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CHARACTERISTICS OF THE FLORA OF FALLOW LANDS ON RENDZINA SOILS ON THE TWARDOWICE PLATEAU (SILESIAN UPLAND)

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Abstract

The paper presents the results of investigations on the flora of fallow lands on rendzina soils. The research was carried out in the area of the Twardowice Plateau (the Silesian Upland) within 9 areas adjacent to xerothermic grasslands. The investigated flora consisted of 220 vascular plant species with the dominance of native taxa. Plants of xerothermic grasslands and thermophilous edges were the most numerous (32%). The dominance of *Libanotis pyrenaica* in 4 of the examined areas should be emphasized. The percentage of meadow species was also considerable (25%). Anthropophytes comprised 18% of the flora of fallow lands and archaeophytes prevailed among them (9%). *Solidago canadensis*, an invasive species, was the constant component of the investigated fallows and sometimes its coverage was remarkable.

As a result of the high proportion of xerothermic and thermophilous plants, plants associated with dry soils and soils having an intermediate character between dry and fresh, as well as plants preferring slightly acidic to alkaline soils poor in nitrogen compounds predominated in the investigated fallows. Perennial plants prevailed (65%) in the studied flora and slightly more than half of the species reproduced only by seeds. Competitive plant species (C strategists) had the highest proportion (39%) and species with intermediate strategies CSR, CR and CS were also numerous.

The investigations have shown that there are favourable conditions for settling and growth of many xerothermic species in the investigated fallow lands. Moreover, the neighbouring grasslands are the seed source for these areas.

Key words: abandoned fields, secondary succession, xerothermic grasslands, anthropophytes, Ellenberg's indicators, life span, seed dispersal, C-S-R strategies.

INTRODUCTION

Over the last two decades, many cultivated fields have been abandoned and left fallow because of structural changes taking place in Polish agriculture after 1989. In many regions of Poland, the role of fallows is still increasing in the landscape and they are becoming a permanent component of the natural environment. Progressive urbanization and transformation of rural areas located on the outskirts of the towns, insufficient profitability of agricultural production, and sometimes the loss of soil productivity are the main reasons for the abandonment of agricultural lands (Orłowski and Nowak, 2004).

In Europe, set-aside is frequent in many countries and problems associated with it are the subject of many scientific studies. Among others, attention has been paid to the conditions conducive to the transformation of abandoned fields in semi-natural grasslands or heathlands as a result of spontaneous succession (Hennekens et al. 1982; Csecserits and Rédei, 2001; Csecserits et al. 2007; Jongepierová et al. 2004; Ruprecht, 2005, 2006; Cousins and Lindborg, 2008; Ejrnćs et al. 2008). It has also been revealed that the abandonment of arable lands often increased biodiversity in the areas of intensive agriculture (Corbet, 1995; Sotherton, 1998; Firbank et al. 2003). The appropriate level of biodiversity is essential for the level of internal regulation of agroecosystem functioning (Altieri, 1999). In Polish scientific literature, more and more attention is paid to the results of abandonment of agri-

cultural lands and changes occurring in their vegetation (Dubiel, 1984; Faliński, 1986; Malicki and Podstawka-Chmielewska, 1998; Barabasz-Krasny, 2002; 2011; Podstawka-Chmielewska et al. 2004; Kurus and Podstawka-Chmielewska, 2006; Skrzyczyńska and Stachowicz, 2007).

In the Silesian Upland, and especially in the part that is located near the cities of the Upper Silesian agglomeration, fallow lands of different age occupy a particularly large area. In many places, farming has been given up not only on the poorest soils, but also on more fertile ones, because people here have more possibilities of finding other ways to earn their living. A part of abandoned fields has been used for building purposes, while different types of vegetation have developed in the other parts of fallows. Multi-hectare areas are very often occupied by aggregations of goldenrods: *Solidago canadensis* and *S. gigantea.* The fallow vegetation rarely relates to semi-natural communities. In this latter case, the vegetation of the immediate surroundings may have a significant impact on the course of succession.

The Twardowice Plateau (Płaskowyż Twardowicki) is one of the Silesian Upland regions where fallow lands occupy large areas. The southern part of it is adjacent to the Upper Silesian agglomeration. Due to the geological structure of the Plateau, a part of fallows is associated here with rendzina soils and sometimes patches of xerothermic grasslands are situated in the immediate vicinity. The aim of the research on the flora of abandoned fields from the Twardowice Plateau was not only to determine its composition and characteristics, but also to answer the questions to what extent xerothermic species from adjacent grasslands are penetrating fallows on rendzina soils.

THE STUDY AREA

The Twardowice Plateau is one of the sub-regions of the Tarnowskie Góry Ridge (Garb Tarnogórski) in the Silesian Upland (Kondracki, 2001). It is built of Triassic limestone, especially Muschelkalk (Mid-Triassic). Its relief is very characteristic – long and broad humps with steep slopes are separated by numerous valleys running latitudinally (Gilewska, 1972).

The Twardowice Plateau is an old settlement area and therefore its natural vegetation is substantially transformed. Forests and woodlands cover only a small area and xerothermic grasslands are a particularly interesting element of the vegetation. They cover steep hill slopes which are unsuitable for agricultural purposes.

Until recently, it was a typically agricultural region and arable fields dominated in its landscape. The Plateau is situated not far from the towns of the Upper Silesian agglomeration such as: Dąbrowa Górnicza, Sosnowiec, Będzin, Czeladź, Wojkowice, and Piekary Śląskie. As a result of such a location, the majority of local people gave up farming. This process intensified in the 90's of the last century.

Fallow lands of different age occupy a large area on the plateau ridges, at the bottom of the slopes and in the valleys between them, especially in the southern part of the Twardowice Plateau. Very often, fallows from the plateaus and bottoms of the slopes are adjacent to xerothermic grasslands growing on the steep slopes of the hills.

Data concerning vascular plants, including xerothermic species, from the Twardowice Plateau can be found in the study dedicated to the flora of the eastern part of the Tarnowskie Góry Ridge (Nowak, 1999). More detailed information about xerothermic species and grasslands of the region are presented by Babczyńska-Sendek et al. (2010). Moreover, such data can also be found in the study relating to this kind of vegetation within the whole Silesian Upland (Babczyńska-Sendek, 2005). Information about the weed communities of the region are included in the papers on segetal vegetation of the Silesian Upland (Węgrzynek, 2003a, b, c, 2004, 2005) and on weeds of cereal crops in the Mid-Triassic Ridge (Próg Środkowotriasowy) (Sendek, 1992).

