ACTA AGROBOTANICA
Vol. 66 (3), 2013: 89–94
Original Research Paper
DOI: 10.5586/aa.2013.042

THE SPECIES DIVERSITY OF CEREAL AND ROOT COMMUNITIES IN THE MUNICIPALITIES LOCATED IN THE STRUG RIVER VALLEY IN PODKARPACKIE VOIVODESHIP

Maria Ziaja

University of Rzeszów, Department of Ecology and Nature Protection, Cicha 2A, 35-326 Rzeszów, Poland
e-mail: mziaja@univ.rzeszow.pl

Received: 18.04.2013

Abstract

The research on segetal flora and agricultural ecosystems has gained special importance in recent years, since they are an important element in biodiversity conservation. An evaluation of the status of the segetal flora was made on the basis of a study conducted in the period 1998–2002 in crop fields of four municipalities located in the Strug River valley in Podkarpackie Voivodeship. This research was carried out in root and cereal crops. Total species richness and the average number of species per relevé were determined in this study. In determining species diversity of the communities, the Shannon-Wiener diversity index (H') was used. In cereal crops, the community *Vicietum tetraspermae typicum* was characterized by the greatest species richness (109 species), while *Vicietum tetraspermae consolidetosum* showed the lowest richness (57 species). In root crops, the association *Oxalido-Chenopodietum polyspermi* exhibited the greatest richness (78 species), whereas *Galinsogo-Setarietum typicum* the lowest richness (53 species). In the cereal communities, a total 149 of weed species were recorded, while in the root communities their total number was 97. The values of the Shannon-Wiener diversity index (H') ranged from 3.10 to 2.42. The phytocoenoses *Oxalido-Chenopodietum polyspermi, Vicietum tetraspermae typicum,* and *Vicietum tetraspermae*, the variant with *Vicia grandiflora,* were characterized by the highest values of the Shannon-Wiener diversity index (H'), whereas the association *Galinsogo-Setarietum typicum* and the impoverished communities from the alliance *Aperion spicae-venti* showed the lowest values.

Key words: segetal communities, floristic diversity, Shannon-Wiener, diversity index, south-eastern Poland

INTRODUCTION

As part of biodiversity conservation efforts undertaken in Poland [1], segetal weed communities are interesting sites due to their role in ecosystems. Changes in weed communities are a continuous process, as they undergo transformations and develop influenced by different abiotic and biotic factors. The threat to Polish segetal flora is constantly increasing and the process of species extinction is intensifying [2, 3]. Tillage and weed control methods [4] as well as agriculture intensification and the devastation of the natural environment [3] have a particularly important impact on species biodiversity and the occurrence of different weed ecotypes. The characteristic and indicator species of weed associations are disappearing; this leads to the impoverishment of arable weed communities and the development of impoverished and species-poor fragmentary patches in which one or two weed species clearly dominate and have significant cover in them. Such dominance, described as the so-called compensation, has been reported by, among others, Siciński [5], Trzcińska-Tacik [6], Stupnicka-Rodzynkiewicz et al. [7] as well as Trąba and Ziemińska-Smyk [8].

Agricultural land is considered to be one of key sanctuaries of biodiversity strongly threatened both in Europe and in Poland as a result of, *inter alia*, the changes in farming practices, hence there is an urgent need to provide protection to this type of rare agricultural ecosystems [5,9]. The development and propagation of sustainable agriculture as well as the introduction of cultivation methods recommended in integrated and ecological production into farming practice can prevent the disappearance of some weeds and have a beneficial effect on environmental biodiversity [4].

Lately, not only the numbers of weeds and their cover have been evaluated in the research on weed infestation of crops, but species diversity and dominance have also been determined using the ecological indicators. The problem of species diversity can be considered both at the global scale and at the local scale by

estimating the number of species in a smaller area. The measure of local species diversity can be the number of species in a particular area as well as the Shannon-Wiener index (H') which, in addition to the number of species, takes into account their percentage contribution to a phytocoenosis [6].

