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MALACOCENOSES OF THE NATURE RESERVE BUKI NAD JEZIOREM LUTOMSKIM

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ABSTRACT: A 15-month study in a beech forest and alder forest in a nature reserve Buki nad Jeziorem Lutomskim revealed the presence of 36 land gastropod species of 14 families. Euryoecious species and forest species of European distribution dominated. The mean density of gastropods in the beech forest was 36 indiv./m^2, in the alder forest 27 indiv./m^2. The density in the beech and alder forest was the highest in winter, the lowest in summer. A highly significant correlation was found between the density and the number of species. In the beech forest malacocenosis, the superdominant was *Discus rotundatus* (O. F. Müller), the eudominant being *Cochlodina laminata* (Montagu). In the alder forest, no superdominant could be distinguished, the eudominants being *Discus rotundatus* (O. F. Müller) and *Cochlodina laminata* (Montagu). Dominant species, as well as the number of species, species diversity, equitability and frequency varied between months. In the beech forest *Discus rotundatus* (O. F. Müller) – an accessory species – showed the highest frequency; in the alder forest all species were accidental. Juvenile individuals were more numerous than adults in spring samples from the beech forest and in autumn samples from the alder forest.

KEY WORDS: nature reserve Buki nad Jeziorem Lutomskim, beech forest, alder forest, terrestrial gastropods, spatial structure of malacocenoses, seasonal changes

INTRODUCTION

The nature reserve Buki nad Jeziorem Lutomskim is located on the north-western end of the Poznań Lakeland within the Wielkopolskie Lakeland. Its aim is protection of natural beech stands. It extends along a narrow (100–200 m) and long (3 km) belt along south-western shore of a groove lake. Two plant communities are found in the reserve. The steep part of the shore is covered by a beech forest, the flat shore, by an alder forest. On the steep parts of the shore there is brown, sandy-clayey soil with a high calcium content. In the beech forest, besides *Fagus silvatica*, there is a slight admixture of *Carpinus betulus*, *Betula verrucosa*, *Tilia cordata*, *Fraxinus excelsior*, *Quercus robur*, *Pinus sylvestris*. The undergrowth is luxuriant only in humid gorges and gullies that cross the slope. In the flat part, just on the lake margin, soils of high organic content occur. *Alnus glutinosa* is the dominant tree in the alder forest, besides there are: *Acer platanoides*, *Betula verrucosa*, *Ulmus campestris*. A lush undergrowth is formed by species characteristic of humid riverine forests.

The objective of the study was to describe the spatial structure of the beech and alder forest malacocenoses, and to trace its seasonal changes.

MATERIAL AND METHODS

The beech and alder forest were treated as separate sampling plots. Each month, from April 1993 till June 1994, I took 16 samples (making a total of 1 m^2) from each sampling plot. The samples were taken randomly from the whole sampling plot, from various vegetation patches. During the whole study period I took a total of 480 samples amounting to 30 m^2 surface area (15 m^2 in the beech and 15 m^2 in the alder forest). I collected a total of 932 live individuals (531 in the beech, and 401 in the alder forest). Quantitative samples from the beech forest contained 17, and those from the alder forest 23 species. The quantitative studies were supplemented with a qualitative survey. The total number of species recorded from the nature reserve was 36. The nomenclature and systematic arrangement follow KERNEY et al. (1983).

When analysing the results I used the methods, indices and ecological and biogeographical groupings described in MARCZEWSKI & STEINHAUS (1959), HORN (1966), PIELOU (1974), KASPRZAK & NIEDBAŁA (1981), ALEKSANDROWICZ (1987), RIEDEL (1988) and TROJAN (1992). The indices used were: abundance and density, dominance (D), frequency (C), species diversity (H') and equitability (J') according to the formula of Shannon-Weaver & Pielou, Marczewski & Steinhaus index, Morisita index, Czekanowski's diagram.

RESULTS

The species recorded represented 14 families (Table 1). Out of the 36 species, 13 were found only during the qualitative survey. The fauna of the reserve was dominated by euryoecious species of open or shady habitats of moderate humidity (10 species) as well as forest species, very rarely encountered in other habitats (9 species). The most abundant were gastropods of two ecological groups: typically forest species and species dwelling mainly in forests but common also in parks, gardens and other rather shady habitats. In the beech forest they constituted 75%, and in the alder forest 65% collected specimens.