MATERIALS AND METHODS

The investigations were carried out in nine fallow areas situated in the central and southern part of the Twardowice Plateau. They were located in Rogoźnik (areas number 1, 4, 5), Strzyżowice (2, 3, 6), Góra Siewierska (7), Siemonia (8), and Myszkowice (9) (Fig. 1). Their areas were approximately 2.5–5 ha. The examined fallows occupied the feet and flat tops of the hills and sometimes their mildly inclined slopes. They were always adjacent to xerothermic grasslands which overgrew the steep slopes of the hills.

The investigations of the flora of the above-mentioned fallows were carried out during the growing season in 2010. A detailed inventory of vascular plant species was prepared for each site. The proportion of particular species in the plant cover was evaluated in a four-level scale: dominant, numerous, not very numerous, and occurring in small numbers. The obtained data were then used to prepare a floristic list of those sites and to make further detailed analysis. First, the proportion of native plant species from different habitat groups was analysed. Eight groups of that type were distinguished based on phytosociological affiliation of

species (Matuszkiewicz, 2001; Zarzycki et al. 2002). In the case of several plants, when phytosociological classification was difficult to determine, their frequent occurrence in xerothermic grasslands of the Twardowice Plateau (Babczyńska-Sendek et al. 2010) was taken into consideration. They were classified in the group of species associated with xerothermic grasslands and thermophilous edge communities. The historical-geographical groups of anthropophytes were distinguished according to Zając (1979), Zając et al. 1998, and Tokarska-Guzik (2005), whereas invasive species according to Tokarska-Guzik (2005). The share of plants with various moisture, pH and fertility requirements was also determined by means of Ellenberg's indicator values (Ellenberg et al. 1991). Subsequently, the percentages of representatives of different biological forms (annual, biennial, perennial, shrubs, and trees) were compared. They were distinguished on the basis of "Rośliny polskie" (Szafer et al. 1976). The proportions of plants with different types of propagation (according to BiolFlor database – www.biolflor.de) and with various ways of seed dispersal (following Frank and Klotz, 1988) were analyzed. The role of plants with different life strategies (Grime, 1979) was also considered (www.biolflor.de). The presence of protected (Rozporządzenie..., 2012) as well as rare and endangered species (Zarzycki and Szeląg, 2006) in the flora of fallows was pointed out. The names of vascular plants follow Mirek et al. (2002).

RESULTS

Characteristics of the flora

The vascular flora of the investigated fallow lands included 220 species. The analysis of their frequency showed that plants present at all the sites constituted 16%, and plants recorded in 8 of them – only 5% (Fig. 2). However, most of these species had a significant quantitative proportion in the fallow vegetation (Table 1). Species occurring only in one of the investigated areas were the most numerous (35%) and those recorded in two of them were relatively numerous (12%). Most of these plants had a small percentage in the plant cover. Moreover, two species which dominated in several fallows, although they were not present in all the locations, are worthy of notice. *Libanotis pyrenaica* should be mentioned first. It was present in 7 investigated fallows and in 4 of them it was definitely dominant (Table 1). *Peucedanum oreoselinum* is another species. It was found in 6 fallows, although it dominated only in one of them.

Native species prevailed (79%) in the flora of the investigated fallow areas (Fig. 3A). Plants of xerothermic grasslands and thermophilous edge communities were the most numerous (32%) among them (Fig. 3B). *Achillea collina*, *Centaurea scabiosa*, *Coronilla varia*, *Galium album,* and *Scabiosa ochroleuca* were the most frequent representatives of this group. They occurred in every studied fallow and reached high coverage (Table 1). *Agrimonia eupatoria*, *Euphorbia cyparissias*, *Falcaria vulgaris,* and *Medicago falcata* were also recorded in all the areas but their share in plant cover was usually insignificant. *Brachypodium pinnatum*, *Phleum phleoides,* and *Fragaria viridis* were also very frequent (8 fallow areas), but generally they did not reach high coverage.

The percentage of other thermophilous plants, including those associated with ruderal thermophilous communities, in the flora of the investigated areas was significant (10%). *Picris hieracioides* and *Senecio jacobea* were the most common and most numerous. Moreover, *Euphorbia esula, Hypericum perforatum,* and *Melilotus officinalis* grew in all fallows, but were less numerous. Xerothermic and thermophilous species constituted together 42% of the studied flora.

Meadow plants were the second largest group (25%) on the investigated fallow fields and 11 of their representatives occurred in all the investigated areas. *Taraxacum officinale*, *Vicia cracca* and *Valeriana officinalis* were the most abundant among them (Table 1).

Woodland and scrub species, which constituted 10%, formed the next habitat group but only *Rubus caesius* grew in all fallows, often rather numerously. *Prunus spinosa* and *Rosa canina* were also quite frequent (6 fallow land areas). The presence of species of forest clearings and nitrophilous edge communities (7%) as well as plants of psammophilous grasslands and poor meadows (6%) was also observed. Two species from the first group (*Artemisia vulgaris* and *Calamagrostis epigeios*) were relatively numerous in all fallows (Table 1). *Trifolium arvense* was the most common (6 fallows) representative of the second group.

Native plant species, which are usually weeds, constituted 9% of the fallow vegetation. Only 3 of them (*Cirsium arvense*, *Convolvulus arvensis,* and *Elymus repens*) were present in all the investigated wastelands and the first species was particularly numerous.

Anthropophytes comprised 18% of the investigated flora (Fig. 3A). Archaeophytes prevailed (49%) and agriophytes were the second largest group (31%). They constituted 9% and 5% of the total flora, respectively. The majority of archaeophytes are usually crop weeds and some of them (*Consolida regalis*, *Lathyrus tuberosus*, *Stachys annua*) are associated with soils abundant in calcium carbonate. *Consolida regalis*, *Lathyrus tuberosus* and *Vicia hirsuta* were the most frequent archaeophytes in the investigated fallow lands. The first two of them grew quite abundantly in some places (Table 1).

The significant proportion of agriophytes and, among them, plants considered to be invasive species, is also noteworthy. Among the invasive species, only *Solidago canadensis* was found in all the investigated fallow areas and sometimes it reached a significant share in the plant cover (Table 1). *Medicago sativa* and *M.* x *varia* were also common agriophytes. Epecophytes were few in number and only *Conyza canadensis* (invasive species) played a more important role in the fallow vegetation.

Moreover, 5 protected plant species were found in the area of investigated fallow lands (Table 1). Four of them (*Carlina acaulis*, *Orobanche bartlingii*, *O. elatior*, *O. lutea*) are strictly protected and one (*Ononis spinosa*) is partially protected. *Orobanche bartlingii* and *O. elatior* have been also included in the "Red list of the vascular plants in Poland" (Zarzycki and Szeląg, 2006) with the category R (rare). One more species from the analyzed flora – *Bromus secalinus* – has been also included in the list with the V (endangered) category.

