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GEOBOTANICAL CONDITIONS OF GRASSLAND HABITATS OF PSAMMOPHYLIC SWARDS

Summary

The paper contains a floristic and soil scientific characteristics of thermophilic psammophylic swards which were extensively utilized. In the vegetation seasons of 2014-2016, twenty-two phytosociological relevés were taken in grasslands of a total area of 13,2 ha. On their basis, a floristic and phytosociological analyses were conducted. The communities were classified to Corynephoretalia canescentis order, Koelerio glaucae-Corynephoretea class. An association of grey hair-grass (Spergulo vernalis-Corynephoretum typicum) and two variants: with a sheep's bit scabious (Jasione montana L.) and with a mouse-ear hawkweed (Hieracium pilosella L.) were classified to Corynephorion association, and in the association of Vicio lathyroidis-Potentillion argenteae, an association of Dianthus and sea thrift (Diantho-Armerietum elongate) was marked. Average values of ecological indicators were calculated for the defined communities. It was observed that species compositions of the defined associations and communities were diversified more due to edaphic than climate conditions. Three soil profiles were prepared (two of black earths and one of arenosoles). In samples collected from each genetic horizon, the following parameters were marked: pH, the content of carbon and total nitrogen, 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 saturated hydraulic conductivity. The texture was light and the content of organic matter was low. These factors determined other characteristic properties to a large extent. Despite low arable and utility value, the examined soils were considered as a valuable element of the habitat covered by thermophilic flora

***Key words**: phytoindication, psammophylic swards, black earths, arenosoles*

WARUNKI GEOBOTANICZNE SIEDLISK ŁĄKOWYCH MURAW PSAMMOFILNYCH

Streszczenie

W pracy przedstawiono charakterystykę florystyczną i gleboznawczą siedlisk ciepłolubnych muraw psammofilnych, użytkowanych ekstensywnie. W sezonie wegetacyjnym 2014-2016, na terenie łąk o łącznej powierzchni 13,2 hektara wykonano 22 zdjęcia fitosocjologiczne, na podstawie których przeprowadzono analizę florystyczno-fitosocjologiczną. Wyróżnione zbiorowiska zaklasyfikowano do rzędu Corynephoretalia canescentis, klasy Koelerio glaucae-Corynephoretea.. Do związku Corynephorion zaliczono zespół szczotlichy siwej Spergulo vernalis-Corynephoretum typicum oraz dwa warianty: z jasieńcem piaskowym (Jasione montana L.) i z jastrzębcem kosmaczkiem (Hieracium pilosella L.), a w związku Vicio lathyroidis-Potentillion argenteae wyróżniono zespół goździka i zawciągu pospolitego: Diantho-Armerietum elongate. Obliczono średnie wartości wskaźników ekologicznych oraz średnie dla wyróżnionych zbiorowisk. Stwierdzono, iż skład gatunkowy wyróżnionych zespołów i zbiorowisk bardziej różnicowały czynniki edaficzne niż klimatyczne. Wykonano 3 profile glebowe (2 czarne ziemie i arenosol). 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. Badane gleby wykazywały lekkie uziarnienie oraz niską zawartość materii organicznej. Czynniki te, w znacznym stopniu, determinowały układ pozostałych, charakteryzujących je właściwości. Pomimo niskiej wartości rolniczej i użytkowej, badane gleby uznano za cenny element siedliska zajętego przez roślinność ciepłolubną.

***Słowa kluczowe**: fitoindykacja, murawy psammofilne, czarne ziemie, arenosole*

1. Introduction

Flora of herbaceous, thermophilic psammophylic sward communities is popular throughout the country, in habitats of extreme conditions – both thermal and moisturization ones. Such communities are found in Cedynia Landscape Park, Drawa Primeval Forest, Szczecin Lowlands, Wielkopolska Lake District and the valleys of such rivers as: Odra, Warta, Wisła and Noteć [9]. In the past, they were phytosociological research objects for, among all, Celiński and Balcerkiewicz [2], Czyżewska [3] and Załuski [28] and Głowacki [8]. Communities of psammophylic swards form irregular patches of usually small areas (from several to several dozen acres) [18]. They are very diverse in terms of habitat conditions and are usually of secondary character. Predominantly, they are located on soils which are poor in nutrients, oligotrophic, acid and sandy. These are usually sandy moraine areas, kames, eskers and valley sands.