Zoogeographically, the species composition was: one E European species, one S European species, two Eurosiberian and two Boreo-Alpine species, three C European and four Palaearctic species, five W European species, six Holarctic species and twelve European species.

The similarity between the species composition of the beech and alder forest was rather slight. When expressed by Marczewski & Steinhaus coefficient it amounted to 0.6. The similarity between the species compositions of particular samples in the beech and alder forests in consecutive months assumed values of 0.0 to 0.6. Species that were numerous in the alder forest, in both quantitative and qualitative samples, were: *Perforatella bidentata, Cochlicopa lubrica, Vertigo pusilla, V. substriata, Punctum pygmaeum, Cepaea hortensis, Euconulus fulvus.* Some species, e.g. *Trichia hispida,* characteristic of the alder forest, which do not occur in beech forests and only penetrate them accidentally, were collected on the border between the beech and alder forests.

The mean gastropod density was higher in the beech forest and amounted to 36 indiv./m^2, in the alder forest it was 27 indiv./m^2 – DZIĘCZKOWSKI (1988) reported the gastropod density in that reserve in 1959: in the beech forest 67 indiv./m^2 and 73 indiv./m^2, and in the alder forest 402 indiv./m^2. The range of densities in consecutive months was wider in the beech forest (3 to 104 indiv./m^2) compared to the alder forest (0–47). The density in consecutive months varied in a similar way, the increasing and decreasing tendencies being parallel (Fig. 1). The samples in the beech and alder forests were taken on the same days, in the same weather conditions. In samples from eight months, the density was higher in the beech than in the alder forest. The number of specimens in the alder forest was higher only in samples taken in May, August and September 1993, and June 1994. The highest gastropod density in the beech forest was observed in November and January, in the alder forest – in August. The correlation between the density and the number of species for the malacocenoses of the beech and alder forests was high, the correlation coefficients being 0.82 and 0.76, respectively. The gastropod density in particular seasons of the year, converted to 1 m^2, was: for the beech forest: 45 indiv. – spring, 17 indiv. – summer, 42 indiv. – autumn and 57 indiv. – winter; for the alder forest: 27 indiv. – spring, 21 indiv. – summer, 26 indiv. – autumn and 32 indiv. – winter. In both the beech and alder forests, the gastropod density was the highest in winter and the lowest in summer. In winter the temperature in litter is higher than on its surface. For example in January, at the air temperature of –10°C, under the litter the temperature was +2°C. The litter protects gastropods from freezing, creating better conditions for wintering. The species with the highest density in the beech forest and in the alder forest were *Discus rotundatus* (no. 9) and *Cochlodina laminata* (no. 15). Besides, in the beech forest *Carychium minimum* (no. 1), and in the alder forest *Clausilia bidentata* (no. 16) and *Trichia hispida* (no. 20) were numerous; the density of all the species is presented in Figs 2 and 3. In the beech forest, *Discus rotundatus* reached the highest density during eight months, and *Cochlodina laminata* mainly during winter months, in February the density was the highest for *Vitrina pellucida.* In the alder forest, *Discus rotundatus* showed the highest density only in November and May, while *Cochlodina laminata* displayed the highest density in samples from six months. In August in the alder forest, the species with the highest density was *Cochlicopa lubrica,* in September and October – *Trichia hispida,* in June *Aegopinella nitidula.*

Table 1. Malacocenoses of beech and alder forests of the nature reserve Buki nad Jeziorem Lutomskim; quantitative samples from a total area of 30 m^2, and qualitative studies; April 1993 – June 1994. D – dominance, C – frequency, species found only in qualitative studies marked with asterisk

