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SIMILARITY, DIVERSITY AND EQUITABILITY OF SNAIL COMMUNITIES IN LOWER MOUNTAIN ZONE IN THE TATRA MOUNTAINS

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ABSTRACT: The malacofauna of 24 localities in the lower mountain zone of the Tatra Mts includes 61 species. The richest communities have a high species diversity H' and a moderate equitability J'. Communities of a lower species diversity H' and of their equitability J' similar as that of the former ones inhabit biotopes with limited food and habitat resources. A very low species diversity H', along with extremely varied values of equitability J', is characteristic for communities inhabiting biotopes whose conditions are unfavourable for snails.
In the discussion on the structural parameters of the snail communities in the Tatra Mts and their qualitative similarity, connections between communities of the same kind appear several times. Qualitatively similar communities show similar structural parameters. A clear structural similarity is marked also when extreme qualitative differences occur. A strong pressure of natural and/or anthropogenous conditions results in the formation of communities of extremely distinct species composition.

KEY WORDS: malacofauna, species diversity H', equitability J', synanthropisation, qualitative similarity

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INTRODUCTION

There is still a quite limited number of malacological studies concerning coenological problems. Before 1950 the mollusc fauna of Poland was investigated mostly from the faunistic or systematic point of view (Riedel 1954, 1957, Wiktor 1964, 1973). Only a few studies deal with phytosociological characteristics of habitats or analyze relations between particular species and species associations with biotopes (Urbański 1939, Drozdowski 1963, Dzięczkowski 1972, 1974, Dyduch 1980). The

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methods applied are similar to those used in plant sociology (Jungbluth 1975). No method has been found applicable to comparisons of the mollusc communities of physiographically remote regions whose biotopes, in addition, are considerably varied. The paper is an attempt at such an analysis based rather on the structural indexes commonly used in ecology of animal communities (e.g. birds: Głowaciński 1975, 1981) than on the species composition.

The present description of snail communities is based on their similarity, species diversity and equitability. Its aim is a comparative analysis of the snail communities of the main types of biotopes in the Tatra Mts. and a study of some aspects of both the snail communities formation and factors determining the community structure and function.

MATERIAL AND METHODS

The material was collected in 1982 - 1983 in the Tatra National Park. A total of 95 samples from 24 localities were taken. The semi-quantitative method was applied: snails were collected for on equal time-span on each locality (sweeping with entomological net, sieving and sorting litter, collecting under stones, pieces of wood, and bark). The frame-square method has been abandoned mainly due to unfavourable weather conditions (drought) but also due to the high diversification (a mosaic pattern) of habitats, low densities, and dispersion characters. Hence, the quantitative data are probably biased towards lower values.

The snail communities of the Tatra Mts. were analysed in respect of their species composition, qualitative similarity, species diversity and equitability. The parameters were calculated according to the following formulas:

$$d_{st.} = \frac{A + B - 2C}{A + B - C}$$

where: $d_{st.}$ - the taxonomical distance between two communities according to Marczewski and Steinhaus (1959)

A - the number of species in the first community

B - the number of species in the second community

C - the number of common species for both the communities.

The results of Romaniszyn (1972) and Legendre and Legendre (1979) justify the application of this index.

$$H' = \frac{c}{N} (N \log_{10} N - \quad n_i \log_{10} n_i)$$

$$J' = \frac{H'}{H_{max}} \qquad \text{where } H_{max} = \log_2 S$$

H' - the species diversity of a community according to the Shannon - Weaver formula

N - the number of individuals in a community

n_i - the number of the individuals of each species

c - 3.321928

J' - the equitability (evenness) according to Pielou (1975)

S - the number of species in a community.

STUDY AREA

The investigated habitats in the Western Tatra Mts. are of the following types:

I. Lower mountain glades - semi-natural biotopes resulting from grazing in the Tatra Mts. All of them regardless of the substratum are overgrown with various varietes of Gladiolo-Agrostietum, Hieracio-Nardetum and intermediate associations:

loc. 1. Chochołowska Glade, the substratum: alluvial cone, slope debris and gravel-loamy moraine fed by waters flowing from the calcareous Mnichy Chochołowskie Mt.;

loc. 4. Niżnia Kominiarska Glade, the substratum: Triassic formations: red sandstones, conglomerates, shales, and dolomites; Cretaceous limestones and marls with sandstone intercalations;

loc. 6. Kondratowa Glade, the substratum: slope debris and gravel-loamy moraine;

loc. 10. Przysłop Miętusi, the substratum: red and greenish shales, conglomerates, and yellowish dolomites;

loc. 12. Mała Łąka Glade, the substratum: gravel-loamy moraine and slope debris fed by waters flowing from the calcareous slopes of Skoruśniak Mt., Grzybowiec Mt., etc.;

loc. 15. Kalatówki Glade, the substratum: slope debris and gravel-loamy moraine fed by waters flowing from the calcareous slopes of Kalacka Turnia Mt. and Kalacki Upłaz Mt.;

loc. 20. Jaworzyna Rusinowa Glade, the substratum: diversified, consisting of light-grey limestones, dark marls with cherts, conglomerates, and gravel-loamy moraine;

loc. 22. Waksmundzka Glade, the substratum: alluvial cone fed by waters flowing from the calcareous slope of Mała Koszysta Mt.;

loc. 24. Kopieniec Glade, the substratum: partly gravel-loamy moraine, partly dolomitic limestones and dolomites.

The substratum is a basic factor influencing the microclimate of the biotopes. The limestone, its pH weakly alkaline so favourable, is markedly warmer than the substrata originated from a crystalline bedrock and unpreferable due to their soil reaction.

II. The forest habitats in the lower mountain zone are covered with various varietes of Piceetum tatricum:

loc. 7. Between Zahradziska Mt. and Przysłop Miętusi, the substratum: fluvial and lacustrine sands and gravels, sandstones, siliceous limestones;

loc. 8. Between Przysłop Miętusi and the Mała Łąka Valley, the substratum: dolomitic limestones nad dolomites;

loc. 11. The Mała Łąka Valley, the substratum: dolomitic limestones, dolomites, and gravel-loamy moraine;

loc. 14. Above Kalatówki Glade, on the slope of Kalacka Turnia Mt., the substratum: light grey limestones and dark marls with cherts;

loc. 16. Between Kuźnice and Kondratowa Glade, the substartum: gravel-loamy moraine;

loc. 17. Between Kalatówki and Kondratowa Glades, the substratum: dolomites, black limestones, and shales;

loc. 18. Between Wierch Poroniec Mt. and Goły Wierch Mt., the substratum of the former one: sands and gravels, of the latter one: dark limestones with intercalations of black shales;

loc. 19. Wiktorówki, the substratum: shales, greenish sandstones and limestones, dolomitic limestones, limestones, and dolomites.

The microclimate of the forest habitats depends on the substratum less than that of the glades. However, their substratum is still of a great significance. The influence of a crystalline component on the habitat conditions is at least partly neutralized on the localities with the mixed calcareous-crystalline substratum.

