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RESPONSE OF *POLYGONATUM MULTIFLORUM* AND *P. ODORATUM* MORPHOLOGICAL CHARACTERISTICS AND POPULATION STRUCTURE TO VARIATION IN ENVIRONMENTAL FACTORS

Birutė Karpavičienė*, Giedrė Elzbieta Mlečkaitė

Nature Research Centre, Institute of Botany, Žaliųjų Ežerų Str. 49, Vilnius LT-08406, Lithuania
*Corresponding author. E-mail: birute.karpaviciene@gamtc.lt

Abstract

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The morphological variation and population structure were studied in seven populations of *Polygonatum multiflorum* and 19 populations of *P. odoratum*. The mean number of flowers per shoot and per inflorescence as well as inflorescence number per shoot in both species correlated negatively with total tree and shrub canopy cover, while the mean number of flowers per inflorescence in *P. odoratum* correlated positively with the soil pH. The shoot density and life stage composition in *P. odoratum* populations depended on total tree and shrub canopy cover, which negatively correlated with the density of generative shoots in populations of both species. The results of this study revealed the crucial effect of light availability expressed via total tree and shrub canopy cover in the habitats of *Polygonatum* species to their flowering intensity and population structure.

Keywords: ecological factor, flowering intensity, life stage, ramet density.

INTRODUCTION

The distribution of species depends on dispersal between habitat patches and stochastic extinctions as well as the environmental sorting (Dupré & Ehrlén, 2002). Whereas species density within habitat patches is determined by the life histories of the species, especially by their capacity for extensive clonal reproduction (Kolb et al., 2006). The population abundance of many clonal species is characterized by slow dynamics, which result from the longevity of these plants (Kosiński, 2013). Studies using spatial variation have identified relationships between vital rates and abiotic environmental factors, including availability of light (Ehrlén et al., 2006), which is one of the most relevant environmental variables by influencing species abundance in the understory vegetation (Tinya et al., 2009). In deciduous forests, the presence of overstory trees and shrubs creates a shifting mosaic of resources for understory plants, with implications for their distribution and abundance (Cole & Weltzin, 2005). Other factors such as variation in the substrate, clonal growth, and the history of a given patch are also important (Atwell et al., 1999).

Polygonatum Miller (Asparagaceae) is a rhizomatous terrestrial or rarely epiphytic herb of forest habitats predominantly in temperate areas (Jeffrey, 1980). In Lithuania, *Polygonatum* is represented by three species, namely *P. multiflorum* (L.) All., *P. odoratum* (Miller) Druce and *P. verticillatum* (L.) All. The latter species occurs only in the western part of Lithuania, while other two species can be found in all parts of the country. The populations of such clonal plants may be studied at two different levels: genets or ramets (Eriksson, 1989). However, the genet identification of clonal plants is complicated even after excavation of study plants, because of clone fragmentation.

The aim of this study was to investigate the effect of some environmental factors on variation in morphological characteristics and population life stage structure of *Polygonatum multiflorum* and *P. odoratum*.

MATERIALS AND METHODS

Study species

Polygonatum multiflorum and *P. odoratum* are the perennial rhizomatous geophytes with arching stems and alternate, sessile or shortly petiolate leaves. Inflorescences of both species are axillary peduncles with 2–6 flowers in *P. multiflorum* and 1–2(4) in *P. odoratum*. Flowering occurs sequentially from the bottom to the top of the shoot (Guitián et al., 2001; Kosiński, 2012). The fruit of *P. multiflorum* is a bluish-black berry containing 1–12 seeds (Kosiński, 2012), and *P. odoratum* produces black berries of about 1 cm in diameter, containing 7–9 seeds (Guitián et al., 2004). In both species, the first winter after sowing is followed by cryptic germination leading to the production of the embryonic radicle with the hypocotyl, and in the subsequent year, the cotyledon emerges above the ground surface (Takagi, 2001; Kosiński, 2015). Individuals of *P. multiflorum* may reach generative maturity most often in the tenth year of development (Kosiński, 2015).

In Lithuania, *P. multiflorum* occurs mainly in deciduous or mixed forests, while *P. odoratum* prefers dry, mostly pine forests (Ribokaitė, 1963). *P. multiflorum* is attributed to ancient forest species (Hermy et al., 1999). Such species are characterized by a limited colonization capacity due to limited dispersal, either by seed or vegetative propagation, or hampered seedling establishment (Bossuyt et al., 1999).

