



# Introduced land snail *Cepaea nemoralis* (Gastropoda: Helicidae) in Eastern Europe: spreading history and the shell colouration variability

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The available data on the present distribution of *Cepaea nemoralis* in Ukraine, Belarus and the European part of Russia, the history and possible ways of penetration of this species into various parts of Eastern Europe, as well as the colour and banding polymorphism of its shells are analyzed. It has been suggested that the process of rapid spreading of *C. nemoralis* in the three compared Eastern European countries began at approximately the same time (late 20th – early 21st centuries) and that it may be caused by active and practically uncontrolled importation of seedlings from other European countries, as well as by global climate change, which can contribute to better survival of snails outside their natural range. Despite the possible initial limitation of the phenotypic and genetic diversity associated with the accidental transfer of a limited number of individuals, in the Eastern European colonies, in general, a fairly large variety of the inherited traits of the shell colouration remains. This concerns, first of all, the polymorphism in the shell ground colour (yellow, pink, less often brown) and the main variants of the shell banding (unbanded, mid-banded, five-banded, less often three-banded).

**Key words:** terrestrial mollusc, grove snail, polymorphism, Belarus, Russia, Ukraine

## Introduction

The grove snail *Cepaea nemoralis* (Linnaeus, 1758) is a species of Western European origin (BOETTGER 1926, TAYLOR 1914), which is possible to confirm by the pattern of its present distribution in Western and Central Europe (BOETTGER 1926) and paleontological data (TAYLOR 1914). It is considered that in Germany, the eastern border of the natural range of this species extends eastward of the Elbe River, in some places reaching the Oder River (BOETTGER 1926). Much further to the east, the natural range of *C. nemoralis* can extend only along the coast of the Baltic Sea, where it can reach the eastern Baltic states or even the Leningrad and Pskov regions in the northwest of the European part of Russia (SHIKOV 2007). However, it is possible that in this part of the present range the grove snail is also an introduced species (WIKTOR 2004).

In any case, in Ukraine, Belarus, and most of European Russia, *C. nemoralis* could have appeared only as a result of anthropochory. Significantly, most of the known findings were made here at the end of the 20th or the beginning of the 21st century (BALASHOV & MARKOVA

2021, EGOROV 2018, GURAL-SVERLOVA et al. 2020, 2021, MUKHANOV & LISITSYN 2018, etc.), which might be associated with the intensification of transport and trade relations with other European countries, the weakening of control over imported seedlings, as well as with global climatic changes, contributing to the better survival of snails far beyond their natural range, like other invasive species of animals and plants (SIMBERLOFF 2000). In particular, colonies of two species of land snails of Crimean origin, *Brephulopsis cylindrica* (Menke, 1828) and *Monacha fruticola* (Krynicky, 1833), previously known only for the south of the country, were first recorded during the same time in Lviv, Western Ukraine (GURAL-SVERLOVA & GURAL 2020, SVERLOVA 1998).

In recent years, a number of publications have appeared that describe the distribution (EGOROV 2018, GURAL-SVERLOVA et al. 2020) and the phenotypic composition of *C. nemoralis* (GURAL-SVERLOVA et al. 2020, 2021, GURAL-SVERLOVA & EGOROV 2021, KOLESNIK & KRUGLOVA 2016, KRUGLOVA 2018, KOVALEVICH & VOSCHANKO 2019, OSTROVSKY & PROKOFIEVA 2017, etc.) in some parts of Eastern Europe. However, the data published so far are not

always complete, and they are often difficult to compare with each other to obtain the general pattern. Therefore, the main goal of this paper was to summarize the available data (published and unpublished) on the known findings and shell colouration of *C. nemoralis* in Eastern Europe, as well as, if possible, to identify trends common to different parts of this territory.

## Material and methods

The basic material for this article were the numerous data on the findings and phenotypic composition of *C. nemoralis* in Western Ukraine, Belarus and the Moscow region of Russia, accumulated by the authors of the article and partially published earlier (EGOROV 2018, GURAL-SVERLOVA & EGOROV 2021, GURAL-SVERLOVA et al. 2020, 2021, KRUGLOVA 2018, etc.). We also used some published data on the phenotypic composition of the studied species in several settlements (BALASHOV & MARKOVA 2021, MUKHANOV & LISITSYN 2018, OSTROVSKY & PROKOFIEVA 2017), as well as information on the findings of single individuals from two databases (iNATURALIST 2021, UKRBIN 2021), that have been confirmed by clear photographs.

When analyzing our samples, the shell ground colour and the banding pattern were scored according to the standard method (CLARKE 1960). Then, the phenotypes were combined into groups according to the combination of ground colour (yellow, pink, or brown) and four main variants of the shell banding (unbanded, with one central band, with three lower bands, five-banded), as in the previous publications (GURAL-SVERLOVA & EGOROV 2021, GURAL-SVERLOVA et al. 2020, 2021). When some specimens with white or almost white shells without traces of yellow, pink, or brown pigment were found in samples, they were combined into one group with yellow (CLARKE 1960, GURAL-SVERLOVA et al. 2021). The orange shells shown in one of our previous publications (GURAL-SVERLOVA et al. 2020: Fig. 2B) were designated as pink, similar to SCHILDER & SCHILDER (1953, p. 18).

In Western Ukraine, where the conchologically similar species *Cepaea hortensis* (O. F. Müller, 1774) is often found, only adults with a reflected apertural margin of the shell were collected in most cases. In the Moscow region of Russia and Belarus, juveniles with a shell diameter of at least 1 cm were often additionally counted. Such samples are marked with an asterisk in Table 1. Other peculiarities of material collecting in the compared parts of Eastern Europe, descriptions of the studied sites, as well as their coordinates and phenotypic composition of the samples are given in a number of previous publications (GURAL-SVERLOVA & EGOROV 2021, GURAL-SVERLOVA et al. 2020, 2021, etc.). We prefer to use the term “colony” rather than “population” to refer to an aggregation of individuals of *C. nemoralis* or other introduced land molluscs found in a certain limited area. Often we are talking about recently formed isolated aggregations with a limited number of individuals. Therefore, it is not known whether they will be able to become established populations in the future, capable of maintaining their numbers for a long time, which is one of the population criteria.

