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RECOLONISATION PROCESS IN ABANDONED *Molinietum caeruleae* MEADOWS – THE INFLUENCE OF POSITION WITHIN GAPS ON MICROSITE CONDITIONS AND SEEDLING RECRUITMENT

Kinga Kostrakiewicz-Gierałt
Jagiellonian University in Krakow

Abstract. Investigations were carried out in patches of *Molinietum caeruleae* meadows dominated by small meadow species (patch I), characterised by prevailing large-tussock grasses (patch II), and overgrown by willow shrubs and bordered by trees (patch III). In each patch, 15 circular gaps with a radius measuring 30 cm were artificially created by the removal of the plant canopy and litter layer. Subsequently, each gap was divided into a central part, with a radius of 20 cm, and a peripheral part. Light intensity and soil temperature were greater in the central parts of these openings than in their peripheries, while ground humidity presented the inverse tendency. Despite heterogenous environmental conditions in the gaps, the total numbers of species/seedlings noted in their central and peripheral parts did not differ significantly. The majority of taxa recruited similarly over the entire surface of openings; a much lower number of species colonized primarily the central parts of gaps; the lowest number of taxa appeared at the edges of openings. In the light of these investigations, it may be assumed that heterogenous microsite conditions in openings enable the recruitment of taxa with various germination requirements and contribute to the maintenance of species diversity.

Key words: blue moor-grass meadow, light intensity, seedling recruitment, soil humidity, soil temperature, species diversity

INTRODUCTION

Meadows from *Molinion* alliance which are among the most species-rich meadows in Europe, have been suffering from a marked decrease in area since the 1970s [see Fuller 1987, Green 1990, Prach 1993, Muller 2000]. As a result they are included

Corresponding author: dr Kinga Kostrakiewicz-Gierałt, Department of Plant Ecology of Jagiellonian University in Krakow, Lubicz 46, 31-512 Kraków,
e-mail: kinga.kostrakiewicz@uj.edu.pl

among the most threatened habitats [Denisiuk 1991], have been designated for conservation by International Conventions [Council Directives 92/43/EC and 97/62/EC], and have been included in the NATURA 2000 network [Anonymous 2003].

A large body of literature has documented that a very promising method for the active protection of *Molinia* meadows is the creation of disturbances in the plant canopy and litter layer. This treatment leads to the appearance of gaps in the vegetation cover and necromass which are considered safe sites for seedling recruitment. Hitherto, the process of seedling germination in various type of openings has been investigated in the greenhouse with soil samples [Hölzel and Otte 2003a, b, Weiterová 2008, Schmiede et al. 2012]. Moreover, some authors [Křenová and Lepš 1996, Kotorová and Lepš 1999, Isselstein *et al*. 2002, Overbeck *et al*. 2003, Poschold and Biewer 2005, Vitová and Lepš 2011] have focused on the process of seedling recruitment following artificial seed introduction into gap areas, whereas other researchers have studied spontaneous gap colonisation in relation to the particulars of gap origins [Špačkova *et al*. 1998, Lepš 1999, Špačkova and Lepš 2004, Janeček and Lepš 2005, Kostrakiewicz-Gierałt 2012, 2013a, Fibich *et al.* 2013, Lepš 2014], the time frame of the creation of gaps [Kostrakiewicz-Gierałt 2015] and the size of gaps [Kostrakiewicz-Gierałt 2014].

Despite growing interest in the colonisation of gaps in *Molinietum caeruleae* patches, the current state of knowledge is still insufficient. Accordingly, the present investigations were carried out. The focus of the main objective was on studies of the recruitment process in the central and peripheral parts of openings. The specific aims were the assessment of: (1) light intensity, as well as soil temperature and humidity; (2) the total number of species and seedlings; (3) the number of seedlings of particular taxa in the centre and at the edge of gaps. My hypotheses were: (1) that microsite conditions differ between the central and peripheral parts of gaps; (2) that the total numbers of species (seedlings) in the central and peripheral parts of openings are different; (3) that in the seedling pool different species present different patterns of gap colonisation (dominating in the central part, prevailing in the peripheral part, or appearing over the entire surface of openings equally).

