Asian Jr. of Microbiol. Biotech. Env. Sc. Vol. 23, No. (4) : 2021 : 672-681

ISSN-0972-3005

PRIMARY MONITORING OF THE HELIX POMATIA POPULATION ON VARIOUS ELEMENTS OF THE URBAN ECOSYSTEM IN THE NORTH-WESTERN PART OF UKRAINE

KLYMENKO M.O., BIEDUNKOVA O.O., PRYSHCHEPA A.M., STATNYK I.I., BUDNIK Z.M. AND TSIPAN YU. R.

National University of Water and Environmental Engineering (Rivne Sity, Ukraine)

(Received 20 September, 2021; Accepted 15 October, 2021)

Key words : *Helix pomatia, Urban ecosystem*

Abstract–Presents the results of study the characteristics of the population of snail *Helix pomatia*, which lives on various elements of the urban ecosystem in the north-western part of Ukraine and to determine the influence of animal settlement factors on their overall development basing on external morphological characteristics. It was revealed that *H. pomatia* population can be characterised by greater biomass in areas with natural landscapes (72% of the total), while relatively urbanised areas have 8% and agricultural lands have 20%.

INTRODUCTION

The range of applications of pulmonate gastropod terrestrial mollusc in the family Helicidae (*Helix pomatia* Linnaeus, common names the Roman snail, Burgundy snail, edible snail or escargot, 1758) is constantly expanding. This trend contributes to the growth of scientific and commercial importance of this species. Having the characteristics of a valuable natural resource, it has decreased the productivity of populations (Andreev, 2006). *H. pomatia* is in the IUCN Red List of threatened species, listed in the "Least Concern" threat status for both World and Europe. Thus, its populations are small, but currently it is not classified as "endangered" and "vulnerable" (IUCN Red List of Threatened Species).

Ovando X. *et al.* (2019) underlines that all terrestrial molluscs are an imperative element of ecosystems. By consuming plants and their remains, they facilitate their processing and mineralisation, which affects the formation of soils. *H. pomatia*, like other molluscs, are intermediate hosts of many species of parasitic worms, namely trematodes, cestodes, nematodes or roundworms (Coen *et al.*, 2015). Some of them cause diseases of domestic animals (Shikhova, 2007). By eating the leaves of grapes and fruit trees, the Burgundy snail can cause significant damage to agriculture (Avagnina, 1998). Hence, in a complex network of food connections, the Burgundy snail *H. pomatia*, like any biological object, has an essential place.

It is worth mentioning that Burgundy snail is in great demand for gastronomic purposes around the world (Gorbunova *et al.*, 2015, Elias, 2021). In those countries where it is treated "barbarically", the population of Burgundy snails in natural habitat catastrophically reduces (to 25-28% of the ecologically functional population) (Franko *et al.*, 2016).

Furthermore, anthropogenic pressure associated with wasting landscapes leads to the destruction of natural habitats and excessive fragmentation of habitats, which has an extremely negative impact on the survival of snail populations (Vrankoviæ *et al.*, 2020). At the same time, according to ecological characteristics, all snails, including the *H. pomatia* species are stenobionts, which population parameters are highly vulnerable to changes in ecosystems (Radwan *et al.*, 2020, El-Gendy *et al.*, 2021).

The presence of geographically isolated populations of Burgundy snails is an excellent object for scientific research of microevolutionary phenomena occurring in modern natural and urban landscapes (El-Gendy *et al.*, 2021).

Hence, the study of phenotype of the shell (combinations of longitudinal brown stripes) of 546 specimens from 12 colonies examined the population structure of *H. Pomatia* in the eastern and south-eastern part of the modern European geographic range limit (Artemchuk *et al*., 2018). The authors of the study found that the average number of morphs of the species did not exceed 3.277 ± 0.521, the phenotype similarity was in the range of 0.727-0.999, and the phenotype similarity index of populations was low (0.024, at P = 0.01). The authors of the research concluded that the selection vectors are similar in the urban environment and the origin of the analysed colonies of Burgundy snails is unique, which leads to the formation of a certain phenotype.

The scholars are aware of similar studies that prove the differences between physiological, structural and biochemical parameters of molluscs from spatially separated populations. The scientists use the changes in such indicators in the bioindication of the environment with varying degrees of environmental well-being (Rumyantseva *et al*., 2004; Khlus *et al.,* 2001).

Today, in the north-western part of Ukraine, scientific research regarding *H. pomatia* is extremely small, despite the fact that this mollusc is actively extracted from ecosystems as a valuable biological resource. In Ukraine, their semi-legal collection is quite common and it gives considerable revenue to private entrepreneurs who do not invest in their reproduction. Therefore, the preservation of the natural environment, assessment of the number of populations of individual species and the development of effective measures for their reproduction is an important task of protection and rational use of biological resources.

Consequently, the foremost objective of our research was to study the characteristics of the population of Burgundy snail *Helix pomatia*, which lives on various elements of the urban ecosystem in the north-western part of Ukraine and to determine the influence of animal settlement factors on their overall development basing on external morphological characteristics.

