Biodiv. Res. Conserv. 23: 75-82, 2011

DOI 10.2478/v10119-011-0016-8

BRC
www.brc.amu.edu.pl

Long-term changes and maintenance of *Phyllitis scolopendrium* (L.) Newman population in the Wodąca Valley (the Cracow-Częstochowa Upland)

Stanisław Wika* & Alicja Barć**

Department of Geobotany and Nature Protection, Faculty of Biology and Environmental Protection, University of Silesia, Jagiellońska 28, 40-032 Katowice, Poland, e-mail: *stanislaw.wika@us.edu.pl, **alicja.barc@us.edu.pl

Abstract: The Cracow-Częstochowa Upland is an important mesoregion for the maintenance of *Phyllitis scolopendrium* (L.) Newman and its habitat with the *Phyllitido-Aceretum* Moor 1952 association. Studies in the Wodąca Valley focused on: the determination of the actual numerical force and quantitative changes in hart's-tongue resources between 1999 and 2009, a comparison of these results with literature, as well as on the indication of appropriate solutions for conservation purposes and for tourist exploitation of the Jurassic outcrops. Results of these studies provide scientific arguments for the maintenance of *Phyllitis scolopendrium* in the Wodąca Valley, on the edge of its European range.

Key words: *Phyllitis scolopendrium*, natural resources, syntaxonomy, conservation

1. Introduction

The Cracow-Częstochowa Upland is at the northern edge of the *Phyllitis scolopendrium* (L.) Newman range, not only in Poland but also in entire Europe. Therefore, it is an important mesoregion for the conservation of this magnificent fern, strictly protected in Poland, but severely threatened with extinction in isolated localities. This problem was noted by, among others: Medwecka-Kornaś (1952), Wika and Szczypek (1982, 1985), Wika (1986, 1989), Szczypek and Wika (1991) and Wika *et al*. (2000). The phytosociological differentiation of *Phyllitido-Aceretum* Moor 1952 in Poland was presented by Bodziarczyk (2002), who also discussed the role and the place of the association patches from the above-mentioned mesoregion in the syntaxonomic system of vegetation in Poland. Moreover, Bodziarczyk and Malik (2006) presented results of their studies regarding the distribution of localities of the *Phyllitido-Aceretum* association and described habitat conditions for its phytocoenoses; they also evaluated quantitative resources of the *Phyllitis scolopendrium* population in the Cracow-Częstochowa Upland in years 2002-2004. Data regarding quantitative changes in approximately the last quarter of the 20th century in patches of this association and threats to the species and its habitats within the area of the Cracow-Częstochowa Upland were given by Wika *et al*. (2005). In addition, a suggestion for monitoring and careful protection of the fern was also given in that paper.

Significant differences in numerical force of resources of the *Phyllitis scolopendrium* given by Bodziarczyk and Malik (2006) in relation to the results obtained by Wika *et al*. (2000, 2005) in the Wodąca Valley provided inspiration for taking up these studies. Also the following question arose: is the numerical force of the species increase a positive confirmation of the currently used effective method of conservation or should methods of species maintenance be improved?

Therefore, the studies performed in the Wodąca Valley focused on: (*i*) the determination of the abundance of hart's-tongue resources in 2009; its comparison with results of counting from 1999 and with literature; (*ii*) quantitative and qualitative changes of its habitat during the period of 33 years taking into account mesoregional and local geographical scales; (*iii*) as well as the indication of appropriate solutions for conservation purposes and touristic exploitation of Jurassic monadnocks covered with *Phyllitis scolopendrium* clumps, with particular attention paid to geomorphological criteria (monadnock-base).

2. Material and methods

Geobotanical studies in the Wodąca Valley (the central part of the Cracow-Częstochowa Upland) were carried out in 2009, between April and June. The study area was located in the Smoleń Range, among the villages of Smoleń, Strzegowa and Złożeniec, at the border between Silesia and the Małopolska provinces. This is also the area of the Landscape Park of Eagle Nests. Eleven localities within distinctive monadnocks in the Wodąca Valley were studied (Fig. 1). Their character, in many cases, was reflected in their names because they were often called 'hills' or 'rocks'. Clumps of living *Phyllitis scolopendrium* growing on monadnocks, beneath them, as well as those on loose limestone rubble were counted and compared with the results of counting made in 1999 (Table 1). Structures with at least 1 living frond or its fragment were treated as clumps; dead clumps were excluded.

Each of the 11 localities was documented by 1 phytosociological relevé made following the Braun-Blanquet's method (1964) in the best maintained patches of vegetation. Then the relevés were collated in an analytic table (not presented in this paper for editorial reasons). However, the effect of this collation is compared with the table published by Wika *et al.* (2005), in which historical relevés from: 1976, 1983, 1987 and 1999 taken entirely in the Wodąca Valley, as well as data from the central part of the Cracow-Częstochowa Upland were gathered. A shortened version of this comparison is hitherto presented (Table 2). In order to make the comparison possible (*i.e.* independent from the number of relevés), the mean number of species per relevé was used in a conversion coefficient.