No	Species	Beech forest			Alder forest		
		Number of individuals	D%	C%	Number of individuals	D%	C%
	Carychium sp.				1	0.2	0.4
1	*Carychium minimum* O. F. Müller, 1774	51	9.5	11.3	23	5.6	3.8
2	*Carychium tridentatum* (Risso, 1826)	4	0.7	1.7	2	0.5	0.8
*	*Succinea putris* (Linnaeus, 1758)						
	Cochlicopa sp.	3	0.6	1.3	2	0.5	0.8
3	*Cochlicopa lubrica* (O. F. Müller, 1774)				13	3.1	3.8
4	*Cochlicopa lubricella* (Porro, 1838)	4	0.7	1.7	14	3.4	5.4
*	*Columella edentula* (Draparnaud, 1805)						
5	*Vertigo pusilla* O. F. Müller, 1774				2	0.5	0.8
6	*Vertigo substriata* (Jeffreys, 1833)				1	0.2	0.4
*	*Vallonia costata* (O. F. Müller, 1774)						
*	*Acanthinula aculeata* (O. F. Müller, 1774)						
7	*Ena obscura* (O. F. Müller, 1774)	22	4.1	7.9	14	3.4	3.8
8	*Punctum pygmaeum* (Draparnaud, 1801)				3	0.7	1.3
9	*Discus rotundatus* (O. F. Müller, 1774)	162	30.1	34.6	84	20.5	22.9
*	*Arion subfuscus* (Draparnaud, 1805)						
*	*Arion intermedius* Normand, 1852						
*	*Arion rufus* (Linnaeus, 1758)						
	Arion sp.	4	0.7	1.3	5	1.2	1.3
10	*Vitrea crystallina* (O. F. Müller, 1774)	6	1.1	2.1	4	1.0	1.7
11	*Vitrea contracta* (Westerlund, 1871)	17	3.2	6.3	7	1.7	3.3
12	*Aegopinella pura* (Alder, 1830)	31	5.8	10.0	19	4.6	6.3
13	*Aegopinella nitidula* (Draparnaud, 1805)	22	4.1	7.5	25	6.1	8.3
14	*Nesovitrea hammonis* (Ström, 1765)	3	0.6	1.3	6	1.5	1.7
*	*Nesovitrea petronella* (L. Pfeiffer, 1853)						
*	*Zonitoides nitidus* (O. F. Müller, 1774)						
*	*Limax maximus* Linnaeus, 1758						
*	*Limax cinereoniger* Wolf, 1803						
15	*Cochlodina laminata* (Montagu, 1803)	127	23.6	18.3	76	18.6	15.8
16	*Clausilia bidentata* (Ström 1765)	21	3.9	7.5	37	9.0	11.3
17	*Laciniaria plicata* (Draparnaud, 1801)	14	2.6	3.3	10	2.4	1.7
18	*Perforatella bidentata* (Gmelin, 1891)				11	2.7	2.9
19	*Perforatella incarnata* (O. F. Müller, 1774)	10	1.9	1.7	10	2.4	3.8
20	*Trichia hispida* (Linnaeus, 1758)	14	2.6	5.0	34	8.3	8.8
*	*Arianta arbustorum* (Linnaeus, 1758)						
21	*Cepaea hortensis* (O. F. Müller, 1774)						
*	*Helix pomatia* Linnaeus, 1758						
22	*Euconulus fulvus* (O. F. Müller, 1774)				1	0.2	0.4
23	*Vitrina pellucida* (O. F. Müller, 1774)	23	4.3	6.7	4	1.0	1.3
	Total	538			409		

Fig. 1. Density of snails in the beech in alder forests in consecutive months

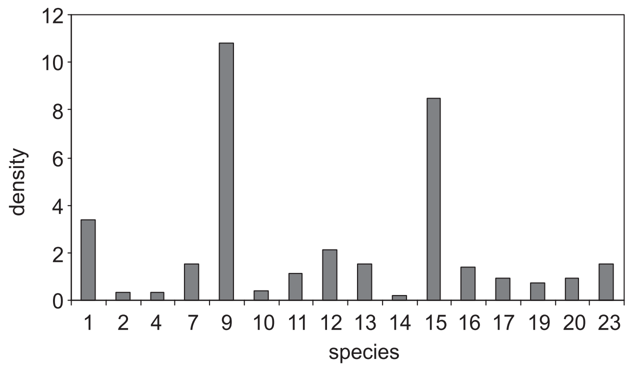

Fig. 2. Mean density of particular snail species in quantitative samples from the beech forest (for species numbers see: Table 1)

