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Original Research

Xerothermic Grassland Communities of the Alliance *Cirsio-Brachypodion pinnati* Hadac et Klika 1944 em. Krausch 1961 in Northwestern Poland

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Abstract

Xeromesophilous grasslands of the alliance *Cirsio-Brachypodion pinnati* were studied in valleys of the Lower Odra and Płonia rivers. These ecosystems have been included in the Habitats Directive. The preservation state of vegetation, threats to it and the methods of its protection are presented. Results of this study show that *Cirsio-Brachypodion* in the examined area is represented by the association *Adonido-Brachypodietum*, and plant community with *Salvia pratensis*. *Adonido-Brachypodietum* develops in a typical form and in two variants: *Anthericum liliago* and *A. ramosum*. The major threat to these grasslands is posed by plant succession. An effective method of their protection is a return to traditional methods of farming, i.e. to moderate, alternate grazing or hay harvesting.

Keywords: xeromesophilous grassland, *Adonido-Brachypodietum*, active protection

Introduction

The xerothermic grasslands of Pomerania are the northernmost extrazonal plant communities dominated by species that came to these areas after glacial retreat from the steppes and forest steppes of south and southeastern Europe. Their present distribution in that region (northwest Poland) is mostly connected with the slopes of river valleys and moraine hummocks with southern and southeastern exposure. Those places are characterized by specific ecological conditions, i.e. high temperature, strong insolation, and high calcium carbonate content of upper soil layers. Such conditions are favorable for grassland communities of the class *Festuco-Brometea*, which includes plant associations of the alliance *Cirsio-Brachypodion pinnati*.

Xerothermic grasslands are rich in rare, threatened and protected species. This makes them an unusually interesting object for studies. Phytosociological research on Polish xerothermic grasslands was carried out, for example, by Libbert [1], Czubiński [2], Celiński [3], Celiński and Filipek [4], Filipek [5, 6], Radomski and Jasnowska [7], Ceynowa [8], and Ćwikliński [9]. Due to progressive degradation of biotopes, which leads to a disappearance of those very valuable natural ecosystems, they have been included in the Habitats Directive. Their effective protection requires not only an inventory of the communities but also an assessment of their preservation state and an analysis of directions of plant succession.

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With this end in view, field research was conducted to identify the current species composition of xeromesophilous grasslands of the alliance *Cirsio-Brachypodion pinnati*. Special attention was paid to dynamic trends of these communities, which should enable their proper protection to ensure the preservation of their floristic wealth.

Study Area

In the western part of Pomerania in Poland, the largest and best-preserved fragments of xerothermic grasslands are found in the Lower Odra River valley (i.e. in Bielinek and Szawin and near Cedynia, Chojna, Nawodna, Moryń and Dolsko), as well as in the Płonia River valley (i.e. in Grędziec and Stary Przylep). Xerothermic plants most often colonize the youngest and the less leached postglacial deposits from which the soils were formed, modified by specific morphological and microclimatic conditions and vegetation. Distribution of the patches of plant communities that develop on slopes corresponds to the mosaic variation of soils, which is typical for these areas. The clear-cut variation of soils is marked, for example, in the Brodogóry Reserve. In places that are more exposed and steep, the humus horizon is poorly developed, calcium carbonate content reaches 13%, and soil reaction is neutral to alkaline. On the other hand, in hollows and on slopes, and in some places with small slope angle, the humus horizon is up to 0.5 m thick, calcium carbonate content falls to ca. 0.3%, and soil reaction is neutral. Sometimes on the slopes of the Odra River valley, e.g. in Bielinek, small soil patches resemble cinnamon soils, which are normally found in Mediterranean areas [10].

The areas where xerothermic grasslands occur are distinguished by the lowest rainfall in this region. Mean monthly precipitation in the growing period does not exceed 500 mm as a rule [11]. However, microclimatic conditions are of vital importance, in particular the intensive insolation, determining temperature, water deficit, evaporation, moisture content of the soil surface, and snow cover duration [12]. Microclimatic conditions are modified by slope angle and vegetation, depending on their density, stratification, and character [8].