III. Strikingly mosaic-pattern bottoms of valleys, limestones, slopes, couloirs (steep mountain gullies) Since the character of the localities is diversified, floristic remarks are given below.

loc. 2. The Chochołowska Valley, overgrown mostly with Piceetum tatricum. Limestones covered with epilithic grasslands were studied with a particular attention. The bottom of the valley is covered with fluvial sands and gravels as well as with lacustrine sediments, while the slopes consist of dolomitic limestones, limestones, and dolomites;

loc. 3. Kamienny Żleb Chimney above Hucisko Glade - covered with patches of epilithic grasslands with Saxifraga aizoon and S. aizoides. The grasslands seem favourable for malacofauna. The chimney is formed by dolomitic limestones, dolomites, and limestones;

loc. 5. The Lejowa Valley - overgrown with Fagetum carpaticum, Piceetum tatricum, and intermediate forms, the substratum: conglomerates, light grey limestones, dark marls with cherts, and red nodular limestones;

loc. 8. Przysłop Miętusi Saddle, a limestone slope covered with epilithic grasslands with some species of Saxifraga. The substratum: yellow dolomites, black limestones, shales, and breccias;

loc. 13. Giewont Mt. - its top parts overgrown with small patches of epilithic grasslands, the substratum: grey, pinkish, and dark limestones;

loc. 21. Gęsia Szyja Mt. - the surrounding of the top overgrown with Carici-Festucetum tatrae (Pięknoś-Mirkowa personal communication), the substratum: dolomitic limestones;

loc. 23. Wielki Kopieniec Mt. - covered with low epilithic grasslands, the substratum: dolomitic limestones, limestones, and dolomites.

The above description of the localities was based on the Geological Map of the Polish Tatra Mountains (1979) and on auhor's observations.

RESULTS

The studied snail communities consist of 61 species occurring regularly on the territory of the Tatra National Park. They are listed in Table 1. The values of the ecological parameters analyzed are given in Table 2, and their relations are shown in Figs 1 and 2.

There is no correlation between the diversity (H´) and equitability (J´), the correlation coefficient r = 0.11. Instead of, the points in the diagram showing their relation form three groups (Fig. 1a). The first one is small and covers the communities characterized by the highest diversity (H´) and a moderate equitability (J´). The group comprises the communities of Niżnia Kominiarska Glade (loc. 4), the Lejowa Valley (loc. 5), a lower mountain zone forest between Kalatówki and Kondratowa Glades (loc. 17), and Gęsia Szyja Mt. (loc. 21). The second group covers the communities characterized by a lower diversity and their equitability oscillating in a slightly wider range than that of the first one. This is the most numerous group consisted of 15 communi-

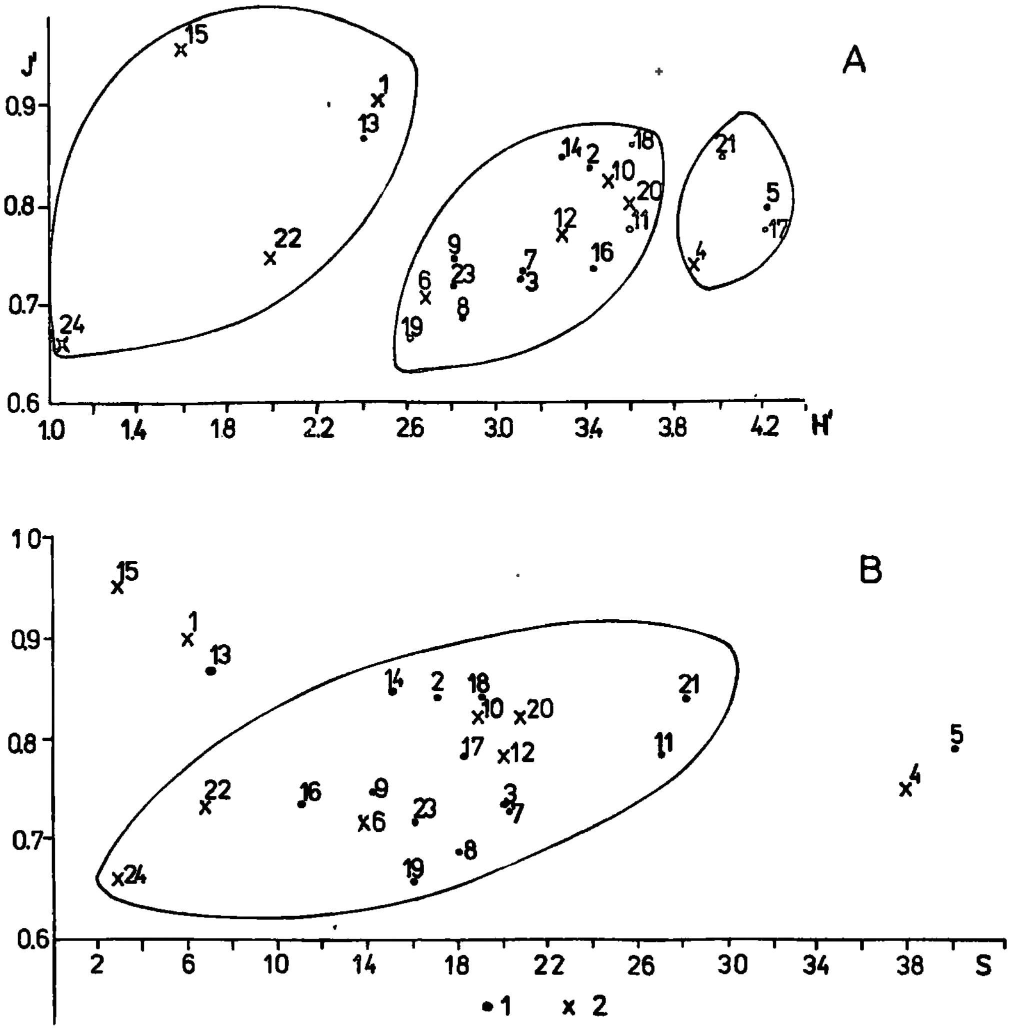


Fig. 1. Relations between (A) H′ and J′, (B) J′ and S; 1 - natural biotopes, 2 - semi-natural biotopes (glades)

ties (Fig. 1a) of the studied 24. The third group covers the communities with strongly diversified parameters: Chochołowska Glade (loc. 1), Kalatówki Glade (loc. 15), Waksmundzka Glade (loc. 22), Kopieniec Mt. (loc. 24), and Giewont Mt. (loc. 13).

Similarly, the correlation between the number of species in a community (S) and the equitability (J′) is low, $r = 0.1109$ (Fig. 1b). Their independence which follows from the formula (Pielou 1975) and was confirmed by the experimental results, allows the application of the furthest neighbour method and Ward's method in the grouping of the communities (the groups of Lance-Williams-Ward hierarchical methods) (Podolec, Zając 1978).

The character of the relations between the species diversity and the number of species is differentiated. The close correlation of these values following form the Shannon-Weaver formula has been confirmed (r = 0.812: Fig. 2).