Ecological requirements

Moisture (Fig. 4A). The analysis of the requirements for soil moisture showed that plants associated with very dry and dry habitats (F 2–3) played an important role (20%) in the flora of the examined fallows. However, the most numerous (30%) were the species preferring soil with intermediate features, being between dry and fresh (F 4). A quite significant part of the analyzed plants was also associated with fresh habitats (F 5) or showed wide tolerance to moisture conditions (18.5% and 14,5%).

Soil reaction (Fig. 4B). Most of the species (47.5%) in the flora of fallows preferred low acidic to alkaline soils (R 7–9). Many others (34%) had wide tolerance of soil reaction. The species which prefer moderately acidic habitats (R 5–6) constituted 11% of the investigated flora. Plants associated with acidic and highly acidic soils (R 2–4) had a small percentage (4.5%).

Nitrogen (Fig. 4C). A significant group (32%) of species found in the investigated fallows was associated with habitats very poor or poor in nitrogen (N 1–3). There were also many species (30.5%) which prefer habitats from relatively poor in nitrogen to fairly rich ones (N 4–6). Plants nitrophilous to varied degree (N 7–9) and species with wide tolerance of soil fertility were also quite numerous. These two groups constituted 18.5% and 15% of the fallow vegetation.

Life span, type of reproduction, and seed dispersal

Perennial plants predominated (65%) in the flora of abandoned fields on the Twardowice Plateau. Herbaceous perennial plants constituted as many as 83%; trees and shrubs were the remaining group (Fig. 5). Short-lived plants (annual and biennial) made up together 28% of the analyzed flora. Typical annual plants were the most numerous in this group.

The analysis of the reproduction type of species found in the investigated fallow lands showed that slightly more than half of them (52%) reproduced only by seeds (Fig. 6). When we included those that can reproduce vegetatively but more often use seeds for this purpose (14%), it appeared that generative reproduction was the most important for 66% of species forming the fallow flora. Therefore, the way of seed dispersal is also important. Species with adaptations to dispersal of seeds over long distances were predominant in the flora of the investigated fallows (Fig. 7). Plants that can spread in several different ways are the vast majority (59.5%) among them and anemochores are the second most numerous group (17%). Autochores, which constitute 8% of the flora, predominated in the group of plants whose diaspores can be shed only for a short distance.

Ecological strategy types (C-S-R)

Competitive plant species (C strategists) had the highest share (39%) in the flora of investigated fallow lands. Species with intermediate strategies CSR, CR and CS were also very numerous and they constituted up to 52% altogether. On the other hand, the share of ruderals (R strategists), stress tolerators (S strategists) and SR strategists was small. They made up 8% of the fallow flora in total and R strategists were the most numerous (6%) among them (Fig. 8).

Table 1.
Vascular plant species found in the investigated fallow areas, their frequency and proportion in the plant cover

Species	Area								
	1	2	3	4	5	6	7	8	9
Galium album Mill.									
Picris hieracioides L.									
Vicia cracca L.									
Achillea collina Becker ex Rchb.									
Centaurea scabiosa L.									
Senecio jacobea L.									
Artemisia vulgaris L.									
Cirsium arvense (L.) Scop.									
Taraxacum officinale Weber									
Scabiosa ochroleuca L.									
Valeriana officinalis L.									
Coronilla varia L.									
Rubus caesius L.									
Calamagrostis epigejos (L.) Roth									
Solidago canadensis L.									
Rumex crispus L.									
Daucus carota L.									
Euphorbia esula L.									
Convolvulus arvensis L.									
Conyza canadensis (L.) Cronquist									
Knautia arvensis (L.) J.M. Coult.									
Euphorbia cyparissias L.									
Arrhenatherum elatius (L.) P. Beauv. Ex J. Presl & C. Presl									
Hypericum perforatum L.									
Dactylis glomerata L.									
Falcaria vulgaris Bernh.									
Medicago falcata L.									
Melandrium album (Mill.) Garcke									
Melilotus officinalis (L.) Pall.									
Lotus corniculatus L.									
Festuca rubra L. s.str.									
Elymus repens (L.) Gould									
Medicago sativa L. s. str.									
Agrostis stolonifera L.									
Agrimonia eupatoria L.									
Pastinaca sativa L. s. str.									
Medicago x varia Martyn									
Trifolium repens L.									
Phleum phleoides (L.) H. Karst.									
Plantago lanceolata L.									
Silene vulgaris (Moench) Garcke									

Species	Area								
	1	2	3	4	5	6	7	8	9
Brachypodium pinnatum (L.) P. Beauv.									
Fragaria viridis Duchesne									
Sedum maximum (L.) Hoffm.									
Phleum pratense L.									
Rumex acetosa L.									
Libanotis pyrenaica (L.) Bourg.									
Lathyrus tuberosus L.									
Consolida regalis Gray									
Melampyrum arvense L.									
Verbascum lychnitis L.									
Campanula rapunculoides L.									
Rumex thyrsiflorus Fingerh.									
Crataegus monogyna Jacq.									
Tragopogon orientalis L.									
Lolium perenne L.									
Potentilla heptaphylla L.									
Leontodon hispidus L.									
Pimpinella saxifraga L.									
Centaurea jacea L.									
Vicia hirsuta (L.) Gray									
Peucedanum oreoselinum (L.) Moench									
Prunus spinosa L.									
Thalictrum minus L.									
Thymus pulegioides L.									
Trifolium arvense L.									
Fragaria vesca L.									
Rosa canina L.									
Trifolium pratense L.									
Seseli annuum L.									
Apera spica-venti (L.) P. Beauv.									
Astragalus glycyphyllos L.									
Astragalus cicer L.									
Chaerophyllum aromaticum L.									
Plantago major L. s. str.									
Lactuca serriola L.									
Chenopodium album L.									
Sanguisorba minor Scop. s. str.									
Bromus inermis Leyss.									
Centaurea cyanus L.									
Linum catharticum L.									
Centaurea stoebe L.									
Equisetum arvense L.									
Papaver rhoeas L.									

