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STRUCTURE AND FLORISTIC DIVERSITY OF THE COMMUNITY *CALAMAGROSTIETUM EPIGEJI* JURASZEK 1928 WITHIN DIFFERENT BIOTOPES

STRUKTURA I ZRÓŻNICOWANIE FLORYSTYCZNE ZBIOROWISKA *CALAMAGROSTIETUM EPIGEJI* JURASZEK 1928 W OBRĘBIE RÓŻNYCH BIOTOPÓW

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Streszczenie. Określono strukturę i skład florystyczny *Calamagrostietum epigeji*, występującego w obrębie różnych biotopów (w wyrobiskach po eksploatacji piasku i żwiru, osadniku poflotacyjnym „Gilów" i na obszarze zurbanizowanym w Szczecinie). Na podstawie wcześniejszych publikacji przygotowano tabelę syntetyczną, w której przedstawiono stałość fitosocjologiczną (S) i współczynniki pokrycia (D) gatunków wchodzących w skład analizowanych fitocenoz. Przeprowadzono analizę podobieństwa zbiorowisk, metodą UPGMA, z wykorzystaniem odległości euklidesowych na podstawie stałości fitosocjologicznej gatunków, przy użyciu pakietu Statistica PL. Wyliczono także współczynniki podobieństwa wyróżnionych fitocenoz metodą Sörensena, a uzyskane wyniki przedstawiono w postaci diagramu Czekanowskiego. Największe podobieństwo wg metody UPGMA wykazały zbiorowiska wykształcone w obrębie wyrobisk „Storkowo I" i „Storkowo II" oraz „Mielenko Drawskie". Są to fitocenozy w początkowym stadium sukcesji, charakteryzujące się wyraźną dominacją *Calamagrostis epigejos* (l.) Roth i małą liczbą gatunków (od 38 do 49 taksonów; średnio w zdjęciu od 10 do 15). Drugą grupę tworzą zbiorowiska reprezentujące dalsze stadia sukcesji w obrębie osadnika poflotacyjnego „Gilów" oraz dawno porzuconych wyrobisk „Krzynka" i „Szczecin-Żydowce". Fitocenozy te są zdecydowanie bogatsze florystycznie (liczba gatunków od 61 do 114; średnio w zdjęciu od 15 do 20), w związku z czym współczynnik pokrycia trzcinnika piaskowego jest dużo mniejszy. Najbardziej odmiennym biotopem jest obszar zurbanizowany w Szczecinie. Tutaj ze względu na lepsze warunki glebowe wykształciły się bogate fitocenozy, ze średnią liczbą 25 taksonów w zdjęciu i z małym pokryciem *Calamagrostis epigejos*.

Key words: biotopes, *Calamagrostietum epigeji*, *Calamagrostis epigejos*, urban area, industrial waste dump, pits.
Słowa kluczowe: biotopy, *Calamagrostietum epigeji*, *Calamagrostis epigejos*, obszar zurbanizowany, osadnik odpadów przemysłowych, wyrobiska.

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INTRODUCTION

The association *Calamagrostietum epigeji* represents grasses from the alliance *Epilobion angustifolii* commonly occurring in Poland in lowland forest clearing areas (Dzwonko and Loster 1996; Janyszek and Szczepanowicz-Janyszek 2003; Matuszkiewicz 2007). The phytocoenoses of this community grow in sandy areas and occur in clearings of dry coniferous forests and mixed forests from the alliance *Dicrano-Pinion*. They usually inhabit soils with acidic reaction and poor in total and mineral nitrogen (Wysocki and Sikorski 2002; Matuszkiewicz 2007). The systematic position of the association is has not been well defined. Matuszkiewicz (2007) reports that some authors regard it as a simple aggregation present in various associations and refute its rank of an association. Such aggregations have a dynamic value and a relatively stable composition and structure, thereby greatly inhibiting the processes of succession and forest regeneration. The author believes that they are equally valuable as simple associations, in which a dominant is considered as a characteristic species.

Calamagrostis epigejos is an expansive, grey-green perennial producing numerous stolons and a well-developed root system, which can penetrate the substrate. This contributes to the strong tendency of the plant to spread and colonise habitats through rapid and multi--directional growth of underground organs as well as abundant and efficient production of seeds (Brandes 1986; Rebele and Lehmann 2001; Balcerkiewicz 2002). Human activity is a factor that promotes the spread of *Calamagrostis epigejos* (Kopecký 1986). The grassy flora with the bushgrass plays an increasingly important role in landscapes affected by strong anthropopressure in urban areas (Kępczyński and Zienkiewicz 1974; Czaplewska 1980; Ziarnek 2003; Woźniak et al. 2007; Klera 2008; Kutyna and Nieczkowska 2009), industrial areas (Balcerkiewicz and Pawlak 1990; Błońska and Kompała 2005, Kutyna and Dziubak 2005; Dziubak 2011), railway embankments (Czaplewska 1981; Kazuń 2005; Kryszak et al. 2006), and roadsides (Wróbel 2004). *Calamagrostis epigejos* is found frequently and abundantly in ruderal communities, abandoned military training grounds and airfields (Kutyna and Młynkowiak 2003; Kutyna et al. 2008), fallow areas (Błońska et al. 2007; Jezierska-Domaradzka and Kuźniewski 2007; Podstawka-Chmielewska et al. 2007; Święs 2007; Węgrzynek et al. 2007; Zawieja and Wojciechowski 2012), and xerothermic grasslands (Friedrich and Semczyszyn 2002; Gamrat 2010; Towpasz et al. 2010; Kutyna and Malinowska 2012).

