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THE DIVERSITY OF *SCIRPETUM SILVATICI* RALSKI 1931 ASSOCIATION AS A RESULT OF INFLUENCE OF VARIABLE HABITAT CONDITIONS

Summary

Research on floristic diversity of Scirpetum silvatici association was conducted in the valleys of Bukówka and Noteć in the years 2012 and 2014. In the association, Shannon-Wiener's ratio of floristic diversity was calculated and the following parameters were determined: systematics, natural values, species diversity and a current state of habitat conditions on the basis of the values of Ellenberg's ratio figures. Two soil profiles were made (sapric-mucky soil and alluvial soil). Morphological structure, texture of various genetic horizons and basic chemical properties of the investigated soils were determined. The examined soils were rich in organic matter and their other traits were typical of Polish soils of similar origin, texture and the content of organic matter. These soils ensure good conditions of water supply to plants. Their epipedons contained optimal amount of organic matter (when compared to the type of deposits they were built of). They are a valuable element of the habitat of the analyzed communities.
Key words*: floristic diversity, sedge communities, Sapric Histosol, Haplic Fluvisol*

ZRÓŻNICOWANIE FLORYSTYCZNE ZESPOŁU *SCIRPETUM SILVATICI* RALSKI 1931 JAKO SKUTEK WPŁYWU ZMIENNYCH WARUNKÓW SIEDLISKOWYCH

Streszczenie

Badania zróżnicowania florystycznego zespołu Scirpetum silvatici przeprowadzono w dolinie Bukówki i Noteci, w 2012 oraz 2014 roku. W zbiorowisku określono jego systematykę, obliczono wskaźnik różnorodności florystycznej Shannona-Wienera, określono walory przyrodnicze, różnorodność gatunkową zespołu oraz aktualny stan warunków siedliskowych na podstawie wartości (F, R i N) liczb wskaźnikowych Ellenberga. Wykonano opis dwóch profili glebowych (gleby: saprowo-murszowa i mada właściwa), oznaczając budowę morfologiczną i skład granulometryczny z poszczególnych poziomów genetycznych profili glebowych oraz podstawowe właściwości chemiczne badanych gleb. Badane gleby wykazywały znaczną zawartość materii organicznej, a w obrębie podstawowych właściwości, wartości typowe, charakterystyczne dla gleb Polski o podobnej genezie, uziarnieniu i zawartości materii organicznej. Gleby te zapewniają dobre warunki zaopatrzenia roślin w wodę. Ich epipedony zawierały optymalną, w stosunku do rodzaju budujących je utworów, zawartość materii organicznej Są one cennym elementem siedliska analizowanych zbiorowisk.
Słowa kluczowe*: różnorodność florystyczna, zbiorowiska szuwarowe, gleby murszowe, mady rzeczne*

1. Introduction

Moisture is one of the most important habitat factors. It influences the character and speed of soil processes and accounts for the diversification of grassland habitats and the floristic composition of plant communities. One of such communities is an association of *Scirpetum silvatici* Ralski 1931 which is usually located on marshy, peaty or mineral soils, especially in river valleys and nearby peaty lakes. It is located in the habitats on the boarders of *Molinietalia* communities and alder forests [25, 33]. According to Trąba [32], *Scirpetum sylvatici* is one of the associations which are poorer in species of little economic value. *Scirpus sylvaticus* L., whose appearance is a symptom of patches being flooded, is the most characteristic and popular species in this association. According to Denisiuk and Korzeniak [3], due to the richness and share of protected species (*Dactylorhiza majalis, D. incarnata , Epipactis palustris, Viola palustris*), *Scirpetum sylvatici* plays an important role in associations located in Bieszczady. This association is rich in reed species [2, 24]. According to Nowiński [27], this association is located in small areas. It was confirmed by Rogut et al. [31] in their research on Kolbuszowski Plateau, where the association formed small patches (of less than 100 m^2) in local depressions in grasslands and nearby *Carex* reeds. Changes in moisturization conditions lead to the limitations of the area covered by the association or even to its total atrophy. Rogut et al. [31] and Kucharski [20] noticed the share of perennials from *Filipendulion* association and *Artemisietea* class. Once the grasslands, where the association was located, were stopped being mown, there was a growth in compaction of the bushes in the form of common alder (*Alnus glutinosa*) and grey willow (*Salix cinerea*) [21] in Roztocze National Park. Such communities are located both on organic (peat, muck) as well as mineral soils (black earths, alluvial soils), in which there is a shallow or medium-deep soil-ground water level [11, 16]. The paper contains a complex characteristic of the habitat which covers the diversity of floristic composition and soil conditions.