The transect method was used to recognize spatial relationships within hart's-tongue populations in the 11 localities. Four-meter-long transects built of 1 x 1 m squares were delimited at places where the fern occurred

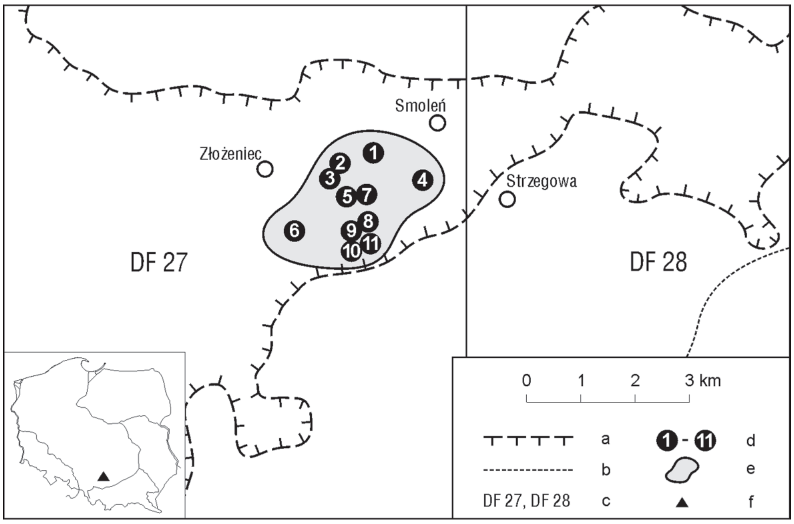

Fig. 1. Distribution of studied monadnocks in the Wodąca Valley
Explanations: a – the boundary of the Landscape Park of Eagle Nests, b – the boundary of buffer zone in the Landscape Park of Eagle Nests, c – squares of ATPOL grid (Zając 1978), d – monadnocks, e – the Smoleń Range, f – study area

Table 1. The number of clumps in *Phyllitis scolopendrium* populations in individual localities of the Wodąca Valley between 1999-2009*

No.	Localities	Number of clumps on particular exposures					
		TNCSM	N	NE	NW	E	W
1.	Smoleń Mt	887/1693	161/124	152/243	413/561	136/110	-/590
2.	Hill 454.1 – between Smoleń Mt and Dziurawa Rock	201/287	38/40	32/93	0/7	46/13	85/130
3.	Dziurawa Rock	1027/1661	143/670	138/263	180/295	426/288	55/45
4.	Hill to the SE of Smoleń Mt	56/60	13/13	0/0	0/8	9/2	34/37
5.	Hill to the E of Dziurawa Rock	119/143	12/23	105/31	0/0	0/89	0/0
6.	Hill to the NE of Ruskowa Rock	25/28	9/15	16/13	0/0	0/0	0/0
7.	Clock Rock	60/134	0/87	2/19	56/27	0/0	2/1
8.	Strzegowa Rock	75/112	10/29	7/0	25/64	0/4	33/14
9.	Chłopskie Earthwork	940/1503	473/795	274/260	138/318	38/69	4/15
10.	Pańskie Earthwork	268/324	40/102	219/62	0/8	2/149	6/0
11.	Gancerzyca Rock	552/1622	184/232	190/265	40/26	83/973	0/37
	Total	4210/7567	1083/2130	1135/1249	852/1314	740/1697	219/869

Explanations: * – number of clumps in the year 1999/2009, TNCSM – total number of clumps per single monadnock

Table 2. The comparison of some actual and historic data regarding transformations of the *Phyllitido-Aceretum* Moor 1952 phytocoenoses in the middle part of the Cracow-Częstochowa Upland

