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EFFECT OF ENVIRONMENTAL FACTORS ON THE STRUCTURE OF POPULATIONS OF PULSATILLA PATENS (L.) MILL.

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K e y w o r d s: *Pulsatilla patens*, N-E Poland, gradient of variability, redundancy analysis.

A b s t r a c t

Pulsatilla patens is a rare and endangered component of the European flora. In Poland, the principal area occupied by the species is in north-eastern part of the country. The study of the *Pulsatilla patens* populations was conducted in 2011–2012, in the 15 sites in the two Natura 2000 wildlife refuges: the Myszynickie Bory Sasankowe and the Military Training Grounds in Orzysz. The purposes of the study have been to analyze the structure of populations of *Pulsatilla patens* growing in two types of habitats: forest and non-forest ones; to analyze the influence of selected habitat-specific characteristics on the structure of Easter pasque flower populations; to work out a model which will explain the dependence of the structure of a population of *Pulsatilla patens* on environmental conditions. Most of the populations (10) grew at the forest sites. They were less numerous, with an average of 9 rosettes at mean in site, in total, comprised 89 rosettes of *P. patens*.

On the non-forest populations, in total 206 rosettes of *P. patens* were counted, the average number of rosettes in a population was about 41; the average number of flowering rosettes reached *ca* 16. On forest sites, flowering rosettes had on average 3 flowers, whereas on non-forest sites the analogous number was 5.5. In forest sites statistical analysis has shown the positive correlation between the number of fruiting rosettes and the shading in the shrub layer as well as the negative correlation between the number of fruiting rosettes and the share of space potentially suitable for germination. In non-forest habitats, the relationship between the number of fruiting rosettes and the shading in the herbaceous vegetation layer is worth noticing. The comparative analysis accomplished with U Mann-Whitney test on both population and habitat characteristics relative to the habitat as a variable (forest or non-forest) showed statically significant differences between the number of rosettes and shading in layer of trees. Ordinance RDA explains about 62.7% of the total population variability.

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WPŁYW CZYNNIKÓW SIEDLISKOWYCH NA STRUKTURĘ POPULACJI *PULSATILLA PATENS* (L.) MILL.

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Słowa kluczowe: sasanka otwarta, północno-wschodnia Polska, gradient zmienności, analiza redundancji.

Abstrakt

Pulsatilla patens to rzadki i zagrożony element flory europejskiej. W Polsce sasanka otwarta występuje najczęściej w północno-wschodniej części kraju. Badania prowadzono w latach 2011–2012 na 15 stanowiskach, na terenie dwóch obszarów Natura 2000 – w Myszynieckich Borach Sasankowych i na Poligonie Orzysz. Badania miały na celu: analizę struktury populacji *Pulsatilla patens* występujących na dwóch typach siedlisk – leśnych oraz nieleśnych, analizę wpływu wybranych czynników siedliskowych na strukturę populacji oraz opracowanie modelu wyjaśniającego zależność struktury populacji *Pulsatilla patens* od czynników siedliskowych. Większość populacji (10) występowała na stanowiskach leśnych, cechowała się niewielką liczbą osobników, średnio na 1 stanowisku odnotowano ok. 9 rozet, kwitnących – średnio 5, łącznie – 89 osobników sasanki. Zdecydowanie więcej osobników liczyły populacje na stanowiskach nieleśnych – rosło tam 206 rozet *Pulsatilla patens*, średnia liczba osobników w populacji wynosiła ok. 41, osobników kwitnących było średnio ok. 16. Na siedliskach leśnych osobniki kwitnące miały średnio po 3 kwiaty, natomiast na siedliskach nieleśnych – 5.5. W analizie korelacji wykazano, że na siedliskach leśnych wystąpiła dodatnia korelacja między liczbą osobników owocujących a ocienieniem w warstwie krzewiastej oraz korelacja ujemna między liczbą osobników owocujących a udziałem powierzchni potencjalnie dogodnej do kiełkowania. Na stanowiskach nieleśnych na uwagę zasługuje zależność między liczbą osobników owocujących a ocienieniem w warstwie roślin zielnych. Porównując testem U Manna-Whitneya wszystkie analizowane cechy zarówno populacji, jak i siedliska względem zmiennej stanowisko (leśne lub nieleśne), wykazano istotne statystycznie różnice między liczbą osobników oraz ocienieniem w warstwie drzew. Ordynacja RDA tłumaczy ok. 62,7% ogólnej zmienności populacji.

