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MALACOFAUNA OF CRIMEA AS A POSSIBLE SOURCE OF INTRODUCTIONS TO OTHER REGION OF UKRAINE: LAND SNAILS OF NON-CRIMEAN ORIGIN

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Background. Due to global climate changes, a number of land mollusc species, previously known only from southern Ukraine or only from Crimea, are increasingly being recorded in different parts of the country. Apparently, not only species of the Crimean origin but also some other molluscs, native or alien to the Crimean Peninsula, could have been introduced from Crimea in different time periods. Therefore, the main purpose of this study was to generalise and give a critical analysis of data on the present distribution in Ukraine outside Crimea for 8 such species, whose primary source of dispersal could be, at least partially, the Crimean Peninsula.

Materials and Methods. We used the results of our own long-term (from 1994 to 2023) research of the land mollusc fauna in different parts of Ukraine, examined collections of other researchers and amateurs, numerous stock materials of the State Museum of Natural History in Lviv, analysed a number of literature sources from the beginning of the 20th century to the present day, as well as reports from two citizen science databases (iNaturalist and UkrBIN).

Results and Discussion. We have sequentially analysed the available data about the present distribution and chronology of discovery in different administrative regions of Ukraine outside Crimea for *Cecilioides raddei*, *Phenacolimax annularis*, *Oxychilus deilus*, *Xeropicta derbentina*, *X. krynickii*, *Monacha cartusiana*, *Eobania vermiculata*, as well as *Helix lucorum* with the shell colouration characteristic of the mountainous Crimea. It has been established that one or more species have now been reliably recorded in all parts and almost all administrative regions of Ukraine, with the exception of Sumy and Kirovohrad ones.

Conclusion. The conducted analysis confirms the potential influence of Crimea on the formation of the present species composition of alien land molluscs not only in the



south, but also in other parts of Ukraine. Most of the analyzed species are so far known only from those administrative regions that border the Black and Azov Seas. Two species, *X. derbentina* and *M. cartusiana*, are now rather widespread in Ukraine, but most of their known records were made no earlier than 1990s. The data systematized in this study can become the basis for monitoring the further spread of the species under study into different parts of Ukraine, which may become especially relevant in the post-war period.

Key words: terrestrial molluscs, Gastropoda, anthropochory

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INTRODUCTION

Due to anthropochory, many land molluscs have significantly expanded their ranges in Ukraine, which has become especially noticeable in recent decades (Balashov & Markova, 2023a, 2023b; Gural-Sverlova & Gural, 2023; Gural-Sverlova & Rodych, 2023; Gural-Sverlova *et al.*, 2022, etc.). Because of global climate warming, some species previously recorded only in the south of Ukraine or even only in Crimea have been able to successfully adapt to living in settlements and several other habitats in the west (see review in Gural-Sverlova & Gural, 2021) and north of the country (Balashov & Markova, 2023a, 2023b; Gural-Sverlova & Rodych, 2023). Some of them have already been found even further north, in Belarus (Balashov & Markova, 2023a; iNaturalist, 2024, etc.).

Previously, we have already emphasized the important role of the Crimean Peninsula as a potential source of the primary introduction of some species of land molluscs into the steppe zone of Ukraine outside Crimea. Having spread widely in the steppe zone, the species of Crimean origin such as *Brephulopsis cylindrica* (Menke, 1828) or *Monacha fruticola* (Krynicky, 1833) then began to increasingly penetrate (as a result of anthropochory) into other parts of Ukraine (Balashov & Markova, 2023a; Balashov *et al.*, 2018; Gural-Sverlova & Gural, 2021, 2023, Vychalkovskaya, 2008, etc.).

However, not only species of Crimean origin, but also a number of other land molluscs, native or alien to the Crimean Peninsula, could have been introduced from Crimea at different times. This was greatly facilitated by the fact that until 2014 Crimea was one of the most popular summer holiday destinations for residents of different parts of Ukraine. Therefore, the main purpose of this study was to generalise and give a critical analysis of data on the present distribution in Ukraine outside Crimea for 8 such species, whose primary source of dispersal could be, at least partially, the Crimean Peninsula. We also attempted to find out the chronology of the discovery of such species in different administrative regions of Ukraine.