MATERIALS AND METHODS

The research area is located in the north-western part of Ukraine. In order to study the snail population in different elements of the urban ecosystem, the study group chose an administrative unit, VelykaOmeliana Village Council in Rivne Oblast (region), where one can find different types of natural and anthropogenic landscapes.

The landscape of the territory is mostly flat. Groundwater lies at a depth of more than 3 metres. The territory is located within the main tectonic structure of Rivne region, i.e. Volhynia-Podillia Plate (also 'Platform'), in particular Rivne Plateau. The average height above sea level is 253 m. The climate of the territory is moderately continental. Chernozemic soils are the most common soils for this area, including typical chernozemic soils, chernozems with a small amount of organic matter (or humus), grey podzols, dark grey podzols, and podzolicchernozems. Meadow and grassland soils are widespread in river valleys due to the downward slope in the landscape.

The degree of total soil tillage for the study area is 55.9%, at the same time, agricultural land accounts for 83.3%. The agricultural development index is 0.68 and it indicates excessive economic load of the territory, ecological imbalance of agricultural landscapes and disturbance of wildlife habitats.

The study detected Burgundy snail settlements within four 0.25 × 3.5 km transects, along the north-south direction. They represented the alternation of natural and urban areas of the territory. At each transect, the research surveyed 5 to 7 registration sites (area: 4 m^2; 2.0 × 2.0 m square) with different types of natural vegetation (grass, shrubs and single deciduous trees). In general, 23 sites with a total area of 92 m^2 were surveyed. The geographical coordinates of the sites were determined using GPS, and then they were marked on a satellite image of Google map database (Fig. 1).

The study selected registration sites within the transects basing on the presence of natural vegetation in open areas of the studied natural and urban area. Thus, out of 23 registration sites, 10 were located within the urbanised area and were mostly represented by the growth of herbaceous meadows (Nos. 3, 4, 7-10, 14, 19, 21), except for the site No.17, which coincided with roadside deciduous trees. Natural landscapes were represented only in four sites (Nos. 1, 6, 12, 16), and the remaining 9 were roadsides of ploughed agricultural lands.

The inventory count of the animals took place during June-August 2018, 2019 in wet weather (but not during rain), mostly in the morning until the dew dries and most molluscs are active. The species was identified according to determinants (Balashov *et al*., 2007; Sverlova 2003).

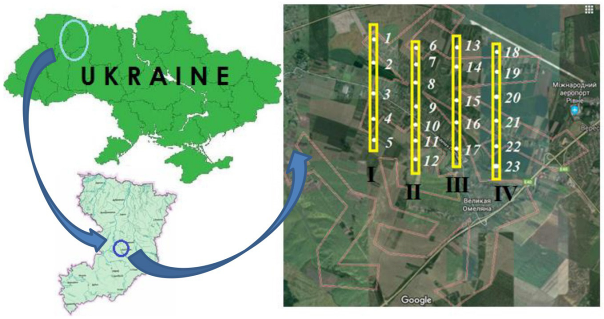

Fig. 1. Location of Registration Sites on Transects of Field Research Regarding Burgundy Snail Population on Different Elements of Urban Ecosystem: 1 – 50°36′38.5"N 26°05′45.4"E; 5 – 50°35′23.3"N 26°05′38.9"E; 6 – 50°36′34.9"N 26°06′39.4"E; 12 – 50°35′06.7"N 26°06′26.0"E; 13 – 50°36′39.3"N 26°07′17.2"E; 17 – 50°35′28.8"N 26°07′03.5"E; 18 – 50°36′30.7"N 26°08′03.1"E; 23 – 0°35′08.4"N 26°07′48.0"E

In parallel with the calculations of the number of snails on the registration sites, we measured the size of mollusc shells using a beam compass according to the standard scheme (Sverlova, 2003) (Fig. 2) and weighing individuals using precision laboratory scales (model TVE-2,1-0,01-a), the second class of accuracy according to DSTU EN 45501.

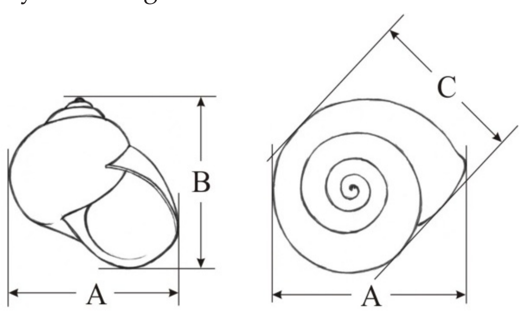

Fig. 2. Major Measurements of Burgundy Snail Shell, Namely A is Large Shell Diameter; B is Height; C is Small Shell Diameter

We have calculated the volume of the shell (V) according to the results of measurements:

$$V = {(A^2 \cdot B)}/{2}\text{, mm}^3 \quad .. (1)$$

We have also calculated the morphometric index of the ratio of the shell height to its large diameter (I):

$$I = B/A \quad .. (2)$$

Statistical processing of the obtained data was carried out by standard methods using Statistica 8.0 and Excel (Microsoft Office) for Windows operating system (Lapach *et al*., 2001). The standard error of measurements and their statistical reliability were tested according to Student's t-test. We performed the analysis of variance (ANOVA) of the dependent variables using the ANOVA module. Furthermore, within its framework we assessed the influence strength of the particular factor on the formation of external morphological characteristics of molluscs according to the following equation:

$$\eta = \left(\frac{S^S_{faktor}}{S^s_{intercept}}\right) \cdot 100\% \quad .. (3)$$

where η is the influence strength of the factor, %; S^S_{faktor} is factorial sum of squares; $S^s_{intercept}$ is random sum of squares (Artemchuk *et al*., 2018).

