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MALACOFAUNA OF A CITY PARK – TURNOVER AND PERSISTENCE OF SPECIES THROUGH 40 YEARS

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ABSTRACT: In urban areas the turnover of species is fairly rapid, species of natural habitats become eliminated and invasion of alien species takes place. An example of these process was investigated in Łódź, Poland. The present mollusc fauna of a city park was compared with the results obtained 40 years ago. The estimated turnover index for terrestrial gastropods was 0.29 and for molluscs of park ponds – 0.4. In the recent inventory 57 species were recorded, compared to the 48 in the 1950s. Some stenoecious gastropods, e.g. *Discus ruderatus*, *Ruthenica filograna*, *Malacolimax tenellus*, *Nesovitrea petronella* were not re-found. Species recorded for the first time included synanthropic *Oxychilus draparnaudi*, *Helix pomatia*, *Cepaea nemoralis*, *Arion rufus*, *Limax maximus* and open-country snails, e.g. *Cochlicopa lubricella* and *Vallonia excentrica*. Considerable changes were observed in the composition of the malacofauna of park ponds. The following species were found for the first time: *Viviparus contectus, Potamopyrgus antipodarum, Hippeutis complanatus* and *Anodonta cygnaea*. The newly recorded species were probably brought with soil, plants, stocking fish, could be transported by birds or introduced on purpose. The changes in the fauna result also from intense penetration by humans, decrease in the ground water level, emptying and cleaning of the ponds and changes in the water supply.

KEY WORDS: urban habitat, synanthropic species, invasive species, extinction, Mollusca

INTRODUCTION

Some urban habitats in Europe are mollusc-rich. The number of terrestrial species varies from about 60 e.g. in Wrocław, Lviv, Köln to as many as 100 in Prague, and the total number of mollusc species exceeds 140 in Prague and Berlin (KOSIŃSKA 1979, JUŘIČKOVÁ 1995, TAPPERT 1996, SVERLOVA 2000). The fact that cities are often richer in species (plants and some animal taxa) than the surrounding areas results from their great habitat diversity (KLAUSNITZER 1993). It is generally agreed that for urban communities the species turnover can be particularly high, since the existing conditions favour both immigration and local extermination (REBELE 1994, and literature cited therein). As the processes are determined by human activity and not by biological interactions or by the dispersal abilities of the species, the number of species is not balanced and can either increase or decrease. Both native and anthropochorous species take part in the colonisation. For plant communities successful colonisers are native species, usually adapted to naturally disturbed habitats e.g. river banks (REBELE 1994). In comparison to near-natural habitats, a higher proportion of species introduced from other geographical regions (alien species) could establish themselves in cities. The local extinction in the cities affects in particular species from communities in natural or near-natural sites such as forests. The reasons for this are direct destruction of habitats by construction work, decreasing ground water level or eutrophication which can lead to changes in population abundance or even local extinction. The park in Łódź, studied in the 1950s, offered a rare opportunity to trace the process of fauna turnover and succession of animal communities.

The aim of this study was to follow the development of an urban mollusc community in Łódź, the second biggest city of Poland. Although the molluscs of the agglomeration have never been inventoried as a whole, there were detailed records of their occurrence in the biggest city park "Na Zdrowiu" (PIECHOC-

