*Studia Quaternaria*, vol. 37, no. 1 (2020): 45–50 DOI: 10.24425/sq.2019.126393

# FLORAL DIVERSITY OF PLANT COMMUNITIES IN FIELD BALKS

**Teresa Skrajna*, Agnieszka Bogusz**

*Department of Agricultural Ecology, University of Natural Sciences and Humanities, B. Prusa 14, 08-110 Siedlce, Poland; e-mail: tskrajna@op.pl, Agnieszka_bogusz@onet.pl*

** corresponding author*

**Abstract:**
The aim of the research was to study the floristic richness of balks, i.e. uncultivated strips separating fields, and to research the dependence of plant communities there on habitat conditions and adjacent crops. The share of segetal species in those communities was also analysed. In the western part of the Siedlce Plateau 70 balks among intensively cultivated fields were examined in 2016–2018. The balks divided fields with corn, winter cereals and spring cereal mixtures. The research was conducted with the Braun-Blanquet method, with 110 phytosociological relevés results used as study material. The flora specified this way was analysed in terms of biological structure, forms of life, persistence, historical and geographical spectrum, species rarity and presence of invasive species. In addition, the interdependence between the species richness of balks and habitat conditions as well as the type of neighbouring crops was studied. Habitat conditions were established with the Ellenberg indicator values, based on indicative species and taking into account light, temperature, moisture, soil reaction and nitrogen content. The development and floristic diversity of balk plant communities as ecotone areas were largely influenced by a proximity of arable fields and habitat conditions, especially by soil moisture and the amount of nitrogen. Balk flora consisted of vascular plants with 161 species, mainly apophytes. Those were mostly perennial species, hemikryptophytes. Among the most common field weeds from the class of *Stellarietea mediae*, 25 species were identified in balks. There were 26 rare and endangered species and 14 species having the status of invasive taxa.

sq

**Key words:** marginal habitats, segetal species, agricultural landscape, Poland

*Manuscript received 14 March 2019, accepted 7 October 2019*

## INTRODUCTION

Nowadays biodiversity conservation is essential both on regional and global scale (Symonides, 2014). Arable land dominant in the agricultural structure of Poland and most European countries plays an important role in maintaining biological diversity, at the same time deciding about the nature of rural landscape (Symonides, 2010, Ługowska *et al*., 2016). Moreover, a continuous increase in the demand for agricultural produce speeds up intensification of production processes. This leads to land consolidation and elimination of marginal habitats, including field balks. Those are narrow uncultivated strips of vegetation marking field boundaries, often the only places left where archaeophytes can be found (Tryjanowski *et al*., 2011; Symonides, 2014). Among marginal habitats, balks are the most common elements in a structure of the agricultural landscape. Floristic composition of plant communities there depends primarily on habitat conditions, balk width and type of crops in adjacent fields. Balks are also a refuge for rare species of natural, semi-natural, and segetal communities and they enrich the network of functional links between ecosystems (Karg, 2003; Symonides, 2010; Strychalska *et al.* 2013). The presence of balks has a significant impact on the biological diversity of adjacent plant communities. Many authors stress a high natural value of boundary balks and encourage their protection (Szwed *et al*., 1999; Symonides, 2008). The need for such an action is also indicated by other authors like Ratyńska (2003) or Kaźmierczakowa *et al.* (2016), with the latter citing a long list of rare and endangered segetal plants.

The aim of the research was a multifaceted analysis of the floristic diversity of field balks in different habitat conditions and determination of the percentage of segetal species.

## MTERIAL AND METHODS

A research in 2016–2018 dealt with 70 field balks occurring between intensively cultivated fields located in the western part of the Siedlce Plateau. The balks were adjacent to fields of maize, winter cereals, and spring cereal mixtures. They varied in width (from 0.5 to 2 m), length (from 100 to 300 m) and habitat conditions. Floristic diversity of the studied ecosystems were distinguished based on

110 phytosociological relevés, taken according to the used Braun-Blanquet method.