Psammophylic swards are important elements of flora, which enriches the landscape of arable and forest cultures. They are habitats for numerous rare and therapeutic species [3, 16]. In terms of economy, these areas are either barrens or barely efficient grasslands [27], which are often subject to strong anthropic pression. Extensive utilization, which is often implemented, allows for an observation of near-natural succession and communities located in this area are often referred to as rare and ecologically valuable [6, 10]. The paper contains a characteristic of this habitat with the consideration of diversification of floral composition and soil conditions.

2. Object and methodology

The research was conducted in vegetation seasons of 2014-2016 (from the middle of May till the end of July) in grasslands (extensively used pastures) of 13,2 ha. The object was located in Lubcz Wielki (a village in Wielkopolskie Voivodeship, district of Czarnków and Trzcianka, Krzyż municipality). Twenty-two phytosociological relevés were taken with Braun-Blanquet's method [1] in the patches of 10-20 m^2 research areas. The communities were examined in terms of species consistency and coverage ratio. On the basis of floristic composition, average values of ecological indicators (insolation, soil's moisturization, reaction, richness of soil in nitrogen) and average values for the defined communities were calculated after Ellenberg et al. [4]. Floral communities were analyzed in terms of flora and phytosociology and classified in accordance with a syntaxonomical system after Matuszkiewicz [19]. The nomenclature of species was adopted after Mirek et al. [20].

3. Soil science research

In terms of geomorphology, the area was flat and situated in the marginal area of central Noteć pre-valley. It was covered by mineral soils formed from alluvial sands and, in some areas, of uplifting and sandy boulder clay. Dominant soil types were black earths and arenosoles. Grass cover was formed of xerothermic swards communities and, in some areas, of thermophilic flora. A leveled ground water level was at the depth of 2 meters. Three soil profiles were completed: profile 1 – typical black earth (Gleyic Phaeozem), profile 2 – cumulative black earth (Gleyic Phaeozem Pahic), profile 3 – arenosol (Haplic Arenosol) [11, 23]. From each genetic horizon, samples of disturbed and undisturbed structure were collected, in order to determine such properties as: texture – with a sewage method (sand) and aerometric method (loam and silt) after dispersion with sodium hexametaphosphate (sand – with a sieving method; silt and loam – with an aerometric method) [22], particle density – with a picnometric method [24], soil density – with Nitzshe's vessels of 100 cm^3, total porosity – determined on the basis of particle density and dry soil density [21], organic matter content after being burnt in 550°C [21], saturated hydraulic conductivity – with the method of constant pressure loss [15], maximum hygroscopic capacity – 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 [14], total and readily available waters – calculated on the basis of pF, the content of carbon and total nitrogen – with Vario Max CNS analyzer and pH – potentiometrically; effective (drainage) porosity (further referred to as drainage porosity), i.e. a sum of soil macro- and mezopores, was calculated as a difference between total porosity and moisture corresponding to field capacity (determined at -10 kPa potential, which corresponds to the value at pF=2,0) and partial capacity of pores of diameter above 30 um. All the published results are averages from five replications.

4. Results and discussion

In the investigated area, two associations were found and classified to *Corynephoretalia canescentis* order, *Koelerio glaucae-Corynephoretea* class. The association of *Corynephorion* included an association of grey hair-grass *Spergulo vernalis-Corynephoretum typicum* and two variants: with sheep's bit scabious (*Jasione montana* L.) and with mouse-ear hawkweed (*Hieracium pilosella* L.), whereas an association of *Dianthus* and sea thrift (*Diantho-Armerietum elongate*) was found in *Vicio lathyroidis-Potentillion argenteae* association.