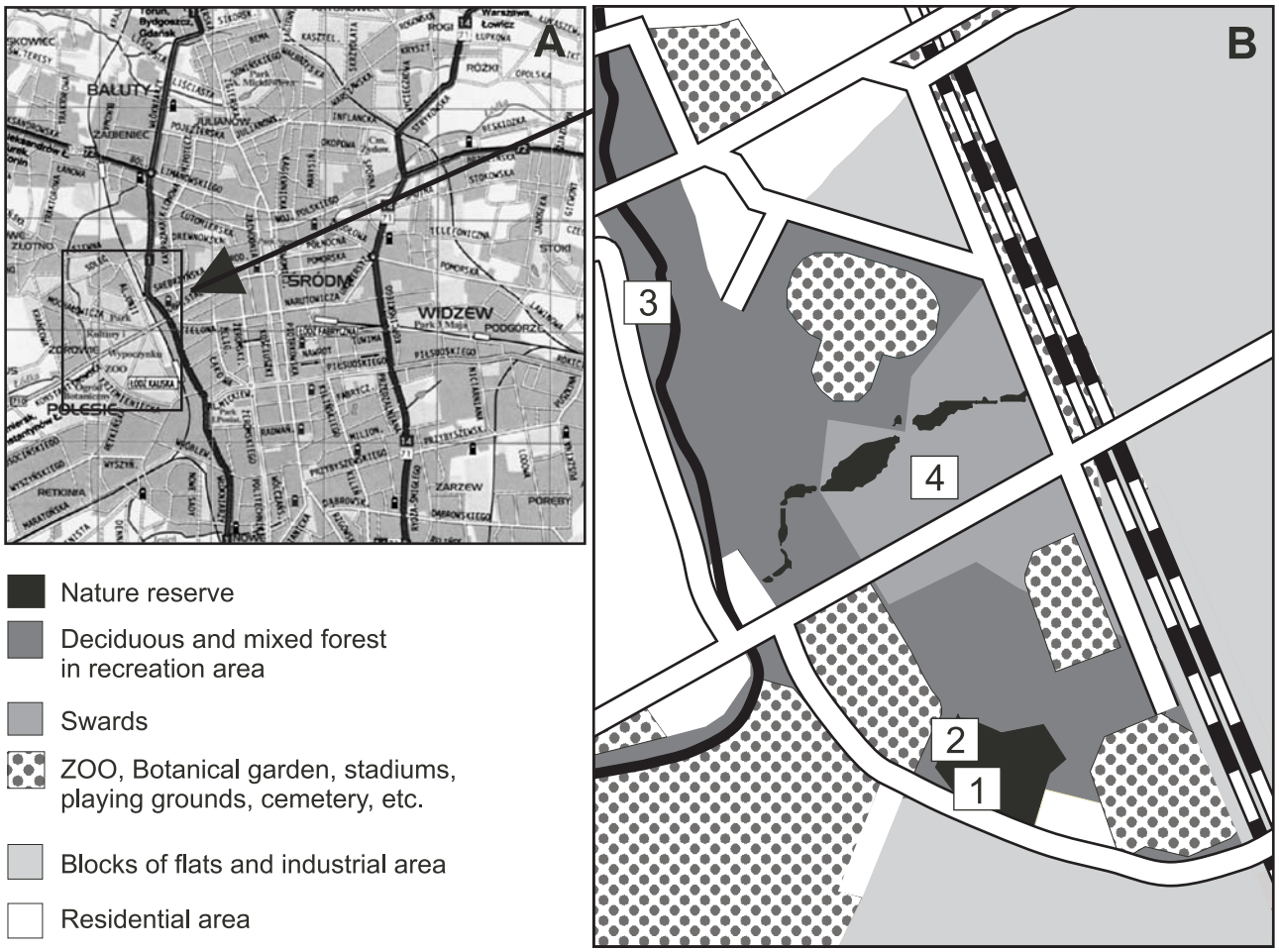

Fig. 1. A – localization of the park "Na Zdrowiu" in the city of Łódź, B – map of the park with sites of quantitative sampling

KI 1963). Since the time of the first study, anthropogenic pressure has become more intense. The park, originally located at the outskirts of Łódź, became surrounded by buildings as the city enlarged (Fig. 1). It was assumed that the intervening period of 40 years was sufficient to observe extinction of some native species and invasion of alien ones. Similar studies in Łódź concerning other groups of animals were reported in MARKOWSKI et al. (1998).

HISTORY OF HUMAN DISTURBANCE

The area of Łódź remained almost entirely forested till very recently. At the end of the 18th c., woods covered about 75% of the region, but at the beginning of the 19th c., as a result of a very rapid development of industry, their surface began to shrink (to 30% in 1828) (KOTER 1980a). Until the 20th c. a large forest patch remained intact at the western outskirts of Łódź. During the construction of the Warsaw–Kalisz railway in 1902 that forest was divided into two parts; the eastern part was converted into a city park in 1910. The western part was heavily depleted during the coal shortage in World War I. At that time the forest surface area shrunk from 400 to 115 ha (MOWSZOWICZ et al. 1962). Conversion of the forest remnants and glades into a large recreation area (ca. 230 ha) began in 1924. The terrain was flattened for stadiums, playgrounds, zoological garden, etc. and planted with thousands of trees and bushes. Additionally, several ponds were dug in a natural depression of the dried-up brook Patok (see maps in KOTER 1980b). They were filled with rainfall and ground water, with a minor supply from an engine-house and a swimming pool. Two brooks, Łódka and Bałutka, which joined at the western edge of the park, were canalised.