Introduction

Pulsatilla patens is a rare and endangered component of the European flora. It is a species listed in the in Bern Convention (*Convention on the conservation*... 1979) and in Annex II and IV of the European Habitats Directive (*Council Directive 92/43/EEC*... 2004). In Poland, it is protected by law and listed as a low risk (LR) taxon in the Red Data Book of Poland, (WÓJTOWICZ 2001) or as a species to be critically endangered in the Red List of Vascular Plants in Poland (ZARZYCKI, SZELĄG 2006).

Most stations *P. patens* (over 80%) are located in northern Poland (within the Podlaskie, Warmia and Mazury and Kuyavian-Pomeranian) (WOJTOWICZ 2004) must be underlined that the species is gradually disappearing in the

whole country – in central Poland both the number of sites and abundance of particular populations have decreased, while in the west and south this species has lost most of its habitats over the past ten years (CIOSEK 1999, NOWAK et al. 2000, CHMURA 2003, WÓJTOWICZ 2004, ZYCH 2007). Also in north-eastern Poland, there are fewer sites occupied by *Pulsatilla patens* (JUŚKIEWICZ--SWACZYNA 2010a, ŁASKA and SIENKIEWICZ 2010). A similar tendency towards disappearance of sites and drastic decrease in the size of existing populations has been observed in other European countries (RÖDER and KIEHL 2006, UOTILA 1996, KALLIOVIRTA et al. 2003). For example, in central Germany the number of *Pulsatilla patens* rosettes has declined by 60% in the last 12 years (RÖDER and KIEHL 2006). The reasons why populations of the *Pulsatilla patens* are threatened include low competitiveness against other undergrowth plant species, lack of natural disturbances (fires, windblows) in forest ecosystems (UOTILA 1996, KALLIOVIRTA et al. 2006), destruction of flowers and fruit--bearing shoots by animals, hybridization with other species belonging to the genus *Pulsatilla* (UOTILA 1996), reduced seed production due to locally decreasing numbers of pollinating insects (ZYCH 2007), and unfavourable weather conditions such as long and freezing cold winters (CHMURA 2003). According to the life cycle stages, KALLIOVIRTA et al. (2003) distinguished three types of *Pulsatilla patens* populations:

i) increasing, in which relatively many rosettes were in the two smallest size classes, the proportion of seedlings were high and the proportions of generative plants averaged 10%;

ii) stable, in which the proportion of the rosettes in various life-cycle stages remained almost unchanged;

iii) decreasing, in which vegetative adults accounted for the vast majority (96 %) of all rosettes and seedlings were usually completely absent.

In Poland, *Pulsatilla patens* was covered by a nature monitoring project run in 2010–2011. Studies carried out at 34 locations then showed that the principal area occupied by the species is in north-eastern Poland (PAWLIKOWSKI 2012). Considering the continual tendency for populations of *Pulsatilla patens* to grow less abundantly, it is essential to conduct comprehensive research on the biology and ecology of this species, which will contribute to possible development and implementation of effective protection methods.

The study presented in this paper was performed in order to gain better understanding of the ecology of populations of *Pulsatilla patens* in north--eastern Poland, where the species is most common. Two nature reserves called the Myszynieckie Bory Sasankowe and the Military Training Grounds in Orzysz, where Easter pasque flower grows relatively numerously, belong to the Nature 2000 network. This means that we should be to protect both the species and its habitats, because in Poland, populations of *P. patens* are disappearing

from many sites (CIOSEK 1999, CHMURA 2003, WÓJTOWICZ 2004). The purposes of the study have been:

1. to analyze the structure of populations of *Pulsatilla patens* growing in two types of habitats: forest and non-forest ones;
2. to analyze the influence of selected habitat-specific characteristics on the structure of *Pulsatilla patens* populations;
3. to work out a model which will explain the dependence of the structure of a population of *Pulsatilla patens* on environmental conditions.