Criteria		The middle part of the Cracow-Wieluń Upland (1976-1999)		The Wodąca Valley (1976-1999)		The Wodąca Valley in 2009	
No. of phytosociological relevés		15		8		11	
No. of species in total		124		94		114	
Mean No. of species per relevé		3.35		2.47		2.48	
Conversion coefficients		37		38		46	
C – constancy, CC – cover coefficient		C	CC	C	CC	C	CC
		all trees					
Abies alba	a	0.00	0.00	0.00	0.00	0.39	4.43
Abies alba	b	0.89	3.22	1.64	5.89	0.98	1.07
Abies alba	c	0.54	0.05	0.33	0.03	0.78	1.04
Acer platanoides	c	0.00	0.00	0.00	0.00	0.98	2.04
Acer pseudoplatanus	a	2.16	60.81	1.64	40.29	1.17	56.33
Acer pseudoplatanus	b	1.27	1.89	1.97	3.42	1.57	7.48
Acer pseudoplatanus	c	1.97	0.19	2.63	0.26	1.57	5.52
Carpinus betulus	a	0.19	0.89	0.00	0.00	0.39	1.98
Carpinus betulus	b	0.19	0.89	0.00	0.00	0.00	0.00
Carpinus betulus	c	0.00	0.00	0.00	0.00	0.20	0.02
Cerasus avium	c	0.00	0.00	0.00	0.00	0.39	0.02
Fagus sylvatica	a	1.27	39.65	0.99	15.63	1.39	20.74
Fagus sylvatica	b	0.54	0.95	0.66	0.05	0.59	0.07
Fagus sylvatica	c	0.19	0.02	0.00	0.00	1.17	0.11
Fraxinus excelsior	a	0.19	3.16	0.33	5.76	0.00	0.00
Fraxinus excelsior	b	0.35	0.04	0.66	0.07	0.00	0.00
Fraxinus excelsior	c	0.35	0.04	0.66	0.07	0.39	0.04
Padus avium	c	0.00	0.00	0.00	0.00	0.20	0.02
Picea abies	b	0.54	1.81	0.33	1.63	0.20	0.01
Picea abies	c	0.19	0.02	0.00	0.00	0.20	0.02
Populus tremula	c	0.00	0.00	0.00	0.00	0.20	0.01
Quercus robur	a	0.19	0.90	0.33	1.63	0.59	11.85
Quercus robur	c	0.19	0.90	0.00	0.00	0.98	0.09
Salix caprea	b	0.00	0.00	0.00	0.00	0.20	0.02
Sorbus aucuparia	c	0.00	0.00	0.00	0.00	0.59	0.07
Tilia cordata	a	0.19	3.16	0.33	5.76	0.00	0.00
Tilia cordata	b	0.19	0.89	0.33	1.63	0.00	0.00
Tilia platyphyllos	a	1.81	43.70	2.30	60.05	1.39	29.65
Tilia platyphyllos	b	0.73	1.84	0.99	3.32	1.39	4.00
Tilia platyphyllos	c	0.00	0.00	0.00	0.00	1.17	0.11
Ulmus glabra	a	0.89	18.46	1.64	33.71	0.59	5.43
Ulmus glabra	b	1.08	13.54	1.97	24.71	0.59	2.96
Ulmus glabra	c	0.73	0.08	1.32	0.13	0.78	0.09
		chosen shrubs					
Corylus avellana	b	2.35	53.65	2.63	58.45	1.78	27.33
Lonicera xylosteum	b	1.92	0.11	1.32	1.76	1.78	10.02
Ribes uva-crispa	b	1.62	1.95	1.63	1.82	1.59	15.39
Sambucus nigra	b	1.43	5.19	1.63	1.76	1.98	17.48

SE	SW	S	Increase in %
9/0	7/49	9/16	91
0/1	0/0	0/3	43
66/91	0/0	19/9	62
0/0	0/0	0/0	7
2/0	0/0	0/0	20
0/0	0/0	0/0	12
0/0	0/0	0/0	123
0/0	0/0	0/1	49
12/32	1/7	0/7	60
0/3	0/0	1/0	21
28/53	19/26	8/10	194
117/180	27/82	37/46	80

abundantly and came down the rocky walls to their bases and limestone rubble. The upper parts of transects (A and B squares) included rocky walls, whereas the lower parts (C and D squares) were situated at the bases of rocks. In cases where it was not possible to establish the transect monadnock-base, a semicircular depression within the monadnock with distinctly noticeable differences at the inclination between the wall and the basal depression was usually treated as the base. All C and D squares from 11 transects were combined with the area of respective phytosociological relevés. The number of *Phyllitis scolopendrium* clumps was counted within each square of the transect (Fig. 2).

Table 2 (cont.)

Criteria		The middle part of the Cracow-Wieluń Upland (1976-1999)		The Wodąca Valley (1976-1999)		The Wodąca Valley in 2009	
No. of phytosociological relevés		15		8		11	
No. of species in total		124		94		114	
Mean No. of species per relevé		3.35		2.47		2.48	
Conversion coefficients		37		38		46	
C – constancy, CC – cover coefficient		C	CC	C	CC	C	CC
		chosen herbal plants					
Actaea spicata	c	1.97	2.84	1.97	3.42	1.98	7.50
Adoxa moschatellina	c	1.27	1.00	1.97	1.82	1.59	3.04
Aegopodium podagraria	c	0.19	0.02	0.32	0.03	1.17	10.43
Asarum europaeum	c	2.35	19.43	2.63	26.37	2.17	17.30
Athyrium filix-femina	c	0.19	0.02	0.32	0.03	1.39	0.15
Campanula persicifolia	c	0.54	0.05	0.32	0.03	0.78	0.07
Cardaminopsis arenosa	c	0.35	0.03	0.66	0.05	2.17	0.20
Chrysosplenium alternifolium	c	1.81	7.73	2.29	12.39	1.98	16.85
Circaea lutetiana	c	0.19	0.02	0.32	0.03	0.78	5.46
Corydalis cava	c	0.54	9.92	0.32	12.34	0.78	16.78
Dryopteris filix-mas	c	2.35	2.89	2.29	1.84	2.17	4.09
Galeobdolon luteum	c	2.51	29.32	2.63	32.95	2.17	32.11
Galium odoratum	c	2.16	10.89	1.63	8.26	2.17	27.70
Hepatica nobilis	c	1.62	2.81	1.63	0.16	0.78	1.04
Impatiens noli-tangere	c	0.35	0.03	0.66	0.05	0.78	4.48
Lamium maculatum	c	0.73	0.51	0.66	5.79	0.20	0.02
Mercurialis perennis	c	1.97	40.57	1.63	36.21	1.17	15.35
Paris quadrifolia	c	0.73	0.08	0.66	0.05	1.39	4.54
Phyllitis scolopendrium	c	2.70	25.70	2.63	34.58	2.17	38.54
Poa nemoralis	c	2.35	4.65	2.29	3.45	1.39	0.13
Polygonatum multiflorum	c	0.89	0.08	1.32	0.13	0.20	0.98
Polypodium vulgare	c	1.62	8.22	1.97	7.53	0.78	1.04
Polystichum aculeatum	c	1.62	2.81	1.63	5.00	1.98	5.02
Pulmonaria obscura	c	1.81	7.32	1.97	5.92	2.17	4.09
Ranunculus lanuginosus	c	0.54	0.05	0.32	0.03	0.20	3.46
Senecio ovatus	c	1.43	1.03	1.97	0.18	0.39	0.04
Urtica dioica	c	1.81	1.05	1.63	1.82	1.98	5.04
		chosen mosses					
Brachythecium rutabulum	d	0.89	6.35	0.32	5.76	0.78	10.37
Brachytheciastrum velutinum	d	0.89	12.62	0.32	12.34	0.20	0.02
Homalothecium philippeanum	d	1.27	22.54	1.97	35.39	0.98	17.28
Mnium stellare	d	1.62	14.46	0.66	3.32	1.59	15.30
Oxyrrhynchium hians	d	0.73	0.08	0.66	0.05	1.78	11.89
Porella platyphylla	d	1.08	24.35	1.32	38.66	0.98	2.04
Thamnobryum alopecurum	d	0.19	0.02	0.32	0.03	0.78	7.91

