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THE STRUCTURE OF SELECTED HART'S TONGUE, *PHYLLITIS SCOLOPENDRIUM* (L.) NEWM. POPULATIONS, AS RELATED TO ECOLOGICAL FACTORS

ABSTRACT: Populations of *Phyllitis scolopendrium* (L.) Newm. display a clumped spatial structure. The distribution pattern mainly depends on the mosaic of gruss. There is a significant negative relationship between the occurrence of hart's tongue clusters and light intensity. Tree stand clearing do not limit the development of the population. A decisive role in shading of hart's tongue is played by the rich forest floor vegetation which retains 43.3–71.8% of light penetrating through tree crowns. In the population from the Gorce Mts. the density of individuals is positively correlated with their size. Analysis of the size structure of individuals indicates that the leaves of the juveniles do not exceed a 6-cm length and that the juveniles form no more than 8 leaves.

KEY WORDS: *Phyllitis scolopendrium*, population, spatial structure, size structure, microhabitat, light intensity.

1. INTRODUCTION

Studies of the structure and dynamics of plant populations mainly focus attention annuals and trees (Harper 1977). Perennials have been dealt with only in few papers, and ferns – in virtually none (Anderson 1961, Willmot 1985). In Poland the studies of *Phyllitis scolopendrium* have so far concerned only its distribution (Frey and Guzik 1969); general observations on the conditions of its occurrence have been derived from phytosociological studies (Medwecka-Kornaś 1952, Pancer-Kotejowa 1973, Święs 1982, Matuszkiewicz 1984, Dzwonko 1986, Winnicki and Zemanek 1987).

Investigations were performed in the years 1987–1989 in Polish West Carpathians: in the Pieniński National Park and in the adjacent Gorce Mts. range. The goal of the present studies was to gain knowledge of the organization and type of the spatial structure of populations, i.e. of the numbers, diaspore formation ability, participation of various developmental stages, tendency for cluster formation etc. In further perspectives these studies are aimed at determining the dynamics of populations and at evaluating their resources, as well as at prognosticating the further fate of this species in Poland. The fact of hart's tongue being under protection creates some limitations in plant material collection. At the present time of enormous changes in the natural environment, studies of this type, performed on permanent plots provide an indispensable basis for watching the changes of rare plant species and the risks entailed by them.

2. MATERIAL AND METHODS

2.1. SELECTION OF SITES AND ESTABLISHMENT OF RESEARCH PLOTS

Studies comprised three hart's tongue populations from the Pieniński National Park, situated in the Pieniński Potok valley, Ociemny Potok valley and under the Sokolica Mt. summit, as well as one population from the Gorce Mts., located in the Ochotnica valley (Fig. 1).

The size of the area occupied by the population from the Gorce Mts. was taken as a model for marking out in the Pieniny Mts. three phytocenoses with dominance of hart's tongue. In the Pieniny Mts. from which many stands of this plant are known (Zarzycki 1981) and where it is often difficult to specify the boundaries of the populations, evidently singled out clusters of *Phyllitis scolopendrium* were selected.

Each research plot was rectangular (32 m × 16 m) and was permanently marked. Theodolite was used for marking out the areas. Each plot was divided into 512 adjoining squares (1 m^2 in area). In every square the number of individuals was counted and the fraction of the soil skeleton was evaluated on a four-score scale (1–25%, 26–50%, 51–75%, 76–100%). In every second square, for each individual the number of leaves and the length of the longest leaf were determined. Thus, the measured individuals accounted for ca. 50% of the total population. The structure of the developmental stages was determined in the next vegetation season. Studies were performed by the end of the vegetation season, i.e. in the second half of September in the beginning of October, when the height of plants was maximal.

On every plot, in blocks of low or high hart's tongue density, 24–48 points were selected for light intensity measurements. The latter were simultaneously taken at three points: in high-density places – at the height of frond rosettes and above the shading layer of forest floor vegetation, as well as in the places of scattered distribution. At every site 20 light intensity measurements were carried out on 7th and 8th September, in cloudy weather, between 11 a.m. and 2 p.m.

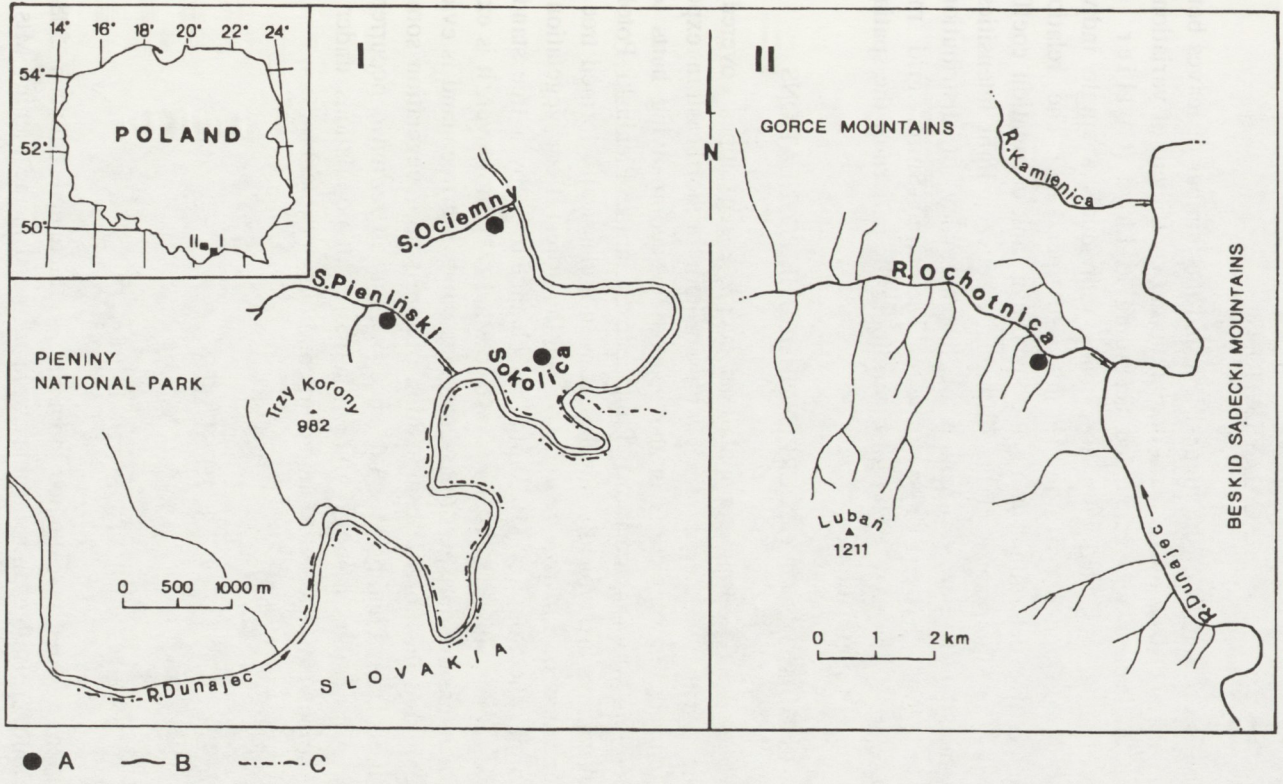

Fig. 1. Location of research plots
I – in Pieniński National Park, II – in the Gorce Mts., A – research plots, B – rivers and streams, C – state boundaries

Phytosociological releves were make using the Braun-Blanquet method (Pawłowski 1977) in the middle of summer and in the Gorce Mts. – also in April, June and September.