All records of *C. nemoralis* in Ukraine, Belarus and the European part of Russia, mentioned in the article, are shown in Figure 1.

## Results and discussion

The first attempt to introduce *C. nemoralis* to Western Ukraine was made in 1892, when several hundred snails brought from Rzeszów were released at three sites located in the central part of present-day Lviv (ŁOMNICKI 1899). Interestingly, this happened only a few years after *C. nemoralis* was first recorded in southeastern Poland (in the Łańcut castle park), where, presumably, it could have been introduced along with plants from Germany (BAKOWSKI 1880). However, in Poland this species successfully established itself in a number of settlements (OŻGO 2005), and in Lviv, the released snails could not form a stable population that would have survived to this day (GURAL-SVERLOVA et al. 2020). URBAŃSKI (1933) discovered in 1926 at the Lychakiv Cemetery in Lviv several immature specimens of *Cepaea*, which he identified as *C. nemoralis*, although, judging by the described shell colouration (4 monochromatic yellow and one yellow with 5 dark brown bands), this record could also refer to *C. hortensis* (GURAL-SVERLOVA et al. 2020). In the late 20th and early 21st centuries, *C. nemoralis* was not found there. In 1994, a small colony of *C. nemoralis*, now almost completely extinct, was found in Stryiskyi park of Lviv. It is possible that it was also formed by snails brought from the southeast of Poland (GURAL-SVERLOVA et al. 2020). This assumption is supported by both territorial proximity and similarity of the phenotypic composition. Although the quantitative analysis of the phenotypic composition in Stryiskyi park was hampered by the extremely low abundance of snails, shells with one central band, most often yellow (Table 1), rarely pink, predominated among the few variants of shell colouration recorded there (SVERLOVA 2002, SVERLOVA et al. 2006). About half of the specimens of *C. nemoralis* now found in the Subcarpathian Voivodeship of Poland also have yellow mid-banded shells, another 17% have pink mid-banded ones (OŻGO 2005).

In 2019–2020, *C. nemoralis* was registered at 15 sites in Lviv and its environs, described in detail in one of the previous publications (GURAL-SVERLOVA et al. 2021). All colonies found are relatively young, although their exact age is difficult to determine. The only exceptions are two cases, when snails were found at small isolated sites, reconstructed and landscaped about 20 (Fig. 2A) and 10 (Fig. 2B) years ago. New colonies are not related to snails from Stryiskyi Park, which is confirmed, as a rule, by a large phenotypic diversity, and, above all, by the presence of snails with unbanded and/or five-banded shells at all sites (GURAL-SVERLOVA et al. 2020, 2021), which, respectively, were completely or almost completely absent in Stryiskyi park (SVERLOVA et al. 2006). An indirect confirmation of their independent origin can be considered the fact that in two cases *C. nemoralis* was found near the garden centres, operating and recently closed (GURAL-SVERLOVA et al. 2021). Also, in many cases, at private or public plots inhabited by snails, junipers (Fig. 2) and other ornamental



**Fig. 1.** Distribution map of *C. nemoralis* in Ukraine, Belarus and the European part of Russia. Background map: **MATY.CZ**, © Seznam.cz, a.s., © OpenStreetMap, adjusted.

shrubs were present, which could be supplied from these or other garden centres.

In general, it is highly probable that the process of fairly rapid colonization of Lviv by *C. nemoralis*, which has been observed in recent years, began at the turn of the 20th and 21st centuries or a little later, at the very beginning of the 21st century. This is in good agreement with the end of a strong economic decline in Ukraine in the 1990s and the beginning of an active and almost uncontrolled import of garden and ornamental plants from other European countries. Around the same time, there was noticeable warming of the climate in Lviv, associated with global climate change and which have already influenced the phenotypic composition of another introduced species, *C. hortensis* (GURAL-SVERLOVA & GURAL 2018).

Apparently, similar processes are now taking place in other

administrative regions of Ukraine, primarily in large settlements, however, the detection of colonies of *C. nemoralis*, which could already have been formed there, is greatly hampered by the absence of persons interested in land molluscs. In addition to Lviv and the Zubra village located on its southern outskirts (GURAL-SVERLOVA & GURAL 2020, 2021), to date, it has been possible to quantitatively study the variability of shell colouration only at a few sites in Ivano-Frankivsk (GURAL-SVERLOVA & GURAL 2020) and Ternopil (Chortkiv, see Table 1) regions. There are also sporadic observations of *C. nemoralis* from other western regions of Ukraine (Rivne, Khmelnytskyi and Volyn), from its central part (Kyiv and Kyiv region, Zhytomyr), as well as from the south (Odessa), east (Dnipropetrovsk region) and north-east of the country (Kharkiv) (Table 1). Since the end of the 19th century, *C. nemoralis* has also



**Fig. 2.** Two small isolated habitats of *C. nemoralis* in Lviv, Western Ukraine, planted with low-growing junipers and other ornamental plants (A – near the monument, up to 15 m long, B – on a trolleybus ring, less than 20 m in diameter). Photos by N. Gural-Sverlova.

been erroneously mentioned from time to time for different regions of Ukraine, and even for the Ukrainian Carpathians as a result of an incorrect identification of a conchologically similar autochthonous species *Caucasotachea vindobonensis* (C. Pfeiffer, 1828), which was previously also placed in the genus *Cepaea*. These references were discussed in detail in the monograph (SVERLOVA et al.

2006). The main reason for the errors was that the keys for identifying land molluscs of the former USSR stated that in *C. vindobonensis*, the umbilicus is never completely closed, as in *C. nemoralis* and *C. hortensis*, and in its place there is always a narrow gap, which did not correspond to reality (SVERLOVA 1996).

