CONTRIBUTIONS TO THE KNOWLEDGE OF GASTROPOD SPECIES (MOLLUSCA: GASTROPODA) FROM THE NORTHWESTERN ROMANIA (TINCA AREA, BIHOR COUNTY)

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Abstract. The observations presented in this paper are the result of research conducted in terrestrial ecosystems representative of north-western Romania, the Tinca area, from the south-western Bihor county. The invertebrate fauna of the area is varied, being represented by molluscs, myriapods, spiders, insects and gastropod molluscs, which have an important role in trophic relationships, constituting a factor of accumulation of mass and energy to higher consumers. 27 species were identified, the dominant ones being those belonging to families Clausilidae, Limacidae, Helicidae. The main determinants of the distribution of gastropod species are soil characteristics and vegetation type. The analysis of the age structure highlighted the fact that most species are dominated by breeding and pre-breeding individuals, which demonstrates a growth tendency of the population. Following the analysis of the chemical composition of the shells of *Helix pomatia*, the presence of radioactive metals was not revealed, which proves that the Tinca area is not polluted from this point of view.

Keywords: invertebrates, gastropods, Tinca, Romania.

Rezumat. Contribuții la cunoașterea speciilor de gasteropode (Mollusca: Gastropoda) din nord-vestul României (zona Tinca, județul Bihor). Observațiile prezentate în această lucrare sunt rezultatul cercetărilor efectuate în ecosisteme terestre reprezentative pentru nord-vestul României, respectiv zona Tinca din sud-vestul județului Bihor. Fauna de nevertebrate a zonei este variată fiind reprezentată de moluște, aranee, insecte, între care gasteropodele au un rol important în relațiile trofice, ele constituind un factor de acumulare şi transfer de masă şi energie către consumatorii de ordin superior. Au fost identificate 27 specii, dominante fiind cele aparținând familiilor Clausilidae, Limacidae și Helicidae. Principalii factori determinanți ai distribuției speciilor gasteropode sunt caracteristicile solului și tipul de vegetație. Analiza structurii vârstelor a pus în evidență faptul că la majoritatea speciilor domină indivizii reproducători și pre-reproducători, ceea ce demonstrează tendinţa de creştere a efectivului populaţional. În urma analizei compoziției chimice al cochiliilor speciei *Helix pomatia* nu s-a evidențiat prezența metalelor radioactive, ceea ce demonstrează că zona Tinca nu este poluată din acest punct de vedere.

Cuvinte cheie: nevertebrate, gasteropode, Tinca, România.

INTRODUCTION

The Tinca area is located in the south-western part of Bihor county, belonging to the historical province of Crișana, in the north-western part of Romania (Fig. 1). The climate is temperate-continental, the average altitude is 110 m. The hydrographical network is various: river Crișul Negru, some lakes. The vegetation belongs to the oak stage having a predominant central – European origin (BERINDEI & POP, 1972).

Figure 1. The map with the location of Tinca area (ILIE et al., 2020).

The studies highlighted the biodiversity of terrestrial ecosystems, among which invertebrates have adapted to terrestrial life, to the morphological and functional heterogeneity of habitats. An important role in the biological production of terrestrial ecosystems in the area is played by the populations of gastropods, organisms that actively respond to the heterogeneity of the microhabitats they populate (CIOBOIU, 2005; PURICE & CIOBOIU, 2012; 2020).

MATERIAL AND METHODS

The researches were carried out in the period 2018 – 2020 in hilly and forest ecosystems in the area and the surroundings of Tinca. Seasonal ecological observations were made, the samples were collected manually, applying conventional classification criteria: body size, adaptation to humidity conditions (hydrophilic, mesophilic) or to the connection with the soil as a place of residence (GROSSU, 1983; 1993; NEACȘU & CIOBOIU, 1999; 2000; POPA et al., 2006; MANU et al., 2017; CHIRIAC et al., 2020). Also, 1000 specimens were measured to determine body size (h-height and l-length) (GROSSU, 1993; BOTNARIUC &VĂDINEANU, 1982; CIOBOIU, 2014) in order to determine the age structure. Different methods were used for the chemical analysis of *Helix pomatia* shells: titration, visible spectrophotometric analysis and atomic absorption spectrometry. Twenty snails individuals were used (ILIE, 2021).