The aim of the present paper is was to determine the structure and floristic diversity of *Calamagrostietum epigeji* occurring in different biotopes (sand and gravel post-excavation pits, “Gilów” post-flotation waste dump, and an urban area in Szczecin). Based on the synthetic phytosociological table presenting the community, the degree of mutual similarity of the phytocoenon developing in the different habitats was determined.

MATERIAL AND METHODS

The basic material used for preparation and compilation of this paper included our earlier publications, which comprised analytical tables of the community *Calamagrostietum epigeji*. They were used for preparation of the synthetic Table 1, which presents the phytosociological constancy (S) and the cover coefficient (D) of species constituting the phytocoenoses of the different biotopes.

All publications that provided information about this association and its characteristic taxon are listed in the References and in Table 1. Analysis of the similarity of the community *Calamagrostietum epigeji* was carried out with the UPGMA method with Euclidean distances based on phytosociological constancy of the species using the STATISTICA PL package (1984–1985). Similarity coefficients were also calculated for the analysed phytocoenoses with the Sörensen method and the results were presented in Czekanowski's diagram (Dzwonko 2007). Names of taxa are given according to Mirek et al. (2002) and syntaxons after Matuszkiewicz (2007).

RESULTS

The phytocoenoses of the association *Calamagrostietum epigeji* can be found in different biotopes. They inhabit the reclaimed sand and gravel post-excavation pits, the "Gilów" post-flotation waste dump, and ruderal communities in urban areas. The characteristic species for this association, *Calamagrostis epigejos*, is a constant component of the community (S = V) and its cover coefficients (D) are varied and range from 542 (urban areas) to 8750 ("Storkowo I" pit) – Table 1. This large range of the D values is related to the different ecological (primarily soil) conditions prevailing in the analysed biotopes. The cover coefficient exhibited substantially higher values on sandy soils (loose sand and slightly loamy sand) and gravel soils (D ranging from 3026 to 8750) than on cohesive soils (light and medium clays, dusty soils and silt), where it achieved lower values of D, i.e. from 542 to 2789 (Table 1). Both types of soils on which the phytosociological relevés were made had alkaline or neutral pH. Calcium carbonate was detected in all the soils and its content varied between the different biotopes (Table 1).

In total, 232 taxa were noted in the association *Calamagrostietum epigeji*, with more than half of the number (121 species) exhibiting constancy class I. This implies high heterogeneity of the floristic composition of the individual phytocoenoses of this association. Many species accidentally colonise community biochores. They represent different phytosociological classes and increase the floristic diversity of the community but do not determine its physiognomy. The greatest number of species represent the class *Molinio-Arrhenateretea* – 50 taxa and *Artemisietea vulgaris* – 44 taxa.

The number of species in the individual communities is highly varied and ranges from 38 in the habitats of the "Storkowo II" pit to 114 in the "Gilów" post-flotation waste dump (Table 2). The inconsiderable number of species within the former biotope is limited by the strong dominance of *Calamagrostis epigejos* in the community. Its cover coefficient reaches a maximum value of 8750. Consequently, it inhibits the development and growth of many other species, which otherwise, in the absence of dominance of one taxon in an area, have an opportunity to develop in a community.

The floristic diversity in the *Calamagrostietum epigeji* phytocoenoses is confirmed by similarity coefficients calculated using the Sörensen method and presented in Czekanowski's diagram (Fig. 1).

Table 1. *Calamagrostietum epigeji* community within ecologically diverse biotopes
Tabela 1. Zbiorowisko *Calamagrostietum epigeji* w obrębie ekologicznie zróżnicowanych biotopów

Biotops Biotopy	Urban area in Szczecin Obszar zurbanizowany w Szczecinie (Kutyna and Nieczkowska 2009)	„Gilów" post–waste dump Osadnik poflotacyjny "Gilów" (Kutyna and Dziubak 2005)	Pit – Wyrobisko				
			Szczecin "Żydowce" (Kutyna et al. 2010)	"Krzynka" (Kutyna et al. 2013)	"Mielenko Drawskie" (Młynkowiak et al. 2009)	"Storkowo I" (Kutyna et al. 2011)	"Storkowo II" (Młynkowiak et al. 2010)
Number of phytosociological relevés Liczba zdjęć fitosocjologicznych	12	39	13	19	10	12	11
Average plant cover on the analysed area Średnie pokrycie roślin na badanej powierzchni [%]	87	68	94	81	88	87	91
Mean numer of species in relevé Średnia liczba gatunków w zdjęciu fitosocjologicznym	25	15	19	20	15	14	10
Number of species in the community Liczba gatunków w zbiorowisku	96	114	76	61	49	43	38
Soils Jednostki glebowe	pgl, pgm, pgmp, glp, płz	pl, psp, płz, gs, i	gl·gs,pglp·glp, płz·glp	pl	pl, żp, ps	pl	ps
pH in H_2O pH w H_2O	7.2–8.2	7.0–8.5	7.5–8.5	7.9	7.6–8.2	7.0	7.6–8.2
pH in 1 M KCl pH w 1 M KCl	7.1–8.1	6.2–8.1	7.0–8.0	7.5	7.0–8.0	6.2	7.0–8.0
$CaCO_3$ content Zawartość $CaCO_3$ [%]	0.4–6.7	0.1–35.5	strongly effervescent with HCl silnie burzy z HCl	1.2	strongly effervescent with HCl silnie burzy z HCl	effervescent with HCl burzy z HCl	strongly effervescent with HCl silnie burzy z HCl
	S D	S D	S D	S D	S D	S D	S D
	A	B	C	D	E	F	G
ChAss. *Calamagrostietum epigeji*							
Calamagrostis epigejos	V 542	V 3412	V 2769	V 3026	V 6375	V 6250	V 8750

Table 1. *Calamagrostietum epigeji* community within ecologically diverse biotopes (cont.)
Tabela 1. Zbiorowisko *Calamagrostietum epigeji* w obrębie ekologicznie zróżnicowanych biotopów (cd.)