For the environs of Moscow, *C. nemoralis* was first men-

tioned at the beginning of the 19th century (DWIGUBSKY 1802), although later many authors considered this reference to be erroneous. Later, this species was not found in the Moscow region until the early 1980s, when it was deliberately brought from Berlin and released at a summer cottage near Zagoryanski (EGOROV 2018, GURAL-SVERLOVA & EGOROV 2021). The first known samples of *C. nemoralis* from Zagoryanski, kept in museum collections (Fig. 3), date back to 1985. Currently, *C. nemoralis* has been registered in various localities in Moscow and the Moscow region (EGOROV 2018), and it was hypothesized that the colonies living there are of different origins (GURAL-SVERLOVA & EGOROV 2021). They are often associated with garden nurseries or places where the produce grown there is used. In addition to 11 localities recently described in detailed studies (EGOROV 2018, GURAL-SVERLOVA & EGOROV 2021), a number of other findings of *C. nemoralis* are already known in Moscow and the Moscow region (Table 1), which still require research. The most eastern settlement where *C. nemoralis* has been found so far is Nizhniy Novgorod (MUKHANOV & LISITSYN 2018). Live *C. nemoralis* were first recorded there in 2014. Single findings in forest biotopes of the north-west of the European part of Russia (Leningrad and Pskov regions) were made as early as 1977 and 1980 and were interpreted as possible marginal populations preserved at the edge of the natural range of *C. nemoralis* (SHIKOV 2007), see also Introduction.

In Belarus, *C. nemoralis* is now known from all six administrative regions (Table 1), however, the largest number of findings relates to two cities and their environs – the capital Minsk and Brest located in the southwest of the country. Unfortunately, the first findings of the grove snail on the territory of Belarus were not properly documented in the malacological literature. At the turn of the 20th and 21st centuries, this species was registered in Brest (IVANKOVA & ZEMOGLYADCHUK 2001), and since 2002, some colonies discovered there have already become the object of student research (SINYAVSKAYA 2010). The phenotypic composition of some colonies of *C. nemoralis* in Minsk began to be studied in 2014, these studies were continued in subsequent years (KOLESNIK & KRUGLOVA 2016, KRUGLOVA 2018). In 2017, similar studies were also carried out in Bobruisk, Mogilev region (OSTROVSKY & PROKOFIEVA 2017) and in Grodno (KRUGLOVA 2018).

Unfortunately, at the initial stages of the study of *C. nemoralis* in Brest, the shell colouration was scored not according to the standard method; for example, the phenotype (12)3(45) was considered as three-banded, (123) (45) and 003(45) as two-banded. Unusual variants of the ground colour were also mentioned – beige, grey and even green (SINYAVSKAYA 2010), apparently caused by the combination of the shell colour and the body of the snail shining through it. The collected snails were then released, making it impossible to redefine these early materials.

Currently, *C. nemoralis* is more common in Eastern Europe compared to another introduced species of the same genus, *C. hortensis* (EGOROV 2018, iNATURALIST 2021). The only exception is Western Ukraine (and especially the Lviv region), where *C. hortensis* was introduced no later

than the second half of the 20th century and has already spread to many settlements (GURAL-SVERLOVA & GURAL 2021).

Despite the possible accidental loss of some inherited traits caused by the transfer of a limited number of individuals outside the natural range of *C. nemoralis*, a rather large variability in shell colouration is observed in all three compared Eastern European countries. Only in very rare cases, the collected samples were monomorphic in the ground colour (GURAL-SVERLOVA & EGOROV 2021), or one of the two ground colours (yellow or pink) was represented by a few individuals (GURAL-SVERLOVA et al. 2020, 2021), which theoretically can lead to its complete disappearance in the future.

At the same time, brown ground colour occurs very sporadically in Eastern Europe, it has not yet been recorded in many settlements or even administrative regions (Table 1). For example, brown shells were found only in 5 out of 11 studied localities from the Moscow region, although in Zagoryanski more than half of the collected specimens had such a ground colour (GURAL-SVERLOVA & EGOROV 2021). In Western Ukraine, such shells were recorded only at a few sites in Lviv (GURAL-SVERLOVA et al. 2021, SVERLOVA et al. 2006). In Belarus, brown shells in *C. nemoralis* have so far been found only in Minsk, Fanipol (Minsk region), and Bobruisk (Mogilev region) (Table 1).

In addition, the discovered brown shells were almost always unbanded, except for single specimens in a few settlements (Table 1). Since in the natural range of *C. nemoralis* brown shells are also less common than yellow and pink ones, and brown banded shells are less common than brown unbanded ones, this can be considered a quite natural consequence of the random transfer of a limited number of individuals, in which more rare hereditary traits disappear in the first place (GURAL-SVERLOVA & EGOROV 2021).

In the Moscow region (GURAL-SVERLOVA & EGOROV 2021) and at two of three sites in Lviv where brown shells were found in 2019–2020 (GURAL-SVERLOVA et al. 2021), all brown shells were dark (GURAL-SVERLOVA et al. 2020: Fig. 2F). Only at one site of Lviv, a well-pronounced variability of the colour intensity of brown shells, up to almost white shells with a slight brownish tint (Fig. 4), was found. At the same time, among yellow and, especially, among pink shells (GURAL-SVERLOVA et al. 2020: Figs 1–2), a wide variety of shades is often observed.

Among the four main variants of the shell banding, the shells with three lower bands were most often absent – both in some samples (GURAL-SVERLOVA & EGOROV 2021, GURAL-SVERLOVA et al. 2020, 2021, KRUGLOVA 2018, MUKHANOV & LISITSYN 2018) and, less often, in some settlements (Table 1). Although three-banded shells are quite common for *C. nemoralis*, they are found, on average, less frequently than the other three forms (SCHILDER & SCHILDER 1957: table 13, SVERLOVA 2002: table 3). In addition, their frequencies are unevenly distributed within the natural range of this species (SCHILDER & SCHILDER 1957: map 71), which should also affect the probability of accidental transfer of individuals carrying the corresponding allele.



**Fig. 3.** The first known samples of *C. nemoralis* from Zagoryanski, dated 1985 and kept in the collections of the Zoological Museum of Moscow State University, Lc-41093 (above, photo by A. Sysoev) and the State Museum of Natural History in Lviv, 4396 (below, photo by N. Gural-Sverlova).



