

A FURTHER NORTHWARD EXPANSION OF THE INVASIVE LAND SNAILS *MONACHA CARTUSIANA* AND *M. FRUTICOLA* (STYLOMMATOPHORA: HYGROMIIDAE) IN EASTERN EUROPE

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ABSTRACT: Land snails of the genus *Monacha* are shown to have expanded widely northward in Eastern Europe during the last decade. Previously their ranges there were limited to Southern Ukraine, Caucasus and several isolated colonies in Western Ukraine. Our new reports cover all parts of Ukraine, as well as some regions of southern Belarus and western Russia. We have sampled 5 large colonies of *M. cartusiana* in Kyiv region (Central Ukraine) and one in Kharkiv city (northeastern Ukraine), as well as two colonies of *M. fruticola* in Kyiv city. We also report 72 new records of the subgenus *Monacha* (*M. cf. cartusiana*) in Eastern Europe, based mostly on the photographs from citizen science databases (iNaturalist, UkrBIN). The distribution of *M. cartusiana* around Kyiv city has shown an especially rapid and wide expansion; we report on 36 colonies, some of which are very abundant and cover several tens of hectares each, while the oldest known record of *Monacha* in this region is only from 2017. Origin, expansion and perspectives of the *Monacha* species in Eastern Europe are discussed.

KEYWORDS: Gastropoda; Mollusca; terrestrial molluscs; Ukraine

INTRODUCTION

In Eastern Europe about 45 species of terrestrial molluscs are known to have extended their natural ranges, which is, in nearly all cases, happening in two directions: from the south to the north and from the west to the east (SVERLOVA et al. 2006, SON 2010, BALASHOV 2016, SCHIKOV 2016, BALASHOV et al. 2018a, b, GURAL-SVERLOVA & SAVCHUK 2019). Most of these species have started or much intensified extension of their ranges during the last 3 decades, mainly due to the change of climate (SVERLOVA et al. 2006, SON 2010, BALASHOV 2016, BALASHOV et al. 2018a, b). Among these invasive species in Eastern Europe there are 3 species of the genus *Monacha* (BALASHOV & GURAL-SVERLOVA 2012, BALASHOV 2016). *Monacha fruticola* (Krynicky, 1833) is originated in the Crimea, where its main range is located, and is also distributed across Southern Ukraine (BALASHOV

& GURAL-SVERLOVA 2012, BALASHOV 2016). Recently new colonies were discovered in Western Ukraine (GURAL-SVERLOVA & GURAL 2020a). *Monacha cartusiana* (O. F. Müller, 1774) is a Mediterranean species distributed also in the regions north from the Black Sea, mostly in Southern Ukraine, including Crimea (BALASHOV & GURAL-SVERLOVA 2012, BALASHOV 2016, GURAL-SVERLOVA et al. 2018), and in Moldova (BALASHOV et al. 2013b). This species has invaded many regions in Central Europe (KERNEY et al. 1983, LESICKI & KORALEWSKA-BATURA 2007, PELTANOVÁ et al. 2012, WELTER-SCHULTES 2012, PIENKOWSKA et al. 2016, 2018). Several colonies of *M. cartusiana* were also reported from Western Ukraine (BALASHOV & GURAL-SVERLOVA 2012, BALASHOV et al. 2013a, GURAL-SVERLOVA & SAVCHUK 2019) and only one area was reported from Russia: near Novorosiysk in

the coastal part of the Northern Caucasus (SYSOEV & SCHILEYKO 2009). *Monacha claustralis* (Menke, 1828) is native to Southern Europe, while in Eastern Europe it was reported once from Sevastopol city in Crimea (HAUSDORF 2000a) and most recently also from Lviv city in Western Ukraine (GURAL-SVERLOVA & GURAL 2022). This species has also invaded Poland recently (PIEŃKOWSKA et al. 2015, 2016, 2018). *M. cartusiana* and *M. claustralis* are very similar species that can be identified only by the structure of the genitalia (HAUSDORF 2000a, PIEŃKOWSKA et al. 2015) or molecular features (PIEŃKOWSKA et al. 2016, 2018, NEIBER & HAUSDORF 2017), therefore it is problematic to clarify which one of them invaded some area if only photos or empty shells available.

Since early 2020 we have received a large number of reports from the multiple sources about occurrence of the land snails of the subgenus *Monacha* (*M. cf. cartusiana*) (Fig. 1) outside their known distribution in Eastern Europe, most often from Central



Fig. 1. *Monacha cartusiana* observed near Poroskoten village, Kyiv region (unusual colouration)

Ukraine. Therefore, the goal of our study was to review expansion of *Monacha* species in Eastern Europe.