	S	D	S	D	S	D	S	D	S	D	S	D	S	D
	A		B		C		D		E		F		G	
I ChCl. *Epilobietea angustifolii*														
Betula pendula c	I	8	III	376	I	135	II	150						
Verbascum nigrum			I	5			IV	318						
Fragaria vesca			I	10	II	150								
Centaurium erythrae subsp. *erythraea*			II	93										
Chamaenerion angustifolium B (3); *Holcus mollis* E (10); *Populus tremula* c B(33), F(8); *Rubus idaeus* B (3); *Salix caprea* c B(5), E(10); *Sarothamnus scoparius* B(45)														
II ChCl. *Artemisietea vulgaris*														
Achillea millefolium D	III	188	III	322	III	169	IV	182	IV	70	III	213	IV	209
Artemisia vulgaris	III	142	I	10	III	54	IV	195	III	140	IV	304	IV	323
Hypericum perforatum D	II	204	III	33	II	69	V	147	I	10	II	25	IV	64
Daucus carota D	III	142	III	64	I	7	III	11	III	50	III	42	I	9
Melandrium album	I	8	I	3	II	38	III	47	I	20	I	8	III	55
Cirsium arvense	III	133	I	28	IV	250	II	229	I	10	I	154		
Tanacetum vulgare	IV	792	I	10	II	54			I	10				
Oenothera biennis	I	8			I	46	II	32	II	30	I	8	I	18
Echium vulgare	I	17	I	5	II	31	I	21	II	40				
Rubus caesius	II	508	I	56	IV	2081								
Galium aparine	II	58	I	3	II	150								
Melilotus alba	I	17	I	15	I	46	I	11						
Solidago gigantea			I	62	IV	1673					I	42		
Urtica dioica	II	204	I	3	II	181								
Berteroa incana	I	50			II	69	I	26					II	27
Erigeron ramosus							I	21	IV	120	V	183	III	82
Artemisia absinthium									I	20	II	33	III	382
Veronica chamaedrys D	II	238			I	7	I	11						
Medicago lupulina D	II	133	I	3										
Picris hieracioides	IV	608												
Solidago canadensis	III	279												
Cichorium intybus	II	133												

Table 1. *Calamagrostietum epigeji* community within ecologically diverse biotopes (cont.)
Tabela 1. Zbiorowisko *Calamagrostietum epigeji* w obrębie ekologicznie zróżnicowanych biotopów (cd.)

	S	D	S	D	S	D	S	D	S	D	S	D	S	D
	A		B		C		D		E		F		G	
Capsella bursa-pastoris D	II	58												
Linaria vulgaris					I	15	II	42						
Melilotus officinalis			I	26					II	40				
Epilobium montanum			II	41										
Aegopodium podagraria D A(42); *Anthriscus sylvestris* A(42); *Arctium lappa* A(50); *Armoracia rusticana* A(8); *Aster novi-belgii* C(38); *Carduus crispus* C(38), F(8); *Chaerophyllum temulum* B(3); *Cirsium vulgare* B(8); *Erysimum cheiranthoides* A(17); *Geranium robertianum* D(5); *Geum rivale* D A(8); *Glechoma hederacea* A(146); *Lamium maculatum* D A(8); *Medicago sativa* B(3), C(7); *Reseda lutea* A(8), B(45); *Saponaria officinalis* C(488); *Torilis japonica* A(8), D(11); *Viola odorata* A(42)													
III ChCl. *Stellarietea mediae*														
Conyza canadensis	I	42	I	10			III	53			III	42	I	18
Lamium purpureum	II	133			II	115								
Bromus tectorum					II	431	I	5			I	8	I	205
Sisymbrium loeselii	I	50			I	46	I	11						
Arabidopsis thaliana	II	58	I	8										
Stellaria media	II	404	I	18										
Vicia sativa	II	238												
Fallopia convolvulus							II	47						
Crepis tectorum											IV	67	I	9
Apera spica-venti											III	42		
Vicia angustifolia											II	25	II	36
Anagallis arvensis B(3); *Anchusa arvensis* G(9); *Anthemis arvensis* B(8); *Aphanes arvensis* F(42); *Atriplex tatarica* D(21); *Centaurea cyanus* G(9); *Chamomilla recutita* A(8); *Chenopodium album* A, C(7); *Echinochloa crus-galli* D(5); *Geranium pussilum* A(42), G(9); *Lactuca serriola* C(7); *Lapsana communis* A(8); *Matricaria maritima* subsp. *inodora* A(8), B(5), F(8); *Myosotis arvensis* A(8); *Papaver dubium* G(9); *Sisymbrium officinale* A(42); *Sonchus arvensis* D A(17), C(7), D(5); *Veronica hederifolia* A(8); *Vicia hirsuta* A(313), D(37), F(50), G(55); *V. tetrasperma* A(154), B(76); *V. villosa* G(9); *Viola arvensis* A(42), F(8), G(9)													
IV ChCl. *Molinio-Arrhenatheretea*														
Festuca rubra	IV	233	II	191	II	258	I	211	I	60			II	182
Dactylis glomerata	III	75	I	18	IV	185			III	50	I	8	II	27
Arrhenatherum elatius	I	8	I	3	V	277	I	32	IV	75	II	133	III	27
Poa pratensis	III	533	I	192	II	85			III	1195				
Holcus lanatus	III	254	I	15	I	481					IV	333		
Rumex acetosa	II	196	IV	140	II	258	I	5	II	70				
Taraxacum officinale	IV	1233			I	7	I	97			I	8	II	27
Potentilla reptans	IV	1467	I	45	II	150								

Table 1. *Calamagrostietum epigeji* community within ecologically diverse biotopes (cont.)
Tabela 1. Zbiorowisko *Calamagrostietum epigeji* w obrębie ekologicznie zróżnicowanych biotopów (cd.)