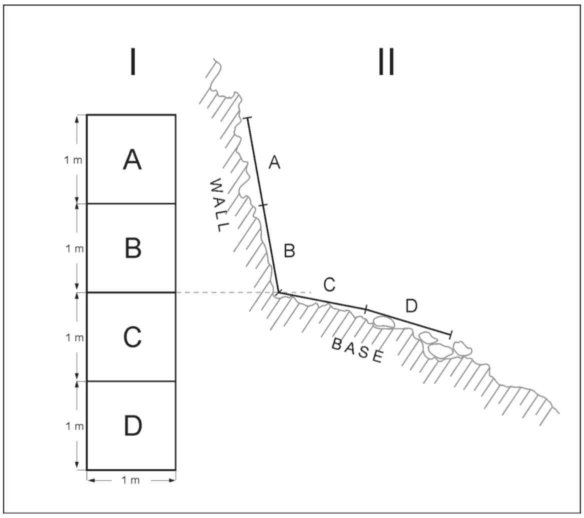

Fig. 2. Transect method used on 11 monadnocks in the Wodąca Valley

Explanations: I – transect's scheme, II – wall-base transect profile; A, B, C, D – squares 1 x 1 m

In the central part of each square of the transect, the inclination on the wall and at the rock base was measured with 5° precision using a SUUNTO clinometer. Exposures were measured in four main and four transitional directions. Altitudes a.s.l. for particular transects and coordinates of the following 11 localities were determined using a GARMIN GPS: 1 – the Smoleń Mt (Góra Smoleń) N50°26'067", E19°40'100"; 2 – the Hill (Wzgórze) 454,1 – between the Smoleń Mt (Góra Smoleń) and the Dziurawa Rock (Dziurawa Skała) N50°26'043"; E19°39'559"; 3 – the Dziurawa Rock (Dziurawa Skała) N50°25'534"; E19°39'502"; 4 – the Hill (Wzgórze) to the SE of the Smoleń Mt (Góra Smoleń) N50°26'024"; E19°40'254"; 5 – the Hill (Wzgórze) to the E of the Dziurawa Rock (Dziurawa Skała) N50°25'531"; E19°40'101"; 6 – the Hill (Wzgórze) to the NE of the Ruskowa Rock (Ruskowa Skała) N50°25'221"; E19°38'305"; 7 – the Clock Rock

(Skała Zegar) N50°25'449"; E19°40'274"; 8 – the Strzegowa Rock (Strzegowa Skała) N50°25'334"; E19°40'151"; 9 – the Chłopskie Encampment (Grodzisko Chłopskie) N50°25'251"; E19°40'046"; 10 – the Pańskie Encampment (Grodzisko Pańskie) N50°25'115"; E19°40'117"; 11 – the Gancerzyca Rock (Skała Gancerzyca) N50°25'195"; E19°40'243".

Cluster analysis for particular squares from all 11 objects in relation to the number of hart's-tongue clumps was carried out using the STATISTICA 8.0 package. The similarity was measured by Euclidean distance and clustering was made using the single-link method. Discriminant analysis (with 9 variables such as: inclination, exposure, number of clumps, number of fronds producing spores, number of crosiers, number of uninjured fronds, number of living fronds, presence of sunburned and presence of mechanically damaged fronds) and correlation analysis of all analysed variables were performed (Stanisz 2007).

The names of syntaxonomic units followed Matuszkiewicz (2001), of vascular plants – Mirek *et al.* (2002) and of mosses – Ochyra *et al.* (2003).

