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Synusial structure of *Lunario-Aceretum* and *Phyllitido-Aceretum* in Kostrza reserve (Beskid Wyspowy Range)

Abstract

Investigations were carried out in a nature reserve, on the north slopes of the Kostrza Mt. (Western Carpathians). Two study plots of 10 x 10 m (one in *Lunario-Aceretum* and one in *Phylitido-Aceretum*) were divided into 100 squares of 1 m^2 each. In each square the floristic composition was recorded together with percentage cover of all vascular plant species. Cluster analysis revealed three synusia in the herb layer: 1. *Ribes alpinium* + *Phyllitis scolopendrium*, 2. *Lunaria rediviva*+ *Mercuriali perennis*, 3. *Petasites albus* + *Corydalis cava*. Species frequency and their mean cover were used in the characteristics of synusia.

Keywords: cluster analysis, *Lunaria rediviva, Phyllitis scolopendrium*, synusium, herb layer

Introduction

One of the main objectives of the Natura 2000 network is the protection of natural habitats of Community interest. They are mentioned in Annex 1 of the Council Directive on the conservation of natural habitats and wild fauna and flora. Among proposed sites are forests of the *Tilio platyphillis-Acerenion pseudoplatani* alliance occurring on steep slopes and ravines (code 9180 according to INTERPRETATION MANUAL ...[1]). Protection methods are individually designed for each type of habitat. It is also necessary to carry out investigations in those habitats. The Kostrza is Site of Community Importance (SCI) - Natura 2000 Site (code of area PLH120009). The above mentioned reasons resulted in the choice of the Kostrza reserve as an area of investigation.

Analysis of synusia is a suitable tool to reveal internal structure of vegetation patch. This also permits for indirect monitoring of condition of the plant

population. It is assumed here, that phytocenosis is the elementary unit of vegetation and synusia are subunits distinguished in herb layer that are limited in time and space and ecologically and floristically differing among themselves. Articles discussing that subject are more and more numerous[2, 3, 4, 5, 6, 7, 8, 9], but there is no information of synusial structure of *Tilio – Acerenion* forests. This article is a result of preliminary investigations. The objective of this study is to distinguish synusia occurring in the herb layer of the investigated patches of *Phyllitido-Aceretum* and *Lunario-Aceretum* as well as answering the question whether they form fine-grained mosaic or homogeneous patches.

Material and methods

Investigations were carried out in may and june 2004 in the nature reserve on the north slopes of the Kostrza Mt., reaching 719.6 m above sea level (Western Carpathians). The area of the reserve is 38.85 ha and it is situated on the grounds of the villages Kostrza (commune Jodłownik) and Rupniów (commune Limanowa) belonging to Małopolska region. Primarily, the Kostrza reserve was created for the preservation of *Phyllitis scolopendrium*, as well as an old-growth forest with *Fagus sylvatica* and *Ulmus glabra* representing *Dentario glandulosae-Fageteum*, *Lunario-Aceretum* and *Phyllitido-Aceretum*[10]. The two last communities occurred in eastern part of the reserve. The studied patches *Phyllitido-Aceretum* and *Lunario-Aceretum* are at the foot of a steep slope, from which rock-blocks of different sizes tear off.

Location of investigated plots was defined on the basis of maps from documentation for the planned reserve "Kostrza"[11]. For the purpose of reconstructing the investigated plots in future the wooden pegs were left in each corner. Two study plots 10 x 10 m (one in *Lunario-Aceretum* and one in *Phylitido-Aceretum*), marked permanently with wooden sticks, were divided into 100 numbered squares – 1 m^2 each. In each square the floristic composition was recorded together with percent cover of all vascular plant species from herb layer using the scale: 1, 5, 10, 15, 20, 25,..., 100%. The limitation of the range of the studies only to undergrowth layer resulted from assuming the synusium definition as an individual distinguished only on the basis of mean cover and occurrence of species in the undergrowth layer. What helped accept this methodology was the fact that on the studied plots in the bush layer there was not any species and in the tree layer there were only single elm trees and maples. The only tree being a part of A layer, rooting on the study plot of *Lunario – Aceretum* was *Acer pseudoplatanus*. Within a few meters from the lines of the studied plots there occurred *Fagus sylvatica* 5 trees, *Acer pseudoplatanus* 4 trees, *Ulmus glabra* 5 trees, *Picea abies* 1 tree, *Quercus robur* 1 trees. On the study plot established at *Phylitido – Aceretum* the trees being part of A layer were two individuals of

Ulmus glabra and *Acer pseudoplatanus.* In the direct vicinity of the plots there were *Fagus sylvatica* 7 trees, *Acer pseudoplatanus* 4 trees, *Ulmus glabra* 1 tree, *Picea abies* 4 trees.