The grasslands within the area of the Lower Odra valley cover the land that was under intensive agricultural management until the 19th century [13] and then abandoned, but it was intensively afforested in the second half of the 20th century. Due to the occurrence of very fertile soils, the Płonia River valley has been greatly deforested since the Neolithic period [14], when human settlements developed and field crops prevailed in land use structure.

Methods

Floristic observations on the xerothermic grasslands of the western part of Pomerania in Poland were initiated in 1995 [15] and continued off-and-on until 2007 [16, 17]. The results presented here are a part of research carried out in 2000-07 within xerothermic reserves in Bielinek, Brodogóry and Stary Przylep, as well as within unprotected areas, i.e. in the vicinity of Dolsko and Nawodna (Fig. 1). In the selected grassland patches, phytosociological relevés were made with the classic Braun-Blanquet [18, 19] method. Two separate scales were used: a combined cover-abundance scale (+: below 1%; 1: 1-5%; 2: 5-25%;

Fig. 1. Some xerothermic areas in the Western Pomeranian Region; ● – protected, ■ – not protected.

3: 25-50%; 4: 50-75%; 5: 75-100%), and a sociability scale of 1-5:

1: singly;
2: small clumps or groups;
3: medium-sized clumps or groups;
4: moderately large aggregations, carpets, or colonies;
5: very large aggregations.

When selecting the patches, the preservation state of grasslands was mainly taken into account, e.g. the presence of species characteristic for various syntaxonomic units of the alliance *Cirsio-Brachypodion pinnati* and the class *Festuco-Brometea*. To illustrate dynamic trends in the examined plant communities, relevés were also made in the patches of transformed communities. Due to differences in the phytosociological approach to xerothermic plants, the synthetic work of Filipek [6], presenting the results of phytosociological studies on the xerothermic grasslands in the western part of Pomerania in Poland, was used in their syntaxonomic classification. Moreover, the works of Ceynowa [8] as well as our field observations, were taken into consideration. The nomenclature of plant associations was adopted after Matuszkiewicz [20], while that of species after Mirek et al. [21]. In soil samples collected from a depth of 0-30 cm in the Brodogóry Reserve, calcium carbonate content was measured according to the widely used Scheibler method [22].

Results

In the examined area, the xerothermic grasslands of the alliance *Cirsio-Brachypodion pinnati* are represented by the association *Adonido-Brachypodietum* and plant community with *Salvia pratensis*.

The patches of *Adonido-Brachypodietum* occur on rather gentle slopes with southern and southwestern exposure, on fertile soils rich in humus and with varying calcium carbonate content. These phytocenoses form a high, colorful grassland of several layers. They are characterized by a high density of vegetation and rich floristic composition, with a large participation of perennials. The number of species on one relevé is 16 to 42. The community develops in a typical form and two variants with *Anthericum liliago* and *A. ramosum.*

The typical form of the association was found in the Bielinek and Brodogóry Reserves, as well as in Nawodna. Besides *Brachypodium pinnatum*, species like *Anthyllis vulneraria, Galium verum,* and *Salvia pratensis* occur here relatively frequently. Rare xerothermic species are also found here, e.g. *Thesium linophyllon, Orchis militaris, Scorzonera purpurea, Pulsatilla pratensis* and *Anthericum liliago*. This association is most widespread in the Bielinek Reserve, where it occurs both on open, sunny, unshaded slopes and in a mosaic with scrub communities and on thermophilous oak wood clearings. The floristically richest patch of this association was found, however, in Nawodna on a scarp within a pine wood clearing.

The variant with *Anthericum liliago* is represented by numerous patches in the Bielinek Reserve as well as in the Brodogóry Reserve. Apart from the numerous or even dominant *A. liliago*, *Brachypodium pinnatum* also is always present in them.

The variant with *Anthericum ramosum* was only found in the Stary Przylep Reserve. It occurs in the form of a small, well-developed patch in a shallow depression. The presence of all species characteristic for the association *Adonido-Brachypodietum* was recorded only here. In the floristic composition of this variant, a large part is played by perennial plants, e.g. *Thalictrum minus, Salvia pratensis, Potentilla heptaphylla,* and *Achillea pannonica*.

