FOLIA MALACOLOGICA
Folia Malacol. 3: 55–72
Cracow, 1989
http://dx.doi.org/10.12657/folmal.003.004

SPATIAL STRUCTURE OF A GASTROPOD COMMUNITY IN THE LITTER OF A BEECH FOREST OF *DENTARIO GLANDULOSAE-FAGETUM* IN THE TATRA MOUNTAINS

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ABSTRACT: The grid method was used in the present study of the spatial structure of a gastropod community. 2,474 specimens representing 29 species were collected from an area of 9 sq m. The numbers of species were higher in squares with higher densities of snails (r_{NS} = 0.9). Species diversity varied between the squares, ranging from about 2.6 to 4.1, and was not very closely correlated with increase in species number (r_{SH} = 0.6). Snail density was not correlated with average dry litter weight in a square (r_{NM} = –0.03). The values of the indices of Lexis and of Morista show that the distribution of snails in the studied forest patches was aggregated. The material suggests an obvious relation between snails and plants.

KEY WORDS: Gastropoda, mountain malacofauna, snail community structure, species composition, abundance, dominance, ecological parameters

Folia Malacologica 3/1989 was originally published as No. 1216 of Scientific Bulletins of University of Mining and Metallurgy, Cracow. This digitalised version was prepared by the Association of Polish Malacologists and first published on-line on December 30th, 2016.

Ministry of Science and Higher Education
Republic of Poland

This digitalised version of Folia Malacologica is funded by the Ministry of Science and Higher Education, Republic of Poland under the agreement no. 646/P-DUN/2016 allocated to the activities of disseminating science and by the courtesy of the Rector of the AGH University of Science and Technology, Cracow

ZESZYTY NAUKOWE
AKADEMII GÓRNICZO-HUTNICZEJ IM. STANISŁAWA STASZICA

Nr 1216 Folia Malacologica z. 3 Kraków 1989

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Abstract: The grid method was used in the present study of the spatial structure of a gastropod community. 2,474 specimens representing 29 species were collected from an area of 9 sq m. The numbers of species were higher in squares with higher densities of snails (r_{NS} = 0.9). Species diversity varied between the squares, ranging from about 2.6 to 4.1, and was not very closely correlated with increase in species number (r_{SH} = 0.6). Snail density was not correlated with average dry litter weight in a square (r_{NM} = -0.03). The values of the indices of Lexis and of Morista show that the distribution of snails in the studied forest patches was aggregated. The material suggests an obvious relation between snails and plants.

INTRODUCTION

The knowledge of the spatial structure is basic for the recognition of the factors that influence animal populations and communities. It seems especially important in the case of the gastropod fauna (Huflejt and Karwowski 1981). Studies concerning molluscs are relatively very few. In the Polish literature several papers on *Helix pomatia* Linnaeus, 1758 can be mentioned (Łomnicki, Wasilewski and Kosior 1964, Łomnicki 1971, Woyciechowski 1980). Also some biocenological studies deal with similar problems (Urbański 1939, Drozdowski 1961, Dzięczkowski 1972, Dyduch 1980 and Dyduch-Falniowska and Fyda 1986).

In the paper the authors have attempted at a description of the spatial structure of a gastropod community in a beech forest of Dentario-glandulosae Fagetum. Additionally, the spatial structure of populations of the most abundant species of the studied communities has been considered.

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MATERIAL AND METHODS

In the present study the grid method was used (Kwiatkowska and Symonides 1980). The material was collected using the method proposed by Diem and modified by Oekland (Dzięczkowski 1972) for mollusc studies. It consists in taking samples with a square frame. The size of the frame used was 20 x 20 cm. The frame surface is referred to as "plot" in the text.

In each of three patches of a beech forest three sites were chosen, 25 samples to be taken from each site. The plots of each site adjoined each other forming a 100 x 100 cm square (Figs 2 - 4). The resulting "big squares" were numbered from I to IX. The frame was stuck in the ground 2 - 3 cm deep, so that each sample contained litter and the superficial soil layer. All samples were hand-sorted, because this most time-consuming method is necessary in both faunistic and quantitative studies (Dzięczkowski 1972, Umiński 1973, Dyduch 1980), and gastropods fixed in 75% ethanol.

2,474 specimens representing 29 species (Tab. 1) were collected altogether. Plants from all plots were determined and counted, the litter collected was dried at 25 - 30°C and weighted. The material was analysed using the following indices:

(1) $$H' = \frac{c}{N}(N \log N - \sum n_i \log n_i)$$

(2) $$J' = \frac{H'}{H_{max}}$$

($c = 3.321928$, H' - species diversity of the community according to the Shannon-Wiener formula, $H_{max} = \log_2 S$, J' - equitability (evenness), N - number of individuals in the community, n_i - number of individuals of ith species, S - number of species in the community);

(3) indices of dispersion according to Lexis: σ^2, and to Morista (I_{Δ}), after Huflejt and Karwowski (1981):

$$I = \frac{\bar{m}^2 + \bar{\sigma}^2 - \bar{m}}{\bar{m}^2}$$

($\bar{m}$ - arithmetic mean of the density of individuals on a plot, σ^2 - variation);

(4) Pearson's correlation coefficient.

STUDY AREA

All the localities studied were situated in the valley of the Spadowiec stream in the western part of the Tatra Mts., between two valleys: the valley of the Biały stream and the valley called Dolina ku Dziurze.

Table 1

Species composition of litter malacofauna of Dentario-glandulosae Fagetum in Tatra Mts.