Species	Area								
	1	2	3	4	5	6	7	8	9
Crepis biennis L.									
Erigeron acris L.									
Medicago lupulina L.									
Vicia angustifolia L.									
Heracleum sphondylium L. s. str.									
Myosotis arvensis (L.) Hill									
Utrica dioica L.									
Dianthus carthusianorum L.									
***Ononis spinosa* L.**									
Briza media L.									
Pinus sylvestris L.									
Artemisia campestris L.									
Agrostis capillaris L.									
Cardaminopsis arenosa (L.) Hayek									
Arenaria serpyllifolia L.									
Cerastium arvense L. s. str.									
Allium oleraceum L.									
***Carlina acaulis* L.**									
Tussilago farfara L.									
Anthyllis vulneraria L.									
Euphrasia stricta D. Wolff ex J.F. Lehm.									
Campanula persicifolia L.									
Cirsium vulgare (Savi) Ten.									
Tanacetum vulgare L.									
Matricaria maritima subsp. *inodora* (L.) Dostál									
Arabis hirsuta (L.) Scop.									
Mentha arvensis L.									
Viola arvensis Murray									
Salvia verticillata L.									
Helianthemum nummularium subsp. *obscurum* (Čelak.) Holub									
Sinapis arvensis L.									
Hieracium pilosella L.									
Picea abies (L.) H. Karst.									
Rumex acetosella L.									
Peucedanum cervaria (L.) Lapeyr.									
Clinopodium vulgare L.									
Carex caryophyllea Latourr.									
Salvia pratensis L.									
Jasione montana L.									
Verbascum thapsus L.									
Rhinanthus serotinus (Schönh.) Oborný									
Chamaenerion angustifolium (L.) Scop.									
Galium verum L. s. str.									

Species	Area								
	1	2	3	4	5	6	7	8	9
Veronica chamaedrys L. s. str.									
Polygonum aviculare L.									
Potentilla reptans L.									
Betula pendula Roth									
Echium vulgare L.									
Pteridium aquilinum (L.) Kuhn									
Torillis japonica (Houtt.) DC.									
Lathyrus pratensis L.									
Galeopsis ladanum L.									
Stachys palustris L.									
Erigeron annuus (L.) Pers.									
Sambucus nigra L.									
Allium vineale L.									
Oenothera biennis L. s. str.									
Galinsoga parviflora Cav.									
Cornus sanguinea L.									
Geranium pusillum Burm. f. ex L.									
Quercus robur L.									
Acer pseudoplatanus L.									

Species found only in one of the investigated fallow areas (not very numerously occuring species are underlined; other species occurred singly):
Area 1: *Anthoxanthum odoratum* L. s. str, *Aster novi-belgii* L., *Avenula pubescens* (Huds.) Dumort., *Carlina vulgaris* L., *Echinocystis lobata* (F. Michx.) Torr. & A. Gray, *Geum urbanum* L., *Malva sylvestris* L., ***Orobanche lutea*** **Baumg.**, *Stachys recta* L., *Trisetum flavescens* (L.) P. Beauv.; **Area 2:** *Poa annua* L.; **Area 3:** *Bromus hordeaceus* L., *Bromus secalinus* L., *Gnaphalium sylvaticum* L., ***Orobanche bartlingii*** **Griseb.**, *Reseda lutea* L., *Trifolium montanum* L.; **Area 4:** *Festuca arundinacea* Schreb., *Galeopsis tetrahit* L., *Juglans regia* L., *Odontites serotina* (Lam.) Rchb. s. str., *Verbascum densiflorum* Bertol; **Area 5:** *Aegopodium podagraria* L., *Berteroa incana* (L.) DC., *Cerastium holosteoides* Fr. emend. Hyl., *Cerinthe minor* L., *Chamomilla recutita* (L.) Rauschert, *Deschampsia caespitosa* (L.) P. Beauv., *Galinsoga ciliata* (Raf.) S.F. Blake, *Polygonum lapathifolium* subsp. *lapathifolium* L., *Polygonum lapathifolium* subsp. *pallidum* (With.) Fr., *Sonchus arvensis* L.; **Area 6:** *Carex flacca* Schreb., *Carex spicata* Huds., *Danthonia decumbens* DC., ***Orobanche elatior*** Sutton, *Poa angustifolia* L., *Rhinanthus minor* L., *Silene otites* (L.) Wibel; **Area 7:** *Galium aparine* L., *Larix decidua* Mill., *Lysimachia vulgaris* L., *Malva alcea* L., *Robinia pseudoacacia* L., *Stachys annua* (L.) L., *Tilia cordata* Mill; **Area 8:** *Echinops sphaerocephalus* L., *Eupatorium cannabinum* L., *Festuca ovina* L. s. str., *Geranium pratense* L., *Rhamnus cathartica* L., *Rubus plicatus* Weihe & Nees, *Solidago gigantea* Aiton, *Vicia tenuifolia* Roth; **Area 9:** *Anthriscus sylvestris* (L.) Hoffm., *Armoracia rusticana* P. Gaertn., B. Mey. & Scherb., *Cerasus vulgaris* Mill, *Corynephorus canescens* (L.) P. Beauv., *Dipsacus sylvestris* Huds., *Holcus lanatus* L., *Leucanthemum vulgare* Lam. s. str., *Lupinus luteus* L., *Onobrychis viciifolia* Scop., *Padus serotina* (Ehrh.) Borkh., *Persica vulgaris* Mill., *Quercus rubra* L., *Ranunculus bulbosus* L., *Saponaria officinalis* L., *Sedum acre* L., *Selinum carvifolia* (L.) L., *Senecio vulgaris* L., *Veronica spicata* L., *Vicia sepium* L., *Vicia villosa* Roth.

Explanations:

