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QUANTITATIVE STUDIES ON TERRESTRIAL GASTROPODS OF THE DRAWA NATIONAL PARK

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ABSTRACT: The terrestrial gastropod fauna of the Drawa National Park includes 39 species, of which 29 (74.4%) were present in quantitative samples and subject to quantitative analysis. Dominant species were *Aegopinella nitidula* (Drap.), *Discus rotundatus* (O. F. Müll.) and *Vitrea crystallina* (O. F. Müll.). Snail communities of acid beech forest and a ruderal site with park tree stands in a mixed forest with beech had the highest species diversity index H', while those of a eutrophic lowland beech forest and acid oak forest showed the highest TDI index of species diversity, and equitability index (J). The mean snail density was 19.3 indiv. m^{-2}. The presence of *Macrogastra ventricosa* (Drap.), *Laciniaria plicata* (Drap.), *Bulgarica cana* (Held) and *Helicigona lapicida* (L.) is noteworthy.

KEY WORDS: Drawa National Park, Poland, terrestrial gastropods, malacocoenosis structure

INTRODUCTION

The Drawa National Park is located in the central part of the Drawa Plain mesoregion which, from natural history viewpoint, is among the most interesting areas in the entire South Pomeranian Lakeland. The apparently monotonous Drawa National Park is actually diverse, since it includes very picturesque valleys of the Drawa and Płociczna rivers, with deep gorges and ravines, and steep slopes covered by acid and eutrophic lowland (Pomeranian) beech forests, as well as hornbeam and oak tree stands. Well-preserved fragments of riverine forests are found on valley bottoms. Most of the Drawa National Park is covered by an oak forest with beech and pine, termed acid oak forest; pine forests grow on the sands in the Płociczna River catchment area.

MATERIAL AND METHODS

Terrestrial gastropods in the Drawa National Park were sampled in nine sites in 1985–1987. Quatitative samples were taken with square frame 25 × 25 cm and then sieved. In each of three seasons (spring, summer, autumn), eight random samples were taken, adding up to a basic sample of 0.5 m^2. During the three years of studies, a total of 136 basic samples were taken from the total area of 68.0 m^2. The quantitative studies were supplemented with visual search. A total of 1,745 specimens were collected representing 39 species; the quantitative samples contained 1,309 specimens of 29 species (74.4%). Nomenclature and systematic arrangement follow KERNEY et. al. (1983).

The following ecological indices were used in the data analysis: density, dominance (D), frequency (C), Q index (combining frequency and abundance), TDI species diversity index, which directly compares equitability and diversity of communities, irrespective of their component taxa; Shannon species diversity index (H'), Pielou's equitability index (J), similarity index according to Marczewski and Steinhaus, as well as ecological and zoogeographical groupings (MARCZEWSKI & STEINHAUS 1959, PIELOU 1974, KASPRZAK & NIEDBAŁA 1981, ŁUCZAK & WIERZBOWSKA 1981, ALEKSANDROWICZ 1987, RIEDEL 1988, TROJAN 1992).

Table 1. Species found in the studied sites of the Drawa National Park; species found only qualitatively marked with an asterisk