MATERIAL AND METHODS

The field trial

The study area is located in the Kostrze district located on the western border of Cracow, south of the Vistula River (southern Poland). It is situated on the low flood terrace of the Vistula at a height of 3.0-6.0 m. The groundwater level is 0.2 m below the surface of the ground. The soils in the Vistula River valley, consisting mostly of black earth and light clay, are covered by *Molinia* meadows. The abandonment of traditional land use over at least the past dozen years has favoured the development of *Phragmites* swamps and willow brushwood, leading to the fragmentation of meadows [Dubiel 1991, 1996].

The studies were carried out in three adjacent abandoned patches of *Molinietum caeruleae* with various species compositions. Patch I was characterised by prevailing meadow species creating delicate, procumbent stems or small tussocks. Patch II was dominated by large-tussock grasses. Patch III was overgrown by willow shrubs and bordered by trees. In 2012, the average height of vascular plants was evaluated on the basis of measurements of 30 randomly chosen stems of different species, performed using a folding tape measure. Statistical analysis, performed using the Kruskal-Wallis H test, showed that the study sites differed significantly in terms of the height of the vascular plant cover. Site conditions in individual patches are described in Table 1.

Table 1. The site conditions in studied patches of *Molinietum caeruleae* in 2012: I – patch dominated by small meadow species, II – patch with prevail of large tussocks grasses, III – patch overgrown by shrub-willows and bordered by trees
Tabela 1. Warunki siedliskowe w badanych płatach *Molinietum caeruleae* w roku 2012: I – płat zdominowany przez niewielkie gatunki łąkowe, II – płat z przewagą wysokokępowych traw, III – płat zarośnięty przez krzewiaste gatunki wierzb i otoczony drzewami

Patch	I	II	III
The patch area, m^2 Powierzchnia płatu	4000	5400	7200
The number of species in patch Liczba gatunków w płacie	48	39	35
The dominants (species, with cover exceeding 20%) Dominanci (gatunki, których pokrycie przekracza 20%)	*Lathyrus pratensis* *Lotus corniculatus* *Dianthus superbus*	*Molinia caerulea* *Deschampsia caespitosa*	*Salix repens* ssp. *rosmarinifolia*
The subdominants (species, with cover level ranging 5-20%) Subdominanci (gatunki których pokrycie waha się od 5-20%)	*Lychnis flos-cuculi* *Centaurea jacea* *Potentilla erecta*	*Phragmites australis* *Poa trivialis* *Galium boreale*	*Betula pendula* *Populus tremula* *Lysimachia vulgaris*
The mean vascular plant height, cm Średnia wysokość roślin naczyniowych	39.8	84.7	120.9

the value of statistical significance of differences (the H Kruskal-Wallis test, df = 2) among patches in vascular plant height achieved 46.60 ($p < 0.001$) – poziom istotności statystycznej różnic w wysokości roślin naczyniowych (test H Kruskala-Wallis'a, df = 2) pomiędzy płatami wynosi 46.60 ($p < 0.001$)

In each patch, 15 circular gaps, with a radius measuring 30 cm, were randomly created on 15 April 2012. The gaps were created through the removal of the plant canopy and necromass, since, according to Kostrakiewicz [2011], this treatment produces the best results. The gaps were separated by belts of untouched vegetation at least 3.0 m wide, located *ca* 2.0 m from the border of the patch. Each gap was divided into a central part with a radius of 20 cm (thus covering an area of 1256 cm^2) and a peripheral part (covering an area of 1570 cm^2). Ramets of neighbouring clonal plants ingrown into the surface of gaps during the entire study period were not removed. The experimental design is shown in Fig. 1.