MATERIAL AND METHODS

Anatomical material was examined from 8 areas, for *Monacha fruticola*: 1) Sofiyska Borshakhivka village near border with Kyiv city, wasteland (former field), 50°24'06.8"N, 30°24'00.6"E, 27.05.2020; 2) Hryshko National Botanical Garden, Pechersk district of Kyiv city, 50°24'28.7"N, 30°33'39.5"E, 10.06.2022; for *Monacha cartusiana*: 3) Sofiyska Borschahivka village near the border of Kyiv city, along the edges of homesteads, 50°24'12.1"N, 30°23'32.3"E, 28.05.2020; 4) Poroskoten village, Borodyans'kyi district, Kyiv region, around the homesteads, from 50°34'49.6"N, 29°56'44.8"E to 50°34'21.5"N, 29°56'09.6"E, from summer of 2020 to October of 2022; 5) Sviatoshyn ponds, Sviatoshyn district of Kyiv city, grasslands and bushes near ponds, from 50°27'51.9"N, 30°19'30.3"E to 50°27'48.4"N, 30°18'47.7"E, from summer of 2020 to summer of 2021; 6) Vyrlytsia lake, Darnytsia district of Kyiv city, bushes and grasslands along the lake, from 50°24'08.8"N, 30°39'49.2"E to 50°23'16.0"N, 30°39'27.7"E, 05.06.2020; 7) Syretsky Gaj park, Podil district of Kyiv city, bushes and grassland along a railroad, 50°29'08.9"N, 30°26'05.8"E, 23.10.2022; 8) Kulynychi, Kharkiv city, around a pond, 49°59'05.9"N, 36°23'01.6"E, 10.10.2021 (collected by A. KHOMENKO).

Material from the 8 main studied areas was collected, handled and identified using common methods of work with terrestrial molluscs (KERNEY et al. 1983, BALASHOV 2016) and is kept in the Collection of terrestrial molluscs of I. I. Schmalhausen Institute of Zoology (Kyiv, Ukraine, henceforth in text: IZ). The taxonomy of *Monacha* proposed by NEIBER &

HAUSDORF (2017) is accepted here. Identification of *M. cartusiana* by the structure of the genitalia, to exclude *M. claustralis* and other species of *Monacha* s.str., was after HAUSDORF (2000a) and PIEŃKOWSKA et al. (2015).

Secondarily, we also used data from online databases iNaturalist (inaturalist.org) and UkrBIN (ukrbin.com) where photos of molluscs were uploaded by the general public (Appendix 1). We only used those observations from these resources where we were able to confirm or make reliable identification. Accuracy of coordinates for such observations relies on the faithfulness of the users who uploaded them (many of these users are scientists or experienced amateur naturalists, at least most of them are reliable). We have discarded several observations where accuracy of coordinates was suspicious for us for one reason or another.

For the map (Fig. 2) we also used some previously published records in Western and Eastern Ukraine (BALASHOV et al. 2013a, GURAL-SVERLOVA & GURAL 2020b, 2022) and personal communications from N. V. GURAL-SVERLOVA (State Natural History Museum NAS Ukraine, Lviv) regarding her records of *M. cartusiana* in Western Ukraine, including anatomically checked colonies. The shaded area on the map that shows a relatively continuous distribution of *M. cartusiana* in the south of Eastern Europe (Fig. 2) is based on previously published data (BALASHOV 2016, GURAL-SVERLOVA et al. 2018, GURAL-SVERLOVA & GURAL 2020b) and, in part, on the data from the IZ collection and iNaturalist.



Fig. 2. Distribution of *Monacha cf. cartusiana* in Ukraine, Moldova, Belarus and Russia (records in other countries are not shown)

RESULTS

We have sampled two colonies of *Monacha fruticola* in and near Kyiv city. These are the first records of this species in Central Ukraine and its northmost known colonies. In Sofiyska Borshakhivka village the snails inhabit an open wasteland that was used as a field until the 2000s; currently neglected, it is an area of about 350 m², largely covered with bushes. In the middle of the area there are a few empty buildings with remains of a large garden with various trees. *M.*

fruticola snails are common there in the grasslands, bushes and on the edges of a former garden. They are found together with an abundant native snail *Caucasotachea vindobonensis* (Pfeiffer, 1828), and in some places also with slugs *Limax maximus* Linnaeus, 1758, *Arion fuscus* (O. F. Müller, 1774) and *Arion fasciatus* (Nilsson, 1823). This area is located right next to a large ring road around Kyiv city on its border and is practically part of the megapolis. In the nearby areas