In order to analyse the available monitoring data regarding the population of *H. Pomatia* we used the results of our own expeditionary surveys of natural landscapes of Rivne region for 2016-2019, which were obtained within the framework of scientific theme named "Sustainable Use of Natural Resource Potential of Ukraine in the Context of Sustainable Development" (State Registration Number: 0117U001988).

RESULTS AND DISCUSSION

Our survey of the number of Burgundy snails in the study area revealed only 159 representatives of the species, which in terms of the entire surveyed area indicates a population density of 1.73 ± 0.39 snails per square metre.

In this case, the average number of species within the first transect was 2.75 ± 1.28 snails per square metre, or 40% of the total; within the second transect there were 2.1 ± 0.81 snails per square metre, or 30%; in the third transect there were 1.15 ± 0.82 snails per square metre, or 17%; in the fifth transect there were 0.92 ± 0.18 snails per square metre, or 13% (Fig. 3).

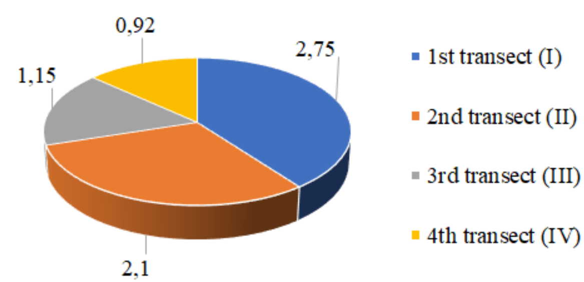

Fig. 3. Density of Burgundy Snails within the Study Transects, number of snails per square metre

Thus, we noticed the decrease in the population density of Burgundy snails in the study area in the direction from west to east. The reason may be linked to the fact that there is an airport on the east side of the city of Rivne. Even though, according to the prevailing directions of winds, the transfer of a significant amount of air pollution from the urban system of Rivne has no significant impact. We assume that the revealed decrease in the number of *H. pomatia* species in the eastern direction may have many other explanations, such as mosaic of soils, natural acidic properties of the soil and proved decrease in calcium content, as calcium is the main building material for mollusc shells; the absence of shaded areas that retain moisture on the underlying surface longer compared to open areas; as well as population level, which surely means different anthropogenic load in the study area etc.

Analysis of the number of Burgundy snails at different types of registration sites reveals that within natural landscapes the density of the species was 4.25 ± 0.46 snails per square metre, or 62% of the total number; in the urbanised area it was 0.94 ± 0.52 snails per square metre, or 14%; on the plots that were located on the roadsides of agricultural lands it was 1.64 ± 0.39 snails per square metre, or 24% (Fig. 4).

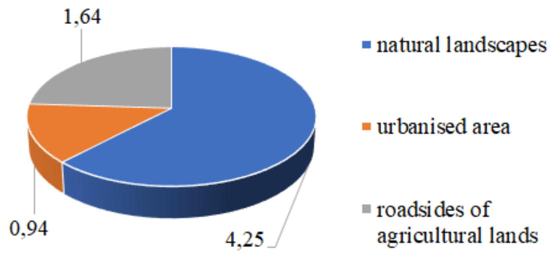

Fig. 4. Density of the Number of Burgundy Snails on Different Types of Registration Sites, snails per square metre

Remarkably, on the registration sites located within the urbanised area, the number of detected empty shells was 25, on the sites within the natural landscapes the number was equal to 26, and on the sites along the agricultural lands there were 24

Table 1. Average Measurement Values of the Major Morphometric Characteristics of *H. Pomatia* External Structure on Various Urban Ecosystem Elements (p≤0.05)

