, new data emerged not only from Croatia but also from Bosnia and Herzegovina. When the campaign concluded, our search for any additional *Perillus* observations also ended. All observers were asked for permission to publish their findings, and all gave their consent.

Results

In total, ten observations of *P. bioculatus* uploaded to iNaturalist were deemed notable as they represented the first records of the species in four countries: Croatia, North Macedonia, Georgia, and Armenia. Five additional observations were posted in a Facebook group ("*Biovr.com - u skladu s prirodom*"), including three more records from Croatia, and one that marked the first sighting of the species in Bosnia and Herzegovina. The specimens were photographed in both urban and rural environments, often near or inside houses late in the season, as well as in gardens, typically on potato plants infested with Colorado potato beetles. Table 1 lists the country, location, date, and iNaturalist link for each observation (if applicable). The following provides further details, including the number and life stage of the individuals, as well as descriptions of the locations where they were reported.

Croatia: numerous individuals in seven locations.

Croatia: Zagreb, 45.8029°N 15.9724°E, 116 m a.s.l., 25.07.2023, 1 adult in an apartment on the first floor; Jakšić, 45.3558°N 17.7686°E, 173 m a.s.l., 20.09.2023, 1 adult on *Tradescantia zebrina* Bosse; *idem*, 30.9.2023, 1 adult on wall; Osijek, 02.04.2024, over 20 individuals (nymphs and adults) found on potato plants feeding on the larvae of *L. decemlineata*; 45.5632°N 18.6958°E, 79 m a.s.l., 02.04.2024, 1 adult found on a bank of the Drava river; Valpovo, 11.04.2024, 1 adult collected with adults of *L. decemlineata*; Pitomača, 23.05.2024, 1 adult on a potato plant feeding on the larvae of *L. decemlineata*; Velika Trnovitica, 03.07.2024, 1 adult found on a potato plant; Gabajeva Greda, 46.1514°N 17.0138°E, 119 m a.s.l., 03.07.2024, 1 adult found on vegetation by a lake.

Bosnia and Herzegovina: 20+ individuals in one location

Bosnia and Herzegovina: Usora Municipality, 44.7050°N 18.0294°E, 256 m a.s.l., 01.07.2024, over 20 individuals were found in all stages; mating pairs and eggs were also observed on potato plants feeding on *L. decemlineata*.

North Macedonia: two adult individuals in two locations.

North Macedonia: Struga, 41.1990°N 20.7009°E, 695 m a.s.l., 19.05.2018, 1 adult male, caught by sweeping the vegetation beside unplanted fields, a location where *L. decemlineata* was also encountered; Kumanovo, 42.1464°N 21.7166°E, 324 m a.s.l., 1 adult found inside a house.

Georgia: two individuals (nymph and adult) in two locations.

Georgia: Tbilisi, 41.8524°N 46.1081°E, 337 m a.s.l., 05.06.2022, 1 nymph found in a forested area; Marani, 42.1676°N 42.2793°E, 26 m a.s.l., 1 adult found in an urban area.

Armenia: one adult individual.

Armenia: Noyakert, 39.8307°N 44.6684°E, 277 m a.s.l., 16.09.2023, 1 adult found in a backyard where it was possibly feeding on pests of nearby garden plants (tomatoes, peppers, and green beans).

All these records are shown in Fig.2 and are represented by red dots, while older records are represented by green dots.

Table I. Observations of *Perillus bioculatus* individuals uploaded to iNaturalist or posted in a Facebook group, representing the first records of the species for Croatia, North Macedonia, Georgia, and Armenia.

	Country	Location	Date	iNaturalist link (if exists)
1	Croatia	Zagreb	Sep 25, 2023	inaturalist.org/observations/184896502
2	Croatia	Jakšić	Sep 20, 2023	inaturalist.org/observations/184248217
3	Croatia	Jakšić	Sep 30, 2023	inaturalist.org/observations/185867813
4	Croatia	Osijek	April 2, 2024	(Uploaded in a FB group)
5	Croatia	Valpovo	April 11, 2024	(Uploaded in a FB group)
6	Croatia	Pitomača	May 23, 2024	(Uploaded in a FB group)
7	Croatia	Osijek	June 5, 2024	inaturalist.org/observations/120419245
8	Croatia	Velika Trnovitica	June 13, 2024	(Uploaded in a FB group)
9	Croatia	Gabajeva Greda	July 3, 2024	inaturalist.org/observations/226858723
10	Bosnia and Herzegovina	Usora	Jul 1, 2024	(Uploaded in a FB group)
11	North Macedonia	Struga	May 19, 2018	inaturalist.org/observations/72305930
12	North Macedonia	Skopje	March 17, 2023	inaturalist.org/observations/151840228
13	Georgia	Tbilisi	June 5, 2022	inaturalist.org/observations/120419245
14	Georgia	Marani	Sep 20, 2023	inaturalist.org/observations/184034785
15	Armenia	Noyakert	Sep 16, 2023	inaturalist.org/observations/183660786

Discussion

From these recent observations, the oldest dates from 2018 from North Macedonia. While it was uploaded to iNaturalist in 2021, no reports of the species' presence in the country were made in subsequent years. Only one of the observations is from 2022, whereas the other six were made in 2023, mostly in September. The latest records are from the spring and summer of 2024 when observations mostly occurred in gardens, on potato plants infested with Colorado potato beetles. The large number of observations during April and May aligns with the development of potato plants and the emergence of the Colorado potato beetle, while sightings in September can be attributed to the species' migration in search of suitable hibernation sites, typically in houses and apartments.