– dominant species

– numerously occurring species

– not very numerously occuring species

– species occuring in small numbers

– lack of species

the names of protected species are written in bold

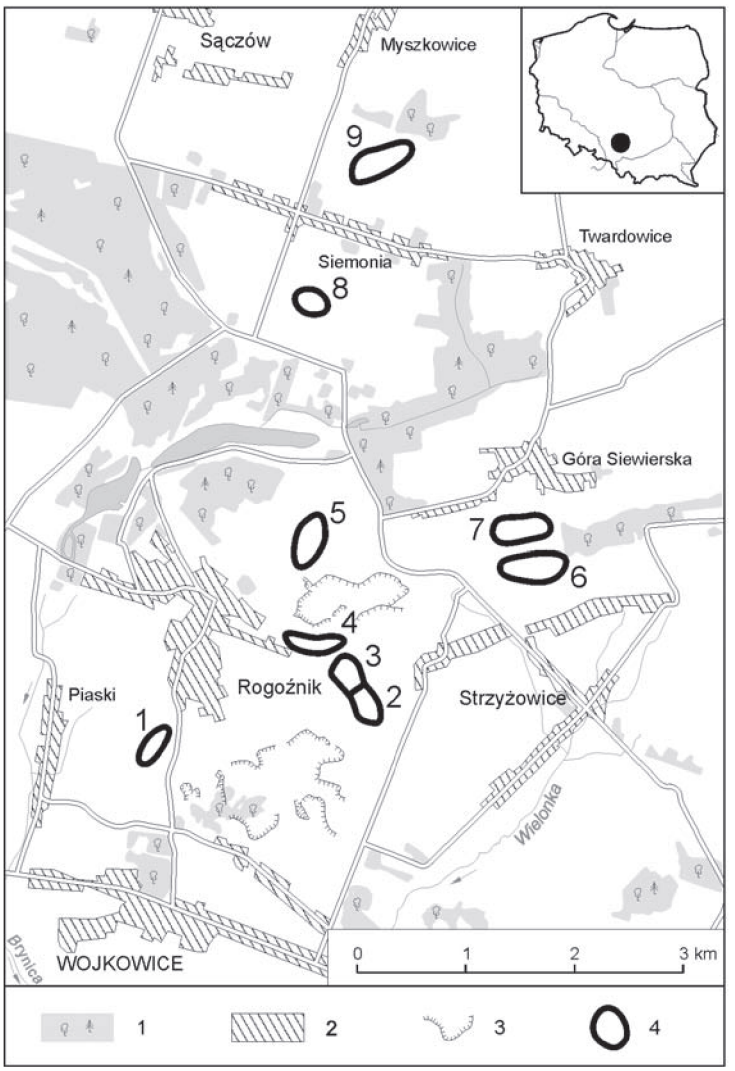

Fig. 1. Location of the investigated fallow areas.
Explanation: 1 – woodlands, 2 – built-up areas, 3 – quarries, 4 – areas of the investigated fallow lands (numbers next to them are consistent with the text of the article).

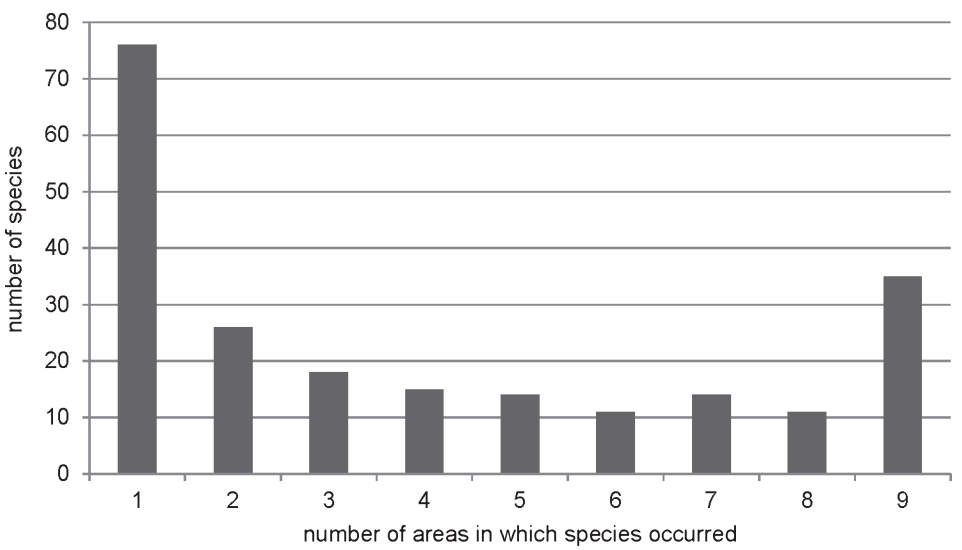

Fig. 2. Number of species with different frequency in the investigated fallow areas.