On their basis, a floristic composition of plant communities occurring there was specified, together with a share of segetal species. The flora was analysed in terms of plant classification, life forms and persistence (Rutkowski, 2007) in geographical and historical spectrum (Zając, 1979; Zając M. and Zając A., 1992, 2011, 2014; Tokarska-Guzik *et al*., 2014). Socio-ecological classification was also made (Jackowiak, 1990) together with categorising plant communities into groups of species using the phytosociological classification of Matuszkiewicz (2001). Current habitat conditions were established based on indicative species, using the Ellenberg indicator values (Ellenberg *et al*., 1992). In addition, the interdependence was studied between balk species richness, habitat conditions and the type of adjacent crops. Species frequency was defined according to the conventional scale, given that the number of relevés is the same as the number of balks, where very rare species occurred in 1–4 relevés, rare species in 5–10, quite common in 11–17, common in 18–32, very common in 33–50 and the most common in 51–77 relevés. Endangered species categories were defined using the works of Zając *et al*. (2009), Bomanowska (2010), Journal of Laws of (2014: no. 0, item 1409) and Kaźmierczakowa *et al*. (2016). Invasive species were specified based on the work of Tokarska-Guzik *et al.* (2014). The nomenclature of the species was used according to Mirek *et al*. (2002).

## RESULTS

Phytosociological research of boundary balks indicated the presence of 161 species of vascular plants belonging to 35 families. The *Poaceae* represented the largest number with 41 species, while 21 species were of the *Asteraceae* and *Polygonaceae* of 9 species. These were mainly native species (73.4%), i.e. apophytes, such as: *Alopecurus pratensis*, *Agrostis alba*, *Poa pratensis*, *Dactylis glomerata*, *Artemisia vulgaris* originating from meadow habitats, and *Galeopsis pubescens*, *Solidago virgaurea*, *Veronica hederifolia* from woodlands (Table 1). Most of the alien species consisted of archaeophytes (19.2%) like *Lithospermum arvense*, *Bromus secalinus*, *Centaura cyanus* or *Valerianella dentata*. There were only 9 kenophyte species (5.6%): *Anthoxanthum aristatum*, *Amaranthus retroflexus* and *Galinsoga parviflora*.

Table 1. Structure of origin, life forms and durability in field balks

| Species | No. species | Participation in % |
|---|---|---|
| Geographical and historical spectrum: | | |
| Apophytes | | |
| meadows (Ał) | 60 | 37.3 |
| above water (Anw) | 13 | 8.1 |
| grassland habitats (Amk, Amps, Aps) | 14 | 8.7 |
| shrub and forestry (Al, Az) | 34 | 19.3 |
| Archaeophytes (Ar) | 31 | 19.2 |
| Kenophytes (Kn) | 9 | 5.6 |
| Life-forms (Raunkiaer): | | |
| terophytes (T) | 55 | 34.2 |
| hemicryptophytes (H) | 79 | 49.1 |
| geophytes (G) | 19 | 11.8 |
| chamaephytes (Ch) | 5 | 3.1 |
| nanophanerophytes (N) | 3 | 1.8 |
| Durability: | | |
| short-lived (K) | 61 | 37.9 |
| perennial (W) | 100 | 62.1 |

Flora of the analysed plant communities was by far dominated by perennial species (62.1%), hemikryptophytes (49.1%) and geophytes (11.8%). There were 61 taxa (37.9%) of the short-lived species, mainly terophytes (34.2%).

Most of the balk species belonged to segetal plant communities of the *Stellarietea mediae* class (24.2%) and *Molinio–Arrhenatheretea* (14.9%) classes, but some of them were typical of woodland or wetland flora (Table 2, Fig. 1). Large fragmentation of agricultural landscape of the area is reflected by a presence of sandy grassland species (8%) of the *Koelerio glaucae–Corynephoretea canescentis* class and xerothermic grasslands (7.4%) represented by *Festuco–Brometea*. However, another significant group, mainly in terms of quantity, with ruderal species of *Agropyretea intermedio–repentis* and *Artemisietea vulgaris* constituted 6.2% and 5.6% of balk vegetation (Fig. 2).