RESULTS AND DISCUSSIONS

In the natural and anthropized ecosystems from the Tinca area, 27 species of gastropods were identified (Annex 1), the dominant ones being those belonging to the families *Clausiliidae*, *Limacidae* and *Helicidae* (Table 1).

Table 1. The taxonomic diversity of gastropod species in the Tinca area during 2018 – 2020 (original).

GASTROPODA CLASS Cuvier, 1798	
PULMONATA SUBCLASS Cuvier, 1917	
STYLOMMATOPHORA ORDER A. Schmidt, 1855	
Succineidae family Beck 1837	*Oxyloma elegans* (Risso 1826) *Succinea putris* (Linnaeus 1758) *Succinea oblonga* (Draparnaud, 1801)
Valloniidae family Morse 1864	*Vallonia costata* (O. F. Muller 1774) *Vallonia pulchella* (O. F. Muller 1774)
Enidae family Woodward 1903	*Merdigera obscura* (O. F. Muller 1774) *Chondrula tridens* (O. F. Muller 1774)
Clausiliidae family J. E. Gray 1855	*Cochlodina laminata* (Montagu 1803) *Clausilia cruciata* (Studer 1820) *Clausilia dubia dubia* Draparnaud 1805 *Clausilia pumila* C. Pfeiffer 1828 *Bulgarica cana* (Held 1836)
Arionidae family Gray 1840	*Arion hortensis* (Ferussac 1819)
Zonitidae family Mörch 1864	*Zonitoides nitidus* (O. F. Muller 1774)
Oxychilidae family Hesse & Geyer 1927	*Oxychilus draparnaudi* (Beck 1837) *Oxychilus glaber* (Rossmassler 1835)
Milacidae family Ellis 1926	*Tandonia budapestensis* Hazay 1880
Limacidae family Linnaeus 1758	*Linacus (Limacus) flavus* Linnaeus 1758 *Limax maximus* (Linnaeus 1758) *Deroceras reticulatum* (O. F. Muller 1774) *Deroceras laeve* (O. F. Muller 1774)
Bradybaenidae family Pilsbry 1934	*Bradybaena fruticum* (O. F. Muller 1774)
Hygromiidae family Tryon 1866	*Helicella obvia* (Menke 1821)
Helicidae family Rafinesque, 1815	*Helicopsis striata* (O. F. Muller 1774) *Helix pomatia* (Linnaeus 1758) *Cepaea vindobonensis* (Ferussac 1821) *Helix lucorum* (Rossmassler 1837)

The soil characteristics and type of vegetation are the main determinants of the distribution of gastropod species (CIOBOIU, 2005). In terms of adaptation to terrestrial life we can say that most gastropods are geophilic and depending on the diet are phytophagous and mycophagous. Most terrestrial species are hygrophilous, living in conditions of high soil moisture. Terrestrial molluscs, insects, mites are found in the structure of forest soils where they participate directly in the decomposition of plant matter, thus increasing soil productivity (NEACȘU & CIOBOIU, 2000; PURICE & CIOBOIU, 2012; MANU et al., 2017).

Grassy vegetation represented by *Ranunculus sardous* Crantz., *Chelidonium majus* L., *Polygonum aviculare* L., *Stellaria media* Vill., *Potentilla reptans* L., *Agrimonia eupatoria* L., *Medicago lupulina* L., *Trifolium repens* L., *Trifolium pratense* L. is the food source and the favourite places of the terrestrial molluscs (ILIE et al, 2018). The shrub layer is very well developed, constituting the habitat of terrestrial molluscs.

In natural ecosystems (especially in orchards and forests), species have a low frequency, such as *Succinea putris* and *S. oblonga*, living near waters, in wet orchards (GROSSU, 1993). *Arion hortensis* is a European species, present in all provinces of Romania, the preferred habitat being represented by forests, meadows, orchards, especially in the plain area.