Study sites and habitats

We studied seven populations of *P. multiflorum* and 19 populations of *P. odoratum* in 2014 (Table 1). Braun-Blanquet (1964) approach was used to describe plant communities in the plots of 100 m^2 in size. The percent of total plant cover was estimated visually for each vegetation layer as well as for all tree and shrub layers together. The soil samples were collected from below the litter layer in each habitat for soil characterization. The soil texture was estimated by feel. The available phosphorus (P_2O_5) content was determined using the Egner-Riehm-Domingo (A-L)

Table 1. Sampling location of *Polygonatum multiflorum* (M) and *P. odoratum* (O)

No.	Location	Species
1	Baniškės, edge of pine forest, 54°45'09" N 25°23'29" E	O
2	Miškonys, edge of mixed forest, 54°48'12" N, 25°24'29" E	O
3	Kreivalaužiai, mixed forest, 54°50'12" N, 25°27'41" E	O
4	Pirčiupiai, edge of pine forest, 54°23'16" N, 24°57'31" E	O
5	Kryžiokai, fir forest, 54°47'19" N, 25°20'15" E	M, O
6	Kryžiokai, mixed forest, 54°47'02" N, 25°19'54" E	M
7	Verkiai, fir forest, 54°45'50" N, 25°18'35" E	O
8	Paneriai, edge of pine forest, 54°37'45" N, 25°09'47" E	O
9	Panoviai, broadleaf forest, 54°53'55" N, 22°52'22" E	M
10	Sintautai, broadleaf forest, 54°52'30" N, 22°58'47" E	M
11	Barandai, broadleaf forest, 54°53'06" N, 22°56'18" E	M
12	Duburiai, edge of mixed forest, 55°16'09" N, 24°48'59" E	O
13	Svistūnai, pine forest, 54°53'05" N, 24°49'07" E	O
14	Narkuškiai, broadleaf forest, 55°05'51" N, 25°18'23" E	M
15	Bartkuškis, broadleaf forest, 54°55'13" N, 24°58'34" E	O
16	Draučiai, pine forest, 54°53'28" N, 24°54'24" E	O
17	Paežerėlis, mixed conifer forest, 54°54'03" N, 24°53'22" E	O
20	Kernavė, pine forest, 54°53'13" N, 24°49'45" E	O
21	Kaniūkai, pine forest, 54°17'02" N, 25°13'38" E	O
22	Kamša, broadleaf forest, 54°54'12" N, 23°48'25" E	M
23	Kryžiokai, fir forest, 54°47'15" N, 25°20'15" E	O
26	Fabijoniškės, pine forest, 54°44'00" N, 25°15'23" E	O
27	Fabijoniškės, pine forest, 54°43'58" N, 25°15'19" E	O
29	Dvarčionys, mixed conifer forest, 54°43'57" N, 25°23'09" E	O
30	Dvarčionys, mixed conifer forest, 54°43'57" N, 25°22'51" E	O

method, the pH was potentiometrically measured in a 1 M KCl suspension (ISO 10390), and the content of organic carbon was determined after dry combustion (ISO 10694:1995).

Plant morphology

The morphology was studied in seven populations of *Polygonatum multiflorum* and 13 populations of *P. odoratum*. Six populations of *P. odoratum* were not included in this study due to absence or low number of flowering shoots. Ten flowering shoots were collected from each population using line-intercept transects. Fourteen quantitative and two ratio morphological characteristics were used to assess the range of phenotypical variation among the species/populations (Table 2).

Table 2. Characteristics used in the morphometric analysis of *Polygonatum* species

Acronym	Definition of the characteristics
PH	Height of the shoot (cm)
SH	Height of stem from ground to the first leaf (cm)
LH	Length of the leafy part of the shoot
SD	Diameter of stem at ground level (mm)
LN	Number of leaves per shoot
MDL	Mean distance between leaves
LL	Length of the lowest leaf (cm)
MLL	Length of leaf taken from the middle of the stem (cm)
LW	Width of the lowest leaf (cm)
MLW	Width of leaf taken from the middle of the stem (cm)
LR	Lowest leaf ratio (LL/LW)
MLR	Middle leaf ratio (MLL/MLW)
FLN	Sequential number of leaf to which axil the lowest flower was attached
IN	Number of inflorescences per shoot
FN	Number of flowers per shoot
IFN	Number of flowers per inflorescence

Population structure

Based on field observations, we distinguished three life stages of *Polygonatum* shoots (ramets), namely juvenile (shoot with one leaf), vegetative (shoot with more than one leaf, but without reproductive organs) and generative (shoot with reproductive organs). The structure of each population was studied using the belt transects laid from the densest *Polygonatum* stands to the periphery. Each transect was 1 m wide and 10 m long, divided into ten plots of 1 m^2 in size. In each plot, the number of shoots was counted at each of the three life stages of *Polygonatum*, and the mean densities and relative proportions of life stages were estimated. The relative frequency (number of quadrats in which species occurs, expressed as a percentage of the total number of quadrats examined) and density (number of shoots in m^{-2}) were calculated for each population.