The community with *Salvia pratensis* is a rather frequent element of xerothermic grasslands. This is documented in the present paper by two relevés made in the vicinity of Dolsko (Table 1, rel. 8, 9). Its patches develop most frequently on soils with a thin humus horizon. They are mainly built by xerothermic species with a broad ecological spectrum, e.g. *Galium verum* and *Centaurea scabiosa*.

The xeromesophilous character of the association *Adonido-Brachypodietum* and the occurrence of its patches close to scrubs and woodlots make it susceptible to transformations. The transformations are caused by various factors and represent various successional stages, leading to the development of scrub communities or, rarely, forests in place of stable grasslands. The initial stage of this process is illustrated by a phytosociological relevé made in the Bielinek Reserve in 2007 (relevé area 50 m^2, inclination 40°, exposure S, cover of herb layer 70%): *Brachypodium*

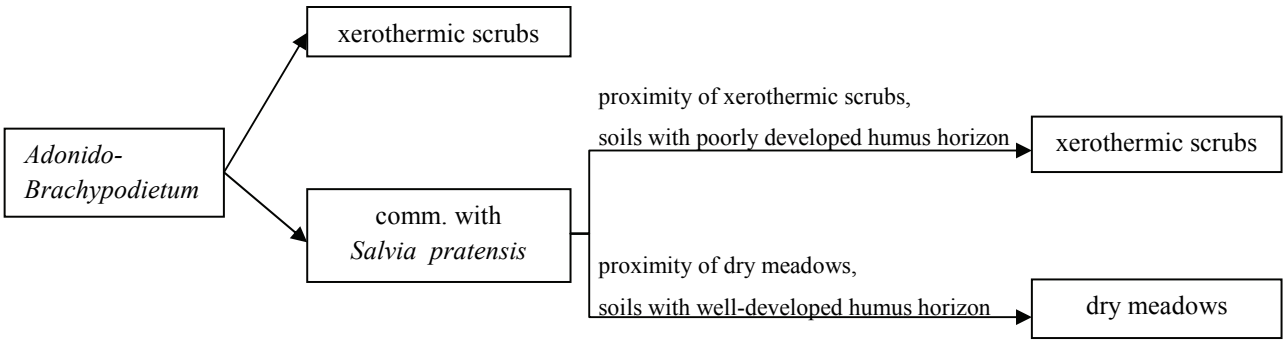

Fig. 2. Succession trends of the xerothermic grasslands from the order *Cirsio-Brachypodion* in the Brodogóry Reserve.

Table 1. Plant communities of xerothermic swards of the *Cirsio-Brachypodion pinnati* Hadac et Klika 1944 em. Krausch 1961 alliance in the western Pomeranian Region.