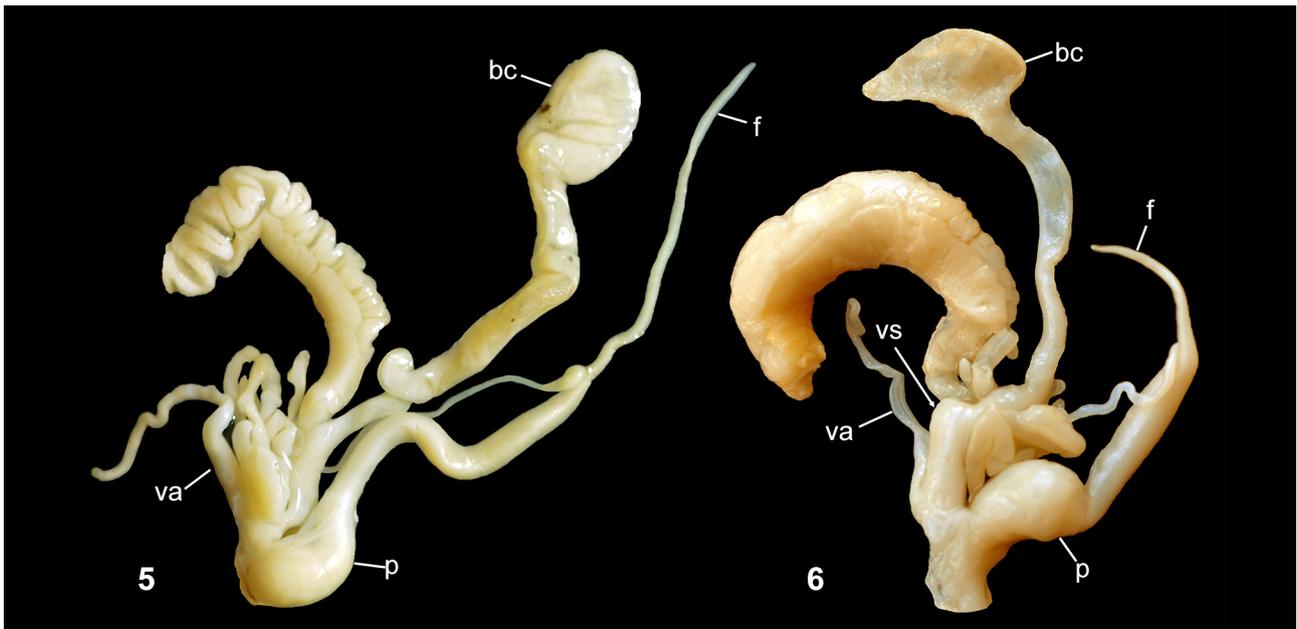
Figs 3–4. Shells of *Monacha* species from Ukraine: 3 – *Monacha fruticola* collected near Kyiv city, No. 1 in “Material and methods”; 4 – *Monacha cartusiana* collected near Kharkiv city, No. 8 in “Material and methods”; same specimens as in Figs 5–6. Scale bar 5 mm

along this road there are numerous major commercial centres that selling the building materials, which indicates a potential way of invasion. We have also studied nearby living areas of Sofiyska Borshakhivka, including some where *M. cartusiana* is living (see below), but *M. fruticola* was not found there.

In the Hryshko National Botanical Garden (Kyiv) *M. fruticola* was found notably along the pathways in

the area with vegetation from Crimea. Therefore, it is very likely that snails of this colony were delivered directly from the Crimea with plants.

Shells of *M. fruticola* collected near Kyiv (Fig. 3) are typical for this species (BALASHOV 2016), their height is 15–17 mm, diameter is 11–13 mm. Genitals (Fig. 5) were checked only in two specimens, one per colony, and they are typical for this species



Figs 5–6. Genitalia of *Monacha* species from Ukraine: 5 – *Monacha fruticola* collected near Kyiv city; 6 – *Monacha cartusiana* collected near Kharkiv city; same specimens as in Figs 3–4; bc – bursa copulatrix, f – flagellum, p – penis, va – vaginal appendix, vs – vaginal thickening

(BALASHOV 2016): penial retractor is present, vaginal appendix is undivided, flagellum is very long, etc. These snails correspond well with the specimens of *M. fruticola* from the Crimea that were studied by us.

The colonies of *M. cartusiana* were sampled in 4 areas in Kyiv region and in one area near Kharkiv city (Fig. 4). The latter one, in Kulinychi village, was sampled on 10.10.2021, but there were several reports with photos from this area on iNaturalist starting from 07.08.2014 (see 49 in Appendix 1). In this area, the colony of *M. cartusiana* is inhabiting some sandy semi-open habitats around a large pond. One specimen from this locality was checked by the structure of genitals (Fig. 6).

From the four areas in Kyiv city we have examined genitals in 5–10 specimens from each colony to exclude *M. claustralis* and all studied snails are corresponding to *M. cartusiana* by having more or less developed vaginal thickening (Fig. 6).

In Sofiyska Borshakhivka village *M. cartusiana* was found on a relatively small area of sideroads along the homesteads, only several tens of meters long. Snails were living along the fences with narrow (1–3 m) belt of grass and bushes along them. In this area *M. cartusiana* is co-inhabiting with invasive *Cepaea nemoralis* (Linnaeus, 1758), which was reported by us from

this exact locality recently (BALASHOV & MARKOVA 2021), as well as the native snail *Chondrula tridens* (O. F. Müller, 1774). The nearby colony of *M. fruticola* (see above) is living in less than 500 m from this place, but the two species were never found together.

In Poroskoten village *M. cartusiana* (Fig. 1) inhabits a large area of homesteads that are used mostly as summer houses (“dacha”) covering at least 1 km². This is a flat area among planted pine forests. Snails are living in private yards with gardens and along the sideroads in grasslands and bushes, also near a large pond, almost continuously. They are especially numerous below the various bushes, most of all lilac (*Syringa vulgaris*). In 2022 the first of two authors of this paper happened to be in this area from late February to early April. No living snails were seen on the soil surface till 02.04.2022 when after significant rains 4 adult specimens of *M. cartusiana* were found under the leaves near bushes in a single spot. Temperatures ranged mostly from 0 °C to +10 °C, sometimes up to +18 °C. Most of the snails were still inactive in soil at this time, which was also the case for all other species of mollusc. In this area, *M. cartusiana* is currently the second commonest species of mollusc following native *C. vindobonensis*. Other mollusc species that co-occur there with *M.*