Data analysis

The nonparametric Mann-Whitney U test was used to analyse the difference between species for soil chemical properties and cover of different vegetation layers in the habitats as well as population characteristics, while the t-test was used to analyse the difference between species morphological characteristics. The Kruskal-Wallis test was used for differences of characteristics among populations. The Wilcoxon matched pairs test was used to analyse the difference between the lowest and middle leaf characteristics. The relationship between morphological as well as population characteristics and the environmental variables was analysed using Spearman's rank correlation. The Principal component analysis (PCA) based on averaged, log-transformed and standardized characteristics of populations were performed for each species to estimate the morphological variation by taking into account the environmental factors as supplementary variables. All statistical analysis was conducted using the Statistica 10.0 software.

RESULTS

Habitat conditions

Polygonatum multiflorum occurred mostly in broadleaf or mixed forests of the class *Querco-fagetea* (66.7% of all populations) and more rarely (33.3%) in the conifer forests of the class *Vaccinio-piceetea*, while *P. odoratum* occurred more often in pine, fir or mixed conifer forests of the class *Vaccinio-piceetea* (52.6%), less often was found in mixed or broadleaf forests (31.5%) and rarely (26.3%) at open sites along forest-meadow ecotones. *P. multiflorum* occurred in the forests with denser total tree and shrub layer and sparser moss layer than *P. odoratum* (Table 3). *P. odoratum* was found more often on sandy soils: sand and sandy loam (94.7% of all populations) and never on heavy loam, while *P. multiflorum* was found on sand (42.9%), sandy loam (28.6%) or loam (28.6%). The chemical composition of soils varied in wide range and did not differ between species, with exception of humus content (Table 3).

Morphology

The studied *Polygonatum* species differed in all morphological characteristics (Table 4). Only stem diameter, mean distance between leaves and ratio of the lowest leaf were higher for *P. odoratum*, while all other characteristics were higher in *P. multiflorum.* The size of leaves in both species depended on their position and the lowest leaf was significantly longer than middle leaf (Z = 9.78 and 6.10, for *P. odoratum* and *P. multiflorum*, respectively, $p < 0.001$) and wider for *P. multiflorum* (t = 4.78, $p < 0.001$), while width of the lowest and middle leaves did not differ for *P. odoratum* (Z = 1.91, $p = 0.056$). Consequently, the ratio of the lowest leaf of *P. odoratum* was significantly higher than the ratio of middle leaf (Z = 9.49, $p < 0.001$).

The results of the Kruskal-Wallis test showed significant differences in all morphological characteristics between populations of *Polygonatum multiflorum* except for the middle leaf ratio only. The PCA reduced 16 morphological characteristics of this species to two principal components, which explained

Table 3. Soil chemical properties and cover of different vegetation layers in the habitats of *Polygonatum multiflorum* (seven populations) and *P. odoratum* (19 populations) as well as *p*-value of the Mann-Whitney U test for differences of characteristics between species

Character	P. multiflorum		P. odoratum		*p*-value
	M ± SD	Min–max	M ± SD	Min–max	
P_2O_5, mg kg^{-1}	21.2 ± 13.5	8.0–45.0	28.2 ± 21.3	8.8–103.4	0.326
Humus, %	7.1 ± 3.7	2.7–13.7	4.2 ± 3.6	1.1–17.1	**0.026**
pH	6.06 ± 1.40	4.16–7.39	5.61 ±1.26	3.66–7.45	0.686
Tree cover, %	55.7 ± 23.7	20–80	37.4 ± 24.7	0–90	0.106
Shrub cover, %	44.3 ± 31.0	10–80	25.8 ± 20.4	0–80	0.203
Total tree and shrub cover, %	81.4 ± 12.1	60–90	49.5 ± 26.6	10–90	**0.008**
Herb cover, %	40.0 ± 26.5	10–80	33.2 ± 18.6	10–70	0.665
Moss cover, %	2.9 ± 4.9	0–10	31.3 ± 31.1	0–90	**0.018**

Significant difference ($p < 0.05$) is given in bold.