Species	Dzięczkowski (1972)	Spadowiec V (1984)
1. *Acicula parcelineata* (Clessin, 1911)	+	+
2. *Acicula polita* (Hartmann, 1840)	+	-
3. *Carychium minimum* O. F. Müller, 1774	-	+
4. *Carychium tridentatum* (Risso, 1826)	+	+
5. *Pyramidula rupestris* (Draparnaud, 1801)	+	-
6. *Columella edentula* (Draparnaud, 1805)	+	+
7. *Vertigo substriata* (Jeffreys, 1833)	+	-
8. *Agardhia bielzi* (Rossmässler, 1859)	+	-
9. *Acanthinula aculeata* (O. F. Müller, 1774)	+	-
10. *Ena montana* (Draparnaud, 1801)	+	-
11. *Cochlodina orthostoma* (Menke, 1830)	+	-
12. *Cochlodina laminata* (Montagu, 1803)	+	+
13. *Clausilia cruciata* Studer, 1820	+	-
14. *Clausilia dubia* Draparnaud, 1805	+	-
15. *Iphigena ventricosa* (Draparnaud, 1801)	+	-
16. *Iphigena latestriata* (A. Schmidt, 1857)	+	-
17. *Iphigena plicatula* (Draparnaud, 1801)	+	-
18. *Iphigena tumida* (Rossmässler, 1836)	+	+
19. *Laciniaria cana* (Held, 1836)	+	-
20. *Laciniaria turgida* (Rossmässler, 1836)	+	+
21. *Pseudalinda stabilis* (L. Pfeiffer, 1847)	+	-
22. *Punctum pygmaeum* (Draparnaud, 1801)	+	+
23. *Discus ruderatus* (Férussac, 1821)	+	-
24. *Vitrea diaphana* (Studer, 1820)	+	+
25. *Vitrea transsylvanica* (Clessin, 1877)	+	+
26. *Vitrea subrimata* (Reinhardt, 1871)	+	-
27. *Aegopinella nitens* (Michaud, 1831)	+	+
28. *Aegopinella pura* (Alder, 1830)	+	+
29. *Oxychilus glaber* (Férussac, 1822)	+	-
30. *Oxychilus depressus* (Sterki, 1880)	+	-
31. *Arion subfuscus* (Draparnaud, 1805)	+	+
32. *Arion circumscriptus* Johnston , 1828	+	-
33. *Arion silvaticus* Lohmander, 1937	-	+
34. *Arion fasciatus* (Nilsson, 1822)	-	+
35. *Eucobresia diaphana* (Draparnaud, 1805)	-	+
36. *Eucobresia nivalis* (Dumont et Mortillet, 1852)	+	+
37. *Vitrina pellucida* O. F. Müller, 1774	-	+
38. *Semilimax kotulae* (Westerlund, 1883)	+	+
39. *Bielzia coerulans* (M. Bielz, 1851)	+	-
40. *Boettgerilla pallens* Simroth, 1912	-	+
41. *Limax tenellus* (O. F. Müller, 1774)	-	+
42. *Lehmannia marginata* (O. F. Müller, 1774)	+	-
43. *Deroceras agreste* (Linnaeus, 1758)	+	-
44. *Deroceras rodnae* Grossu et Lupu, 1965	-	+
45. *Euconulus fulvus* (O. F. Müller, 1774)	+	+
46. *Euomphalia strigella* (Draparnaud, 1801)	-	+
47. *Zenobiella vicina* (Rossmässler, 1842)	+	+
48. *Zenobiella incarnata* (O. F. Müller, 1774)	+	-
49. *Trichia unidentata* (Draparnaud, 1805)	+	+
50. *Helicigona faustina* (Rossmässler, 1835)	+	+
51. *Arianta arbustorum* (Linnaeus, 1758)	+	+
52. *Isognomostoma personatum* (Lamarck, 1792)	+	+

The valley of the Spadowiec stream lies on the Spadowiec nappe, and is a strict nature reserve. The localities differed between each other in humidity, altitude, bedground and plant cover (Fig. 1).

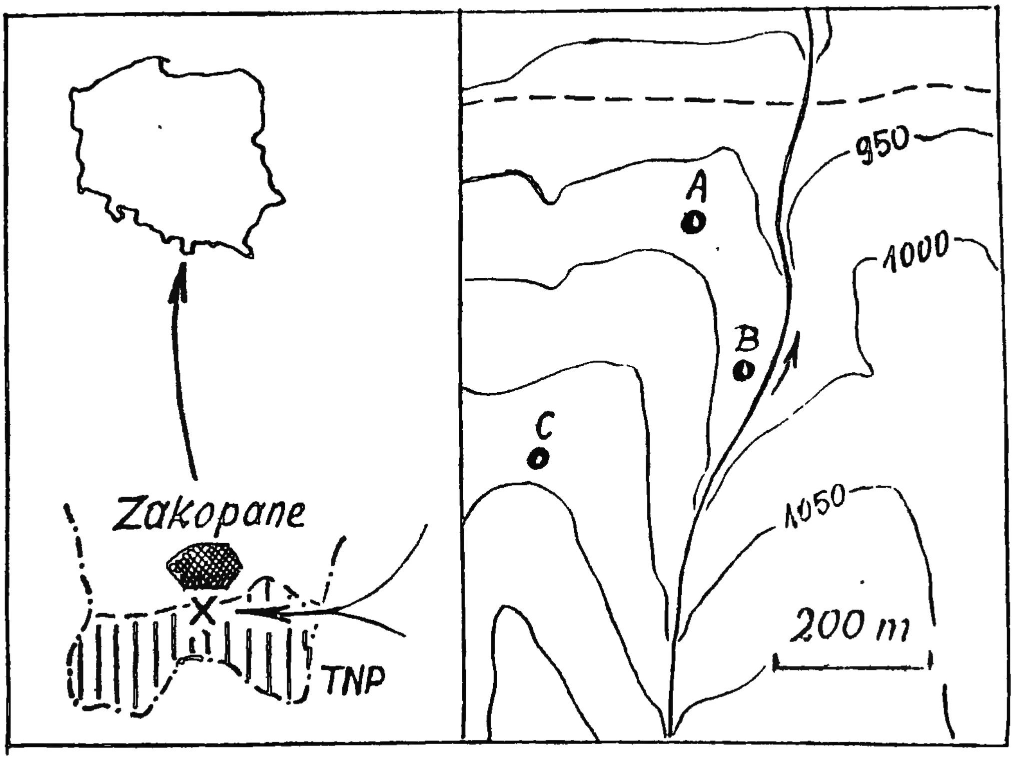

Fig. 1. Location of Spadowiec Valley (TPN - Tatra National Park)

Locality A (squares I, II, III)

This eastward exposed locality was situated at 950 m a. s. l., on a humid flattening of a ridge. It was covered with a quite thick forest of beech and fir 60 - 100 years old. The cover of trees was about 70% resulting in a prevalence of semi-darkness. The herb layer of 70 - 80% of cover comprised 24 species out of which the most abundant were Oxalis acetosella L., Dentaria glandulosa W. K., Dryopteris filix-mas (L.) Schott, and Senecio nemorensis L. The thickness of the leaf litter of the forest was 5 - 8 cm. The soil and litter were moderately humid. The bedground consisted of sandy sediments and loams.