Number of relevés	1	2	3	4	5	6	7	8	9
Locality	Brod.	Biel.	Naw.	Brod.	Brod.	Biel.	St. P.	Dol.	Dol.
Relevé area, m²	40	60	80	60	50	80	15	80	50
Inclination	40°	20°	10°	30°	60°	30°	10°	30°	25°
Exposition	SW	S	S	SW	S	S	SW	S	S
Data	2006	2007	2000	2006	2000	2007	2000	2007	2007
Cover of layer c, %	80	100	100	100	100	90	90	80	80
Number of species in relevé	20	31	39	42	16	25	25	24	23
Community	*Adonido-Brachypodietum*							*with Salvia pratensis*	
Variant	typical			with *Anthericum liliago*			*with A.r.*		
Ch. *Adonido-Brachypodietum*									
Brachypodium pinnatum	3.3	3.3	4.4	2.2	4.3	3.3	2.2	2.2	1.1
Trifolium montanum	1.1	1.1	.	+	.	.	+	.	.
Prunella grandiflora	.	.	+	.	.	+	1.2	.	.
Ch. D. *Cirsio-Brachypodion pinnati*									
Filipendula hexapetala	.	+	1.1	1.1	.	+	.	+	+
Asperula tinctoria	.	.	1.1	2.2	1.1		.	.	.
Thesium linophyllon	.	+	2.2	.	.	+	.	+	.
Anthyllis vulneraria	2.2	+	1.1	.	.		.	.	.
Plantago media	.	.	1.1	+	.	+	.	.	.
Fragaria viridis	.	.	2.2	+	.	.	.	.	.
Briza media	.	.	+	+	.	.	.	.	.
Thymus pulegioides	.	.	.	.	.	.	1.1	.	1.1
Viola hirta	.	.	.	.	.	.	+	+	.
Sporadic: 4 *Melampyrum arvense* +; *Peucedanum cervaria* +; 7 *Potentilla heptaphylla* 3.2; *Scabiosa columbaria* +; 9 *Campanula rapunculoides* +									
Ch. *Festucetalia valesiacae*									
Anthericum liliago	.	+	1.1	3.3	3.3	2.2	.	.	.
Achillea pannonica	.	1.1	+	1.1	1.1	1.1	1.1	+	.
Centaurea rhenana	.	+	.	+	+	1.1	.	.	.
Campanula sibirica	+	+	+	+	.	+	.	.	.
Artemisia campestris	+	.	.	.	.	.	.	+	.
Orobanche caryophyllacea	.	.	.	.	.	.	.	+	+
Sporadic: 3 *Pulsatilla pratensis* +; 6 *Anthemis tinctoria* +; 7 *Stipa capillata* 1.2; Scabiosa canescens +									
Ch. *Festuco-Brometea*									
Anthericum ramosum	.	.	.	.	.	.	4.4	.	.
Salvia pratensis	+	1.1	2.2	+	1.1	1.1	2.2	3.3	3.3
Galium verum	1.1	1.1	2.2	1.1	1.1	1.1	+	1.1	2.2
Thalictrum minus	+	+	1.1	1.1	2.2	+	2.2	1.1	+
Medicago falcata	.	1.1	1.1	1.1	1.1	1.1	.	.	+
Dianthus carthusianorum	.	1.1	+	1.1	1.1	2.2	+	+	.
Euphorbia cyparisias	.	1.1	1.1	1.1	.	1.1	+	.	.
Centaurea scabiosa	1.1	.	+	+	+	.	+	+	+
Falcaria vulgaris	1.1	1.1	+	+	.	.	.	.	.

Table 1. Continued.

Number of relevés	1	2	3	4	5	6	7	8	9
Carex caryophyllea	+	1.1	.	.	.	+	.	.	.
Veronica spicata	.	+	+	+	.	.	+	1.1	.
Stachys recta	+	+	.	2.2	1.1	.	.	.	.
Asparagus officinalis	.	+	+	+	+	.	.	+	+
Scorzonera purpurea	.	+	1.1	+	.	.	.	.	.
Allium oleraceum	.	.	+	.	+	.	1.1	.	.
Sanguisorba minor	.	.	+	.	+	.	+	.	.
Ranunculus bulbosus	.	.	+	.	.	.	.	+	1.1
Agrimonia eupatoria	.	.	.	+	.	.	.	+	+
Phleum phleoides	.	.	.	+	.	.	+	.	.
Verbascum lychnitis	.	+	.	+	.	.	.	.	.
Pimpinella saxifraga	.	.	.	+	.	.	.	+	.
Polygala comosa	.	.	+	.	.	.	.	.	+
Sporadic: 1 *Malva alcea* +; 2 *Acinos arvensis* +; 4 *Koeleria macrantha* +; 8 *Avenula pratensis* +									
Ch. Molinio-Arrhenatheretea									
Holcus lanatus	.	+	.	1.1	.	1.1	.	.	.
Dactylis glomerata	.	.	+	1.1	+	.	.	1.1	+
Achillea millefolium	.	.	+	.	.	.	1.1	1.1	1.1
Phleum pratense	.	.	+	.	.	.	.	.	1.1
Poa pratensis	.	.	+	.	.	.	.	.	1.1
Viccia cracca	.	.	+	.	.	.	.	.	+
Sporadic: 1 Knautia arvensis + 4 Tragopogon orientalis + 7 Arrhenatherum elatius + 8 Centaurea jacea +, Festuca pratensis +									
Ch. Rhamno-Prunetea									
Prunus spinosa	.	1.1	+	1.1	.	1.1	.	.	.
Crataegus monogyna	+	1.1	.	+	.	1.1	.	+	.
Rosa canina	.	+	.	+	.		.	.	.
Acer campestre	.	+	.	.	.	+	.	.	.
Sporadic*: 6 Cornus sanguinea* +									
Accompanying:									
Origanum vulgare	.	.	.	1.1	.	+	.	2.2	+
Rubus sp.	1.1	.	.	1.1	.	.	.	.	.
Poa angustifolia	1.1	.	+	1.1	.	.	.	.	.
Coronilla varia	+	.	+	+	.	.	.	.	.
Hypericum perforatum	.	.	1.1	.	.	.	.	.	+
Arenaria serpyllifolia	.	1.1	.	.	.	1.1	.	.	.
Pyrus pyraster	.	+	.	+	.	.	.	.	+
Ulmus campestris	.	+	.	.	.	+	.	.	.
Sporadic: 1 *Lithospermum arvense* 1.1; *Lappula myosotis* +; 3 *Orchis militaris* 2.2; *Trifolim alpestre* +; 4 *Cichorium intybus* +; 7 *Calamagrostis epigejos* +; *Peucedanum oreoselinum* +; 9 *Equisetum arvense* +									

