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THE INFLUENCE OF HABITAT CONDITIONS ON DEVELOPING AND FLORISTIC CHARACTER OF *ARRHENATHERETUM ELATIORIS* COMMUNITY SYNTAXONS IN THE FLINTA VALLEY (CENTRAL POLAND)

Summary

Differentiation of habitat conditions results in the development of areas of ryegrass grasslands of significant floristic variation and provides a basis for the distinction of lower phytosociological units. The paper contains a floristic characteristic of Arrhenatheretum elatioris syntaxons regarding their habitats. The aim of the study was a detailed characteristic of habitats including their phytosociological as well as soil properties. The analysis of 44 phytosociological relevés of ryegrass grasslands areas enabled a comparison of their botanical and phytosociological structures as well as of their floristic diversity. Three subassociations were found in it: Arrhenatheretum elatioris typicum, Arrhenatheretum elatioris ranunculetosum repentis and Arrhenatheretum elatioris dactylidosum glomeratae. Furthermore, the paper contains a detailed description and interpretation of soil conditions. Two soil profiles were performed in mucky soils (Mollic Gleysols). In the samples collected from various genetic horizons, such properties were marked: pH, the content of carbon and total nitrogen, calcination loss, texture, soil density and particle density, total and drainage porosity, hygroscopic moisture and maximum hygroscopic capacity, potential of water bonding in soil and its total and readily available waters, total retention and filtration ratio. The examined soils were rich in organic matter and light texture of mineral endopedones which determined their high total porosity. Drainage porosity and filtration ratio were balanced and high, which gave good conditions for natural drainage. Water capacities, at each water bonding potential, were of similar characteristics to soils of similar texture.
***Key words**: habitat, floristic composition, soil properties, Mollic Gleysols*

WPŁYW WARUNKÓW SIEDLISKOWYCH NA WYKSZTAŁCENIE SIĘ I CHARAKTERYSTYKĘ FLORYSTYCZNĄ SYNTAKSONÓW ZESPOŁU *ARRHENATHERETUM ELATIORIS* W DOLINIE FLINTY (ŚRODKOWA POLSKA)

Streszczenie

Zróżnicowanie warunków siedliskowych przyczynia się do wykształcania płatów łąk rajgrasowych o znacznym zróżnicowaniu florystycznym i daje podstawy do wyróżnienia niższych jednostek fitosocjologicznych. W pracy przedstawiono charakterystykę florystyczną syntaksonów zespołu Arrhenatheretum elatioris w zależności od siedliska. Celem pracy była szczegółowa charakterystyka siedlisk, uwzględniająca zarówno ich fitosocjologię, jak i właściwości glebowe. Analiza 44 zdjęć fitosocjologicznych płatów łąk rajgrasowych umożliwiła porównanie ich struktury botanicznej i fitosocjologicznej oraz różnorodności florystycznej. Oznaczono trzy subasociacje: Arrhenatheretum elatioris typicum, Arrhenatheretum elatioris ranunculetosum repentis, Arrhenatheretum elatioris dactylidosum glomeratae. Ponadto w pracy szczegółowo opisano i zinterpretowane warunki glebowe. Wykonano 2 profile glebowe w glebach murszowatych (Mollic Gleysols). W próbkach, pobranych z poszczególnych poziomów genetycznych, oznaczono takie właściwości jak: pH, zawartość węgla i azotu ogólnego, straty prażenia, uziarnienie, gęstość gleby oraz jej fazy stałej, porowatość całkowitą i drenażową, wilgotność higroskopową oraz maksymalną pojemność higroskopową, potencjał wiązania wody przez glebę oraz jej potencjalną i efektywną retencję użyteczną, retencję całkowitą, współczynnik filtracji. Gleby badanych siedlisk wykazywały dość niską zawartość materii organicznej oraz lekkie uziarnienie endopedonów. Układ tych właściwości, w znacznym stopniu, określał ich cechy funkcjonalne. Ich gęstość była niska, a porowatość całkowita wysoka. Poszczególne pojemności wodne były wysokie, jednakże znaczna część wody była trudno dostępna. Całkowite zdolności retencyjne ocenić można jako korzystne. Obserwowane w ostatniej dekadzie, niekorzystne warunki pogodowe oraz coraz intensywniejsza presja rolnicza, będą prawdopodobnie powodować ewolucję tych gleb w kierunku gleb mineralnych.
***Słowa kluczowe:** siedlisko, skład florystyczny, właściwości gleby, gleby murszowate*