2. Object and methodology

2.1. Floristic research

The research was conducted in the valley of Bukówka and Noteć in the years 2012 and 2014. In order to determine a systematic affiliation and a floristic composition of the syntaxons, a comparative analysis of twenty-four phytosociological relevés taken with Braun-Blanquet's method [1] was conducted. The analysis was conducted in well-developed patches of irregular shapes from a few to over a dozen square meters. Floristic relevés were classified to phytosociological units and compared in tables on the basis of Matuszkiewicz's works [22]. Nomenclature was cited after Mirek et al. [23].

On the basis of a floristic composition of phytosociological relevés, average values of ecological ratios for each relevé (F – soil's moisturization, R – soil's reaction, N – richness in nitrogen) were calculated with a phytoindicative method by Ellenberg et al. [4]. Furthermore, Shannon-Wiener's ratio of floristic diversity [5], natural values and species diversity of the association were calculated for the diversified communities.

2.2. Soil scientific research

Two soil profiles were performed. In samples collected from each genetic horizon, the following properties were marked: pH, the content of total nitrogen, calcination loss, texture, bulk density, particle density, total and drainage porosity, hygroscopic moisture, maximum hygroscopic capacity, water boding potential, total and readily available waters, total retention and a filtration ratio. In terms of geomorphology, the object was situated in the area of river proglacial valleys.. It was covered with organic soils (profile 1 – Sapric Histosol; sapric-mucky soil) and mineral soils (profile 2 – Haplic Fluvisol; alluvial soil) [12, 30]. From each genetic horizon, samples of disturbed and undisturbed structure were collected, in order to determine such properties as: texture (in mineral deposits) – with a sewage method (sand) and aerometric method (loam and silt) after dispersion with sodium hexametaphosphate [29], particle density (in mineral deposits) with a picnometric method [34] and with Okruszko's formula [28] (in organic deposits), soil density – with Nitzshe's vessels of 100 cm^3 [27], total porosity – determined on the basis of particle density and bulk density [27], calcination loss after being burnt in 550^{o}C [27], filtration ratio – with the method of constant pressure loss [18], maximum hygroscopic capacity (moisture at pF=4.5) – in a vacuum chamber at a negative pressure of 0,8atm and with a saturated K_2SO_4 solution, water bonding potential of a soil – with the method of Richard's pressure chambers [17], total and readily available waters – calculated on the basis of pF, the content of total nitrogen – with Vario Max CNS analyzer and pH – potentiometrically. All the published results are averages from five replications.

3. Results and discussion

3.1. Floristic research

On the basis of the collected relevé material, an association of *Scirpetum silvatici* Ralski 1931 was identified and classified to *Molinio-Arrhenatherea* R. Tx. 1937 class, *Molinietalia caeruleae* W order and *Calthion palustris* R.Tx. 1936 em. Oberd. 1957 association. In the community located on an alluvial soil, forty-one plant species were found (nineteen in a phytosociological relevé on average) and thirty-eight species on a mucky soil (twenty-one on average) (Tab. 1). A species composition was dominated by *Scirpus sylvaticus* of a high (the 4th) constancy level and a coverage ratio of D=4286. *Poaceae* family was represented be seven species (*Alopecurus pratensis*, *Deschampsia caespitosa*, *Festuca arundinacea*, *Poa palustris*, *Poa trivialis*, *Festuca pratensis* and *Glyceria maximae*). *Fabaceae* were sparse, including *Lotus uliginosus* (S=II and D=88.2) and *Lathyrus pratensis* (S= I and D=18.0). Apart from a dominant species (*Scirpus sylvaticus*), *Carex* was represented by: *Carex vesicaria*, *Carex, gracilis*, *Carex nigra* and *Carex rostrata.* Species which were more popular, yet present in smaller amounts, were: *Lysimachia vulgaris*, *Filipendula almaria*, *Cirsium oleraceum*, *Caltha palustris*, *Juncus conglomeratus*, *Equisetum palustre* and *Lysimachia nummularia*.

Natural valorization ratio was an indicator of natural values. The ratio was (3.1) and (2.7), respectively, which was a proof of moderate natural values of the community (Tab. 2). A biodiversity ratio was H'=2.2 and H'=1.8, which proved a moderate floristic diversity.