Species	Site								
	1	2	3	4	5	6	7	8	9
Ellobiidae									
Carychium minimum O. F. Müller, 1774	+	+	-	+	-	-	-	-	-
Cochlicopidae									
Cochlicopa lubrica (O. F. Müller, 1774)	+	-	+	+	+	-	+	+	+
Cochlicopa lubricella (Porro, 1838)	+	-	+	+	+	-	+	-	+
Cochlicopa nitens (Gallenstein, 1852)	+	-	+	+	-	-	+	+	+
Vertiginidae									
Columella edentula (Draparnaud, 1805)	+	-	-	+	-	-	-	-	-
Vertigo pusilla O. F. Müller, 1774	+	-	+	-	-	-	-	-	-
Valloniidae									
Vallonia costata (O. F. Müller, 1774)	+	-	-	+	-	-	-	-	+
Vallonia pulchella (O. F. Müller, 1774)	+	-	-	-	-	-	+	-	+
Acanthinula aculeata (O. F. Müller, 1774)	+	-	-	+	+	-	-	-	-
Enidae									
Ena obscura (O. F. Müller, 1774)	+	-	-	+	-	-	-	+	+
Endodontidae									
Punctum pygmaeum (Draparnaud, 1801)	-	-	-	-	*	-	-	-	*
Discus ruderatus (Férussac, 1821)	+	+	-	+	+	+	-	-	-
Discus rotundatus (O. F. Müller, 1774)	+	+	+	+	+	+	+	-	+
Arionidae									
Arion rufus (Linnaeus, 1758)	*	-	-	*	-	-	-	-	-
Arion subfuscus (Draparnaud, 1805)	*	-	-	*	*	*	-	-	-
Arion circumscriptus Johnston, 1828	*	-	-	-	-	-	-	-	-
Vitrinidae									
Vitrina pellucida (O. F. Müller, 1774)	+	-	-	+	-	-	-	-	-
Zonitidae									
Vitrea crystallina (O. F. Müller, 1774)	+	+	+	+	-	+	-	+	+
Vitrea contracta (Westerlund, 1871)	-	-	-	-	-	-	+	-	-
Aegopinella pura (Alder, 1830)	+	+	+	+	+	+	-	-	+
Aegopinella nitidula (Draparnaud, 1805)	+	+	+	+	+	+	+	+	+
Nesovitrea hammonis (Ström, 1765)	+	+	+	+	+	+	+	+	+
Nesovitrea petronella (L. Pfeiffer, 1853)	-	-	-	-	-	-	-	+	+
Zonitoides nitidus (O. F. Müller, 1774)	-	-	-	+	-	*	-	+	-
Limacidae									
Limax cinereoniger Wolf, 1803	*	-	-	*	-	-	-	-	-
Malacolimax tenellus O. F. Müller, 1758	*	-	-	*	*	*	-	-	-
Lehmannia marginata (O. F. Müller, 1774)	*	-	-	-	-	-	-	-	-
Agriolimacidae									
Deroceras reticulatum (O. F. Müller, 1774)	*	-	-	-	-	-	-	-	-
Euconulidae									
Euconulus fulvus (O. F. Müller, 1774)	+	+	+	+	+	*	+	+	*
Clausiliidae									

Cochlodina laminata (Montagu, 1803)	+	+	+	+	+	+	-	-	+
Macrogastra ventricosa (Draparnaud, 1801)	+	+	-	+	-	-	-	-	+
Clausilia bidentata (Ström, 1765)	+	+	+	+	+	*	+	-	*
Laciniaria plicata (Draparnaud, 1801)	-	-	-	-	-	-	-	-	*
Bulgarica cana (Held, 1836)	+	*	-	-	-	-	-	-	-
Helicidae									
Perforatella bidentata (Gmelin, 1891)	+	-	-	+	-	-	-	+	+
Perforatella rubiginosa (A. Schmidt, 1853)	-	-	-	*	-	-	-	-	-
Helicigona lapicida (Linnaeus, 1758)	+	-	-	*	-	-	-	-	-
Cepaea hortensis (O. F. Müller, 1774)	+	-	-	*	-	-	-	-	-
Helix pomatia Linnaeus, 1758	+	-	-	*	-	-	-	-	-
Number of species	33	12	12	29	14	12	10	10	19

RESULTS AND DISCUSSION

Site 1 was located near the canoe campsite called "Piaskownica". It included steep banks of the Drawa covered by an acid variety of beech forest *Luzulo pilosae-Fagetum*. The trees were fairly sparse, and the slope was devoid of litter which was removed by wind; the shrub layer was well-developed, and the herb layer rich in species; rotting timber was abundant. A total of 33 terrestrial gastropod species were found, 26 of them in quantitative samples (Table 1). The occurrence of *Helicigona lapicida* is noteworthy; the species seemed to have become extinct in Wielkopolska (URBAŃSKI 1956, BERGER 1961), and is becoming increasingly rare in other regions of Poland (RIEDEL 1988). Superdominant was *Aegopinella nitidula* (32.0%), with eudominants – *Vitrea crystallina* (17.4%) and *Cochlicopa lubrica* (14.8%), and the dominant *Aegopinella pura* (7.8%). With respect to frequency, an absolutely constant species was *Cochlicopa lubrica* (78.3%), *Aegopinella nitidula* (73.9%) and *Vitrea crystallina* (73.9%) being constant. The mean density was 38.1 indiv. m^{-2} (Table 2). The species diversity index H' was 3.30, the equitability index – 70.2%, and the TDI index was high – 0.83 (Table 3).