The vegetation richness of boundary balks was affected by neighbouring crops (Tables 2 and 3) and habitat condi-

Table 2. Participation of phytosociological groups of analyzed field balks depending on the neighboring crops

| Class | Total | | Communities in the vicinity of crops | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | winter cereals | | spring cereals | | maize | |
| | no. of species | share (%) | no. of species | share (%) | no. of species | share (%) | no. of species | share (%) |
| *Stellarietea mediae* R.Tx., Lohm. et Prgs., 1950 | 39 | 24.2 | 25 | 33.3 | 20 | 24.4 | 24 | 39.3 |
| *Molinio–Arrhenatheretea* R.Tx., 1937 | 24 | 14.9 | 14 | 18.7 | 19 | 23.2 | 12 | 19.7 |
| *Koelerio glaucae–Corynephoretea canescentis* Klika in Klika et Novak, 1941 | 13 | 8.0 | 10 | 13.3 | 2 | 2.4 | - | - |
| *Festuco–Brometea* Br. Bl.et R.Tx.1943 | 12 | 7.4 | 8 | 10.6 | 2 | 2.4 | 1 | 1.6 |
| *Agropyretea intermedio–repentis* (Oberd. *et al*., 1967) Müller et Görs, 1969 | 10 | 6.2 | 6 | 8.0 | 8 | 9.7 | 8 | 13.1 |
| *Glechometalia hederacea* R.Tx. in R.Tx. et Brun-Hool, 1975 | 10 | 6.2 | 1 | 1.3 | 7 | 8.5 | 5 | 8.2 |
| *Artemisietea vulgaris* Lohm., Prsg et R.Tx. in R.Tx., 1950 | 9 | 5.6 | 5 | 6.7 | 10 | 12.2 | 5 | 9.8 |
| Other | 44 | 27.4 | 6 | 8.0 | 14 | 17.1 | 5 | 8.2 |
| Total | 161 | 100 | 75 | 100 | 82 | 100 | 61 | 100 |

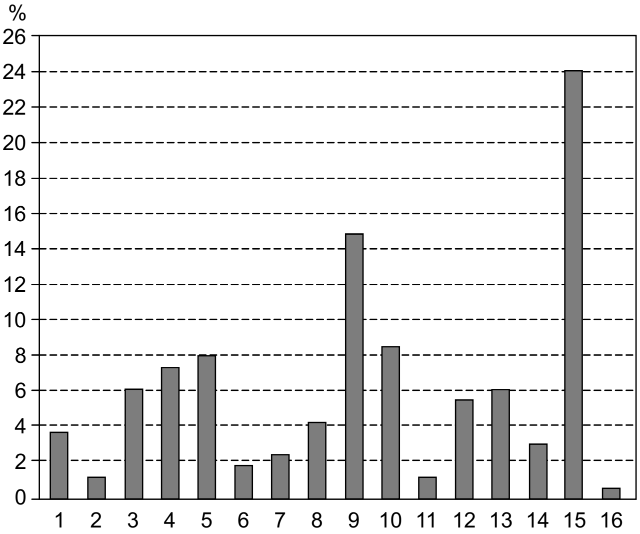


Fig. 1. Share of sociological-ecological groups of species in the field balk flora. 1 – *Querco–Fagetea*, *Rhamno–Prunetea*, 2 – *Vaccinio–Piceetea*, *Querceta robori–petracea*, *Epilobion angustifolii*, *Nardo–Calunetea*, 3 – *Sambuco–Salicion*, *Glechometalia chederacea*, 4 – *Festuco–Brometea*, *Trifolio–Geranietea sanguinei*, 5 – *Koelerio glaucae–Corynephoretea canescentis*, 6 – *Alnetea glutinosae*, *Scheuchzerio–Caricetea canescentis*, 7 – *Salicetea purpurae*, *Phragmition*, 8 – *Molinietalia*, 9 – *Arrhenatheretalia*, *Molinio–Arrhenatheretea*, 10 – *Trifolio–fragiferae–Agrostietalia stoloniferae*; *Plantaginetalia majoris*, 11 – *Bidentetea tripartiti*, *Isöeto–Nanojuncetea*, 12 – *Molinio–Arrhenatheretea*, *Convolvuletalia sepium*, 13 – *Agropyretea intermedio–repentis*, 14 – *Sisymbrietalia*, *Eragrostietalia*, 15 – *Stellarietea mediae*, 16 – species with undefined syntaxonomy.