The diagram (Fig. 3) of the taxonomical distance ($d_{st.}$) was based on the Marczewski-Steinhaus index. The distances between the most similar communities are the only ones taken into account. The similarity coefficients (s = 1-$d_{st.}$) between Niżnia Kominiarska Glade (loc. 4), the

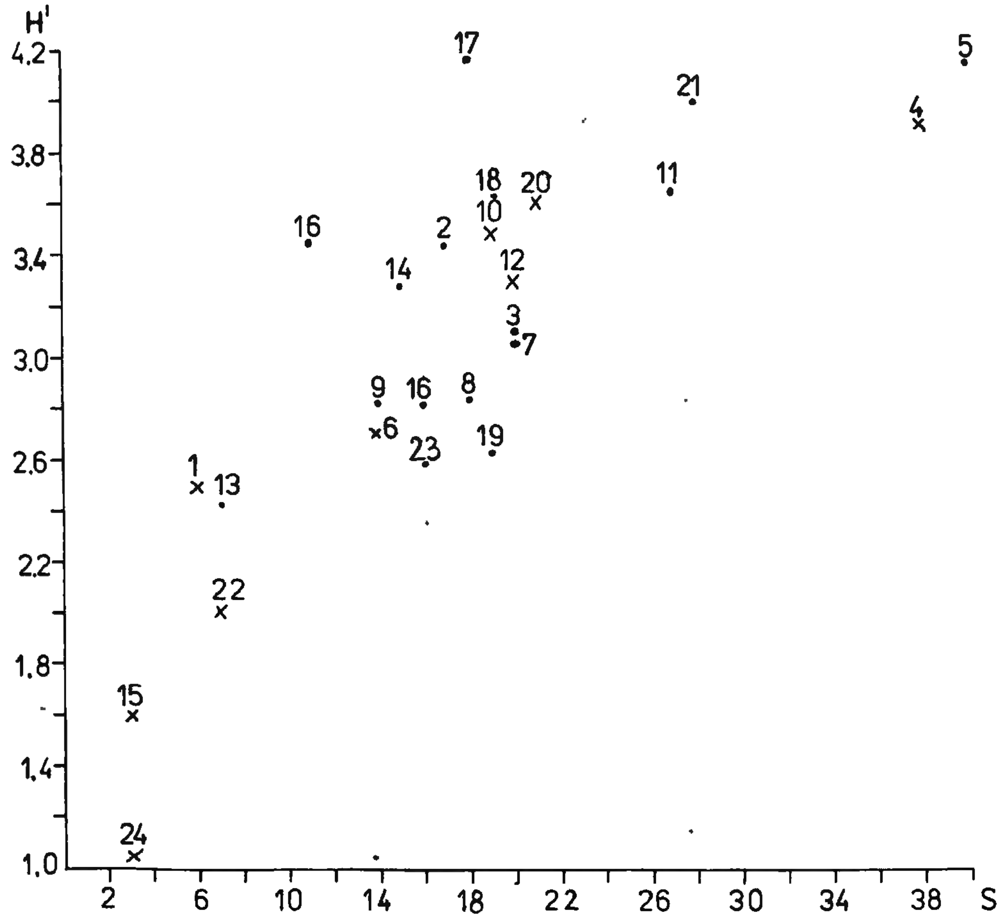


Fig. 2. Relation between H' and S

Lejowa Valley (loc. 5), and Gęsia Szyja Mt. (loc. 21) are highest. The distances between Gęsia Szyja Mt. (loc. 21), Goły Wierch Mt. and Wierch Poroniec Mt. (loc. 18) as well as between the forests in the lo-

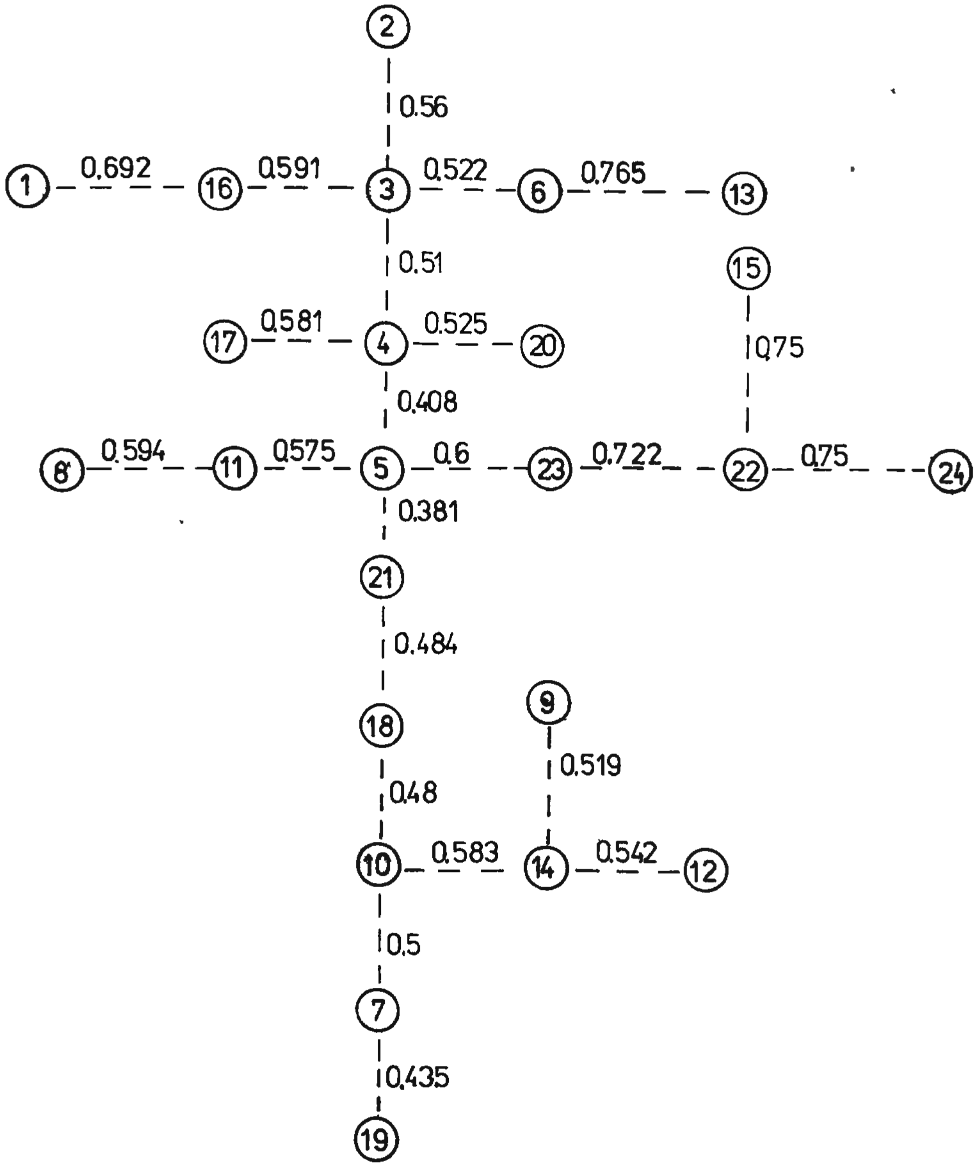


Fig. 3. Dendrite of the taxonomical distances between the gastropod communities

wer mountain zone at Wiktorówki (loc. 19) on a slope between Zahradziska and Przysłop Miętusi (loc. 7) are rather short. The distances between the other communities are longer (s < 0.5).

