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THE SIGNIFICANCE OF QUANTITATIVE FLUCTUATIONS IN EURIVALENT LAND SNAILS *(MOLLUSCA: GASTROPODA TERRESTRIA)* IN MALACOCOENOSES

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In this paper the quantitative fluctuations of seven taxa of land snails in the malacocoenoses of forest communities on the Medvednica mountain (north - western Croatia) are investigated. These taxa *Aegopinella epipedostoma* (FAGOT, 1879), *Aegopis verticillus* (FÉRUSSAC, 1822), *Cochlodina laminata grossa* (ROSSMÄSSLER, 1835), *Perforatella incarnata* (O. F. MÜLLER, 1774), *Semilimax carinthiacus* (WESTERLUND, 1886), *Punctum pygmaeum* (DRAPARNAUD, 1801) and *Vitrea subrimata* (REINHARDT, 1871) occur in all the malacocoenoses where research was conducted, and they are eurivalent in the Medvednica area within the context of forest phytocoenoses.

Their absolute quantitative values were recorded - the densities of these taxa expressed by the number of specimens per unit volume, and the relative densities of taxa expressed as a percentage proportion of taxon in the malacocoenosis.

The eurivalent species of snails have their maximum absolute densities in qualitatively and quantitatively rich malacocoenoses of basophilic, thermophilic phytocoenoses, and their minimum densities in qualitatively and quantitatively poor acidophilic phytocoenoses. The relative densities of the eurivalent species are greater in acidophilic phytocoenoses and least in thermophilic, basophilic phytocoenoses. Thus it was shown that a high absolute density of specific taxon does not have in consequence a correspondingly high percentage density, because the percentage density is the result of quantitative interrelationships between all the taxa in the malacocoenoses. The problem of utilising adequate methods to gather snail specimens is also considered.

Key words: absolute density of land snails, relative density of land snails, malacocoenoses, forest communities.

Abbreviations: as. = association, subas. = subassociation.

U ovom radu prikazane su kvantitativne promjene sedam taksona kopnenih puževa u malakocenozama šumskih zajednica na području planine Medvednice (sjeverozapadna Hrvatska). Ti taksoni *Aegopinella epipedostoma* (FAGOT, 1879), *Aegopis verticillus* (FÉRUSSAC, 1822), *Cochlodina laminata grossa* (ROSSMÄSSLER, 1835), *Perforatella incarnata* (O. F. MÜLLER, 1774), *Semilimax carinthiacus* (WESTERLUND, 1886), *Puntcum pygmaeum* (DRAPARNAUD, 1801) i *Vitrea subrimata* (REINHARDT, 1871) dolaze u svim istraživanim malakocenozama te su na području Medvednice u okviru šumskih fitocenoza eurivalentni.

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Praćene su njihove apsolutne kvantitativne vrijednosti - gustoće taksona izražene brojem primjeraka po jedinici volumena, te relativne gustoće taksona izražene kao postotna zastupanost taksona u malakocenozi.

Eurivalentne vrste puževa imaju najveće apsolutne gustoće u kvalitativno i kvantitativno bogatim malakocenozama bazifilnih, termofilnih fitocenoza, a najmanje u kvalitativno i kvantitativno siromašnim acidofilnim fitocenozama. Relativne gustoće eurivalentnih vrsta su najveće u acidofilnim fitocenozama, a najmanje u termofilnim, bazifilnim fitocenozama. Tako se pokazalo da velika apsolutna gustoća određenog taksona nema za posljedicu i njegovu veliku procentualnu gustoću, jer je procentualna gustoća rezultat međusobnih kvantitativnih odnosa taksona u malakocenozama. Razmatran je i problem primjene adekvatne metode skupljanja puževa.

Ključne riječi: apsolutna gustoća taksona, procentualna gustoća taksona, malakocenoze, šumske zajednice.

Kratice: as. = asocijacija, subas. = subasocijacija.