The microenvironmental conditions in the centre and the peripheral parts of each opening (on the northern side of the gap's edge) were monitored once a week from 24 April to 6 November 2012 and from 9 April 2013 to 19 November 2013. All measurements were taken between 10 and 12 a.m. Light intensity at the soil level was examined with a Voltcraft MS-1300 digital photometer (accuracy ± 5% + 10 digits; measuring range 0.01-50,000 lx). Humidity at the ground level was measured using an OMEGA HSM50 handheld digital soil moisture sensor (accuracy ± 5% + 5 digits; measuring range 0% to 50% moisture content in soil). Soil temperature at the depth of 5 cm was measured using a HANNA Instruments electronic temperature sensor (accuracy ± 0.1°C; measuring range –10ºC to +60ºC).

The process of gap colonisation was monitored at weekly intervals from 24 April to 12 November 2012 and from 9 April to 19 November 2013. Seedlings and juvenile individuals were removed and examined, according to the method proposed by Csapodý [1968] and Muller [1978], with the support of the author's comparative collection. The nomenclature of taxa follows Mirek *et al.* [2002]. The colonisation of the central and the peripheral parts of gaps were characterized by mean cumulative number of species and seedlings, calculated by adding species (seedlings) that appeared over the course of two years. Subsequently, absolute values were recalculated based on the relative numbers of species (seedlings) which might appear in an area of 1 m^2. The recruitment rates of particular taxa were computed similarly.

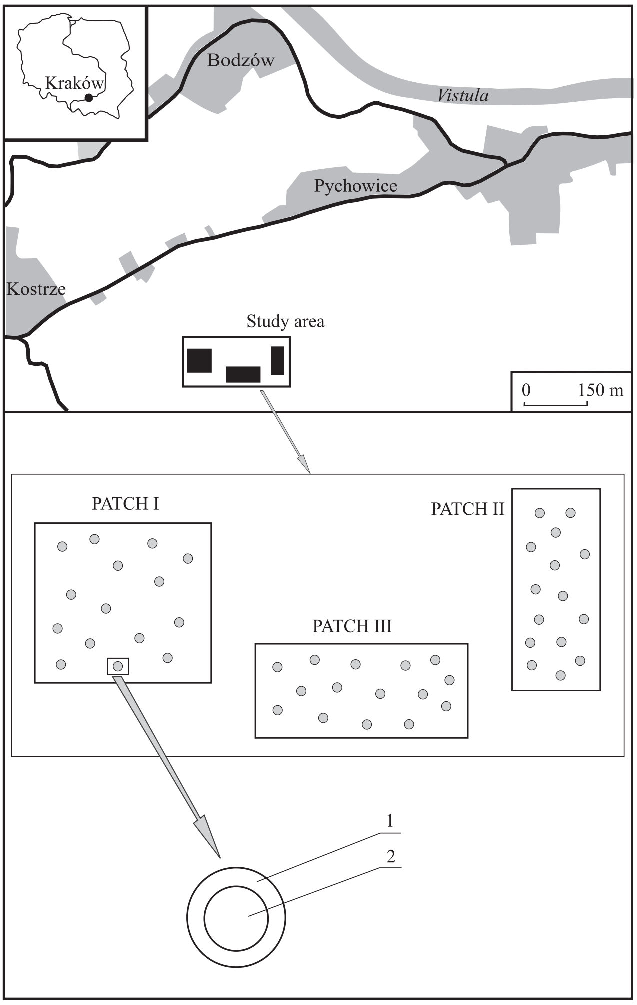

Fig. 1. The localization of study area and design of experiment: 1 – peripheral part of gaps, 2 – central part of gaps

Rys. 1. Lokalizacja terenu badań i schemat eksperymentu: 1 – część peryferyjna luk, 2 – część centralna luk

Statistical analysis

Statistical analysis of data on light intensity, soil humidity and soil temperature was based on a Student's t-test (comparison between means), which was used to establish whether there had been significant differences in:

a) light intensity at the soil surface in the central and peripheral parts of gaps at every study site,
b) soil humidity in the central and peripheral parts of gaps at every study site,
c) soil temperature in the central and peripheral parts of gaps at every study site.