2.2. CALCULATIONS

The distribution of length of the longest leaf and the number of leaves between individuals was characterized by standard deviation and coefficient of variation. The mean crowding coefficient was calculated according to Lloyd (Collier et al. 1978). This coefficient indicated with how many individuals a single individual co-occurred, on the average, per area unit (in this case – per 1 m^2). The relationship between characters was determined using the Spearman rank correlation coefficient (Parker 1978). The significance of the differences between light intensities was evaluated by the t test. For verification of the normalcy of distribution the Kołmogorov test was used (Perkal 1967). The Greig-Smith grid method (Thompson 1958, Kershaw 1978) for determining the pattern of the spatial was employed structure of populations.

2.3. CONDITIONS OF OCCURRENCE OF THE POPULATIONS

The investigated hart's tongue populations occupy steep slopes covered with rooks and gruss (gritty weathered rock), with northern or northeastern exposure. There are differences between plots in the vegetation accompanying harts tongue (Phyllitido-Aceretum Moor association). Phytocenoses in the Pieniński Potok and Ociemny Potok valleys are typically developed, with a classically formed tree stand and large abundance of *Lunaria rediviva* L. in the forest floor vegetation. The phytocenosis under the Sokolica Mt. summit is characterized by a tree stand with untypical species composition (Pancer-Kotejowa 1973); moreover, it is exposed to the impact of intensive tourism. In the Ochotnica valley the tree stand is evidently changed by Man, and the floristic composition of forest floor vegetation somewhat differs from that of the Pieniny Mts. (absence of *Lunaria rediviva,* occurrence of species of the Alno-Padion association). Furthermore, all populations under study develop under somewhat different topographic conditions (Table 1).

3. RESULTS

3.1. POPULATION NUMBERS – DENSITY

The numbers of the investigated populations fluctuated between 508–1376 individuals (Table 2). Both extreme values were recorded in the Pieniny Mts. Since all four test areas were equal (512 m^2), the values of the mean density are only a distinct manner of expressing the population numbers, and fail to contribute – by themselves – any additional information. They allow, however, for assessing the value of another index, i.e. of the mean crowding index. On the average, the

Table 1. Conditions of occurrence of the investigated *Phyllitis scolopendrium* (L.) Newm. populations

Population	Elevation above sea level (m)	Exposure	Slope of terrain	Microtopography	Soil
Ochotnica (A)	430	NE	35–38°	Convex mountain slope. High degree of gruss covering the middle and lower part of the area. Locally – protruding rocks. The population is limited at the bottom by a high river terrace of the Ochotnica Stream, on the top by protruding sandstone blocks, and from the east by the river-bed of a small stream	grey-brown soil (Bodziarczyk 1989)
Pieniński Potok valley (B)	550	N	35–40°	Under the Wielka Pustelnica Mt., at the bottom of the valley. Concave mountainside. The eastern part of the population is shaded by a limestone rock wall. The whole area covered with poorly stabilized limestone gruss	deep-humus muck rendzina (Pancer-Kotejowa and Zarzycki 1976)
Sokolica (C)	650	NE	35°	Under Sokolica Mt. summit. Convex mountainside. Nonuniformly distributed gruss disappears locally due to the accumulation of a thick layer of beech litter	
Ociemny Potok valley (D)	500	N	35–37°	Convex mountainside uniformly covered with poorly stabilized limestone gruss. Population limited from the east and west by two cut-in streams	

Table 2. Characterization of the spatial structure of *Phyllitis scolopendrium* (L.) Newm. populations A–D – denotations as in Table 1

Population	Numbers (indiv.)	Mean density (indiv. · m^{-2})	Coefficient of variation of density	Mean crowding coefficient	Mean size of clusters (m^2)
A	795	1.55 ±2.68	1.73	5.2	16, 64
B	608	1.19 ±1.69	1.42	2.6	4, 32
C	508	0.99 ±1.54	1.54	2.4	16, 128
D	1376	2.69 ±2.72	1.01	4.4	4, 16, 64

individuals of the Gorce Mts. populations are most crowded, because in this case the highest crowding coefficient is paralleled by a relatively small value of mean density.

3.2. SPATIAL STRUCTURE OF THE POPULATIONS

All four populations display a clumped spatial structure, as testified to by e.g. the high value of the coefficient of variation of population density. Analysis of variance of the densities at various blocks sizes indicated that, except for the population from the Pieniński Potok valley, the three remaining populations are characterized by variance culminations at mean cluster size of 16 m^2. The population from the Gorce Mts. is least variable exhibiting only one distinct culmination and another, not very clear-cut one (Fig. 2). The structure of the population from the Ociemny Potok valley is interesting, since there occur three patterns of clumped distribution (4, 16, 64 m^2).

Spatial distribution of populations is also presented graphically (Figs. 3–6). The crowded and uncrowded areas are evident. Their sizes correspond to the values obtained by the analysis of variance.

3.3. HABITAT FACTORS INFLUENCING THE SPATIAL STRUCTURE OF POPULATIONS

From among the many microhabitat factors which could influence clumping of individuals, two were considered: the light factor determined by analysis of the projections of tree crowns and by light intensity measurements, as well as the degree of surface covering by gruss. Both these factors, relatively easy to be measured, seemed to be essential in formation of hart's tongue clusters.

3.3.1. Light intensity

Comparison of tree crown projections with the areas occupied by hart's tongue did not reveal to any clear-cut relationship. Clusters of this plant coincided both with gaps in tree stand and with closed forest canopy (Figs. 2–5). Accurate measurements