MATERIALS AND METHODS

The following sources of information were analysed:

- 1) the results of our own long-term (from 1994 to 2023) research of land molluscs in different parts of Ukraine;
- 2) the collections of other researchers and amateurs that we personally examined, many of which are now stored in the malacological collection of the State

- Museum of Natural History of the National Academy of Sciences of Ukraine in Lviv (Gural-Sverlova, Gural, 2020), hereinafter referred to as SMNH NASU;
- 3) the data published in different time periods: the beginning of the 20th century (Lindholm, 1908), the second half of the 20th century (Korniushin, 1980, 1986), the beginning of the 21st century (Balashov & Baidashnikov, 2012; Balashov & Markova, 2023a);
 - 4) reports from two citizen science databases (iNaturalist, 2024; UkrBIN, 2024), if they were accompanied by sufficiently high-quality photographs of molluscs or their shells to allow reliable species identification.

This paper is limited to shelled land molluscs (snails) and does not discuss several slug species, which could also have been introduced from Crimea to the continental part of Ukraine. Reliable identification of species in slugs is often impossible without anatomy, which makes the use of some literature sources and observations in databases problematic (Gural-Sverlova & Rodych 2023).

RESULTS AND DISCUSSION

None of the land snail species analyzed below was recorded in the Northern Black Sea region of Ukraine in the Pleistocene (Kunitsa, 1974). **Table 1** shows the chronology of species discovery in different administrative regions of Ukraine.

Information on the present distribution of *Xeropicta derbentina*, *X. krynickii*, *Eobania vermiculata* and *Helix lucorum* in Ukraine outside Crimea has been supplemented to some extent due to citizen science databases used. In particular, only in the database iNaturalist (2024) did we find evidence of the presence of *Xeropicta* in the Luhansk (Popasna district and Rubizhne, observed in 2021), Kharkiv (Budy, 2022) and Cherkasy (Mankivka district, 2021) regions, *E. vermiculata* in Odesa (2023), *H. lucorum* with the shell colouration characteristic of the mountainous Crimea (see below) in Zaporizhzhia (2016) and Kyiv (2023). In photographs of *Xeropicta* from the two localities in the Kharkiv and Cherkasy regions mentioned above, as well as from Poltava (2021), marked with crosses in **Fig. 1**, the shape of the shell umbilicus is not visible, which allows reliable identification only at the genus level. However, given the great distance of these records from the Black and Azov Seas, they can very likely be attributed to *X. derbentina*.

***Cecilioides raddei* (Boettger, 1879), Ferussaciidae.** Almost until the very end of the 20th century, *C. raddei* was known in Ukraine only from Crimea. In the 1990s, A. M. Shklyaruk found this species in the Odesa region: near the Mother-in-law Bridge (Odesa), together with two other species of land molluscs, clearly introduced from Crimea (see below), and in an artificial forest on the steep slopes of the right bank of the Dniester estuary between the villages of Moloha and Semenivka, Bilhorod-Dnistrovskiy district (Lymanskyi Landscape Reserve). Shells from both localities were studied by us; one shell from Odesa is stored in SMNH NANU (Gural-Sverlova & Gural, 2020).

***Phenacolimax annularis* (Studer, 1820), Vitrinidae.** In Ukraine, *Ph. annularis* was known only from Crimea for a long time. At the turn of the 20th and 21st centuries, this species was found near the Mother-in-Law Bridge in Odesa on shell rock walls together with the Crimean endemic *Mentissa gracilicosta* (Rossmäessler, 1836), which may indicate a possible joint introduction from the Crimean Peninsula. In 2017, it was found in collections from the Vasylivka district in the northwestern part of the Zaporizhzhia region, along the banks of the Kakhovka reservoir (Balky, Maiachka, Pidhirne, Skelky,