The association of *Scirpetum silvatici* was formed in a fresh and partially moist habitat (F=7.6) on alluvial soils, and in a very moist habitat (F=8.3) – on mucky soils (Tab. 3). The reaction was slightly acid and neutral (R=4.9 and R=5.2); the richness in nitrogen was high (N=6.3 and N=7.1).

Table 1. Species diversity of community with dominance *Scirpetum silvatici*
Tab. 1. Różnorodność gatunkowa zbiorowiska z dominacją zespołu Scirpetum silvatici

Type of soils / Locality	Number of relevés	Total number of species	Share in sward (%)			
			Total grasses	Fabaceae	Cyperaceae	Herbs and weeds
Haplic Fluvisol						
- stand 1	4	40 (18)	7	2	3	30
- stand 2	2	36 (17)	4	2	1	34
- stand 3	2	44 (23)	7	1	4	26
Total / Average	10	41 (19)	6	2	3	27
Sapric Histosl						
- stand 1	5	38 (21)	6	2	4	24
- stand 2	6	27 (16)	4	1	2	20
- stand 3	3	38 (26)	7	1	2	29
Total / Average	14	34 (21)	6	1	3	24

Source: own work / Źródło: opracowanie własne

Table 2. Species diversity and valorization of *Scirpetum silvatici* natural association
Tab. 2. Różnorodność gatunkowa i waloryzja wartości przyrodnicznej zespołu Scirpetum silvatici

Type of soils	Average valorization ratio	Valorization classes	Natural values	Shannon-Wiener index
Haplic Fluvisol	3.1	VI	Moderately high	2.2
Sapric Histosol	2.7	VI	Averagely moderate	1.8

Source: own work / Źródło: opracowanie własne

Table 3. Habitat conditions of a community with the domination of *Scirpetum silvatici*
Tab. 3. Warunki siedliskowe zbiorowiska z dominacją zespołu Scirpetum silvatici

Type soils / Localization	Wskaźniki fitoindykacyjne *Phytoindication indexes*					
	Soil moisture figures (Ellenberg) F		*Soil nitrogen figures* *N*		*Soil reaction figures* R	
Haplic Fluvisol - stand 1 - stand 2 - stand 3- stand 2 - stand 3	7.1 7.9 7.7	Fresh and partly moist	5.7 6.7 6.6	moderate high high	4.9 4.8 5.1	Slightly acid and neutral Slightly acid and neutral Slightly acid and neutral
Total / Average	7.6	Fresh and partly moist	6.3	high	4.9	Slightly acid and neutral
Sapric Histosol - stand 1 - stand 2 - stand 3	8.6 8.1 8.1	Very moist	7.1 6.9 7.3	high high high	5.6 4.9 5.2	Slightly acid and neutral Slightly acid and neutral Slightly acid and neutral
Total / Average	8.3	Very moist	7.1	high	5.2	Slightly acid and neutral

Source: own work / Źródło: opracowanie własne

3.2. Soil scientific research

An epipedon of profile 1 was built of muck (prof. 1). Traces of intensive mineralization declined at the depth of ca. 35 cm, where the deposit transformed into a moderately decomposed low peat, deeply underlain with sand. In a top horizon and in a near-top horizon, profile 2 was formed of silty loam and silty clay, moderately deeply underlain with peat and deeply – with sand [6] (Tab. 4).

Particle density of organic deposits was the highest in epipedons. In mineral horizons composed of silt and sand, it oscillated from 2.63 to 2.65 $Mg{\cdot}m^{-3}$. In organic horizons, the values were lower: from 1.75 – in peats (prof. 2; Oe) to 2.14 $Mg{\cdot}m^{-3}$ – in muck (prof. 1; MOe) (Tab. 5).