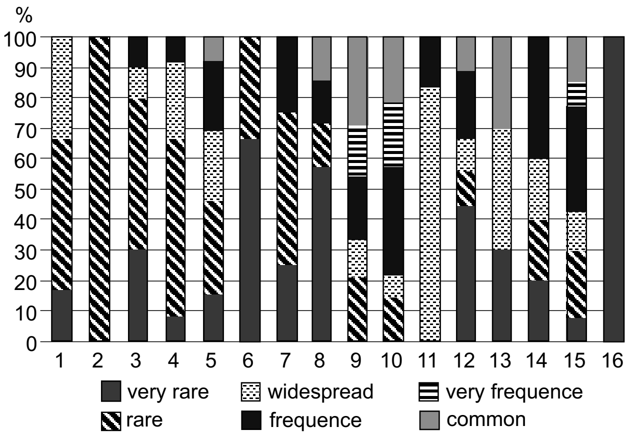


Fig. 2. Share of frequency classes among sociolo-ecological groups of species in field balk flora.

tions (Table 4). The richest communities (82 species) were those in balks between spring cereal fields while the smallest number of plant taxa was in balks close to maize fields, with only 61 species.

The studies indicated not only differences in species richness between balks and neighbouring fields but also differences in the share of the most common species. In all plant communities irrespective of the neighbouring field, there were always the same 13 species (Table 3). In phytocoenoses located in the vicinity of winter cereals those were: *Elymus repens*, *Lolium perenne* and *Bromus hordeaceus*, with the following species growing in balks neighbouring with spring cereals: *Elymus repens*, *Lolium perenne*, *Dactylis glomerata*, *Matricaria maritima* subsp. *inodora* and *Avena fatua*, and with *Elymus repens*, *Lolium perenne*, *Matricaria maritima* subsp. *inodora*, *Chenopodium album* and *Echinochloa crus–galli* growing in balks next to maize fields.

An analysis of balk flora using Ellenberg indicator values (Ellenberg *et al*., 1992) (Table 4) indicated that most species preferred moderate light (L = 6.65) e.g. *Poa trivialis*, *Apera spicaventi*, or *Rorippa palustris.* A slight percentage of species that required sheltered places and better exposure to light like, among others *Echium vulgare*, *Geranium pratense* or *Cichorium intybus*. They were found more often in balks with neighbouring spring cereal fields.

An analysis of the distribution of temperature indicators showed dominance of species with moderately low thermal requirements (T 3.82–4.11). However, there were clear differences between other FRN factors (soil moisture, soil reaction, nitrogen content) and the effect of adjacent crops. An analysis of the distribution of humidity showed dominance of species with moderate soil moisture requirements (F 5.11; 5.21) in balks neighbouring with spring ce-

Table 3. Dominant species of communities in the field balks

| | Communities in the vicinity of crops | | |
|---|---|---|---|
| | winter cereals | spring cereals | maize |
| No. of phytosociological relevès | 30 | 40 | 40 |
| No. of species | 75 | 82 | 61 |
| | S D | S D | S D |
| *Elymus repens* L. | V 1480 | V 2855 | V 2840 |
| *Lolium perenne* L. | V 1505 | V 1935 | V 1585 |
| *Dactylis glomerata* L. | V 385 | V 733 | V 685 |
| *Agrostis stolonifera* L | IV 540 | IV 450 | IV 330 |
| *Matricatia maritima* subsp. *inodora* L. | III 160 | V 415 | V 750 |
| *Festuca rubra* L. | III 320 | III 250 | V 355 |
| *Artemisia vulgaris* L. | V 185 | IV 315 | IV 215 |
| *Convolvulus arvensis* L. | IV 165 | V 90 | IV 150 |
| *Bromus hordeaceus* L. | V 970 | IV 165 | IV 360 |
| *Tanacetum vulgare* L. | IV 125 | IV 480 | III 255 |
| *Chenopodium album* L. | IV 185 | V 190 | V 275 |
| *Ehinochloa crus-galli* L. | II 75 | V 160 | V 715 |
| *Avena fatua* L. | III 75 | V 365 | IV 85 |

Explanations: S – constancy; D – cover index.