Since 1930 the most natural part of the forest has been protected as a nature reserve "Polesie Konstantynowskie" (KUROWSKI et al. 1996). It covered 9.8 ha and was surrounded by a fence to prevent from treading. The oak-hornbeam forest predominates in the protected area. There are also patches of humid

euthrophic forests (alder carr and ash-alder riverine forest) in the reserve. In the early spring the ground is usually partly submerged but depressions and ditches almost completely dry up during the summer and autumn. As many as 150 plant species were recorded in the nature reserve; canopy layer: *Carpinus betulus*, *Alnus glutinosa*, *Quercus robur*, *Betula verrucosa*; shrubs: *Frangula alnus*, *Padus avium*, *Corylus avellana*, *Sambucus nigra*, *Sambucus racemosa*, *Evonymus europaea*; dominant herbs: *Anemone nemorosa*, *Stellaria nemorum*, *Ranunculus repens*, *Asarum europaeum* and *Hedera helix*.

In 1970s the park was entirely surrounded by residential areas and the blocks of flats for ca. 50,000 inhabitants. Negative consequences of the drainage of the surrounding areas were soon visible in the park. The ponds began to dry up in the 1980s. At present the water is pumped every week in the summer from a deep well to maintain the water level, but in the winter the ponds are allowed to dry up. Recently extinction of *Abies alba* and receding of *Picea abies* in the nature reserve have also been noticed (KUROWSKI et al. 1996).

MATERIAL AND METHODS

The sampling was carried out in 2002–2005; in terrestrial habitats (the nature reserve and managed park area) repeated visual search for snails and slugs was supplemented with quantitative sampling. The litter samples (4×0.25 m^2) were collected in four types of habitats. Molluscs from the ponds were collected twice: in June and July 2002, with a swiping net by Dr. G. Tończyk. The brooks Łodka and Bałutka were not sampled because the water quality is very low as they gather waste from the city rainfall. The total number of identified specimens exceeded 4,500.

For comparison with the present results the data from PIECHOCKI (1963), PIECHOCKI & POTOCKI (1976), ABRASZEWSKA-KOWALCZYK (1996) and KOWALCZYK (1996) were used. Nomenclature throughout follows FAUNA EUROPAEA (2004).

Malacocoenosis persistence was measured with the faunal turnover index (DIAMOND & MAY 1977): $T=(C+E)/(S1+S2)$, where: C – number of species that colonised the area, E – number of species that became extinct in the area, S1 and S2 – number of species identified in samples in the 1950s and in 2002–2005. Persistence (PR) was calculated as: $PR=1-T$. The values of both indices vary from 0 to 1.

RESULTS AND DISCUSSION

Some authors, e.g. KOSIŃSKA (1979) and PROSCHWITZ (1988) have already shown that terrestrial species composition in urban environments depends on two phenomena: 1. only some native species survive constant human influence, 2. introduced fauna spreads easily. The comparison of the previous and contemporary species lists of the study area (Table 1) reveals that the land snail fauna of the park changed significantly during the last 40 years, though most earlier recorded species were still present. For example the author re-found rich populations of *Alinda biplicata* and *Oxychilus alliarius*, which are quite rare in Central Poland. Nevertheless, the direction of the faunal changes corresponds with the previously mentioned scheme. The total number of species slightly increased, and in the turnover of species gastropods inhabiting natural forests were replaced by eurytopic or synanthropic species.

Among the species which probably withdrew from the park are forest gastropods *Discus ruderatus* and *Ruthenica filograna*. Both species have retreated from many previously known localities in Poland (RIEDEL 1988, WIKTOR 2004). *R. filograna* has become eliminated also from the city of Lviv during the last 100 years (SVERLOVA 1999). PIECHOCKI (1963) recorded *Nesovitrea petronella* from mixed and dry pine forests in the park. This boreo-montane species, which usually lives in humid and well-shaded places (RIEDEL 1988), was not re-found recently. *Malacolimax tenellus,* inhabiting mainly humid deciduous forests, sometimes parks and coniferous forests (WIKTOR 2004), has not been recorded at present, and in the 1950s it was collected only in the nature reserve (PIECHOCKI 1963). Stenoecious species are negatively affected by intense penetration by humans, which is unavoidable because of the location and function of the area. The absence of hygrophilous *Succinella oblonga* and *Oxyloma elegans* suggests that the area dried up to some extent. This view is supported by the first records of *Cochlicopa lubricella*, *Vallonia costata* and *V. excentrica*, grassland dwellers, characteristic for warm and dry habitats.