	S	D	S	D	S	D	S	D	S	D	S	D	S	D
	A		B		C		D		E		F		G	
Vicia cracca	III	629			IV	130								
Plantago lanceolata	IV	175	I	3	I	173	I	5						
Galium mollugo					II	381	I	37	IV	239				
Trifolium pratense	III	254	I	3										
Trifolium repens	III	254	I	3										
Poa trivialis	III	213					I	26						
Agrostis stolonifera subsp. *stolonifera*	II	92	I	60										
Lathyrus pratensis	II	67			I	46								
Cerastium holosteoides	II	58	I	26										
Plantago major	II	58	I	3										
Alopecurus pratensis	II	25												
Campanula patula	II	25									I	8		
Festuca pratensis	I	48			II	219								
Carex hirta	I	48	I	18	II	62								
Bromus hordeaceus											II	25		
Leucanthemum vulgare													II	36
Agrostis gigantea B(60); *Bellis perennis* A(83); *Cardamine pratensis* A(83); *Centaurea jacea* B(5); *Crepis biennis* D(26); *Deschampsia caespitosa* A(50), C(15); *Festuca arundinacea* B(47); *Heracleum sibiricum* C(7); *Juncus compressus* B(3); *J. conglomeratus* B(195); *J. effusus* B(100); *Knautia arvensis* E(10), G(9); *Leontodon autumnalis* A(8), B(3); *L. hispidus* D(92); *Lolium perenne* A(50); *Lotus corniculatus* B(5), E(550); *Lychnis flos-cuculi* A(8); *Lythrum salicaria* B(3); *Pastinaca sativa* C(38); *Phleum pratense* B(5); *Poa annua* B(45); *Ranunculus acris* subsp. *acris* A(17); *R. repens* A(154); *Rumex crispus* A(8), E(10); *Tragopogon pratensis* D(5)													
V ChCl. *Agropyretea intermedio-repentis*														
Equisetum arvense	III	158	I	88	I	38	I	11	II	70			I	9
Convolvulus arvensis	I	8			II	54	III	105	I	20			I	91
Elymus repens	III	904			II	54								
Tussilago farfara			II	197					I	10			I	9
Bunias orientalis					II	496								
Falcaria vulgaris					II	38								
Bromus inermis C(38), D(21)														
VI ChCl. *Vaccinio-Piceetea*														
Ajuga reptans	III	25												

Table 1. *Calamagrostietum epigeji* community within ecologically diverse biotopes (cont.)
Tabela 1. Zbiorowisko *Calamagrostietum epigeji* w obrębie ekologicznie zróżnicowanych biotopów (cd.)

	S	D	S	D	S	D	S	D	S	D	S	D	S	D
	A		B		C		D		E		F		G	
VII ChCl. *Koelerio glaucae-Corynephoretea canescentis*														
Helichrysum arenarium	I	146	I	28	I	135			II	30	III	92	I	9
Rumex acetosella	I	8	I	13	I	15	I	5			IV	200	I	9
Trifolium arvense			I	5	I	15	III	47	IV	200	V	1517		
Ceratodon purpureus d			III	114					II	200	III	771		
Brachythecium albicans d			I	15							III	396	I	159
Hypochoeris radicata			I	5			V	850			I	8		
Jasione montana							IV	137	I	10	III	58		
Sedum acre					I	288	I	53	II	30				
Filago arvensis							II	213			IV	108		
Potentilla argentea			I	53	I	7	III	132	II	30				
Solidago virgaurea					III	365			IV	200				
Festuca ovina			I	78	I	7			II	80				
Senecio vernalis			I	13									III	82
Thymus serpyllum							II	79						
Cerastium semidecandrum B(3); *Erophila verna* A(8); *Scleranthus perennis* F(42); *Trifolium campestre* A(48), D(21), *Viola tricolor* B(3)														
VIII ChCl. *Nardo-Callunetea*														
Hieracium pilosella			I	38	I	7	IV	547	I	50	I	42		
Agrostis capillaris A(17), B(31), E(10), F(32); *Calluna vulgaris* B(3); *Pseudoscleropodium purum* d A(146); *Viola canina* B(3)														
IX ChCl. *Rhamno-Prunetea*														
Rosa canina c					II	31	III	95	I	20				
Crataegus monogyna c			I	3	II	23								
Ligustrum vulgare c C(7); *Rubus plicatus* c C(7); *Sorbus aucuparia* c A(8)														
X ChCl. *Festuco-Brometea*														
Artemisia campestris			II	70	I	142	IV	450	IV	110			I	45
Euphorbia cyparissias			II	99	II	573								
Centaurea stoebe			I	3	II	181								
Dianthus carthusianorum							II	79						
Anthyllis vulneraria E(20); *Carlina vulgaris* B(10), D(129); *Centaurea scabiosa* E(10); *Poa compressa* G(45); *Potentilla arenaria* F(8)														

Table 1. *Calamagrostietum epigeji* community within ecologically diverse biotopes (cont.)
Tabela 1. Zbiorowisko *Calamagrostietum epigeji* w obrębie ekologicznie zróżnicowanych biotopów (cd.)