3. Results

The occurrence of 7567 clumps of hart's-tongue was ascertained in the Wodąca Valley during the spring of 2009. They were found on walls of 11 monadnocks, at their bases and beneath bases on loose limestone rubble. In comparison with the result of the counting from 1999 (4210 clumps), which was made using the same method, it indicated an increase of approximately 80% in total (Table 1).

The analytic table (not included) consisted of 11 phytosociological relevés made in 2009 in localities on monadnocks of the Wodąca Valley. Typical patches of the *Phyllitido-Aceretum* association were distinctly four-layered. However, none of the layers had full cover. The tree stand with a mean density of 68% was made up of 9 species, but only 3 of them – *Acer pseudoplatanus, Tilia platyphyllos* and *Fagus sylvatica*, could be acknowledged as canopy-forming species. Despite the fact that all 3 species achieved the highest (5th) constancy, the layer was dominated by *Acer pseudoplatanus*. In some patches, *Corylus avellana* appeared as a tree. Brushwood, excluding tree undergrowth, was formed by 11 shrub species. *Corylus avellana, Ribes alpinum, R. uva-crispa* and *Sambucus nigra* played the main role. Species from the *Fagetalia sylvaticae* order and the *Querco-Fagetea* class dominated the herb vegetation. The physiognomy of the association patches was created by the character species – *Phyllitis scolopendrium*; it had a quantitative projection of the cover from 25% up to 50%. *Corydalis cava, Galeobdolon luteum* and *Galium odoratum* sporadically formed facies among herbal plants; amongst mosses these were *Brachythecium rutabulum* and *Cirriphyllum crassinervium.*

In the analytic table of the *Phyllitido-Aceretum* from the Wodąca Valley mentioned above, the total of 114 species of plants was recorded. However, 19 of them were various species of common mosses, which were present in each phytosociological relevé. Their cover varied from 10% to 40%. In addition, there were some difficulties in distinguishing between epigeic and epipetric mosses because of thinness of the soil layer (initial rendzina). That was earlier indicated by Wika (1989). The comparison of selected data regarding long-term transformations of the *Phyllitido-Aceretum* association in the central part of the Cracow-Wieluń Upland and, in particular, in the Wodąca Valley is presented in Table 2.

In the discussed analytic Table, two variants were distinguished – the typical one, with a high share of *Phyllitis scolopendrium,* documented by 4 relevés, and the *Ulmus glabra-Aegopodium podagraria* variant represented by 7 phytocoenoses. The second unit of lower rank was positively distinguished by the following species: *Ulmus glabra, Aegopodium podagraria, Acer platanoides, Corydalis cava* and *Circaea lutetiana* which achieved 2nd or 3rd constancy.

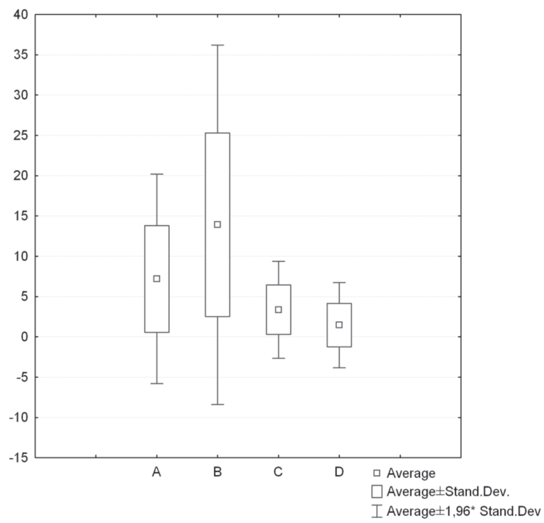

Fig. 3. The number of *Phyllitis scolopendrium* clumps in individual squares of all transects in the Wodąca Valley
Explanations: A, B – monadnock wall; C, D – base of monadnocks

Short wall-base transects were delimited on 11 monadnocks in the Wodąca Valley in patches of the *Phyllitido-Aceretum* association, in spatial contact with phytosociological relevés made at the base of rocky outcrops. A statistical analysis showed that the highest quantitative diversity of *Phyllitis scolopendrium* clumps, in particular, squares (A, B, C, D) of all transects applied to B square, *i.e.* to the zone from the base of the wall up to 1 m on the wall. The highest number of hart's-tongue

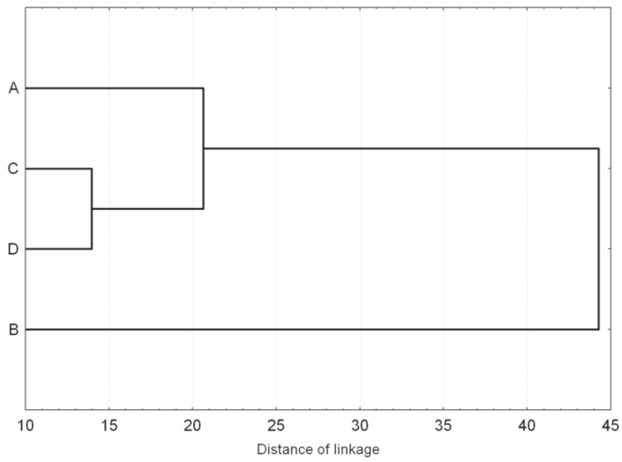

Fig. 4. Similarity of particular types of squares
Explanations: A, B – monadnock wall; C, D – base of monadnocks

clumps, on average, occurred there and values of this parameter had the largest range. These features distinguished B from the other squares (Fig. 3). In the basal zone of monadnocks (squares C and D), the number of clumps was significantly lower, but quite even. The observed diversity was confirmed by the results of cluster analysis for all 11 monadnocks in relation to 1 feature – the number of clumps (Fig. 4).