The following species not recorded earlier were found: *Arion fasciatus*, *Limax maximus*, *Deroceras sturanyi*, *Oxychilus draparnaudi*, *Helix pomatia* and *Cepaea nemoralis*. These were classified by most authors (e.g. KOSIŃSKA 1979, SVERLOVA 2000) as synanthropic, preferring man-made habitats to natural ones. Large helicids *Arianta arbustorum*, *Cepaea nemoralis* (both

Table 1. List of mollusc species recorded in the park "Na Zdrowiu"

	Species	Data sources			
		PIECHOCKI (1963)	PIECHOCKI & POTOCKI (1976)	ABRASZEWSKA-KOWALCZYK (1996), KOWALCZYK (1996)	Field sampling 2003–2005
1	*Carychium minimum* O. F. Müller, 1774	+			+
2	*Carychium tridentatum* (Risso, 1826)	+		+[2]	+
3	*Succinea putris* (Linnaeus, 1758)	+		+[2]	+
4	*Oxyloma elegans* Risso, 1826	+			
5	*Succinella oblonga* Draparnaud, 1801	+			
6	*Cochlicopa lubrica* (O. F. Müller, 1774)	+			+
7	*Cochlicopa lubricella* (Porro, 1838)				+
8	*Vertigo substriata* (Jeffreys, 1833)				+
9	*Vertigo pusilla* O. F. Müller, 1774	+			+
10	*Vertigo pygmaea* (Draparnaud, 1801)	+			+
11	*Columella edentula* (Draparnaud, 1805)	+			+
12	*Pupilla muscorum* (Linnaeus, 1758)	+			+
13	*Vallonia costata* (O. F. Müller, 1774)				+
14	*Vallonia pulchella* (O. F. Müller, 1774)	+			+
15	*Vallonia excentrica* (Sterki, 1893)				+
16	*Acanthinula aculeata* (O. F. Müller, 1774)				+
17	*Discus rotundatus* (O. F. Müller, 1774)	+			+
18	*Discus ruderatus* (Férussac, 1821)	+			
19	*Punctum pygmaeum* (Draparnaud, 1801)				+
20	*Arion rufus* (Linnaeus, 1758)			+[2]	+
21	*Arion fuscus* (O. F. Müller, 1774)	+			+
22	*Arion fasciatus* (Nilsson, 1822)				+
23	*Arion circumscriptus* Johnston, 1828	+			+
24	*Vitrina pellucida* (O. F. Müller, 1774)	+			+
25	*Vitrea crystallina* (O. F. Müller, 1774)				+
26	*Nesovitrea hammonis* (Ström, 1765)	+			+
27	*Nesovitrea petronella* (L. Pfeiffer, 1853)	+			
28	*Oxychilus alliarius* (Miller, 1822)	+			+
29	*Aegopinella pura* (Alder, 1830)	+			+
30	*Oxychilus draparnaudi* (Beck, 1837)				+
31	*Zonitoides nitidus* (O. F. Müller, 1774)	+			+
32	*Limax maximus* Linnaeus, 1758				+
33	*Malacolimax tenellus* (O. F. Müller, 1774)	+			
34	*Deroceras reticulatum* (O. F. Müller, 1774)	+			+
35	*Deroceras sturanyi* (Simroth, 1894)				+
36	*Deroceras leave* (O. F. Müller, 1774)	+			+
37	*Deroceras agreste* (Linnaeus, 1758)	+			
38	*Euconulus fulvus* (O. F. Müller, 1774)	+			+
39	*Balea biplicata* (Montagu, 1803)	+			+
40	*Ruthenica filograna* (Rossmässler, 1836)	+			
41	*Fruticicola fruticum* (O. F. Müller, 1774)	+			+
42	*Arianta arbustorum* (Linnaeus, 1758)			+[2]	+