	S	D	S	D	S	D	S	D	S	D	S	D	S	D
	A		B		C		D		E		F		G	
XI ChCl. *Phragmitetea*														
Phragmites australis			II	41										
Carex elata B(13); *Phalaris arundinacea* C(38)														
XII ChCl. *Alnetea glutinosa*														
Salix cinerea c			II	13							I	8		
XIII ChCl. *Vaccinio-Piceetea*														
Pinus sylvestris c			III	614			V	724	III	50				
XIV Accompanying species − Gatunki towarzyszące														
Senecio vulgaris	II	92			I	7								
Erigeron annuus	II	58	I	31										
Veronica arvensis	II	25												
Bryum caespiticum d			IV	320										
Robinia pseudoacacia c			II	154			I	118						
Funaria higrometrica d			II	111										
Sedum maximum					II	23								
Cerasus vulgaris c					II	23								
Pyrus communis c					II	23								
Lupinus polyphyllus									I	30			IV	73
Senecio jacobaea			I	5			I	11	II	30	I	8		
Arenaria serpyllifolia							I	16					II	477
Alyssum alyssoides E(10); *Brachythecium rutabulum* d B(13); *Campanula rotundifolia* B(3); *Carex ovalis* B(3); *Cladonia* sp. d B(191); *Erigeron acris* B(3); *Erodium cicutarium* A(8), D(11); *Eurhynchium schleicheri* d B(8); *Frangula alnus* c B(3); *Lathyrus sylvestris* E(10); *Myosotis stricta* B(10); *Padus avium* c B(15); *Pleurozium schreberi* d E(20); *Polygonum persicaria* B(3); *Prunus spinosa* c D(5); *Silene vulgaris* B(3); *Verbascum thapsus* B(3)														
ChCl. *Scheuchzerio-Caricetea nigrae*: *Carex nigra* B(2); *Juncus articulatus* B(18). **ChCl. *Trifolio-Geranietea sanguinei*:** *Agrimonia eupatoria* C(7), E(20); *Astragallus glycyphyllos* C(7), F(42). **ChCl. *Salicetea purpurea*:** *Populus alba* c B(33); *P. nigra* c B(8); *Salix purpurea* c B(18); *S. viminalis* c D(37). **ChCl. *Querco-Fagetea*:** *Alnus glutinosa* c B(3); *Dryopteris filix-mas* C(142); *Fraxinus excelsior* c D(11); *Poa nemoralis* B(65); *Quercus petraea* c B(5); *Q. robur* c B(15), E(20)														

Notes: S – phytosociological constancy, D – cover coefficient. Species listed under phytosociological classes occur exclusively in constancy class I. A respective column for each species is provided (A, B, C, D, E, F, or G); the cover coefficient value in parentheses.
Objaśnienia: S – stałość fitosocjologiczna, D – współczynnik pokrycia. Gatunki wymienione pod klasami fitosocjologicznymi występują wyłącznie w I stopniu stałości. Przy każdym gatunku podano kolumnę (A, B, C, D, E, F lub G), w której występuje, w nawiasie – wartość współczynnika pokrycia.

Table 2. Number of species according to constancy classes in the *Calamagrostietum epigeji* community within the different biotopes
Tabela 2. Liczba gatunków w stopniach stałości w zbiorowisku *Calamagrostietum epigeji* w obrębie różnych biotopów

Biotopes Biotopy	Constancy classes – Stopnie stałości				
	IV, V	III	II	I	total razem
"Gilów" post-flotation waste dump Osadnik poflotacyjny "Gilów"	3	6	10	95	114
Urban area in Szczecin Obszar zurbanizowany w Szczecinie	7	15	22	52	96
"Szczecin-Żydowce" post-excavation pit Wyrobisko "Szczecin-Żydowce"	7	3	28	38	76
"Krzynka" post-excavation pit Wyrobisko "Krzynka"	10	7	8	36	61
"Mielenko Drawskie" post-excavation pit Wyrobisko "Mielenko Drawskie"	8	5	11	25	49
"Storkowo I" post-excavation pit Wyrobisko "Storkowo I"	8	8	5	22	43
"Storkowo II" post-excavation pit Wyrobisko "Storkowo II"	5	5	7	21	38

Biotopes Biotopy	"Gilów" post-flotation waste dump Osadnik poflotacyjny "Gilów"	"Szczecin Żydowce" post-excavation pit Wyrobisko "Szczecin-Żydowce"	Urban area in Szczecin Obszar zurbanizowany w Szczecinie	"Mielenko Drawskie" post-excavation pit Wyrobisko "Mielenko Drawskie"	"Krzynka" post-excavation pit Wyrobisko "Krzynka"	"Storkowo I" post-excavation pit Wyrobisko "Storkowo I"	"Storkowo II" post-excavation pit Wyrobisko "Storkowo II"
"Gilów" post-flotation waste dump Osadnik poflotacyjny "Gilów"	x	**69**	**67**	**65**	**61**	**61**	56
"Szczecin-Żydowce" post-excavation pit Wyrobisko "Szczecin-Żydowce"	**69**	x	**64**	**62**	**61**	55	55
Urban area in Szczecin Obszar zurbanizowany w Szczecinie	**67**	**64**	x	50	55	52	53
"Mielenko Drawskie" post-excavation pit Wyrobisko "Mielenko Drawskie"	**65**	**62**	50	x	58	54	55
"Krzynka" post-excavation pit Wyrobisko "Krzynka"	**61**	**61**	55	58	x	54	55
"Storkowo I" post-excavation pit Wyrobisko "Storkowo I"	**61**	55	52	54	54	x	**66**
"Storkowo II" post-excavation pit Wyrobisko "Storkowo II"	56	55	53	55	55	**66**	x