Site 2 adjoined the nature reserves Zawilcowe Gaje and Radęcin. It was a patch of acid beech forest on a steep bank of the Drawa River, and included a deep ravine with accumulations of beech litter, which was surrounded by a mixed tree stand with a high proportion of beech. Quantitative samples from a total area of 8.5 m^2 contained 11 gastropod species. *Bulgarica cana* was also found on beech logs (Table 1). Superdominant of the community was *Discus rotundatus* (45.3%), eudominants *Aegopinella nitidula* (19.8%) and *Nesovitrea hammonis* (17.0%). *Discus rotundatus* (82.4%) was absolutely constant, and *Aegopinella nitidula* (52.9%) – constant. Quantitative samples revealed the mean density of 12.5 indiv. m^{-2} (Table 2). The species diversity index H' was 2.34, the equitability index J – 31.3%, the TDI index – 0.73 (Table 3).

Site 3 was an acid beech forest on the cliff of the Płociczna River, with closed canopy and thick litter layer. The steep slope at the bottom passed into a narrow belt of temporarily flooded ground which was covered by *Alnus glutinosa* (L.). Quantitative samples from 9.5 m^2 contained 12 gastropod species (Table 1). Superdominant was *Discus rotundatus* (60.6%), eudominant *Aegopinella nitidula* (24.4%). No species was absolutely constant; *Aegopinella nitidula* (52.6%) was constant, and *Discus rotundatus* was accessory (36.8%). The mean density was 13.4 indiv. m^{-2} (Table 2), the diversity index H' was 1.11, the equitability index J – 31.1%, the TDI index – 0.57 (Table 3).

Site 4 was located near the mouth of the Korytnica River to the Drawa. The steep banks were covered by acid beech forest. The valley bottom was covered by mixed forest with dominant *Alnus glutinosa*. Quantitative samples contained 21 species, visual search yielded further 8 species: *Arion rufus*, *Arion subfuscus*, *Limax cinereoniger*, *Malacolimax tenellus*, *Perforatella rubiginosa*, *Helicigona lapicida*, *Cepaea hortensis* and *Helix pomatia* (Table 1). *Aegopinella nitidula* was superdominant (39.6%) and absolutely constant (100%). Absolutely constant species included also *Vitrea crystallina* and *Discus rotundatus* (83.3% each), which were eudominants. The density was 47.2 indiv. m^{-2} (Table 2), the diversity index H' was 3.03, the equitability index J – 69.1%, TDI – 0.80 (Table 3).

Site 5 was located in the nature reserve Radęcin. It was a eutrophic lowland beech forest, called Pomeranian beech forest – *Melico-Fagetum* – a fragment of the primaeval Drawa Forest. The reserve includes the most valuable forest fragment in the Drawa National Park, with many very old trees. The canopy is fairly closed, high and admitting little light. Shrubs are few, mainly young beeches, with much litter in the herb layer. A total of 14 species were found, 3 of which were collected as a result of visual search (Table 1). Superdominant was *Discus rotundatus* (71.8%), which

Table 2. Number of individuals (N), dominance (D), frequency (C) and mean density of snails in the studied sites