The species composition of the herb layer was slightly differentiated between the squares, the following plant species having been recorded: square I: Oxalis acetosella L. (426 specimens), Asarum europaeum L.(1 specimen), and Senecio nemorensis L. subsp. nemorensis L. (1 specimen); square II: almost entirely covered with O. acetosella (644 specimens); square III: O. acetosella (453 specimens), and Cardamine trifolia L. (4 specimens).

The litter dry weight also differed between the squares. In square I it ranged from 35 to 135 g depending on plot, the average being 68.8 g. In square II the average was slightly lower: 65.9 g, the dry weight ranging from 28.9 to 94.3 g. In square III the dry weight ranged from 26 to 108.2 g, its average being the highest (69.9 g) of the nine squares.

Locality B (squares IV, V, VI)

The locality was situated 915 m a. s. l., about 400 m from the path called Droga pod Reglami, on the right (square IV) as well as on the left (squares V and VI) bank of the stream Spadowiec, in a patch of fir trees with an admixture of beech and spruce. The cover of trees reached about 50%. Rubus idaeus L. occurred abundantly apart from fir, beech and spruce seedlings constituting the shrub layer. The much diversified herb layer (49 species) reaching 100% of cover consisted of the following vascular plant species: Petasites albus (L.) Gaertn., Stellaria nemorum L., Primula elatior (L.) Grufb., Senecio nemorensis L. subsp. nemorensis L., Caltha laeta Sch. N. K., as well as of some species of mosses, lichenes and liverworts. The soil and litter humidity was high. The leaf litter was moderately (4 - 5 cm) thick. Shales, greenish sandstone and organodetritic limestone formed the bedground.

Out of the nine squares examined square IV was the one most densely covered with vegetation. The plant species recorded there were: Petasites albus (L.) Gaertn . (68 leaves of 29 individuals), Stellaria nemorum L. (25 specimens), Oxalis acetosella L. (20 specimens), Chaerophyllum cicutaria L. (8 specimens). In square V the following plant species were found: Petasites albus (34 leaves of 14 individuals), Chaerophyllum cicutaria (14 specimens), Oxalis acetosella (46 specimens), Stellaria nemorum (32 specimens). The plant species recorded from square VI were: Oxalis acetosella (102 specimens), Petasites albus (35 leaves of 14 individuals), Stellaria nemorum (51 specimens), Cardamine trifolia L. (2 specimens).

The litter dry weight in square IV ranged from 14.4 to 65.2 g, the average being 43.6 g, while in squares V and VI it ranged from 20 to 92.6 g and from 16.3 to 50.5 g respectively, the corresponding averages being 53.7 and 34.2 g.

Locality C (squares VII, VIII, IX)

The locality was situated at about 1025 m a. s. l., 100 m from the path Droga pod Reglami, slightly below a ridge. It was covered with a dry beech forest with an admixture of fir (4%) and spruce (1%). The cover of trees was 80 - 85%. There was no shrub layer. Oxalis acetosella L. and Cardamine trifolia L. were the most abundant plant species in the herb layer. The soil was rather dry, stony, penetrated with roots of Oxalis acetosella. The litter layer was varied in thickness (i. e. thicker in depressions, thinner elsewhere) but in general moderately thick. The bedrock of the locality was formed of dolomites and limestones.

In square VII the following herb species were recorded: Petasites albus (L.) Gaertn. (35 leaves of 11 individuals), Oxalis acetosella L. (82 specimens), Stellaria nemorum L. (2 specimens), while in square VIII: Oxalis acetosella (657 specimens), Senecio nemorensis L. subsp. nemorensis L. (3 specimens), and in square IX: Oxalis acetosella (418 specimens), Petasites albus (5 leaves), Senecio nemorensis subsp. nemorensis (20 specimens), Cystopteris fragilis (L.) Bernh. (1 specimen), Prenanthes purpurea L. (1 specimen) were found.

The litter dry weight in square VII ranged from 10.8 to 89.4 g per plot, the average being 45 g, while in square VIII: from 6.9 to 29.5 g, the average being 19.08 g that is the lowest from among the squares. In square IX the dry weight varied between 6.1 and 45.7 g, the average amounting to 22.5 g.

RESULTS

29 gastropod species were found occurring in the litter of the studied patches of a beech forest (Tab. 1). Figs 1 - 3 illustrate the gastropod spatial distribution in each square.

Locality A, Square I (Fig. 2)

72 specimens of 12 species were recorded, out of which Vitrea transsylvanica (15 specimens), V. diaphana (11 specimens), Aegopinella nitens (8 specimens), and Boettgerilla pallens (6 specimens) were the most abundant comprising 55% of the material from this square. The maximum number of specimens per plot was 8, representing 6 species. Species diversity H', sometimes referred to as "organisation" amounted to 3.2, and equitability J' to 0.86.

Locality A, Square II (Fig. 2)

The square was 3.5 m distant from square I. 160 collected specimens represented 15 species. The dominants were: Vitrea transsylvanica (18 specimens), V. diaphana (48 specimens), Aegopinella nitens (19 specimens), and Boettgerilla pallens (12 specimens). They comprised 60.6% of the material from this square. The maximum number of individuals per plot was 14, belonging to 7 species. H' = 2.6, J' = 0.66.