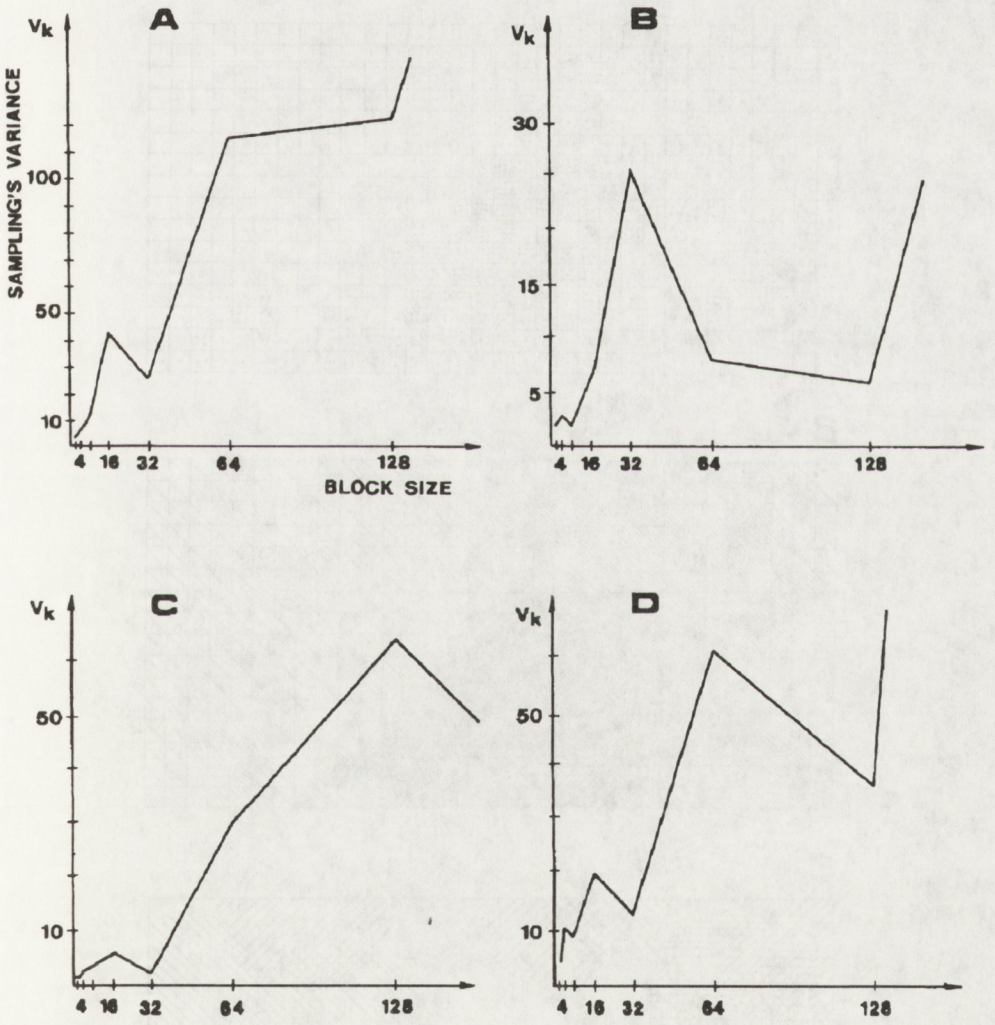

Fig. 2. Variance graphs of the numbers of the investigated *Phyllitis scolopendrium* populations
A – Ochotnica Stream valley, B – Pieniński Potok valley, C – Sokolica, D – Ociemny Potok valley

of light intensity gave a univocal result. Namely, in all hart's tongue populations under study, in the clusters of this plant light intensity was definitely lower by an average of 39.1% (max. 49.9% – Sokolica, 48.6% – Ochotnica Stream valley; min. 23.8% – Pieniński Potok valley, 34.1% – Ociemny Potok valley) than at the sites where the plants were scattered or occurred singly. The difference is significant on confidence level $\alpha = 0.05$.

In all studied hart's tongue populations shading greatly depended on the rich forest floor vegetation (*Dryopteris filix-mas* (L.) Schoot, *Athyrium filix-femina* (L.) Roth., *Urtica dioica* L. and other ones) which retains 43.3–74.8% of light penetrating

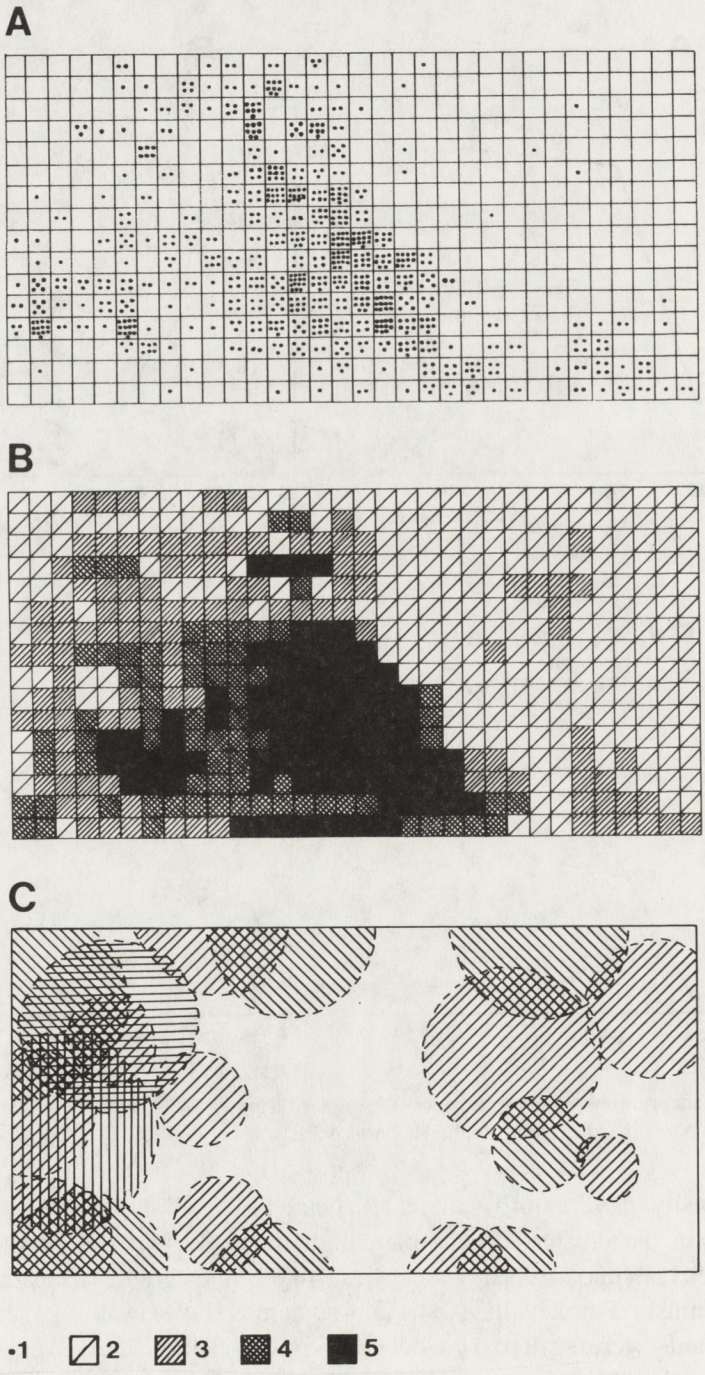

Fig. 3. Research plot in the Ochotnica Stream valley
A – distribution of individuals in the *Phyllitis scolopendrium* population, B – distribution of gruss, C – schematic projections of tree crowns,
1 – single individual; distribution of individuals within the square is schematic, 2 – 1–25% of gruss covering per 1 m^2, 3 – 26–50%, 4 – 51–75%, 5 – 76–100%