Transect	Registration Site Number	Sample Size, n*	Large Shell Diameter A, mm	Shell Height B, mm	Small Shell Diameter C, mm	Weight of Molluscm, g
1st(I)	1	18 (5)	29.3±1.13	26.2±0.75	25.7±1.23	10.2±1.21
	2	24 (11)	31.2±1.45	28.1±1.34	27.2±0.98	15.1±1.05
	3	0 (0)	-	-	-	-
	4	2 (0)	19.3±1.17	16.3±1.56	15.4±1.07	7.2±1.21
	5	11 (7)	20.2±1.11	16.8±0.97	16.5±1.231	5.9±0.78
2nd(II)	6	21 (9)	32.3±1.22	32.1±0.77	23.6±1.01	19.1±0.43
	7	3 (0)	21.2±0.98	8.4±1.34	17.5±1.04	4.2±0.77
	8	0 (0)	-	-	-	-
	9	9 (3)	13.4±0.67	11.6±0.65	11.3±0.86	4.2±0.56
	10	0 (2)	-	-	-	-
	11	11 (3)	23.2±0.69	20.8±0.82	19.1±0.59	8.4±0.43
	12	15 (7)	36.7±0.84	35.3±0.46	27.0±0.91	18.4±0.72
3rd(III)	13	9 (2)	28.2±1.21	26.5±1.33	24.4±1.61	12.8±1.15
	14	0 (0)	-	-	-	-
	15	0 (0)	-	-	-	-
	16	14 (5)	24.7±1.65	23.8±1.25	21.9±0.43	12.5±0.87
	17	0 (0)	-	-	-	-
4th(IV)	18	6 (2)	26.4±1.47	24.6±1.35	22.8±1.42	8.5±1.34
	19	5 (0)	17.2±0.53	16.8±0.52	12.9±0.44	6.5±0.83
	20	2 (1)	25.0±1.22	24.7±1.13	22.8±1.07	6.8±1.09
	21	2 (9)	12.4±1.11	10.9±1.13	10.4±1.15	5.4±0.92
	22	4 (5)	18.8±0.75	17.4±0.89	13.8±0.76	7.9±0.82
	23	3 (3)	19.3±1.44	17.5±0.97	14.8±0.24	8.1±0.91
Average	159 (75)	23.46±1.67	21.05±1.88	19.24±1.40	9.42±1.14	

* Note: The number of empty shells, which were found, is given in parentheses

empty shells (Table 1). Explicitly, their number was approximately the same in different types of territory. However, if we do not take into account the number of empty shells on the second registration site (11 shells), which is located in the administrative territory of the village and adjacent to the fish pond (where the conditions are obviously favourable for the existence of molluscs), then the number of empty shells will be the lowest in the sites within urbanised zones of the study area, i.e. 15 shells.

Hence, one can assume that the empty shells, which remain primarily after the wintering of animals (Artemchuk *et al*., 2018), allow identifying relatively constant sites of *H. pomatia* localisation in the study area.

The areas where there were no empty shells can be attributed to temporary mollusc locations. Basing on the measurements in samples we identified morphometric external characteristics of a Burgundy snail (Table 1).

Thus, the average large diameter for all analysed *H. Pomatia* individuals on the registration sites along the four transects was 23.46 ± 1.67 mm, the average height of the shell was 21.05 ± 1.88 mm, and the average small diameter was 19.24 ± 1.40 mm with an average weight of 9.42 ± 1.14 g. It is worth mentioning that the measurements were conducted only on live molluscs. In case of analysing the averaged data of the estimated parameters for different types of landscapes, it is evident that the weight of molluscs is the largest within natural landscapes, and the smallest within the urban area.

Statistically confirmed reliability of the averaged data allowed analysing the mathematical dependences of morphometric features of the external structure of the snail population living in different elements of the urban ecosystem of the research area within the north-western part of Ukraine (Table 2).

Large and small shell diameter had a functional connection (r=0.9588). The large shell diameter and its height were very closely related (r =0.9262). Other estimated connections include the following: large shell diameter and mollusc weight (close connection, r =0.8247), height and small shell diameter (r =0.8780), shell height and mollusc weight (r =0.8688); small shell diameter and mollusc weight had a noticeable connection (r =0.6992). Thus, the large and small shell diameter and the weight of the mollusc are definitely more interdependent. Among the dependences of the analysed morphometric features, the shell height is less significant.

Comparison of the shell volume (Fig. 5-a), the index of the ratio of the shell height to its large diameter (Fig. 5-b) and the weight of the molluscs (Fig. 5-c) does not reveal clear patterns of the studied parameters by transects.

In the course of the analysis of variance (ANOVA), it was found that the share of spatial settlement of molluscs by transects in the formation of the shell volume (V) is 9.6%. The Fisher's exact test (a statistical significance test), in this case, had no factorial statistical significance (F = 0.726; p = 0.5539). The force of the spatial settlement influence with the index of the shell height to its large diameter ratio (I) reached only 0.38% (F = 0.7623; p = 0.5351), and with the mollusc weight (m) it is 3.73% (F = 0.859; p = 0.4867). According to the obtained results, in the last two dependencies the statistical significance was not confirmed either.