The communities from Chochołowska Glade (loc. 1), Kondratowa Glade (loc. 6), Przysłop Miętusi (loc. 8), a forest between Przysłop Miętusi and the Mała Łąka Valley (loc. 9), Giewont Mt. (loc. 13), Kalatówki Glade (loc. 15), a forest between Kuźnice and Kalatówki (loc. 16), Waksmundzka Glade (loc. 22) differ markedly from each other and from all the remaining communities. The value of the similarity index does not exceed (or only in one case exceeds) 0.4 (Fig. 3). The group of the localities whose similarity index in relation to at least 5 other localities is higher than 0.4 is less numerous. These are the biotopes which are particularly qualitatively rich: Kamienny Żleb Chimney above Hucisko Glade (loc. 3), Niżnia Kominiarska Glade (loc. 4), the Lejowa Valley (loc. 5), a forest between Zahradziska and Przysłop Miętusi (loc. 7), Przysłop Miętusi (loc. 10), Mała Łąka Glade (loc. 12), a forest between Wierch Poroniec Mt. and Goły Wierch Mt. (loc. 18), and Gęsia Szyja Mt. (loc. 21).

DISCUSSION

A. Relation between indexes H´ and J

Their correlation is statistically insignificant (r = 0.11). Consequently the organization level, as H´ is often called, is not determined by the equitability (J´) of a community. On the other hand, three groups of communities are distinguishable. The habitat conditions concerned are expected to differ in their functioning mechanism. The first community group comprises the communities inhabiting the biotopes which offer to molluscs the especially favourable conditions, i.e. Niżnia Kominiarska Glade (loc. 4), the Lejowa Valley (loc. 5), a forest between Kalatówki Glade and Kondratowa Glade (loc. 17), and Gęsia Szyja Mt. (loc. 21). The species diversity of the communities is high (the highest among the studied communities) and their equitability is moderate. The food base and carrying capacity of the communities are probably so rich and high respectively, that they do not limit the species diversity and the populations of each particular species develop practically independently on the others. According to Thompson (1982) it may suggest that due to the relatively high number of species, none of them dominating, the competition in the communities is not very strong. However, close interactions between pairs cannot be excluded, as a part of the long-term co-evolution process; hence the equitability is moderate.

The second group includes the communities whose species diversity is lower and the equitability is similar as in the preceding one. The values of their species diversity vary widely (2.6-3.6) and the diversity increases along with the equitability. The latter increases gradually from 0.6 to 0.85. Thus, the group is somewhat polarized. One pole are the communities from the habitats which are unfavourable in respect of their climate resulting from the situation (Kondratowa Glade - loc. 6, Przysłop Miętusi and Mała Łąka Valley - loc. 9, Wiktorówki - loc. 19, Wielki Kopieniec - loc. 23). The second one are the communities from the richer and quite climatically favourable habitats (e.g. Chochołowska Valley - loc. 2, Przysłop Miętusi - loc. 10, a forest on Kalacki Upłaz - loc. 14). The field observations suggest that this most numerous group is distinct with an increasing competition caused by the limited food base and the habitat conditions. The rather strong competition results in changes in the community structure and in the differences between the numbers of the particular species. Thus, competition could be a factor determining both the structure and qualitative-quantitative relations in a community.

The third group consists of the communities with a very low species diversity and a diversified equitability. They inhabit extremely unfavourable biotopes. All the biotopes except Giewont Mt. (loc. 13) where such conditions are natural, are semi-natural due to a past and present human impact (glades: Chochołowska - loc. 1, Kalatówki - loc.15, Waksmundzka - loc. 22, Kopieniec Mt. - loc. 23). Their crystalline substratum and the resulting microclimate conditions, which are unfavourable for malacofauna, along with too intensive grazing; prevent the mollusc communities from reaching a stable structure (i.e. similar to that of the communities inhabiting natural biotopes in the Tatra Mts.). It is probable that on the above localities the populations of each species develop independently on each other. Their abundances are limited by climatic and/or physico-chemical conditions and they do not interact between each other in the way described for the preceding group.

The above suggestions to a great extent base on arbitrary statements and field observations. Further malacological and ecological studies might support and explain the observed relationships.

The observations presented above indicate only the existence of three groups of snail communities in the lower mountain habitats of the Tatra Mts.

B. Relation between indexes J´and S

Due to the lack of correlation between the two parameters, following from the J" formula and evidenced by a low correlation coefficient ($r = 0.11$), it was possible to group the communities according to the hierarchical methods of Lance - Williams - Ward. The results of the grouping are partly in agreement with the above classification based on the values of H´ and J´. Two tests were applied here: the furthest neighbour method and Ward´s method. The results of the tests group the communities of: Chochołowska Glade (loc. 1), Kalatówki Glade (loc. 15), and Giewont Mt. (loc. 13) (Fig. 1b). The conclusion is drawn that the effects of the human impact on loc. 1 and loc. 15 are approximatelly as harmful as the extremely hard habitat conditions on Giewont Mt. (loc. 13). However, on the latter locality the influence of a tourist movement on the development of the epilithic grasslands should not be neglected, as the grasslands are the main mollusc habitat there.

On the contrary, the communities of Niżnia Kominiarska Glade (loc. 4) and the Lejowa Valley (loc. 5) have a high number of species. The further neighbour method allows to classify them as a distinct group, while Ward´s method indicates that they should be listed together with the communities of the Mała Łąka Valley (loc. 11) and Gęsia Szyja Mt.(loc. 21). However, the former two differ so much from the remaining ones in their species diversity, that the results of the furthest neighbour test should rather be admitted. Among the remaining communities the polarization mentioned in the proceding chapter becomes still more pronounced. The communities of the glades: Waksmundzka (loc. 22) and Kopieniec Mt. (loc. 24), extremely quantitatively and qualitatively poor, form a distinct group. They differ from those of Giewont Mt. (loc. 13), Chochołowska Glade (loc. 1), and Kalatówki Glade (loc. 15) in their markedly lower equitability. They may be regarded as a pole of a large group within which a steady increase of the species number occurs (Fig. 1b). This suggests that the low species numbers in these communities are in a lesser degree related with the human impact than in those of Chochołowska Glade (loc. 1) and Kalatówki Glade (loc. 15). The qualitative impoverishment of the previous communities results mostly from natural, unfavourable conditions of microclimatic or another character. The remaining 15 communities constitute a distinct, though not very homogenous group within which some subgroups may be distinguished. However, due to the lack of precise measurements of the habitat conditions, there are no bases for such a detailed classification.

The above results show that the number of species in the studied communities does not influence the equitability index that is the highest (ca. 0.9) in the habitats where the human impact is the strongest (loc. 1, 13, 15). The index frequently reaches extreme values at similar species numbers (e.g. Kalatówki Glade - loc. 15, Kopieniec Glade - loc. 24). Each of the groups distinguished in the present paper comprises the communities whose equitability is similar at approximately the same species number. This indicates their similar structure, i.e. the effect of the habitat conditions and factors determining the population interactions in the communities is qualitatively and quantitatively similar.

The high correlation (r = 0.812) of the species diversity and number evidences the relationship of these parameters, following from the definition of H´. The fact that the correlation coefficient is lower than, for instance, in bird populations (Głowaciński 1981), and lower than could be predicted from the formula, indicates the diversified quantitative relations influencing considerably the organization level (H´) in the studied communities.

C. The qualitative similarity of the communities

The present paper deals, among others, with the mollusc communities of the lower mountain glades in the Tatra Mts. which are semi-natural biotopes, as well as with the relations of these biotopes to the natural habitats. Basing on the quantitative similarity an attempt was made to establish: 1. to what degree the malacofauna of such biotopes is determined by the occurrence of the typical species of the natural habitats of the Tatra Mts., 2. whether or not the grazing process results in the formation of the communities by which the semi-natural biotopes can be distinguished as a separate category of habitats.