**Fig. 4.** Variability of the intensity of brown colour, which was found in a single site in Western Ukraine, Lviv (A – live snails; B – empty shells). In all other cases, brown shells were absent or dark. Photos by N. Gural-Sverlova.

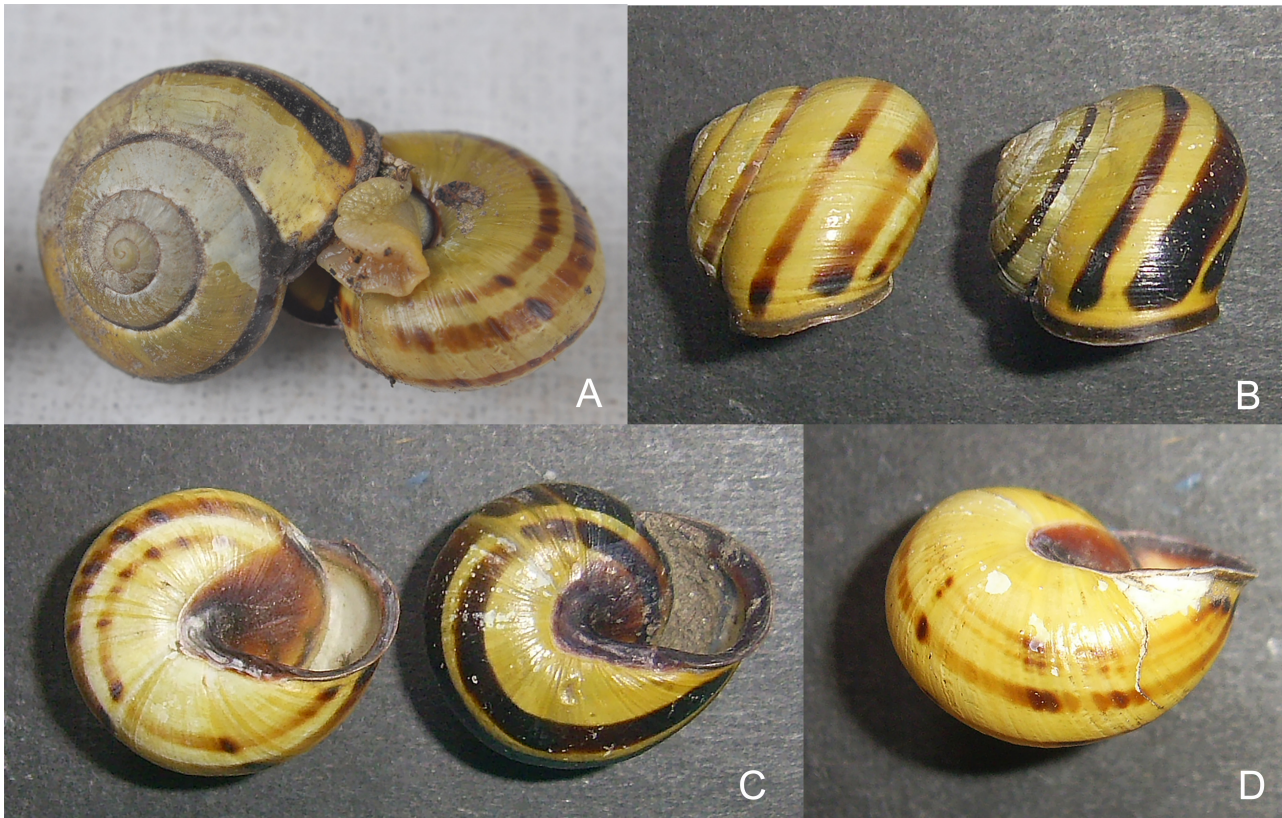
Of the rarer colouration traits sporadically occurring in the natural range of *C. nemoralis* (SCHILDER & SCHILDER 1957) and having a hereditary nature (MURRAY 1975), in one locality in Western Ukraine, individuals with unevenly pigmented bands were recorded, on which lighter and darker fragments alternate, giving an impression of spotting, intermittent bands, the “so-called form *interrupta* Moquin-Tandon 1855” (Fig. 5). In the only studied sample from the Ternopil region (Chortkiv), about 18% of snails with pink banded shells and about 41% of those with yellow banded shells had such unevenly pigmented bands. In some cases, this was also accompanied by longitudinal splitting of one of the bands (Fig. 5D).

At one of the 14 investigated sites in Lviv, three adults were also found with a light coloured lip and weakly pigmented or hyalozonate bands (Fig. 6), at the other – one juvenile snail with hyalozonate bands (GURAL-SVERLOVA et al. 2021). Although the mentioned traits are generally hereditary (MURRAY 1975), it is possible that modifications were found in this case. From other parts of Eastern Europe, such specimens have not yet been recorded. In the contrary, one colony of an introduced related species

*C. hortensis* with untypical (dark) lip colouration in some snails has already been found both in Moscow and Lviv (GURAL-SVERLOVA & GURAL 2021).

When comparing four areas in Eastern Europe, where the largest number of findings of *C. nemoralis* was recorded and simultaneously the largest amount of data on the phenotypic composition of this species was accumulated (Fig. 7), one can notice a slightly larger proportion of yellow shells in the samples from Belarus. Perhaps this is due to rarer occurrence here of the lightest of the pink phenotypes (pink unbanded) (Fig. 8), which was noted in more than a quarter of the specimens collected in the Moscow region (GURAL-SVERLOVA & EGOROV 2021) and in more than a third from Lviv (GURAL-SVERLOVA et al. 2021). At the same time, the share of pink banded shells was more stable and ranged from 22% in Lviv to 35% in the Minsk region.

According to the banding type, mid-banded shells predominated in Minsk, unbanded in Lviv, five-banded in Brest. In samples from the Moscow region, unbanded and five-banded shells were almost equally frequent (Fig. 7). Only in Brest, the number of multi-banded shells (with



**Fig. 5.** Unevenly pigmented bands in part of individuals from Chortkiv, Ternopil region of Ukraine, giving the impression of spotting (A-C – compared to a shell with normally pigmented bands; D – fifth band split in two). Photos by O. Lyzhechka (A) and N. Gural-Sverlova (B-D).