5. Systematics of plant associations and communities:

Class: *Koelerio glaucae-Corynephoretea canescentis* Klika in Klika et Novak 1941
Order: *Corynephoretalia canescentis* R.Tx. 1937
Association: *Corynephorion canescentis* Klika 1934
Association: *Spergulo vernalis-Corynephoretum* R.Tx. 1928) Libb. 1933 *typicum*
Variant: typical; *Jasione montana*; *Hieracium pilosella*
Association: *Vicio lathyroidis-Potentillion argenteae* Brzeg in Brzeg et M. Wojt.1996
Association: *Diantho-Armerietum elongate* Krausch 1959.

An association of *Spergulo vernalis-Corynephoretum* in a typical variant was observed in an uplifted, sandy area (tab. 1). A species which was characteristic of the association was *Spergula morisonii* of the 4th constancy level and low coverage ratio (318). Grey hair-grass (*Corynephorus canescens*), a species characteristic of *Corynephoretalia* order, was found with the 5th constancy level and high coverage ratio (5188). In this variant, presence of segetal species was observed e.g. annual vernalgrass (*Anthoxanthum aristatum*) and annual knawel (*Scleranthus annuus*).

A variant with a differentiated syntaxon of sheep's bit scabious (*Jasione montana* L.) was found in the patches with the 5th constancy level and a coverage ratio of 4289. A species which was characteristic of this order and class, was common soapwort (*Saponaria officinalis*) of the 3rd constancy level. Among other species, grey hair-grass and mouse-ear hawkweed were of the 5th constancy level (tab. 1).

A variant with mouse-ear hawkweed (*Hieracium pilosella*) of the 5th constancy level and low coverage ratio (2686), was rich in field sorrel (*Rumex acetosella*), false dandelion (*Hypochoeris radicata*) and common bent (*Agrostis capillaris*). Groundcover of this community was dense (tab. 1). *Diantho-Armerietum elongatae* association was classified to *Vicio lathyroidis-Potentillion argenteae* association. It developed on extensively used, one-crop grasslands. A species characteristic to this association was maiden pink (*Dianthus deltoides*) of the 5th constancy level and low coverage ratio (4312) (tab. 1). Among characteristic species, high constancy level (4^{th}-3^{rd}) and high coverage ratio was observed in: wild thyme (*Thymus serpyllum*), sheep fescue (*Festuca ovina*), stone clover (*Trifolium arvense*). A species of ruderal character, which was present in bigger amount, was spiked speedwell (*Veronica spicata*) and common toadflax (*Linaria vulgaris*). Among grasses, red fescue (*Festuca rubra*) was popular and of high constancy.

According to the analysis of floral patches conducted with a phytoindicative method, insolation ratios were similar and on average oscillated from 7,0 to 7,5. Therefore, thermal conditions in the defined syntaxons were minor (tab. 2). Slightly bigger differences were observed in moisturization, reaction and richness in nitrogen ratios. The driest habitats were covered by *Spergulo Corynephoretum* associations in a typical variant, and the most moisturized ones – by a *Diantho-Armerietum* association. *Spergulo Corynephoretum* association in a typical variant was found on soils which were the most acid and the poorest in nitrogen, whereas soils of *Spergulo vernalis-Corynephoretum* habitat (variant with *Jasione montana*) were the richest in nitrogen.

6. Soil science research

Sands with 7-19% of silt and 1-2% loam were present in all top horizons. In endopedones of profile 1 and 3, the character of soil material did not change. Profile 2 had the richest silt and loam fraction (clayey sand on light clay) (tab. 3) [5].

Particle density of the examined soil profiles oscillated from 2,02 to 2,65 $Mg{\cdot}m^3$. Its value was determined by texture and the content of organic matter (tab. 1, 2). Bulk density of epipedons was low and oscillated between 0,82 (prof. 1 - muck) and 1,49 $Mg{\cdot}kg^{-3}$ (prof. 3) in epipedons, and between 1,28 (prof. 1; A2) and 1,66 $Mg{\cdot}kg^{-3}$ (prof. 2; AC) in endopedones (tab. 2). Total porosity was the highest in top horizons – from 43,35 (prof. 3; Au) to 59,40%v (prof. 2; Au). Values of this property dropped along with the depth; in endopedones it decreased to the values from 36,64 (prof. 2; AC) to 51,33%v (prof. 1; A2). Drainage porosity was high and balanced – from 29,66 (prof. 2; C) to 39,87%v (prof. 1; Au), which was a proof of intensive natural drainage of precipitation waters in the investigated soils. The influence of organic matter on soil's density and porosity was evident (tab. 4) [21].