Table 1. Chronology of discovery of analyzed species in Ukraine outside Crimea

Time periods	Administrative regions
<i>Cecilioides raddei</i> (2 localities in one region)	
1990s	Odesa
<i>Phenacolimax annularis</i> (2 regions)	
2000	Odesa
2017	Zaporizhzhia
<i>Oxychilus deilus</i> (2 localities in 2 regions)	
1978	Kherson
2017	Zaporizhzhia
<i>Xeropicta derbentina</i> (10–12 regions)	
1990s	Donetsk, Dnipropetrovsk, Kherson, Mykolaiv, Odesa
2000s	Poltava, Vinnytsia, Zaporizhzhia
2014	Transcarpathian
2021	*Cherkasy (?), *Luhansk
2022	*Kharkiv (?)
<i>Xeropicta krynickii</i> (5 regions)	
Early 20th century	Odesa
1990s	Kherson, Mykolaiv
2006	Donetsk
2017	Zaporizhzhia
<i>Monacha cartusiana</i> (20 regions)	
Mid 20th century	Mentioned for southern Ukraine with Crimea, without details
1970s	Kherson, Mykolaiv
1990s	Donetsk, Odesa, Transcarpathian
2000s	Chernivtsi, Dnipropetrovsk, Khmelnytskyi, Lviv, Rivne
2014	Kharkiv
2017	Zaporizhzhia
2018	Kyiv
2019	Ivano-Frankivsk
2020	Volyn
2021	Cherkasy, Chernihiv, Luhansk, Ternopil
2022	Zhytomyr
<i>Eobania vermiculata</i> (a few localities in 3 regions)	
1990	Odesa
2006	Donetsk
2017	Zaporizhzhia
<i>Helix lucorum</i> , only with the shell colouration characteristic of Crimea (3 settlements in 2 regions)	
2016	Zaporizhzhia
2023	*Kyiv

Notes: * – only based on observations in the database iNaturalist; ? – identification at the species level requires confirmation (see Materials and Methods)

Vasylivka, Zlatopil) (Gural-Sverlova & Gural, 2020). Then it was recorded by Gensytskyi (2021) in the south of the Zaporizhzhia region – at one site in Melitopol, on a vacant lot among the railway tracks. However, SMNH NANU contains now shells of *Ph. annularis* collected by this researcher also in Berdiansk district (Radyvonivka), Melitopol district (Nove, Terpinia), Pryazovske district (Novovasylivka, Stepanivka Persha), Prymorsk district (Bolharka, Yelyzavetivka). Most of the samples were made in 2020.

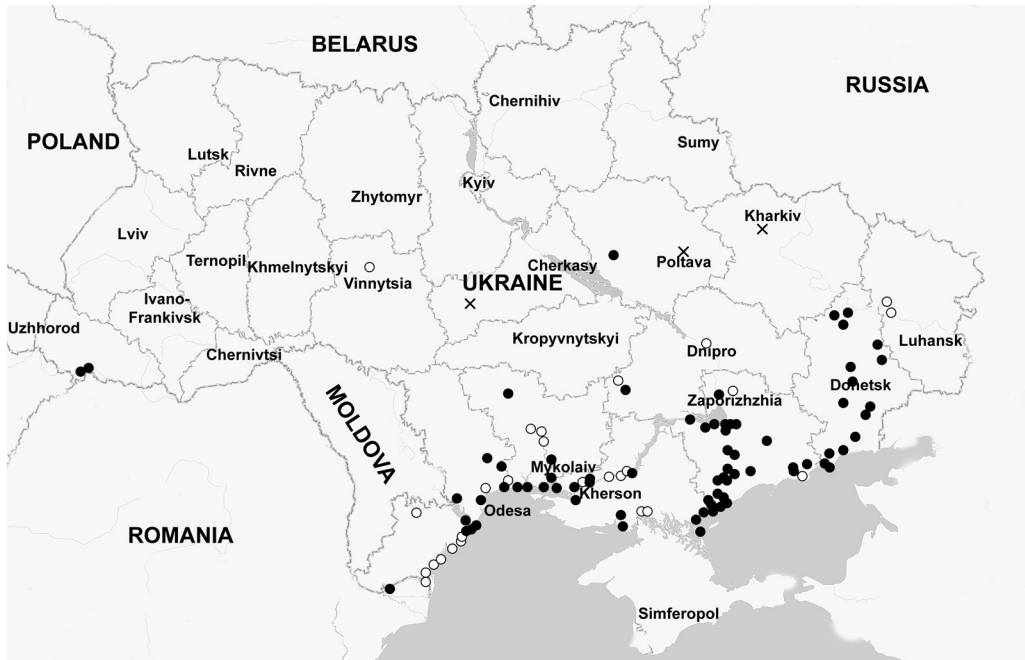


Fig. 1. Known records of *Xeropicta derbentina* in Ukraine outside Crimea: black circles – stock materials of the State Museum of Natural History in Lviv (mainly) and other personally examined materials; white circles – other sources of information; crosses – identification at the species level requires confirmation (see Materials and Methods)

***Oxychilus deilus* (Bourguignat, 1857), Zonitidae.** So far, only two localities of *O. deilus* are known in Ukraine outside Crimea. The first record was made in 1978 in the Askania-Nova arboretum in the Kherson region (Korniushin, 1986). The additional presence of two Crimean species (*Brephulopsis cylindrica* and *Monacha fruticola* mentioned in Introduction) allowed the author to make a fair assumption that these molluscs could have been brought from Crimea along with plants when replenishing the arboretum collection. SMNH NANU contains later samples of *O. deilus* from Askania-Nova, dated 2002 and 2004 (Gural-Sverlova & Gural, 2020). Then, shells of *O. deilus* collected in 2017 in the Dubovyi Hai Park in Zaporizhzhia were also transferred to the museum (Gural-Sverlova & Gural, 2020).