Species	Site																							
	1			2			3			4			5			6			7			8			9		
	N	D%	C%	N	D%	C%	N	D%	C%	N	D%	C%	N	D%	C%	N	D%	C%	N	D%	C%	N	D%	C%	N	D%	C%
Carychium minimum	8	1.8	13.0	2	1.9	11.8				3	1.1	16.7															
Cochlicopa lubrica	65	14.8	78.3				3	2.4	10.5	8	2.8	41.7	1	1.0	5.6				5	13.2	25.0	9	15.0	35.7	29	21.2	55.0
Cochlicopa lubricella	10	2.3	30.4				2	1.6	10.5	15	5.3	50.0	1	1.0	5.6				1	2.6	12.5				2	1.5	5.0
Cochlicopa nitens	1	0.2	4.3				1	0.8	5.3	2	0.7	16.7							2	5.3	12.5	1	1.7	7.1	1	0.7	5.0
Columella edentula	1	0.2	4.3							1	0.4	8.3															
Vertigo pusilla	1	0.2	4.3				1	0.8	5.3																		
Vallonia costata	1	0.2	4.3							1	0.4	8.3													1	0.7	5.0
Vallonia pulchella	2	0.5	8.7																4	10.5	12.5				1	0.7	5.0
Acanthinula aculeata	3	0.7	8.7							1	0.4	8.3	1	1.0	5.6												
Ena obscura	12	2.7	34.8							13	4.6	50.0										2	3.3	14.3	7	5.1	25.0
Discus ruderatus	1	0.2	4.3	2	1.9	11.8				2	0.7	16.7	4	3.9	16.7	2	11.8	40.0									
Discus rotundatus	8	1.8	17.4	48	45.3	82.4	77	60.6	36.8	36	12.7	83.3	74	71.8	72.2	2	11.8	40.0	4	10.5	50.0				8	5.8	20.0
Vitrina pellucida	2	0.5	4.3							2	0.7	16.7															
Vitrea crystallina	76	17.4	73.9	3	2.8	17.6	2	1.6	5.3	44	15.5	83.3				3	17.6	60.0				7	11.7	35.7	27	19.7	15.0
Vitrea contracta																			1	2.6	12.5						
Aegopinella pura	34	7.8	43.5	1	0.9	5.9	1	0.8	5.3	5	1.8	16.7	2	1.9	5.6	1	5.9	20.0							8	5.8	15.0
Aegopinella nitidula	140	32	73.9	21	19.8	52.9	31	24.4	52.6	112	39.6	100.0	8	7.8	11.1	3	17.6	40.0	6	15.8	37.5	23	38.3	42.9	33	24.1	55.0
Nesovitrea hammonis	21	4.8	21.7	18	17.0	47.1	2	1.6	10.5	2	0.7	16.7	3	2.8	16.7	5	29.4	60.0	10	26.3	37.5	8	13.3	28.6	5	3.6	15.0
Nesovitrea petronella																						4	6.7	21.4	2	1.5	5.0
Zonitoides nitidus										12	4.2	25.0										1	1.7	7.1			
Euconulus fulvus	1	0.2	4.3	3	2.8	5.9	5	3.9	15.8	2	0.7	8.3	3	2.9	16.7				1	2.6	12.5	1	1.7	7.14			

Cochlodina laminata	8	1.8	21.7	4	3.8	11.8	1	0.8	5.3	5	1.8	33.3	1	1.0	5.6	1	5.9	20.0							10	7.3	15.0
Macrogastra ventricosa	5	1.1	13.0	1	0.9	5.9				2	0.7	16.7													1	0.7	5.0
Clausilia bidentata	12	2.7	17.4	3	2.8	11.8	1	0.8	5.3	6	2.1	33.3	5	4.9	16.7				4	10.5	37.5						
Bulgarica cana	1	0.2	4.3																								
Perforatella bidentata	22	5.0	43.5							9	3.2	41.7										4	6.7	14.3	2	1.5	5.0
Helicigona lapicida	1	0.2	4.3																								
Cepaea hortensis	1	0.2	4.3																								
Helix pomatia	1	0.2	4.3																								
Number of individuals	438			106			127			283			103			17			38			60			137		
Number of species	26			11			12			21			11			7			10			10			15		
Number of samples (0.5 m^2)	23			17			19			12			18			5			8			14			20		
Mean density ind. m^{-2}	38.1			12.5			13.4			47.2			11.4			6.8			9.5			8.6			13.7		

was also a constant species (72.2%). There were no eudominants. The mean density was 11.4 indiv. m^{-2} (Table 2), the diversity index H' was 1.69, equitability index J – 22.7%, and the TDI index – 0.48 (Table 3).