INTRODUCTION

There are already on record numerous investigations into land snails with a view to identifying communities and their qualitative and quantitative features. Various methods of gathering snail specimens are used, but the commonest method involves taking soil samples of a specific volume or from a specific area, (ANT 1963, 1968, 1969, BÁBA 1969, 1969a, 1974, 1974a, 1979, 1989, BÁBA et al. 1983, BUTOT 1962, 1965, DROZDOWSKI 1966, 1966a, 1968, KOFLER 1965, MÖRZER BRUIJNS 1947, MÖRZER BRUYNS 1943, OEKLAND 1929, THIELE 1956), or else taking soil samples along with the collection of individual snails (ALONSO 1977, BOLE 1976, 1979, CAMERON 1973, EBLE 1974, FRANK 1975, 1975a, 1976, 1981, 1983, 1984, 1985, 1987, HAGEN 1952, KÖRNIG 1966, 1985, 1987, 1989, MARTIN 1987, MEIER 1987, VALOVIRTA 1968, WALDÉN 1955).

Smaller species, or juvenile specimens of larger species are collected by taking soil samples, usually from a surface area of 25 x 25 cms. Adult specimens of the larger species are rarely collected in this way, for the chances of finding, say, one or more specimens of *Helix* (which may be up to 5 cms in height) within an area of 1/16 m^2 are very slight. On the oder hand, in a soil sample taken from that sort of area it is not surprising to find 50 or even 100 specimens, e.g. of the species *Truncatellina* or *Punctum pygmaeum*, since their size is between 1,2 - 2 mms. Thus, the method of collecting soil samples will give reliable quantitative data for the species found in the samples, but it will not give a qualitative impression of the region from which the samples were taken, for not all species will have been collected. This may be avoided by enlarging the area from which samples are taken, or by determining a minimal area. This significantly increases the number of samples and time required to extract the snails from the samples. This is why many malacologists employ another method: the taking of soil samples together with manual collection of larger individual specimens. This method will yield a good qualitative impression, for all species will be taken into account. The accuracy of the quantitative data may be questionable, however, because the smaller species will as a rule not be included in manual collection. The probability that, in the field, we will detect a snail measuring 2 mms or less is very slight. There is also a strong probability that all the medium - sized specimens may not be detected in manual collection. Thus the question arises as to the evaluation of the quantitative relationships of the various species in malacocoenoses. In order to avoid this, in the present paper the quantitative data from the malacocoenoses of the 11 forest communities investigated are considered for each species separately. We have taken into account those species that occurred in all the malacocoenoses we examined, i. e. those that proved to be eurivalent in the relevant region within the forest communities into which research was conducted.

DESCRIPTION OF THE RESEARCH AREA

The Medvednica mountain is located in north-western Croatia. It is elliptical in shape, 42 kms long and 30 kms wide. Its highest summit is 1033 m above sea level. It has a typical Central European climate and it's larger part is covered with forest.

VEGETATION

The forest communities into which research was carried out are located in 11 phytocoenoses. On the lower slopes occur neutrophilic association (as.) *Querco-Carpinetum croaticum* HORVAT 1937, acidophilic subas. *Querco-Carpinetum croaticum luzuletosum* ŠUGAR 1972, acidophilic as. *Querco-Castanetum croaticum* HORVAT 1938, acidophilic and thermophilic as. *Luzulo-Quercetum petraeae* (HILITZER) PASSARGE 1953, basophilic and thermophilic as. *Lathyro-Quercetum petraeae* HORVAT 1958, a distinctly basophilic and distinctly thermophilic as. *Querco-Ostryetum carpinifoliae* HORVAT (1937) 1938. In the middle altitude zone the following associations occur: neutrophilic *Fagetum croaticum montanum* HORVAT 1938, basophilic thermophilic *Tilio-Taxetum* GLAVAČ 1958, acidophilic *Luzulo albidae-Fagetum* WRABER (1955) 1956. In the uppermost, coolest region of Medvednica, two acidophilic associations occur: *Abieti-Fagetum dinaricum* TREGUBOV 1948 and *Aceri-Fraxinetum croaticum* HORVAT 1938. Most of the phytocoenoses referred to are not strictly linked to one of the altitude zones defined here, but may extend into other zones, depending on orographic, pedological and other conditions.

METHODS

The land snails were gathered in forest phytocoenoses of Medvednica on the basis of a vegetation map drawn up by Dr. I. ŠUGAR (1981).