Material and Methods

Study species

Pulsatilla patens has a circumpolar distribution (HULTÉN and Fries 1986). In Europe, it occurs in the central and central-eastern parts (*Atlas florae europaeae*... 1989). In Poland, *P. patens* appears in boreal forests *Vaccinio-Piceetea* (MATUSZKIEWICZ 2001), xerothermic and psammophilous grasslands (CEYNOWA 1968, CIOSEK 1999, JUŚKIEWICZ-SWACZYNA 2010b), dry heath (JUŚKIEWICZ-SWACZYNA 2010b). In other regions of Europe, this species exists in calcareous grasslands in Germany (RÖDER and KIEHL 2006); open, dry and pine-dominated forests in Finland, mainly on eskers and adjacent sandy areas, pastures, off paths and roads, and at the edges of yard areas (UOTILA 1996, KALLIOVIRTA et al. 2006); in steppe and wood communities in Russia (RYSINA 1981); and in pine-dominated boreal heath forests of the *Cladonia* or *Calluna* site type and in dry boreal forests of the *Vaccinium vitis-idaea* site type, occasionally also in more humid *Vaccinium myrtillus* site type habitats in Estonia (PILT and KUKK 2002).

The *Pulsatilla patens* is a hemicryptophyte and blooms from March to early May. The number of flowers produced by one individual is varied, e.g. from 1 to 12 in north-eastern Poland (JUŚKIEWICZ-SWACZYNA 2010b) up to 50 in Finnish populations (KALLIOVIRTA et al. 2006). Leaves do not develop until the end of flowering and remain on plants until autumn; fruits ripen from April to June (WÓJTOWICZ 2000, 2004).

According to KALAMEES et al. (2005), important factors that affect germination and seedling establishment of *Pulsatilla patens* are cyclic, natural, or controlled wood fires, which change light intensity conditions and destroy moss and litter layers. The seeds are dispersed by wind in June and July over short distances. In good conditions (warm and moist weather) germination occurs in late summer, but if the weather is cold and dry, it is delayed until the next spring, or seeds may remain in the transient seed bank (PILT and KUKK 2002). Effective germination takes place only in the gaps in the vegetation

cover, where other plants circuit is negligible (PILT and KUKK 2002, WÓJTOWICZ 2004, KALLIOVIRTA et al. 2006, RÖDER and KIEHL 2006, JUŚKIEWICZ-SWACZYNA 2010b, JUŚKIEWICZ-SWACZYNA and CHOSZCZ 2012). Intensity of flowering and fruit production is affected by climatic conditions, e.g. snow cover, winter temperature or insolation. Mild winters with warmer periods act adversely, but abundance of *P. patens* populations may increase in years when the continental climate prevails (UOTILA 1996, WÓJTOWICZ 2004).

Study area

The study of the *Pulsatilla patens* populations was conducted in 2011–2012, in the Natura 2000 wildlife refuges: the Myszynickie Bory Sasankowe (PLH140049) and the Military Training Grounds in Orzysz (PLB280014) – Figure 1. The Myszynieckie Bory Sasankowe lies in the mesoregion called Kurpiowska Plain, which belongs to the macroregion of Northern Masovian Lowland. The refuge lies in the southern part of the masurian sandur. The landscape consists of glacial lakes, sandy dunes, moraine hills composed of loams and gravel, and waterlogged terraces. The area called the Military Training Grounds in Orzysz lies in the mesoregion of the Great Masurian Lakes, which belongs to the macroregion named the Masurian Lake District. The landscape consists of sandy plains and moraine hills. This vast and open area is overgrown with well-developed xeric sand calcareous grassland and dry heaths. The northern part of the area is overgrown by pine forest (KONDRACKI 2001).