1. Introduction

Habitat conditions of grasslands and pastures are one of the most important factors which influence their utilization as a source of fodder, as well as any other function. What mainly influences the differentiation of habitat conditions, and simultaneously – the composition of plant communities, that is moisturization. It does so by conditioning the direction and speed of soil processes [3]. It is a significant issue to conduct a multidimensional valorization of grassland communities which are located in river valleys while taking into consideration both the need to protect environment and potential yield possibilities of grasslands and pastures [7]. Flinta River, a right tributary of Wełna River which flows into Warta River nearby Oborniki is one of the rivers with outstanding utilization and natural values. Grasslands (mainly hay ones) in the Flinta valley, usually located on organic soils, cover an area of ca. 2000 ha.

Geobotanical research on a current state of grasslands and pastures in the Flinta valley, which allows for the assessment of their quality and production possibilities, is of great importance for the conduction of reasoned farm management [4]. Over the years, as a result of a complex impact of an anthropogenic and zoo biotic factor (i.e. utilization, foddering and fertilization), various changes in the floristic composition of green growth have been observed. The aim of the study was a detailed characteristic of habitats including their phytosociological as well as soil properties. The paper contains a floristic characteristic of *Arrhenatheretum elatioris* (*A.e. typicum*, *A.e. dactylidetosum glomeratae* and *A.e. ranunculetosum repentis*) syntaxons located in this area, with the consideration of changing habitat conditions.

2. Object and methodology

Geobotanical research was conducted in vegetation periods of 2009-2013 in the area of over 151 ha of grasslands and pastures. The object was located in Ryczywół (a village in Wielkopolskie Voivodeship, district of Oborniki, Ryczywół municipality). In terms of geomorphology, the valley of Flinta mainly forms a wide sandy and gravelly area, called Flinta's *zandr*. Areas adjacent to the riverbed are periodically flooded or submerged. Soils located nearby are mainly peats and mucks which usually cover alluvial sand and are significantly mudded. Nowadays, almost the whole riverbed of Flinta is regulated.

2.1. Floristic research

In order to determine a systematic adherence and floristic composition of *Arrhenatheretum elatioris* syntaxons, a comparative analysis of 44 phytosociological relevés (taken with Braun-Blanquet's method [1]) was conducted in well developed areas of 10x10 m^2. Most of the relevés covered the central part of Flinta. Floristic relevés were classified to various phytosociological units and compiled into tables on the basis of Matuszkiewicz's papers [11]. The degree of species consistency and the number of species in sub-associations of *Arrhenatheretum elatioris* were calculated, as well as a percentage of species distinguished in each plant community. Terminology was cited after Mirek et al. [12].

2.2. Soil science research

The research object was located in the pre-valley of Flinta. It was mainly covered by mucky soils, formed from sands and alluvial silts. The depth of a groundwater level was from 0.7 to 1.1 m. Two soil profiles were completed in the points considered as the most representative for the described community. These were mucky soils (Mollic Gleysols) [5, 16]. Arable and utilization values of these soils were marked at 3rd valuation class and 3z of a complex of arable suitability [13]. From each genetic horizon, samples of disturbed and undisturbed structure were collected, in order to determine such properties: texture – after dispersion with sodium hexametaphosphate (sand – with a sieving method; silt and loam – with an aerometric method) [15], particle density of organic horizon -calculated with Okruszko's formula [14], particle density – with a picnometric method [17], soil density – with Nitzshe's vessels of 100 cm^3, total porosity – determined on the basis of particle density and dry soil density [13], organic matter content after being burnt in 550°C [13], saturated hydraulic conductivity – with the method of constant pressure loss [9], maximum hygroscopic capacity – in a vacuum chamber at a negative pressure of 0.8 atm and with a saturated K_2SO_4 solution, water bonding potential of a soil – with the method of Richard's pressure chambers (produced by Eijkelkamp Soil & Water) [8], total and readily available waters – calculated on the basis of pF and the content of carbon and total nitrogen – with Vario Max CNS analyzer (produced by Leco Corp.) and pH – potentiometrically (Ph-meter produced by Elmetron). All the published results are averages from five replications.