The nonparametric Mann-Whitney U-test was used to establish if there had been significant differences in:

a) the total number of taxa/seedlings appearing in the central and peripheral parts of gaps at every study site,
b) the abundance of seedlings of particular taxa appearing in the central and peripheral parts of gaps at every site.

All analyses were computed using *STATISTICA* 10 software (StatSoft).

RESULTS

Taking all patches into account, light intensity and soil moisture in the centres of openings were greater than in the peripheries, to a remarkable extent. Light intensity in the centres of gaps ranged from 38500 to 46900 lx, while in the peripheries it measured from 33100 to 40200 lx. Soil temperature in the middle of openings measured from 11.2ºC to 14.8ºC; at the edges of gaps, from 11.6ºC to 12.5ºC. Soil humidity presented the inverse tendency: the water content of the ground in the central parts of openings measured from 22.1 to 32.3%, whereas in the peripheral parts it ranged from 18.9% to 38.0% (Table 2).

For all study sites, the numbers of species found in the central and peripheral parts of openings were quite similar, from 8.1 to 23.5 and from 7.8 to 21.6, respectively (Table 3). The numbers of seedlings recorded in the central and peripheral parts of gaps did not differ significantly either, ranging from 239.7 to 865.8 and from 187.7 to 703.8, respectively.

Species found in the seedling pool presented different patterns of gap colonisation (Table 4). The majority of taxa colonized the central and peripheral parts of openings in a similar way. There were 33, 32 and 28 species in patches I, II and III, respectively. Among taxa appearing most abundantly in all sites were: *Cirsium arvense*, *Polygonum bistorta*, *Serratula tinctoria*, *Solidago canadensis*, *Succisa pratensis*. In all patches, taxa were found which colonised the centres of openings particularly. Among the best colonisers in patch I were: *Filipendula ulmaria*, *Achillea millefolium*, *Galium boreale*, *Lysimachia vulgaris*, *Betula pendula*, *Leucanthemum vulgare*, *Galinsoga* sp., *Erigeron* sp. The central parts of gaps in patch II were colonised by *Filipendula ulmaria* and *Sonchus arvensis*, while in patch III *Leucanthemum vulgare* appeared most abundantly. The lowest number of taxa appeared mostly at the edges of openings. This group of species was represented by *Sanguisorba officinalis*, *Betonica officinalis* and *Lychnis flos-cucculi*, which was noted in patch I.

Table 2. The mean (±SD) light intensity level, soil moisture and soil temperature in peripheral and central parts of gaps in patch dominated by small meadow species (I), prevailed by large-tussock grasses (II) and overgrown by shrubs and trees (III) in 2012-2013

Tabela 2. Średnie (±SD) wartości natężenia światła, wilgotności gleby oraz temperatury gleby w obwodowej i centralnej części luk w płacie zdominowanym przez niewielkie gatunki łąkowe (I), z przewagą wysokokępowych traw (II) oraz zarośniętym przez krzewiaste gatunki wierzb i otoczonym drzewami (III) w latach 2012-2013

Environmental parameter Czynnik środowiskowy	Patch Płat	Peripheral part Część obwodowa	Central part Część centralna	The statistical significance level (Student's t-; *P*) Poziom istotności statystycznej (test t-Studenta; *P*)
Light intensity (lx) Natężenie światła (lx)	I	40200 (± 5026) N = 930	46900 (± 4248) N = 930	31.3 (P < 0.001)
	II	36700 (± 4438) N = 930	40 900 (± 4 810) N = 930	19.5 (P < 0.001)
	III	33100 (± 4867) N = 930	38 500 (± 4 528) N = 930	24.9 (P < 0.001)
Water content in the soil Zawartość wody w glebie %	I	22.1 (± 6.0) N = 930	18.9 (± 4.0) N = 930	-14.4 (P < 0.001)
	II	33.1 (± 6.0) N = 930	30.5 (± 6.0) N = 930	-8.9 (P < 0.001)
	III	39.3 (± 7.0) N = 930	38.0 (± 4.0) N = 930	-5.3 (P < 0.001)
Soil temperature Temperatura gleby ºC	I	12.5 (± 5.7) N = 930	14.8 (± 6.1) N = 930	8.9 (P < 0.001)
	II	11.4 (± 5.9) N = 930	12.0 (± 6.0) N = 930	2.1 (P ≤ 0.05)
	III	11.2 (± 5.6) N = 930	11.6 (± 5.4) N = 930	2.3 (P ≤ 0.05)