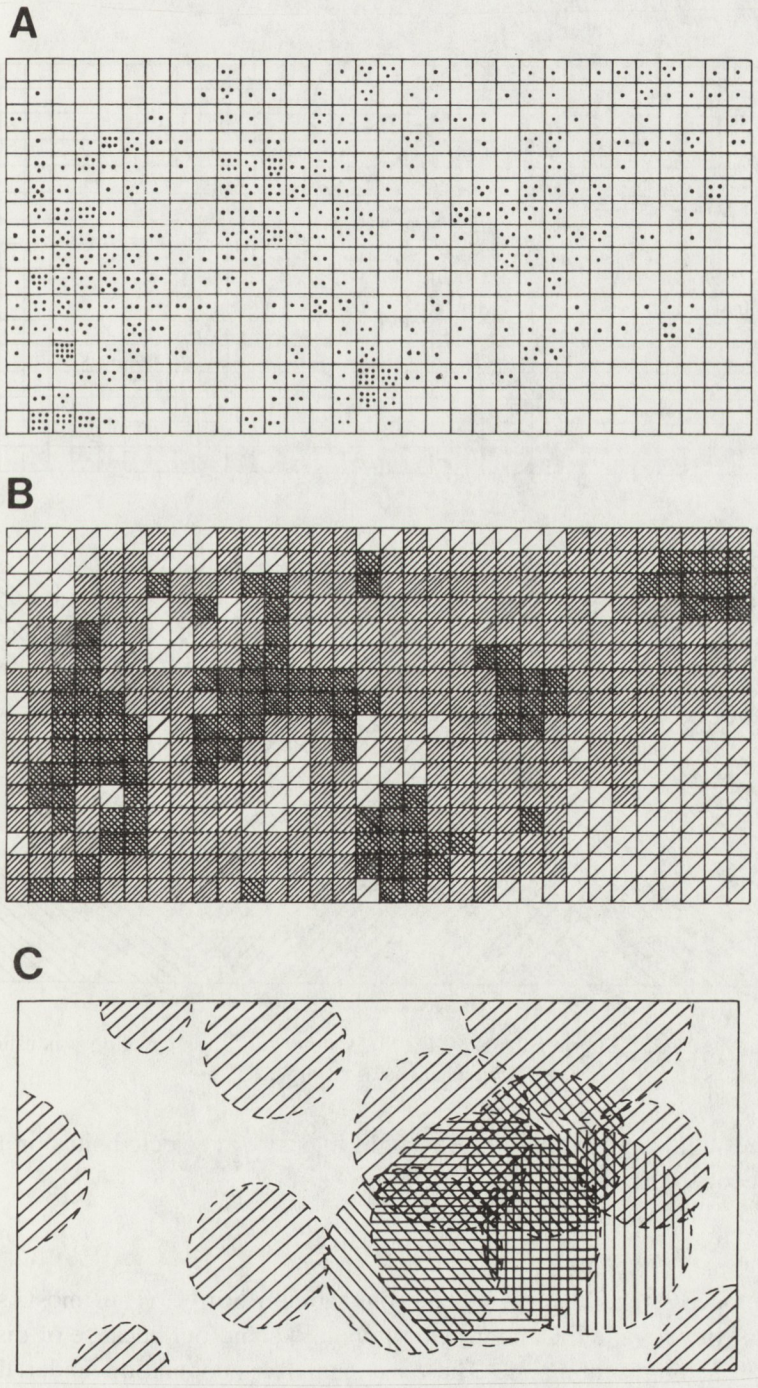

Fig. 4. Research plot in the Pieniński Potok valley
Explanations as in Figure 3

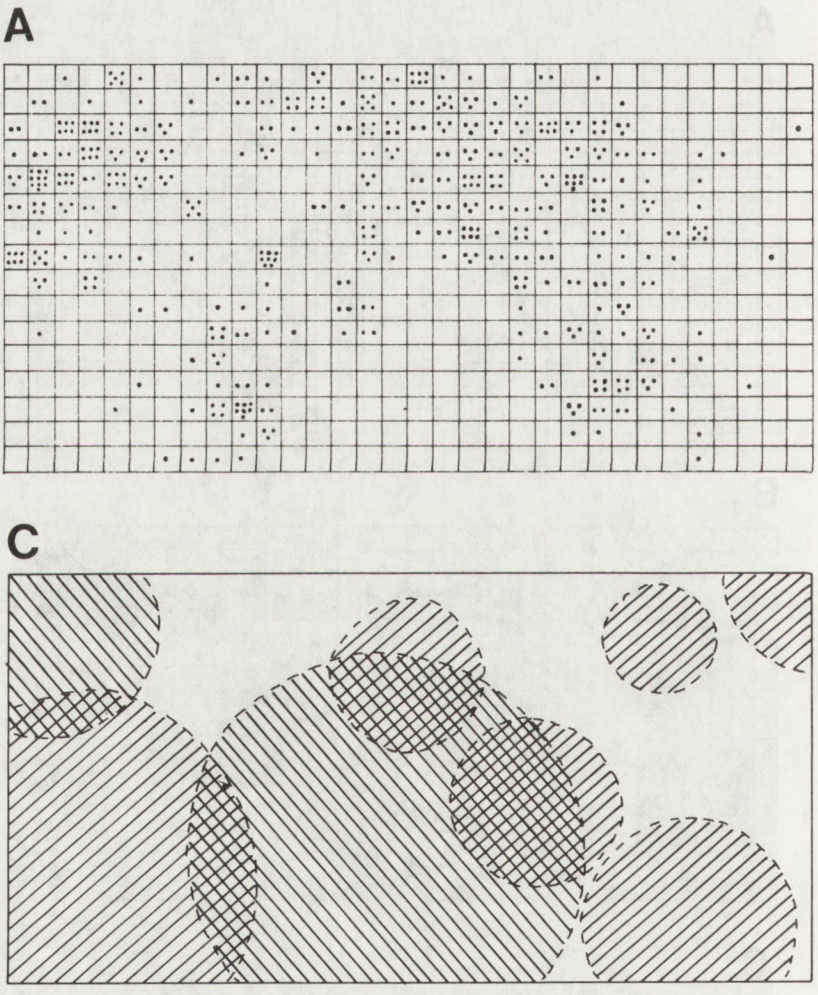

Fig. 5. Research plot under the Sokolica Mt. summit (no gruss covering was estimated)
Explanations as in Figure 3

through tree stand. The mean values of light intensity at selected sites on the research plots are recorded in Figure 7.

3.3.2. Gruss

Gruss occurs on all test areas, but nonuniformly. The most stony areas (Ochotnica Stream valley, Ociemny Potok valley) stand out because of displaying the greatest hart's tongue numbers. The least numerous population under the Sokolica Mt. summit develops at sites least covered with gruss. The correlation between the density of individuals and the degree of gruss covering is significant and amounts for the population from Ochotnica, Pieniński Potok and Ociemny to $r = 0.655$, 0.473 and 0.668, respectively.