Locality A, Square III (Fig. 2)

The square was richest of the locality in respect of the number of specimens, 218 snails of 16 species having been collected. The dominants: Vitrea diaphana (72 specimens), Aegopinella nitens (20 specimens), and V. transsylvanica (18 specimens) made up 56.7% of the material from the square. Only Carychium minimum (a single specimen found) could be regarded as a rare species (not exceeding 10 specimens in the whole material). The highest number of individuals per plot was 18, representing 7 species. H′ = 2.9, J′ = 0.72.

Locality B, Square IV (Fig. 3)

It was situated close to the stream. 558 specimens of 22 species were found altogether. The predominance of Carychium tridentatum (191 specimens) which occurred so abundantly only in that square was striking. Vitrea diaphana (105 specimens) was also rather abundant. Boettgerilla pallens (1 specimen), Euconulus fulvus (25 specimens) and Columella edentula (27 specimens) were relatively numerous. The rare species recorded were: Arion fasciatus (1 specimen), Trichia unidentata (2 specimens) and Helicigona faustina (2 specimens). The maximum number of individuals per plot was 41 belonging to 20 species. H′ = 3.00, J′ = 0.65.

Locality B, Square V (Fig. 3)

512 specimens of 28 species were recorded altogether. The following species occurred most abundantly: Vitrea diaphana (78 specimens), Aegopinella pura (68 specimens), Carychium tridentatum (60 specimens) and Iphigena tumida (34 specimens). They comprised 46.8% of the snails found in the square. As many as 6 rare species were found: Trichia unidentata (2 specimens), Deroceras rodnae (1 specimen), Carychium minimum (1 specimen), Cochlodina laminata (1 specimen) and Helicigona faustina (1 specimen). The maximum number of individuals per plot was 36 of 11 species. H′= 4.08 (a relatively high value), J′= 0.83.

Locality B, Square VI (Fig. 3)

This was the richest square in respect of the gastropod density. The total number of snails collected was 594 representing 25 species. Vitrea diaphana (103 specimens), Carychium tridentatum (68 specimens), Aegopinella pura (64 specimens) and Vitrea transsylvanica (59 specimens) were the most numerous species constituting 50% of the material from this square. Out of the rare species Isognomostoma personatum (1 specimen) and Limax tenellus (the only specimen of the species in the whole material) were recorded. H′ = 3.33, J′ = 0.70.

Locality C, Square VII (Fig. 4)

283 snails of 22 species were recorded. The most abundant species were: Vitrea diaphana (91 specimens) and V. transsylvanica (23 specimens) constituting 40.2% of the snails from the square. Out of the nonnumerous species Arion fasciatus (1 specimen), Deroceras rodnae (3 specimens), Isognomostoma personatum (1 specimen) and Euomphalia strigella (1 specimen) were found. The maximum number of specimens per plot was 25 belonging to 7 species. H′ = 3:09, J′ = 0.68.

	A	B	C	D	E
1	Ap2 Zv1 Av1 Bp1	Vt1	Vd2 An1		Pp2 Z1
2	Vt1 An1 Ae1	Vt1 An2 A1 Bp1		Ap1	Vd1 Vt3 Av1 Bp1
3	Lt1 Vt1 An1 Vp1	Z1 As1	Vd1 Z1 Av1	V1 Z1	Vd2 Ap1 Vt1 Av2 Z1 An1
4	Vd1 An2 Bp2	Vt1	Vt1	Vt3 Ap1 Sk2	Vd2 Z1 Sk1 Bp1
5	Vt1	Pp1 Vd2	Vt1	Z1 Av1	Sk1

I

	A	B	C	D	E
1	Vt1	Vt1 An2	Vt4 Li1	Lt1 V3 Vt1 An1 Bp2	Vd2 Vt1 Ap2 V3
2	Pp1 C2 Vd1 An1 Ap2	Vd3 Vt1	Vd2 Vt1 An2 Bp1	Lt1 Bp1 Vd2 V1 Vt1 An1	Vt2 An1
3	Ar1 Ap1 Pp1 Bp1 Vd1 H1 An1	En1 Bp1 Ae1	Vd2 Vt1	Ct1 An1 Pp1 Sk1 Vd6 C2 Vt1	Ar1
4	Lt1 Bp1 Vd1 An2 Sk1	Lt2 Ap2 Bp2 V2	Ct1 Ae1 Vd9 Sk1 Ap1 Bp1	Vd2 Av1 Vt1 An3 En1	Pp1 Aa1 Vd3 H1 Sk1 Av1
5	Vt1 V1 Sk2 Ef1 C1	Pp2 Vd8 An1 Av1	Vd5 C1 An1 Ap1 Bp2	Vd2 Av1 Vt1 C1 An1 Ap1	An1

II

	A	B	C	D	E
1	Ct1 Ap1 Pp1 Bp2 Vd2 Ef1 An1 C2	Ar1 An2 Ct2 As1 Vd4 Bp1 Vt2 Z1	Ct2 Bp1 Lt1 Aa1 Vd4 C1 Ap2 Ae1	Ct1 Sk1 Vd3 Bp2 An3 Ap1	Cm1 An1 Ct2 Ap1 Vd1 Ae1 Vt1 Z1
2	Bp2 V1 Ae2	Ar1 C1 Vd9 Z1 An3 As1.	Vt3 Z2 An1 Bp1 Ef1	Ct3 Av1 Vd2 Bp1 An2 Z6 Ap2	Ct2 Ef1 Vd3 C1 Vt1 An1
3	Vd1 An2 Av2	Lt2 Bp1 Vd5 Vt1 An1	Vt1 C1	Ct1 Vd2 Av1	Vd1 Vt2 Ap2
4	Vd7 An1 Ap1 Sk1	An1 Av1 Bp2	Vt1 Ap2 Z2	Vd1 Vt1	Ct1 Vd4 Bp1 Z2
5	Lt1 Vd4 Ap1 Sk1	It1 An1 Ed1 Pp1 Ap1 Z4 Vd3 As1 Vt1 Bp1	Vd11 Z1 Bp1 Sk1 V1	Vd5 Vt2 Ap1 Ae1	Vt2 An1 Bp1 Z1