Table 4. Descriptive statistics of morphological characteristics of *Polygonatum multiflorum* (N = 70) and *P. odoratum* (N = 130), results of the t-test for differences between species. An explanation of the character acronyms is given in Table 2

Character	*P. multiflorum*		*P. odoratum*		t	*p*
	M ± SD	Min–max	M ± SD	Min–max		
PH	44.1 ± 14.3	22.9–83.0	36.2 ± 9.7	19.0–70.6	4.62	0.000
SH	18.4 ± 5.3	10.3–33.6	16.8 ± 5.4	2.0–34.9	3.20	0.000
LH	25.7 ± 10.3	10.2–54.6	19.4 ± 6.3	9.2–42.0	5.37	0.000
SD	3.2 ± 1.0	1.9–5.5	3.9 ± 1.0	2.0–6.9	–4.53	0.000
LN	13.2 ± 3.3	8–23	9.3 ± 2.0	6–16	10.37	0.000
MDL	1.9 ± 0.3	1.3–2.9	2.1 ± 0.4	1.1–3.6	–2.65	0.009
LL	12.2 ± 1.7	9.0–15.4	10.8 ± 2.1	5.8–18.4	4.73	0.000
MLL	11.2 ± 1.3	7.8–14.0	9.2 ± 1.7	5.2–13.8	8.64	0.000
LW	3.6 ± 0.7	2.2–5.4	3.1 ± 0.9	1.5–5.9	4.77	0.000
MLW	3.4 ± 0.6	2.1–5.0	3.1 ± 0.7	1.7–5.3	2.71	0.007
LR	3.4 ± 0.6	2.5–4.8	3.7 ± 0.8	2.1–6.4	–2.35	0.020
MLR	3.4 ± 0.5	2.3–5.1	3.0 ± 0.5	2.0–4.8	4.84	0.000
FLN	4.0 ± 0.9	3–8	2.9 ± 0.6	2–5	9.56	0.000
IN	5.8 ± 4.0	1–15	4.5 ± 2.1	1–9	3.16	0.002
FN	12.8 ± 12.3	1–51	5.5 ± 3.8	1–16	6.22	0.000
IFN	1.9 ± 0.5	1.0–3.4	1.2 ± 0.3	1.0–2.1	13.40	0.000

87.81% of the total variance. The shoot height correlated with most characters and had the strongest negative correlation with PC1, while the ratio of the lowest leaf had the strongest negative correlation with PC2 (Fig. 1a). The characteristics related to shoot size and reproduction (mean number of flowers per shoot and per inflorescence as well as inflorescence number per shoot) negatively correlated with total tree and shrub canopy cover. Accordingly, the scattering of *P. multiflorum* populations in PCA score plots revealed relationship between morphological variation and the environmental factors, namely between total tree and shrub canopy cover (Fig. 1b). The largest morphometrical values were recorded in population No. 22, which occurred in the sparsest forest, while populations No. 5, 9 and 10, situated in the densest forests were characterized by the smallest values of all morphological characteristics (Fig. 1). The lowest inflorescence position was the only characteristic, which correlated directly with total tree and shrub canopy cover, while characteristics related to shoot size, flower and inflorescence numbers correlated negatively.

The Kruskal-Wallis test showed significant differences in all morphological characteristics between populations of *Polygonatum odoratum.* Sixteen morphological characteristics of this species were reduced to two principal components, which explained 71.29% of the total variance. The stem diameter and shoot height were correlated with most characteristics and had the strongest negative correlation with PC1, while the reproductive characteristics had the strongest positive and the length of the lowest and middle leaf had negative correlation with PC2 (Fig. 2a). The total tree and shrub canopy cover negatively correlated with reproductive characteristics of *P. odoratum.* However, this environmental factor had no effect on the characteristics related to shoot height, and scattering of *P. odoratum* populations in PCA score plots was only slightly related to total tree and shrub canopy cover (Fig. 2). The mean number of flowers per inflorescence in *P. odoratum* correlated positively with the soil pH ($r_s = 0.58$, $p = 0.037$).