The similarity of the most similar communities of Niżnia Kominiarska Glade (loc. 4) and the Lejowa Valley (loc. 5) is almost self-evident, and may be explained by their close situation and the ecological conditions. Both the communities are surprisingly similar to the malacofauna of Gęsia Szyja (loc. 21). This locality, slightly ecotonal and peripheral in character (located on the foreland of the crystalline High Tatra Mts.), is considerably drier and situated at a greater altitude. Perhaps the similarity results from the warm calcareous substratum, cooled by winds on Gęsia Szyja (lok. 21) and by humidity in the Lejowa Valley (loc. 5) and Niżnia Kominiarska Valley (loc. 4). Eventually, a complex of microclimatic conditions would arise to promote the development of the quantitatively similar malacofauna.

The small distance separating Gęsia Szyja Mt. (loc. 21) from the forest between Wierch Poroniec Mt. and Goły Wierch Mt. (loc. 18) explains the significant similarity of their malacofaunae. The distinct mosaic-pattern of the latter locality results probably from the fact that some species might have come from Gęsia Szyja and survive in Piceetum tatricum near Goły Wierch. The conditions in the spruce forest are generally unfavourable for snails; only the most resistant species can tolerate brown, acid (pH~5) soil frequented by humidity falls resulting from the fast flow of surface waters; other soil factors also limit the occurrence of snails in such a forest (Komornicki 1975, Dyduch 1980).

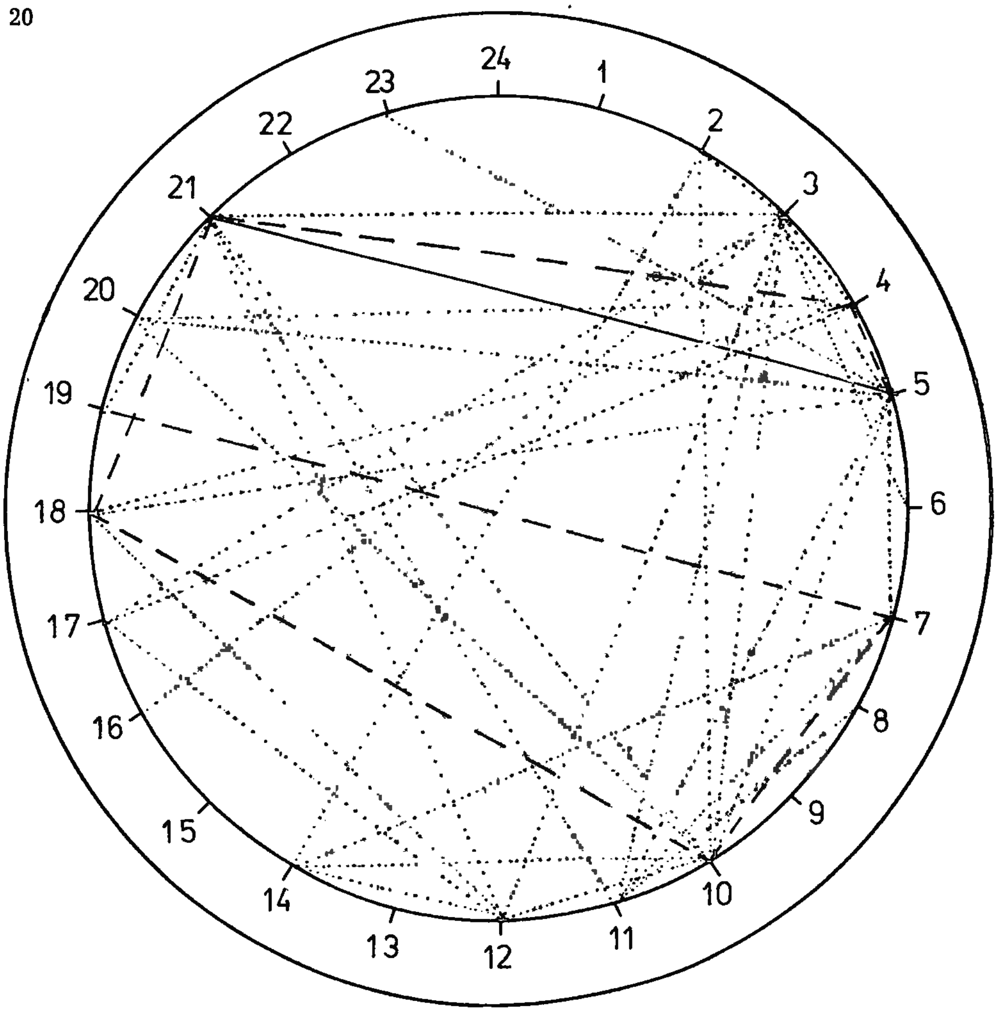
Concerning the long distance between Wiktorówki (loc. 19) and the slope between Zahradziska and Przysłop Miętusi (loc. 7) as well as their different altitudes, the great similarity of the mollusc communities of the localities may be caused by their geobotanical resemblance.

The localities mentioned above are inhabited by the communities whose similarity to at least five other communities is: s 0.4. Also the communities of: Kamienny Żleb (loc. 3), Przysłop Miętusi Glade (loc. 10), the Mała Łąka Valley, and some others (Fig. 4) belong to this category.

Among the communities showing distinct differences in relation to at least five others, there are five inhabiting glades (their similarity index reaches the value s = 0.4 only once if at all). These are: Chochołowska Glade (loc. 1), Kondratowa Glade (loc. 6), Kalatówki Glade (loc. 15), Waksmundzka Glade (loc. 22), Kopieniec Glade (loc. 24). Besides, such a distinct character and specificity were observed only in the habitats of extremely unfavourable conditions - natural ones (Przysłop Miętusi - loc. 8), those caused by man (a forest along the road Kuźnice - Kalatówki - loc. 16), or of both origins (Giewont Mt. - loc. 13). The influence of grazing on the five glades mentioned above is strong enough to cause the elimination of almost all the specialized species. Only the tolerant ones as: *Arion subfuscus*, *Cochlicopa lubrica*, *Vitrina pellucida* survive - a particular species on each glade, depending probably on local habitat conditions. This is why each particular glade (especially those most affected) differs qualitatively from the others.

D. Relations between qualitative similarity (s), species diversity (H′), and equitability (J′)

The relations between the same communities appear several times in the discussion on the structural parameters (H′ and J′) and the qualitative similarity, as well as in the groupings based on the structural



Rys. 4. The similarity between the gastropod communities from the Tatra Mts., continuous line - s 0.6, broken line - 0.5 s 0.6, dotted line - 0.4 s 0.5

parameters. For example, the malacofaunae of Niżnia Kominiarska Glade (loc. 4), Lejowa Valley (loc. 5), and Gęsia Szyja (loc. 21) show both the qualitative and structural resemblance. Among the communities of a distinct character (Fig. 4) only that inhabiting Kondratowa Glade (loc. 5) is structurally more similar to the common natural communities of the Tatra Mts. than to those of Chochołowska Glade (loc. 1), Giewont Mt. (loc. 13), Kalatówki Glade (loc. 15), and Waksmundzka Glade (loc. 22).