III

Fig. 2. Distribution of gastropods in litter of forest of old beech and fir (locality A), I - square I, II - square II, III- square III, Ar - A. parcelineata, Cm - C. minimum, Ct - C. tridentatum, Ce - C. edentula, It - I. tumida, Lt - L. turgida, Cl - C. laminata, Pp - P. pygmaeum, Vd - V. diaphana, Vt - V. transsylvanica, An - Ae. nitens, Ap - Ae. pura, Vp - V. pellucida, Ed - E. diaphana, En - E. nivalis, Sk - S. kotulae, As - A. subfuscus, Av - A. silvaticus, Af - A. fasciatus, Bp - B. pallens, Ln - L. tenellus, L - Lehmannia sp., Dr - D. rodnae, Ef - E. fulvus, Es - Euom. strigella, Zv - Z. vicina, Tu - T. unidentata, Hf - H. faustina, Aa - A. arbustorum, Ip - I. personatum, C - Clausiliidae sp. juv., V - Vitrea sp. juv., Z - Zonitidae sp. juv., Ae - Aegopinella sp. juv., Vr - Vitrinidae sp. juv., A - Arionidae sp. juv., Li - Limacidae sp. juv., D - Deroceras sp. juv , H - Helicidae sp. juv., T - Trichia sp. juv. (for full gastropod names see Table 1).

Locality C, Square VIII (Fig. 4)

This was the poorest square in respect of the gastropod number. Only 67 snails of 11 species were found there. The most numerous of the species were: Vitrea diaphana (12 specimens) and Arion subfuscus (11 specimens). These two comprised 62.6% of the snails from the square. No rare species was recorded. Six individuals of three species was the highest number per plot. H′ = 3.0, J′= 0.86.

Locality C, Square IX (Fig. 4)

70 gastropods representing 6 species were recorded. The most numerous

	A	B	C	D	E
1	Ct11 As1 Ce4 Bp2 Vd2 C1 Vt1	Ct18 Ap2 Ef1 Ce2 Vp1 Zv1 It2 En1 Vd9 Bp4	Ct7 Av2 C1 Ce1 Bp3 Z2 Vd7 Ef1 Sk1 Aa1	Ct5 Vt1 Bp4 Ce1 Ap1 It2 En1 Vd7 Av1	Ct4 Sk1 Hf1 Ce1 Bp2 C2 Vd3 Ef1 Z1 Vt4 Zv1
2	Ct21 Vt4 Ef4 Ce2 En1 Ip1 It3 Sk1 Ae4 Vd8 Bp1 Z3	Ct9 Vt6 Ef1 Ce3 Ap2 C1 It2 Ed1 Vd8 Sk1	Ct12 Bp1 Vd6 Ef3 Ap1 Zv1 En1 H1	Ct9 Vt2 Ef2 Ce1 An1 It1 Ap2 Vd6 Bp3	Ct3 Vd7 Ed1 Bp1
3	Ct7 H1 Ce2 Vd4 Ef2	Ct4 Vd1 Ap2 Af1	Ct16 Ef1 Pp1 C4 Vd8 A1 En3	Ct3 T1 Vd3 Bp2 Z7	Ar2 An1 V4 Ct4 Ap4 Ef1 Ce3 Vp1 Vd3 Av1
4	Ct11 Tu1 Ce1 Vd3 As2	Ar1 Vt5 Ef2 Ct7 Ap2 C2 Ce1 En1 Z2 Vd3 Bp2	Ct4 Bp3 It1 Ef2 Vd2 C1 Av1	It2 Ip1 Ap1 As1 Z1 Ef1 V2	Ct1 Sk1 Vt1 C1 Ap1 H2 En1
5	Ct24 Bp1 Ce3 Hf1 Lt3 Ae4 As1	Ct5 En1 Ce1 Ef2 Vd3 Ae2 Ap1 V1	Ct2 Ap1 Vd4 Av3 Vt2 An1	Ct4 Sk1 It1 Av1 Vd3 V2 Ap3	Ar1Bp2 Ct3 Vd5 Ap2

IV

	A	B	C	D	E
1	It2 C4 Vd1 Vt1 Bp1	Ct1 Vd1 Ef1 Ce1 Vt2 C2 It3 Ap3 H1 Lt1 Bp3	Ar1 Vd8 Hf1 Ct2 Vt2 C1 Ce1 An1 Ae3 It4 Ap6 H3 Lt2 Ef1	Ar1 Vt3 Et2 Ce1 An2 Ed1 It9 Ap2 Li1 Vd2 Vp2	Ct7 Ap5 C8 Ce1 Vp1 Z11 It2 Ef1 A1 Vd1 Hf1 H1
2	Ar1 Lt2 Bp1 Ct4 Vd13 C2 Ce2 Ap2 It1 Av1	Ct1 Ap1 C2 Lt2 En1 Vd3 As1 Vt3 Ef1	Ar1 Vd4 Bp1 Ct1 An1 C1 It1 Ap3 Pp1 Av2	Ct5 Vp3 H1 It3 Bp1 Vd8 Ef1 Ap5 C4	Ct2 Vd3 Ce1 An1 It1 Vp1 Lt1 C2
3	Vd1 D2 An1 As1 L1	It1 Sk2 Vd3 Vt1 Ap3	Ct1 V4 Ce1 Vd1 Zv1	Ct1 An3 Dr1 Ce1 Ap2 Zv2 Vd2 Vp2 Tu1 Vt2 Ed2 C2	Ct2 Vp6 Z4 It2 Sk1 A1 Cl1 As1 H1 Ap2 V1
4	Ct3 Vt4 Aa1 It1 Ap7 C3 Lt1 Sk1 Z4 Vd3 Zv1	Ct2 Ap3 Ce1 Bp1 Lt3 C4 Vt2 V5	Ct7 Ap1 C1 It1 Bp1 Li1 Vd4 Zv1 H5 Vt1 Tu1	Ct1 Vd4 C4 Cm1 Ap2 It1 Vp2 Lt1 Bp3	Ct2 It2 Ap2 Z3
5	It3 En1 T1 Vd1 Av1 Vt1 Bp1 Ap3 Ae1	Ct6 Vd5 As1 Ce1 Vt2 Ef2 It3 Ap7 Ip1 Pp1 Up1 C2 T1	Ct7 Ap4 Z2 Ce1 En2 Vd4 Av1 An2 C4	Ct3 Sk1 Ef2 Ce2 As2 Vd3 C2 Ap6 T1	Ct2 C4 Ce2 Ae4 Vd3 Li1 Ap1