65–70% 60–64% 50–59%

Fig. 1. Diagram of the ecological similarity of *Calamagrostietum epigeji* phytocoenoses distinguished within the different biotopes
Rys. 1. Diagram ekologicznego podobieństwa fitocenoz *Calamagrostietum epigeji* wyróżnionych w obrębie zróżnicowanych biotopów

The mutual similarity is not high. Higher mutual similarity (67–69%) is exhibited by the communities developing on clay, dusty, and silty soils in the "Gilów" post-flotation waste dump, "Szczecin-Żydowce" pit, and the urban area in Szczecin. In turn, lower values (in the range from 50 to 65%) are exhibited by the phytocoenoses developing on the soils formed on sands and gravels in the other pits. The highest floristic similarity (66%) among the communities present within the pits was noted between the phytocoenoses of "Storkowo I" and "Storkowo II". Despite the small distance between these communities and a similar particle size distribution of the substrates of both biotopes, the communities do not exhibit considerable floristic similarity. The relatively low mutual similarity of the phytocoenoses of the other pits is associated with their labile floristic composition. The communities are undergoing an initial phase of formation of a stable structure and, at this level of organisation of the phytocoenoses, high species diversity can be observed in their structure. This is a typical phenomenon in the process of ecological succession. This is also confirmed by the number of species representing each constancy class (Table 2). There a few constant (S = V) and very frequent (S = IV) species in the communities. The number of taxa in the communities of the biotopes does not exceed 10. They mainly represent the class *Molinio-Arrhenateretea* and *Artemisietea vulgaris*.

The highest similarity was shown by UPGMA (Fig. 2) between the communities developed within the "Storkowo I and II" pits and in "Mielenko Drawskie".

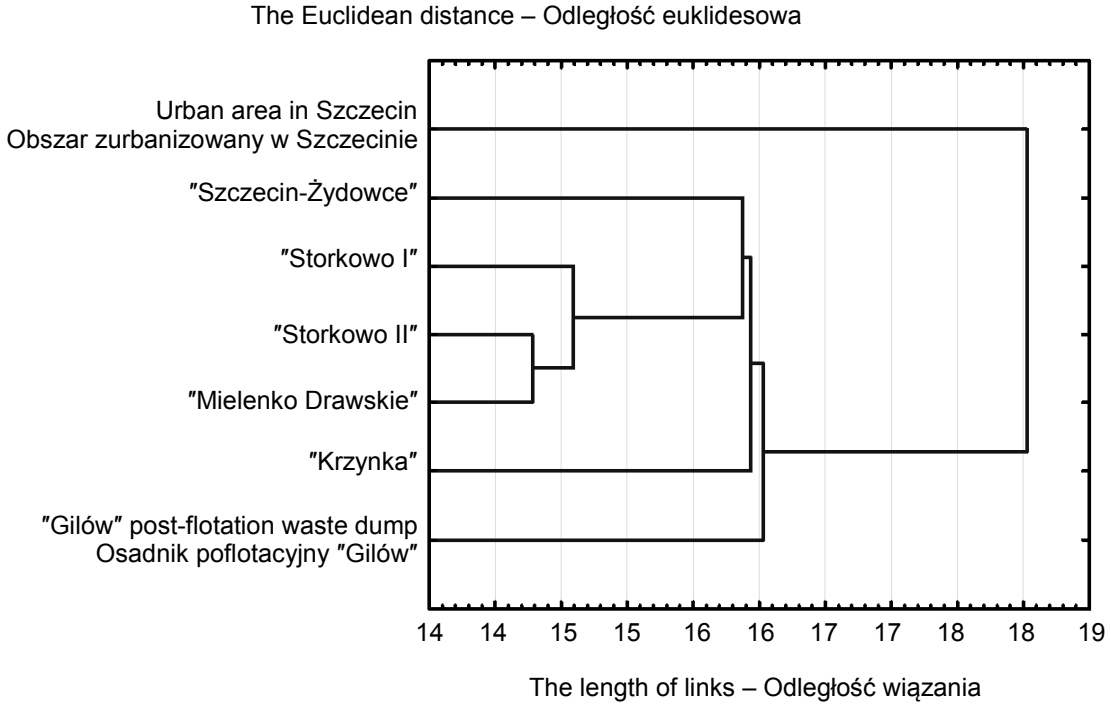

Fig. 2. Dendrogram of the similarity of *Calamagrostietum epigeji* phytocoenoses distinguished within the different biotopes
Rys. 2. Dendrogram podobieństwa fitocenoz *Calamagrostietum epigeji* wyróżnionych w obrębie zróżnicowanych biotopów

These phytocoenoses undergoing the initial stage of succession are characterised by clear dominance of *Calamagrostis epigejos* and a low number of species (from 38 to 49 taxa, on average from 10 to 15 per relevé). The other group includes communities representing later stages of succession and located within the "Gilów" post-flotation waste dump and the long abandoned "Krzynka" and "Szczecin Żydowce" pits. These phytocoenoses exhibit clearly higher floristic richness (from 61 to 114 species, on average from 15 to 20 per relevé); hence, the cover coefficient of the bushgrass is substantially lower. The urban area in Szczecin is the most diverse biotope. It is characterised by good soil conditions of the substrate, which has been covered by organic soils containing numerous diaspores of species from meadow communities. This resulted in development of rich phytocoenoses in this area characterised by a mean number of 25 taxa per relevé and a low cover of *Calamagrostis epigejos.*