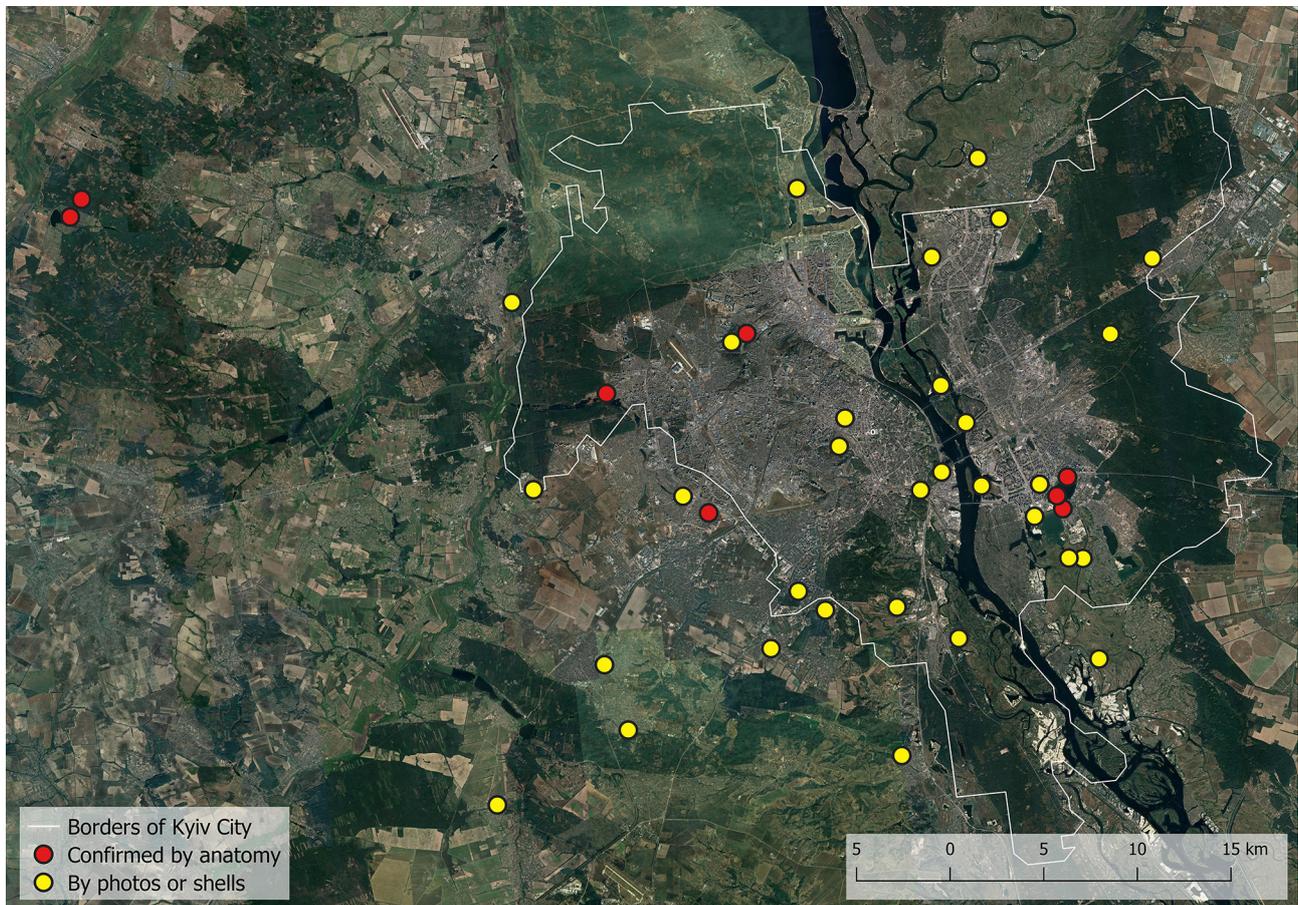


Fig. 7. Distribution of *Monacha* cf. *cartusiana* in Kyiv city and around it (localities No. 4 and 6 are represented by 2–3 dots)



cartusiana include *Pupilla muscorum* (Linnaeus, 1758), *C. tridens*, *Deroceras reticulatum* (O. F. Müller, 1774), *Deroceras caucasicum* (Simroth, 1901), *Arion fuscus*, *Fruticicola fruticum* (O. F. Müller, 1774), *Helix pomatia* Linnaeus, 1758, *Trochulus hispidus* (Linnaeus, 1758), and *Euomphalia strigella* (Draparnaud, 1801).

Near Sviatoshyn ponds in Kyiv city *M. cartusiana* is living in the sandy grasslands and bushes alongside the ponds covering about 300 m². These habitats are much transformed and other terrestrial molluscs are not numerous in this sandy area, with some *C. vindobonensis* and *H. pomatia* present.