The average shell volume for *H. Pomatia* was the largest on the registration sites within natural

Table 2. Linear Dependence of the Values of Morphometric Features* of the *H. Pomatia* External Structure

No.	Equation	r	r2	p
1	A = 6.1194+0.8248 B B = -3.3777+1.0402 A	0.9262	0.8579	0.00000
2	A = 1.3471+1.1492 °C C = 0.4741+0.8 A	0.9588	0.9194	0.00000
3	A = 12.0561+1.2025 M M = -3.785+0.5656 A	0.8247	0.6801	0.00005
4	B = -1.7156+1.1818 C C = 5.5269+0.6523 B	0.8780	0.7709	0.00000
5	B = 7.5325+1.4228 M M = -1.672+0.5306 B	0.8688	0.7549	0.00001
6	C = 11.1744+0.8507 M M = -1.5763+0.5747 C	0.6992	0.4889	0.0018

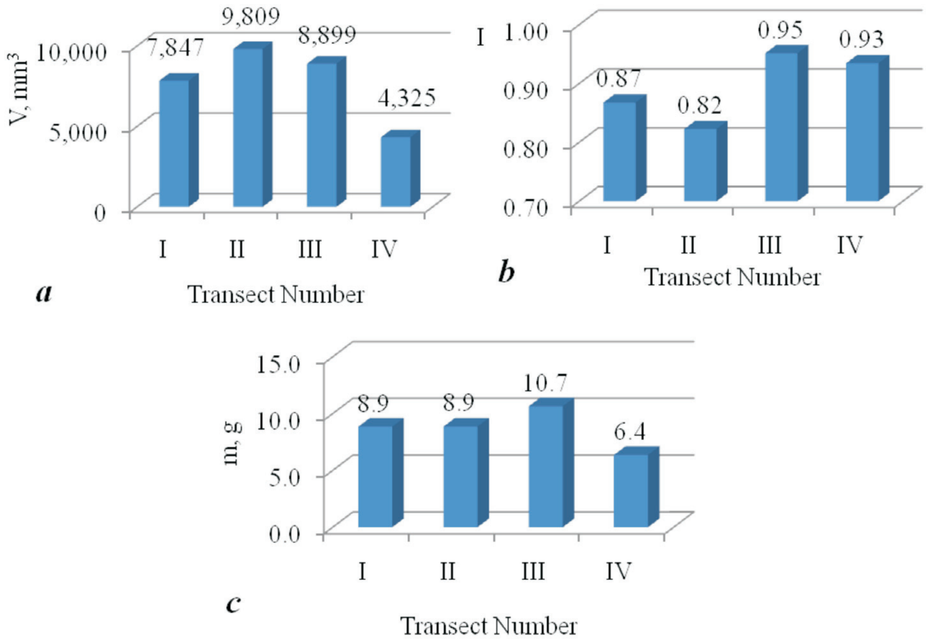

Fig. 5. External Morphometric Features of *H. Pomatia* on the Studied Transects: *a* is the Average Mollusc Shell Volume for the Transect; *b* is the Average Index of the Height to Large Shell Diameter Ratio for the Transect; *c* is the Average Mollusc Weight for the Transect

landscapes 14,756 ± 4,133.36 mm^3, within the urbanised areas it was the smallest (3,827 ± 2,189.98 mm^3), and on the sites along the roadsides of ploughed agricultural lands it had an intermediate

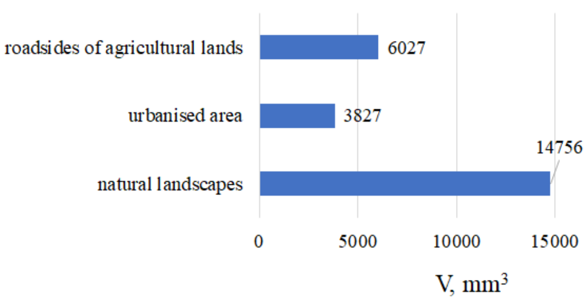

Fig. 6. Average Shell Volume of H. pomatia on the Registration Sites within Various Urban Ecosystem Elements

position equal to 6,027 ± 1,327.59 mm^3 (Fig. 6).

The average index of the height to large shell diameter ratio for *H. pomatia* (I) did not have a significant difference in different types of landscapes. However, the noted index was the highest in the registration sites within the urbanised areas and amounted to 0.95 ± 0.02. At the same time, within natural landscapes and on the roadsides of agricultural lands it had corresponding values of 0.81 ± 0, 09 and 0.92 ± 0.02 (Fig. 7).

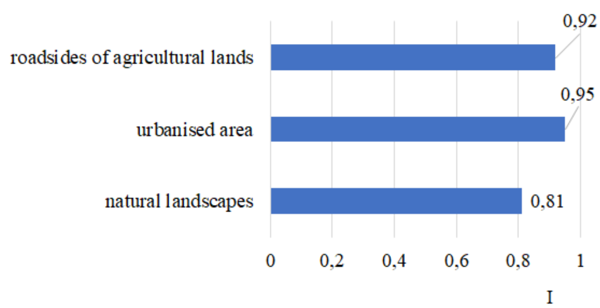

Fig. 7. Average Indices of the *H. Pomatia* Height to Its Large Shell Diameter Ratioon the Registration Sites within Various Urban Ecosystem Elements

We observed a similar pattern for the weight of molluscs that were collected at the registration sites within various urban ecosystem elements. For instance, within natural landscapes the average *H. pomatia* weight was 14.8 ± 2.66 g, on the sites within the urbanised area it was 7.1 ± 1.83 g, and on the roadsides of agricultural lands it was 8.3 ± 0.94 g (Fig. 8).