Biel. – Bielinek Reserve, Brod. – Brodogóry Reserve near Grędziec, Dol. – Dolsko, Naw. – Nawodna, St. P. – Stary Przylep Reserve; *A.r.* – with *Anthericum ramosum*.

pinnatum 3.3, *Prunus spinosa* 2.2, *Crataegus monogyna* 1.1, *Achillea pannonica* 1.1, *Anthericum liliago* 1.1, *Galium verum* 1.1, *Euphorbia cyparissias* 1.1, *Medicago falcata* 1.1, *Salvia pratensis* 1.1, A*cer campestre* +, *Campanula sibirica* +, *Carex caryophyllea* +, *Centaurea rhenana* +, *Cornus sanguinea* +, *Filipendula vulgaris* +, *Origanum vulgare* +, *Pyrus pyraster* +, *Rosa canina* +, and *Ulmus campestris* +.

On the other hand, transformations of the xerothermic grasslands with *Salvia pratensis* towards communities of dry meadows (Table 1, rel. 9) may be evidenced by the numerous participation of species of the order *Arrhenatheretalia*. Classification of such phytocenoses is sometimes questionable and must be preceded by evaluation of the quantitative and qualitative relations between the plants that accompany them, and an assessment of the condition of the site. It results from field observations of the authors that different directions of the succession of grasslands with *Salvia pratensis* within the area of the Brodogóry Reserve are related to soil conditions. Xerothermic scrubs usually grow on soils with better developed humus horizon, while mineral soils with poorly developed humus horizon are covered by dry meadow vegetation (Fig. 2).

Discussion

The xeromesophilous grasslands of the alliance *Cirsio-Brachypodion pinnati* are widespread in Pomerania [6]. However, the well-developed and floristically rich patches of the association *Adonido-Brachypodietum* are not found in many places. They usually cover small surfaces, mainly in the areas that have been long-known for large patches of xerothermic vegetation, e.g. in the marginal zone of valleys of the Lower Odra and Płonia rivers [1, 23]. According to Celiński and Filipek [4], most of the plant communities with the participation of *Brachypodium pinnatum* in the Bielinek Reserve are in transitional stages between xerothermic grassland and thermophilous oak wood, while both their development and preservation are connected with human activity.

The loose structure of forest stands and the presence of small sunny clearings in the oak woods of that reserve, have enabled preservation of the *Adonido-Brachypodietum* patches, even though they have not been in use since the reserve was created in 1956. This is pointing to a quite considerable tolerance of the species of that plant association to moderate shading and may be also evidence of a relatively stable character of this community. The stability and the transformation resistance of its patches in some biotopes have earlier attracted attention, among others, of Celiński and Filipek [4]. However, a condition for preserving a forest-grassland mosaic, being typical for thermophilous oak forest, is to mow grasslands periodically, at 5-10-year-long intervals. It is favorable to apply very late mowing, after diaspore seeding [24].