Fig. 1. Location of the research sites in the Natura 2000 wildlife refuges in NE Poland: *1* – Military Training Grounds in Orzysz, *2* – Myszynieckie Bory Sasankowe

North-eastern Poland lies within the climatic region of Mazury and Podlasie, which encompasses the eastern part of the Masurian Lakes and Podlasie (WOŚ 1996). The weather is characterized by strong affinity to the continental climate with its typical duration of seasons, such as long and freezing winter (110 days), long summer (90 days), but shorter spring and autumn. The snow cover remains here for a long time (85–96 days) and can be up to 10 cm thick. The average annual temperature is low (7°C) and the growing season is short, lasting about 200 days (GÓRNIAK 2000).

Data collection and treatment

The research sites were identified according to the authors' knowledge and documentation of the location of *P. patens* sites supplied by the Forest District Office in Myszyniec. The 15 sites were divided into two groups: forest habitats in boreal forests *Peucedano-Pinetum* and non-forest ones located in open areas, such as dry heath and roadsides. Because of the phenology of the species (KALLIOVIRTA et al. 2003, PAWLIKOWSKI 2011), field observations were carried out twice: during the inflorescence stage (in April) and in the summer (in July). For determination of the number of rosettes in a population, a rosette was considered as a unit (a specimen) (PAWLIKOWSKI 2011), while leaf rosettes closer than 10 cm from each other were assuemd to belong to the same individual (KALLIOVIRTA et al. 2006). In order to assess the condition of a population, the following indicators were determined: total number of rosettes, number of flowering rosettes, number of fruiting rosettes. The following habitat-specific characteristics which could potentially have considerable influence on populations of *Pulsatilla patens* were evaluated: shading (assessed separately percentage for layers – *a* – layer of trees, *b* – layer of shrubs and *c* – layer of understory), average height of understory in the summer season within the area covered by *P. patens*, share of expansive herbaceous plants and cover of bare soil area available for germination accordance with the methodology PAWLIKOWSKI 2011.

Spearman's rank correlations at a significance level of $\alpha = 0.05$ were applied for testing statistical significance of relationships between characteristics of the populations and parameters of the habitats. Comparisons of populations growing in forest and non-forest habitats were completed with U Manna-Whitney's test. All statistical analyses were performed using STATISTICA 10.

A preliminary detrended correspondence analysis (DCA) revealed a first gradient length of 0.16 SD, inferring that models based on linear species response models were appropriate for the data structure (TER BRAAK and SMILAUER 1998, LEPŠ and ŠMILAUER 2007).

The data on the environment and morphometryof *Pulsatilla patens* was explored using redundancy analyses (RDA) (VAN DEN WOLLENBERG 1977), a constrained form of principal components analysis (HOTELLING 1933) in CANOCO (TER BRAAK and ŠMILAUER 2002).

Statistical significance tests were carried out using Monte Carlo permutation tests. The Monte Carlo test was used to test the significance of the axis eigenvalues generated in the analysis and species-environmental correlation (using 5 000 unrestricted iterations).

Results

In the Natura 2000 network wildlife refuge called the Myszynieckie Bory Sasankowe, populations of *Pulsatilla patens* grew mainly at 10 forest sites, with just 2 populations located in open area: on a sandy bank of a road and on a roadside. The total number of Easter pasque flower specimens was 133. In the other refuge, named the Military Training Grounds, studies comprised 5 populations growing in non-forest habitats: 3 on dry heath and 2 near forest roads; the total number of rosettes was 162.

The forest populations were less numerous. They consisted of 10 sites, with an average of 9 rosettes at a single site. In total, the 10 sites comprised 89 rosettes of *P. patens*. Two populations had only vegetative rosettes and the other 8 populations presented on average 5 flowering specimens. The number of fruiting rosettes was small, no more than 6. Much better results were obtained from observations on the non-forest populations, where in total