***Xeropicta derbentina* (Krynicky, 1836), Geomitridae.** Almost until the very end of the 20th century, *X. derbentina* was mentioned in Ukraine only for Crimea. However, starting from the 1990s, this species began to be increasingly found in the steppe zone of Ukraine outside the Crimean Peninsula, which is reflected in the stock materials of SMNH NANU (Gural-Sverlova & Gural, 2020). The largest number of reliable records of

X. derbentina has so far been made, listed from west to east, in the Odesa, Mykolaiv, Kherson, Zaporizhzhia, and Donetsk regions (**Fig. 1**). A few localities of *X. derbentina* are also known in Dnipropetrovsk, Luhansk, Poltava, Transcarpathian, Vinnytsia, and quite possibly also in the Cherkasy and Kharkiv regions (**Table 1**).

In the future, we can expect the discovery of *X. derbentina* in urbanized biotopes of the northern regions of Ukraine, which can be indirectly indicated by recent (2022–2023) records of this species even further north – in the southern part of Belarus: in Gomel and Brest.

Since *X. derbentina* is also widespread in the Caucasus, we cannot exclude the possibility that the introduction of this species, at least to the east of Ukraine, could have occurred from two sources at once. Anyway, the first known find of *X. derbentina* in the Donetsk region is dated 1990 (Gural-Sverlova & Gural, 2020), as well as the first record there of the Caucasian snail *Harmozica ravergiensis* (Férussac, 1835). However, the present distribution of these two species in Ukraine is very different. *H. ravergiensis* has already been recorded in the central (Balashov & Markova, 2023b, p. 26) and even in the western part of Ukraine (in Lviv and near Ternopil). But *H. ravergiensis* is not yet known from the large areas of southern Ukraine, from the Odesa region in the west to the Zaporizhzhia region in the east, where *X. derbentina* (**Fig. 1**) and several snail species of Crimean origin (*Brephulopsis cylindrica*, *Monacha fruticola*, *Helix albescens* Rossmässler, 1839) are so common.

***Xeropicta krynickii* (Krynicky, 1833), Geomitridae.** Unlike *X. derbentina*, *X. krynickii* was mentioned for the vicinity of Odesa already at the beginning of the 20th century (Lindholm, 1908). However, the present distribution of this species in Ukraine outside Crimea remains limited almost exclusively to coastal areas (**Fig. 2**). Further from the sea coasts, *X. krynickii* is found mainly along estuaries (limans) or beds of large rivers. The northernmost known records of *X. krynickii* were made along the lower reaches of the Dnieper River – in the cities of Zaporizhzhia and Vasylivka (Gural-Sverlova & Gural, 2020). In both cases, the microclimate of urbanized biotopes inhabited by molluscs could be additionally influenced by the proximity of the Kakhovka Reservoir (**Fig. 2**).

Although both *Xeropicta* species tend to expand their ranges in Ukraine, this trend is much stronger for *X. derbentina*. It is likely that *X. derbentina* has greater ecological plasticity, in particular, it is better adapted to living in a more continental climate. Due to this, *X. derbentina* does not show such a strong connection with sea coasts or other large bodies of water as *X. krynickii*.

***Monacha cartusiana* (O. F. Müller, 1774), Hygromiidae.** *M. cartusiana* is a sub-Mediterranean species, the present range of which has been significantly expanded due to anthropochory. For southern Ukraine including Crimea, *M. cartusiana* is often mentioned as a native species (Balashov, 2016), although this is not confirmed by paleontological data (Kunitsa, 1974). For southern Ukraine outside Crimea, *M. cartusiana* was first mentioned in the mid-20th century (Gural-Sverlova & Gural, 2023), but without definite localities or administrative regions. In the 1970s this species was found in large numbers in the Black Sea Biosphere Reserve (Korniushin, 1980).