3. Results and discussion

3.1. Floristic research

Differences between the subassociations of ryegrass grasslands were visible in their phytosociological structure as well as in their richness and floristic diversity. Patches of *Arrhenatheretum elatioris* association were the most popular in wet-groud forests which were located higher and which were not flooded. Thirty-eight species were found in this taxon. It was dominated by grasses (58.9%) and herbs and weeds (32.6%), whereas the smallest share was represented by *Carex* (2.8%). In *Arrhenatheretum elatioris typicum* subassociation, the biggest share in terms of amount and constancy was observed in: *Arrhenatheretum elatius* (L.) (P. Beauv. ex J. Presl & C. Presl), spreading bellflower (*Campanula patula* L.), raw hawksbeard (*Crepis biennis* L.), meadow geranium (*Geranium pratense* L.), common dandelion (*Taraxacum officinale* F. H. Wigg[560]) and common yarrow (*Achillea millefolium* L.). In strongly moisturized places, with high groundwater level (40-70 cm in spring and 50-85 cm in summer), *Arrhenatheretum elatioris ranunculetosum repentis* subassociation developed. As many as 46 species were found in this syntaxon, with the domination of herbs and weeds (48.8%) and grasses (40.5%), and with the smallest share of *Cyperaceae* (4.1%). In the phytocenoses of this subassociation, large amount and consistency of *Arrhenatherum elatius* (L.) P. Beauv. ex J. Presl & C. Presl, *Ranunculus acris* L., *Plantago media* L., *Achillea millefolium* L. *Heracleum sphondylium* L, *Agropyron repens* P. Beauv., *Medicago falcata* L., *Falcaria vulgaris* Bernh., *Tanacetum vulgare* L., *Equisetum arvense* L. were observed.

In a slightly dryer habitats (groundwater level up to 120 cm), phytocenoses of *Arrhenatheretum elatioris dactylidetosum glomeratae* developed. Forty-four species were found in the patches of this subassociation with the domination of grasses (48.6%) and herbs and weeds (43.8%), and with the smallest share of *Cyperaceae* (1.7%). Also, there was a big amount and consistency of *Arrhenatherum elatius* (L.) P. Beauv. ex J. Presl & C. Presl, *Dactylis glomerata* L. *Tragopogon dubius* Scop., *Phleum pratense* L., *Achillea millefolium* L., *Trifolium repens* L., *Poa pratensis* L., *Festuca pratensis* Huds. *Artemisia vulgaris* L. (Table 1).

3.2. Soil science research

Epipedons were formed from muck (prof. 1) and clayey mucky sand (prof. 2). They were shallowly covered with common or loamy silt which was located at a mediocre depth of loose sand [2]. Apart from a 30-centemeter layer of loamy silt (prof. 1; depth 21-71 cm), there were deposits of very light texture (Table 2).

Particle density of the examined soil profiles oscillated from 2.12 to 2.29 $Mg \cdot m^3$ (in mucky epipedons) and to 2.65 $Mg \cdot m^3$ (in sands) (Table 3).

Due to high content of organic matter, bulk density in epipedons was low and oscillated from 0.64 (prof. 1 - muck) to 0.83 $Mg \cdot kg^{-3}$ (prof. 2 – mucky sand). In sandy endopedones it was higher: from 1.58 (prof. 1; C1g) to 1.69 $Mg \cdot kg^{-3}$ (prof. 2; 2Cg) (Table 3).