Table 4. Texture of mineral horizons of the soils studied
Tab. 4. Uziarnienie poziomów mineralnych badanych gleb

Profile number	Horizon	Depth (cm)	Percent of fractions (mm)						Texture acc. FAO
			2.0-0.1	0.10-0.05	0.05-0.02	0.02-0.005	0.005-0.002	<0.002	
1	Auk	0-28	28	19	26	16	4	7	Sil
	Ck	28-42	27	22	24	19	2	6	SiL
	C2k	42-66	2	14	37	11	5	31	SiCL
	3Cg	130-220	83	9	4	1	1	2	S
2	2Cg	130-220	91	5	2	1	0	1	S

Explanation: S – sand, SiL – silty loam, SiCL – silty clay / *Objaśnienia: S – sand, SiL – silty loam, SiCL – silty clay*

Source: own work / Źródło: opracowanie własne

Table 5. Basic physical and chemical properties of the studied soils
Tab. 5. Podstawowe właściwości fizyczne i chemiczne badanych gleb

Profile number	Horizon	Depth (cm)	Particle density ($Mg{\cdot}m^{-3}$)	Bulk density ($Mg{\cdot}m^{-3}$)	Total porosity (%v)	Organic mater ($g{\cdot}kg^{-1}$)	Natural moisture (%v)	Hygroscopic water (%v)	Saturated hydraulic conductivity ($\mu m{\cdot}s^{-1}$)	pH in 1M KCl	Total nitrogen ($g{\cdot}kg^{1}$)
1	Auk	0-28	2.63	1.32	49.81	27.1	17.44	2.56	4.3	6.1	1.2
	Ck	28-42	2.65	1.46	44.91	4.3	21.37	1.88	1.6	5.9	0.7
	C2k	42-66	2.65	1.61	39.25	1.3	26.86	3.16	0.8	6.2	0.9
	2COei	66-130	1.87	0.49	73.80	619.7	54.28	8.45	12.4	6.6	8.7
	3Cg	130-220	2.65	1.29	51.32	n.d.	39.86	0.27	46.8	5.4	0.2
2	M	0-36	2.14	0.93	56.54	372.5	23.42	6.40	29.5	6.5	17.5
	Oe	36-85	1.75	0.56	68.00	728.1	46.99	7.45	9.8	6.4	11.4
	Oei	85-130	1.82	0.74	59.34	660.7	51.35	6.82	14.2	6.2	9.1
	2Cg	130-220	2.65	1.34	49.43	n.d.	33.28	0.39	89.1	5.5	0.1

Explanation: n.d. – not determined / *Objaśnienia : n.d. – nie oznaczono* *Source: own work / Źródło: opracowanie własne*

Table 6. Soil water potentials and the total and readily available water in the studied soils
Tab. 6. Potencjał wiązania wody oraz potencjalna i efektywna retencja użyteczna badanych gleb

Profile number	Horizon	Depth (cm)	Water capacity at pF: (%v)						Total available water (%v)	Readily available water (%v)
			0.0	2.0	2.5	3.7	4.2	4.5	2.0-4.2	2.0-3.7
1	Auk	0-28	47.65	22.54	20.16	12.02	5.35	3.10	17.19	10.52
	Ck	28-42	41.72	21.36	18.70	10.42	4.51	2.92	16.85	10.94
	C2k	42-66	6.77	31.40	25.28	19.76	16.88	6.78	14.52	11.64
	2COei	66-130	70.26	61.00	51.71	42.25	27.32	19.76	33.68	18.75
	3Cg	130-220	48.18	9.36	8.68	2.84	2.35	1.36	7.01	6.52
	M	0-36	53.59	45.85	41.27	34.36	24.67	10.54	21.18	11.49
2	Oe	36-85	66.14	58.87	52.17	40.41	25.65	8.55	33.22	18.46
	Oei	85-130	57.91	67.22	61.29	37.48	24.49	9.16	42.73	29.74
	2Cg	130-220	46.40	8.27	7.19	2.42	1.90	1.07	6.37	5.85

Source: own work / Źródło: opracowanie własne

Bulk density of organic deposits was low and oscillated from 0.49 (prof. 1; 2COei) to 0.93 $Mg\cdot m^{-3}$ (prof. 2; M). The values were higher in silts and sands: from 2.63 to 2.65 $Mg\cdot m^{-3}$ (Tab. 5). Porosity, which is a function of the above mentioned properties, was high: from 56.54 (prof. 2; M) to 73.80%v (prof. 1; 2COe1) in mucks and peats, and from 39.25 (prof. 1; C2k) to 49.81 $Mg\cdot m^{-3}$ (prof. 1; Auk) in silts and sands (Tab. 5).

The content of organic matter was characteristic to each deposit. Its highest amount was observed in peaty horizons: from 660.7 (prof. 2; Oei) to 728.1 $g\cdot kg^{-1}$ (prof. 2; Oe), a bit lower ones – in mucks (372.5 $g\cdot kg^{-1}$), and the lowest – in silts: from 1.3 (prof. 1; C2k) to 27.1 $g\cdot kg^{-1}$ (prof. 1; Auk). Trace amounts of it were found in sands (Tab. 5).