From the observations undertaken in north-western Romania it was found that the species *Helix pomatia* develops mainly in anthropogenic ecosystems (GROSSU, 1983; NEACȘU & CIOBOIU, 1999, 2000). It is a euribiont species, generally in shady and humid places, it is oviparous (Fig. 1). It is a polyphagous species, feeding on hyphae of fungi and superior plants.

Figure 1. *Helix pomatia* L. – adult and eggs (photo Ilie A. L.).

In general, terrestrial gastropods hibernate in a sheltered place or in the ground. The nature of the soil is of great importance to terrestrial gastropods. They prefer the calcareous substrate, because it provides them with material for building the shell, retains water, has a certain humidity, allows the development of a rich vegetation.

Other terrestrial species, common in natural ecosystems (orchards, forests, bushes in hilly areas) and anthropized, respecively cultivated areas (vegetable gardens, fruit tree plantations, viticultural lands) and ruderal lands are: *Helicella obvia*, *Cepaea vindobonensis*, *Helix lucorum*.

Cepaea vindobonensis is a thermophilic species that prefers deciduous and mixed forests, especially in foliage, and the main threat to local populations is the total or partial destruction of vegetation (deforestation, soil erosion, fires). Also, in natural ecosystems, a species harmful to vegetable crops is *Deroceras reticulatum* which causes great damage (GROSSU, 1993; CIOBOIU, 2005).

Physiologically, Bodenheimer (1958) (cited by BOTNARIUC & VĂDINEANU, 1982) divides the life of an organism into three age categories: pre-reproductive (juvenile), reproductive (mature) and post-reproductive (senescent). In populations in which the physiological ages are not obviously marked, the assessment of age according to body size is used. This category includes gastropod populations (Table 2).

The criterion that was the basis for determining the body size of different ages is that of the appearance of the maturation of the sexual elements and their disappearance. For this purpose, measurements were applied to determine the height – the value in mm of the distance between the apex and the tip of the siphon channel and the length (l) – the distance between the outer edge of the last turn (anfract) and the outer edge of the aperture, except for species of the genera *Arion, Tandonia, Limax* and *Deroceras* in which only the length of the body is measured.

The age structure was established based on the analysis of a number of 1000 specimens. Measurements show that the size of juvenile (pre-reproductive) specimens of the species *Oxyloma elegans*, *Succinea putris*, *S. oblonga*, *Vallonia costata*, *V. pulchella*, *Zonitoides nitidus*, *Oxychilus draparnaudi*, *O. glaber*, *Helicella obvia*, *Helicopsis striata* is between h = 01 and 5-6 mm and l = 0.1 and 2-5 mm, reproductive specimens (sexually mature) h = 5,1 and 4,1-18 mm, l = 1.9-20 mm, and post-reproductive (senescent) h = 1.8-11 mm, l = 3-18 mm. The dimensions of other species are included (Table 2) for pre-reproductive specimens: h = 0.1-14 mm, l = 0.1-100 mm; reproductive specimens: h = 10-40 mm, l = 15-200 mm; post-reproductive specimens: h = 18-60 mm, l = over 40 mm.

Table 2. Dimensional values for different age categories in gastropod populations.

SPECIES	**BODY DIMENSIONS CHARACTERISTIC OF DIFFERENT AGE CATEGORIES (h, l = mm)**		
	Pre-reproductive	**Reproductive**	**Post-reproductive**
Oxyloma elegans	h = 8-14; l = 3-5	h = 14.1-20; l = 5.1-8	h = over 20.1; l = over 8.1
Succinea putris	h = 10-16; l = 5-8	h = 16.1-22; l = 8.1-11	h = over 22.1; l = over 11.1
Succinea oblonga	h = 3-7; l = 1-3	h = 7.1-8; l = 3.1-5	h = over 8.1; l = over 6.1
Vallonia costata	h = 0.1-1; l = 0.1-2	h = 1.1-1.3; l = 2.1-2.7	h = over 1.3; l = over 2.7
Vallonia pulchella	h = 0.1-0.9; l = 0.1-1.5	h = 1-1.2; l = 1.6-2.2	h = over 1.2; l = over 2.2
Merdigera obscura	h = 5-8; l = 1-2	h = 8.1-10; l = 2.1-4	h = over 10.1; l = over 4.1