Table 3. The mean number of species and seedlings (±SD) in 1 m^2 of peripheral and central parts of gaps in patch dominated by small meadow species (I), prevailed by large-tussock grasses (II) and overgrown by shrubs and trees (III) in 2012-2013

Tabela 3. Średnia liczba gatunków i siewek (±SD) na 1 m^2 części obwodowej i centralnej luk w płacie zdominowanym przez niewielkie gatunki łąkowe (I), z przewagą wysoko-kępowych traw (II) oraz zarośniętym przez krzewiaste gatunki wierzb i otoczonym drzewami (III) w latach 2012-2013

	Patch Płat	Peripheral part Część obwodowa	Central part Część centralna	The statistical significance level (the U Mann-Whitney test) Poziom istotności statystycznej (test U Manna-Whitneya)
Taxa Taksony	I	21.6 (± 7.8)	23.53 (± 5.8)	91.5^{ns}
	II	14.8 (± 5.9)	15.20 (± 6.2)	109.5^{ns}
	III	7.8 (± 4.1)	8.13 (± 3.1)	104.5^{ns}
Seedlings Siewki	I	703.7 (± 235.5)	865.77 (± 187.5)	63.5 *
	II	275.5 (± 128.1)	277.78 (± 125.8)	108.0^{ns}
	III	187.6 (± 90.8)	239.71 (± 110.2)	85.0^{ns}

the symbols mean the level of statistical significance of differences between peripheral and central parts of gaps: *P ≤ 0.05; ns – not significant – symbole oznaczają poziom istotności statystycznej różnic pomiędzy peryferyjną i centralną częścią luk: *P ≤ 0.05; ns – nieistotny

Table 4. The mean number of seedlings of particular taxa per 1 m^2 of peripheral (1) and central (2) parts of gaps in patch dominated by small meadow species (patch I), prevailed by large-tussock grasses (patch II) and overgrown by shrubs and trees (patch III) in the years 2012-13

Tabela 4. Średnia liczba siewek poszczególnych gatunków na 1 m^2 peryferyjnej (1) i centralnej (2) części luk w płacie zdominowanym przez niewielkie gatunki łąkowe (płat I), z przewagą wysokokępowych traw (płat II) oraz zarośniętym przez krzewiaste gatunki wierzb i otoczonym drzewami (płat III) w latach 2012-13