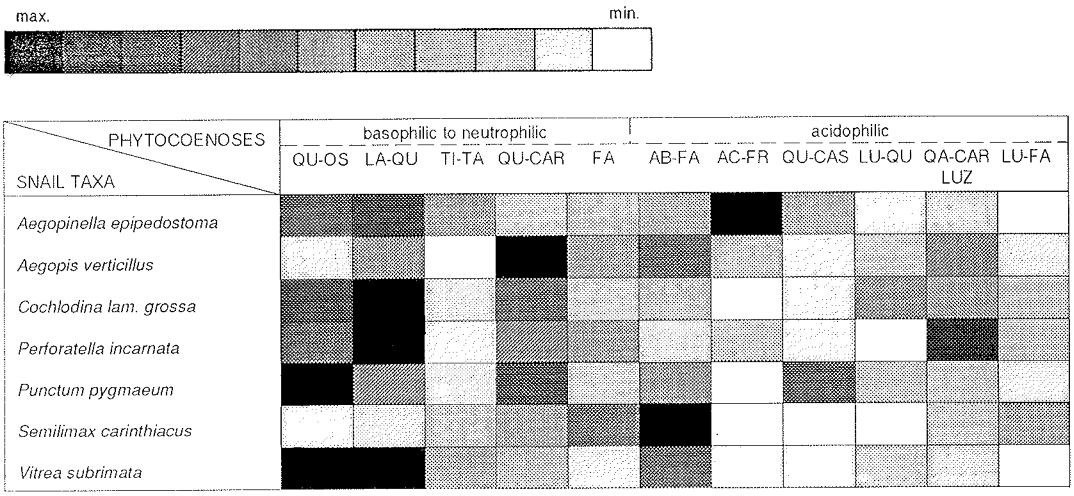
In each of the phytocoenoses examined at least five sites were specified on which snails were gathered individually by hand and 1-4 soil samples were taken. The number of sites was less than this only in cases where the plant community occupied only a fairly small area and it was not possible to investigate a larger number of sites.

Table 1. The percentage densities of land snails in malacocoenoses of the forest phytocoenoses (1a. numerical; 1b. graphical). The black square marks the highest density value of certain taxon, while the white square marks the lowest one. Intervalues are denoted according to the enclosed scheme.

1a.

PHYTOCOENOSES / SNAIL TAXA	basophilic to neutrophilic					acidophilic					
	QU-OS	LA-QU	TI-TA	QU-CAR	FA	AB-FA	AC-FR	QU-CAS	LU-QU	QA-CAR LUZ	LU-FA
Aegopinella epipedostoma	4,67	12,07	5,23	2,58	4,29	11,20	75,00	31,07	3,86	6,25	3,91
Aegopis verticillus	0,18	0,99	0,23	6,66	3,06	5,81	3,18	4,60	4,63	6,25	6,51
Cochlodina lam. grossa	2,70	9,78	0,78	8,81	4,29	6,64	0,91	9,21	14,67	10,63	18,23
Perforatella incarnata	1,56	5,69	0,55	7,09	8,58	3,73	9,09	8,06	3,86	35,00	18,23
Punctum pygmaeum	3,30	2,49	1,41	6,45	5,82	9,54	3,64	29,92	16,22	11,88	20,83
Semilimax carinthiacus	0,18	0,70	1,02	3,87	8,88	14,11	1,36	3,45	2,32	7,50	18,23
Vitrea subrimata	1,24	2,69	0,94	1,72	1,23	9,96	0,91	2,30	5,41	2,50	1,30

2b.



The soil samples comprised 4 dm^3. Most methods of soil sampling are based on gathering from a specific area, regardless of the volume of the samples. In compiling quantitative data I consider that it is not only the area from which the samples are taken that matters, but also the volume of the samples. Collecting larger individual specimens was effected on an area of 100 square metres.

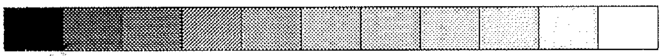
The period of search ("die Zeitfänge" HEROLD 1928, 1929) was taken into account. Thus, in stands rich in snails the time spent searching for suitable places where snails could be found and specimens gathered was relatively brief (10-15 minutes), with