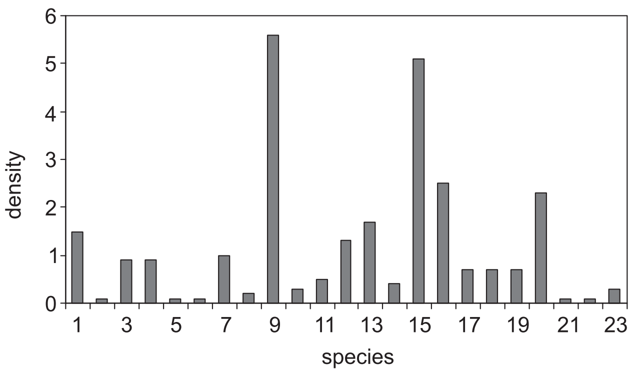

Fig. 3. Mean density of particular snail species in quantitative samples from the alder forest (for species numbers see: Table 1)

The increase in the number of species was accompanied by the increase in the number of specimens. The only exception were the data obtained in the beech forest in December where I found a high number of species (14) represented by only 51 indiv./m^2 and in February, where the total density of thirteen species was twice as high (104 indiv./m^2). The number of species collected in eight cases was higher in the alder than in the beech forest (Fig. 4). The difference between the number of species collected in the beech and alder forests was the greatest in August and April 1993 and in May 1994. In the beech forest, the number of species was considerably higher only in December and January. In the alder forest, the number of species was the highest in summer (18), and the lowest in winter (11). The situation was the reverse in the beech forest: I found 11 species in summer and 15 – in winter. *Discus rotundatus* and *Cochlodina laminata* were more abundant in the beech forest, both in summer and in winter.

Depending on the month, the number of species in the beech forest ranged from 2 to 13, and in the alder forest from 0 to 14. The species diversity index H' underwent similar changes, ranging from 0.62 to 3.03 for the beech, and from 0.0 to 3.42 for the alder forest (Fig. 5). For the pooled data from the beech forest, the species diversity index was 3.22, for the alder forest 3.64. The diversity was the highest for the snail community of the beech forest sampled in December and October 1993, and April 1994, and for the malacocenosis from the alder forest sampled in April, August and October 1993 and March 1994. The Shannon-Weaver index of species diversity in the beech forest was the highest in winter and spring, the lowest in summer.

The equitability J' in the beech forest reached its minimum value of 44% in September and maximum of 99.6% in June; in the alder forest it was 68% in May and 1993 and 100% in May 1994 – excluding the August data when I found no snails in an area of 1 m^2 (Fig. 6). For pooled data from the beech forest the equitability was 80.5%, for the alder forest 71.9%. The diversity index was highly correlated with the number of species. For the beech forest the correlation coefficient was r = 0.93, for the alder forest r = 0.95. No such strict correlation was found for the equitability, though the coefficients were also high: for the beech forest r = 0.5; for the alder forest r = 0.6.

The dominance structure was analysed jointly and separately for samples in each type of forest. In the beech forest the superdominant was *Discus rotundatus.* In the alder forest and in joint analysis there was no superdominant. The eudominant in the beech forst was *Cochlodina laminata*. In the alder forest the eudominant group included two species: *Discus rotundatus* and *Cochlodina laminata*. For both forests combined, the eudominants were *Discus rotundatus* and *Cochlodina laminata,* while the dominants included *Carychium minimum, Clausilia bidentata, Aegopinella pura, Trichia hispida* and *Aegopinella nitidula*. Of these, the dominants in the beech forest included *Carychium minimum* and *Aegopinella pura*, and in the alder forest *Clausilia bidentata, Trichia hispida*, *Aegopinella nitidula* and *Carychium minimum*. Dominant species were found to vary between months; for example *Clausilia bidentata* was eudominant only in winter, while *Vitrina pellucida* was dominant in the beech forest only in win-

Fig. 4. Number of species in quantitative samples from consecutive months from the beech and alder forests

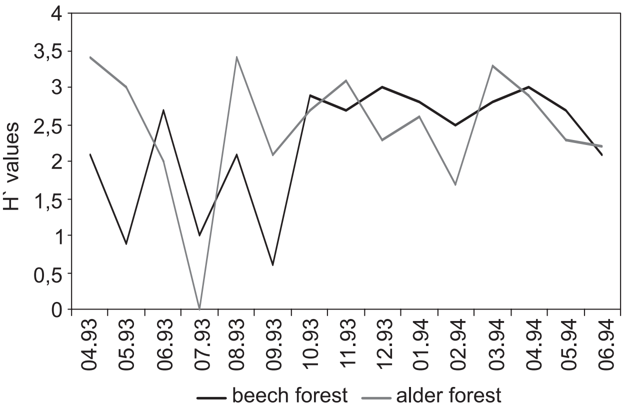

Fig. 5. Variation in the species diversity index of Shannon--Weaver (H') from April 1993 till June 1994