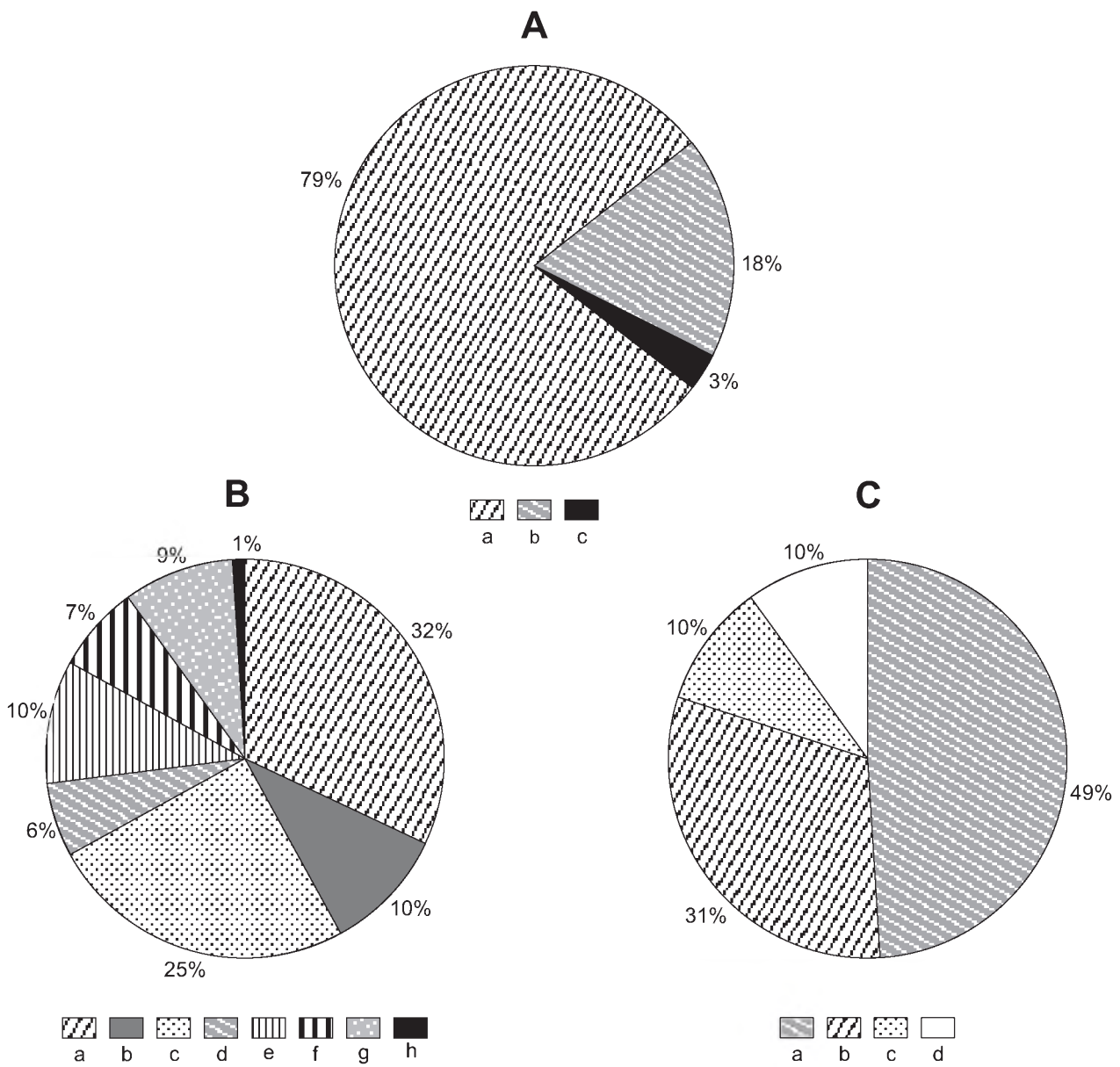

Fig. 3. Participation of native and alien species in the investigated flora: A – main groups: a – native plants, b – probable anthropophytes, c – anthropophytes; B – habitat groups of native plant species: a – species of xerothermic grasslands and thermophilous edge communities, b – other thermophilous species, c – meadow species, d – species of psammophilous grasslands and poor meadows, e – woodland and scrub species f – species of nitrophilous edge communities and of forest clearing, g – native weeds, h – others; C – groups of anthropophytes: a – archaeophytes, b – agriophytes, c – epecophytes, d – ergasiophygophytes.

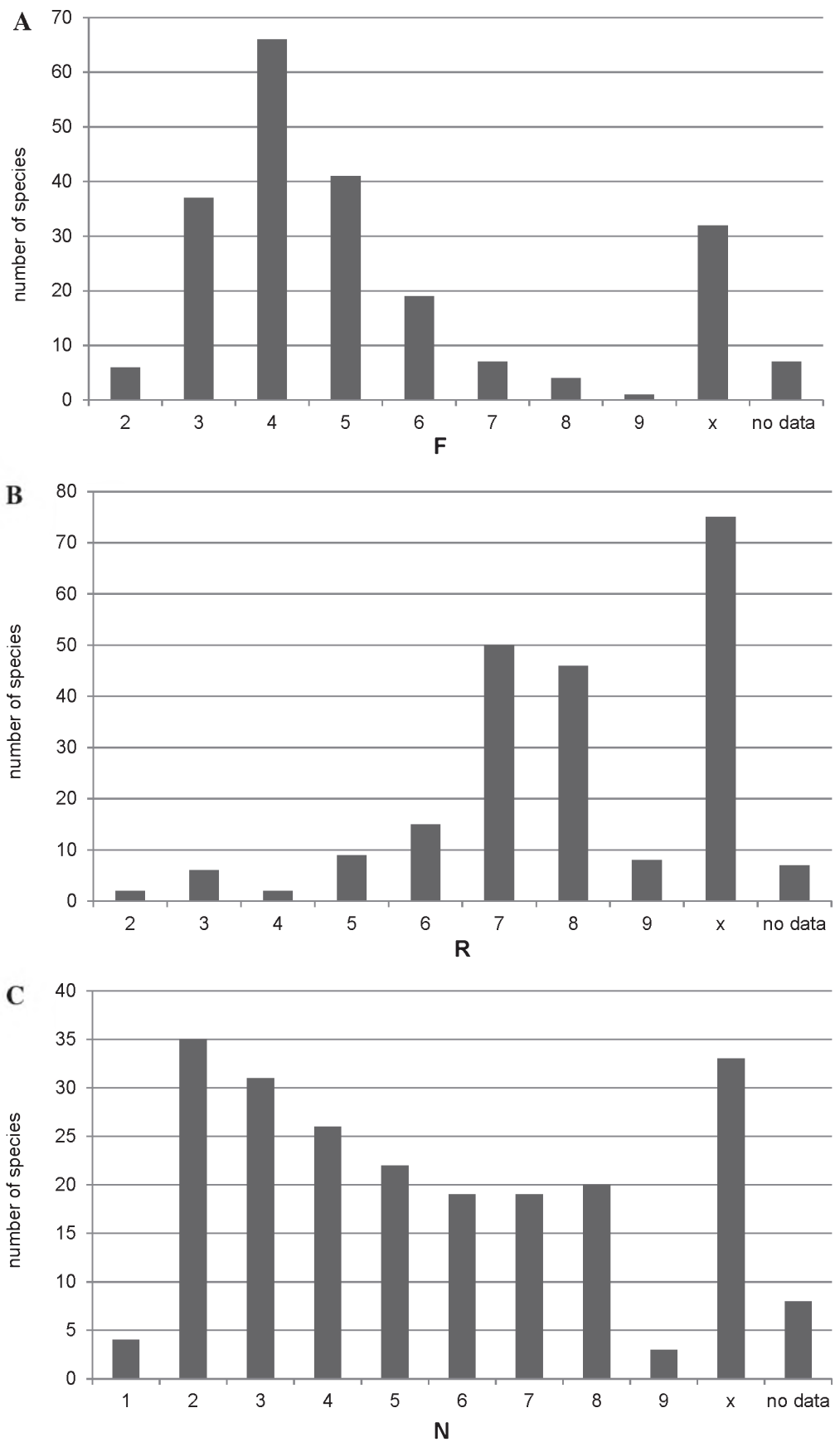

Fig. 4. Number of species with different ecological requirements for: A – soil moisture, B – soil reaction, C – nitrogen content.

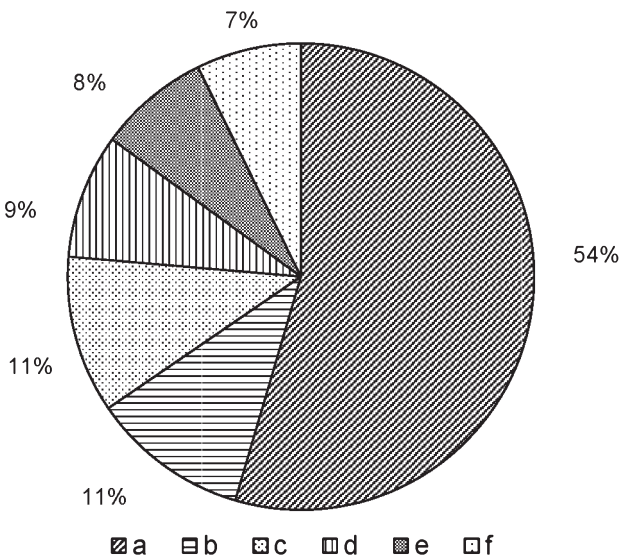

Fig. 5. Participation of species with different life spans: a – perennial, b – annual, c – trees and shrubs, d – biennial, e – annual or biennial, f – annual, biennial or perennial.