V

	A	B	C	D	E
1	Ct1 An2 T1 It2 Ap6 V1 Vd1 Ed1 Vt1 Zn1	It4 An2 T1 Lt3 Ap5 C7 Pp1 Zn1 Vd6 Ip1	C4 Z3 H3	It2 Vp1 Vd2 As1 Vt3 Ef1 Ap1 Ae3	Ct5 An2 D1 It2 Av1 Ef1 Vd8 Af1 C4 Vt5 En1 Ae1 Vr1
2	Ce2 Ap5 It1 En2 Lt2 As1 Vd1 Ef1	Ct2 Ap4 V3 It3 Vp1 Ae1 Vd1 Av2 H1 Vt3 Ef2	Ct1 Aa1 Lt1 Vd1 Ap1	Ct1 Vd3 En2 Ce2 Vt4 Sk1 It2 An2 As1 Lt1 Ap5 Ef2	Cm1 Vt2 Ct4 Ap1 It2 Av1 Vd2
3	Ct3 Ap3 H2 Lt1 As1 Vd2 Ef1 Vt3 C2	Ct3 Ef2 Vd6 C9 Ap4 T1 Av1	Ct3 Lt3 As1 Ce1 Vd4 Ef1 Pp1 Vt3 Ae1 It2 En3	Ct7 Vd3 Ef2 Ce2 Ap3 C2 It5 En1 V3 Po1 Sk1 Z4 Vt3 Af1 D1 T1	Ar1 Vt4 Ef7 Ct4 Ap5 C3 It1 As1 V3 Pp3 En3 A1 Vd3 Ed2 Z1
4	Ct1 Vt1 En1 Ce2 Ap2 H2 Lt1 Af1 Vd3 Ed1	Ar1 Lt3 Ap3 Ct3 Vd2 Ed1 Ce4 Vt2 Ef1 It1 An2 C6 T2	Ct4 Vt7 Ef1 Ce1 Ap4 C5 It2 Ed1 Vd13 En1	Ct8 Vt2 Ef1 Ce2 Vp3 C2 It4 Tu1 Z3 Vd10 Ip1	Vd7 Af1 Z5 Vt3 Ef1 H1 Ap7 C7 En1 V1
5	Ct5 Vp1 Ce7 As1 Vd4 Ef1 An2 L1	Ct2 Sk1 C4 Vd2 Av1 Ln2 Vt1 Ef1 D1 An1 Aa1	Vd5 Vp1 V1 Vt3 En1 An3 Ln1 Ap1 C2	Ct9 Vt7 Ef2 Ce1 An2 C3 Lt2 Ap2 Vd8 En2	Ct2 Ap2 It1 Vp1 Vd6 Ef1 Vt2 C1

VI

Fig. 3. Distribution of gastropods in litter of fir forest with admixture of beech and spruce (locality B), IV - square IV, V - square V, VI - square VI. For symbol descriptions see Fig. 2.

were: Vitrea diaphana (18 specimens), Semilimax kotulae (8 specimens) and Arion subfuscus (6 specimens) constituting 45.7%. The only rare species found was Euomphalia strigella (1 specimen). The highest number of individuals per plot was 7, representing 3 species. H´= 3.24, J´= 0.81.

DISCUSSION

In the literature on the subject no papers can be found whose results are closely comparable to those of the present study. There are, indeed, not less than two approaches to the problem this paper deals with. The first is to study the structure of a litter snail community, that is, its species composition (S), species diversity (H´), equitability (J´), density (N), etc., which has been done by several malacologists, particulary those dealing with forest gastropods (Drozdowski 1961, Dzięczkowski 1972, 1974, Dyduch 1980, Dyduch-Falniowska and Fyda 1986).

	A	B	C	D	E
1	Vd1	Ct1 Vd3 Aa1	Sk1 Av1 Aa1	Vd1 Sk1 Af1 H1	Vd3 En1 H1
2	Pp1 C1 Vd5 Vt1 Ef2	Pp1 Vd11 Ef1 Aa1	Pp1 Dr2 Vd1 Vt1 C4	Vd1 Es1 An1 Aa1 Av1 C1 Ed1 Li1	Lt1 C2 Vd1 Z2 Sk1 Ef2
3	Pp1 Ae2 Vd3 Dr1 C1	Lt2 Bp1 Vd5 H1 Vt1 Sk1	Ct3 Sk1 Z3 Pp2 Ef3 H1 Vd5 Zv1 Vt5 C1	It2 Ef2 Vd4 H1 Ap3 Av1	Vt1 C1 En1 H1 As1 Ef1
4	Vd3 An1 Dr1	Vd4 Z2 Vt2 V1 Vp1 Li2 C1 H1	Lt2 As1 A1 Ct2 Dr1 H4 Vd3 Zv1 Vt2 Z2	Pp6 Z5 Vd9 Vr2 Ef1 Li1 C2	It1 Vd1 En1 Ef1
5	It2 Ap2 C3 Lt3 Av2 V1 Vd6 Ef2 Vt2 Sk1	Ct1 Sk1 It1 Ef1 Vd5 C1 Vt3 D1	Lt1 Ef2 Vd6 C1 Vt2 Z1 An1 D1	Vd4 C4 Vt3 V3 Ap1 Li1 As1 D1	Lt1 Bp1 Pp1 Ef2 Vd6 Z2 Sk1

VII

	A	B	C	D	E
1	Vd3 An1 As1 Bp1	Vd1 Vt1 Sk2 As1	Pp1 Ae1 Vt1 V1 Sk1 Ae1	Vd1 Ap1 As1 Ae1	Vd2 Ap2 As1 H1
2	D1	As1 Z1	Vt3 An1 Sk1	As1	
3	Vd1 Vt1 As1 H1	An1 Aa1 H1		As1	
4	Vt2 C1	Vd2 En1 Sk1		Ap1 Sk1 D1	As1
5	A1	Vd1 Vt1 A1 Sk1	Vd1 Vt1	Vd1 Sk1	Aa2