The distinct separateness of the wall of a monadnock (squares A, B) from its base (squares C, D) with regard to the analysed 9 features, *i.e.*: inclination, exposure, number of clumps, number of fronds producing spores, number of crosiers, number of uninjured fronds, number of living fronds, presence of sunburned and presence of mechanically damaged fronds, was confirmed by the results of the discriminant analysis (Fig. 5).

The high differentiation of exposures taken by hart's-tongue meant that whether that trait was significantly correlated with the analysed features, in particular, transect squares was checked. The analysis of correlation coefficients showed a lack of statistically significant correlation between the exposure of the transect and the number of clumps and the number of fronds (features which influenced the discrimination of groups in discriminant analysis).

4. Discussion

It was demonstrated that local populations of *Phyllitis scolopendrium* in the Wodąca Valley, based on counts in 1999 and 2009, showed distinct tendencies to their quantitative increase (Wika *et al.* 2000, 2005), in general, confirming the results reported by Bodziarczyk and Malik (2006). However, the abundance of the *Phyllitis scolopendrium* population from the Wodąca Valley, in terms of a range of values (Bodziarczyk & Malik 2006), in almost half cases was significantly higher in comparison with our studies (Table 1). The differences could have probably resulted from methods used by them during the field studies (*i.e.* two-year period of study, double counting during the vegetation season, using a field-glass in problematic places, multi-personal team). In our opinion, only the scale of increase still remains controversial. Repeated counting made by the same team of authors can be prejudicial to the final verdict. The assessment of living resources is the most reliable, when field data are collected during a long period of time and the same methods are used.

General conclusions regarding the development and processes which took place in the *Phyllitido-Aceretum* phytocoenoses in the area of the central part of the Cracow-Częstochowa Upland were based on the comparison of some selected historical and current data

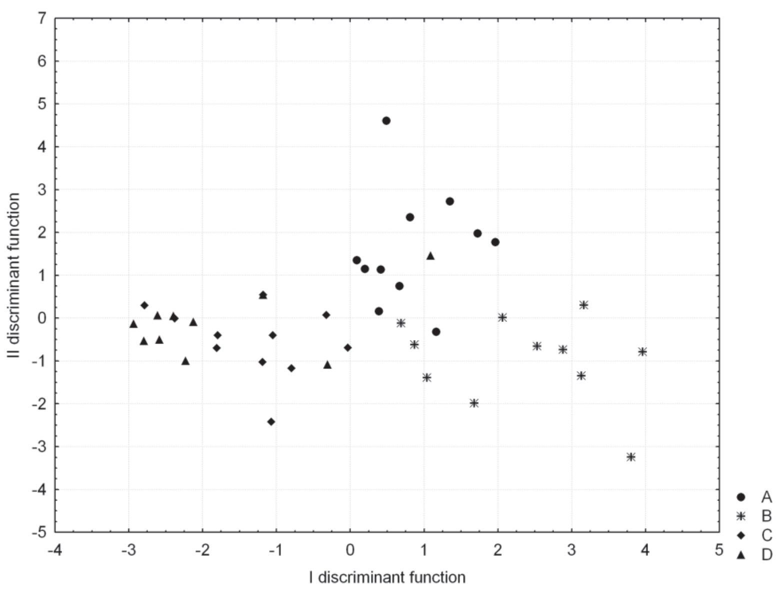

Fig. 5. Differentiation of the analysed squares
Explanations: A, B – monadnock wall; C, D – base of monadnocks

(Table 2). The composition of tree stands and brushwood layers became more diversified in species regarding data from approximately the last quarter of the 20th century. However, the share of valuable habitat-forming species decreased. Species important for *Phyllitido-Aceretum, i.e. Tilia platyphyllos* and *Ulmus glabra* were still cut out in the Wodąca Valley. This was clearly indicated in studies from 2009. Similarly, as in the case of the tree stand and brushwood, also in the herb layer the number of species from the two highest constancy classes changed. This proved that the floristic composition in patches of *Phyllitido-Aceretum* in that part of the Jurassic area was becoming more balanced, but this did not predict the phytocoenotic value of species components. The phenomenon might also be caused by the encroachment of some nitrophilous species, among others: *Aegopodium podagraria, Chelidonium majus, Moehringia trinervia, Ribes uva-crispa, Urtica dioica, Sambucus nigra* and species from the *Rubus* genus which was probably connected with the intensity of tourism and the applied forest management system. The direction of transformations in relation to sporadic species within the period discussed was much more difficult to assess.