Population structure

The distribution of shoots of both species in habitats was clumped and species frequency varied from 40 to 100% for *P. multiflorum* populations and from 10 to 100% for *P. odoratum* populations. The mean density of *P. multiflorum* varied from 2.7 to 49.6, while this characteristic in *P. odoratum* varied from 2.3 to 25.7 shoots in one square meter of populations

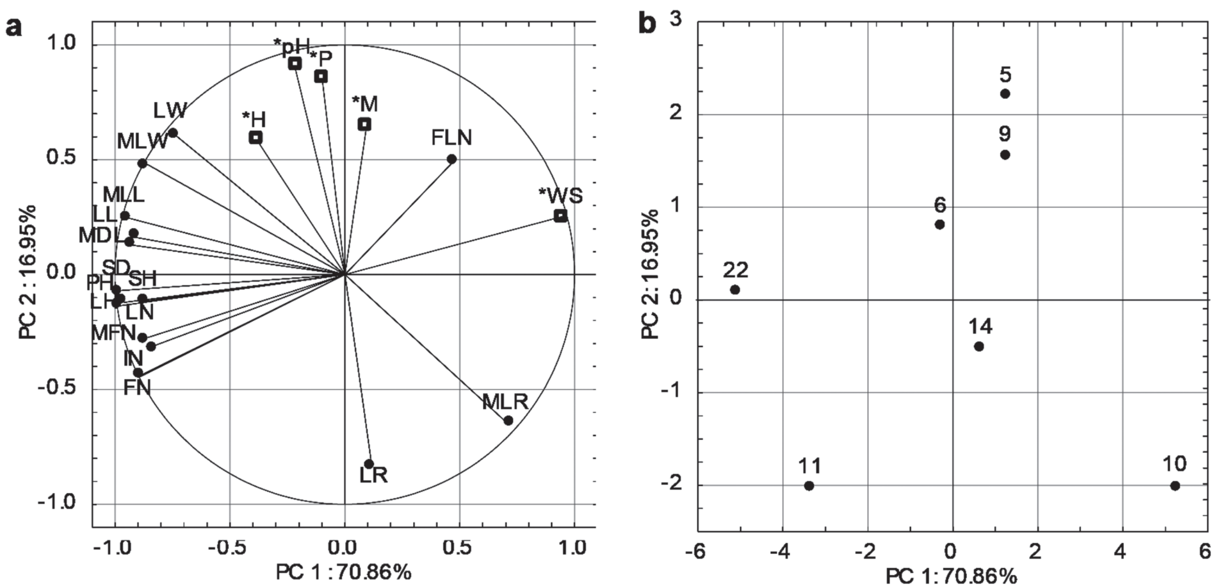

Fig. 1. PCA loading plots of morphological variables (a) and score plots of populations of *Polygonatum multiflorum* (b) based on the analysis of 16 morphological characteristics. The numbers of populations are presented as in Table 1. An explanation of the active variable (character) acronyms is given in Table 2; supplementary variables (*): WS – total tree and shrub canopy cover, M – moss cover; pH – soil reaction, H – humus content, P – phosphorus content