For the southern (mountainous) Crimea, *M. cartusiana* was mentioned much earlier (Retowski, 1883). However, even now *M. cartusiana* occurs mainly in anthropogenic rather than natural coastal habitats of the southern Crimea (Balashov & Markova

2023a), which may indicate that this species is alien there. Easily spread by vehicles (Gural-Sverlova & Gural, 2023), *M. cartusiana* could have been accidentally introduced from Crimea to other coastal regions of Ukraine in the 20th century. For comparison: in the Zaporizhzhia region, where *Monacha* species were not known at the beginning of the 20th century (Lindholm, 1908), now *M. cartusiana* is found much less frequently than the species of Crimean origin *M. fruticola* (Gensytskyi, 2021; Gural-Sverlova & Gural, 2020, 2023, etc.) that has become widespread and mass there.

The present distribution of *M. cartusiana* in Ukraine, as well as the chronology of the discovery of this species in the west of the country, have been reviewed in several publications (Balashov & Markova, 2023a; Gural-Sverlova & Gural, 2023). In 2023, we made additional anatomically verified finds of *M. cartusiana* in some settlements of the Lviv region, namely in Drohobych, Zapytiv, Zolochiv, Solonka, near Chyshky and Stebnyk.



Fig. 2. Known records of *Xeropicta krynickii* in Ukraine outside Crimea; symbols are similar to Figure 1

***Eobania vermiculata* (O. F. Müller, 1774), Helicidae.** *E. vermiculata* is a species of the Mediterranean origin, now quite widespread in Crimea. According to different versions, it could have been brought there either during the Russian-Turkish wars (mid-19th century), or even earlier – by the Greeks or Genoese as an edible species. In 1990, one introduced population of *E. vermiculata* was found near the Morska railway station in the Bilhorod-Dnistrovskiy district of the Odesa region. Snails spread along the spit that separates the Dniester estuary from the Black Sea. It was assumed that *E. vermiculata* could have been brought in by trucks from Crimea. The successful acclimatization and further expansion of *E. vermiculata* in this area is confirmed by some observations made in 2008–2017 in the northern part of the Carolino-Buhaz Spit near the Morska station and between it and the village of Karolino-Buhaz and placed in two databases (iNaturalist, 2024; UkrBIN, 2024). In 2023, *E. vermiculata* began to be

observed in Odesa, where specimens of this species were recorded at two distant sites in the Kyiv district of the city (iNaturalist, 2024).

A few records of *E. vermiculata* are known for two other administrative regions in southern Ukraine. In 2006, *E. vermiculata* was found in the botanical garden of Donetsk, where snails of this species were observed en masse in greenhouses. In 2017, the species was recorded in the south of the Zaporizhzhia region – in the central park of Melitopol. Both finds are confirmed by the stock materials of SMNH NANU (Gural-Sverlova & Gural, 2020).

***Helix lucorum* Linnaeus, 1758, Helicidae.** Similarly to the previous species, *H. lucorum* is not native to Crimea. Supposedly, this large edible snail could have been brought to Crimea by Greek colonists (Korábek *et al.* 2018). At the beginning of the 21st century, colonies of *H. lucorum* began to be occasionally found in other administrative regions of Ukraine. Although, judging by the shell colouration (Balashov *et al.*, 2013, Khlus & Tkachuk, 2012), not all of them could have been founded by individuals from Crimea. Crimean specimens of *H. lucorum* are distinguished by a shell without clearly pronounced dark spiral bands, but with well-developed dark radial streaks (Korábek *et al.* 2018, fig. 3A). Such colouration was recorded in 2016–2023 in *H. lucorum* from Melitopol (Gural-Sverlova & Gural, 2020), Zaporizhzhia and Kyiv (iNaturalist, 2024).

One or more species of land snails analyzed above have now been reliably registered in almost all administrative regions of Ukraine, with the exception of the Sumy region in the northeast of the country and the Kirovohrad region in its central part. A larger number of such species were recorded in the south of Ukraine, especially in the Odesa and Zaporizhzhia regions (Fig. 3). However, with the exception of three coastal regions (Odesa, Mykolaiv, Kherson), most of the known records of the analyzed species outside Crimea were made over the past few decades (Table 2), often in recent years (Table 1).