Table 1. Systematic value and floristic composition of syntaxons of the Arrhenatheretum elatioris association
Tab. 1. Systematyka i skład florystyczny syntaksonów zbiorowiska Arrhenatheretum elatioris

Syntaxon	Number of species in relevé	Percentage proportion of useful groups				Species with the highest quantity and constancy
		grasses	legumes	sedges	herbs and weeds	
Arrhenatheretum elatioris typicum	38 (25–29)	57.9	6.7	2.8	32.6	*Arrhenatherum elatius* (L.) P. Beauv. ex J. Presl & C. Presl, *Campanula patula* L., *Crepis biennis* L., *Geranium pratense* L., *Taraxacum officinale* F. H. Wigg, *Achillea millefolium* L., *Leucanthemum vulgare* Lam. s.s..
Arrhenatheretum elatioris ranunculetosum acris	41 (22–33)	40.5	5.9	4.8	48.8	*Arrhenatherum elatius* (L.) P. Beauv. ex J. Presl & C. Presl, *Ranunculus acris* L., *Plantago media* L., *Achillea millefolium* L. *Heracleum sphondylium* L, *Agropyron repens* P. Beauv., *Medicago falcata* L., *Falcaria vulgaris* Bernh., *Tanacetum vulgare* L., *Equisetum arvense* L.,
Arrhenatheretum elatioris daktylidetosum glomeratae	44 (26–30)	48.6	5.9	1.7	43.8	*Dactylis glomerata* L. *Tragopogon dubius* Scop., *Phleum pratense* L., *Achillea millefolium* L., *Trifolium repens* L., *Poa pratensis* L., *Festuca pratensis* Huds. *Artemisia vulgaris* L.,

Source: own study / Źródło: opracowanie własne

Table 2. Texture of investigated soils
Tab. 2. Uziarnienie badanych gleb

Profile number	Soil horizon	Depth [cm]	Percentage content of particle-size fraction [mm]						Texture class acc.	
			2.0-0.10	0.10-0.05	0.05-0.02	0.02-0.005	0.005-0.002	<0.002	PTG 2008	FAO
1	Au	0-21	n.d.	n.d.	n.d.	n.d.	n.d.	n.d	mursz	muck
	C1g	21-71	9	14	26	29	7	15	pyi	SiL
	2Cg	71-150	69	29	7	2	0	1	pl	S
2	A	0-26	64	17	8	2	6	3	pg	LS
	C	26-68	48	27	10	11	1	3	pz	SiL
	2Cg	68-150	66	27	3	1	2	1	pl	S

Explanation: pl – piasek luźny, pg – piasek gliniasty, pz – pył zwykły, pyi – pył ilasty, S – sand, LS – loamy sand, SiL – silt, n.d. – not determined

Source: own study / Źródło: opracowanie własne

Table 3. Basic physical and water properties of studied soils
Tab. 3. Podstawowe właściwości fizyczne i wodne badanych gleb

Profile number	Horizon	Depth [cm]	Natural moisture [%v]	Soil organic matter [$g \cdot kg^{-1}$]	Hygroscopic water [%v]	Maximal hygroscopic capacity [%v]	Particle density [$Mg \cdot m^{-3}$]	Bulk density [$Mg \cdot m^{-3}$]	Porosity		Saturated hydraulic conductivity [$\mu m \cdot s^{-1}$]
									total [%v]	drainage [%v]	
1	Au	0-21	46.18	37.2	5.41	13.56	2.12	0.64	69.81	23.09	36.1
	C1g	21-71	32.68	1.3	1.87	4.02	2.65	1.58	40.38	4.65	0.95
	2Cg	71-150	34.37	0.2	0.77	1.49	2.65	1.63	38.49	24.36	84.6
2	A	0-26	35 79	27.9	2.17	7.00	2.29	0.83	63.75	21.83	26.4
	C	26-68	23.61	1.2	1.63	3.66	2.65	1.61	39.25	8.03	1.14
	2Cg	68-150	32.52	0.1	0.49	1.28	2.65	1.69	36.23	20.74	67.2

Source: own study / Źródło: opracowanie własne

Table 4. Soil water potentials and the total and readily available water
Tab. 4. Potencjały wiązania wody oraz całkowita i efektywna retencja użyteczna