The conducted analysis of variance (ANOVA) statistically confirms the strength of the impact of different urban ecosystem elements on the formation of two external morphological features of *H. pomatia*. In case of the shell volume (V) dependence was at the level of 15.29% ($F = 4.657$; p

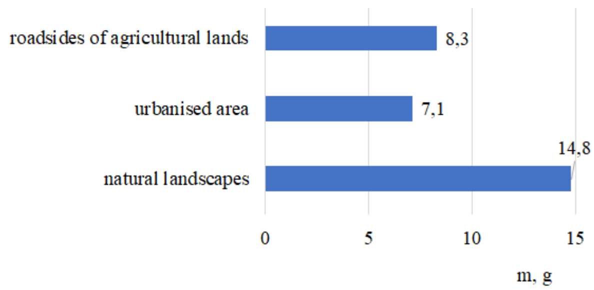

Fig. 8. Average Weight of *H. pomatia* Individuals on the Registration Sites within Various Urban Ecosystem Elements

= 0.0282). At the same time for the mollusc weight (m) is equal to 8.72% (F = 6.209; p = 0.0117). The index of the height to large shell diameter ratio for *H. Pomatia* (I) did not confirm the factor dependence of the impact of different urban ecosystem elements, as the impact reached only 0.43% and had no statistical probability (F = 1.663; p = 0.2249).

Consequently, we can state that random spatial settlement by transects has no effect on the formation of *H. pomatia* external morphometric features. However, the conditions of various urban ecosystem elements affect the development of molluscs, in particular the volume of their shells and weight. Furthermore, although the impact strength is confirmed by relatively low values (15.29% and 8.72%, respectively), their static probability allows us to draw this conclusion. In addition, such values of the impact strength can be explained by the presence of several important factors that act comprehensively and determine the characteristics of natural and climatic conditions of the research area.

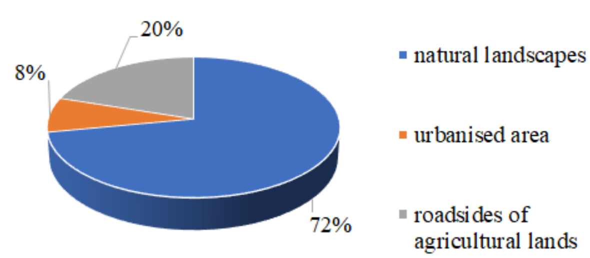

Fig. 9. *H. pomatia* Population Biomass Distribution on the Registration Sites within Various Urban Ecosystem Elements, %

Thus, it is argued that the metric characteristics of mollusc shells are indicators of the climatic zones in which the molluscs live. Nonetheless, this statement is valid only in cases when it comes to the natural habitats of species, when their gene pools are formed during a long period of time (Andreev 2006). Considering the fact that the *H. pomatia* population, which we study, is confined to the urbanised area, there is a certain microclimate, which differs to some extent from the general climatic conditions of the entire north-western part of Ukraine.

Evidence also suggests that terrestrial molluscs can be affected by physical and chemical properties of soils. For instance, dense soils result in the formation of more elongated shell forms (Artemchuk *et al.*, 2018). In addition, these soils contribute to the increase of the main locomotor organ, i.e. the muscular foot, which helps the snails to move and bury themselves. The foot increase is accompanied by an increase in the mouth size and an increase in large diameter (Snegin, 2012). It has been scientifically proven that the hydrological conditions of the terrain and the concentration of soil saline affect the settlement and survival of terrestrial snails (Starodubtseva *et al*., 2003).

Unquestionably, according to the primary monitoring, it can be stated that figuring out the factors that influence the development of external morphological features. *H. pomatia* within the study area is somewhat difficult. Nevertheless, in our results, the elongated shape of mollusc shells collected in an urbanised area, against a relatively smaller shell volume and weight of molluscs than in other types of terrain. Notwithstanding the fact that ANOVA identifies such external morphometric features as shell volume and mollusc weight as the only indicator of anthropogenic load of the territory.

Weighing of the found molluscs allowed us to estimate the biomass of this species within the study area. Hence, *H. Pomatia* biomass on the registration sites within natural landscapes (Nos. 1, 6, 12, 16) was 0.0000148 t/m^2, or 0.0015 t/ha; for the urbanised areas (Nos. 2- 4, 7-10, 14, 15, 17, 19, 21) it was 0.000007 t/m^2, or 0.0007 t/ha; for the roadsides of agricultural lands (Nos. 5, 11, 13, 18, 20, 22) it was 0.000008 t/m^2, or 0.0008 t/ha. Total average biomass for all surveyed types of terrain on the studied transects was 0.1 t/ha.

Thus, the *H. pomatia* population in the study area is characterised by greater biomass in areas with natural type of landscapes, as it makes up 72% of the total (Fig. 9).

Within the urbanised area, the biomass of animals was the lowest and amounted to only 8% of the total. At the registration sites located along the roadsides of agricultural lands, on average the biomass of molluscs accounted for 20% of its total at all sites.