VIII

	A	B	C	D	E
1	Vd1 Ap2 En1 V1	Vd2 As1 Av1 Ae1	Vd1 H1 Ap1 Ae1 Sk1	Vt1 Av1 A1	
2	Ct1 As1 Aa1	Lt1 Sk1 H1	Ap1 Vp1	Sk1 As1	Ap1 En1
3	Pp2 Vd1 Ap1 Av1	Vd2 En1 As1	It1 Vd1 Z1	Vd1 Ap1 Sk1	
4	Vd2 Av1 C1	A1	Vd4 Sk2 Bp1	Vd3 Ed1	Sk1
5	Es1	Ap1 As2 Ae1	Aa1	Sk1 Ae1	

IX

Fig 4. Distribution of gastropods in litter of dry beech forest with <u>Oxalis acetosella</u> (locality C), VII- square VII,VIII- square VIII,IX - square IX. For symbol descriptions see Fig. 2.

Another approach is to study the spatial structure of the community, that is, distribution interrelations and dispersion characters of particular species, the age structure of dominants, etc. This approach is not common in the malacological literature. Łomnicki (1971) and Woyciechowski (1980) in their studies on <u>Helix pomatia</u> have applied some methods that render their results slightly similar to this type of analysis.

Yet another possible approach is to study factors influencing the microhabitat dispersion of a snail fauna. In such studies it is necessary to examine not only the snail fauna but also plants and litter of the studied plots. All the mentioned approaches are considered here in a preliminary analysis, which is to provide a basis for a study on interspecific interrelations within a gastropod community as well as on factors influencing the community structure and function. The sampling method used in our study should allow to trace relationships overlooked in studies completed using other methods.

In the material collected 29 species were recorded, the species number varying from 11 to 28 per square. In squares I, II, VIII and IX (Tab. 2) it was lower than 20. Similar numbers of gastropod species (S) were recor-

Table 2

Ecological parameters and mean values of litter dry weight on particular squares

Square	S	N	H′	J′	M
I	12	72	3.19	0.86	68.8
II	15	160	2.58	0.66	65.9
III	16	218	2.95	0.72	69.5
IV	22	558	2.97	0.65	43.6
V	28	512	4.08	0.83	53.7
VI	25	594	3.33	0.70	34.2
VII	22	283	3.09	0.68	44.9
VIII	11	67	2.99	0.86	19.0
IX	16	70	3.24	0.81	22.5

ded rom various deciduous forest habitats: 25 (Drozdowski 1961: Płutowo), 27 (Dzięczkowski 1974: Morasko, together with aquatic species), 21 (Dyduch 1980: Niepołomice Forest). The number of species found in the valley of the Spadowiec stream as well as 43 species given for the Tatra National Park by Dzięczkowski (1972) suggest that the malacofauna in the Carpathian beech forest Dentario-glandulosae Fagetum is qualitatively rich.

The snail density (N) in the studied valley differed between squares, ranging from 67 (VIII) to 594 (VI) individuals per sq m. Lower densities were recorded from riverine forest habitats: 125 - 221 ind./sq m (Dzięczkowski 1974), 284 ind./sq m (Drozdowski 1961), and 112 ind./sq m (Dyduch 1980).

In our study the species numbers were more strongly correlated with snail densities in the squares (r_{SN} = 0.9) than with the values of H′ ($r_{SH'}$ = 0.6) that ranged from 2.6 to 4.1. The values of the indices and their relations do not depart from those calculated for other localities in the Tatra Mts. Neither the species number nor snail density were correlated with the average dry litter weight in a square (r_{SM} = 0;01, r_{NM} = = -0.03).

The two methods combined for the purposes of this study (the grid method and square frame method) have provided information on the distribution of particular snail species within the community (Figs 2 - 4) as well as on the dispersion of the populations of the most abundant species. The Lexis and Morista indices have been used here to describe the gastropod

Table 3

Dispersion indices

Index \ Locality	Community			Population of *V. diaphana*			Population of *V. transsylvanica*			Population of *C. tridentatum*
	A	B	C	A	B	C	A	B	C	B
$\frac{\sigma^2}{\bar{m}}$	2.96	6.74	6.31	3.42	2.28	3.03	1.10	2.11	1.95	5.50
J^*	1.33	1.27	1.94	2.39	1.33	2.24	1.15	1.73	3.11	2.07