Profile number	Soil horizon	Depth [cm]	Water capacity at pF [%v]						Readily available water [%v]	Total available water [%v]
			0.0	2.0	2.5	3.7	4.2	4.5	2.0-3.7	2.0-4.2
1	Au	0-21	66.11	43.02	49.69	17.86	11.05	5.41	25.16	31.97
	C1g	21-71	38.25	33.60	29.52	21.72	9.47	1.87	11.88	24.13
	2Cg	71-150	36.82	12.46	10.24	4.78	3.82	0.77	7.68	8.64
2	A	0-26	51.57	38.74	32.18	11.15	6.37	2.17	27.59	32.37
	C	26-68	36.42	28.39	26.75	14.27	7.83	1.63	14.12	20.56
	2Cg	68-150	34.74	14.00	10.71	5.05	2.29	0.49	8.95	11.71

Source: own study / Źródło: opracowanie własne

Total porosity was the highest in top horizons: from 63.75 (prof. 2; A) to 69.81%v (prof. 1; Au). These values were decreasing along with the depth and reached from 36.23 (prof. 2; 2Cg) to 40.38%v (prof. 1; C1g) in endopedones. Drainage porosity of silts was low: from 20.74 (prof. 2; 2Cg) to 24.36%v (prof. 2; 2Cg). It was a prove of favorable conditions for natural drainage of precipitation waters in the investigated soils. What was visible, that was the influence of organic matter on soil's density and porosity (Table 3).

The content of organic matter was typical for mucky soils and oscillated from 27.9 (prof. 2) to 37.2 $g\cdot kg^{-3}$ (prof. 1) in mucky epipedons. In sandy and silty endopedones, their values were extremely low: from 0.1 (prof. 2; 2Cg) to 1.3 $g\cdot kg^{-3}$ (prof. 2; C1g) (Table 3).

Contents of hygroscopic water and maximum hygroscopic capacity were the highest in deposits with a defined content of colloid fractions both mineral (a fraction of silt) and organic ones [13]. The highest values of this properties were observed in endopedones: H = 5.41; MH = 13.56%v (prof. 1; Au) and H = 2.17; MH = 7.00%v (prof. 2; A). Hygroscopic water and maximum hygroscopic capacity decreased along with the depth and oscillated from H = 0.49 and MH = 1.28%v (prof. 2; 2Cg) to H = 1.87 and MH = 4.02%v (prof. 1; C1g) (Table 3) in endopedones.

The highest natural moisture was found in horizons rich in organic matter - 46.18%v (prof. 1; Au - muck) and 35.79%v (prof. 2; A – mucky sand) (Tables 2, 3). In other horizons, moisturization was lower, yet relatively high in relation to porosity, due to a close contact of these horizons and soil-ground waters (Table 3).

Values of maximum water capacity were slightly lower than total porosity (by about 2-4%v). The optimum of agrotechnical moisture (field water capacity) was the highest in horizons rich in organic matter (prof. 1; Au – PPW=43.02%v and prof. 2; A – PPW=38.74%v) and of heavier texture (prof. 1; C1g and prof. 2; C). It oscillated from 28.39 to 33.60%v. In endopedones composed of loose sands, the values of field water capacity were much lower (12.46-14.00%v). At pF 2.5 water capacity dropped by about 2 – 6 %v. At the point of production water (pF 3.7), moisture was strongly diversified and oscillated: from 11.15%v (prof. 2) to 17.86 (prof. 1) in epipedons and from 4.78 (prof. 2; C) to 21.72%v (prof. 1; C1g) in endopedones. At a wilting point (pF 4.2), moisturization was lower by 1-12%, respectively. It oscillated from 2.29 (prof. 2; 2Cg) to 11.05%v (prof. 1; Au) (Tables 2, 3, 4).

Readily available water in top horizons was between 25.16 (prof. 1) and 27.59%v (prof. 2). It was lower in the horizons situated deeper (12-14%v) and the lowest – in sands (ca. 7.5-9%v). Moisturization was higher in case of total available water: from 31.97 (prof. 1) to 32.37%v (prof. 2) in epipedons; from 8.64 (prof. 1; 2Cg) to 24.13%v (prof. 1; C1g) (Table 4) in endopedones. Values of total and readily available waters were slightly higher than the ones provided by Ślusarczyk [18] and Kaczmarek [6] for soils and mineral deposits.