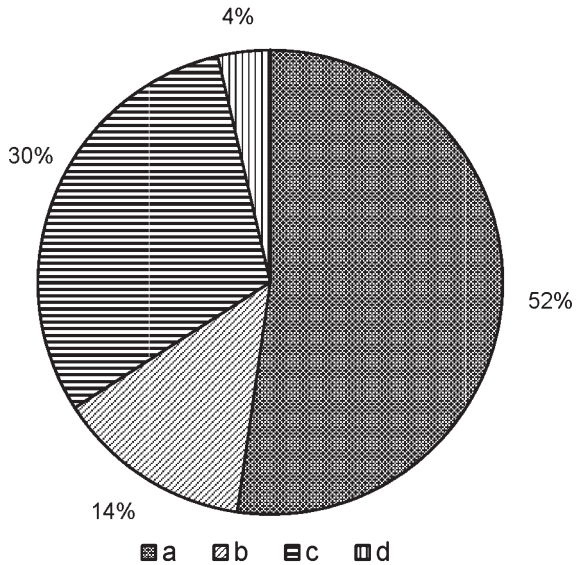

Fig. 6. Participation of species with different types of reproduction: a – by seeds, b – mostly by seeds, rarely vegetatively, c – by seeds and vegetatively, d – mostly vegetatively, rarely by seeds.

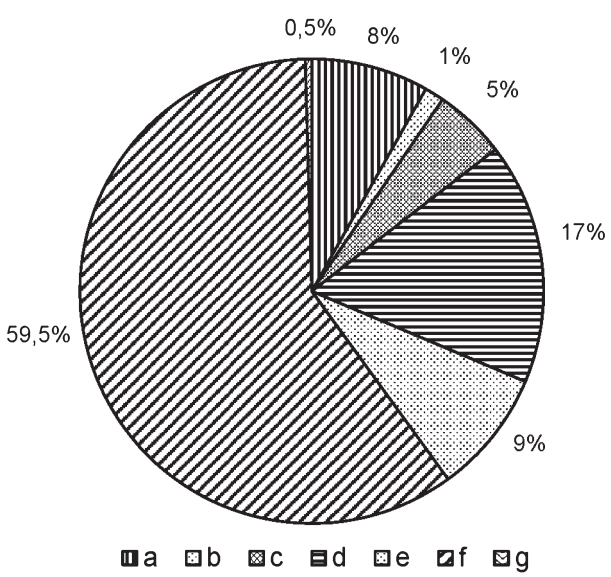

Fig. 7. Participation of species with different types of seed dispersion: a – autochores, b – myrmecochores , c – species with different adaptations to short-distance seed dispersal, d – anemochores, e – zoochores, f – species with different adaptations to long-distance seed dispersal, g – no data.

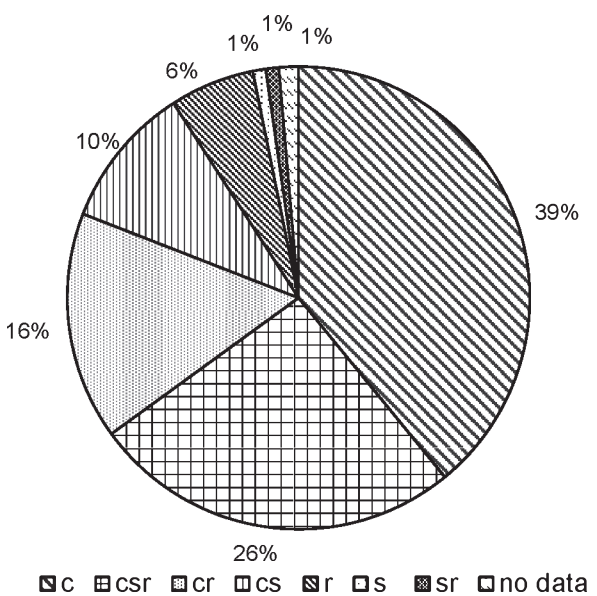

Fig. 8. Participation of species with different ecological strategy types (C-S-R).

DISCUSSION AND CONCLUSIONS

During the investigations it was found that some plant species which were present in all the investigated areas were also regular or very frequent components of the xerothermic grasslands of the Twardowice Plateau (Babczyńska-Sendek et al. 2010). Xerothermic species which were common in the grasslands, such as *Brachypodium pinnatum*, *Fragaria viridis*, *Phleum phleoides*, and *Silene vulgaris,* occurred in the majority of the fallows, while *Seseli annuum* and *Thymus pulegioides* were slightly less frequent. On the other hand, *Agrimonia eupatoria*, *Coronilla varia,* and *Falcaria vulgaris* were more frequent in the abandoned fields than in the grasslands, whereas *Libanotis pyrenaica* definitely prefers fallows. Some of meadow

species (*Festuca rubra*, *Knautia arvensis*, *Leontodon hispidus*, *Lotus corniculatus,* and *Plantago lanceolata*) recorded in the investigated waste lands were also constant or frequent components of xerothermic grasslands in the Twardowice Plateau (Babczyńska-Sendek et al. 2010). However, many other meadow plants found in the fallows occurred sporadically in grassland phytocoenoses or did not occur at all.

It should also be noted that archaeophytes from the investigated fallows such as *Consolida regalis*, *Lathyrus tuberosus,* and *Vicia hirsuta* were quite frequent in the eastern part of the Tarnowskie Góry Ridge (Nowak, 1999). Within this area, they were also recorded in weed communities of the *Caucalidion* alliance (Węgrzynek, 2003c).

The flora of investigated fallow lands from the Twardowice Plateau is quite abundant. If compared with the data from the area of the Podlaski Przełom Bugu mesoregion (Skrzyczyńska and Stachowicz, 2007), it can be stated that the number of vascular plants found in these abandoned fields is considerable. The flora of fallows from the areas on the Bug River was twice as numerous as the investigated flora, but the data were derived from 77 localities and, undoubtedly, from the areas with much more diversified habitat conditions. The increase of species diversity in the flora of fallow lands during the succession has been pointed out by some botanists (e.g. Ruprecht, 2005, 2006; Podstawka-Chmielewska et al. 2007). The large percentage of rare species, occurring only at one of the investigated sites, should be explained by the fact that fallow communities are deprived of the balance and open to newcomers from other habitats (Dubiel, 1984). An even higher percentage of very rare and rare species has been found in abandoned fields of the Podlaski Przełom Bugu mesoregion (Skrzyczyńska and Stachowicz, 2007) and in the Wierzbanówka valley (Dubiel, 1984).