3–5 bands) prevailed over the lighter variants of shell colouration (unbanded, mid-banded). Given the relative youth of the studied colonies, these differences may be related to the founder effect. In particular, in Brest, low frequencies of unbanded shells were noted already at the beginning of studies of the phenotypic composition of this species (SINYAVSKAYA 2010). Although at one of the first surveyed sites, located at the intersection of Lenin and Masherov Streets, the proportion of unbanded shells slightly increased in the period from 2002 to 2009 (Table 2).

As in other parts of the present range of *C. nemoralis* (SVERLOVA 2007), in Eastern Europe, there is often a different ratio of the banding types among shells with different ground colours, which is seen in the summary diagram (Fig. 8). The consequence of this is the aforementioned almost complete absence of banded phenotypes among brown shells as well as a relatively rare occurrence of unbanded specimens among yellow shells, which was already noted earlier for the Moscow region (GURAL-SVERLOVA & EGOROV 2021). This disproportion, which may be at least partially related to the linked inheritance of the ground colour of the shell and the presence/absence of bands on it (MURRAY 1975), turned out to be less pronounced in

Belarus compared to other studied Eastern European areas (Fig. 8).

Thus, since the end of the 20th and the beginning of the 21st century, both the rapid spreading of *C. nemoralis* and an increase in interest in the study of the shell colour and banding polymorphism of this species outside its natural range are observed in different parts of Eastern Europe. Although that the accidental transfer of a limited number of individuals (or clutches of eggs located on the roots of plants) is often associated with an initial limitation of phenotypic and genetic diversity, in Ukraine, Belarus and the European part of Russia, both all three main shell ground colours and all four main variants of the shell banding were found. At the same time, in individual colonies or settlements, the brown ground colour and shells with three lower bands are most often absent, i.e. traits that are regularly but relatively less often found also in the natural range of *C. nemoralis*. More rare colouration traits (spotty, light-coloured or hyalozonate bands, light lip) or combinations of traits (brown banded shells) were found only in a few studied colonies.

The significant phenotypic diversity that persists on the territory of Eastern Europe and the relative youth of most

**Table 2.** Frequencies of unbanded shells at one site in Brest, studied in the first decade of the 21st century (SINYAVSKAYA 2010).

Year	2002	2003	2004	2005	2008	2009
Sample size	70	145	200	204	107	100
Unbanded, %	7.1	11.7	10.0	17.1	14.0	24.0





**Fig. 6.** Unusually light coloured bands and lip in single specimens of *C. nemoralis* collected in Lviv, Western Ukraine (A – pinkish brown bands, pinkish lip; B – light brown band, pinkish lip; C – hyalozonate bands, almost completely white lip). Photos by N. Gural-Sverlova.

of the colonies of *C. nemoralis* found here make them promising objects for monitoring subsequent changes in the phenotypic composition, which can be both selective and nonselective. Parallel observation of possible future changes in this composition, carried out in different parts of Eastern Europe, differing both in climatic conditions and in the ratio of the main inherited variants of shell colouration, may turn out to be no less interesting.

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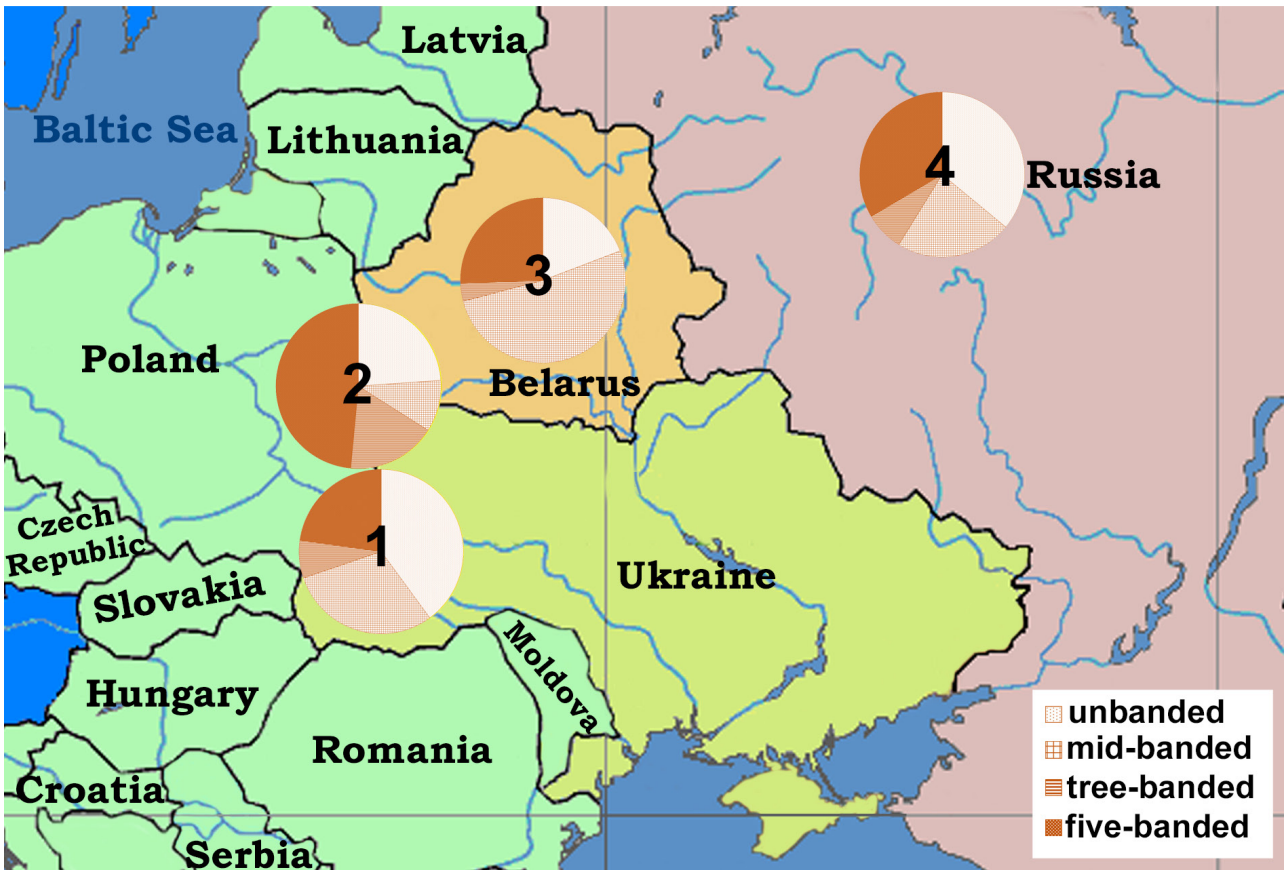