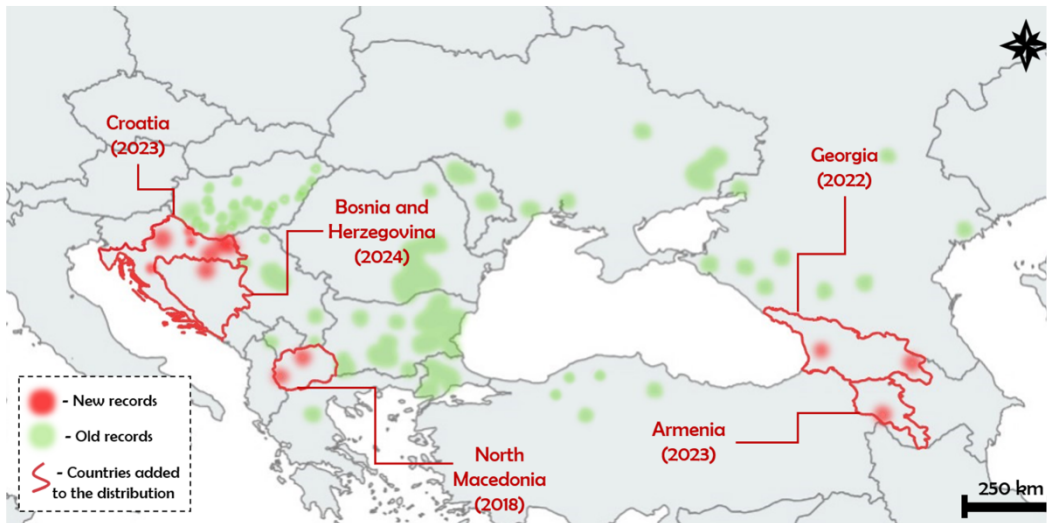


Figure 2. Updated distribution map (using literature and iNaturalist) of *P. bioculatus* in Europe, with new records (red color) and old records (green color). Countries added to the known distribution are outlined in red with the year of the first record highlighted.

Individuals from Croatia and Bosnia and Herzegovina were probably originally part of a population that spread from neighboring Serbia, where *Perillus bioculatus* was first identified in the wild in 1954 at Obedska Bara, and later in 1997 at Veliko Djeravičko Jezero (Protić & Živić, 2012; Protić *et al.*, 2022). More recent records also show the species near the Croatian border (Nadaždin & Šeat, 2022). Their history in North Macedonia is similar: in addition to bordering Serbia to the north, North Macedonia also shares a border with Bulgaria to the east. Likewise, specimens were previously reported near the border, with sightings in Gorna Breznitsa as early as 2002 (Simov *et al.*, 2012), and several new records have since appeared on iNaturalist. The records from Georgia and Armenia are probably related to the species' spread from the north (i.e., Russia), as sightings from Turkey are located far from the borders of these countries (Çerçi *et al.*, 2021). Natural dispersion very likely occurred in all of these cases, as the neighboring countries have stable populations; however, some human involvement cannot be ruled out.

The Croatian records present the westernmost known sightings of the species in Europe. The further spread of *P. bioculatus* throughout the newly reported countries and even further west is expected, as this has occurred

in the past. Monitoring the species' presence is recommended in neighboring, undocumented countries, as well as in the already known countries of distribution. New records and additional research will enhance our understanding of the species' spread and its impact in Europe and beyond.

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НОВИ ПОДАЦИ О РАСПРОСТРАЊЕЊУ
PERILLUS BIOCULATUS (HETEROPTERA: PENTATOMIDAE):
ПРВИ НАЛАЗ ЗА ХРВАТСКУ, БОСНУ И ХЕРЦЕГОВИНУ,
СЕВЕРНУ МАКЕДОНИЈУ, ГРУЗИЈУ И ЈЕРМЕНИЈУ

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Извод

Perillus bioculatus, врста смрдибубе пореклом из Северне Америке унета је у Европу почетком 20. века као предатор кромпирове златице *Leptinotarsa decemlineata*. Уложени су напори да се успостави популација, али није примећена у природи све до последњих деценија. У овом раду *P. bioculatus* је први пут евидентиран у пет земаља: Хрватска, Босна и Херцеговина, Северна Македонија, Грузија и Јерменија. Јединке су примећене у јесен у баштама на биљкама кромпира док су се храниле кромпировом златицом. Приказани су детаљи о новим налазима, а укратко се говори о пореклу и даљем ширењу врсте.

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