Chondrula tridens	h = 3.5-8; l = 1-3.4	h = 8.1-15; l = 3.5-5	h = over 15.1; l = over 5.1
Cochlodina laminata	h = 5-12; l = 0.5-2	h = 12.1-18; l = 2.1-4	h = over 18.1; l = over 4.1
Clausilia cruciata	h = 5.1-9; l = 0.1-1	h = 9.1-11; l = 1.1-2.5	h = over 11.1; l = over 2.6
Clausilia dubia dubia	h = 6-11; l = 1-2	h = 11.1-15; l = 2.1-3.5	h = over 15.1; l = over 3.6
Clausilia pumila	h = 5-10; l = 0.5-3	h = 10.1-13; l = 3.1-4	h = over 13.1; l = over 4.1
Bulgarica cana	h = 10-15; l = 0.5-2	h = 15.1-17; l = 2.1-3.7	h = over 17; l = over 3.8
Arion hortensis	l = 10-20	l = 20.1-33	l = over 33.1
Zonitoides nitidus	h = 0.1-2; l = 1-3	h = 2.1-3.5; l = 3.1-6	h = over 3.6; l = over 6.1
Oxychilus draparnaudi	h = 2.1-4.6; l = 6.1-11	h = 4.7-7; l = 11.1-14	h = over 7.1; l = over 14.1
Oxychilus glaber	h = 2-4; l = 7-11	h = 4.1-6.5; l = 11.1-14	h = over 6.6; l = over 14.1
Tandonia budapestensis	l = 15-30	l = 30.1-60	l = over 60.1
Linacus (Limacus) flavus	l = 35-60	l = 60.1-110	l = over 110.1
Limax maximus	l = 50-100	l = 100.1-200	l = over 200.1
Deroceras reticulatum	l = 20-45	l = 45.1-75	l = over 75.1
Deroceras laeve	l = 10-25	l = 25.1-90	l = over 90.1
Bradybaena fruticum	h = 6-11; l = 9-15	h = 11.1-18; l = 15.1-21	h = over 18.1; l = over 21.1
Helicella obvia	h = 2.5-4; l = 7-11	h = 4.1-8.2; l = 11.1-16	h = over 8.3; l = over 16.1
Helicopsis striata	h = 1.5-3; l = 4-7	h = 3.1-6; l = 7.1-10	h = over 6.1; l = over 10.1
Helix pomatia	h = 12-22; l = 7-25	h = 22.1-38; l = 25.1-40	h = over 38.1; l = over 40.1
Cepaea vindobonensis	h = 6-12; l = 8-15	h = 12.1-18; l = 15.1-21	h = over 18.1; l = over 21.1
Helix lucorum	h = 10-24; l = 12-30	h = 24.1-35; l = 30.1-60	h = over 35.1; l = over 60.1

It should be emphasized that in the case of natural populations, without exception, the distribution by size and age classes is constantly changing, leading to a differentiated elimination by age. Thus, in the researched gastropod populations, the age structure is characteristic of each species (Table 3).

From the analysis of table 3 it results that in most species (23 species) the pre-reproductive and reproductive ages between 23.08 % - 37.74 % and 50.08 % - 63.15 % respectively, dominated. In the species *Oxyloma elegans* there were no pre-reproductive specimens, and in the species *Succinea putris* and *Merdigera obscura* there were no post-reproductive specimens. This can be considered an accident due to the collection system.

The dominance of pre-reproductive and reproductive specimens in most species indicates that their populations are in full numerical progress. In the species *Oxyloma elegans*, *Succinea putris* and *Merdigera obscura*, the lack of age categories shows a reduction in population numbers.

Table 3. Age distribution in the analysed gastropod populations in the Tinca area (total and percentage values).