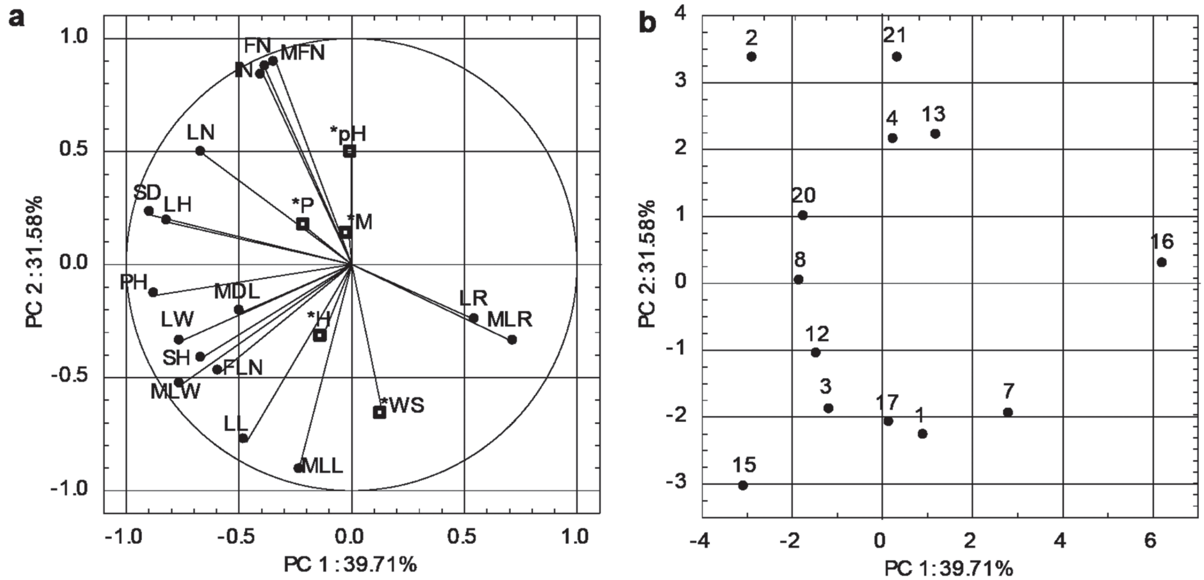

Fig. 2. PCA loading plots of morphological variables (a) and score plots of populations of *Polygonatum odoratum* (b) based on the analysis of 16 morphological characteristics. The numbers of populations are presented as in Table 1. An explanation of the active variable (character) acronyms is given in Table 2; supplementary variables (*): WS – total tree and shrub canopy cover, M – moss cover; pH – soil reaction, H – humus content, P – phosphorus content

Table 5. Descriptive statistics for characteristics of shoot frequency, density (D) and composition of life stages in seven populations of *Polygonatum multiflorum* and 19 populations of *P. odoratum*, and *p*-value of the Kruskal-Wallis test for differences in characteristics between species. An explanation of the character acronyms is given in Table 2

Character	*P. multiflorum*			*P. odoratum*			*p*-value
	Mean	Means' range	Range	Mean	Means' range	Range	
Frequency, %	72.9	40–100	–	52.1	10–100	–	**0.002**
Mean D, m^{-2}	16.3	2.7–49.6	0–107	10.2	2.3–25.7	0–255	**0.002**
Juvenile D, m^{-2}	5.7	0.2–24.9	0–53	0.9	0–5.3	0–24	**< 0.001**
Vegetative D, m^{-2}	8.4	0.2–15.0	0–47	5.8	1.3–25.4	0–162	**0.002**
Generative D, m^{-2}	2.4	0.1–9.8	0–28	3.5	0–14.0	0–81	0.251
Juvenile, %	25.0	1.3–50.2	0–100	12.4	0–56.4	0–100	**0.003**
Vegetative, %	56.2	6.5–98.1	0–100	51.8	10.7–98.8	0–100	0.197
Generative, %	18.7	0.7–83.9	0–100	35.7	0–82.8	0–100	**0.032**

Significant difference ($p < 0.05$) is given in bold.

(Table 5). The intraspecific variation in composition of life stages was revealed in both species. The vegetative shoots dominated in most populations of *P. odoratum* and in three populations of *P. multiflorum* (Fig. 3). The generative shoots dominated in one population of *P. multiflorum* and seven populations of *P. odoratum.* Juveniles prevailed only in three populations, in one *P. odoratum* and in two *P. multiflorum* populations. The *P. multiflorum* population (No. 22), in which generative shoots prevailed, had the largest values of all morphological characteristics (Fig. 1). However, *P. odoratum* population (No. 21) with the highest proportion of generative shoots had only the maximal values of the reproductive characteristics.

Most *Polygonatum* shoots (56.2 and 51.8% on average for *P. multiflorum* and *P. odoratum*, respectively) were at vegetative stage. The density of generative shoots correlated negatively with the total tree and shrub canopy cover ($r_s = –0.87$, $p = 0.011$ and $r_s = –0.50$, $p = 0.031$ in *P. multiflorum* and *P. odoratum*, respectively; Fig. 4). The ratio of generative shoots of *P. odoratum* correlated positively with the soil pH ($r_s = 0.47$, $p = 0.042$) and the ratio of juvenile shoots correlated negatively with the cover of moss layer ($r_s = 0.79$, p = 0.034).