Near Vyrllytsia lake in Kyiv city *M. cartusiana* is living in a belt of sandy grasslands and bushes along the shore, about 1.5 km long. We have studied this area in 2020, but the first record on iNaturalist from there was on 02.09.2017 (see 26 in [Appendix 1](#)), which was the earliest known record of any *Monacha* in Central

Ukraine. In this area *M. cartusiana* is co-occurring mostly with *C. vindobonensis*. On one small plot here it lives together with an invasive snail *Xerolenta obvia* (Menke, 1828) (identification by the genitalia).

Near Syretsky Gaj park *M. cartusiana* was found among the bushes and in grassland right next to a railroad. The species is absent in a nearby forest (park itself) and lives only on its edge along the railroad. The invasive slugs *Krynockillus melanocephalus* Kaleniczenko, 1851 and *Deroceras reticulatum* were found in the same place.

The data collected by us together with the data from other sources (see [Appendix 1](#)) was used to create a map showing distribution of *M. cf. cartusiana* in Ukraine and some neighboring countries ([Fig. 2](#)) and more detailed map showing wide expansion of *M. cf. cartusiana* in Kyiv city and around it ([Fig. 7](#)).

DISCUSSION

Present findings of *M. fruticola* in Central Ukraine are making identification of the local molluscs to be more problematic. The shell in this species is very similar to that in the common native species *Fruticicola fruticum*. Although in *M. fruticola* the shell is usually smaller, less globular and with narrower umbilicus, the variability of these characters causes overlap with those in *F. fruticum* ([BALASHOV 2016](#)). The two species can be reliably distinguished by the presence of the microscopic spiral sculpture on the shell's surface in *F. fruticum* ([BALASHOV 2016](#)), but it cannot usually be seen by eye or on the regular photographs. Consequently, it will be often impossible, or at least much more difficult, to distinguish *M. fruticola* and *F. fruticum* in the field.

Present data ([Fig. 2](#)) shows a wide expansion of *Monacha* species outside their previously known ranges in Eastern Europe with *M. cartusiana* becoming very abundant in some areas. Considering that molluscs of these newly-occupied regions were relatively well-studied ([SVERLOVA et al. 2006](#), [SYSOEV & SCHILEYKO 2009](#), [BALASHOV & GURAL-SVERLOVA 2012](#), [BALASHOV 2016](#), [SCHIKOV 2016](#), [GURAL-SVERLOVA & GURAL 2020b](#), etc.) it can be assumed that at least most of the expansion into Central, Northern and north-eastern Ukraine, as well as into Belarus and western regions of Russia, has happened during the last decade (in contrast to the previously known distribution in Southern Ukraine and Caucasus). It is even more evident on the smaller scale for Kyiv city and adjacent areas ([Fig. 7](#)) where terrestrial molluscs were studied repeatedly for a long time ([JELSKI 1863](#), [BAIDASHNIKOV 1992](#), [TAPPERT et al. 2001](#), [SVERLOVA et al. 2006](#), [BALASHOV 2016](#), etc.), but *Monacha* species were never found before

2017. We have reported here 36 colonies of *M. cf. cartusiana* in Kyiv region with some of them being very abundant and covering several tens of hectares each. We often visited and searched for molluscs in some of these areas in 2000s and 2010s, but no *Monacha* was found there. Therefore, there is no doubt that expansion of *Monacha* in Kyiv region has happened mostly during the last few years.

Considering that all our specimens of *Monacha* s. str. from Central and north-eastern Ukraine that were identified by the structure of the genitalia are *M. cartusiana*, it suggests that at least most of the new records ([Fig. 2](#)) represent this species. It is even more likely for all colonies in Kyiv region ([Fig. 7](#)) where we have examined genitals in over 35 specimens from 5 areas. Although, considering that *M. cartusiana* and *M. claustralis* are both present in Western Ukraine and Poland, where they sometimes co-occur ([PIEŃKOWSKA et al. 2016, 2018](#)), it cannot be ruled out that some of our records refer to *M. claustralis*.

In its new area of distribution in Eastern Europe ([Fig. 2](#)) *M. cartusiana* is mostly living in the sandy habitats, often around ponds or lakes. Some of these habitats are semi-natural and situated outside settlements. In Kyiv city and around it *M. cartusiana* forms large continuous colonies that cover many square hectares or maybe even square kilometers ([Fig. 7](#)). It especially applies to the areas on the left (east) bank of the Dnipro River where we have studied only one area around Vyrllytsia lake, but there are several other findings near neighboring lakes and elsewhere ([Fig. 7](#)). Perhaps all these records represent one huge continuous colony. It could be the case also for some other series of records on the right (west) bank of the Dnipro River around Kyiv ([Fig. 7](#)). Therefore,

M. cartusiana is currently not depending on the anthropogenic environment outside its native range in Eastern Europe. Apparently, such situation is mostly a result of the climate change. In Southern Ukraine, where species is known to occur for at least 140 years, *M. cartusiana* is also living largely in the coastal sandy habitats, mostly in more or less transformed by human activity. In the southern Crimea *M. cartusiana* is absent in the dry coastal habitats with complex native communities, such as the sparse forests of Greek juniper (BALASHOV & BAIDASHNIKOV 2013), instead it is mostly associated with the anthropogenic coastal habitats (BALASHOV 2016). There are no fossil records of *Monacha* from Pleistocene or Holocene of Ukraine (KUNITSA 2007, BALASHOV 2016). It all suggests that expansion of *Monacha* species on the plains of present-day Southern Ukraine has happened rather recently, perhaps in the Holocene, in response to the natural change of climate after the last glacial. Perhaps it is even happened in the historic time with assistance from humans, as it was shown for an old invasion of *Helix lucorum* Linnaeus, 1758 in the Crimea from Anatolia (KORÁBEK et al. 2018). In such a case, *M. cartusiana* could be a non-indigenous species for all parts of Eastern Europe, including the Crimea.