Table 4. Characteristics in field balk habitats

| Ellenberg indicator values | Neighboring crop | | | |
|---|---|---|---|---|
| | mean for balks | mean for winter cereals | mean for spring cereals | mean for maize |
| L - light | 6.65 | 6.52 | 6.80 | 6.20 |
| T - temperature | 4.11 | 4.02 | 4.27 | 3.82 |
| F – moisture content | 4.31 | 3.82 | 5.11 | 5.21 |
| R – soil reaction (pH) | 3.66 | 3.52 | 4.92 | 4.98 |
| N - nitrogen content | 4.75 | 4.12 | 5.94 | 6.21 |

Table 5. Rare and endangered species in field balk flora

| Species | Frequency of occurrence | Socio-ecological groups | Geographical and historical spectrum | Life forms | Durability | Threat category Bomanowska, 2010; Kaźmierczakowa *et al.*, 2016 |
|---|---|---|---|---|---|---|
| *Agrostemma githago* | rz | 15 | Ar | T | W | EN.V |
| *Arnoseris minima* (L.) Schweiagg & Korte | rz | 1 | Amps | T | K | LR |
| *Asperugo procumbens* L. | brz | 13 | Kn | T | K | E. VU |
| *Bromus secalinus* L. | cz | 15 | Ar | T | K | V.VU |
| *Carex sylvatica* Hudson | rz | 1 | Al | G | W | I |
| *Centaurea cyanus* L. | cz | 15 | Ar | T | K | I |
| *Chenopodium polyspermum* L. | rz | 15 | Anw | T | K | I |
| *Centaurium erythraea* Rafn | brz | 4 | Anw | T | K | CR.!! |
| *Consolida regalis* Gray | cz | 15 | Ar | T | K | I |
| *Dianthus arenarius* L. | brz | 5 | Ał | Ch | W | RC |
| *Dianthus carthusianorum* L. | brz | 5 | Amk | Ch | W | RC |
| *Epipactis palustris* (L.) Crantz | brz | 6 | Al | G | W | V.VU.!! |
| *Lithospermum arvense* L. | rp | 15 | Ar | T | K | I.V |
| *Neslia paniculata* (L.) Desv. | rp | 15 | Ar | T | K | I.V |
| *Papaver argemone* L. | rz | 15 | Ar | T | K | I.R |
| *Papaver dubium* L. | brz | 15 | Ar | T | K | I.R |
| *Papaver rhoeas* L. | rp | 15 | Ar | T | K | IR |
| *Polygonum bistorta* L. | brz | 8 | Ał | G | W | IR |
| *Rhinanthus serotinus* (Schonh.) Oborny | rz | 15 | Ał | T | W | RC |
| *Spergularia rubra* (L.) J. Presl & C. Presl | rp | 11 | Ał | T | K | I |
| *Valerianella locusta* (L.) Latter. em. Betcke | brz | 15 | Ar | T (U) | K | R.V |
| *Valerianella dentata* (L.) Pollich | brz | 15 | Ar | K | T | DD |
| *Veronica triphyllos* L. | rz | 15 | Amk | T | K | R |
| *Veronica agrestis* L. | rz | 15 | Ar | K | T | DD |
| *Viola odorata* L. | brz | 3 | Al | H | W | DD |
| *Viola tricolor* L. | rz | 5 | Al | T | K | R |

Explanations: Threat category by: Kaźmierczakowa *et al.*, 2016; Bomanowska 2010; Zając *et al.*, 2009; and the Journal of Laws of 2014, No 0. item 1409.

reals and maize. However, communities close to winter cereals were formed by species tolerating dry periods like *Bromus tectorum*, *Artemisia campestris*, *Rumex acetosella* and *Verbascum thapsus*, i.e. plants typical for grassland and branched habitats (F 3.82).

An analysis of soil acidity for species growing next to spring cereal fields or maize fields showed the dominance of native species with a wide tolerance of soil reaction (R 4.92; 4,98). In balks adjacent to winter cereals there were more species preferring acidic soil (R 3.66). A similar trend was observed for nitrogen content (N) in balk habitats. It was substantially higher for balks close to spring cereals and maize (N 5.94, 6.21) than winter cereals (N 4.12).