SPECIES	**AGE**					
	Pre-reproductive		**Reproductive**		**Post-reproductive**	
Oxyloma elegans	-	-	2	66.66 %	1	33.33 %
Succinea putris	2	28.57 %	5	71.43 %	-	-
Succinea oblonga	2	33.33 %	3	50.00 %	1	16.67 %
Vallonia costata	3	30.00 %	6	60.00 %	1	10.00 %
Vallonia pulchella	4	30.77 %	7	53.85 %	2	15.38 %
Merdigera obscura	1	25.00 %	3	75.00 %	-	-
Chondrula tridens	3	23.08 %	8	61.54 %	2	15.38 %
Cochlodina laminata	2	28.57 %	4	57.14 %	1	14.29 %
Clausilia cruciata	10	35.71 %	15	53.57 %	3	10.72 %
Clausilia dubia dubia	15	32.61 %	25	54.35 %	6	13.04 %
Clausilia pumila	9	34.62 %	14	53.85 %	3	11.53 %
Bulgarica cana	8	30.77 %	16	61.54 %	2	7.69 %
Arion hortensis	5	35.71 %	8	57.14 %	1	7.15 %
Zonitoides nitidus	8	40.00 %	10	50.00 %	2	10.00 %
Oxychilus draparnaudi	12	36.36 %	18	54.54 %	3	9.10 %
Oxychilus glaber	11	37.93 %	16	55.17 %	2	6.90 %
Tandonia budapestensis	5	33.33 %	9	60.00 %	1	6.67 %
Linacus (Limacus) flavus	4	30.77 %	8	61.54 %	1	7.69 %
Limax maximus	12	34.29 %	18	51.43 %	5	14.28 %
Deroceras reticulatum	8	32.00 %	14	56.00 %	3	12.00 %
Deroceras laeve	6	31.59 %	12	63.15 %	1	5.26 %
Bradybaena fruticum	8	34.78 %	12	52.17 %	3	13.05 %
Helicella obvia	15	32.61 %	25	54.35 %	6	13.04 %
Helicopsis striata	25	35.71 %	35	50.00 %	10	14.29 %
Helix pomatia	60	35.29 %	85	50.00 %	25	14.71 %
Cepaea vindobonensis	50	35.71 %	75	53.57 %	15	10.72 %
Helix lucorum	60	37.74 %	80	50.31 %	19	11.95 %

The share of young specimens but also of mature ones is relevant, an essential factor for a constant, weighted growth of populations. This demonstrates that environmental and biotic factors (those related to food) are conducive to the development of gastropod populations (CIOBOIU, 2014).

Studies have also been carried out on the chemical composition of *Helix pomatia* shells in the Tinca area (ILIE, 2021). Titration was performed to identify $CaCO_3$, highlighting a high percentage, between 87.15 – 93.17%. To identify silica, the visible spectrophotometric analysis method was used. An amount of SiO_2 between 32 – 37 mg/l was identified.

For the identification of zinc, the analysis was applied by atomic absorption spectrometry, highlighting an amount of zinc between 9.29 – 9.56. No traces of radioactive metals were identified, which means that the Tinca area is not polluted from this point of view.

CONCLUSIONS

Out of the total of 27 species of gastropods identified in the terrestrial ecosystems from north-western Romania (Tinca area, Bihor county), the dominant ones are those belonging to the families Clausiliidae, Limacidae and Helicidae. The main determining factors of the distribution of gastropod species are the characteristics of the soil and the type of vegetation.

The age structure was established based on the analysis of a number of 1000 specimens. Following the measurement of body size and age distribution, the predominance of pre-reproductive and reproductive specimens in most species was found, which indicates that their populations are in full numerical progress. It demonstrates that abiotic and biotic (trophic) environmental factors are conducive to the development of gastropod populations.

Following the analysis of the chemical composition of the shells of *Helix pomatia*, the presence of radioactive metals was not revealed, which proves that the Tinca area is not polluted from this point of view.

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Annex 1. Species of gastropods from the Tinca area (Photo: ILIE A. L.)

Tandonia budapestensis Haz.

Limacus flavus L.

Limax maximus L.

Deroceras reticulatum Mull.

Deroceras laeve Mull.

Cepaea vindobonensis Fer.

Bradybaena fruticum Mull.

Vallonia pulchella Mull.