It appears that the genus *Monacha* originated mainly in Anatolia with several species being endemic to Caucasus, Balkans and other southern regions of Europe, including one Crimean species (HAUSDORF 2000a, b, IRIKOV 2008, NEIBER & HAUSDORF 2017). A few species of *Monacha* have naturally colonised most of Western and Central Europe, while *M. cartusiana* and *M. fruticola* represent expansion of this genus in a northeastern direction.

As with *M. cartusiana*, the presence of *M. fruticola* on the plains in southern regions of Eastern Europe is the product of a relatively recent expansion. The

role of human activity in this expansion is uncertain. We note that the main range of *M. fruticola* is placed in the Crimean Mountains (NEIBER & HAUSDORF 2017), much closer to those regions than that of *M. cartusiana*. There are two other species of land snails of the Crimean origin that colonized plains of Southern Ukraine outside Crimea: *Helicopsis filimargo* (Krynicky, 1833) (BALASHOV et al. 2021) and *Brephulopsis cylindrica* (Menke, 1828) (BALASHOV et al. 2018). The borders of the natural ranges in these species, especially *B. cylindrica*, are uncertain, same as in *M. fruticola*.

Aided directly or not, it appears that current invasion of two *Monacha* species into the central part of Eastern Europe is a response to the anthropogenic change of climate that in some way represents a continuation of the natural processes associated with changes of climate following the last glacial. With further warming of climate the *Monacha* species, first of all *M. cartusiana*, are expected to become widespread and common in Eastern Europe.

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APPENDIX 1

Records of *Monacha* s. str. (*M. cf. cartusiana*) identified by photos or empty shells. The numeration given is a continuation of the 8 main locations listed in “Material and methods”.

Cherkasy region of Ukraine

- 9 – Ivanky village, Uman district, near a pond, 48°58'02.4"N, 30°26'25.1"E, 15.10.2021 (iNaturalist 116750150);
 10 – Yablunivka village, Zvenyhorodka district, 49°24'32.8"N, 31°10'40.1"E, 27.06.2021 (iNaturalist 85442516);
 11 – Smila city, Cherkasy district, 49°13'15.6"N, 31°52'41.6"E and 49°11'48.7"N, 31°51'21.8"E, 06.07.2022 and 07.08.2022 (iNaturalist 125126169, 129833526);

Kyiv region of Ukraine

- 12 – Myronivka village, Obukhiv district, 49°40'23.8"N, 30°58'18.2"E, 11.06.2021 (iNaturalist 82651532);
 13 – Shkarivka village, Bila Tserkva district, 49°45'34.0"N, 30°09'22.1"E, 07.07.2021 (iNaturalist 86022920; UkrBIN 209703, 209704, 209705);
 14 – Bila Tserkva city, 49°48'10.1"N, 30°08'05.1"E, 21.07.2018 (UkrBIN 81813);
 15 – Tarasivka village, Fastiv district, 50°20'13.3"N, 30°18'08.9"E, 26.05.2021, 11.07.2021 (iNaturalist 80389388, 86599414);
 16 – Boyarka city, Fastiv district, near a pond, 50°18'18.6"N, 30°18'54.8"E, 12.06–10.09.2022 (iNaturalist 121594683, 134652458);
 17 – Lypovyi Skytok village, Fastiv district, near a pond, 50°16'34.5"N, 30°12'42.1"E, 10.07.2022 (iNaturalist 129391475);
 18 – Chabany village, Fastiv district, 50°20'11.5"N, 30°25'41.8"E, 24.08.2022 (iNaturalist 132175446);
 19 – Khodosivka village, Kyievo-Sviatoshynskiy district, 50°16'47.4"N, 30°31'02.8"E, 26.06.2021 (iNaturalist 84576449);
 20 – near Gnidyln village, Boryspil district, 50°18'55.3"N, 30°40'21.1"E, 18.07.2021 (iNaturalist 87565107);
 21 – Pogreby village, Brovary district, 50°33'24.1"N, 30°37'21.1"E, 28.08.2021 (iNaturalist 93147099);
 22 – Irpin city, Bucha district, 50°30'42.4"N, 30°15'40.7"E and 50°32'15.0"N, 30°14'29.2"E, 23.08.2021 and 24.08.2022 (iNaturalist 92325039, 132241177);
 23 – Sofiiivska Borschahivka village, Bucha district, 6 records around 50°24'44.8"N, 30°22'27.9"E, 25.07.2020–04.06.2022 (iNaturalist 54268966, 57076191, 84964446, 94570708, 94867773, 120212954);
 24 – Shevchenkove village, Bucha district, 50°25'21.7"N, 30°15'46.6"E, 06.08.2022 (iNaturalist 129719372);
 25 – Brovary city, Brovary district, 50°30'03.1"N, 30°44'42.4"E, 08.06.2022 (iNaturalist 121111593);