There were 26 species with different plant protection status in the region and the country (Głowacki *et al.*, 2003; Bomanowska, 2010; Kaźmierczakowa *et al.*, 2016) (Table 5). These were mainly species very rare and rare on balks, but common in segetal habitats and less common in natural and semi-natural ones Those were the following protected and endangered species: *Agrostemma githago, Asperugo procumbens, Bromus secalinus, Epipactis palustris* and *Lithospermum arvense.* Some rare plant species were also identified: *Centaurium erythraea*, *Dianthus arenarius*, *Dianthus carthusianorum*, *Neslia paniculata*, *Papaver argemone*, *Papaver dubium*, *Papaver rhoeas*, *Polygonum bistorta*, *Rhinanthus serotinus*, *Valerianella locusta*, *Veronica triphyllos* and *Viola tricolor.* There were some species with an unidentified protection status: *Carex sylvatica*, *Centaurea cyanus*, *Chenopodium polyspermum*, *Consolida regalis*, *Spergularia rubra*, *Valerianella dentata*, *Veronica agrestis* and *Viola odorata*. In addition, in the above group of plants, *Epipactis palustris* and *Centaurium erythraea* are listed as the protected species.

Among the identified balk flora there were 14 invasive species (Tokarska-Guzik *et al.*, 2014) (Table 6). Those were mostly alien species, i.e. kenophytes, growing in both

Table 6. Invasive species in field balk flora

| Species | Frequency of occurrence | Socio-ecological groups | Geographical and historical spectrum | Life forms | Durability |
|---|---|---|---|---|---|
| *Alopecurus myosuroides* Huds | cz | 10 | Ar | H | W |
| *Amaranthus retroflexus* L. | cz | 14 | Kn | T | K |
| *Anthoxanthum aristatum* Boiss | rz | 15 | Kn | T | W |
| *Avena fatua* L. | cz | 15 | Ar | T | K |
| *Echinocystis lobata* (Michaux) Torrey et A. Gray | rz | 12 | Kn | T | K |
| *Echinochloa crus-galli* L. | p | 15 | Ar | T | K |
| *Erigeron annuus* L. | rz | 14 | Kn | T(H) | K |
| *Galinsoga parviflora* Cav. | cz | 15 | Kn | T | K |
| *Impatiens parviflora* CD | rz | 3 | Kn | T | K |
| *Lolium multiflorum* Lam. | cz | 14 | Kn | T | W |
| *Rumex confertus* (Willd) | rz | 10 | Kn | H | W |
| *Setaria viridis* L. | cz | 15 | Ar | T | K |
| *Setaria pumila* L. | cz | 15 | Ar | T | K |
| *Solidago canadensis* L. | cz | 12 | Kn | H | W |

Explanations: Invasive species from work Tokarska-Guzik *et al*., 2014.

anthropogenic and natural habitats. They often constituted significant vegetation coverage, with *Avena fatua*, *Galinsoga parviflora*, *Solidago canadensis*, *Rumex confertus*, *Impatiens parviflora* and others.

## DISCUSSION

Field balks in the western part of the Siedlce Plateau represent a much greater floristic richness than in other regions of the country (Strychalska *et al*., 2013; Kryszak *et al*., 2017). It is determined by many factors, among others, by a large diversity of agricultural landscape, significant fragmentation of fields, extensive contacts of crops with neighbouring natural habitats and presence of poor-quality arable land left fallow for economic reasons (Bomanowska, 2010). Floristic diversity is typical, affected by neighbouring plant communities. The poorest balks are those neighbouring with maize fields; they are often narrow and the impact of anthropogenic activity is the greatest, related to the intensive technology used to grow maize (Gołębiewska *et al*., 2015). Such balks are characterized by a dominant share of grass, which indicates a low stability of communities and significant participation of annual and biennial species, dicotyledonous plants mainly of foreign origin (Łabza, 2007; Balcerkiewicz and Pawlak, 2010). Some species growing in balks show significant dynamic trends, often adapting to new conditions well, but also leaving their habitat of arable land as a result of strong anthropogenic activity. According to Kapeluszny and Haliniarz (2010), such species include grasses (*Poaceae*), e.g. *Echinochloa crus–galli*, *Elymus repens*, *Avena fatua* or *Apera spica–venti*. Species diversity of balk phytocoenoses is dependent on habitat conditions and a dominant share of species of the class *Stellarietea mediae* indicating a neighbourhood of maize points out also to decisive anthropogenic factors (higher content of N) in shaping plant communities of balks. As a research of Krasicka-Korczyńska and Borzych (2002) and Karg (2003) indicates, even with strong anthropogenic activity balks are rich in flora, which is represented in particular by plants with herbal meaning.