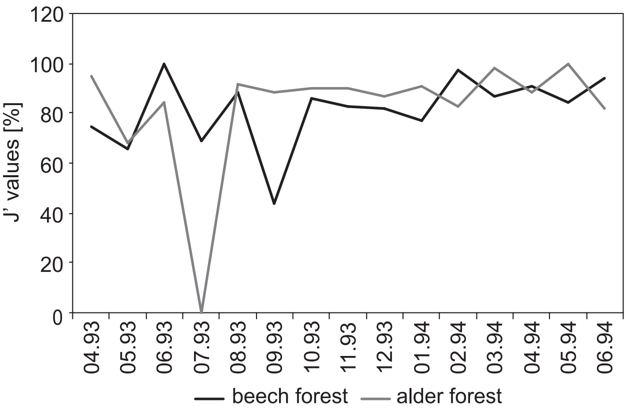

Fig. 6. Variation in the equitability index (J') from April 1993 till June 1994 for malacocenoses of the beech and alder forests

ter. Some species, e.g. *Discus rotundatus,* were dominant in both types of forest in all seasons of the year. However, in some months dominant position was occupied by another species. Among samples taken each month, from April 1993 till June 1994, in the beech forest the dominant was *Discus rotundatus,* while in June *Carychium minimum* dominated, in November, January, May and June *Cochlodina laminata,* and in February *Vitrina pellucida.*

In order to compare all the dominance structures of the beech and alder forests, I used the index of Morisita, as modified by HORN (1966). The results are presented as Czekanowski diagram (Figs 7, 8). In the beech forest, the largest group included dominance structures of four consecutive months – October, November, December and January, as well as of December and February, and March, May and June. A characteristic feature of all the dominance structures in that group was the presence of two or three species of high dominance values (15–57%) and several species of lower values. *Discus rotundatus* and *Cochlodina laminata* were the dominant species. The second group did not include winter months. Only one species – *Discus rotundatus* – showed a very high dominance value (42–85%). The remaining ones constituted a small proportion. The structures of June 1993 and February 1994 were the most dissimilar compared to the remaining ones. *Carychium minimum* and *Vitrina pellucida* were the superdominants in those structures, respectively. In the diagram for the alder forest only a few structures were similar to each other. They were structures from four consecutive months, from November to February. The second group included two structures, from September and October. The former group was characterised by the presence of two species of high dominance values (18–48%): *Discus rotundatus* and *Cochlodina laminata.* In the second group also two species codominated, but they were *Trichia hispida* and *Discus rotundatus. Trichia hispida* was superdominant. The remaining structures did not show any high similarity. They came from the spring-summer period and various species dominated.

In the samples from the total area of 15 m^2 taken in the beech forest, the most frequent species was *Discus rotundatus* (C = 34.6 %), being only an accessory species. All the remaining species were accidental. In the alder forest all the species were accidental. The highest frequency (22.9%) was that of *Discus rotundatus.* In samples from the total area of 1 m^2 in the beech forest, snails of the highest frequency were constant, and in the alder forest accessory species. The frequency of the same species, in both the beech and the alder forsts, varied between months. In samples from November, January and March *Discus rotundatus* was within the constant class, while in May, June, July, August and February it was only accessory. In the alder forest *Trichia hispida* was an accessory species in April, and accidental in the remaining months. Both in the beech and in the alder forests there were differences in the highest-frequency species between months. In the beech forest, the most constant species was *Carychium minimum,* in August – *Carychium minimum* and *Vitrea contracta,* in November – *Cochlodina laminata.* In the remaining months the highest fre-