The constancy and cover increased in the tree stand and new-growth in patches of the *Phyllitido-Aceretum* association from the Wodąca Valley in comparison to phytosociological data gathered during the period from 1976-1999. It refers to such species as: *Abies alba, Carpinus betulus, Fagus sylvatica, Padus avium* and *Quercus robur.* This reveals also *Salix caprea* growing as brushwood and species occurring exclusively as new-growth in the herb layer: *Acer platanoides, Cerasus avium, Populus tremula* and *Sorbus aucuparia.*

Whereas the decrease of constancy and cover in relation to all forest layers was observed with respect to *Fraxinus excelsior* and *Ulmus glabra, Tilia cordata* disappeared from the tree stand and brushwood layers altogether (did not occur in the herb layer at all). *Tilia platyphyllos* decreased its share in the tree stand, but regenerated in brushwood and appeared as new-growth. On the other hand, the constancy of *Acer pseudoplatanus* decreased but the cover increased in all forest layers. Taking into consideration the cover, this was actually the most important, habitat-forming species in the *Phyllitido-Aceretum,* leaving other species like *Tilia platyphyllos* and *Fagus sylvatica* behind.

The share of *Corylus avellana* decreased almost by half in the shrub layer, while in the case of *Lonicera xylosteum* and *Sambucus nigra* it increased significantly. In the herb layer, *Aegopodium podagraria* revealed a particular growth of frequency and cover. Other species like: *Asarum europaeum, Galeobdolon luteum, Lamium maculatum, Mercurialis perennis, Poa nemoralis, Polypodium vulgare, Senecio ovatus* became less frequent and decreased their cover. On the other hand, *Phyllitis scolopendrium* decreased constancy, but increased its cover (similarly to *Acer pseudoplatanus*).

Larger (mesoregional) spatial scale *i.e.* the comparison with the central part of the Cracow-Częstochowa Upland failed to change general relationships as evidenced by the Wodąca Valley. Differences concerned both constancy and cover of: *Acer pseudoplatanus* – decreased in the tree stand and increased in brushwood, *Carpinus betulus* – decreased in the brushwood, *Ulmus glabra* – increased insignificantly in the herb layer. In relation to the central part of the Cracow-Częstochowa Upland, the Wodąca Valley was enriched in *Abies alba* in the tree stand, *Padus avium* - in the herb layer and new-growths of: *Acer platanoides, Carpinus betulus, Cerasus avium* and *Tilia platyphyllos* in the herb layer. The so called ,clearing species' such as: *Salix caprea* and *Populus tremula* with *Sorbus aucuparia* improved brushwood and new-growths, respectively.

The *Ulmus glabra-Aegopodium podagraria* variant corresponds with the subvariant with *Ulmus glabra* (Wika *et al.* 2005), but it is positively distinguished by: *Acer platanoides* and *Aegopodium podagraria.* Actually, both variants from the Wodąca Valley correspond with interpretation of syntaxonomic units presented by Bodziarczyk (2002) – (upland race, form with *Tilia platyphyllos*), despite the Author mentioned used only 9 phytosociological relevés compiled by Wika (1989) in the synthetic table.

Results of our studies in transects provide additional (geomorphological) arguments for the conservation of *Phyllitis scolopendrium* in the Wodąca Valley (the Smoleń Range), which occurs at the edge of its range in Europe. The distinct separateness of the wall of the monadnock from its base was proved. Effective conservation of the *Phyllitis scolopendrium* localities requires that special attention is paid to the zone up to 1 m above the base of the wall of monadnock, where, on average, the highest number of fern clumps occurred. Simultaneously, values of this parameter were characterized by the largest range. This appears to indicate that clumps of the fern were influenced by factors which caused high variability of their abundance in that zone or that the above-mentioned factors acted with different intensity than in other parts of the transect. Therefore, the protection of B-zone by basal parts of the transect (C, D) can be of crucial significance for the effectiveness of the fern maintenance not only on a scale of a single monadnock or the Valley itself but the entire mesoregion.

Up to now, tourist routes in many sections were delimited as closely as possible to walls of the monadnock in order to increase their attractiveness to visitors. Taking into consideration results of our studies, the maintenance of *Phyllitis scolopendrium* should include an absolute ban of entrance to the 2-meter-wide zone surrounding monadnocks covered with that fern. Administrators of this area should not accept plans of tourist routes or tracks breaking this ban. The exception could include a few platforms used exclusively for didactic purposes. Monadnocks covered with hart's-tongue should only be used by tourists in restricted areas e.g. at easily accessible upper parts and/or platforms. The whole touristic-recreation traffic should be promoted and directed to other attractive rocks or their fragments not taken up by the *Phyllitis scolopendrium* or its valuable, Natura 2000' habitat – the *Phyllitido-Aceretum*.