Retention abilities of the investigated soils were high. At a time, these soils can retain 105 mm of production water and from 133 to 137 cm of potentially available water in a 0-50 cm horizon. Respective values were higher by about 50% for the horizon of 0-100 cm (Table 5).

Table 5. Water retention in the layers 0-50 and 0-100 cm
Tab. 5. Retencja całkowita w warstwach 0-50 i 0-100 cm

Profile number	Layer [cm]	Water retention at RAV [mm]	Water retention at TAV [mm]
1	0-50	87.3	137.1
	0-100	134.5	212.9
2	0-50	105.6	133.5
	0-100	159.6	208.0

Source: own study / Źródło: opracowanie własne

Filtration was high and balanced in endopedones. The values of a filtration ratio oscillated from 26.4 (prof. 2) to 36.1 $\mu m^{*} s^{-1}$ (prof. 1). It was low, however, in the horizons of a silty composition (from 0.95 to 1.14 $\mu m^{*} s^{-1}$). The speed of filtration was the highest in sandy deposits, where it oscillated from 67.2 (prof. 2; 2Cg) to 84.6 $\mu m^{*} s^{-1}$ (prof. 1; 2Cg) (Table 3). The values were in accordance with relatively wide ranges provided by numerous authors for the soils of similar origin and texture [10, 19].

PH of top horizons was slightly acid and oscillated from 6.52 (profile 2) to 6.62 (profile 1). Its values were similar in endopedones composed of silt. Acid reaction (from 5.28 to 5.91) was also marked in horizons of sandy composition. The content of total carbon in endopedones was typical for mucky soils: from 12.3 (prof. 2) to 14.8 $g\cdot kg^{-3}$ (prof. 1). In endopedones, this parameter lowered significantly: from 0.1 (prof. 2; 2Cg) to 0.8 $g\cdot kg^{-3}$ (prof. 1; C1g). The content of total nitrogen was also low: from 1.1 (prof. 2; A) to 0.3 (prof. 1; C1g). The relation of carbon and nitrogen in top horizons was favorable – about 11. It lowered dramatically along with the depth – from 1.0 (prof. 2; 2Cg) to 2.7 (prof. 1; C1g). (Table 6).

Table 6. Basic chemical properties
Tab. 6. Podstawowe właściwości chemiczne

Profile number	Horizon	Depth [cm]	pH in 1 M KCl	Total carbon [$g\cdot kg^{-1}$]	Total nitrogen [$g\cdot kg^{-1}$]	C:N
1	Au	0-21	6.62	14.8	1.3	11.4
	C1g	21-71	6.07	0.8	0.3	2.7
	2Cg	71-150	5.28	0.2	0.1	2.0
2	A	0-26	6.52	12.3	1.1	11.2
	C	26-68	6.64	0.5	0.2	2.5
	2Cg	68-150	5.91	0.1	0.1	1.0

Source: own study / Źródło: opracowanie własne

4. Summary

An association of *Arrhenatheretum elatioris* located in the valley of Flinta was very diverse in terms of floristics. Three subassociations were found in it: *Arrhenatheretum elatioris typicum*, *Arrhenatheretum elatioris ranunculetosum repentis* and *Arrhenatheretum elatioris dactylidosum glomeratae*. Variability of each patch depended on current habitat conditions, yet a phytosociological structure of it was dominated by species characteristic to *Arrhenatheretum elatioris*, the association of *Arrhenatherion* from *Arrhenatheretalia* and *Molinio-Arrhenatheretea* class, which allows them to be classified to this association. Soils of the investigated habitats were relatively rich in organic matter and texture of their endopedones was light. A system of these parameters had a strong impact on their functional characteristics. Their density was low, and total porosity – high. Each water capacity was high, however, most of the water was hardly available. Total retention abilities may be assessed as favorable. Bad weather conditions (witnessed especially in the last decade) and more and more intensive agricultural pressure will probably cause the evolution of these soils in the direction of mineral soils.

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