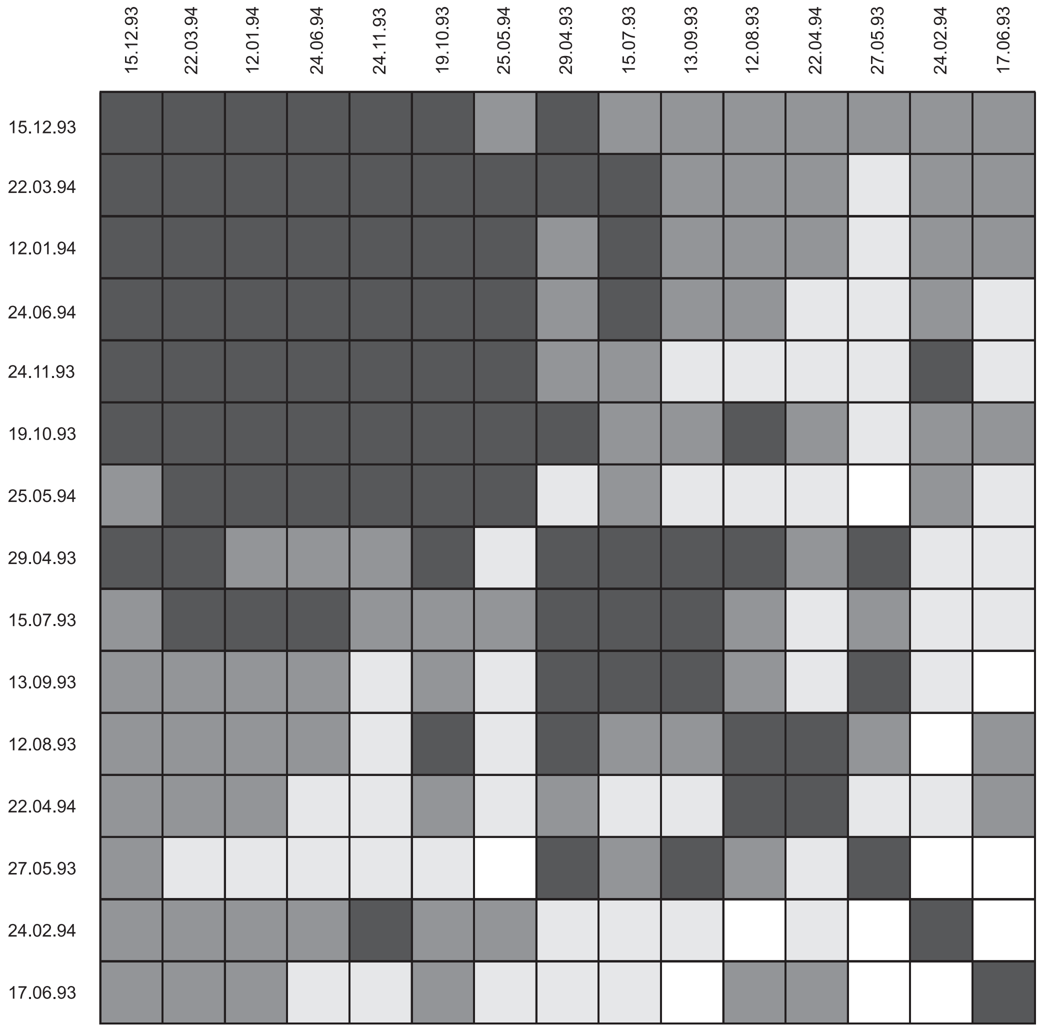

Fig. 7. Similarity of dominance structures based on Morisita index as modified by HORN (1966) for the beech forest malacocenosis

quency was that of *Discus rotundatus*. In the alder forest in April 1993, the most frequent species was *Clausilia bidentata*, in June *Vitrea contracta* and *Discus rotundatus*, in August 1993 *Cochlicopa lubrica*, in February 1994 *Clausilia bidentata* and *Cochlodina laminata*, in March 1994 *Aegopinella nitidula*, in April *Trichia hispida* and in the remaining months – *Discus rotundatus*.

In all the samples jointly, among the snails of the litter of the beech and alder forests, from April 1993 till June 1994, adult snails predominated. The proportion of juvenile individuals varied between months, in the beech forest from 10 to 70%, and in the alder forest from 20 to 70% of all snails (Figs 9, 10). Juvenile snails dominated in the beech forest in September, and in the alder forest in September, as well as in May and June.