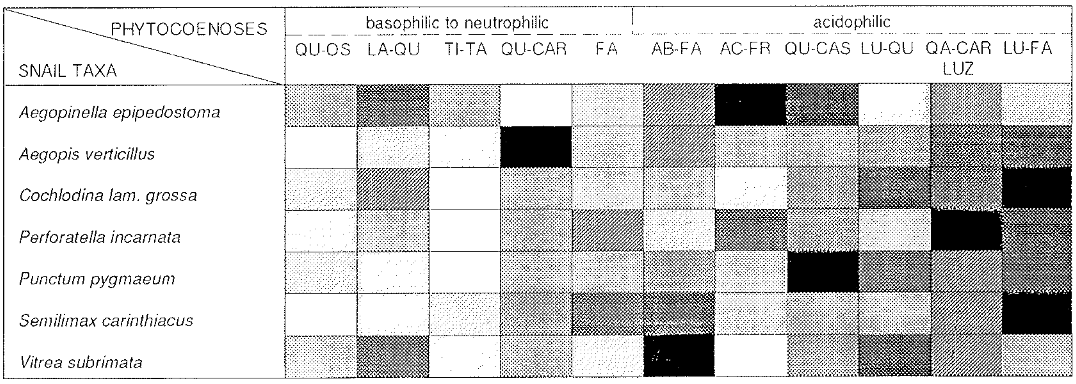
Table 2. The absolute densities of land snails in malacocoenoses of the forest phytocoenoses (2a - numerical; 2b - graphical). The black square marks the highest density value of certain taxon, while the white square marks the lowest one. Intervalues are denoted according to the enclosed scheme .

2a.

PHYTOCOENOSES / SNAIL TAXA	basophilic to neutrophilic					acidophilic					
	QU-OS	LA-QU	TI-TA	QU-CAR	FA	AB-FA	AC-FR	QU-CAS	LU-QU	QA-CAR LUZ	LU-FA
Aegopinella epipedostoma	10,2	12,1	6,7	1,2	1,4	2,7	16,5	2,7	0,5	1,0	0,3
Aegopis verticillus	0,4	1,0	0,3	3,1	1,0	1,4	0,7	0,4	0,6	1,0	0,5
Cochlodina lam. grossa	5,9	9,8	1,0	4,1	1,4	1,6	0,2	0,8	1,9	1,7	1,4
Perforatella incarnata	3,4	5,7	0,7	3,3	2,8	0,9	2,0	0,7	0,5	5,6	1,4
Punctum pygmaeum	7,2	2,5	1,8	3,0	1,9	2,3	0,8	2,6	2,1	1,9	1,6
Semilimax carinthiacus	0,4	0,7	1,3	1,8	2,9	3,4	0,3	0,3	0,3	1,2	1,4
Vitrea subrimata	2,7	2,7	1,2	0,8	0,4	2,4	0,2	0,2	0,7	0,4	0,1
COENOSIS DENSITIES	218,30	100,26	128,00	46,52	32,64	24,10	22,00	8,69	12,95	16,00	7,68

1b.





three or four samples being taken. In stands thinly populated with snails more time was needed to find a favorable place for gathering samples and finding the larger specimens (25-30 minutes), and the number of samples was smaller (one or two).

The determination of lands snails cited in this paper was carried out according to KERNEY et al. (1983) and GITTENBERGER (1967). The nomenclature of the snails has also been adopted from these authors.

The quantitative proportions of taxa per phytocoenoses is determined on the basis of their percentage representation in the density of the coenosis. The percentage density of taxon T in coenosis C is calculated according to the formula:

$$d_P = \frac{d_T}{D_C} * 100$$

where:

d_p - percentage density of taxon T in coenosis C

d_T - density of taxon T per sample in coenosis C

D_C - density of coenosis C.

The taxon density d_T is calculated by dividing the total number of specimens of taxon T in coenosis C by the number of samples taken in coenosis C.

The coenosis density D_C tells us the total number of all taxa per sample in coenosis C. It is calculated according to the formula:

$$D_c = \sum d_T$$

RESULTS AND DISCUSSION

In the malacocoenoses of the forest communities investigated 42 taxa of land snails were found (ŠTAMOL 1991). Of these, seven taxa *Aegopinella epipedostoma*, *Aegopis verticillus*, *Cochlodina laminata grossa*, *Perforatella incarnata*, *Punctum pygmaeum*, *Semilimax carinthiacus* and *Vitrea subrimata* occurred in all the malacocoenoses and we may regard these as eurivalent in the area of research. The quantitative values for all the taxa quoted are expressed in terms of taxa density in Table 2, and in terms of percentage density of taxa in Table 1. The percentage density of taxon is a relative value which reflects the quantitative relationship between taxa in the coenosis. The taxon density is an absolute quantitative value expressing changes in the number of specimens in the coenosis and is not linked to the quantitative representation of other taxa. For this reason changes in the percentage values of taxa are more significant for research into malacocoenoses.