Fig. 3. Number of analyzed species recorded in different administrative regions of Ukraine

Table 2. Chronology of the first known records of analyzed species in different administrative regions of Ukraine outside Crimea

Time periods	Administrative regions
Early 20th century	Odesa
1970s	Kherson, Mykolaiv
1990s	Dnipropetrovsk, Donetsk, Transcarpathian
2000s	Chernivtsi, Khmelnytskyi, Lviv, Poltava, Rivne, Vinnytsia, Zaporizhzhia
2010s	Ivano-Frankivsk, Kharkiv, Kyiv
2020–2023	Cherkasy, Chernihiv, Luhansk, Ternopil, Volyn, Zhytomyr

CONCLUSIONS

The possible influence of Crimea on the species composition of alien land molluscs is now felt in all parts and almost all administrative regions of Ukraine. In addition to some species of Crimean origin, a similar review of which will be given in a separate publication, this also applies to a number of snails of non-Crimean origin discussed above. Most of them have so far been registered only in the administrative regions that border the Black and Azov Seas. Two species, *Xeropicta derbentina* and *Monacha cartusiana*, are now quite widespread in Ukraine, but most records of *M. cartusiana* and all known records of *X. derbentina* outside Crimea were made no earlier than the 1990s.

The data systematized in the article can become the basis for monitoring the further spread of the analyzed species of land snails into different parts of Ukraine. In particular, they can be used to assess the impact of the war on the ecosystems of Ukraine. It is possible to expect that military actions contribute both to accidental transportation of alien species and to the destruction of the habitats of native species.

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COMPLIANCE WITH ETHICAL STANDARDS

Conflict of Interest. The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Animal Rights. This article does not contain any experimental studies with animal subjects.

AUTHOR CONTRIBUTIONS

Conceptualization, [G-S.N.; G.R.]; methodology, [G-S.N.; G.R.]; validation, [G-S.N.; G.R.]; formal analysis, [G-S.N.; G.R.]; investigation, [G-S.N.; G.R.]; resources, [G-S.N.; G.R.]; data curation, [G-S.N.; G.R.]; writing – review and editing, [G-S.N.]; visualization, [G-S.N.; G.R.] supervision, [G-S.N.]; project administration, [G-S.N.].

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МАЛАКОФАУНА КРИМУ ЯК МОЖЛИВЕ ДЖЕРЕЛО ІНТРОДУКЦІЇ ДО ІНШИХ ОБЛАСТЕЙ УКРАЇНИ: НАЗЕМНІ РАВЛИКИ НЕ-КРИМСЬКОГО ПОХОДЖЕННЯ

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Вступ. Завдяки глобальним кліматичним змінам, у різних регіонах України дедалі частіше знаходять деякі інтродуковані види наземних молюсків, раніше відомі лише для її південної частини або лише для Криму. У різні часові періоди з Криму могли бути завезені не тільки окремі види кримського походження, але й деякі інші молюски, нативні або чужорідні для Кримського півострова. Тому головною метою цієї публікації стали узагальнення та критичний аналіз даних щодо сучасного поширення в Україні поза межами Криму 8 таких видів, первинним джерелом розселення яких міг бути, хоча б частково, Кримський півострів.

Матеріали та методи. Було використано результати власних багаторічних (з 1994 до 2023 р.) досліджень наземної малакофауни в різних регіонах України, опрацьовано збори інших науковців і аматорів, численні фондові матеріали Державного природознавчого музею у м. Львові, низку літературних джерел від початку ХХ ст. до наших днів, а також критично проаналізовано спостереження у двох базах даних громадської науки (iNaturalist та UkrBIN).

Результати. Послідовно проаналізовано наявні відомості про сучасне поширення та хронологію виявлення в різних адміністративних областях України за межами Криму *Cecilioides raddei*, *Phenacolimax annularis*, *Oxychilus deilus*, *Xeropicta derbentina*, *X. krynickii*, *Monacha cartusiana*, *Eobania vermiculata*, а також *Helix lucorum* із забарвленням черепашки, характерним для гірського Криму. Встановлено, що хоча б окремі з них тепер достовірно зареєстровані в усіх регіонах і майже в усіх адміністративних областях України, за винятком Сумської та Кіровоградської областей.

Висновки. Проведений аналіз підтверджує потенційний вплив Криму на формування сучасного видового складу чужорідних наземних молюсков не лише півдня, але й інших регіонів України. Більшість із проаналізованих видів досі відомі лише з тих адміністративних областей, які межують з Чорним і Азовським морями. Два види, *X. derbentina* і *M. cartusiana*, тепер досить широко розповсюджені в Україні, проте більшість їхніх відомих знахідок датована не раніше 1990-х рр. Систематизовані нами дані можуть стати основою для моніторингу подальшого розселення проаналізованих видів у різних частинах України, що видається нам особливо актуальним у повоєнний час.

Ключові слова: наземні молюски, Gastropoda, антропохорія