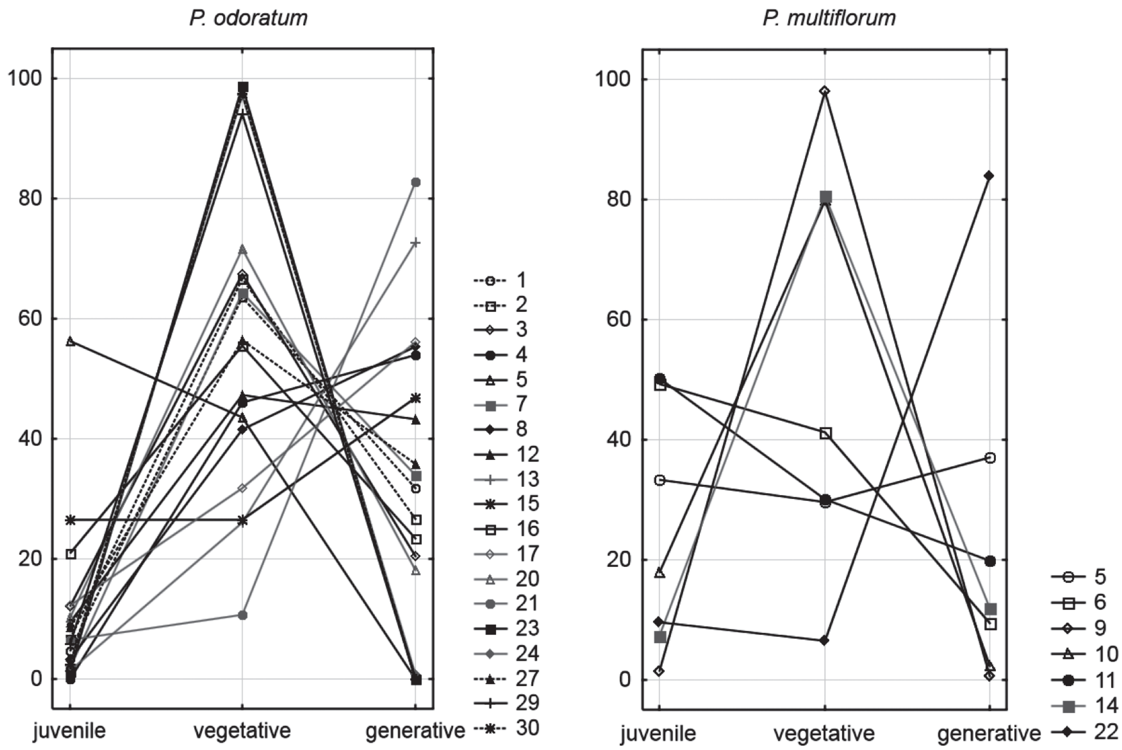

Fig. 3. Proportional life stage composition (%) in 19 populations of *Polygonatum odoratum* and seven populations of *P. multiflorum*

DISCUSSION

The studied *Polygonatum* species prefer different habitats. *P. odoratum* is characteristic of thermophilous forest fringes (alliance *Geranion sanguinei* Tüxen in Müller), while *P. multiflorum* is characteristic of broad-leaved forests of the order *Fagetalia sylvaticae* Pawłowski in Pawłowski (Rašomavičius, 1998; Matuszkiewicz, 2001). According to Ellenberg et al. (1991), *P. odoratum* prefers well-lit places, but also occurs in partial shade, and *P. multiflorum* is a shade plant (values 7 and 2, respectively), while according to Hill et al. (1999), the difference in light preferences found between species in Great Britain is negligible (5 and 4, for *P. odoratum* and *P. multiflorum*, respectively). Consequently, the total tree and shrub canopy cover had a significant negative effect on more characteristics of *P. odoratum* than *P. multiflorum*. Nevertheless, according to Kosiński (2013), the mixed forest is a suitable habitat for *P. odoratum* providing that there are gaps in the canopy, which provide accessibility of enough light to the forest floor, where the plants can flower and fruit.

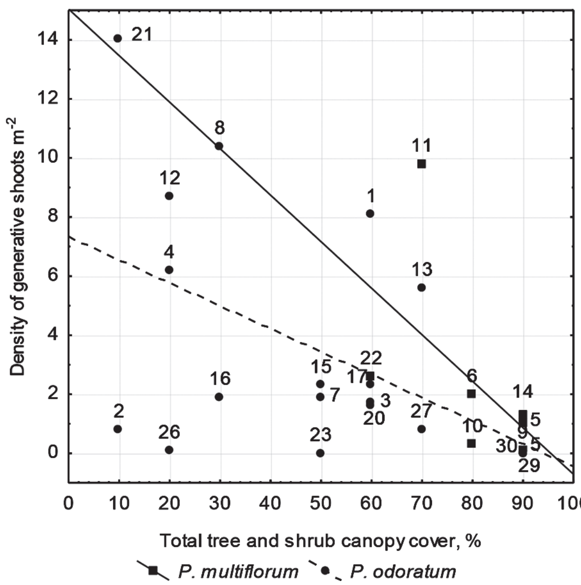

Fig. 4. Relationship between generative shoot density and total tree and shrub canopy cover in the habitats of *Polygonatum odoratum* and *P. multiflorum* populations. The numbers of populations are presented as in Table 1