	Species	Data sources			
		PIECHOCKI (1963)	PIECHOCKI & POTOCKI (1976)	ABRASZEWSKA-KOWALCZYK (1996), KOWALCZYK (1996)	Field sampling 2003–2005
43	*Helix pomatia* Linnaeus, 1758			+[2]	+
44	*Trichia hispida* (Linnaeus, 1758)	+			+
45	*Cepaea nemoralis* (Linnaeus, 1758)			+[2]	+
46	*Cepaea hortensis* (O. F. Müller, 1774)	+		+[2]	+
47	*Monachoides incarnatus* (O. F. Müller, 1774)	+			+
48	*Perforatella bidentata* (Gmelin, 1791)	+			+
49	*Xerolenta obvia* (Menke, 1828)	+			+
50	*Bithynia tentaculata* (Linnaeus, 1758)			+[2]	
51	*Potamopyrgus antipodarum* (Gray, 1843)				+
52	*Viviparus contectus* (Millet, 1813)				+
53	*Gyraulus crista* (Linnaeus, 1758)	+		+[2]	+
54	*Gyraulus albus* (O. F. Müller, 1774)	+[2]		+[2]	+
55	*Gyraulus leavis* (Alder, 1838)	+	+		
56	*Gyraulus rossmaessleri* (Auerswald, 1851)				+[3]
57	*Planorbarius corneus* (Linnaeus, 1758)	+	+	+[2]	+
58	*Planorbis planorbis* (Linnaeus, 1758)	+			
59	*Bathyomphalus contortus* (Linnaeus, 1758)			+[2]	
60	*Segmentina nitida* (O. F. Müller, 1774)	+[1]		+[2]	
61	*Hippeutis complanatus* (Linnaeus, 1758)				+
62	*Radix auricularia* (Linnaeus, 1758)	+	+	+[2]	+
63	*Stagnicola palustris* (O. F. Müller, 1774)	+[1]		+[2]	
64	*Radix labiata* Rossmässler, 1835		+	+[2]	+
65	*Lymnaea stagnalis* (Linnaeus, 1758)	+	+	+[2]	+
66	*Galba truncatula* (O. F. Müller, 1774)	+		+[2]	+[3]
67	*Aplexa hypnorum* (Linnaeus, 1758)	+[1]			+[3]
68	*Physella acuta* (Draparnaud, 1805)		+		
69	*Sphaerium corneum* (Linnaeus, 1758)	+[1]			
70	*Musculium lacustre* (O. F. Müller, 1774)	+		+[2]	+
71	*Pisidium obtusale* (Lamarck, 1818)				+[3]
72	*Pisidium subtruncatum* Malm, 1855	+			
73	*Anodonta cygnea* (Linnaeus, 1758)				+
	Number of species	48	6	19	57

[1] – recorded only in a clay-pit close to the park
[2] – recorded in the Botanical Garden
[3] – recorded only in temporarily submerged places in the nature reserve

very abundant and more common now than *C. hortensis*), *Helix pomatia* and a slug *Arion rufus* were initially found in the Botanical Garden (KOWALCZYK 1996). These species could be brought with soil or ornamental plants or were introduced on purpose. The only known intentional introduction took place in the 1960s, when about 100 specimens of *A. rufus* brought from the Polish coast were released close to the mouth of the Bałutka stream (PIECHOCKI, pers. comm.). Nowadays the slugs are very abundant in the park (on lawns and in mixed forest) and are occasionally found also in the nature reserve. Although the species was regarded as indifferent to anthropogenic habitats in Wrocław (KOSIŃSKA 1979), it can be classified as a true synanthrope in Central Poland, where it is outside its natural range.

The numbers of species in quantitative samples in the nature reserve and the recreation area were similar but the density of molluscs differed locally (Table 2). The difference in fauna composition between the

Table 2. Species richness, abundance and dominant taxa in quantitative samples

Locality	1 Nature reserve	2 Nature reserve	3 Recreation area	4 Recreation area
Type of habitat	Hornbeam forest	Alder forest	Alder forest	Grassland
No. species	13	17	14	15
Density (No. specimens/m^2)	177	885	395	561
Dominant species (>5%)	*Alinda biplicata*	*Carychium tridentatum*	*Discus rotundatus*	*Vallonia excentrica*
	Arianta arbustorum	*Discus rotundatus*	*Cochlicopa lubrica*	*Cochlicopa lubrica*
	Nesovitrea hammonis	*Nesovitrea hammonis*	*Arianta arbustorum*	*Nesovitrea hammonis*
	Oxychilus alliarius		*Nesovitrea hammonis*	*Trichia hispida*
	Discus rotundatus		*Zonitoides nitidus*	*Vertigo pygmaea*
	Aegopinella pura		*Trichia hispida*	*Vallonia costata*
	Carychium tridentatum			Agriolimacidae*