Taking into account that a structure of agricultural landscape is becoming poorer, the presence of balks has a positive effect on preserving biodiversity at multiple levels (Kozłowski, 2005; Dabrowski *et al*., 2008; Symonides, 2010). Floristic studies of field balks located in the western part of the Siedlce Plateau emphasize a role of those narrow strips of land in preservation of rare and endangered plant species. Balks are a special refugee for endangered segetal weeds, mainly archaeophytes, which are difficult to come across in neighbouring agrocenoses. In addition, balks are also a place where invasive species like *Echinocystis lobata*, *Rumex confertus*, *Impatiens parviflora*, *Erigeron annuus*, *Avena fatua* or *Solidago canadensis* grow and spread.

## CONCLUSIONS

- Plant communities in balks are characterized by high species richness, made up mainly by native plants with a wide range of habitats.
- Presence and share of segetal species in balks depend on soil conditions and adjacent agrocenoses.
- Balks between winter cereal fields are rich in species and those adjacent to maize are the poorest.
- Balks also play a role of a refugee for rare and endangered species both in segetal and natural habitats and they constitute corridors for invasive species.

## REFERENCES

Balcerkiewicz, S., Pawlak, G., 2010. The role of alien plant species in the segetal communities of Poland. Fragmenta Agronomica 27(2), 19–30.

Bomanowska, A., 2010. Threat to arable weeds in Poland in the light of national and regional red lists. Plant Breeding and Seed Science 61, 55–74.

Dabrowski, Z.T., Boczek, J., Kropczyńska-Linkiewicz, D., Garnis, J., 2008. Znaczenie infrastruktury ekologicznej w produkcji. Progress in Plant Protection 48 (3), 761–770.

Ellenberg, H., Weber, H.E., Düll, R., Wirth, V., Werner, W., Paulißen, D., 1992. Zeigerwerte von Pflanzen in Mitteleuropa. Scripta Geobotanica, 18.

Głowacki, Z., Falkowski, M., Krechowski, J., Marciniuk, J., Marciniuk, P., Nowicka-Falkowska, K., Wierzba, M., 2003. The red list of vascular plants of the Południowopodlaska Lowland – Chrońmy Przyrodę Ojczystą 59, 5–41.

Gołębiowska, H., Snopczyński, T., Domaradzki, K., Rola, H., 2015. Changes in weed infestation in corn crops in southwestern region of Poland in 1963–2013 years. Progress in Plant Protection 55(3), 327–339.

Jackowiak, B., 1990. Anthropogenic changes of flora of vascular plants in Poznań. Wyd Nauk. UAM, Poznań, ser, Biologia 42, 232.

Kaźmierczakowa, R., Bloch-Orłowska, J., Celka, Z., Cwener, A., Dajdok, Z., Michalska-Hejduk, D., Pawlikowski, P., Szczęśniak, E., Ziarnek, K., 2016. Polish red list of pteridophytes and flowering plants. Institute of Nature Conservation, Polish Academy of Sciences, Kraków. 44 pp.

Kapeluszny, J., Haliniarz M., 2010. Expansive and treatend segetal flora species in middle-eastern Poland. Annales UMCS, Sect. E, Agricultura 65 (1), 27–33.

Karg, J., 2003. Stubs of midfield buffer zones of ground. Agencja Reklamowo-Wydawnicza „Skigraf", Warszawa, 1–28.

Kozłowski, J., 2005. Host plants and harmfulness of the *Arion lusitanicus* Mabille, 1868 slug. Journal of Plant Protection Research 45 (3), 221–233.