Table 1. Floristic composition of plant associations of the *Corynephorion canescentis* and *Vicio lathyroidis-Potentillion argenteae*
Tab. 1. Skład florystyczny zespołów roślinnych związków Corynephorion canescentis i Vicio lathyroidis-Potentillion argenteae

Syntaxon	Number of relevés	Total number of species	Mean number of species in the relevé	Species with the highest quantity and constancy
Spergulo vernalis-Corynephoretum typicum	6	26	14	*Corynephorus canescens, Rumex acetosella, Spergula morisonii, Teesdalea nudicaulis, Conyza canadensis, Scleranthus annuus, Anthoxanthum aristatum, Jasione montana, Hieracium pilosella, Hypericum perforatum*
Spergulo vernalis-Corynephoretum variant: *Jasione montana*	4	22	11	*Jasione montana, Corynephorus canescens, Saponaria officinalis, Rumex acetosa, Agrostis capillaris, Artemisia campestris*
Spergulo vernalis-Corynephoretum variant: *Hieracium pilosella*	5	23	11	*Hieracium pilosella, Rumex acetosella Corynephorus canescens, Festuca ovina, Oenothera biennis, Agrostis capillaris, Sedum acre*
Diantho-Armerietum elongate	7	32	18	*Dianthus deltoides, Corynephorus canescens, Hieracium pilosella, Veronica spicata, Festuca rubra, Linaria vulgaris, Polytrichum piliferum, Thymus serpyllum, Racomitrium canescens, Festuca ovina, Agrostis capillaris*

Source: own work / Źródło: opracowanie własne

Table 2. Site conditions of selected associations
Tab. 2. Warunki siedliskowe wybranych zbiorowisk

Syntaxon	Mean of Ellenberg's index			
	Insolation L	Moisture F	Soil reaction R	Nitrogen content N
Spergulo vernalis-Corynephoretum typicum	7.0-8.0 (7.5)	2.1-2.9 (2.5)	2.2-3.2 (2.7)	1.7-3.1 (2.4)
Spergulo vernalis-Corynephoretum variant: *Jasione montana*	7.1-7.6 (7.4)	2.6-3.1 (2.9)	3.1-4.1 (3.6))	2.1-3.9 (3.0)
Spergulo vernalis-Corynephoretum variant: *Hieracium pilosella*	6.8-7.2 (7.0)	2.3-2.8 (2.6)	2.9-3.2 (3.1)	1.9-3.3 (2.6)
Diantho-Armerietum elongate	7.3-7.6 (7.5)	n.d.	3.2-4.9 (4.0)	1.9-3.1 (2.5)

Source: own work / Źródło: opracowanie własne

Table 3. Texture of the studied soils
Tab. 3. Uziarnienie badanych gleb

Profile number	Horizon	Depth	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	Au	0-17	74	15	7	1	1	2	S
	A2	17-31	71	14	10	3	0	2	LS
	A2C	31-53	78	13	3	2	0	4	S
	Cg	53-150	73	15	4	4	0	4	LS
2	Au	0-26	54	26	11	7	1	1	SL
	A2	26-62	48	27	10	11	1	3	SCL
	A2C	62-74	46	14	9	14	8	9	SCL
	C	74-150	49	13	6	13	8	11	SCL
3	Au	0-14	87	6	4	2	1	1	S
	Bv	14-21	92	4	2	1	1	1	S
	C	21-65	92	4	2	2	0	1	S
	C2	65-150	94	3	1	1	1	0	S