Table 1

Pulsatilla patens – population and environmental characteristics

Characteristic	Forest sites $n=5$			Non-forest sites $n=10$		
	min.	max.	X ± SD	min.	max.	X± SD
Total number of rosettes	4	28	8.9 ± 7.42	8	145	41.2 ± 58.69
Number of flowering rosettes per population	0	9	4.8 ± 2.78	0	38	15.8 ± 16.24
Number of flowers per population	0	38	14.6 ± 10.58	0	221	87.6 ± 103.82
Number of fruiting rosettes per population	0	6	1.9 ± 1.85	0	41	14.2 ± 18.78
Shading in layer of trees [%]	20	70	45.0 ± 21.60	0	5	1.0 ± 2.24
Shading in layer of shrubs [%]	0	60	20.5 ± 20.88	0	25	9.4 ± 12.10
Shading in layer of understory [%]	20	95	52.5 ± 26.69	10	90	42.0 ± 39.62
Height of understory [cm]	20	45	30.0 ± 10.00	25	40	30.0 ± 6.12
Share of expansive herbaceous species [%]	0	80	18.0 ± 28.69	5	25	14.0 ± 8.94
Place for germination [%]	2	40	11.4 ± 15.12	5	30	15.0 ± 10.00

206 rosettes of *P. patens* were counted. The average number of rosettes in a population was about 41; the average number of flowering rosettes reached *ca* 16. On forest sites, flowering rosettes had on average 4,8 flowers, whereas on non-forest sites the analogous number was 15.8 (Table 1).

Correlation analysis has shown numerous statistically significant relationships present in forest habitats (Table 2). Noteworthy is the positive correlation between the number of fruiting rosettes and the shading in the shrub layer as well as the negative correlation between the number of fruiting rosettes and the share of space potentially suitable for germination. In non-forest habitats, the relationship between the number of fruiting rosettes and the shading in the herbaceous vegetation layer is worth noticing (Table 3).

Table 2

Spearman correlation coefficients (r_s) of the characteristics of the *Pulsatilla patens* populations and environmental characteristics in forest sites ($p \leq 0.05$)

Characteristic	r_s
Total number of rosettes – number of flowering rosettes	0.72
Total number of rosettes – number of fruiting rosettes	0.84
Number of flowering rosettes – number of fruiting rosettes	0.74
Number of flowering rosettes – number of flowers	0.65
Number of fruiting rosettes – shading in layer of shrubs	0.67
Number of fruiting rosettes – place for germination	-0.74
Shading in layer of shrubs – place for germination	-0.65
Shading in layer of understory – share of expansive herbaceous species	0.74

Table 3

Spearman correlation coefficients (r_s) of the characteristics of the *Pulsatilla patens* populations and environmental characteristics in non-forest sites ($p \leq 0.05$)

Characteristic	r_s
Total number of rosettes – number of flowers	0.90
Number of flowering rosettes – number of flowers	0.90
Number of fruiting rosettes – shading in layer of understory	0.89

The comparative analysis accomplished with U Mann-Whitney test on both population and habitat characteristics relative to the habitat as a variable (forest or non-forest) showed statically significant differences between the number of rosettes ($p=0.004$) and shading in layer of trees ($p= 0.003$).

In order to determine the effect of all the analyzed habitat-specific factors on the structure of the *Pulsatilla patens* populations, RDA ordinance was applied (Figure 2). It explains about 62.7% of the total population variability.