E. Synanthropization of the malacofauna of the Polish Tatra Mts.

The degree of synanthropization of the studied communities was determined basing on the percentage of ubiquitous (eurytopic) species, whose increase in the Tatra Mts. seems caused by the human impact. The eurytopic species are: *Cochlicopa lubrica*, *Arion subfuscus*, *Nesovitrea hammonis*, *N. petronella*. They occur rather regularly, though never numerously in the natural biotopes of the Tatra Mts., while in the conditions of a strong human impact their number increases (Dyduch-Falniowska, Fyda in press).

Among the studied communities there are some whose low diversity is caused by other factors than man-caused changes. Their low values of species number and diversity result from the natural conditions, unfavourable for malacofauna (loc. 8, 9, 13, 19, 22, 24).

The communities of a rather high diversity (H´ 3) and with a moderate percentage of ubiquitous species (15%) are related with the optimum natural lower mountain biotopes, whose conditions are apparently the best for most snails of the Tatra Mts.

The communities with the highest level of synanthropization (the percentage of eurytopic species 25%) are the most endangered group. On Niżnia Kominiarska Glade (loc. 4) in spite of grazing and the high percentage of eurytopic species, the diversity is rather high due to the exceptionally favourable habitat and the topographic conditions. The complex of microclimatic and physico-chemical conditions on Kondratowa Glade (loc. 6) is naturally not favourable for molluscs, and the high degree of synanthropization must have resulted from the former grazing. Also the characters of the snail dispersion verify this; snails were found mainly near hut ruins etc. The glades: Chochołowska (loc. 1), Kalatówki (loc. 15), and Rusinowa (loc. 20) are inhabited by the communities of the most disturbed structure. On Chochołowska Glade (loc. 1) a very high synanthropization level (58%), low diversity and high equitability indicate an advanced process of degradation in the community. The human impact seems the main factor determining the qualitative-quantitative structure of these communities. It is probable, that grazing directly prevents the development of the populations into a pattern in which the community structure is significantly influenced by the food and habitat competition. Other results of grazing are observable in the limited mosaic-pattern and an increase of water flow. The latter is an effect of the re-arrangement of stones and boulders, which previously were rather regularly scattered, and now are arranged in long prisms, parallel to the slope. Consequently, a quantitative impoverishment of the boulderless patches, while compared with those with boulders, is even observable with semi-quantitative methods. The changes caused by grazing eliminate all the more sensitive species, whereas the remaining ones take approximately good chances to develop themselves. The level of the grazing impact is comparable with the extremely unfavourable climatic conditions on the Giewont Mt. (loc. 13). It is reflected in the diagram (Fig. 4) by the distance separating Chochołowska Glade (loc. 1) from the Chochołowska Valley (loc. 2): s = 0.1. The situation on Kalatówki Glade (loc. 15) is similarly bad. At the slightly lower synanthropization level the inconsistency of the equitability ($J' = 0.95$) and the diversity ($H' = 1.6$) indicates that the community is much more destroyed than the previous one. It is probably connected with the humidity conditions, which are worse here than on Chochołowska Glade (loc. 1).

The Glade Jaworzyna Rusinowa (loc. 20), in spite of its high synanthropization level, is characterized by a favourable combination of the studied parameters. However, the presence of all the four species, whose number increase indicates synanthropization, is noteworthy. In the conditions of a livestock farming a semi-natural community has formed, with a rather high species number (S = 21), a relatively high diversity ($H' = 3.6$) and a moderate equitability ($J' = 0.82$).

The influence of the synanthropization of the malacofauna on the values of ecological structural parameters is various. The species number S and the species diversity H' are not correlated with the degree of synanthropization, whose correlation coefficient with S: $r = 0.14$, with H': $r = 0.23$, while its correlation with the equitability J' is significant ($r = 0.56$).

Since the values compared, i.e. the synanthropization degree and the remaining parameters, are independent as regards their calculation, the latter correlation value suggests that the quantitative increase of the eurytopic species (resulting from synanthropization) brings about the increase of J'. A gradual increase of the J value was observed in the range of 2 - 14% of eurytopic species. It is attributable to the destabilizing tendency of the community, as the index reaches higher values in the communities of the disturbed ecological equilibrium, when the habitat conditions change due to natural (succession) or man-caused factors. In extreme cases the impact is as strong as to determine, instead of the natural food and habitat competition, the community organization and, consequently, its structure (Dyduch-Fálniowska, Fyda in press). In such a case the percentage of the synanthropization indicative species reaches ca. 50% (Fig. 5).