DISCUSSION

The increase in the density of snails in each plant community in any month was associated with the increase in the number of species, as indicated by the high correlation between the values of these parameters. A close neighbourhood of the beech and alder forests, of different humidity, substratum, vegetation patches and availability of shelter made it possible for the snails to select more favourable places. The highest snail density was observed in the beech forest in the winter months, and in the alder forest in summer. In summer, the alder forest was richer in species compared to the beech forest, the situation was the reverse in winter. During the fifteen months of observations, in both types of forests, the highest densities were reached by *Discus rotundatus* and *Cochlodina laminata*. However, in particular months, also other species were characterised by the highest densities which was probably associated with their life cycles. A

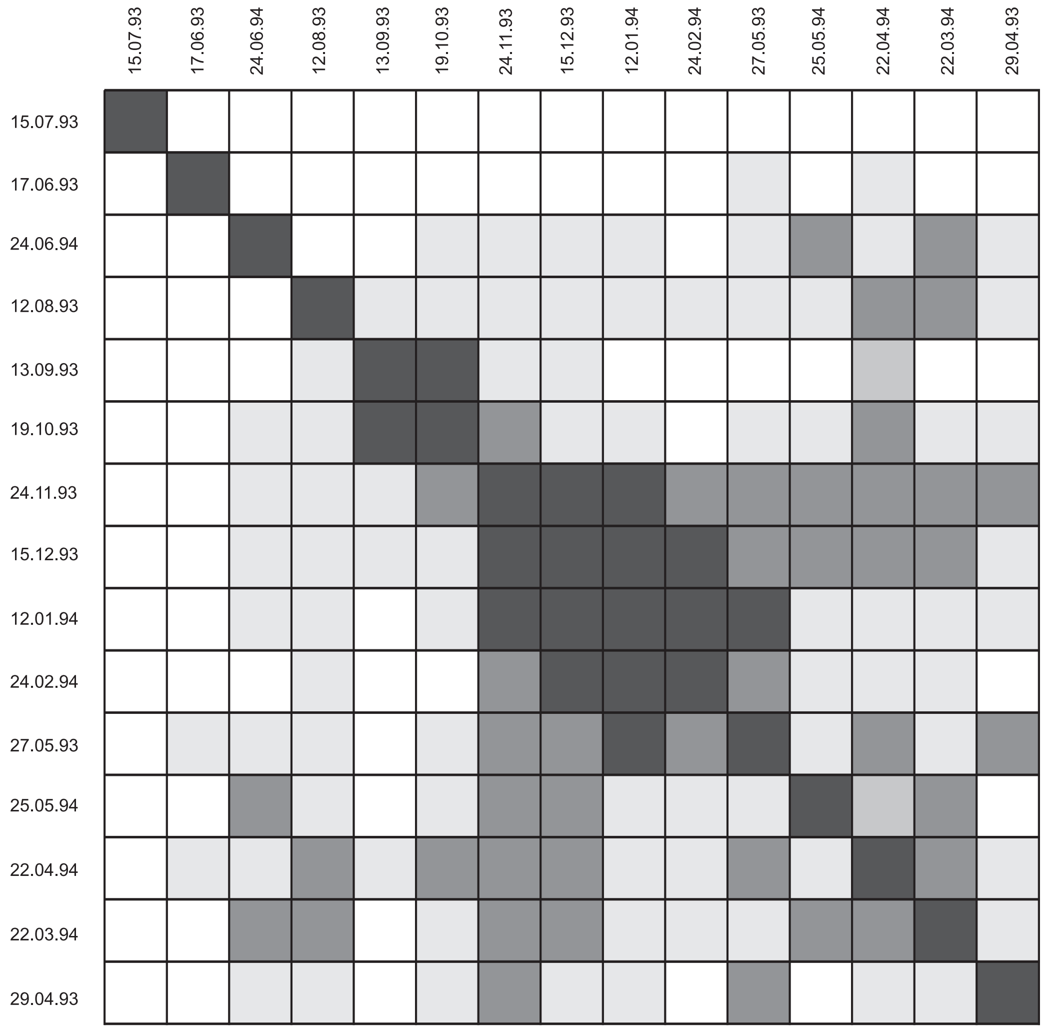

Fig. 8. Similarity of dominance structures based on Morisita index as modified by HORN (1966) for the alder forest malacocenosis