A survey of the percentage quantitative fluctuations in a particular species depending on the malacocoenoses investigated reveals that the eurivalent snails have their lowest values in thermophilic, basophilic to neutrophilic phytocoenoses, while their highest values in acidophilic phytocoenoses (Table 1). These results appear to run counter to data relating to the quantitative richness of snails in the malacocoenoses into which research was carried out (ŠTAMOL 1991). In fact, the research referred to indicated that basophilic, thermophilic phytocoenoses have qualitatively and quantitatively the richest malacocoenoses, while acidophilic phytocoenoses are the poorest. It is clear that the malacocoenoses of basophilic termophilic phytocoenoses owe these features to calciphilic snails which are not present in acidophilic communities. The more a phytocoenosis is acidophilic, the smaller is the number of species and specimens. A consequence of this is an increase in the percentage density in the acidophilic phytocoenoses of eurivalent snails, i. e. of those snails which occur in all the malacocoenoses that were investigated.

A question then arises as to the accuracy of the quantitative data for species collected, besides soil samples, also by hand individually. Both modes of gathering are used together for almost all taxa, with the exception of *Punctum pygmaeum*. As far as they are concerned, there is a possibility that, from time to time, they were not observed on the ground in the course of manual collection, and that errors may have thus been made in ascertaining their quantitative values. However, it may be assumed that these errors were identical or similar in the collection of one and the same species, so the research gives a rough overall impression of the relative quantitative situation in determining the percentage densities, and of the absolute quantitative situation in ascertaining the densities of taxa. Only the data relating to the absolute density of the species *Punctum pygmaeum* may be regarded as accurate. *Punctum pygmaeum* achieves its maximum values in terms of percentage density in malacocoenoses of acidophilic plant communities, and its minimal values in thermophilic basophilic plant associations (Table 1).

As far as data relating to the (absolute) density of eurivalent taxa in the phytocoenoses investigated are concerned, the situation is almost reversed. In thermophilic, basophilic phytocoenoses the densities of the relevant snail species have their highest values, while in acidophilic phytocoenoses they register minimal values (Table 2). *Punctum pygmaeum* also has its maximum density in the thermophilic, basophilic phytocoenosis *Querco-Ostryetum* and its lowest density in the acidophilic *Aceri-Fraxinetum*. This research corroborated the claim by CAMERON (1973:364) that *Punctum pygmaeum* is tolerant to soil acidity. We find differences in comparison with Valovirta's research in Finland (1968: 249). His research showed that the number of specimens of Punctum pygmaeum per litre of soil is greater on acid soil than the number of specimens on neutral soil (basic soils were not included in Valovirta's research). This suggests that the numerosity relations of *Punctum pygmaeum* are not directly governed by the soil pH factor alone, but by a combination of many ecological factors.

CONCLUSIONS

A quantitative analysis of the inter-relationships between seven taxa of land snails occuring in the malacocoenoses of 11 phytocoenoses on Medvednica mountain showed that:

1. the taxa have their maximum (absolute) densities in basophilic, thermophilic phytocoenoses and minimal (absolute) densities in acidophilic phytocoenoses (Tab. 2);

2. the land snails in question attain their maximum percentage densities in acidophilic phytocoenoses, and their minimal percentage densities in basophilic phytocoenoses (Tab. 1);

3. only the data on absolute densities relating to the species *Punctum pygmaeum* may be considered accurate because they were obtained by using a single method of collecting specimens: the taking of soil samples of 4 dm^3 volume;

4. quantitative results obtained by combining soil samples and individual

culling (there are measurements of absolute densities for all relevant kindred species, except for *Punctum pygmaeum*, and all relative percentage densities) have to be treated with caution, for errors may arise in culling individual specimens by hand;

5. fewer errors arise in recording absolute values for each species separately per researched malacoenoses, for it is probable that cognate errors will arise during the collection of a certain species;

6. as far as quantitative features are concerned - the proportions of snails in the malacocoenoses, relative (percentage) relationships are very important, because they express quantitative inter-relationships that are the result of ecological conditions in the biotope and the biocoenosis.

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