Explanation: S – sand, LS – loamy sand, SL – sandy loam, SCL – sandy clay loam

Source: own work / Źródło: opracowanie własne

Table 4. Basic physical and water properties of the studied soils
Tab. 4. Podstawowe właściwości fizyczne i wodne badanych gleb

Profile number	Horizon	Depth (cm)	Particle density ($Mg \cdot m^{-3}$)	Bulk density ($Mg \cdot m^{-3}$)	Total porosity (%v)	Drainage porosity (%v)	Organic mater ($g \cdot kg^{-1}$)	Natural moisture (%v)	Hygroscopic water (%v)	Maximum hygroscopic capacity (%v)	Saturated hydraulic conductivity ($\mu m \cdot s^{-1}$)
1	Au	0-17	2.62	1.14	56.49	39.87	14.28	15.26	1.67	5.26	75.39
	A2	17-31	2.63	1.28	51.33	35.05	13.62	9.86	2.03	4.99	32.20
	A2C	31-53	2.65	1.36	48.68	39.47	4.24	5.19	0.48	1.72	88.76
	Cg	53-150	2.65	1.47	44.53	35.47	2.34	3.78	0.20	0.91	225.11
2	Au	0-26	2.02	0.82	59.40	20.56	43.17	61.25	4.27	13.67	54.15
	A2	26-62	2.59	1.42	45.17	32.43	52.03	18.78	7.65	21.56	33.60
	A2C	62-74	2.62	1.66	36.64	27.76	17.16	15.22	2.80	8.26	17.96
	C	74-150	2.63	1.63	38.02	29.66	13.03	20.19	2.01	6.04	1.36
3	Au	0-14	2.63	1.49	43.35	31.82	12.56	7.89	2.78	4.41	22.83
	Bv	14-21	2.64	1.51	42.80	32.03	7.23	4.17	2.42	3.19	64.18
	C	21-65	2.65	1.55	41.51	31.76	2.11	9.45	0.77	2.25	79.95
	C2	65-150	2.65	1.47	44.53	34.99	1.05	22.25	0.54	1.72	53.09

Source: own work / Źródło: opracowanie własne

The content of organic matter was low. In epipedons it oscillated from 12,5 (prof. 3) to 42,8 $g \cdot kg^{-3}$ (prof. 1). In endopedones the values decreased and oscillated from 1,0 (prof. 3; C2) to 17,6 $g \cdot kg^{-3}$ (prof. 2; AC). Only muck in an accumulative horizon in profile 2 contained much of it (52,0 $g \cdot kg^{-3}$) (tab. 4).

The content of organic matter and colloid loam depended on the size of hygroscopic moisture (H) and maximum hygroscopic capacity (MH). These parameters are influenced by the content of colloid fractions – both mineral one (loam fraction) and organic one (humus) [21]. The highest values of hygroscopic moisture and maximum hygroscopic capacity were observed in horizons of heavier texture and significant amount of organic matter. The values were: H = 4,27; MH = 13,67%v (prof. 2; Au) and H = 7,65; MH = 21,56%v (prof. 2; A2). The values of both properties dropped along with the depth. In top horizons, they were the lowest in loose sands – from H = 0,20 and MH = 0,91%v (prof. 1; Cg) to H = 0,54 and MH = 1,72%v (prof. 3; C2) (tab. 4).

The highest natural moisture was observed in horizons with high amount of organic matter - 61,25%v (prof. 2; Au) and with clay texture – 20,19%v (prof. 2; C) (tab. 1, 2, 3). In loose and slightly clayey sand, moisturization was much lower – from 3,78 (prof. 1; Cg) to 22,25%v (prof. 3; C2) (tab. 3, 4).

Maximum water capacity was by about 2-3% lower than total porosity. The highest field capacity was found in a soil rich in organic matter (prof. 2; Au, A2) and heavier texture (prof. 2; AC, C). It oscillated between 36,42 and 38,84%v. In profiles 1 and 3 (composed of loose and slightly clayey sands), corresponding values were much lower (11,53-19,62%v for epipedons; 9,06-16,28%v for endopedones).