Site 6 was a patch of eutrophic lowland beech forest on the Drawa River, near Zatom. The compact canopy admitted little light, and the litter among the herb layer was abundant. A total of 12 species were found, 7 of them in quantitative samples (Table 1). None of them was superdominant or absolutely constant. The eudominant class included *Discus ruderatus, Discus rotundatus, Vitrea crystallina, Aegopinella nitidula* and *Nesovitrea hammonis.* Among them *Vitrea crystallina* and *Nesovitrea hammonis* were constant (60%), the remaining species were accessory. The mean density was 6.8 indiv. m^{-2} (Table 2), the diversity index H' was 2.60, the equitability index J – 92.7%, the TDI index – 0.87 (Table 3).

Site 7 was located on a peninsula of Lake Ostrowieckie. The forest, composed of oak and beech, was an acid oak forest *Quercion roburii-petraeae.* Ten species were found in quantitative samples from the site (Table 1). Eudominants included 6 species of relative abundance ranging from 15.8 to 10.5%, but none of them was absolutely constant or constant. The mean density was 9.5 indiv. m^{-2} (Table 2), the diversity index H' was 2.87, the equitability index J – 86.2%, the TDI index – 0.87 (Table 3).

Site 8 was a mixed forest patch on the Płociczna River near its outlet to Lake Płociczno. *Alnus glutinosa* (L.) and *Fraxinus excelsior* L. were dominant trees, and the herb layer was rich. The patch corresponded to *Circeo-Alnetum.* Quantitative samples contained 10 species (Table 1). Superdominant was *Aegopinella nitidula* (38.3%), eudominants *Cochlicopa lubrica* (15.0%), *Vitrea crystallina* (11.7%) and *Nesovitrea hammonis* (13.3%). Superdominants and eudominants with respect to their frequency were accessory species. The mean density was 8.6 indiv. m^{-2} (Table 2), the diversity index H' was 2.70, the equitability index J – 81.1%, the TDI index – 0.80 (Table 3).

Site 9 was located near the hydro power station on the Drawa River, in Kamienna. The right, hilly bank was covered by beech, the low bank – by mixed forest, while next to the power station the habitat was ruderal, with park-like tree stands. Nineteen species were found in the site, four of them by visual search (Table 1). None of them was superdominant or absolutely constant. Eudominants were *Aegopinella nitidula* (24.1%), *Cochlicopa lubrica* (21.2%) and *Vitrea crystallina* (19.7%). *Aegopinella nitidula* and *Cochlicopa lubrica* (55.0%) were constant, while *Vitrea crystallina,* of high relative abundance, was accessory. The mean density was 13.7 indiv. m^{-2} (Table 2), the diversity index H' was 3.05, the equitability index J – 70.1%, the TDI index – 0.85 (Table 3).

The quantitative analysis of the malacocoenoses of the Drawa National Park included 74.4% all species