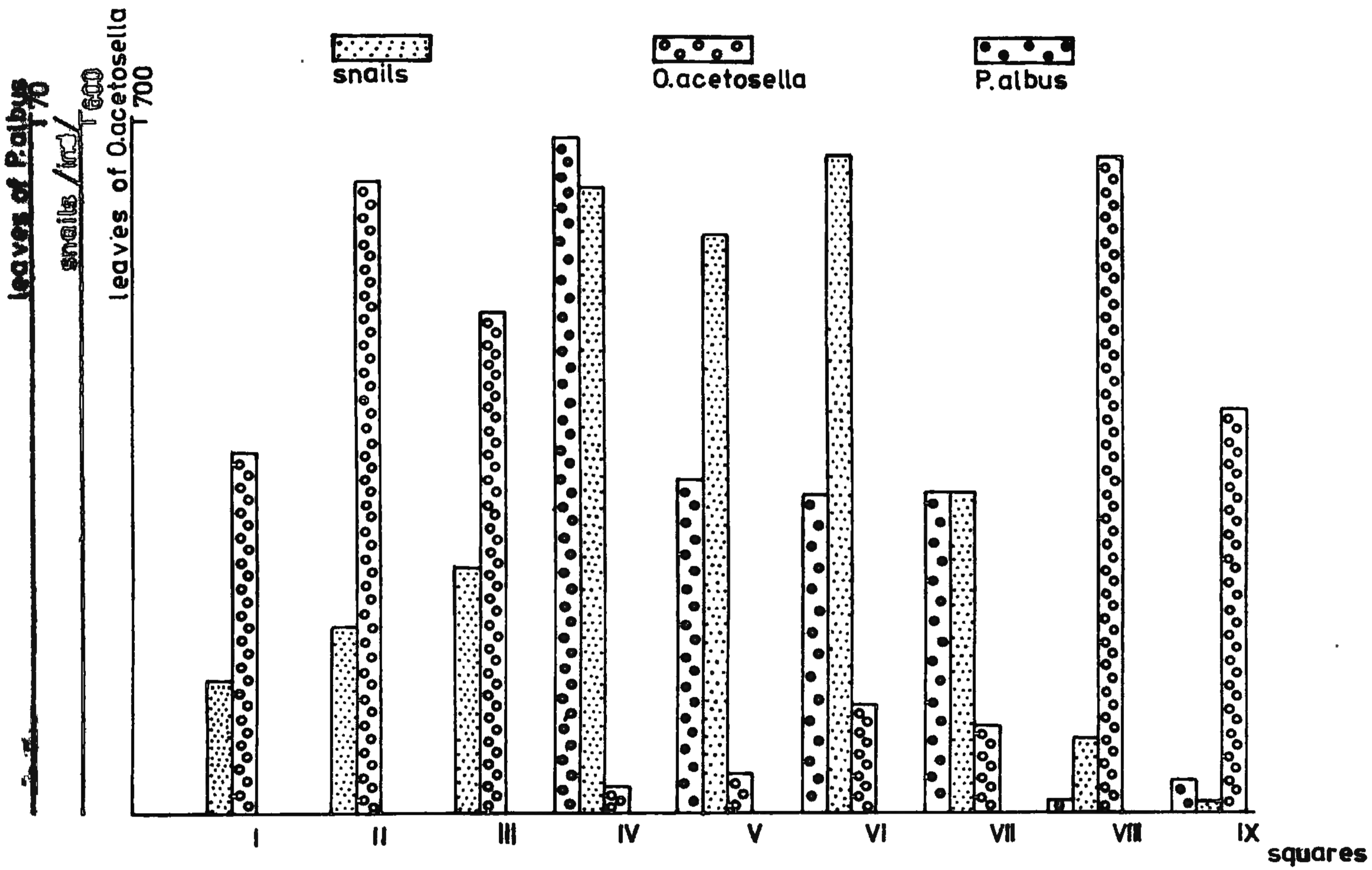

Fig. 5. Abundance of snails and plants (*Petasites albus, Oxalis acetosella*) in squares

distribution. The Lexis index was applied in a population analysis of Helix pomatia (Łomnicki 1971). Both indices are based on variance, and then depend on sample size. Since in our study the samples taken were of a similar snail number, this source of error can be neglected. The values of the two indices (Tab. 3) show that the distribution of snails in the studied forest patches was aggregated ($\frac{s^2}{m}$ 1, $I_\Delta > 1$). The data, however, are not sufficient for a more detailed characteristics. For instance, Huflejt and Karwowski (1981) observed that the indices are not adequate for parameters of an ecological significance. The present results obtained by means of the two indices differ between the patches. In one case (squares IV - VI) the highest value of $\frac{s^2}{m}$ accompanied the lowest of I, this proportion being not maintained in the other cases (squares I - III and VII - IX, Tab. 3).

In further studies of this kind it would be necessary to apply a comparative analysis of theoretic and empiric distribution patterns. This concerns not only the spatial distribution of species in the community but also the distribution within populations of the most abundant species: Vitrea diaphana, V. transsylvanica and Carychium tridentatum. The values of Morista and Lexis indices calculated for these populations also indicate their aggregated spatial distribution (Tab. 3).

Correlation coefficient values for snail and plant densities indicate some snail-plant interrelations. The gastropod densities were strongly positively correlated with the densities of Petasites albus, but negatively correlated with the densities of Oxalis acetosella (r = 0.84, and r = = -0.84 respectively: Fig. 5). O. acetosella takes adventage of local increases in soil acidity, since it can grow in habitats of an increased acidity, avoided by other herbs (S. Michalik personal communication). The negative correlation indicates that such habitats are also avoided by gastropods.

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STRUKTURA PRZESTRZENNA ZGRUPOWANIA ŚLIMAKÓW W ŚCIÓŁCE LASU BUKOWEGO, DENTARIO-GLANDULOSAE FAGETUM, W TATRACH

S t r e s z c z e n i e : W badaniu struktry przestrzennej zgrupowania ślimaków ściółki buczyny karpackiej wykorzystano metodę "kraty". Próby pobierano ramką o wymiarach 20 x 20 cm, stycznie jedna obok drugiej tak, że tworzyły kwadrat o boku 100 cm. W trzech płatach Dentario-glandulosae Fagetum, położonych w Dolinie Spadowca, pobrano łącznie 225 prób (9 m^2).

Zebrano łącznie 2 474 ślimaki należące do 29 gatunków (Tab. 1, Figs. 2 - 4). Liczba gatunków w kwadracie wahała się od 11 do 28, mniej niż 20 było w kwadratach I, II, VIII i IX; zagęszczenie N wahało się od 67 do 594 osobników/m^2. Różnorodność gatunkowa H' mieściła się w granicach 2,6 - 4,1 i była niezbyt silnie skorelowana z liczbą gatunków S ($r_{SH'}$ = 0.6). Liczba gatunków i zagęszczenie nie były skorelowane ze średnią masą ściółki na poletku (r_{NM} = 0,01; r_{SM} = -0,03).

Rozmieszczenie wszystkich ślimaków w zespole, a także populacji gatunków występujących najliczniej, było skupiskowe - wartości wskaźników Lexisa i Moristy były większe od 1. Stwierdzono wyraźny związek pomiędzy rozmieszczeniem ślimaków a rozmieszczeniem roślin zielonych. Zaobserwowano silną korelację dodatnią zagęszczenia ślimaków z występowaniem lepiężnika Petasites albus (r = 0,84), a ujemną z obecnością Oxalis acetosella (r = -0,84).