It is a well-known fact that the biomass of organisms, along with their number in a given area, indicates the efficiency of the population, i.e. maintaining it at a level, which is sufficient for reproduction. In order to obtain an objective and broader view of the Burgundy snail population in the study area, we used the method of comparing the results with the available monitoring data regarding this species, which we conducted during 2016-2019 throughout the Rivne Oblast (region).

Subsequently, we estimated that in Rivne region the reserves of mature *H. pomatia* individuals on average were equal to 570 tons (about 18 – 19 million specimens) during 2016-2019. At the same time, the total number of all age groups was about 90 million specimens, a total biomass was at the level of 2,900 t (0.39 t/km^2) and a population density was 2.65 snails/m^2. These data apply only to areas with natural landscapes and do not take into account urban areas and agricultural land. That is why we made the comparison of the results only for areas with a natural type of landscape.

As a result, we noticed that the average density of *H. pomatia* in the natural landscapes of the research area (4.3 snails/m^2) is higher compared to the data for Rivne Raion (district) and Oblast (region), where this figure is 3.2 ± 0.17 snails/m^2 and 2.65 ± 0.23 snails/m^2, respectively. Simultaneously, in the natural landscapes of the study area the *H. Pomatia* biomass is much lower (0.15 t/km^2) than its average values for Rivne region, where it is 0.39 t/km^2.

We assume that a larger number of Burgundy snails in the study area is associated with the accumulation of animals in natural landscapes, because their area is extremely limited due to significant agricultural development (especially ploughing) and urbanisation. That is, as a reaction to the conditions of existence one can see a mosaic of the distribution of the species.

We believe that significantly lower values of animal biomass in the research area are evidence of the stagnation of the *H. Pomatia* population due to complications, namely the complete absence of food migration and settlement in comfortable natural landscapes for animals. Apart from that, there may be changes in the age structure of the population, or environmental pollution.

Thus, the obtained results give an initial idea of the nature of settlements and current state of the Burgundy snail population in various urban ecosystem elements in the north-western part of Ukraine, where such studies have not yet been conducted.

Relatively high values of the number of animals in natural landscapes reflect the satisfactory condition of the *H. Pomatia* population in the study area. Reduced values of mollusc biomass may be due to various reasons mentioned above. However, among all possible options, the fact of complicated settlement of molluscs due to the heterogeneity of terrain types and the presence of natural vegetation or greenery surely remains undeniable.

It is obvious that snail populations are able to survive in small areas of favourable habitat. Moreover, usually, such favourable areas are available even if the landscapes are maximally transformed into arable land or pastures. However, in the long run, the fragmentation of the habitat favourable for terrestrial molluscs can have negative consequences. According to the research (Baur *et al*., 1989), population maintenance becomes impossible when the relationship between sites falls below a critical level, and the number of immigrants to areas where members of the species are disappearing becomes insufficient to maintain the population.

Therefore, we would like to underline that one of the measures to protect *H. pomatia*, as well as other wild animals, is the conservation of natural habitats, which function as corridors for resettlement and food migration, as well as ensuring the maintenance of populations in adverse weather conditions.

CONCLUSION

In summer 2018-2019, *H. pomatia* population density in the study area of the urban ecosystem within the north-western part of Ukraine was at the level of 1.73 ± 0.39 snails per square metre. The distribution of the indicator between natural landscapes, urbanised area and agricultural land was 62%, 14% and 24%, respectively. The study revealed that the density of the number of Burgundy snails reduced along the transect lines in the direction from west to east .

H. pomatia population can be characterised by greater biomass in areas with natural landscapes (72% of the total), while relatively urbanised areas have 8% and agricultural lands have 20%.The average density of Burgundy snail in the natural landscapes of the study area (4.3 specimens per square metre) was higher compared to the data for the administrative Rivne Oblast (region), where this figure was 2.65 ± 0.23 snails per square metre, respectively. At the same time, the *H. Pomatia* biomass in the natural landscapes of the study area (0.15 t/km^2) is much lower than its average values for the Rivne region in general (0.39 t/km^2).

External morphological features show an elongated shape of mollusc shells, smaller shell volumes and mollusc weight for the snails collected in the urban area, compared to other urban ecosystem elements.

In case of the influence of the urban ecosystem elements on the formation of external morphological features, the impact strength is statistically confirmed for the shell volume (15.29%) and the weight of the Burgundy snail (8.72%). This evidently confirms the sensitivity of the species to anthropogenic fragmentation of their habitats.

In order to restore an effective part of the population, we recommend to make arrangements for artificial plantings in the urban areas of the surveyed transects in the form of green fences from local species of shrubs. We also believe that aiming to prevent reckless depletion of the *H. pomatia* resource base there is a need to conduct periodic monitoring observations of the species.

REFERENCES

Andreev, N. 2006. Assessment of the status of wild populations of *Helix Pomatia* L. in Moldova: the effectof exploitation. CBM Master Theses. Uppsala.