In the urban area, species from the classes *Artemisietea vulgaris* and *Molinio--Arrhenateretea* have a considerable share in the structure of the association. From the class *Artemisietea vulgaris*, two species *Tanacetum vulgare* and *Picris hieracioides* exhibited the highest frequency of occurrence (S = IV) and the greatest abundance (Table 1). These taxa either do not occur or are sporadic in the phytocoenoses of the other biotopes (Table 1). Irrespective of the soil conditions, species from the class *Artemisietea vulgaris*: *Achillea millefolium* and *Artemisia vulgaris* occur frequently within each biotope. The class *Molinio-Arrhenetheretea* is often represented by *Festuca rubra* in the phytocoenoses of the community. Similarly, irrespective of the soil conditions, *Taraxacum officinale* and *Dactylis glomerata* occur abundantly. They are typical species of semi-natural communities and their considerable cover and frequent occurrence in the phytocoenoses of the urban areas is related to land reclamation that was carried out after completion of construction work. These disturbed areas were covered by an organic-muck and peat soil substrate mixed with mineral soils. Meadow soils contain numerous diaspores, i.e. vegetative organs that have been introduced in these areas during the reclamation work. Consequently, the species of ruderal communities (*Artemisietea vulgaris*) are accompanied by a variety of species of meadow communities (*Molinio-Arrhenetheretea*). Additionally, *Potentilla reptans*, *Plantago lanceolata*, *Vicia cracca*, and *Rumex acetosa* occur relatively often on the cohesive soils (clay, dust, and silt) (Table 1). *Rubus caesius* and *Solidago gigantea* also occur on these soils very frequently and abundantly. The communities inhabiting the soils formed of sands and sandy gravel ("Storkowo I" and "II", "Mielenko Drawskie", and "Krzynka") often comprised *Holcus lanatus*, *Galium mollugo*, and *Arrhenaterum elatius* from the class *Molinio-Arrhenetheretea* and *Erigeron ramosus* and *Artemisia absinthium* from *Artemisietea vulgaris* (Table 1). They were accompanied by abundant species from the class *Koelerio glaucae-Corynephoretea canescentis*, with *Trifolium arvense*, *Solidago virgaurea*, *Rumex acetosella*, *Filago arvensis*, *Hypochoeris radicata*, and *Helichrysum arenarium* noted most frequently (S = III–V). These biochores are often colonised by bryophytes, e.g. *Brachythecium albicans* and *Ceratodon purpureus*.

The class *Agropyretea intermedio-repentis* is mainly represented by three species: *Elymus repens*, *Equisetum arvense*, and *Convolvulus arvensis*. They are mainly found in the association on clayey soils and less frequently in the phytocoenoses on the sandy soils.

There are many representatives of other phytosociological classes, but they usually reach constancy class I and low cover coefficients. The most frequent of these are *Hieracium pilosella* (*Nardo-Callunetea*) and *Rosa canina* (*Rhamno-Prunetea*). The class *Festuco-Brometea* is represented by the largest number of taxa (9) with *Artemisia campestris* noted most frequently, usually in the post-excavation pits on sandy soils. Seeds of the Scots pine (*Pinus sylvestris*) were frequently found within the communities covering the sandy soils. The development of the species initiates succession yielding a forest community in future.

DISCUSSION

The presented investigation results indicate a heterogeneous floristic composition of the association *Calamagrostietum epigeji*. Similar conclusions were drawn by Ratyńska (2001) in her research of communities with *Calamagrostis epigejos* in areas that are flooded every several years. The author reported single occurrence of as many as 70% of species.

Calamagrostis epigejos is common in different biotopes. Fudali and Pilczuk (1998) found a community with *Calamagrostis epigejos* on phosphogypsum waste heaps of the "Police" Chemical Plant. Patches with dominant bushgrass develop both along the tops of the phosphogypsum waste heaps and on their slopes. The number of species per relevé ranges from 8 (on "young" waste heaps) to 23 (on "older" ones). *Calamagrostis epigejos* is a constant component of the community (S = V) and reaches a high cover coefficient (D = 4300). The classes *Molinio-Arrhenetheretea* (12 taxa) and *Artemisietea vulgaris* (9 species) are numerously represented in the community. Comparison of the structure of this community and the floristic composition of the analysed associations *Calamagrostietum epigeji* revealed similar floristic structures of these phytocoenoses. The community developing on the waste heaps is dominated by *Vicia cracca*, *Artemisia vulgaris*, and *Tanacetum vulgare*, which were characterised by frequent occurrence in the structure of the communities analysed in this study.

Calamagrostis epigejos has been frequently noted by many researchers in post-industrial areas (dumps, post-flotation waste sites, iron and coal smelting waste heaps, and sand pits). Balcerkiewicz and Pawlak (1990) described a community with this species in the area of the Konin Brown Coal Basin. They formulated a thesis that this is the most constant vegetation formation in the industrial landscape. Błońska and Kompała (2005) regarded the association *Rubo-Calamagrostietum* dominated by the bushgrass (S = V, D = 8333) as the most prevalent in the area of the Upper Silesian Industrial District. Trzcińska-Tacik (1966) noted occurrence of *Calamagrostis epigejos*, which sometimes formed compact canopies (abundance scale 4–5), on the slopes of Cracow Soda Works waste dumps. The author considered it as an advanced succession stage on the dry tops of the heaps. In total, she recorded 40 species (including 7 moss species) in the patches. Patrzałek et al. (2012) found that two taxa *Calamagrostis epigejos* and *Solidago* sp. dominated in a plant community comprising 42 species growing on technically and biologically reclaimed mine waste heaps of the Sośnica mine in Zabrze. Among 143 vascular plant species recorded on nine iron--smelting waste heaps located in the Katowice Province, Krzaklewski (1986) noted the highest frequency of occurrence for *Calamagrostis epigejos*. In the oldest parts of the analysed areas, the author distinguished the *Calamagrostis epigejos – Betula pendula* stage,

and the bushgrass achieved constancy class V and a substantial cover value (D = 2729) in the community. Similarly, Dziubak (2011) found that *Calamagrostis epigejos* very frequently and abundantly colonised the slopes of the functioning "Żelazny Most" post-flotation waste dump. In *Calamagrostietum epigeji*, it reached constancy class V and a considerable cover value D = 4934. Cabała and Sypień (1987) determined the composition of the vegetation cover on five waste dumps of the Upper Silesian Industrial District (around Zabrze). They distinguished three types of communities: herbaceous vegetation on the slopes, scrub-shrub vegetation on flat surfaces, and forest vegetation on elevated areas. *Calamagrostis epigejos* inhabited all these communities: as a dominant in the former two and a co-dominant in the forest communities, together with *Betula pendula* reaching the highest cover values in these phytocoenoses. In total, the species reached S = V and D = 2785 in all the communities.