Krasicka-Korczyńska, E., Borzych, W., 2002. Medicinal plants of environmental islands in the agricultural landscape on the example of the Kcynia commune. In: Banaszak, J. (Ed.), Environmental islands, biodiversity and typology tests, 25–34. Wydawnictwo Akademii Bydgoskiej, Bydgoszcz.

Kryszak, A., Kryszak, J., Owsiankowska, P., Klarzyńska, A., 2017. Floristic diversity of field balks. Fragmenta Agronomica 34 (4), 67–76.

Łabza, T., Dąbkowska, T., Stupnicka-Rodzynkiewicz, E., 2007. Changes in the succession of vegetation of fields excluded from cultivation. Acta Botanica Warmiae et Masuriae 4, 11–21.

Ługowska M., Pawlonka Z., Skrzyczyńska J. 2016. The effects of soil conditions and crop types on diversity of weed communities. Acta Agrobotanica 69 (4), 1–9.

Matuszkiewicz, W., 2001. Guidebook to plant communities of Poland. PWN, Warszawa, 537 pp.

Mirek, Z., Piękoś-Mirkowa, H., Zając, A., Zając, M., 2002. Flowering plants and pteridophytes of Poland – a checklist. In: Mirek, Z. (Ed.), Biodiversity of Poland 1, 442 pp. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Ratyńska, H., 2003. Zanim zginą maki i kąkole… Wydawnictow Klubu Przyrodników, Świebodzin, 55 pp.

Rutkowski, L., 2007. An identification key to vascular plants in lowland Poland. PWN, Warszawa.

Strychalska, A., Maćkowiak, Ł., Kryszak, A., Kryszak, J., Klarzyńska, A., 2013. Grasses (*Poaceae*) in balks association of Wielkopolska. Fragmenta Floristica et Geobotanica Polonica 20 (2), 237–244.

Symonides, E., 2008. Nature protection. Wydawnictwo Uniwersytetu Warszawskiego, 767 pp.

Symonides, E. 2010. The role of ecological interactions in the agricultural landscape. Water-Environment-Rural Areas, 10, 4 (32), 249–263.

Symonides, E., 2014. Contemporary biological diversity – its importance for humans, threats and opportunities for protection. In: Galwas, B., Wyżnikiewicz, I., Symonides, E. (Eds), Biological diversity of Poland. Is the crisis of world resources? Komitet Prognoz „Polska 2000 Plus" PAN, Warszawa.

Szwed, W., Ratyńska, H., Danielewicz, W., Mizgajski, A., 1999. Przyrodnicze podstawy kształtowania marginesów ekologicznych w Wielkopolsce. Katedra Botaniki Leśnej, Akademia Rolnicza, Poznań. 144 pp.

Tokarska-Guzik, B., Dajdok, Z., Zając, M., Zają,c A., Urbisz, A., Danielewicz, W., Hołdyński, Cz., 2014. Alien plants in Poland with particular reference to invasive species, 1–169.

Tryjanowski, P., Dajdok, Z., Kujawa, K., Kałuski, T., Mrówczyński, M., 2011. Threats to biodiversity in farmland: are results from Western Europe good solutions for Poland? Polish Journal of Agronomy 7, 113–119.

Zając, A., 1979. Pochodzenie archeofitów występujących w Polsce. Zeszyty Naukowe Uniwersytetu Jagiellońskiego, Rozprawy Habilitacyjne 29.

Zając, M., Zając, A., 1992. A tentative list of segetal and ruderal apophytes in Poland. Zeszyty Naukowe Uniwersytetu Jagiellońskiego, Prace Botaniczne 24, 11–23.

Zając, M., Zając, A., Tokarska-Guzik, B., 2009. Extinct and endangered archaeophytes and the dynamics of their diversity in Poland. Biodiversity Research and Conservation 13, 17–24.

Zając, M., Zając, A., 2011. Methodical problems in distinguishing the group of archaeophytes. Synantropizacja w dobie zmian różnorodności biologicznej. Acta Botanica Silesiaca 6, 55–62.

Zając, M., Zając, A., 2014. Survival problems of archaeophytes in the Polish flora. Biodiversity Research and Conservation 35, 47–56.