The group of species Grupa gatunków	Species	Patch I Płat I		Statistical significance level Poziom istotności statystycznej	Patch II Płat II		Statistical significance level Poziom istotności statystycznej	Patch III Pat III		Statistical significance level Poziom istotności statystycznej
		1	2		1	2		1	2	
1	2	3	4	5	6	7	8	9	10	11
	Caltha palustris	9.7	10.0	ns	8.9	6.5	ns	8.1	8.4	ns
	Cardamine pratensis							0.8	3.1	ns
	Carex sp.	0	2.6	ns	1.2	2.5	ns	1.6	2.5	ns
	Centaurea jacea	14.4	16.4	ns	8.4	8.4	ns			
	Cirsium arvense	21.6	31.8	ns	15.7	29.7	ns	12.6	20.7	ns
	Crepis paludosa				2.5	4.7	ns	2.6	2.6	ns
	Chenopodium album	8.9	31.8	ns	3.3	12.2	ns	2.5	4.7	ns
	Daucus carrota	9.7	9.5	ns	4.6	8.9	ns	11.8	16.4	ns
	Dianthus superbus	7.6	7.4	ns	4.2	4.7	ns	3.3	4.7	ns
	Geranium pratense	25.0	13.8	ns	18.2	15.9	ns	8.4	11.6	ns
	Iris sibirica	10.6	30.2	ns	5.5	12.7	ns	8.1	12.2	ns
	Juncus sp.	5.5	9.5	ns	5.1	5.8	ns	5.5	8.4	ns
	Lathyrus pratensis	6.3	9.5	ns	2.1	1.5	ns	1.2	1.1	ns
	Lotus corniculatus	14.8	22.2	ns	18.2	21.9	ns	13.5	18.0	ns
	Mentha sp.	14.4	12.7	ns	16.9	16.4	ns	6.7	7.4	ns
	Myosotis sp.	1.6	4.2	ns	0.8	2.1	ns	1.2	2.1	ns
	Plantago lanceolata	6.3	8.9	ns	0.8	0.9	ns	3.8	1.1	ns
A	*Poaceae*	16.5	16.4	ns	13.1	11.6	ns	4.6	5.3	ns
	Polygonum bistorta	26.7	31.3	ns	22.5	27.1	ns	16.1	24.4	ns
	Populus sp.	0	1.0	ns				8.4	10.0	ns
	Potentilla erecta	36.9	35.7	ns	16.9	11.6	ns	7.2	11.1	ns
	Prunella vulgaris	5.0	12.2	ns	4.6	4.1	ns			
	Ranunculus acer	4.2	4.7	ns	2.5	3.7	ns			
	Rumex acetosa	1.6	2.1	ns	4.2	6.9	ns	4.6	4.2	ns
	Salix sp.	0	2.1	ns	2.5	3.1	ns	5.9	6.9	ns
	Selinum carvifolia	21.7	12.7	ns	16.4	6.9	ns			
	Serratula tinctoria	39.0	19.5	ns	30.5	15.9	ns	23.3	18.5	ns
	Solidago Canadensis	29.0	52.5	ns	16.5	29.1	ns	13.5	31.3	ns
	Succisa pratensis	36.7	18.0	ns	26.7	9.0	ns	16.5	9.0	ns
	Taraxacum sp.	5.0	5.3	ns	2.5	2.6	ns			
	Trifolium pretense	3.5	5.3	ns	3.3	3.1	ns			
	Urtica dioica	2.1	3.1	ns	1.6	2.1	ns	1.6	1.0	ns
	Valeriana officinalis	5.5	6.9	ns	4.2	6.3	ns	9.3	10.6	ns
	Vicia cracca	5.0	5.8	ns						
	Viola sp.	2.1	2.6	ns	2.5	2.1	ns	2.5	1.5	ns

Table 4 continue – cd. tabeli 4

1	2	3	4	5	6	7	8	9	10	11
	Achillea millefolium	20.8	42.9	*	15.2	26.0	ns	14.4	23.8	ns
	Betula pendula	7.6	20.1	*	7.2	27.6	ns	7.2	27.6	ns
	Erigeron sp.	8.9	21.2	*	3.3	3.7	ns			
	Filipendula ulmaria	36.9	66.3	**	12.7	37.6	*	10.7	20.7	ns
B	*Galinsoga* sp.	4.2	17.5	*						
	Galium boreale	12.7	37.6	**	16.1	34.5	ns	14.4	24.2	ns
	Leucanthemum vulgare	28.0	61.4	**				1.7	11.6	*
	Lysimachia vulgaris	10.6	35.0	*	16.5	27.1	ns	10.1	23.8	ns
	Sonchus arvensis	9.3	18.5	ns	1.6	10.6	*			
	Betonica officinalis	54.7	35.6	**	44.1	29.7	ns	13.2	19.1	ns
C	*Lychnis flos-cucculi*	18.6	6.3	*	7.6	9.0	ns			
	Sanguisorba officinalis	76.4	24.4	***	30.5	16.4	ns	21.2	19.6	ns