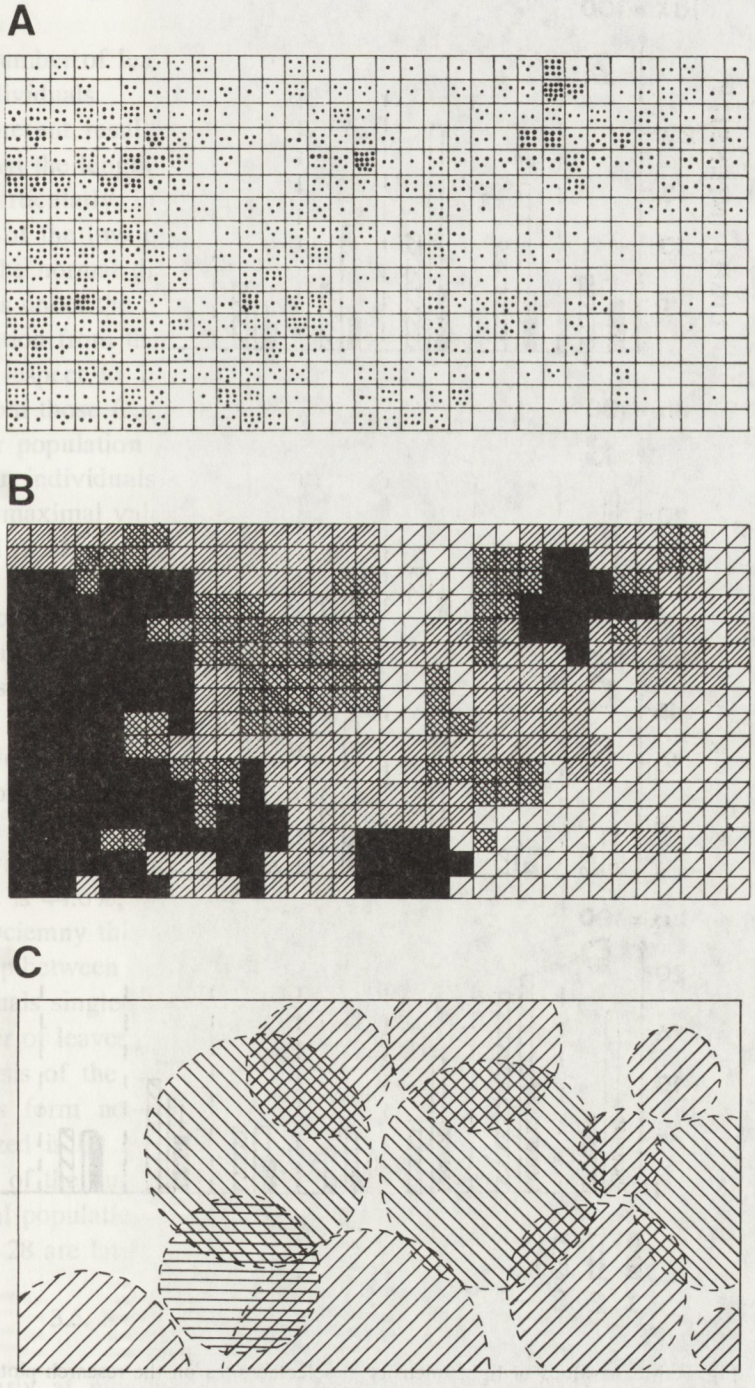

Fig. 6. Research plot in the Ociemny Potok valley
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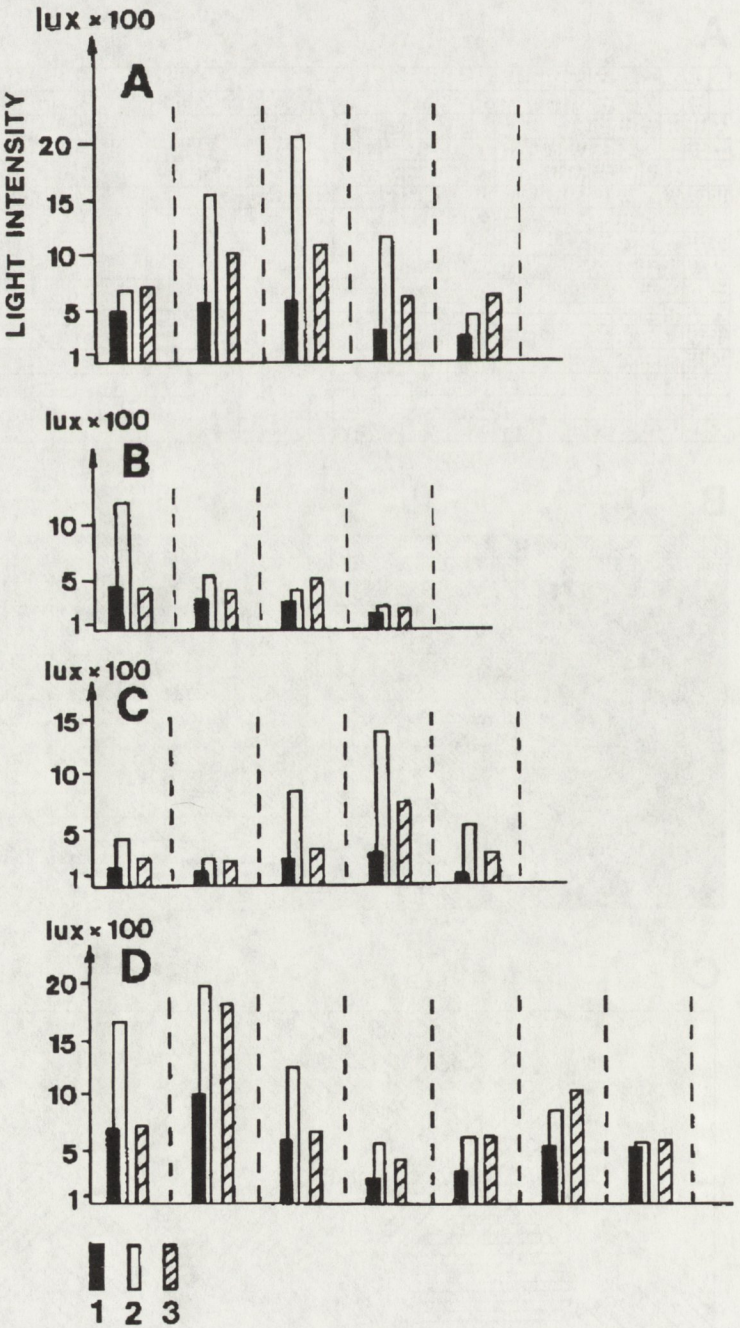

Fig. 7. Mean values of light intensity at selected sites on the research plot
A – Ochotnica Stream valley, B – Pieniński Potok valley, C – Sokolica, D – Ociemny Potok valley, 1 – mean value of light intensity at sites with high density of hart's tongue – at the level of frond rosettes, 2 – mean value of light intensity above the forest floor vegetation shading hart's tongue, 3 – mean value of light intensity at sites with low density (if any) of hart's tongue

3.4. ANALYSIS OF THE SIZE OF INDIVIDUALS

The number of leaves and length of the longest leaf served as a measure of the size of individuals.

The present results indicate that the number of leaves per individual is more variable that the length of the longest leaf. Distributions of the number of leaves are skewed particularly in the case of the Pieniny Mts. populations for which the frequency of the low classes is high (Fig. 8, A–D). Distributions of leaf length are closer to the normal distribution. The Kołmogorov test normal distribution in the populations under the Sokolica Mt. and in the Ociemny Potok the values obtained for the population from the Pieniński Potok valley are close to the critical ones.

With respect to both investigated traits the population from the Gorce Mts. departs from those from the Pieniny Mts. The outward appearance of individuals of the former population is superior, and the variation range comprises more classes. There occur individuals with a greater number of leaves, with regard to both the mean value and maximal value (Ochotnica population – 49, and the remaining populations – 21, 18, 13). Moreover, in the population from the Gorce Mts. the highest frequency is attained by the class II (5–8 leaves) and not by the class I (up to 4 leaves), as it is found for the populations from the Pieniny Mts. (Fig. 8).