Fig. 7. Ratio of different variants of shell ground colour (top) and banding (bottom) in the four most studied areas of Eastern Europe: 1 – Lviv and its environs (N = 3039); 2 – Brest (N = 2533); 3 – Minsk and Minsk region (N = 4105); 4 – Moscow and Moscow region (N = 2112). The percentages were calculated from the total number of shells collected in each of the areas and indicated in parentheses. For Lviv and the Moscow region, the few shells collected at the end of the 20th century (see Table 1) were not taken into account.

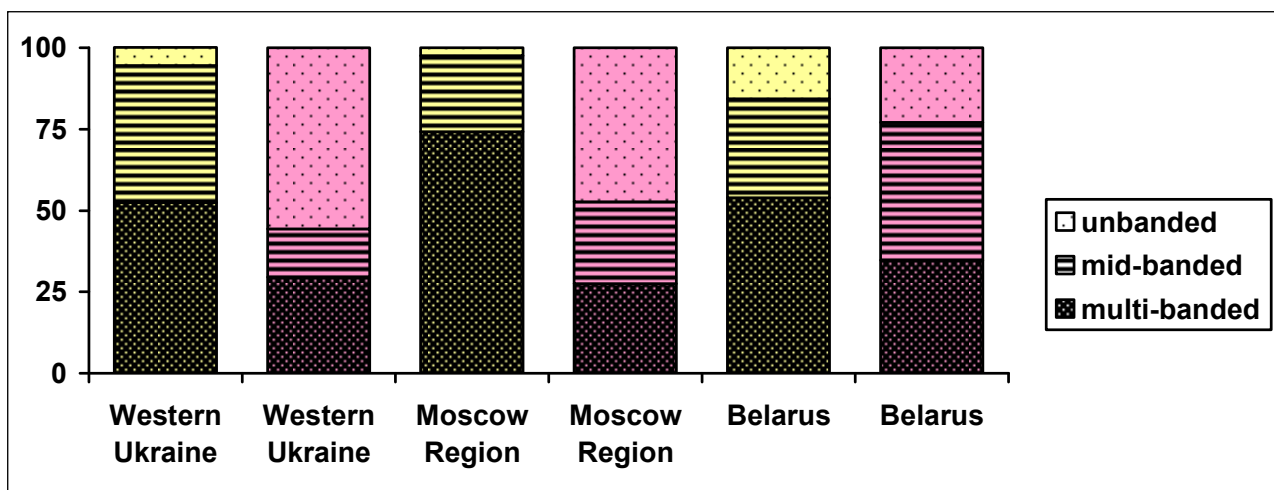


Fig. 8. Ratio of different banding types among shells with yellow and pink ground colours in three compared Eastern European countries, in percent. The colour of the columns matches the shell ground colour.

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**Table 1.** Phenotypic composition of *C. nemoralis* from different localities in Eastern Europe. Abbreviations: \* – the samples also included juveniles with a shell diameter of at least 1 cm; \*\* – the colouration variant was scored only in juveniles; \*\*\* – only within the Moscow Ring Road; ? – it is impossible to accurately determine the phenotype from photographs in databases; B-0 – brown unbanded; B-b – brown banded (all types); P-0 – pink unbanded; P-1 – pink mid-banded; P-3 – pink three-banded; P-5 – pink five-banded; SMNH NANU – State Museum of Natural History of the National Academy of Sciences of Ukraine, Lviv; SO – single observations; Y-0 – yellow unbanded; Y-1 – yellow mid-banded; Y-3 – yellow three-banded; Y-5 – yellow five-banded; ZM MSU – Zoological Museum of Lomonosov Moscow State University.