*Agriolimacidae – *Deroceras reticulatum*, *D. sturanyi* and juveniles = 10.7% of community

protected and unprotected area concerns the percentage of woodland, hygrophilous and open-country snails in the malacocenoses, but the species lists are quite similar. For example, *Alinda biplicata, Oxychilus alliarius* and *Perforatella bidentata* were frequently found in the nature reserve, but sporadically also in its close vicinity. In the reserve 28 species of terrestrial gastropods were found (7 species only here, e.g. woodland snails *Acanthinula aculeata, Fruticicola fruticum* and hygrophilous species *Carychium tridentatum, Columella edentula* and *Vertigo substriata*). The reserve is inhabited also by some aquatic molluscs, such as *Galba truncatula*, *Aplexa hypnorum*, *Gyraulus rossmaessleri* and *Pisidium obtusale*, typical for unstable, temporary water bodies. The last two species were not previously recorded from the area. As many as 36 species were recorded outside the nature reserve (14 species only in the managed area). The majority of them are open-country species: *Cochlicopa lubricella*, *Vallonia costata*, *V. pulchella*, *V. excentrica*, *Vertigo pygmaea, Xerolenta obvia* and *Pupilla muscorum,* but also euryecious *Vitrina pellucida* and *Punctum pygmaeum* were present.

The malacofauna of the park ponds is not diverse. *Gyraulus albus, Planorbarius corneus* and *Musculium lacustre* were the most common (6–7 out of 9 water bodies) and abundant. In the present study the following species were found for the first time: *Potamopyrgus antipodarum* (recorded only in the biggest pond), *Anodonta cygnea* (1 adult specimen probably introduced) and *Viviparus contectus* (abundant in two ponds). In the 1970s an abundant population of *Physella acuta* was observed in one of the ponds (PIECHOCKI & POTOCKI 1976). Despite the repeated sampling in this place the species was not found in this study.

During the last forty years changes in the park environment resulted mainly from the decreased ground water level and more intensive trespassing by visitors. For the land molluscs the turnover index was estimated as 0.29, thus fauna persistence index was 0.71. For the aquatic malacofauna (estimation only for the park ponds) the turnover index was even higher (0.40). Similarly, water malacofauna experienced a quicker turnover in the Prague agglomeration (JUŘIČKOVÁ 1995). Considerable changes in the composition of water malacofauna in the studied park could be enhanced by emptying of the reservoirs, cleaning their bottom and changes in the water supply to the ponds. New species were introduced during stocking with fish, transported by birds or released by aquarists.

PROSCHWITZ (1988) distinguished four groups of species in the malacofauna of Gothenburg: indigenous/native with different ability to survive in man-made habitats and antropochorous of different time of introduction. In his opinion *Arion lusitanicus* and *Boettgerilla pallens* were the last immigrants to Sweden. None of these were collected in Łódź, but their distribution range in Poland is still extending (WIKTOR 2004). In the present study *Arion rufus* and *Cepaea nemoralis* seemed to be the most widespread among species introduced recently in the park. The fact of spreading of *C. nemoralis* more rapidly than before was also observed in the Czech Republic (DVOŘAK & HONĚK 2004).

Where the whole city was sampled for molluscs it was possible to recognise different zones of human impact, with corresponding snail communities. According to JUŘIČKOVÁ (1995), *Acanthinula aculeata, Punctum pygmaeum*, *Arion subfuscus* and *Nesovitrea hammonis* were indicator species for the zone with moderate human impact, while *Malacolimax tenellus, Euconulus fulvus*, *Columella edentula* and *Vertigo pusilla* inhabited only the near-natural habitats. In Lviv the malacofauna of parks located in forest remnants differed from the fauna of the parks created in previously open habitats in the presence of some stenoecious species, such as *Bulgarica cana* and *Limax cinereoniger* (SVERLOVA 2000). The species number in the first kind of parks was 23–34, while in the second type only 8–9 species were recorded, mainly synan-

thropic snails and slugs such as *Cepaea hortensis* and *Deroceras reticulatum* (SVERLOVA 1999, 2000). Compared to the results of JUŘIČKOVÁ (1995), the malacofauna in the park "Na Zdrowiu" is at present at a transitional stage, probably closer to moderate human impact zone, while in the 1950s it was clearly one of a near-natural habitats.

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