Water capacity at pF 2,5 lowered by about 2-9%v. At a production water point (pF 3,7), moisture was strongly differentiated: in epipedons it oscillated from 8,75 (prof. 3) to 30,178%v (prof. 2), and from 3,00 (prof. 1; Cg) to 29,33%v (prof. 2; A2) in endopedones. At a wilting point (pF 4,2) moisture was by about 0,7-13% lower, respectively. It oscillated from 1,98 (prof. 1; Cg) to 26,36%v (prof. 2; Au) (tab. 3, 4, 5).

Table 5. Soil water potentials and the total and readily available water in the soils studied
Tab. 5. 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	Au	0-17	53.12	19.62	14.20	9.63	7.54	5.26	53.12	12.08	9.99
	A2	17-31	48.33	16.28	13.55	8.74	6.27	4.99	48.33	10.01	7.54
	A2C	31-53	45.15	9.21	7.31	3.48	2.05	1.72	45.15	7.16	5.73
	Cg	53-150	40.99	9.06	7.15	3.00	1.98	0.91	40.99	7.08	6.06
2	Au	0-26	46.01	38.84	32.23	30.17	26.36	13.67	46.01	12.48	8.67
	A2	26-62	41.84	36.42	32.07	29.33	25.86	21.56	41.84	10.56	7.09
	A2C	62-74	33.10	25.88	16.63	13.95	10.75	8.26	33.10	15.13	11.93
	C	74-150	35.21	24.36	15.51	11.23	8.87	6.04	35.21	15.49	13.13
3	Au	0-14	40.75	11.53	10.41	8.75	7.68	5.26	40.75	3.85	2.78
	Bv	14-21	39.73	10.77	9.02	5.01	2.06	4.99	39.73	8.71	5.76
	C	21-65	38.22	9.75	7.21	4.83	2.44	1.72	38.22	7.31	4.92
	C2	65-150	41 76	9.54	7.96	4.12	2.68	0.91	41 76	6.86	5.42

Source: own work / Źródło: opracowanie własne

Readily available water oscillated from 2,78 (prof. 3) to 9,99%v (prof. 1) in top horizons. In lower horizons composed of sands, readily available water was varied, usually lower, though. The highest values of readily available water in clayey endopedones oscillated between 11,13 (prof. 2; C) and 11,93%v (prof. 2; AC). Corresponding values of moisture were higher for total available water. The oscillated from 3,85 (prof. 3) to 12,48%v (prof. 2) in epipedons and from 6,86 (prof. 3; C2) to 15,49%v (prof. 2; C) for endopedones (tab. 5). The defined values of total and readily available water were similar or slightly higher than the parameters provided by Ślusarczyk [25] and Kaczmarek [12, 13] for various soils and mineral deposits.

The lowest total retention abilities were observed in soils formed from sands (profiles 1 and 3). In a horizon of 0-50 cm, retention was only 22,52-31,50 mm at readily available water and 32,69-50,31 mm at total available water. In the horizon of 0-100 cm corresponding values were slightly higher: 48,15-57,41 mm at readily available water and 67,70-83,59 mm at total available water (tab. 6). These values are very low. These soils may effectively retain as little as 4-12% of annual precipitation. Slightly better retention abilities were observed in soils formed from clay (profile 2), however, its retention in 0-100 cm and 0-150 cm horizons was such only due to deeper-located horizons of heavier composition. At the depth which is crucial from an agronomic point of view (0-50cm), the ability to retain water was poor. In all cases, the obtained values of retention turned out to be very similar or slightly higher than the ones provided by Ślusarczyk [25] for various mineral deposits and soils in Poland.

The speed of filtration was relatively balanced and high in endopedones. The accepted values of filtration ratio oscillated from 22,83 (prof. 3) to 75,39 $\mu m \cdot s^{-1}$ (prof. 1). Endopedones composed of sands were permeable from 32,20 (prof. 1; A2) to 225,11 $\mu m \cdot s^{-1}$ (prof. 1; Cg), which accounted for good conditions for fast and natural drainage of precipitation waters. The lowest filtration ratio was found in clays - from 1,36 (prof. 2; C) to 17,96 $\mu m \cdot s^{-1}$ (prof. 2; AC) (tab. 7). Water permeability of the investigated soils was high, however, its values did not differ from typical values of a filtration ratio in deposits of similar texture and origin. The defined values corresponded to the wide ranges provided by numerous authors [17, 29].