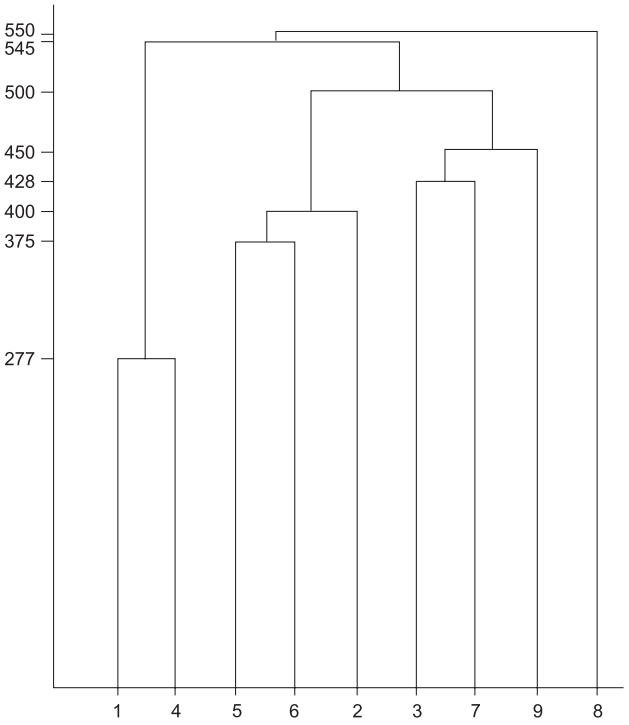

Fig. 1. Similarity of the studied malacocoenoses

recorded. The mean density was 19.3 indiv. m^{-2}. In Table 4 the species were arranged according to decreasing Q values, so that the first positions are occupied by dominant species, the end positions by accessory species. Dominant species in the Drawa National Park were *Aegopinella nitidula*, *Discus rotundatus* and *Vitrea crystallina* – they were eudominants of the whole fauna, the first species being constant, the remaining two – accessory. *Cochlicopa lubrica* and *Nesovitrea hammonis* were dominants, the former because of its frequency being accessory, the latter – accidental. The remaining species were accidental and, with respect to their dominance, subdominants (2.2–3.9%), recedents (1.1–1.2%) and subrecedents (0.1–1.0%) (Table 4). The species richness was the highest in site 1 – acid beech forest on the banks of the Drawa (33 species) and site 4 – acid beech forest near the mouth of Korytnica R. to the Drawa (29 species) (Table 1). In these sites the mean density was also the highest (Table 2). Sites 1 and 4, as well as 9 – mixed forest with beech and ruderal park-like patch – showed the highest diversity indices H', of 3.30, 3.03, 3.05, respectively. The corresponding TDI indices were 0.83, 0.80 and 0.85. The TDI and equitability indices were the highest in site 6 – eutrophic beech forest, and 7 – acid oak forest, the values being TDI – 0.87, J – 92.7%, 86.2%, respectively (Table 3).

Table 3. Community structure indices: H', J and TDI for the studied malacocoenoses

Site	H'	J (%)	TDI
1	3.30	70.2	0.83
2	2.34	31.3	0.73
3	1.11	31.1	0.57
4	3.03	69.1	0.80
5	1.69	22.7	0.48
6	2.60	92.7	0.87
7	2.87	86.2	0.87
8	2.70	81.1	0.80
9	3.05	70.1	0.85

Table 4. Number of individuals (N), dominance (D), frequency (C) and Q index for the whole malacofauna of the Drawa National Park

Species	N	D%	C%	Q
Aegopinella nitidula	377	28.0	52.2	38.2
Discus rotundatus	257	19.6	47.1	30.4
Vitrea crystallina	162	12.4	34.6	20.9
Cochlicopa lubrica	120	8.9	28.6	16.0
Nesovitrea hammonis	74	5.7	22.8	11.4
Aegopinella pura	52	3.9	12.9	7.1
Perforatella bidentata	37	2.8	12.5	5.9
Ena obscura	34	2.5	11.6	5.4
Cochlicopa lubricella	31	2.3	12.2	5.3
Cochlodina laminata	30	2.2	11.6	5.1
Clausilia bidentata	31	2.3	10.9	5.0
Euconulus fulvus	16	1.2	7.5	3.0
Discus ruderatus	11	0.8	6.8	2.3
Carychium minimum	13	1.0	4.8	2.2
Zonitoides nitidus	13	1.0	2.9	1.7
Macrogastra ventricosa	9	0.7	4.1	1.7
Vallonia pulchella	7	0.5	2.7	1.2
Nesovitrea petronella	6	0.4	2.7	1.0
Acanthinula aculeata	5	0.4	2.7	1.0
Cochlicopa nitens	8	0.6	0.7	0.6
Vitrina pellucida	4	0.3	0.7	0.5
Vallonia costata	3	0.2	2,0	0.6
Cepaea hortensis	1	0.1	3.4	0.5
Columella edentula	2	0.1	1.4	0.4
Vertigo pusilla	2	0.1	1.4	0.4
Vitrea contracta	1	0.1	0.7	0.2
Bulgarica cana	1	0.1	0.7	0.2
Helicigona lapicida	1	0.1	0.7	0.2
Helix pomatia	1	0.1	0.7	0.2

Similarities between the snail communities were calculated based on their qualitative composition (Fig. 1). The communities of acid beech forests (sites 1 and 4) were the most similar, with 27 species in common. In both the dominant was *Aegopiella nitidula* (Table 2). Communities of eutrophic beech forests were also highly similar (sites 5 and 6), with the acid beech for-

est community from the banks of the Drawa River close to them. Botanically these sites were different, but they were adjacent to one another, with habitat difference as the only barrier. There was a fairly high similarity between sites 3, 7 and 9, each with a few dominant, but accessory and accidental species. The community of the ash-alder riverine forest (site 8) was dissimilar to any of the above sites.