A – taxa colonizing peripheral and central parts of openings in similar extent – gatunki kolonizujące w równym stopniu część centralną i peryferyjną luk
B – taxa dominating in central parts of gaps – gatunki dominujące w części centralnej
C – taxa prevailing in peripheral parts of gaps – gatunki dominujące w części peryferyjnej

the symbols mean the level of statistical significance of differences between peripheral and central parts of gaps: *P ≤ 0.05; **P < 0.001; ***P < 0.001; ns – not significant – symbole oznaczają poziom istotności statystycznej różnic pomiędzy peryferyjną i centralną częścią luk *P ≤ 0.05; **P < 0.001; ***P < 0.001; ns – nieistotny

DISCUSSION

The studies showed that microenvironmental conditions differ depending on a given position in a gap. The much lower light availability in the periphery of an opening compared to the centre may be due to shading of the gap's edge by the leaves and stems of adjacent plants. Additionally, the peripheries of openings were particularly prone to clonal ingrowth of individuals occurring in the immediate vicinity, such as *Galium boreale*, *Potentilla erecta*, *Poa trivialis*, and *Lysimachia vulgaris*. Rapid ramet encroachment may lead to rapid occupation of bare soil and may contribute to substantial reductions in irradiance level. According to the predictive model proposed by Anten and Hirose [1999], both tall and short taxa may intercept the photoperiod very effectively. Our investigations proved that, with a decrease in solar radiation reaching the ground surface in the peripheries of gaps, soil temperature diminishes and ground humidity increases, while deep light penetration in the centres of openings leads directly to rapid increases in soil temperature and ground desiccation. The effect of plant canopy shading on the retardation of water evaporation and modification of ground temperature has been observed over a wide spectrum of habitats [Pierson and Wright 1991, Todd *et al.* 1991, Van Miegroet *et al.* 2000, Raz-Yaseef *et al.* 2010, Myers-Smith and Hik 2013].

Our investigations documented that, despite the heterogeneity of microclimatic and edaphic conditions recorded in the central and peripheral parts of gaps, the number of recruits was similar. Moreover, the majority of species colonize the centres and edges of gaps in a similar fashion. These findings are in disagreement with previous studies documenting that plant cover may remarkably reduce seedling recruitment of *Dianthus superbus* [Kostrakiewicz-Gierałt 2013b], *Selinum carvifolia* [Špačkova *et al.* 1998], *Serratula tinctoria* [Stammel *et al.* 2006], *Solidago canadensis* [Rebele 2000], and *Succisa pratensis* [Kotorová and Lepš 1999, van der Meer 2013].

Our results showed that taxa preferring the central parts or edges of openings appeared in the seedling pool. The occurrence of such species, particularly in patch I, may be linked with the low height of standing vegetation, allowing the influx of diaspores into gaps. The absence of differences observed in patches II and III may be due to the proximity of large tussock grasses, as well as high-growing herbaceous species and shrubs. Such species may act as effective traps for hydrochorous and anemochorous seeds, reducing the influx of propagules and their deposition in openings. In addition, other authors [McEvoy and Cox 1987, Bullock and Moy 2004, Pounden *et al.* 2008] have argued that diaspores with appendages, such as kapok, comae or pappi, may be caught by umbels and stems with fully deployed leaves. Additionally, the dense vegetation in patches II and III may slow the wind, modify the turbulence regime, and finally suppress the dispersal and deposition of anemochorous diaspores in openings. A similar phenomenon was observed by Greene and Johnson [1996] in forest communities, where the probability of seed deposition in clearings diminished with their distance from the edge of forest.