Finally, we would like to deal with the question connected with a proposed stronger protection of *Phyllitis scolopendrium* in spite of significant increase of its population. This is because *Phyllitis scolopendrium* does not spread but only increases the density of population as shown by Bodziarczyk and Malik (2006). This kind of strategy makes it dependent on changes which can locally be very intensive and can be associated with improper use of space, e.g. touristic or other purposes which cause trampling, collecting or digging out the fern. Also planned forest management with deforestation of rocky outcrops or excessive light exposure in clear cuttings can cause damage in hart's-tongue resources.

5. Conclusions

As regards *Phyllitis scolopendrium* and its habitat in the Wodąca Valley (the central part of the Cracow-Częstochowa Upland), results of the studies from 2009 and their comparison with other data including 33 years made it possible to draw the following conclusions:

- The number of *Phyllitis scolopendrium* clumps in the population of the *Phyllitido-Aceretum* association in the Wodąca Valley increased.
- *Phyllitido-Aceretum* still maintains its specific features, but measurable changes can be noticed in all layers. Transformations refer to quantitative and quality parameters.
- Effective conservation of hart's-tongue needs controlled tourist management and restrictive treatment of natural resources. The ban of entrance should extend to 2 meters from the base of monadnocks covered with the *Phyllitis scolopendrium* clumps.
- High number of *Phyllitis scolopendrium* clumps should not restrict research, improvement of protection methods and monitoring, because of the edge character of hart's-tongue sites, Natura 2000 regulations and increasing pressure of tourism.

References

Bodziarczyk J. 2002. Zróżnicowanie zespołu jaworzyny górskiej z języcznikiem *Phyllitido-Aceretum* w Polsce. Fragm. Flor. Geobot. Polonica 9: 187-218.

Bodziarczyk J. & Malik R. 2006. Rozmieszczenie, warunki występowania i ocena liczebności populacji *Phyllitis scolopendrium* (*Aspleniaceae*) na Wyżynie Krakowsko-Częstochowskiej. Fragm. Flor. Geobot. Polonica 13(1): 155-170.

Braun-Blanquet J. 1964. Pflanzensoziologie, Grundzüge der Vegetationskunde. 3. Aufl. Springer-Verlag, Wien-New York.

Matuszkiewicz W. 2001. Przewodnik do oznaczania zbiorowisk roślinnych Polski. In: J. B. Faliński (ed.). Vademecum Geobotanicum 3, 537 pp. Wyd. Nauk. PWN, Warszawa.

Medwecka-Kornaś A. 1952. Zespoły leśne Jury Krakowskiej. Ochr. Przyr. 20: 133-236.

Mirek Z., Piękoś-Mirkowa H., Zając A. & Zając M. 2002. Flowering plants and pteridophytes of Poland. A checklist. In: Z. Mirek (ed.). Biodiversity of Poland, 1, 442 pp. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Ochyra R., Żarnowiec J. & Bednarek-Ochyra H. 2003. Census Catalogue of Polish Mosses. In: Z. Mirek (ed.). Biodiversity of Poland, 3, 372 pp. Polish Academy of Sciences, Institute of Botany, Kraków.

Stanisz A. 2007. Przystępny kurs statystyki z zastosowaniem Statistica PL na przykładach z medycyny. T. 3. Analizy wielowymiarowe. Wyd. StatSoft, Kraków.

Szczypek T. & Wika S. 1991. Osobliwości geomorfologiczno-botaniczne Zegarowych Skał i Biśnika. In: T. Szczypek & S. Wika (eds.). Kształtowanie środowiska geograficznego i ochrona przyrody na obszarach uprzemysłowionych i zurbanizowanych. UŚ Katowice-Sosnowiec 2: 47-52.

Wika S. 1986. Zagadnienia geobotaniczne środkowej części Wyżyny Krakowsko-Wieluńskiej. Prace Nauk. UŚ, 815, pp. 156. Katowice.

Wika S. 1989. Lasy liściaste środkowej części Wyżyny Krakowsko-Wieluńskiej. II. *Fagion silvaticae* i *Calamagrostio-Quercetum petraeae*. Bad. Fizjogr. Pol. Zach., seria B-Botanika 39: 37-86.

Wika S. & Szczypek T. 1982. O ochronę nowego stanowiska języcznika zwyczajnego *Phyllitis scolopendrium* w środkowej części Wyżyny Krakowsko-Wieluńskiej. Chrońmy Przyr. Ojcz. 38(4-5): 89-94.

Wika S. & Szczypek T. 1985. Ważniejsze osobliwości przyrodnicze uroczyska Smoleń koło Pilicy. Chrońmy Przyr. Ojcz. 41(4): 47-50.

Wika S., Szczypek T. & Barć A. 2005. Stanowiska jaworzyny górskiej *Phyllitido-Aceretum* Moor 1952 na obszarze środkowej części Wyżyny Krakowsko-Wieluńskiej – dynamika przemian i stan ich zagrożenia. Natura Silesiae Superioris 8: 55-69.

Wika S., Szczypek T. & Snytko V. A. 2000. Krajobrazy Doliny Wodącej na Wyżynie Krakowsko-Wieluńskiej. Prace Wydz. Nauk o Ziemi UŚ 4: 4-84.

Zając A. 1978. Atlas of distribution of vascular plants in Poland ATPOL. Taxon 27(5-6): 481-484.