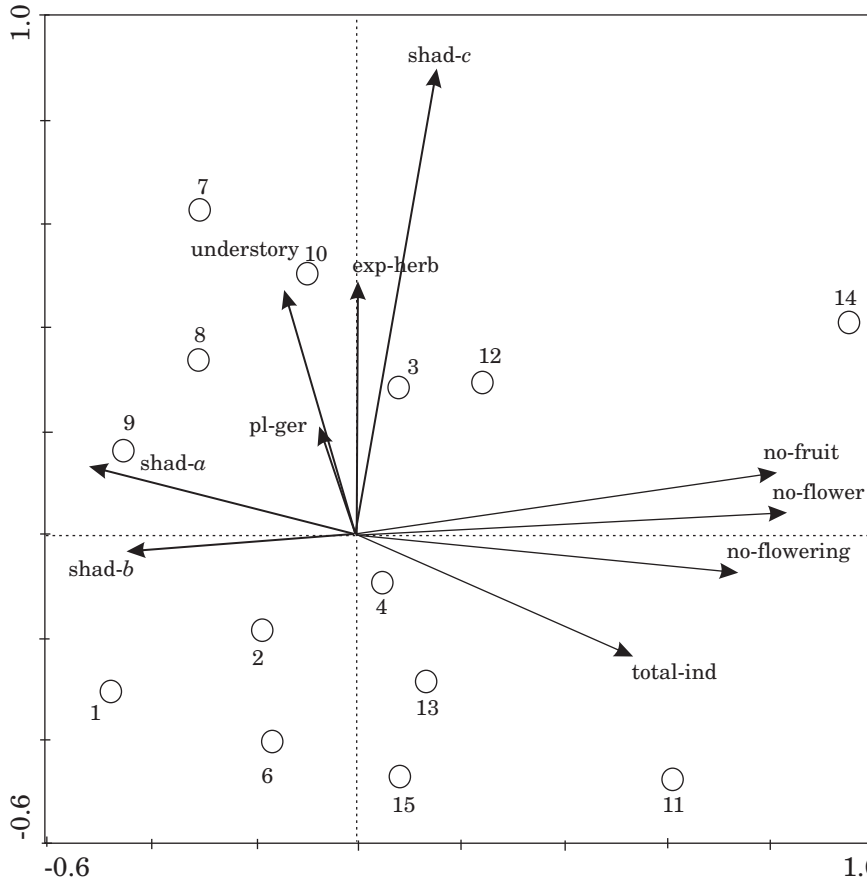

Fig. 2. RDA diagram of variability of the *Pulsatilla patens* populations: total-ind – total number of rosettes; no-flowering – number of flowering rosettes; no-flower – number of flowers; no-fruit – number of fruiting rosettes; shad-*a,b,c* – shading in layer of trees, shrubs, understory; understory – height of understory; exp-herb – share of expansive herbaceous species; pl-ger – place for germination

The first axis explains 97.7% of the total variability and the second one – 2.2%. The results of the significance test for the first canonical axis showed the presence of a gradient which caused variation of the analyzed *P. patens* populations. Correlations with the first and second axis are presented in Table 4. The parameter that proved to be statistically significant (Monte Carlo permutation test $p=0.05$) was the available germination space ($\lambda=0.18$; $p=0.05$; $F=3.85$), which explained 28.7% of the total variability of the analyzed populations. The RDA diagram (Figure 2) shows the variations between sites versus the gradient of habitat-related factors. Group A comprised typical forest habitats, in which Easter pasque flower grew in pine forests. Group B en-

compassed typical non-forest sites (1, 2, 13, 14, 15) as well as the sites located in a forest but near forest roads and stand boundaries (3 ,4, 6) or on slopes on the edge of a forest (11, 12).

Table 4

Correlations of environmental parameters with the first and second axis

Characteristics	AX1	AX2
Shading in layer of trees	-0.4283	0.0481
Shading in layer of shrubs	-0.3723	-0.0122
Shading in layer of understory	0.1266	0.3354
Height of understory	-0.1166	0.1756
Place for germination	-0.0595	0.0797
Share of expansive herbaceous species	0.0049	0.1837

Discussion

The paper presents results of a study on 15 populations of *Pulsatilla patens*. This is a relatively large number of sites, which proves that the two analyzed wildlife refuges, both in the Natura 2000 network, are the principal area in Poland where this species occurs. The monitoring studies covering 34 sites and completed in 2010–2011 showed that most of *P. patens* sites are located in broadly understood north-eastern Poland. The number of Easter pasque flowers at particular sites in Poland ranges from 1 to 939, with most of the populations being very small, holding fewer than 5 rosettes (PAWLIKOWSKI 2012). In the light of these results, the populations presented herein seem quite large since 73% of them contained over 5 rosettes (from 6 to 30). One site, growing on dry heat in the Military Training Grounds in Orzysz, was exceptionally big, consisting of over 100 rosettes of *P. patens*. However, the Polish resources of *P. patens* populations compared with relevant data from the literature are small. For example, the smallest sites studied in Estonia comprise 10 rosettes and the largest ones have up to 10 000 specimens (PILT and KUKK 2002). In Finland, populations are composed of 400 rosettes on average (KALLIOVIRTA et al. 2006).

Pulsatilla patens begin to bloom when they are a few years old (WÓJTOWICZ 2000, UOTILA 2007), so these populations might be composed of very young plants, which have not produced flowers yet. According to KALLIOVIRTA et al. (2003), it is difficult to determine whether a given plant is a juvenile, adult or senile one without analyzing its root system.