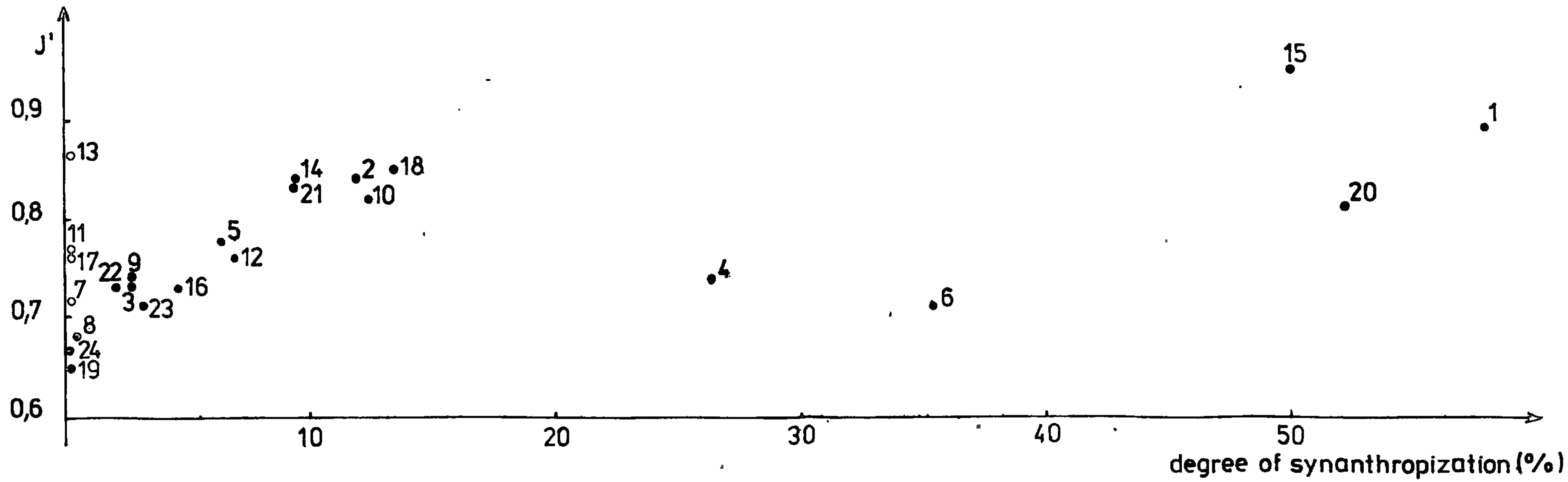


Fig. 5. Synanthropization of studied communities

Table 1

Species composition of studied localities

Species \ Locality	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Acme polita				1	3			3			2						8							
Carychium minimum			2	1																				
Carychium tridentatum				2																				
Cochlicopa lubrica	10	5		110	45	19		1		8		2		3				1		48	16		11	
Pyramidula rupestris		4	10	55	238	1		35	30		37	7	11				47				63		6	
Columella ed. edentula				10	2		53		21		24		6						68	1	1			
Columella ed. columella													2											
Truncatellina cylindrica								90																
Vertigo pusilla					1																			
Vertigo alpestris		1	4	1	55			5			15													
Pupilla sterri																					15			
Agardhia bielzi											1													
Orcula dolium			3														50							
Vallonia costata					9																			
Acanthinula aculeata								1			1													
Ena montana		1	2	2	17		1		4	2	3	14									2			
Succinea putris					8																			
Punctum pygmaeum					2																			
Discus ruderatus			1	41	7	56						36					1	10		23	16	35	1	1
Arion subfuscus	3			23	20				2						4	1		12		12	5	2	1	
Arion silvaticus				2	3												3	2		2	2			
Arion fasciatus				2																				
Vitrina pellucida	2		1	11	27	2	3	2		4	1	37	2		2	1		1	27	13	1	2	2	
Semilimax semilimax						1													2					2
Semilimax kotulae				1	4				4	2		9		1				18		6			1	
Eucobresia diaphana						2	5	23				6		3								2		
Eucobresia nivalis	1		1	5	12					2		1				5		1	1		2		5	
Vitrea diaphana			36	26	42		2			20	26							1			17			
Vitrea inopinata											1													
Vitrea transsylvanica		2	4	3	9	2		2		3	3			2			1	1			3	24		
Vitrea contracta							1																	
Vitrea crystallina				11								8								6				
Vitrea subrimata									2				1											
Aegopinella nitens		5	3	39	83		6		1	20	8			8		1	1	11					7	
Aegopinella pura		2	7	7	17	1	4	10	2	2	3	1		3			9	3	1	17	15			
Perpolita petronella	5			3		24						18								41				
Perpolita radiatula		2	2	24	6	10				4				2						44	4		3	
Oxychilus depressus					1				2		1										1		1	
Deroceras rodnae																2								7
Limax tenellus				39	22		6			5				4				4		21	2	14	13	
Lehmannia marginata				3	6													1			1			
Lehmannia macroflagellata		1			1																		3	
Belzia coerulans				3	6			2								3	2	3			6			
Euconulus fulvus		1	4	13	10	7	2	13		2	1	13						3	3	3	9			
Cochlodina orthostoma			1	3	29			5	1		1			2			13			4	4			
Cochlodina laminata				3	7			1		1	1	4					11	4		4	14			
Clausilia dubia		16		24	154		2	9		1	7		6							20			9	
Clausilia cruciata		1		1	8							1					4	4			8			
Iphigena plicatula		5	1	7	51		2	1	6			2		1		1	13		6	7	18			
Iphigena latestriata				3							1													
Iphigena tumida		1			3		3												2	1				
Iphigena ventricosa					1																			
Laciniaria turgida	6		1	11	4	2	4	8		7	5	92	2	15		1	6	4	6		10			
Monachoides vicina				1	17		4			1	1								10	1	7			
Trichia unidentata		4	1	14	25	1	9		2	9	18	17		1	2	1	7	12	35	2	13		52	
Trichia villosula				95	78		64			1									1	1				
Euomphalia strigella											1								1					
Helicigona cingulella																	1							
Helicigona faustina	4	3	3				11	2	5	1	12	6		3		4	1		1				2	
Isognomostoma personatum				1	24		4				5	1		2		1	11		1		2			
Isognomostoma holosericum											1										3			
Arianta arbustorum		4	1	2	9	20	11		1		4		4	1					4			3	1	
Total:	31	58	88	603	1078	148	197	213	83	95	184	283	34	51	8	21	189	96	169	277	260	82	118	10

CONCLUSIONS

The malacofauna of the 24 studied localities in the lower mountain zone of the Tatra Mts. includes 61 species (Tab. 1). They form the communities characterized by diversified ecological parameters (Tab. 2).

A. The structural similarity of the communities

Three groups of snail communities were distinguished (Fig. 1a): I. The quantitatively and qualitatively richest ones inhabit the most favourable for malacofauna biotopes; their diversity H´ is high, and the equitability J´ - moderate. II. The communities of the diversity H´ lower and equitability J´ similar to those of the first group inhabit the biotopes with limited food and habitat resources. Hence, each population of this kind can only develop to a certain limited degree. Competition in such a community is sharper in comparison with the preceding type, and it is probably the factor determining the structure and quantitative-qualitative relations in the community. III. A very low species diversity H´ along with the equitability J´ reaching the extremely varied values is characteristic of the communities which inhabit the biotopes, whose conditions are unfavourable for snails. It is possible that in some extreme cases (low H´, high J´) the populations develop independently on each other, with no inter-population interactions; their abundance is limited by the climatic or other physico-chemical factors. The above remarks agree with the results of the grouping based on the equitability J´ and the species number S (Fig. 1).

B. The qualitative similarity

The great qualitative similarity of the malacofaunae of Niżnia Kominiarska Glade (loc. 4) and the Lejowa Valley (loc. 5) can be attributed to the very close situation of the localities, and to their similar habitat conditions. The short distance separating the two malacofaunae from that of Gęsia Szyja (loc. 21) is surprising. The latter locality of a somewhat ecotonal character resulting from its situation on the foreland of the High Tatra Mts. is considerably drier and located at a higher altitude (1450 m a.s.l.). The locality differs much from the preceding two in its ecological conditions.

The communities inhabiting the intensely grazed glades and/or remaining under a strong pressure of unfavourable natural conditions are of a distinct character. The most strongly affected glades differ immensely from the rest in the qualitative respect; their similarity index in relation to any other community frequently does not reach 0.4 (Fig. 4).

Table 2

Number of species S, species diversity H′ and equitability J′ of the malacofauna of studied localities

No	Locality	S	H′	J′
1	Chochołowska Glade	6	2.50	0.89
2	Chochołowska Valley	17	3.45	0.84
3	Kamienny Żleb above the Hucisko Glade	20	3.14	0.73
4	Niżnia Kominiarska Glade	38	3.91	0.74
5	Lejowa Valley	40	4.17	0.78
6	Kondratowa Glade	14	2.70	0.71
7	Forest between Zahradziska and Przysłop Miętusi	20	3.12	0.72
8	Przysłop Miętusi	18	2.84	0.68
9	Forest between Przysłop Miętusi and Mała Łąka Valley	14	2.81	0.74
10	Przysłop Miętusi Glade	19	3.49	0.82
11	Mała Łąka Valley	27	3.66	0.77
12	Mała Łąka Glade	20	3.51	0.76
13	Giewont	7	2.42	0.86
14	Kalacki Upłaz	15	3.29	0.84
15	Kalatówki Glade	3	1.58	0.95
16	Forest between Kuźnice and Kalatówki	11	3.46	0.73
17	Forest between Kalatówki and Kondratowa Glades	18	4.17	0.77
18	Forest between Wierch Poroniec and Goły Wierch	19	3.60	0.85
19	Wiktorówki	16	2.61	0 65
20	Rusinowa Glade	21	3.60	0.82
21	Gęsia Szyja	28	4.03	0.84
22	Waksmundzka Glade	7	2.04	0.73
23	Wielki Kopieniec	16	2.84	0.71
24	Kopieniec Glade	3	1.07	0.67

C. Relations between the structural and qualitative similarity

In the discussion on the structural parameters of the snail communities in the Tatra Mts. and the qualitative similarity of the communities, associations between the communities of the same group appear several times. The qualitatively similar communities show similar structural parameters. This concerns, for instance, Gęsia Szyja (loc. 21), the Lejowa Valley (loc. 5) and Niżnia Kominiarska Glade (loc. 4).