Artemchuk, O.Yu. and Snegin, E.A. 2018. Analysis of the population structure of Helix pomatia (*Mollusca, pulmonata*) on the basis of phenetic features of the shell. 44-47. *Regional Environmental Issues.* ¹3. Belgorod.

Avagnina, G. 1998. Snail Farming: Intensive Snail Farming, Fully Biological Cycle Production. The Trading Hardcover. *International Snail Farming Association.* Ð. 112. Italy

Balashov, I.O., Lukashov, D.V. *and* Sverlova, N.V. 2007. Groundmollusks of Middle Pridnepra: a methodicalmanualand a guide. Kyiv.

Baur, B. and Klemm, M. 1989. Absence of isozyme variationin geographically isolated populations of the landsnail *Chondrinaclienta.* Heredity. V. 63. N 2, P. 239–244. Great Britain.

Coen, L.D. and Bishop, M.J.2015. The ecology, evolution, impacts and management of host–parasite interactions of marine molluscs. *Journal of Invertebrate Pathology.* 131 : P. 177-211. DOI10.1016/ j.jip.2015.08.005. Australia.

El-Gendy, K. S., Radwan, M. A. and Gad, A. F. 2021. Physiological and behavioral responses of land molluscs as biomarkers for pollution impact assessment: A review. *Environmental Research.* 193. P.110558. DOI10.1016/j.envres.2020.110558

Elias, S.A. 2021. Imperiled Invertebrates: Introduction and Overview. *Reference Modulein Earth Systems and Environmental Sciences.* DOI10.1016/b978-0-12-821139-7.00075-1.

Franco, A., Bartz, M., Cherubin, M., Baretta, D., Cerri C., Feigl, B., Wall, D., Davies, C. and Cerri, C. 2016. Loss of soil (macro) fauna due to the expansion of Brazilian sugarcane acreage. P. 160-168. *Science of The Total Environment.* 563 : 160-168. DOI10.1016/ j.scitotenv.2016.04.116.

Gorbunova, N.A. and Nasonova, V.V. 2015. Unconventional sources of animalmeat. *Allaboutmeat.* ¹5. : 46-51. Russia

IUCN Red List of Threatened Species. URL: https:// www.iucn.org/resources/conservation-tools/iucn-red-list-threatened-species

Khlus, L. M., Khlus, K. M. and Gritsyuk, S. B. 2001. Variability of the conlogological features of Helixpomatia L. due to the level of anthropogenicloading. Ð. 90–93. Science. vyn. Uzhgorod. nationalun-tu. Series: Biology. ¹ 10.Uzhgorod.

Lapach, S.N., Chubenko, A.V. and Babich, P.N. 2001. Statistical methods in biomedical research using Excel - 2 d. revised. and up. Morion. Kyiv.

Ovando, X., Miranda, M., Loyola, R. and Cuezzo, M. 2019. Identifying priority areas for invertebrate conservation using land snails as models. *Journal for Nature Conservation.* 50 : 2019. P. 125707 DOI10.1016/ j.jnc.2019.04.004.

Radwan, M. A., El-Gendy, K. S. and Gad, A. F. 2020. Biomarker responses in terrestrial gastropods exposed to pollutants: A comprehensive review. Chemosphere, 257 : 127218. DOI10.1016/ j.chemosphere. 2020.127218.

Rumyantseva, E.G. and Dedkov, V.P. 2004.Population dynamics, size composition and growth rate of young grape snail in Kaliningrad region / Gazette KGU. Ð. 40-46. Pow. 5: Sir. Ecology of the Baltic Sea region. - Kaliningrad.

Shikhova, T.G. 2007. Molluscs are intermediate hosts of helminthintheVyatkaregion / Modern problems of natural resourcemanagement, hunting and animal husbandry. ¹1. p. 483-485. URL:https:// cyberleninka.ru/article/n/mollyuski-promezhutochnye-ozyaeva- gelmintov-promyslovyh-mlekopitayuschih-vyatskogo-regiona Russia

Snegin E. A.2012. Spatial and temporal aspects of the ecological-genetic structure of invertebrate animal populations (for example, ground-based molluscs and insects of the south of the Central Russian Upland). *Autoref. dis... doc. biol. Belgorod.*

Starodubtseva, E.G., Dedkov, V.P. 2003. Helispomatia L. grape snail distribution in the territory of Kaliningrad region, distribution by biotopes and estimation of the number. Gazette of Kaliningrad

Gos. un-ta. Ser. *Ecology of the Baltic Sea region.* Kaliningrad.

Sverlova, N.V. 2003. Scientific nomenclature of ground mollusk fauna of Ukraine. Lviv.

Vrankovic, J., Jankovic-Tomanic, M. and Vukov, T. 2020. Comparative assessment of biomarker response to tissue metal concentrations in urban populations of the land snail Helix pomatia (Pulmonata: Helicidae). *Comparative Biochemistry and Physiology Part B: Biochemistry and Molecular Biology.* 245 : 110448. DOI10.1016/j.cbpb.2020.110448.