The floristic data (from 200 squares) was used to perform numerical classification by Mulva–5 software package[12]. During analysis we used square root transformation of cover values, coefficient of correlations as a resemblance measure and minimum variance clustering (Ward's method) as a classification method[13]. Distinction of synusias types was a result of these stages of analysis. Their reciprocal similarity was illustrated on a dendrogram. Names of synusias were created from names of dominating or codominating species. Species frequency and mean values of cover (with statistical important differences between synusias) were used for synusia characteristics. The variance analysis and Tukey's test for samples of different size were applied (significance of differences were estimated for $p < 0,01$). In the studies there was also analyzed the relation between distinguished synusia and developing moss layer. There was estimated the total percentage cover of all moss species on each square of 1m x 1m. Kruskal-Wallis ANOVA, Median tests and after this Multiple comparisons of mean ranks for all groups were applied. Significance of differences in moss layer cover in individual synusia was estimated for $p < 0,01$.

Results

As many as 45 vascular plant species occurred in the two plots: 31 species in *Lunario-Aceretum,* and 35 in *Phyllitido-Aceretum*. Cluster analysis revealed 3 synusia. Dendrogram indicated high similarity between synusia *Ribes alpinium* + *Phyllitis scolopendrium* and *Lunaria rediviva*. Synusium *Petasites albus* + *Corydalis cava* clearly differ from them (Fig. 1).

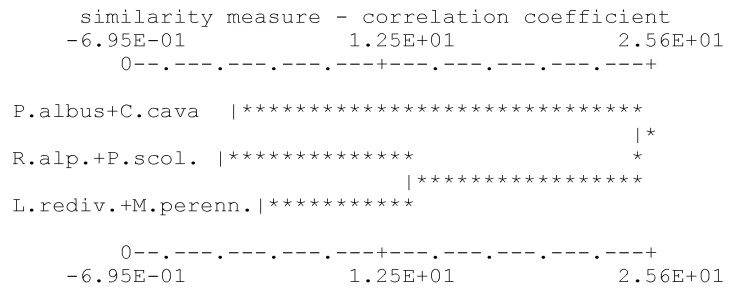

Fig. 1. Dendrogram similarity of the distinquished synusias.
Explanation:
P.albus+C.cava - synusium *Petasites albus* + *Corydalis cava*,
R.alp.+P.scol. - synusium *Ribes alpinum* + *Phyllitis scolopendrium*,
L.rediv.+M.perenn. - synusium *Lunaria rediviva* + *Mercurialis perennis,*.

Synusium *Petasites albus + Corydalis cava.* *Petasites albus* and *Corydalis cava* occur with comparatively high mean cover (about 15%) and high frequency (respectively 78% and 88%; Tab. 1). *Urtica dioica* and *Asarum europaeum* occur here with low cover, but statistically higher than in other synusia. The frequency of *U. dioica* is high (62%). In this synusium, *Rubus sp.* occurs with lowest frequency than in the other synusia.

S**ynusium *Ribes alpinium + Phyllitis scolopendrium.*** Codominant species *Ribes alpinium* and *Phyllitis scolopendrium* appear with relatively high cover (respectively 16% and 12%) as well as high frequency (62% and 87%; Tab.1).

Synusium *Lunaria rediviva + Mercurialis perennis*. In this synusium *Lunaria rediviva* is the dominant species with mean cover 11% and frequency of 82%. This species occurs quite frequently in other two synusia, but with lower coverage. *Mercurialis perennis* and *Galium odoratum* are species that positively distinguish this synusium from the two others. Their frequency is very high, but they cover small areas (respectively 4% and 3%; Tab. 1).

In *Lunario-Aceretum* the largest area (59%) is occupied by synusium *Petasites albus + Corydalis cava* (Fig. 2). *Lunaria rediviva + Mercurialis perennis* synusium occurs on remaining area of this plot. Synusium *Ribes alpinum + Phyllitis scolopendrium* was not recorded in this plot. In *Phyllitido-Aceretum,* 36% squares represent *Ribes alpinum + Phyllitis scolopendrium* synusium, and 60% – *Lunaria rediviva + Mercurialis perennis* synusium, whereas *Petasites albus + Corydalis cava* synusium occurs only in 4% of squares.