A clear structural resemblance may also occur along with extreme qualitative differences. Chochołowska Glade (loc. 1) and Giewont Mt. (loc. 13) are examples. A strong impact of natural and/or man-caused factors results in the formation of the communities which are extremely distinct in respect of their species composition. One can suppose that in natural communities such an impact causes a common type of structural changes, that gradually lead to the formation of the systems, which structurally resemble each other, but differ extremely in their species composition. Further detailed studies on both the categories of snail communities in the Tatra Mts. seem necessary. Both the structural and temporal aspects should be considered.

D. The effect of synanthropization on the structural parameters

It is obvious that the increase of the percentage of some species (<u>C. lubrica</u>, <u>A. subfuscus</u>, <u>N. hammonis</u>, <u>N. petronella</u>) resulting from the man-caused changes of a habitat, leads to the receding of some others (e.g. <u>Clausiliidae</u>), i.e., to the qualitative changes of a community. It is difficult to decide whether the species originally inhabiting a given area were eliminated, or receded for some other reasons. The changes have various influence on the values of the ecological structural parameters. Equitability J´ appears much influenceable, as its value increases within the range of 2 to 14% of the eurytopic species mentioned above (Fig. 5). It is attributable to the destabilization tendency of the community.

LIST OF THE SPECIES RECORDED IN THE STUDIED LOCALITIES

1. <u>Acme polita</u> Hartmann 1840; 2. <u>Carychium minimum</u> O. F. Müller, 1774; 3. <u>Carychium tridentatum</u> (Risso, 1826); 4. <u>Cochlicopa lubrica</u> (O. F. Müller, 1774); 5. <u>Pyramidula rupestris</u> (Draparnaud, 1801); 6. <u>Columella edentula edentula</u> (Draparnaud, 1805); <u>C. edentula columella</u> (G. v. Martens, 1830); 7. <u>Truncatellina cylindrica</u> (Férussac, 1807); 8. <u>Vertigo pusilla</u> O. F. Müller, 1774; 9. <u>Vertigo alpestris</u> Alder, 1838; 10. <u>Pupilla sterri</u> (Voith, 1838); 11. <u>Agardhia bielzi</u> (Rossmässler,

1859); 12. *Orcula dolium* (Draparnaud, 1801); 13. *Vallonia costata* (O.F. Müller, 1774); 14. *Acanthinula aculeata* (O. F. Müller, 1774); 15. *Ena montana* (Draparnaud, 1801); 16. *Succinea putris* (Linnaeus, 1758); 17. *Punctum pygmaeum pygmaeum* (Draparnaud, 1801); 18. *Discus ruderatus* (Férussac, 1821); 19. *Arion subfuscus* (Draparnaud, 1805); 20. *Arion silvaticus* Lohmander, 1937; 21. *Arion fasciatus* (Nilsson, 1822); 22. *Vitrina pellucida* (O. F. Müller, 1774); 23. *Semilimax semilimax* (Férussac, 1802); 24. *Semilimax kotulae* (Westerlund, 1883); 25. *Eucobresia diaphana* (Draparnaud, 1805); 26. *Eucobresia nivalis* (Dumont et Mortillet, 1852); 27. *Vitrea diaphana* (Studer, 1820); 28. *Vitrea inopinata* (Uličný, 1887); 29. *Vitrea transsylvanica* (Clessin, 1877); 30. *Vitrea contracta* (Westerlund, 1871); 31. *Vitrea crystallina* (O. F. Müller, 1774); 32. *Vitrea subrimata* (Reinhardt, 1871); 33. *Aegopinella nitens* (Michaud, 1831); 34. *Aegopinella pura* (Alder, 1830); 35. *Perpolita petronella* (L. Pfeiffer, 1853); 36. *Perpolita radiatula* (Alder, 1830); 37. *Oxychilus depressus* (Sterki, 1880); 38. *Deroceras rodnae* Grossu et Lupu, 1965; 39. *Limax tenellus* (O. F. Müller, 1774); 40. *Lehmannia marginata* (O. F. Müller, 1774); 41. *Lehmannia macroflagellata* Grossu et Lupu, 1962; 42. *Bielzia coerulans* (M. Bielz, 1851); 43. *Euconulus fulvus* (O. F. Müller, 1774); 44. *Cochlodina orthostoma* (Menke, 1830); 45. *Cochlodina laminata* (Montagu, 1803); 46. *Clausilia dubia* Draparnaud, 1805; 47. *Clausilia cruciata* Studer, 1820; 48. *Iphigena plicatula* (Draparnaud, 1801); 49. *Iphigena latestriata* A. Schmidt, 1857; 50. *Iphigena tumida* Rossmässler, 1836; 51. *Iphigena ventricosa* (Draparnaud, 1801); 52. *Laciniaria turgida* (Rossmässler, 1836); 53. *Monachoides vicina* (Rossmässler, 1842); 54. *Trichia unidentata* (Draparnaud, 1805); 55. *Trichia villosula* (Rossmässler, 1838); 56. *Euomphalia strigella* (Draparnaud, 1801); 57. *Helicigona cingulella* (Rossmässler, 1837); 58. *Helicigona faustina* (Rossmässler, 1835); 59. *Isognomostoma personatum* (Lamarck, 1792); 60. *Isognomostoma holosericum* (Studer, 1820); 61. *Arianta arbustorum* (Linnaeus, 1758).

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PODOBIEŃSTWO JAKOŚCIOWE, RÓŻNORODNOŚĆ GATUNKOWA I RÓWNOMIERNOŚĆ ZESPOŁÓW ŚLIMAKÓW SIEDLISK DOLNOREGLOWYCH W TATRACH

S t r e s z c z e n i e : W skład malakofauny 24 badanych stanowisk, położonych w serii dolnoreglowej Tatr, wchodzą 62 gatunki (tab. 1). Tworzą one trzy rodzaje zespołów. Najbogatsze, o dużej różnorodności gatunkowej H′ i niezbyt dużej równomierności J′, zamieszkują siedliska najbardziej sprzyjające rozwojowi ślimaków. Zespoły o nieco mniejszej różnorodności H′ i zbliżonej do poprzedniej grupy równomierności J′ zamieszkują biotopy mniej sprzyjające, o ograniczonej bazie pokarmowej.

Stopień różnorodności H′ jest bardzo niski, a wskaźnik równomierności J′ przyjmuje wartości skrajne (tab. 2) w zespołach siedlisk o bardzo niekorzystnych dla malakofauny warunkach siedliskowych.

W dyskusji nad parametrami strukturalnymi i podobieństwem jakościowym badanych zespołów pojawiają się kilkakrotnie te same związki. Zespoły jakościowo najbardziej podobne mają zbliżone parametry strukturalne. Tylko w przypadkach silnej presji czynników naturalnych i/lub sztucznych powstają zespoły skrajnie odrębne pod względem składu jakościowego, a strukturalnie podobne.