Basic chemical properties of soils were typical for black earths and arenosoles of similar texture and origin [7]. The reaction of top horizons was slightly acid and oscillated from 6,12 (profil 3) to 6,56 (profil 2). Its values were lower in endopedones – from 5,06 (prof 3; C2) – 6,24 (prof. 2; A2). The content of total carbon in humus and accumulative horizons was relatively low – from 9,4 (prof. 3; Au) to 17,4 $g \cdot kg^{-3}$ (prof. 2; Au). The values decreased in endopedones – from 0,2 (prof. 3; C2) to 9,8 $g \cdot kg^{-3}$ (prof. 1; A2). Total nitrogen was also low: from 1,2 (prof. 3; Au) to 2,8 $g \cdot kg^{-3}$ (prof. 2; Au) in epipedons and accumulative horizons, and from 0,1 (prof. 3; C2) to 0,6% (prof. 1; A2) in endopedones. The proportion of carbon to nitrogen in top horizons was from 6,1 to 9,6. It limited along with the depth – from 2,0 (prof. 3; C2) to 6,8 (prof. 3; Bv) (tab. 5).

Table 6. Retention of the studied soils
Tab. 6. Zdolności retencyjne badanych gleb

Profile number	Retention at TAV in layers		Retention at RAV in layers	
	0-50	0-100	0-50	0-100
	(cm)		(cm)	
1	50.31	83.59	31.50	57.41
2	63.56	140.50	31.14	63.27
3	22.52	48.15	32.69	67.70

Source: own work / Źródło: opracowanie własne

Table 7. Basic chemical properties
Tab. 7. Podstawowe właściwości chemiczne badanych gleb

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	0-17	6.40	12.2	1.3	9.6
	A2	17-31	5.99	9.8	0.6	16.6
	A2C	31-53	5.84	2.4	0.4	6.0
	Cg	53-150	5.27	0.6	0.1	6.0
2	Au	0-26	6.56	17.4	2.8	6.1
	A2	26-62	6.24	14.5	1.6	9.2
	A2C	62-74	6.00	0.7	0.3	2.3
	C	74-150	5.41	0.4	0.2	2.0
3	Au	0-14	6.12	9.4	1.2	8.0
	Bv	14-21	5.93	2.7	0.4	6.8
	C	21-65	5.29	0.6	0.2	3.0
	C2	65-150	5.06	0.2	0.1	2.0

Source: own work / Źródło: opracowanie własne

7. Summary

In the investigated area two psammophylic associations were differentiated and classified to *Corynephoretalia canescentis* order, *Koelerio glaucae-Corynephoretea* class. Among them, a *Spergulo vernalis-Corynephoretum* association in three variants was classified to a *Corynephorion* association, and a *Diantho-Armerietum elongate* association – to a *Vicio lathyroidis-Potentillion argenteae* association.

Spergulo vernalis-Corynephoretum assoiation in a *Jasione montana* variant was the poorest in terms of flora, whereas a *Diantho-Armerietum elongate* association was the richest and the most advanced in succession development. Species composition of the differentiated associations and communities proved that these communities are more varied due to edaphic than climate factors.

The investigated soils had light texture and low content of organic matter. These factors significantly determined the composition of other characteristic properties. Their density was low, and their total porosity was high. Drainage porosity and filtration ratio were balanced and high, which accounted for good conditions for natural drainage. At each water bonding potential, the values of water capacities were characteristic of soils of similar texture. Total and readily available water were extremely low, which was unfavorable. In spite of low arable and utilization values, the examined soils are a valuable element of a habitat covered by thermophilic and xerothermic flora. Their use as extensive pastures should be considered proper and justified.

8. References

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