Regions	Localities	Years	N	Y-0	Y-1	Y-3	Y-5	P-0	P-1	P-3	P-5	B-0	B-b	Sources
<b>Ukraine</b>														
Dnipropetrovsk	Novooleksandrivka	2021	SO	–	–	–	–	–	–	+	–	–	–	(UKRBIN 2021)
Ivano-Frankivsk	Ivano-Frankivsk	2019	12	–	**	–	–	9	3	–	–	–	–	(GURAL-SVERLOVA et al. 2020)
	Bohorodchany	2019	454	–	3	–	87	163	5	–	196	–	–	(GURAL-SVERLOVA et al. 2020)
	Uhryniv	2018	SO	–	–	–	–	–	–	–	+	–	–	(UKRBIN 2021)
		2019	7	–	–	1	1	2	**	–	3	–	–	(GURAL-SVERLOVA et al. 2020)
Kharkiv	Kharkiv	2019	SO	–	?	–	–	–	?	–	–	–	–	(iNATURALIST 2021)
Khmelnitskyi	Khmelnitskyi (vicinities)	2020	SO	–	–	–	+	–	–	–	–	–	–	(iNATURALIST 2021, UKRBIN 2021)
	Kytaihorod	2007 or 2008	SO	–	–	–	+	–	–	–	–	–	–	(BALASHOV et al., 2013)
Kyiv	Kyiv	2019–2021	SO	**	–	–	–	–	+	–	+	–	–	(BALASHOV & MARKOVA 2021, iNATURALIST 2021)
	Severynivka	2020	SO	–	?	?	–	–	–	–	–	–	–	(iNATURALIST 2021)
	Sofivska Borshchahivka	2020–2021	SO	+	?	?	+	+	–	+	–	–	–	(iNATURALIST 2021)
		2020	≈20	–	+	+	+	–	+	–	+	–	–	(BALASHOV & MARKOVA 2021)
	Vyshhorod	2019–2020	SO	–	–	–	–	+	–	–	+	–	–	(iNATURALIST 2021, UKRBIN 2021)
		2020	24	–	–	–	+	+	–	–	+	–	–	(BALASHOV & MARKOVA 2021)
	Zabiria	2018	SO	–	–	–	–	+	–	–	–	–	–	(iNATURALIST 2021)
Lviv	Lviv	1994–2004	SO	–	+	+	–	–	+	+	+	–	+	(SVERLOVA et al. 2006: 65)
		1994–2002	11*	–	6	–	–	–	2	1	1	–	1	Collection of SMNH NANU
		2019–2020	2986	52	570	129	437	1103	328	97	237	33	–	(GURAL-SVERLOVA et al. 2021)
	Zubra	2019–2020	53	23	9	–	18	1	–	–	2	–	–	(GURAL-SVERLOVA et al. 2021)
Odessa	Odessa	2020	2	–	+	–	–	–	–	–	–	–	–	(BALASHOV & MARKOVA 2021)
		2021	SO	–	–	+	–	–	–	–	–	–	–	(iNATURALIST 2021)
Rivne	Sarny	2018	SO	–	–	+	–	–	–	–	–	–	–	(UKRBIN 2021)
Ternopil	Chortkiv	2017	SO	–	–	–	+	–	–	–	+	–	–	(UKRBIN 2021)
		2020	224*	3	6	34	28	2	5	77	69	–	–	Data of N. Gural-Sverlova, 1 site
Volyn	Svitiaz	2021	15*	2	1	–	1	4	+	–	7	–	–	Collection of SMNH NANU, observation of V. Rizun
Zhytomyr	Zhytomyr	2018	SO	–	–	–	+	–	–	–	–	–	–	(UKRBIN 2021)

Table 1. Continued.

Regions	Localities	Years	N	Y-0	Y-1	Y-3	Y-5	P-0	P-1	P-3	P-5	B-0	B-b	Sources
<b>Belarus</b>														
Brest	Brest	2010–2011	189	13	51	45	20	1	32	24	3	–	–	Data of N. Kovalevich, 2 sites
		2017–2020	2228	134	105	204	715	456	32	148	434	–	–	Data of N. Kovalevich, 11 sites
		2018, 2020	116*	–	16	15	30	1	20	8	26	–	–	(KRUGLOVA & GUMINSKAYA 2019) and later data of O. Kruglova, altogether 2 sites
		2015–2020	SO	–	?	?	+	+	+	+	–	–	–	(iNATURALIST 2021)
	Brest, in total	2010–2020	2533*	147	172	264	765	458	84	180	463	–	–	see above
	Drogichin	2021	SO	–	?	?	–	–	–	–	–	–	–	(iNATURALIST 2021)
	Ivanovo	2020	SO	–	+	–	–	–	–	–	–	–	–	(iNATURALIST 2021)
	Kobrin	2020	SO	–	–	–	–	–	–	+	–	–	–	(iNATURALIST 2021)
	near Lake Beloe	2020	SO	–	+	–	–	–	–	–	–	–	–	(iNATURALIST 2021)
Gomel	Gomel	2016	SO	–	–	–	–	+	–	–	+	–	–	(iNATURALIST 2021)
		2020	212	–	27	1	152	32	–	–	–	–	–	Data of O. Kruglova
Grodno	Grodno	2017	297*	2	22	1	115	1	58	–	98	–	–	(KRUGLOVA 2018) and 2 additional samples
	Lida	2020	54	11	11	–	3	9	14	–	6	–	–	Data of O. Kruglova
Minsk	Minsk	2014–2015	682*	61	185	6	86	5	220	1	45	72	1	Data of V. Kolesnik
		2017–2018	766*	51	225	3	127	8	320	1	19	12	–	Data of A. Guminskaya
		2019–2020	519*	65	126	24	48	42	87	56	41	30	–	Data of O. Kruglova & Ya. Volk
		2016–2020	1061*	228	196	21	239	49	183	10	83	52	–	Data of O. Kruglova
		2019–2021	SO	+	+	?	+	+	+	?	+	–	–	(iNATURALIST 2021)
	Minsk, in total	2014–2020	3028*	405	732	54	500	104	810	68	188	166	1	see above
	Borovlyanyi	2020	SO	–	+	–	–	–	–	–	–	–	–	(iNATURALIST 2021)
	Cherkassyi	2020	SO	–	–	–	+	–	–	–	–	–	–	(iNATURALIST 2021)
	Fanipol	2017	60	–	–	–	46	13	–	–	–	1	–	Data of O. Kruglova
	Goncharovka	2020	SO	+	–	–	–	–	–	–	–	–	–	(iNATURALIST 2021)
	Kolodishchi	2015, 2017–2018	403	61	86	–	245	7	3	1	–	–	–	Data of O. Kruglova, V. Kolesnik & A.Guminskaya
	Leskovka	2020	113	2	16	2	–	5	70	6	12	–	–	Data of E. Navakovskaya
	Lesnoy	2019	47	–	17	–	5	–	24	–	1	–	–	Data of E. Navakovskaya
	Mazha	2020	75	11	1	–	1	–	51	5	6	–	–	Data of E. Navakovskaya
	Migdalovichi	2019	SO	–	–	–	–	–	–	–	+	–	–	(iNATURALIST 2021)
	Mikhanovichi	2017	5	–	–	–	–	1	1	–	3	–	–	Data of O. Kruglova
	Prilesye	2017	151	–	42	2	16	–	71	–	20	–	–	Data of O. Kruglova

Table 1. Continued.