The soil pH was the second environmental factor, which significantly correlated with some population characteristics in *P. odoratum.* More shoots were at generative stage in the habitats with higher pH. According to Hill et al. (1999), both species are indicators from weakly acid to weakly basic soils and is never found on very acid soils, the Ellenberg's reaction value 7. However, soil reaction of *P. odoratum* habitats in this study varied from pH 3.66 to 7.45, with average of 5.61. The occurrence of *P. odoratum* on acid soils has also been found in Sweden and the adjustments from 7 to 4 of Ellenberg's reaction values for this species has been done by Gustafsson (1994) and from 7 to 5 by Diekmann (1995). Similarly, *P. multiflorum* occurs on more acid soils with average pH value of 4.3 for 124 sites in Sweden (Brunet, 1993) than in our study. Generally, Ellenberg's soil nutrient and pH values for plant species decrease with increasing latitude (Wasof et al., 2013).

Most evident impact of the environmental factors on morphological variation was related to light availability in the habitats. The dense total tree and shrub canopy cover negatively affected the number of flowers per shoot and per inflorescence in both species. However, *P. multiflorum* occurring in fully open habitat (pasture) has the lowest morphometric values compared to plants occurring in forest and forest edges (Riznichuk, 2017). According to Meekins & McCarthy (2000), shade often increases carbon allocation to stem and leaf tissue and decreases allocation to roots and may also reduce allocation to sexual reproductive tissues.

The shoot density in the studied *P. odoratum* populations was comparatively low (2.3–25.7 m^{-2}) compared to populations from the forest in Northern Poland, where only generative shoot density of this species is 4–53 in m^{-2} (Kosiński 2013), or compared to the populations from the open habitats of the Ukrainian Carpathians, where mean shoot density is 33–89 m^{-2} (Riznychuk, 2012). Similarly, the mean density of *P. multiflorum* generative shoots was less in the studied populations than in Northern Poland (Kosiński, 2012). The differences in shoot densities may be caused by the unfavourable environmental conditions in the studied populations, or younger age of populations. The rather high share of juvenile shoots in some studied populations might be a result of efficient generative reproduction or slower ontogenetic development caused by unfavourable abiotic or biotic conditions. Sometimes senile individuals may resemble juvenile shoots. According to Kosiński (2012), the proportion of *P. multiflorum* single-leafed juvenile individuals of several years of age increases after shoot damage, which results in the regression of the number of leaves in the following year. Under unfavourable environmental conditions such as low light availability through canopy closure, forest plant species may alter their growth form and exhibit prolonged clonal growth (Gratani, 2014). Moreover, the lack of generative and predominance of vegetative shoots in *Polygonatum* populations may be a result of the rhizome fragmentation or herbivore activity (Kosiński, 2012, 2015; Istomina et al., 2016).

In conclusion, the results of this study revealed the crucial effect of light availability expressed via total tree and shrub canopy cover in the habitats of *Polygonatum* species on their flowering intensity and population structure.

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POLYGONATUM MULTIFLORUM IR *P. ODORATUM* MORFOLOGINIŲ POŽYMIŲ IR POPULIACIJŲ STRUKTŪROS ATSAKAS Į APLINKOS VEIKSNIŲ VARIJAVIMĄ

Birutė Karpavičienė, Giedrė Elzbieta Mlečkaitė

Santrauka

Morfologinis varijavimas ir populiacijų struktūra buvo tirta septyniose *Polygonatum multiflorum* ir 19 *P. odoratum* populiacijų. Abiejų rūšių vidutinis vieno ūglio žiedynų ir žiedų skaičius bei vieno žiedyno žiedų skaičius neigiamai koreliavo su bendru medžių ir krūmų padengimu, o *P. odoratum* vidutinis vieno žiedyno žiedų skaičius teigiamai koreliavo su dirvožemio pH. Ūglių tankis ir amžiaus grupių sudėtis *P. odoratum* populiacijose priklausė nuo sumedėjusių augalų padengimo, kuris neigiamai koreliavo su generatyvinių ūglių tankiu abiejų rūšių populiacijose. Šio tyrimo rezultatai atskleidė esminį šviesos kiekio, išreikšto per bendrą medžių ir krūmų padengimą, poveikį *Polygonatum* rūšių žydėjimo intensyvumui ir populiacijų struktūrai.