Kyiv city

- 26 – Vyrlыtsia lake, Darnytsia district, 50°23'26.0"N, 30°39'17.0"E, 02.09.2017 (iNaturalist 7760105);
 27 – Bortnychi, Darnytsia district, 50°21'48.2"N, 30°40'07.1"E, 02.06.2021 (iNaturalist 81363704);
 28 – Neberezh lake, Darnytsia district, 50°23'08.2"N, 30°38'09.2"E, 03.06.2021 (iNaturalist 81460250);
 29 – Lebedyne lake, Darnytsia district, 50°24'01.5"N, 30°38'32.5"E, 09.06.2021–10.09.2022 (iNaturalist 82401383, 82401553, 121571220, 134407576);
 30 – Viazky lake, Darnytsia district, 50°21'51.4"N, 30°39'29.4"E, 17.06.2022 (iNaturalist 122297583);
 31 – Osokorky, Darnytsia district, 50°24'09.3"N, 30°35'55.2"E, 11.07.2021 (iNaturalist 99986153);
 32 – Dolobetskyi island, Dnipro district, 50°27'06.5"N, 30°34'35.0"E, 27.09.2021 (iNaturalist 96387577);
 33 – Rusanivka, Dnipro district, 50°25'59.1"N, 30°35'31.7"E, 07.10.2022 (iNaturalist 137897574);
 34 – Rybne lake, Dnipro district, 50°28'02.9"N, 30°42'27.1"E, 17.09.2022 (iNaturalist 135380716);
 35 – Verhne Vygurivske lake, Desna district, 50°31'37.9"N, 30°38'01.2"E, 30.06.2020 (iNaturalist 51463419);
 36 – Gnylusha lake, Desna district, 50°30'45.4"N, 30°34'47.6"E, 03.08.2022 (iNaturalist 130096206);



- 37 – Vita Lytovska, Holosiiv district, 50°19'55.3"N, 30°34'10.1"E to 50°19'43.1"N, 30°34'18.5"E, 10.08.2021–17.07.2022 (iNaturalist 90665625, 126933599);
- 38 – Pyrogiv, Holosiiv district, 50°20'59.3"N, 30°31'32.6"E to 50°21'01.4"N, 30°31'10.2"E, 22.07.2021–08.08.2022 (iNaturalist 102652189, 122205656, 129846246, 130523196);
- 39 – Feofaniya, Holosiiv district, 50°21'06.9"N, 30°28'18.9"E, 24.08.2022 (iNaturalist 132122034);
- 40 – Teremky, Holosiiv district, 50°21'43.6"N, 30°27'11.6"E, 30.06.2021 (iNaturalist 85123938, 85121526);
- 41 – Vydubychi, Holosiiv district, 50°24'13.0"N, 30°33'09.8"E, 16.06.2021 (iNaturalist 83468606);
- 42 – Batyieva Hora, Solomyanka district, 50°25'41.6"N, 30°29'43.0"E, 07.11.2020 (iNaturalist 64593473);
- 43 – Saksaganskogo st., Solomyanka district, 50°26'28.4"N, 30°30'07.0"E, 26.05.2021 (iNaturalist 80389972);
- 44 – Redky, Obolon district, 50°33'05.3"N, 30°29'03.7"E, 17.06.2021 (iNaturalist 83367065);
- 45 – gas station near Barenboima street, Pechersk district of Kyiv city, near a railroad, 50°24'39.9"N, 30°34'11.9"E, 09.06.2022 (iNaturalist 120948778);
- 46 – Syretsky Arboretum, Podil district, 50°28'56.9"N, 30°25'22.8"E, 31.03.2022 (iNaturalist 110072825);

Zhytomyr region of Ukraine

- 47 – Kroshnia, Zhytomyr city, 50°17'35.9"N, 28°40'05.8"E, 03.08.2022 (iNaturalist 135287216, 135420413);

Chernihiv region of Ukraine

- 48 – Staryi Bykiv, Bobrovytsia district, 50°36'03.4"N, 31°38'57.8"E, 25.08.2021 (iNaturalist 92448289);

Kharkiv region of Ukraine

- 49 – Kulynychi, Kharkiv city, 49°59'01.9"N, 36°23'03.1"E, 07.08.2014, 11.06.2020, 07.08.2020 (iNaturalist 28630304, 49255628, 58816534, 58817310);
- 50 – Kosolapivka, Kharkiv city, 49°57'02.3"N, 36°14'26.7"E, 29.08.2021 (iNaturalist 92919290);
- 51 – Oleksiivka, Kharkiv city, 50°02'27.0"N, 36°12'38.3"E to 50°02'46.7"N, 36°12'30.7"E, 22.08.2021–03.08.2022 (iNaturalist 116676012, 118571516, 119641456, 124889875, 129265137);
- 52 – Grigorivka, Kharkiv city, near a pond, 49°57'57.9"N, 36°08'50.5"E, 25.10.2022 (iNaturalist 139955796);
- 53 – Zhykhor, Kharkiv city, near a pond and a railroad, 49°55'04.2"N, 36°15'19.9"E, 17.07.2022 (iNaturalist 126717334, 126883978, 127356473);