Natural moisture was high: from 17.44 (prof. 1; Auk) to 54.28%v (prof. 1; 2COei). In horizons located below the depth of 70 cm, values of this property were close to the values of total porosities, due to the influence of a deeply located soil-ground water level (Tab. 5).

Due to a minimal content of mineral colloids, the values of hygroscopic moisture (H) and maximum hygroscopic capacity (MH) depended on the content of colloid fractions, both organic one (humus) and mineral one (colloid loam) [26]. The lowest values of H and MH were observed in sands (0.27-0.39%v), higher – in silts (1.88-3.16%v) and the highest – in muck (6.40%v) and peats (6.82-8.45%v) (Tab. 5).

The speed of filtration was diversified. In organic deposits, the values of a filtration ratio oscillate from 9.8 (prof. 2; Oe) to 29.5 $\mu m \cdot s^{-1}$ (prof. 2; M), whereas in silts: from 0.8 (prof. 1; C2k) to 4.3 (prof. 1; Auk) $\mu m \cdot s^{-1}$. The highest speed of filtration was observed in sandy deposits – from 46.8 (prof. 1; 3Cg) to 89.1 $\mu m \cdot s^{-1}$ (prof. 2; 2Cg) (Tab. 5). The values were in accordance with wide ranges provided by numerous authors for the soils of similar origin and graining [7, 9, 10, 11, 13, 15, 16, 19, 36].

The reaction of each genetic horizon was neutral or slightly acid (pH from 6.2 to 6.6 in organic deposits and from 5.9 to 6.1 in silts). The reaction of a sandy bedrock was acid (pH from 5.4 to 5.5) (Tab. 5). The content of total nitrogen in mucks and peats was much higher than in silts and sands (Tab. 4).

Maximum water capacities (pF=0.0) were by 2-3%v lower than the values of total porosities. Field capacity (pF=2.0) was the highest in peats – from 58.87 (prof. 2; Oe) to 67.22%v (prof. 2; Oei), and a bit lower in muck – 45.85 (prof. 2; M). Its values were much lower in mineral deposits – from 8.27 (prof. 2; 2Cg) to 31.40%v (prof. 1; C2k). At pF=2.5, moisture was by a few or over a dozen %v (ca. 1-6%v) lower. At the point of production water (pF 3.7), moisture was diversified and oscillated from 34.36 (prof. 2; M) to 42.25%v (prof. 1; 2COei) in organic deposits and from ca. 2.42 (prof. 2; 2Cg) to 19.76%v (prof. 1; C2k) in mineral deposits. At a wilting point (pF 4.2), water capacity was by about 10-15 (mucks and peats) and 0.5-10%v (sands and silts) lower, respectively (Tab. 6).

Total available water oscillated from 6.37 (prof. 2; 2Cg) to 29.74%v (prof. 2; Oe3). It was the highest in peats: from 33.22 (prof. 2; Oe) to 42.73%v (prof. 2; Oei), lower – in mucks: 21.18%v, and the lowest in mineral deposits: from 6.37 (prof. 2; 2Cg) to 17.19%v (prof. 1; Auk). Moisture was lower for readily available water: from 11.49 (prof. 2; M) to 29.74%v (prof. 2; Oei) in mucks and peats and from 5.85 (prof. 2; 2Cg) to 11.64%v (prof. 1; C2k) in silts and sands (Tab. 6). The values of total and readily available waters were slightly higher than the ones cited by Ślusarczyk [35], Kaczmarek [14] and Gajewski et al. [8] for various soils and mineral deposits.

4. Summary

Scirpetum silvatici community, classified to *Calthion palustris* R.Tx. 1936 em. Oberd. 1957 association, developed in a fresh and partly moist habitat on an alluvial soil, and in a very moist habitat – on a mucky soil. The community was dominated by *Scirpus sylvaticus* of a high constancy level and a high coverage ratio. Altogether, forty plant species of high water requirements were found. The association had moderate natural values and floristic diversity.

In terms of basic properties, the ones of the investigated soils were typical of Polish soils of similar origin, texture and the content of organic matter. They provided good conditions for water supply. Their epipedons contained an optimal content of organic matter when compared to the type of their structure deposits. The reaction of each horizon was favorable for vegetation. They are a valuable habitat element of the analyzed communities.

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