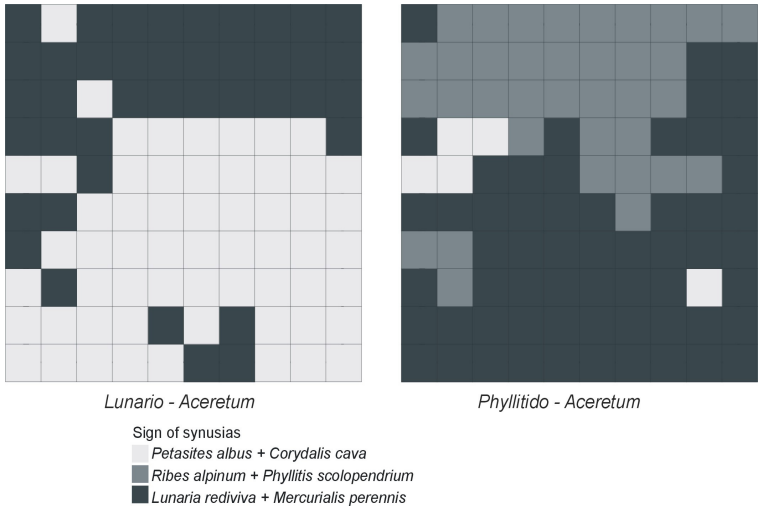

Fig. 2. Occurence of distinquished symusias on the study areas: *Lunario - Aceretum* and *Phyllitido – Aceretum*

Table 1. The occurrence of individual species in distinguished synusia. Values of cover with significant differences in comparison to all the other synusia were highlighted. Values of cover with significant differences in comparison to only some of synusia were marked with a star with the group numbers in relation to which the difference was shown. Significant differences for p<0,01. Synusia designations: *P.a+C.a - Petasites albus + Corydalis cava, R.a+P.s - Ribes alpinum + Phyllitis scolopendrium, L.r+M.p - Lunaria rediviva + Mercurialis perennis*

Name of species	Mean cover of species at synusia [%]			Frequency of species at synusia [%]		
	P.a+C.a	***R.a+P.s***	***L.r+M.p***	***P.a+C.a***	***R.a+P.s***	***L.r+M.p***
Petasites albus	**15,16**	0,00*[1]	0,55*[1]	78	0	11
Corydalis cava	**14,64**	0,07*[1]	0,27*[1]	88	2	7
Urtica dioica	**3,60**	0,15*[1]	0,28*[1]	62	10	12
Asarum europaeum	**1,28**	0,00*[1]	0,12*[1]	20	0	2
Rubus sp.	**0,01**	1,14*[1]	0,68*[1]	1	21	22
Ribes alpinum	0,00*[2]	**15,58**	0,06*[2]	0	62	2
Phyllitis scolopendrium	0,01*[2]	**12,31**	1,32*[2]	2	87	24
Lunaria rediviva	5,37*[3]	2,69*[3]	**11,14**	69	63	82
Mercurialis perennis	2,08*[3]	0,72*[3]	**4,31**	28	21	65
Galium odoratum	1,62*[3]	0,53*[3]	**2,91**	32	14	61
Dentaria glandulosa	7,31*[2]	2,90*[1]	5,95	82	39	63
Galeobdolon montanum	4,91	5,72	5,69	73	88	83
Lamium maculatum	2,79	2,13	2,64	59	48	56
Aegopodium podagraria	1,93*[2]	0,07*[1]	1,46	45	2	36
Fagus sylvatica	0,47*[2]	0,00*[1]	0,20	20	0	15
Pulmonaria officinalis	0,38	0,10	0,57	14	5	21
Circaea lutetiana	0,38	0,07	0,26	14	2	10
Salvia glutinosa	0,22	1,43*[3]	0,10*[2]	4	14	4
Impatiens noli - tangere	0,07	0,28	0,03	7	12	1
Melandrium rubrum	0,01*[2]	0,49*[1]	0,13	1	14	3
Acer pseudoplatanus	0,06	0,15	0,22	2	5	4
Carpinus betulus	0,04	0,01	0,03	2	2	3
Geranium robertianum	0,03	0,22	0,01	1	5	2
Cystopteris Montana	0,03	0,01	0,17	1	2	8
Ulmus gabra	1,40	-	-	4	0	0
Ficaria verna	0,13	-	-	2	0	0
Ajuga genevensis	0,03	-	-	1	0	0
Carex sylvatica	0,01	-	-	1	0	0
Viola reichenbachiana	0,01	-	-	1	0	0
Anemone nemorosa	0,24*[3]	-	0,01*[1]	12	0	1
Primula Eris	0,09	-	0,04	7	0	4
Glechoma hirsuta	0,14	-	0,01	7	0	2
Dentaria bulbifera	0,13	-	0,05	7	0	3
Chaerophyllum hirsutum	0,13	-	0,03	3	0	1
Abies alba	0,02	-	0,09	3	0	10
Ranunculus lanuginosus	0,01	-	0,01	2	0	1
Tilia mordata	-	-	0,16	0	0	4
Cystopteris fragilis	-	-	0,08	0	0	4
Asplenium ruta - muraria	-	-	0,01	0	0	1