Special attention was given to the participation of the smallest (juvenile) individuals (length of the longest leaf <6 cm) whose leaves do not form fertile fronds, as well as to the frequency of the largest individuals (length of the longest leaf >42 cm). In every population the medium – size individuals (the longest leaves of 6–42 cm) are dominant. The smallest individuals are as a rule sparse (5–7%), and only the population from the Sokolica Mt. stands out by the numbers of this group (20%). The large individuals dominate of only in the population from the Gorce Mts. where their proportion is 44.6%, whereas in the populations from the Pieniński Potok, Sokolica Mt. and Ociemny this proportion amounts to 26.8, 11.5 and 4.2%, respectively. The relationship between both investigated traits, i.e. between the proportion of the groups of individuals singled out according to the longest leaf length, on the one hand, and the number of leaves, on the other, is illustrated in Figure 8E.

Analysis of the present results indicates that in all four populations the small individuals form no more than 8 leaves. The population from the Gorce Mts. characterized is by the dominance of large individuals which, beginning from the IIIrd class of the number of leaves (above 12 leaves), account for more than 66.7% of the total population. In this population all individuals with the number of leaves exceeding 28 are large plants with the longest leaf length exceeding 42 cm.

3.5. STRUCTURE OF THE DEVELOPMENTAL STAGES

Similarly at most ferns, *Phyllitis scolopendrium* is a species for which it is difficult to determine the age of individuals on the grounds of the morphological traits. Therefore, only the developmental stages have been determined (Falińska and Żyromska-Rudzka 1986). In the present studies four principal develop-

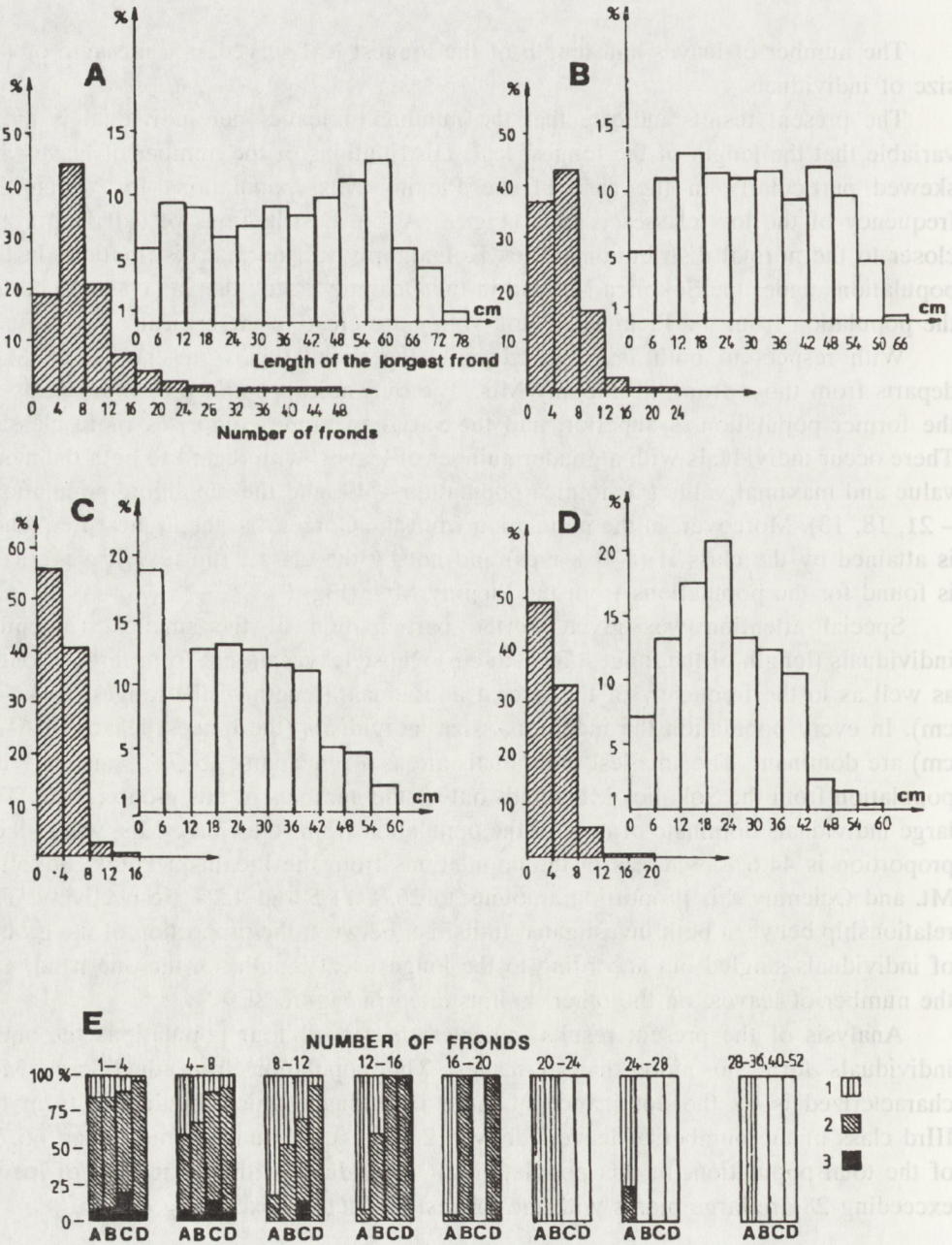

Fig. 8. Distributions of the size of individuals according to the traits of the longest leaf and number of leaves

A – Ochotnica Stream valley, B – Pieniński Potok valley, C – Sokolica, D – Ociemny Potok valley, E – participation of the distinguished groups of individuals' size in classes of the number of leaves (1 – large individuals – length of the longest leaf >42 cm, 2 – medium individuals – length of the longest leaf 6–42 cm, 3 – juvenile individuals – length of the longest leaf <6 cm)

mental stages of hart's tongue were distinguished:
(1) juvenile stage: individuals with leaves less than 6 cm in length, a small underground stem and all fronds sterile; (2) maturation stage: individuals with a well formed underground stem, a part of fronds being fertile and the remaining ones – sterile; (3) full maturity stage: individuals with a large underground stem and all fronds sporiferous; (4) senile stage: individuals with a large extended underground stem, all fronds sterile, of modified shape and of a smaller size.

Analysis of the distinguished developmental stages indicates that in the populations from the Ochotnica, Ociemny the highest frequency is displayed by the full-maturity stage and the lowest one – by the senile stage (Table 3); despite the great distance between these populations, they are characterized by similar traits. In contrast, in the population from the Pieniński Potok valley the highest frequency is shown by the maturation stage; the participation of senile individuals is fairly high (13.8%).

Table 3. Percentage of the developmental stages of *Phyllitis scolopendrium* (L.) Newm.
A, B, D – denotations as in Table 1

Developmental stage	Population		
	A (%)	B (%)	D (%)
Juveniles	5.8	5.1	7.3
Maturation	11.8	43.7	12.8
Maturity	81.3	37.5	77.6
Senile stage	1.1	13.7	2.3

3.6. DENSITY VS. SIZE OF INDIVIDUALS

The population from the Gorce Mts., exhibiting the greatest crowding coefficient (5.2) and the highest density per area unit (max. 15 indiv. per 1 m^2), was characterized by a highly significant positive correlation between the size of individuals and number of leaves per individual, on the one hand, and density (r = 0.866 and r = 0.748, respectively) (Fig. 9A). In contrast, in the population from the Sokolica Mt. both above – mentioned traits are negatively correlated with the density (r = –0.798 and r = –0.663, respectively). Likewise, in the population from the Pieniński Potok valley an increase in density adversely affects the size of individuals, but only with respect to leaf length; as concerns the numbers of leaves, this relationship is insignificant. In the population from the Ociemny Potok valley, in the presence of high mean density and great crowding coefficient (4.4) no significant relationship is found; the values expressing the size of individuals oscillate at all density levels around the mean value for the whole population.