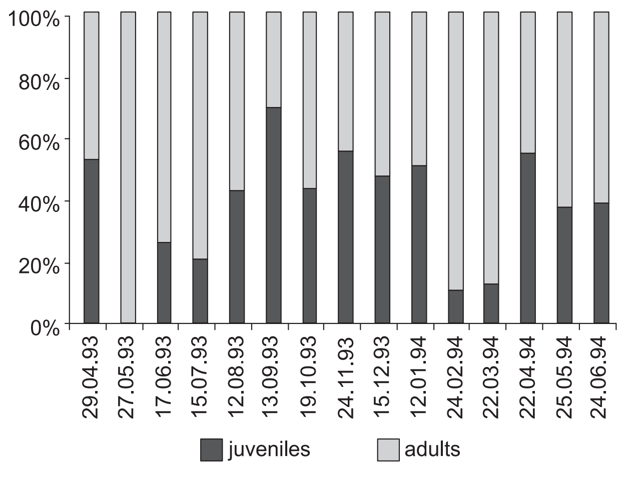

Fig. 9. Percentage of age classes in the beech forest malacocenosis

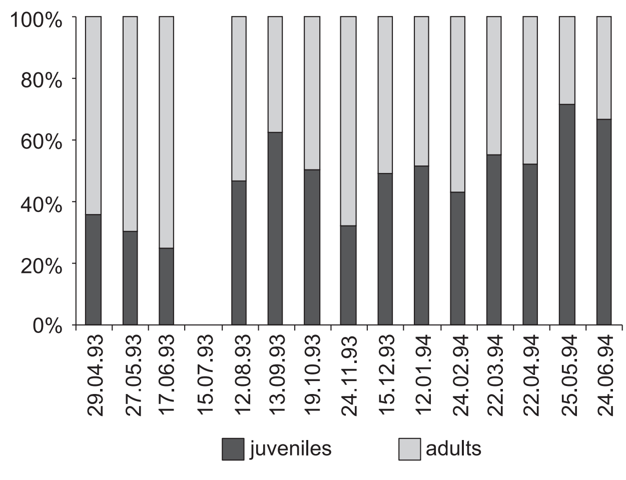

Fig. 10. Percentage of age classes in the alder forest malacocenosis

comparison of the snail density in the two different plant communities reveals increases and decreases in the density in the same months, thus indicating that the density is affected by the same factors in both malacocenoses. These may include phenological and climatic factors, and life cycles of species shared by both communities. The density of the same species increased in the same months in both sampling plots. In summer, spring and autumn, the snails were observed to gather in great numbers in rotting timber; the fact was also observed by DZIĘCZKOWSKI (1988). This affects the density of snails in the litter in particular months. In both the beech and the alder forests the density in the litter was the highest in winter. This is associated with wintering of species that occur in the litter permanently and those moving to the litter for winter from fallen and living tree trunks.

The dominance structure considered separately for each malacocenosis differed from that considered for both kinds of forest jointly. It was found to vary with time. *Discus rotundatus* was the superdominant only in the beech forest. The eudominants in both types of the forest were *Discus rotundatus* and *Cochlodina laminata*. In both habitats particular species changed their position in the dominance hierarchy from month to month. There exists a possibility of a relation between the snail dominance distribution during the year and some plant species (DYDUCH-FALNIOWSKA & TOBIS 1989). In the beech forest a large group of samples from seven months (October-January and March-June) shows a similar dominance structure; a smaller group includes samples from summer and spring; there is a very small group of samples dissimilar to the former two groups, with other dominants – *Vitrina pellucida* and *Carychium minimum*. In the alder forest there is only a small group of samples of similar structure. The malacocenosis of the beech forest has a more stable dominance structure compared to the alder forest.

The frequency of species in the malacocenoses of the beech and alder forests varies seasonally. There is a marked difference in the frequency between the samples taken from the same habitat in different months. Different species reach the highest frequencies and constitute different constancy classes in samples from particular months and samples of several months treated jointly.

The age structure of both malacocenoses would indicate a declining tendency in the malacocenosis, but juvenile individuals predominate in spring samples from the beech forest and in autumn samples from the alder forest.

The species diversity index for both malacocenoses is high. Its values vary between months, showing regular fluctuations. The highest species diversity was observed in spring and winter in the beech forest, and in spring and summer in the alder forest. The species diversity in particular months is proportionate to the species richness and equitability in both malacocenoses. The poorest malacocenoses (the lowest number of species and diversity) were those of the beech forest in September and of the alder forest in February.

Quantitative studies on malacocenoses in different months and seasons indicate that the structure of snail communities varies with time.

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