Regions	Localities	Years	N	Y-0	Y-1	Y-3	Y-5	P-0	P-1	P-3	P-5	B-0	B-b	Sources
	Prusy	2019	48	–	23	–	–	–	25	–	–	–	–	Data of E. Navakovskaya
	Slutsk	2019	40	–	16	1	2	–	18	1	2	–	–	Data of E. Navakovskaya
	Zasulie	2020	SO	+	–	–	–	–	–	–	–	–	–	(iNATURALIST 2021)
	Zenkovichy	2020	85	5	25	1	–	7	40	2	5	–	–	Data of O. Kruglova & E. Navakovskaya
	Zhdanovichy	2019	50	–	42	–	–	–	8	–	–	–	–	Data of O. Kruglova
Mogilev	Mogilev	2020–2021	SO	?	+	–	?	?	–	–	?	–	–	(iNATURALIST 2021)
	Bobruisk	2017	280	–	14	6	28	85	79	13	40	15	–	(OSTROVSKY & PROKOFIEVA 2017)
		2021	SO	–	–	–	–	+	–	–	–	–	–	(iNATURALIST 2021)
Vitebsk	Begoml	2020	SO	–	+	–	–	–	–	–	–	–	–	(iNATURALIST 2021)
	Polotsk	2020	39	–	2	–	2	18	14	–	3	–	–	Data of O. Kruglova
<b>European part of Russia</b>														
Bryansk	Novozybkov	2021	SO	–	–	–	–	–	?	?	+	–	–	(iNATURALIST 2021)
Ivanovo	Bogorodskoe	2021	SO	–	–	–	–	–	–	–	?	–	–	(iNATURALIST 2021)
Moscow	Moscow***	2015–2018	498*	12	95	–	97	80	88	1	112	13	–	(GURAL-SVERLOVA & EGOROV 2021)
		2014, 2020–2021	SO	–	+	+	+	+	+	+	+	–	–	(iNATURALIST 2021)
	Aprelevka	2021	SO	–	?	?	–	–	–	–	–	–	–	(iNATURALIST 2021)
	Buzlanovo	2021	SO	–	+	–	–	–	–	–	–	–	–	(iNATURALIST 2021)
	Chashnikovo	2021	SO	–	–	+	–	–	–	–	–	–	–	(iNATURALIST 2021)
	Dmitrov	2014–2017	160*	–	3	–	–	26	114	–	17	–	–	(GURAL-SVERLOVA & EGOROV 2021)
		2019, 2021	SO	–	+	–	–	–	?	?	–	–	–	(iNATURALIST 2021)
	Dolgoprudnyi	2017, 2019	290*	3	10	6	100	21	47	27	76	–	–	(GURAL-SVERLOVA & EGOROV 2021)
		2019–2020	SO	–	–	–	+	–	–	+	–	–	–	(iNATURALIST 2021)
	Dubrovo	2021	SO	–	+	–	–	+	+	–	+	–	–	(iNATURALIST 2021)
	Fryazino	2017–2021	SO	+	–	–	–	+	+	+	+	–	–	(iNATURALIST 2021)
	Glazyinino	2020	SO	–	–	–	+	–	+	–	–	–	–	(iNATURALIST 2021)
	Khimki	2020	SO	–	+	–	–	–	–	–	–	–	–	(iNATURALIST 2021)
	Kotlyakovo	2021	SO	–	?	?	–	–	–	–	–	–	–	(iNATURALIST 2021)
	Korolev	2021	SO	+	–	–	–	–	–	–	–	–	–	(iNATURALIST 2021)
	Kryokshino	2020	SO	–	+	–	–	–	+	+	?	–	–	(iNATURALIST 2021)
	Lobnya	2018–2020	28*	1	1	9	1	15	1	–	–	–	–	(GURAL-SVERLOVA & EGOROV 2021) and additional collecting in 2020
	Malakhovka	2015–2017	66*	–	2	–	3	–	14	–	25	22	–	(GURAL-SVERLOVA & EGOROV 2021)
	Mar'ino	2020	SO	–	–	–	+	–	–	–	–	–	–	(iNATURALIST 2021)
	Medvezhi Ozera	2021	SO	–	–	–	–	–	–	+	–	–	–	(iNATURALIST 2021)
	Mytishchi	2017–2018	228*	–	37	8	39	94	21	2	26	1	–	(GURAL-SVERLOVA & EGOROV 2021)



Table 1. Continued.

Regions	Localities	Years	N	Y-0	Y-1	Y-3	Y-5	P-0	P-1	P-3	P-5	B-0	B-b	Sources
	Nakhabino	2006	129	–	2	23	28	76	–	–	–	–	–	(GURAL-SVERLOVA & EGOROV 2021)
		2017–2018	551*	–	13	78	134	270	4	9	9	34	–	(GURAL-SVERLOVA & EGOROV 2021)
	Obushkovo	2020	SO	–	–	–	+	–	–	–	–	–	–	(iNATURALIST 2021)
	Osorgino	2020	SO	–	+	–	–	+	–	–	–	–	–	(iNATURALIST 2021)
	Pushchino	2016	10*	–	3	–	2	1	2	–	2	–	–	(GURAL-SVERLOVA & EGOROV 2021)
		2020–2021	SO	–	–	–	+	–	–	–	–	–	–	(iNATURALIST 2021)
	Severnyi	2021	SO	–	–	–	+	–	–	–	–	–	–	(iNATURALIST 2021)
	Zagoryanski	1985	39*	–	2	–	1	2	7	–	27	–	–	Collections of ZM MSU and SMNH NANU
		2016, 2018	152	1	1	–	1	3	22	–	35	88	1	(GURAL-SVERLOVA & EGOROV 2021)
	Zelenograd	2018–2021	SO	–	+	–	+	–	+	–	+	–	?	(iNATURALIST 2021)
Nizhniy Nov-gorod	Nizhniy Nov-gorod	2014–2016	218	–	+	–	+	+	+	–	–	–	–	(MUKHANOV & LISITSYN 2018)
		2019, 2021	SO	–	?	+	+	–	+	–	+	–	–	(iNATURALIST 2021)
Pskov	Pustoshka	2017	SO	–	–	–	–	–	+	–	–	–	–	(iNATURALIST 2021)
Tula	Tula	2021	SO	–	+	–	+	–	+	+	+	–	–	(iNATURALIST 2021)
Tver	Ostashkov	2013	SO	–	+	–	–	–	+	–	–	–	–	(iNATURALIST 2021)