Qualitative and quantitative richness of the malacofauna of individual sites depended not only on the kind of plant community but also on the combination of various biotic and abiotic factors. The more varied were the habitat conditions, the higher the number of species in the community.

The malacocoenosis of the whole national park is composed of eight ecological groups, the largest being the forest and euryoecious groups (57%) (Fig. 2). Most specimens (90%) represent typical forest species or species which can live in forests, but also in other habitats; fewer individuals represent euryoecious species (Fig. 3). The fauna of the Drawa National Park includes species of various zoogeographical origin (Fig. 4), with a high proportion of widely distributed: European and Holarctic components (53%). Preserving natural habitats in the Drawa National Park will provide protection for the snail communities and may even lead to an increased density.

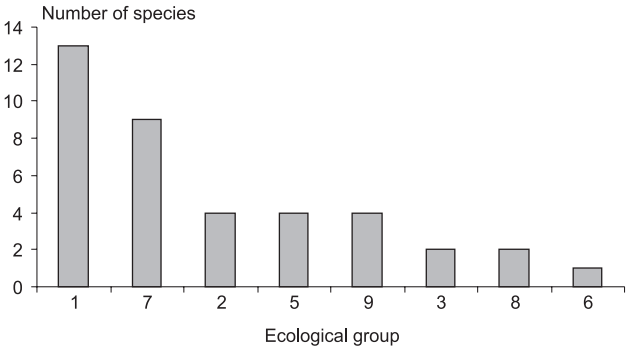

Fig. 2. Ecological structure of the snail fauna of the Drawa National Park – species spectrum, 1–9 ecological groups: 1 – forest species rarely found in other habitats; 2 – species occurring mainly in forests but common in parks, gardens and other shaded places; 3 – forest and shade-loving species; 4 – species of humid and sometimes marshy habitats; 5 – snails of open habitats of varied humidity; 6 – xero-thermophilous species; 7 – euryoecious species; 8 – species of humid but not marshy habitats of various degree of shading; 9 – snails of very humid, periodically flooded habitats

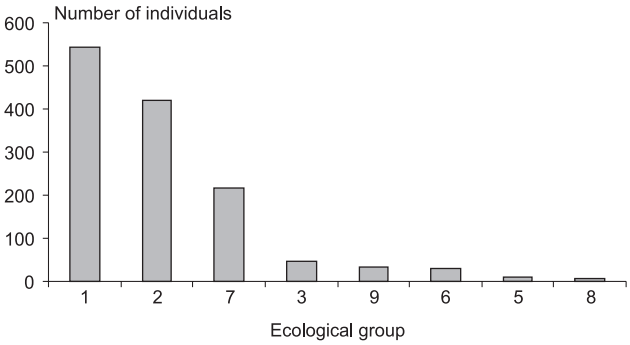

Fig. 3. Ecological structure of the snail fauna od the Drawa National Park – specimen spectrum; for explanations of ecological groups see Fig. 2

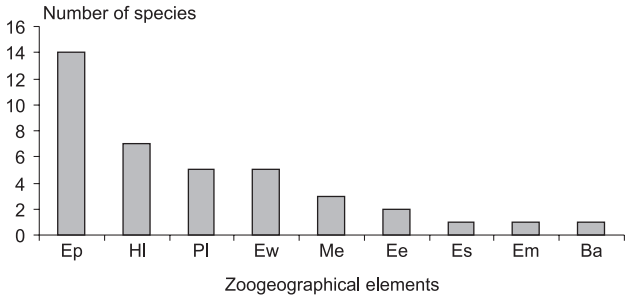

Fig. 4. Zoogeographical composition of the gastropod fauna of the Drawa National Park: Ep – European, Hl – Holarctic, Pl – Palaearctic, Ew – W European, Me – C European, lowland and upland, Ee – E European, Es – Eurosiberian, Em – S European, Ba –Boreo-alpine

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