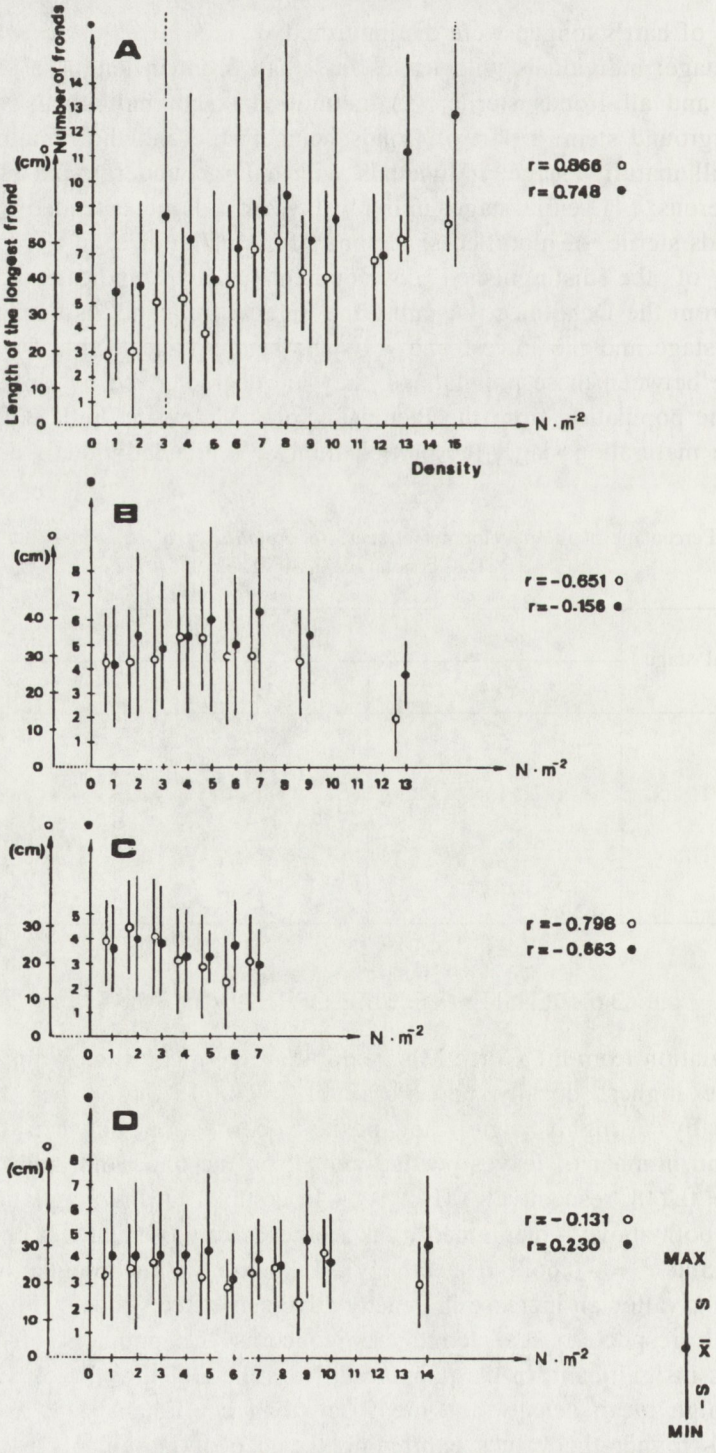

Fig. 9. Correlation between the size of individuals (according to the traits of the longest leaf and number of leaves) and density of the investigated populations
A – Ochotnica Stream valley, B – Pieniński Potok valley, C – Sokolica, D – Ociemny Potok valley, $\bar{x}$ – mean value, s – standard deviation

The density and dominance of fully mature individuals exert some effect on the regeneration of populations. Juvenile individuals evidently tend to form new clusters; this is most manifest in the population from the Sokolica Mt. where small clusters of young individuals occupy new areas separately from mature individuals. In the Ociemny and Pieniński the juveniles occur both as single individuals in small clusters (2–4 individuals), their mean density being 6 individuals per 1 m^2 always assembled around mature plants.

4. DISCUSSION

The ecological amplitude of *Phyllitis scolopendrium* is narrow. Within its whole range (Meusel et al. 1965) it is associated with strongly shaded moist habitats and stony slopes on limestone substrate (Hess et al. 1967, Karpowicz 1969, Hegi 1984, Zarzycki 1984, Kornaś and Medwecka-Kornaś 1985, Dostal 1989).

In the present studies the properties of the habitat of the investigated populations were analyzed on a "micro" scale in order to elucidate the reasons of the clustery spatial structure of hart's tongue.

In plants the cases of random distribution of individuals in the population are sparse (Falińska 1971, Kwiatkowska 1972, Szwagrzyk 1990). A clustery distribution is most frequent (Wilkoń-Michalska 1976, Falińska 1978, 1979, Kotańska 1983, Towpasz and Szymska 1983). Whereas the tendencies for clustering of plants most frequently result from their morphological and biological properties, as a rule they are the effect of vegetative reproduction (Andrzejewski and Symonides 1986, Falińska 1990).

In the case of ferns, determining the mechanism of spatial organization may be additionally complicated by their specific life cycle. Two generations (gametophyte and sporophyte) are characterized by striking differences in morphology, anatomy and ecology; they also differ in adaptability (Schneller 1988). As compared with seed plants, the "shortcomings" related to the independence of the gametophyte generation are, however, to some extent relieved by the enormous number of spores. According to Schneller (1975), this number is ca. 100 millions yearly per one *Dryopteris filix-mas* individual with a mean number of 5 fertile fronds.

As concerns hart's tongue which does not reproduce vegetatively, the clustery spatial structure is mainly associated with the mosaic nature of the habitat. According to the present studies, the formation of clusters is supported by the presence of gruss. Possibly, the proximity of two evidently distinct microhabitats: rock with a sparse layer of bryophytes and interstone space filled with humic soil, is the most important factor allowing for the occurrence and normal development of the hart's tongue population. Whereas prothallia germinating on stabilized gruss in the bryophyte layer or on rotting tree trunks were frequently observed, no prothallia were found immediately on soil. Stabilized substrate with high moisture content permits the development and survival of the frail gametophyte. Over time this specific

microhabitat becomes a barrier to the developing sporophyte. For further growth contact with soil is required. Owing to these specific conditions of adaptations of both generations, it is impossible for the latter to grow far apart. It may thus be assumed that the presence of gruss and immediate vicinity of soil ensure success in spreading of the population. Separate occurrence of both these substrates does not suffice for full development of hart's tongue. Thus, the biological and ecological factors are closely interrelated.