The dominance of native species in the studied flora is not surprising. It is a generally known pattern which is confirmed in many publications on fallow flora as well as on succession in this type of habitats (Kurus et al. 2006; Podstawka-Chmielewska et al. 2007; Ruprecht, 2005, 2006; Jezierska-Domaradzka and Kuźniewski, 2007; Mazur-Rylska et al. 2007; Skrzyczyńska and Stachowicz, 2007; Węgrzynek et al. 2007). Many researchers (Dubiel, 1984; Barabasz-Krasny, 2002, 2011; Jongepierová et al. 2004, Ruprecht, 2005, 2006) have also emphasized that plant communities from the immediate vicinity have an impact on the composition of fallow flora and on their vegetation. Thus, a large proportion of xerothermic species in the studied areas is closely associated with the presence of xerothermic grassland phytocoenoses, often very extensive, in their vicinity. All protected plants recorded within the studied areas are the species of grassland communities.

The occurrence of xerothermic vegetation in fallow lands has also been found in the vicinity of Jaworzno and Trzebinia (the borderlands of the Silesian Upland and the Kraków-Częstochowa Upland) where the *Geranio-Peucedanetum cervariae* association has been identified in old abandoned fields (Woch, 2011). Communities with a substantial share of xerothermic species overgrowing fallows have also been described from the vicinity of Pilica at the eastern edge of the Kraków-Częstochowa Upland (Babczyńska-Sendek et al. 2011). In Europe, such penetration of xerothermic plants into abandoned fields has been observed, e.g., in South Limburg (the southern part of the Netherlands) (Hennekes et al. 1982) and in the Transylvanian Lowland in Romania (Ruprecht, 2005, 2006).

It should be stressed that *Cirsium arvense*, *Elymus repens,* and *Artemisia vulgaris*, native weeds and ruderal plants that are common and quite numerous in the fallow lands of the Twardowice Plateau, had a similar character in other regions of Poland (Dubiel, 1984; Podstawka-Chmielewska et al. 2004, 2007; Barabasz-Krasny, 2011), whereas *Lathyrus tuberosus*, an archaeophyte frequent in the investigated fallows, persisted for a long time in similar habitats in the Pogórze Przemyskie foothills (Barabasz-Krasny, 2011). The dominance of archaeophytes among anthropophytes occurring in the studied fallows was similar as in many other cases (Kurus et al. 2006; Kapeluszny and Haliniarz, 2007; Skrzyczyńska and Stachowicz, 2007; Węgrzynek et al. 2007).

The significant proportion of xerothermic plants in the investigated flora is reflected by species requirements concerning habitat factors such as soil moisture, pH and nitrogen content. As a result of this, there is a substantial share of plants associated with dry soils and soils having an intermediate character between dry and fresh, as well as plants preferring slightly acidic to alkaline soils poor in nitrogen compounds. However, the considerable proportion of species which prefer habitats abundant in nitrogen is a result of post-agricultural character of these habitats, on the one hand, and the lack of any use, on the other hand, which leads to the so-called auto-eutrophication (Moog et al. 2002). Prévosto et al. (2011) revealed that the number of nitrophilous species and species preferring more alkaline habitats decreases usually in the early stages of succession on abandoned fields. The predominance of perennials over short-lived plants was recorded on abandoned fields in different regions of Poland (Podstawka-Chmielewska et al. 2004, 2007;

Mazur-Rylska et al. 2007; Skrzyczyńska and Stachowicz, 2007) and England (Firbank et al. 2003; Boatman et al. 2011). The proportion of annual and biennial plants in the flora of fallows is decreasing with succession (Dubiel, 1984; Kurus et al. 2006; Kapeluszny and Haliniarz, 2007). A large number of species spreading by seeds and a small number of those that spread vegetatively have also been found in fallow lands in Saxony. The role of plants from the former group decreased during succession in favour of those that can reproduce both by seeds and vegetatively (Prévosto et al. 2011).

The significant share of competitors and the small proportion of ruderals indicate the advanced stage of succession in the investigated fallow lands. It has been proved that the increase of competitors and the decrease of ruderals is a result of spontaneous succession in different types of non-forest habitats, including abandoned fields. On the other hand, the share of stress tolerators is considerably lower in former arable fields, whilst it slightly increases with time (Boatman et al. 2011; Prévosto et al. 2011).

Based on the survey, it can be concluded that there are favourable conditions for settling and growth of many xerothermic species on rendzina soils of fallow lands on the Twardowice Plateau. Undoubtedly, the close proximity of xerothermic grasslands, which are the seed source for these plants, is conducive to this process. If they were grazed, even valuable phytocenoses of xerothermic grasslands could develop there.

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Charakterystyka flory odłogów na rędzinach Płaskowyżu Twardowickiego (Wyżyna Śląska)

Streszczenie

W pracy przedstawiono wyniki badań flory odłogowanych pól, na glebach typu rędzin. Badania prowadzono na terenie Płaskowyżu Twardowickiego (Wyżyna Śląska), na 9 powierzchniach zlokalizowanych w pobliżu muraw kserotermicznych. Flora badanych odłogów liczyła 220 gatunków roślin naczyniowych, a dominowały w niej taksony rodzime. Najliczniejsze były rośliny muraw kserotermicznych i ciepłolubnych okrajków (32%). Podkreślić należy dominację *Libanotis pyrenaica* na czterech badanych powierzchniach. Znaczny był też udział roślin łąkowych (25%). Antropofity tworzyły 18% badanej flory, a przeważały wśród nich archeofity (9%). Stałym składnikiem badanych odłogów, osiągającym niekiedy znaczny udział, była *Solidago canadensis* – gatunek inwazyjny.

Duży udział gatunków kserotermicznych i ciepłolubnych sprawił, że na badanych odłogach przeważały rośliny związane z glebami suchymi oraz o charakterze pośrednim pomiędzy suchymi i świeżymi, a także rośliny preferujące podłoże od słabo kwaśnego do zasadowego oraz bardzo ubogie i ubogie w azot. W badanej florze przeważały rośliny trwałe (65%), a ponad połowę stanowiły gatunki rozmnażające się wyłącznie za pomocą nasion. Największy udział (39%) miały rośliny o dużych zdolnościach konkurencyjnych (strategia C), a liczne były także te o strategiach mieszanych CSR, CR i CS.

Badania wykazały, że na badanych odłogach istnieją warunki sprzyjające osiedlaniu się i trwaniu wielu gatunków kserotermicznych, dla których źródłem diaspor są pobliskie murawy kserotermiczne.