Rivne region of Ukraine

- 54 – near Rivne city, 50°37'35.3"N, 26°17'37.5"E, 14.08.2020 (iNaturalist 56433989);
- 55 – Zdolbuniv city, Rivne district, 50°31'34.9"N, 26°14'36.2"E, 19.07.2020–27.08.2022 (iNaturalist 53607585, 53610815, 54619521, 54620032, 58014341, 58077007, 58485548, 104568003, 132155335, 132585437);
- 56 – Chervona Kalyna resort, near Zhobryn village, Rivne district, 50°49'13.4"N, 26°01'31.1"E, 24.08.2020 (iNaturalist 57827916);
- 57 – Novostav village, Rivne district, 50°45'41.3"N, 25°57'32.2"E, 25.07.2021 (UkrBIN 213091);
- 58 – Nova Ukrainka, Rivne district, 50°42'26.7"N, 26°24'29.5"E, 23.05.2022 (iNaturalist 123091531);
- 59 – Sarny city, Sarny district, 51°20'52.8"N, 26°35'00.5"E, 12.07.2020 (UkrBIN 168025);
- 60 – Varkovychi village, Dubno district, near a pond, 50°27'46.5"N, 25°58'13.7"E, 15.07.2022 (iNaturalist 126365959);
- 61 – Batkiv village, Dubno district, 50°06'14.8"N, 25°17'37.1"E, 19.06–07.08.2022 (iNaturalist 122515094, 124263096, 125447650, 128318017, 129834281);

Volyn region of Ukraine

- 62 – Volodymyr city, Volodymyr-Volynskiy district, 50°51'45.7"N, 24°18'06.8"E and 50°51'54.8"N, 24°15'34.5"E, 31.07.2021 and 20.07.2022 (iNaturalist 89379110, 129667635);
- 63 – Zelena village, Kovel district, 51°10'07.4"N, 24°41'16.2"E, 05.06.2022 (iNaturalist 48539483, 48539869, 48540325, 48540429);
- 64 – Kalynivka village, Kovel district, 51°12'43.7"N, 24°32'21.4"E, 06.09.2020 (iNaturalist 59131720);
- 65 – Bilyn village, Kovel district, 51°14'02.6"N, 24°48'41.9"E, 31.08.2020 (iNaturalist 58220758);
- 66 – Lublynets village, Kovel district, 51°11'01.9"N, 24°37'23.7"E to 51°10'38.1"N, 24°37'06.9"E, along a railroad (iNaturalist 107385352, 107649120);
- 67 – Kovel city, Kovel district, 51°13'10.8"N, 24°42'01.7"E, 08.09.2020 (iNaturalist 119387694);

Khmelnyskyi region of Ukraine

- 68 – Holoskiv village, Khmelnytskyi district, 49°23'34.1"N, 27°21'23.5"E, 01.08.2020 (UkrBIN 171919);
- 69 – Furmanivka village, Kamianets-Podilsky district, 48°39'38.9"N, 26°45'21.7"E, 24.07.2021 (iNaturalist 116820992);

**Transcarpathian region of Ukraine**

70 – Rakhiv city, Rakhiv district, [48°02'34.4"N](#), [24°13'00.3"E](#), 08.09.2016 (iNaturalist 122037835; shells examined by us, IZ collection);

Donetsk region of Ukraine

71 – Makiivka city, Donetsk district, spoil tip of Kalinin mine, [48°01'25.1"N](#), [37°49'48.1"E](#), 2005 (collected by A. Shklyaruk, material in IZ collection);

72 – Mariupol city, Mariupol district, bank of Kalchik River, [47°06'28.4"N](#), [37°34'52.4"E](#), 11.2004 (collected by A. Shklyaruk, material in IZ collection);

73 – near Bilenke village, Kramatorsk district, [48°46'15.8"N](#), [37°38'35.7"E](#), 04.07.2021 (iNaturalist 85642758);

Lugansk region of Ukraine

74 – Lysychansk city, Severodonetsk district, [48°51'42.5"N](#), [38°28'36.3"E](#), 11.06.2021 (iNaturalist 89200948);

Brest region of Belarus

75 – Kobryn city, Kobryn district, [52°12'42.6"N](#), [24°23'33.9"E](#), 19.07.2020 (iNaturalist 53604613);

76 – Galeva village, Pinsk district, [52°09'30.0"N](#), [26°05'35.9"E](#), 21.07.2020 (iNaturalist 53859290);

Rostov region of Russia

77 – Taganrog city, [47°12'59.9"N](#), [38°51'02.9"E](#), 26.20.2019 (iNaturalist 34929263);

78 – Temernytsky village, Aksay district, [47°21'04.8"N](#), [39°41'56.0"E](#), 17.07.2021 (iNaturalist 87415510);

79 – Bataysk city, [47°07'41.3"N](#), [39°43'58.7"E](#), 08.06.2021 (iNaturalist 82121122);

Moscow region of Russia

80 – Belokamennaya rail station, Eastern administrative okrug of Moscow city, [55°49'49.2"N](#), [37°42'04.1"E](#), 07.08.2020 (iNaturalist 56047299, 56069514, 56163325)