The second of the investigated habitat factors, i.e. light, seems to exert a definitely smaller effect on the distribution of hart's tongue, even though the present results confirm the shade tolerance of this species. This is mainly due to the late "start" of hart's tongue which begins growth later than all co-occurring plants (B o d z i a r c z y k 1989). On account of the rich forest floor vegetation, except for late autumn and early spring hart's tongue is constantly shaded and tree stand openings plays no significant role.

Moreover, it was attempted to determine the correlation between the size of individuals and density (Fig. 9) The results were surprising, particularly in the case of the population from the Ochotnica where the largest individuals grew under conditions of the highest density. The interpretation of this fact is difficult, because it is impossible to determine the age of individuals and thus the age of the population. However, we can put forward the hypothesis that the population from the Ochotnica Stream valley (86% of mature individuals – Table 3) occurs at its ecological optimum. The fact that the individuals are large despite their high density evidently testifies to the richness of the habitat and absence of competition. It cannot be ruled out, however, that after depletion of the resources some intraspecific competition and changes in dominance structure may take place. It can also be assumed that this is the oldest fragment of the population, this accounting for the large size of individuals according to the trait of leaf length, number of leaves, size of underground stem and probably biomass.

In the populations from the Sokolica Mt. and Pieniński Potok an increase in the density adversely affects the size of individuals. Also the high proportion of senile individuals (13.8%) is of some importance. Gruss covers the area in a lesser measure (at most blocks with 51–75% covering were singled out). Under the Sokolica Mt. summit a thick layer of beech litter may be decisive of hindering the regeneration of the population. The effect of interspecific competition seems hardly probable. Hart's tongue attains its optimal growth in gaps in the gruss, and under these habitat conditions no other species can compete with this plant.

It will probably be possible to answer many questions upon long-term systematic observations on individuals labelled at the juvenile stage. Moreover, complex studies of soil were initiated. An edaphic approach may dispel some doubts and allow for more complete ecological characterization of *Phyllitis scolopendrium*.

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5. SUMMARY

The main goal of these studies was to determine the type of spatial structure of *Phyllitis scolopendrium* (L.) populations, as related to habitat factors. The size structure of individuals of the populations studied was analyzed, the developmental stages were examined and the effect of population density on the size of individuals was determined. Field studies were performed in the years 1987–1989 on 3 research plots in the Pieniński National Park and on 1 test area in the Gorce Mts. (in the Ochotnica Stream valley). Each plot (32 m×16 m) comprised a population within the Phyllitido-Aceretum association. The pattern of the spatial structure of the populations was determined using the Greig-Smith grid method; this analysis revealed that the populations are characterized by clumped distribution (Fig. 2). As concerns the microhabitat factors, the light factor determined by analysis of the projections of tree crowns (Figs. 3–6) and by light intensity measurements (Fig. 7), as well as the extent of area covering with gruss were examined. There was a strong positive correlation between the number of individuals and extent of area covered with gruss. In the case of all 4 populations light intensity was by an average of 39.1% lower in hart's tongue clusters than in blocks with scattered occurrence of this plant. It was found that tree stand openings does not limit the growth of populations, because hart's tongue in spring develops later than all other co-occurring plants, and is all the time shaded by the rich forest floor vegetation which retains 43.3–74.8% of light penetrating through tree stand. Analysis of the size of individuals indicated that the number of leaves is more variable than the length of the longest leaf. The distributions of the number of leaves are skewed particularly in the case of the populations from the Pieniny Mts. where the frequency of the low classes is high (Fig. 8 A–D), and where the distributions according to the trait of the longest leaf display a normal distribution (Sokolica Mt. and Ociemny) or approximate it (Pieniński Potok valley). Juvenile individuals have leaves of a length not exceeding 6 cm and form no more than 8 leaves.

The population from the Gorce Mts., which definitely exceeds in size of individuals that from the Pieniny Mts., exhibits the greatest crowding coefficient (5.2) and the highest density per area unit (15 individuals per 1 m^2); this population displays a significant correlation between the density of individuals, on the one hand, and leaf length (r = 0.866) and number of leaves (r = 0.748). In contrast, in the populations from the Pieniny Mts. both these traits are either negatively correlated with the density (Sokolica Mt. and Pieniński Potok valley) or there is no significant relationship (Ociemny Potok valley).

6. POLISH SUMMARY

Zasadniczym celem badań było poznanie typu struktury przestrzennej populacji języcznika zwyczajnego *Phyllitis scolopendrium* (L.) Newm., w powiązaniu z czynnikami siedliskowymi. Wykonano analizę struktury wielkości osobników populacji, określono stadia rozwojowe oraz zbadano wpływ zagęszczenia na wielkość osobników. Badania terenowe przeprowadzono w latach 1987–1989 na 3 powierzchniach w Pienińskim Parku Narodowym i na 1 powierzchni w Gorcach – w dolinie Ochotnicy. Każda z powierzchni, o wymiarach 32 m×16 m obejmowała całą dobrze wyodrębnioną lokalnie populację w obrębie zespołu Phyllitido-Aceretum. Do wykrycia wzorca struktury przestrzennej populacji posłużono się metodą bloków Greiga-Smitha. Z analizy tej wynika, że badane populacje wykazują rozkład skupiskowy (rys. 2). Z czynników mikrosiedliskowych zbadano czynnik świetlny określony przez analizę rzutów koron (rys. 3–6) i pomiar natężenia światła (rys. 7) oraz pokrycie powierzchni przez rumosz skalny. Otrzymano wysoką dodatnią zależność pomiędzy liczbą osobników

a stopniem pokrycia rumoszem. Natężenie światła we wszystkich populacjach jest średnio o 39,1% niższe w skupiskach języcznika niż w blokach o rozproszonym występowaniu. Stwierdzono, że prześwietlenie drzewostanu nie ogranicza rozwoju populacji, gdyż języcznik wiosną rozwija się najpóźniej ze wszyskich współwystępujących roślin, a przez cały okres pozostaje w cieniu bujnej roślinności runa, która zatrzymuje od 43,3% do 74,8% światła przenikającego przez drzewostan. Z analizy wielkości osobników wynika, że liczba liści jest cechą bardziej zmienną niż długość najdłuższego liścia. Rozkłady liczby liści mają charakter wyraźnie skośny, zwłaszcza w populacjach z Pienin, gdzie jest duża frekwencja klas niskich (rys. 8 A–D), a rozkłady wg cechy najdłuższego liścia mają charakter normalny (Sokolica i dolina Ociemnego Potoku) lub zbliżony do normalnego (dolina Pienińskiego Potoku). Osobniki młodociane nie wykształcają więcej niż 8 liści, a ich najdłuższe liście nie przekraczają 6 cm długości.

Populacja z Gorców, która zdecydowanie przewyższa populacje z Pienin pod względem dorodności osobników, wykazała najwyższy współczynnik zatłoczenia (5,2) oraz największe zagęszczenie na jednostkę powierzchni (15 osobników na 1 m^2). W populacji tej stwierdzono statystycznie istotną zależność pomiędzy zagęszczeniem osobników a długością liści (r = 0,866) i liczbą liści (r = 0,748). W populacjach z Pienin (Sokolica i dolina Pienińskiego Potoku) obydwie cechy są ujemnie skorelowane z zagęszczeniem lub brak jest istotnej zależności (dolina Ociemnego Potoku).

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