Because *P. patens* multiplies mainly generatively, the future of a given population depends on generative rosettes. The share of this fraction

in *P. patens* populations is highly varied. KALLIOVIRTA et al. (2006), who described this species in Finland, report an average 11% of generative rosettes in a population. On Sodowa Mountain in Silesia (south Poland) the share of generative rosettes in the populations was from 3 to 97% (CHMURA 2003). In north-eastern Poland, between 26 to 100% of flowering rosettes were counted (average 44%) in the populations growing in the Myszynieckie Bory Sasankowe and in the Military Training Grounds in Orzysz, of which between 0 to 100% produced fruit (average 21%) (JUŚKIEWICZ-SWACZYNA and CHOSZCZ 2012). Unfortunately, the data on nmber of fruiting rosettes cannot be compared with other populations as such information in lacking in world literature. There is just one mention concerning *P. patens* in Finland, where 62% of flowers were found to produce seeds (KALLIOVIRTA et al. 2006). It seems recommendable to conduct more detailed studies on this speciesthat will not only deal with shares of rosettes in different life stages but also try to determine the role of fruiting rosettes, including their number and the number of seeds. Our comparison of such results indicates that the Polish populations of *Pulsatilla patens* have a large biological potential, while the observed decrease in the number of sites and number of rosettes (CIOSEK 1999, CHMURA 2003, WÓJTOWICZ 2004) may be caused by unfavourable habitat conditions.

At this point, one need to underline that there is dependence between the intensity of flowering and fruiting of *Pulsatilla patens* and climatic conditions, generally mild winters with periods of warming adversely affects the intensity of flowering and fruiting (UOTILA 1996, WÓJTOWICZ 2000). Similar relationships have been described for other species from the family *Ranunculaceae*, e.g. *Delphinium nuttallianum*, where flower production and abundance of flowering plants vary between years and that this variation can be related to the inter-annual variation in the weather conditions (SAAVEDRA et al. 2003). It is therefore essential to conduct steady and long-term studies, which will help to elucidate the role of climatic conditions in the dynamics of fluctuations of *P. patens* population abundance.

Numerous investigations suggest that the structure of *Pulsatilla patens* populations depends on such factors as thick moss layer, most frequently occurring juvenile specimens observed in sites having an average thickness of compactness and moss (UOTILA 1969, KALLIOVIRTA et al. 2006), cover of: phanerogams, cryptogams, litter and bare soil (KALLIOVIRTA et al. 2003, KALLIOVIRTA et al. 2006, RÖDER and KIEHL 2006, JUŚKIEWICZ-SWACZYNA 2010b, JUŚKIEWICZ-SWACZYNA and CHOSZCZ 2012). The present results confirm that the cover of bare soil as a condition for successful seed germination is likewise important – a relationship has been demonstrated between this habitat-specific parameter and the number of fruiting rosettes. The available germination space is a component which, in a statistically significant manner, affects

the variability of populations, a claim verified by the RDA ordination diagram (cf. Figure 2).

Another interesting aspect is the dependence of *Pulsatilla patens* occurrence on light conditions. Studies accomplished in Estonia (PILT and KUKK 2002) a relationship between the number of rosettes in a population and light availability, according to which habitats are divided into open, half-open or closed. Extremely large populations (up to 10 000 rosettes) have been found in half open/open locations with good light availability. On the other hand, KALAMEES et al. (2005) showed that the decrease in germination success with successional age is attributable to some environmental factor other than decreasing light availability. Our study suggests that sunlight conditions have strong influence on populations of *Pulsatilla patens* because populations growing in non-forest habitats were more numerous, contained more flowering and fruiting rosettes and the number of flowers produced by a single plant was also higher (cf. Table 1).

The objective of this study has been to determine the effect of habitat-related conditions on the analyzed Easter pasque flower populations. The role of shading, height of understory, share of expansive plants and cover of bare soil available for germination have been examined. Based on the results, it should be concluded that the above set of factors largely explains (about 63%) the variation of the analyzed populations.

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