Paris quadrifolia	-	-	0,01	0	0	1
Oxalis acetosella	-	0,63	0,30	0	7	8
Polystichum braunii	-	0,07	0,09	0	2	1
Senecio nemorensis	-	0,01	0,01	0	2	2
Actaea spicata	-	0,28	-	0	3	0
Athyrium filix - femina	-	0,15	-	0	3	0

The moss layer was more developed and it showed much bigger diversity of cover values in the studied plot of *Phyllitido-Aceretum* in comparison to the studied plot of *Lunario-Aceretum* (Fig. 3). The moss layer was the poorest in the synusium of *Petasites album+Corydalis cava*. The mean cover of this layer did not exceed there 1% and the maximum value amounted to 10% (Table 2). Nearly 10% mean cover of the moss layer was in the synusium of *Lunaria rediviva + Mercurialis perennis.* The moss layer was the best developed in the synusium of *Ribes alpinum + Phyllitis scolopendrium*. The mean cover of this layer was 28,6%. Differences between values of mean cover of moss layer in the synusia were statistically important (p = 0,01).

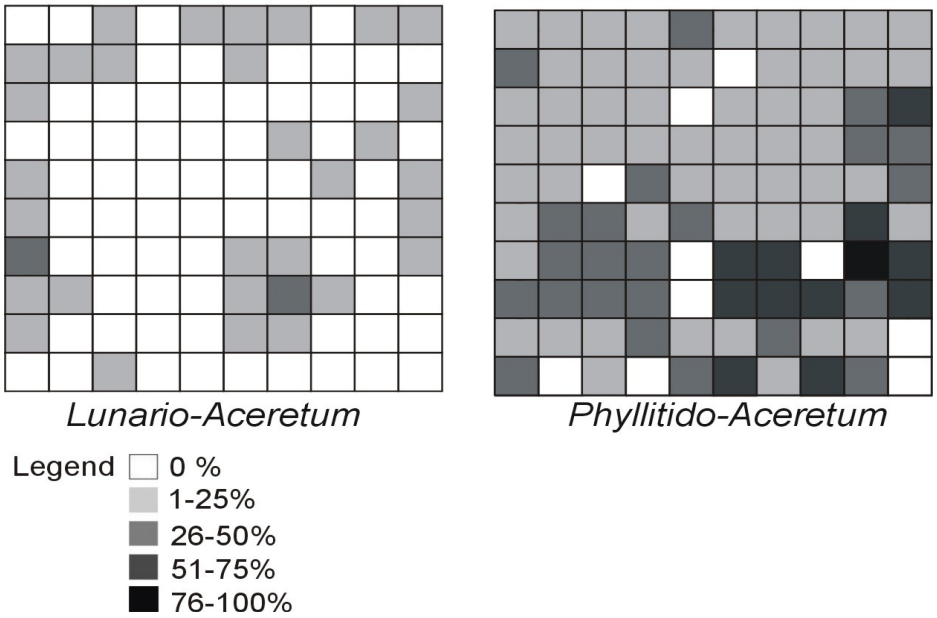

Fig. 3. Cover of moss layer on the study plots: *Lunario - Aceretum* and *Phyllitido – Aceretum*

Table 2. Cover of moss layer on the study plots: *Lunario - Aceretum* and *Phyllitido – Aceretum*

	Cover of moss layer [%]				
Synusium	**Mean**	**S.D.**	**Min**	**Max**	**N**
Petasites album+Corydalis cava	0,8	2,0	0	10	51
Ribes alpinum + Phyllitis scolopendrium	28,6	18,2	0	60	36
Lunaria rediviva+ Mercurialis perennis	9,9	14,2	0	80	113