Other biotopes that are abundantly overgrown by *Calamagrostietum epigeji* phytocoenoses is sand, gravel, and marl post-excavation areas. Błońska et al. (2003) noted spontaneous encroachment of *Calamagrostis epigejos* into an area of filling sand post-excavation pits. In the area of the Szczakowa Sand Mine, Woch (2007) distinguished five stages of succession (encroachment of vegetation, turf formation, shrub development, formation of groups, and afforestation). *Calamagrostis epigejos* was present in all the phytocoenoses, but it was noted most frequently and abundantly in the older succession stages.

Klera (2008) described the community *Calamagrostietum epigeji* and its variants developing on tram tracks and roadsides in Szczecin. The author distinguished two variants of the association – a typical one and an association with *Convolvulus arvensis*. The patches of the typical variant were characterised by a substantial cover value of the bushgrass (D = 8214). Species dominance in the patch led to reduction of the number of species in the community. The structure of the association was relatively poor (6–13 taxa, on average 9). *Calamagrostis epigejos* was quite abundant (D = 7500) in the patches of the variant with *Convolvulus arvensis. Convolvulus arvensis* was relatively abundant as well (D = 1045). As reported by the author, within the tram infrastructure, the phytocoenon is related to considerably sloping sites; as many as 65% of all patches were noted on slopes with average inclination of 40º. Additionally, most of the slopes were characterised by SW, S, and SE exposure, which confirms the high demand of the bushgrass for light and heat.

Ziarnek (2003) observed phytocoenoses with *Calamagrostis epigejos* in Szczecin growing in vast areas of ruderal wasteland, tracksides, managed spaces between tracks and railway embankments, as well as meadows, drying up peatland edges, and a waterlogged wasteland. *Calamagrostis epigejos* was a constant component of these communities (S = V) and reached a substantial cover coefficient (D = 7171).

CONCLUSIONS

1. *Calamagrostis epigejos* inhabits different biotopes (post-flotation waste dumps, sand mines, and urban areas).
2. As a characteristic species of the association *Calamagrostietum epigeji*, *Calamagrostis epigejos* most frequently (S = V) and most abundantly occurs within the sand and gravel post-excavation pits in: "Storkowo I" and "Storkowo II" (D = 6250–8750), "Mielenko Drawskie"

(D = 6375), and "Szczecin-Żydowce" (D = 4071). It reaches a lower cover coefficient in the post-industrial areas ("Gilów" post-flotation waste dump) and in the urban area in Szczecin.

3. The floristic composition of the *Calamagrostietum epigeji* phytocoenoses is varied, which is confirmed by the values of the mutual similarity coefficients in the compared communities.
4. The important factors determining the floristic composition of *Calamagrostietum epigeji* include soil conditions (particle size distribution, in particular) and the stage of succession taking place in the phytocoenosis.
5. On the cohesive soils (clay and dust), species from the classes *Artemisietea vulgaris* and *Molinio-Arrhenatheretea* are dominant, while a considerable proportion of taxa from the class *Koelerio glaucae-Corynephoretea canescentis* is additionally noted on the sandy soils.
6. The "young" phytocoenoses developing on the sandy soils are clearly dominated by the bushgrass, which is accompanied by a low number of species per relevé. In older communities on the cohesive soils, *Calamagrostis epigejos* reaches lower cover coefficients and there is a great number of species per relevé.

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Abstract. The aim of the present paper was to determine the structure and floristic diversity of *Calamagrostietum epigeji* occurring within different biotopes (sand and gravel post-excavation pits, “Gilów” post-flotation waste dump, and an urban area in Szczecin). Based on previous publications, a synthetic table was compiled to present the phytosociological constancy (S) and cover coefficient (D) of species occurring in the analysed phytocoenoses. Analysis of the similarity between the communities was performed with the UPGMA method and Euclidean distances on the basis of species phytosociological constancy using the Statistica PL package. Similarity coefficients were also calculated for the distinguished phytocoenoses with the Sörensen method and the results were presented in Czekanowski’s diagram. As revealed by the UPGMA method, the greatest similarity was exhibited by communities developing within the “Storkowo I” and “Storkowo II” pits and in the “Mielenko Drawskie” pit. These phytocoenoses, which are undergoing the initial succession stage, are characterised by distinct dominance of *Calamagrostis epigejos* and a low number of species (from 38 to 49 taxa, on average from 10 to 15 per relevé). The other group comprises communities representing later stages of succession from the “Gilów” post-flotation waste dump and the long abandoned “Krzynka” and “Szczecin-Żydowce” pits. These phytocoenoses exhibit substantially higher floristic richness (from 61 to 114 species, on average from 15 to 20 per relevé); hence, the cover coefficient of the bushgrass is considerably lower. The urban area in Szczecin is the most diverse biotope, in which, due to the more favourable soil conditions, rich phytocoenoses characterised by a mean number of 25 taxa per relevé and a low cover of *Calamagrostis epigejos* have developed.