Based on a combination of our results and the published data, it may be concluded that colonizers of the central parts of gaps include annuals producing numerous light, wind-dispersed, positively photoblastic diapores such as *Galinsoga sp.* [Jursik *et al.* 2003, Ivany 1973, De Cauwer *et al.* 2014], *Sonchus arvensis* [Lewin 1948], *Erigeron* sp. [Regehr and Bazzaz 1979], the light-demanding pioneer tree *Betula pendula* [Atkinson 1992], and the perennial *Galium boreale* [Jankowska-Błaszczuk *et al.* 1998], which prefers sunny stands. On the other hand, the greater abundance of seedlings of *Leucanthemum vulgare* in the centres of gaps is not consistent with findings of Howarth and Williams [1968], who argued that achenes of the aforementioned plant are insensitive to light intensity. Our results are in accordance with many observations concerning the influence of adjacent plants on seedling recruitment. Our investigations showing that *Lysimachia vulgaris, Filipendula ulmaria* and *Achillea millefolium* recruit mostly in the centres of openings support the findings of several authors [Hutchings and Booth 1996, Roth *et al.* 1999, Allison 2002, Falińska *et al.* 2010] documenting that substantial competitive pressure from established vegetation might hamper the appearance and survivability of generative offspring.

Moreover, our results documenting that the offspring of *Sanguisorba officinalis* and *Betonica officinalis* predominantly colonize the edges of gaps are consistent with the findings of Lepš [1999], who argued that these species may recruit in the vicinity of neighbouring plants. On the other hand, contrary to our results, Rasran *et al.* [2007] found that location in the immediate vicinity of established vegetation had a negative impact on the density of seedlings of *Lychnis flos-cuculi*.

Comparing our observations with previous findings [Kostrakiewicz-Gierałt 2015], it might be concluded that species prevailing in the centres of gaps also dominate in large openings, while taxa prevailing in the peripheries of gaps dominate in small openings. This phenomenon supports the observations of Kotanen [1997], who claimed that the colonisation process in the centres and peripheries of gaps of considerable size corresponds with the colonisation of large and small openings.

In light of our investigations, it can be stated that heterogenous microsite conditions in openings enable the recruitment of taxa with various germination requirements and contribute to the maintenance of species diversity.

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PROCES REKOLONIZACJI W PŁATACH OPUSZCZONYCH ŁĄK *Molinietum caeruleae* – WPŁYW POZYCJI W LUKACH NA WARUNKI MIKROSIEDLISKOWE ORAZ REKRUTACJĘ SIEWEK

Streszczenie. Badania były prowadzone w płatach nieużytkowanych łąk *Molinietum caeruleae:* płat I był zdominowany przez niewielkie gatunki łąkowe, w płacie II przeważały wysokokępowe trawy, natomiast płat III był zarośnięty przez krzewiaste gatunki wierzb i otoczony drzewami. W każdym płacie losowo wykonano po 15 okrągłych luk o promieniu 30 cm przez usunięcie roślin i ściółki. Następnie każdą lukę podzielono na część centralną (o promieniu 20 cm) oraz część obwodową. Natężenie światła oraz temperatura gleby były znacznie wyższe w środku odsłonięć niż na ich obrzeżach, natomiast wilgotność gruntu prezentowała odwrotną tendencję. Pomimo heterogennych warunków całkowita liczba gatunków/siewek odnotowana w środku i na skraju odsłonięć były podobne. W puli siewek przeważały gatunki kolonizujące równomiernie całą powierzchnię luk, odnotowano również taksony pojawiające się głównie w centralnej części odsłonięć oraz kiełkujące zwłaszcza na obrzeżach luk. W świetle przeprowadzonych badań stwierdzić można, że niejednorodne warunki siedliskowe umożliwiają rekrutację taksonów o rożnych wymaganiach, przyczyniając się do wzrostu zróżnicowania gatunkowego w płatach nieużytkowanych łąk.

Słowa kluczowe: łąka trzęślicowa, natężenie światła, rekrutacja siewek, różnorodność gatunkowa, temperatura gleby, wilgotność gleby

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