Disscusion

According to information included in elaboration of STASZKIEWICZ et al.[11], from herb layer species belong to *Phyllitido – Aceretum,* only *Lunaria rediviva* and *Phyllitis scolopendrium*, reached 3rd degree of Braun – Blanquet quantitatively scale. It means, that all of these species can occupy from 25m^2 to 100m^2 of area (after taking into consideration largeness of surface on which phytosociological surveys were executed). Present research shows that these two species are dominated in different synusia, but *P. scolopendrium* creates synusium in which is codominated species with *Ribes alpinum. Lunaria rediviva+ Mercurialis perennis* and *Ribes alpinum + Phyllitis scolopendrium* synusia are constant elements which creating *Phyllitido – Aceretum.*It is obvious, that *Ribes alpinum + Lunaria rediviva* synusium is the most important element creating *Lunario – Aceretum.*

Analysis of phytosociological tables placed in documentation of planned Kostrza reserve[11], allows nominating a hypothesis, that above-mentioned synusia are not the only which are creating *Lunario – Aceretum*. *Dentaria glandulosa* and *Impatiens noli-tangere* are also species with 3rd degree of Braun – Blanquet quantitatively scale (phytosociological survey executed in central part of reserve). High cover of this species suggests that they can create different synusia. Verification of this hypothesis requires conducting of further investigations on large number of investigated plots.

Conclusion

In the light of preliminary research, the herb layer of *Lunario – Aceretum* is created by two kinds of synusia: *Lunaria rediviva+ Mercurialis perennis* synusium and *Petasites albus + Corydalis cava* synusium. *Phyllitido – Aceretum* is created by *Ribes alpinium + Phyllitis scolopendrium* synusium, which accompanies *Lunaria rediviva + Mercurialis perennis* synusium. Numerous occurrences of *Lunaria rediviva + Mercurialis perennis* synusium in both groups, has result from their approximated syntaxonomical position. On investigated surfaces, synusia create large and compact homogeneous patches.

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Struktura synuzjalna jaworzyny górskiej z miesiącznicą trwałą (Lunario-Aceretum) i języcznikiem zwyczajnym (Phyllitido-Aceretum) w rezerwacie Kostrza (Beskid Wyspowy)

Abstrakt

Obiektem badań były zbiorowiska jaworzyny górskiej z miesiącznicą trwałą i języcznikiem zwyczajnym. Badania prowadzono na dwóch powierzchniach badawczych (10x10m, podzielonych na 100 kwadratów). Zostały one założone na północnych stokach Góry Kostrza. i obejmowały swoim zasięgiem fragmenty zespołów *Lunario – Aceretumi* i *Phyllitido - Aceretum.* W toku analizy numerycznej wyróżniono trzy typy synuzjów budujących warstwę runa (Ryc. 1). Ich nazwy utworzono od dominujących w nich gatunków, a scharakteryzowano je na postawie średniego pokrycia i frekwencji występujących w nich gatunków. W synuzjum *Lunaria rediviva+Mercurialis perennis,* poza miesiącznicą trwałą i szczyrem trwałym spotyka się, występującą z wysoką frekwencją *Galium odorum* (Tab. 1.). W synuzjum *Petasites albus + Corydalis cava* lepiężnikowi białemu i kokoryczy pustej towarzyszą występujące z mniejszym pokryciem *Urtica dioica i Asarum europaeum*. Trzecie synuzjum *Ribes alpinium + Phyllitis scolopendrium* charakteryzuje jedynie wysokie pokrycie porzeczki alpejskiej i jezycznika zwyczajnego. Porównując częstość występowania wyróżnionych synuzjów w obrębie badanych powierzchni (100m^2 każda) zauważyć można, iż na powierzchni badawczej zlokalizowanej w *Lunario - Aceretum* większy obszar zajmuje synuzjum *Petasites albus + Corydalis cava* (59%) (Ryc. 2). Na pozostałej części powierzchni występuje synuzjum *Lunaria rediviva+Mercurialis perennis*. Należy zauważyć tu całkowity brak synuzjum *Ribes alpinum + Phyllitis scolopendrium*. Na powierzchni badawczej założonej w *Phyllitido - Aceretum* 36% poletek reprezentuje synuzjum *Phyllitides scolopendium*. Na 60% powierzchni obecne jest synuzjum *Lunaria rediviva+Mercurialis perennis* natoniast synuzjum *Petasites albus + Corydalis cava* wykształciło się jedynie na 4% powierzchni, co może wskazywać na jego marginalne znaczenie w tym zespole. Liczne występowanie synuzjum *Lunaria rediviva + Mercurialis perennis* w obydwu zespołach wynika z ich zbliżonej przynależności syntaksonomicznej. Na badanych powierzchniach synuzja tworzą zwarte stosunkowo duże homogeniczne płaty.