Disappearance of the xeromesophilous phytocenoses with *Brachypodium pinnatum* is mainly caused by the invasion of dense xerothermic scrubs of the class *Rhamno-Prunetea*, in particular by *Prunus spinosa* [4, 25]. This is shown by observations of the dynamics of the association *Adonido-Brachypodietum* in the Brodogóry Reserve, where the patches situated on the slopes over the village of Grędziec, documented by Filipek in 1974 [6], are absent now. The xerothermic plants have been completely ousted by trees and spreading shrubs. It can be estimated that the time of transformation for the grassland community into scrub amounts to about 15-20 years [3, 6, 26].

Both the small size of patches of the communities with *Brachypodium pinnatum* and location of some patches in the vicinity of meadows and plowland, make them susceptible to penetration by meadow and segetal species. Studies carried out in the North Down Natural Area showed that the most degraded grassland biotopes are surrounded by intensively fertilized arable fields, while the transformation of xerothermic biotopes is connected with penetration of nutrients into them [27]. The effect of this factor in Pomerania has been relatively rarely observed so far, due to less intensive fertilization and the location of many xerothermic grasslands in areas that are not favorable for cultivation.

Because of the rate of transformations, and the disappearance of xeromesophilous grasslands from the alliance *Cirsio-Brachypodion pinnati,* researchers need to answer the question: what is still a xerothermic grassland and what is not?

Barańska and Żmihorski [28] demonstrate that more common xerothermic grassland species can be used as indicator species, marking out the biotopes that should be protected. One may agree with this hypothesis only in the case of grasslands that indeed have become poor floristically but are situated in locations where a specific, xerothermic character of biotope has been preserved and which at the same time are not too isolated from other well-developed grassland ecosystems. This cannot, however, be applied to some phytocenoses composed of the xerothermic species with a broader ecological scale, such as, for instance, *Anthyllis vulneraria, Anthemis tinctoria,* and *Falcaria vulgaris,* which in northwestern Poland, in particular in the Odra River valley, show a tendency to spread over sunny and dry synanthropic biotopes, like railway embankments, roadsides, gravel pits, and fallow land [29]. In these locations, pioneer or replacement communities are developing with the participation of *Salvia pratensis.* Their floristic composition is related both to partly developed xerothermic communities and sandy grasslands (class *Koelerio-Corynephoretea canescentis*).

On the other hand, many patches of the association *Adonido-Brachypodietum* located within well-preserved grasslands documented in the past [e.g. 1, 3, 5, 9] are characterized by floristic impoverishment due to the disappearance of rare xeromesophytes. In their floristic composition, more common species are predominant at present, e.g. *Salvia pratensis, Brachypodium pinnatum* and *Veronica spicata*. As a result, these phytocenoses, being characterized by a simplified structure and no characteristic combination of species, resemble the aforesaid pioneer communities. Only comparison with historical data and a general

evaluation of biotopic transformations allow defining these communities as a degenerative stage of the association (as formulated by Faliński) [30].

In Europe, xerothermic grasslands are classified as vanishing biotopes that deserve protection [31, 32]. The greatest threat for grasslands of the alliance *Cirsio-Brachypodion pinnati* is posed by the invasion of trees and shrubs, which causes not only a considerable deterioration of environmental conditions, but also fragmentation of their patches [33]. In Pomerania, this is mainly a result of afforestation and natural succession processes intensified by discontinuation of their traditional use. The creation of strict reserves within the areas of xerothermic grasslands has repeatedly contributed to a reduction or even a disappearance of populations of many xerothermic species [16]. Grassland ecosystems in northwestern Poland, like in many areas of Europe, are anthropoclimaxes, i.e. stable communities that developed and survived owing to the human economy over many centuries [31-33]. Results of research on their succession, for instance [34, 35] demonstrate that an effective method of protection is reversion to traditional methods of farming, i.e. to moderate, alternate grazing or hay harvesting. Restoration of extensive farming, as a form of active protection, is a basic condition for preserving grassland biodiversity. This is because it enables their recolonization by species that are characteristic of xerothermic grasslands, including rare and protected plants. Their presence may be a symptom of reaching a certain environmental stability of these ecosystems and the relative persistence of the effects of applied protective measures, which is also desirable for economic reasons.

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