The aim of the present study was to determine the floristic diversity of plant communities of cereal and root crops found in the Strug River valley on the basis of the Shannon-Wiener diversity index (H') and species richness.

MATERIALS AND METHODS

A field study was conducted in the period 1998–2002 in crop fields in 43 villages situated in four municipalities located in the Strug River valley in Podkarpackie Voivodeship [10]. Relevés made during the growing season from June to September, using the commonly applied Braun-Blanquet method [11], were the basis for characterizing the floristic diversity of the communities. The study covered cereal crops, in which 126 relevés were made, and root crops, in which 60 relevés were made. The soils and soil complexes were identified based on agricultural soil maps at a scale of 1:5000.

The study area is characterized by diverse topography, with ranges of hills running from the north west to the south east predominant in the landscape. Its northern part is a flat area, not higher than 207 m a.s.l., whereas the southern part is steeper, reaching even 395 m a.s.l. Leached and acidic brown soils derived from loess, silts and silt loams are predominant in the study area. Podzolic and pseudopodzolic soils derived from loess and flysch deposits with the composition of silt occur in the northern part of this area, whereas alluvial soils formed as a result of accumulation of alluvium are found in the river valley itself. The following soil complexes occur most frequently in the study area: the mountain wheat soil complex – 10 and good wheat soil complex – 2, while the defective wheat soil complex – 3 and strong cereal-fodder soil complex – 8 are found sporadically.

The collected material was used to determine species richness in the studied area. Species diversity at the level of communities was evaluated based on the Shannon-Wiener diversity index (H') using the following formula: $H = - \Sigma(P_i \times \ln P_i)$, where P_i means the ratio of $_i$-individuals of a particular species in a community to the number of all individuals in this community [12], whereas species richness was determined based on the number of species in a community and the average number of species per relevé. The botanical nomenclature followed M i r e k et al. [13], while the nomenclature for communities was based on the system developed by M a t u s z k i e w i c z [14].

RESULTS

This paper presents an evaluation of species richness and floristic diversity of cereal and root communities located in four municipalities in the Strug River valley.

In cereal crops within the study area, 6 phytocoenoses at the rank of association and subassociation as well as 2 impoverished communities were distinguished, while in root crops 4 phytocoenoses (Table 1). *Vicietum tetraspermae* and impoverished communities from the alliance *Aperion spicae-venti* were the most widespread association in cereal crops. The association *Galinsogo-Setarietum* was predominant in root crops; it occurred in its typical form and with a large proportion of *Gnaphalium uliginosum.*

The plant species diversity differed significantly between communities. A total of 149 weed species were found in all cereal crops; the community *Vicietum tetraspermae consolidetosum* had the lowest number of species (57), whereas the highest number of species (109) was found in *Vicietum tetraspermae typicum*. The highest number of taxa per relevé was recorded in *Vicietum tetraspermae*, the form with *Vicia grandiflora* (27.9 species), while the lowest number in both impoverished communities from the alliance *Aperion spicae-venti* (16.7 and 17.7 species, respectively). In the case of the root communities, a total of 97 species were found; the lowest number was in the community *Galinsogo-Setarietum typicum* (53 species) and the highest number in the association *Oxalido-Chenopodietum polyspermi* (78 species). This was the same for the average number of species per relevé (Table 1).

The value of the Shannon-Wiener diversity index (H') in the communities in the study area ranged from 2.42 to 3.10 (Table 1). Similarly as in the case of species richness, in the cereal communities patches of *Vicietum tetraspermae typicum* reached the highest values of this index (H' = 2.95), while *Vicietum tetraspermae*, the form with *Vicia grandiflora*, showed a slightly lower value (H' = 2.91). The lowest index H' was found for the impoverished communities from the alliance *Aperion spicae-venti*: for the typical form H' = 2.42 and for the form with *Matricaria maritima* ssp *inodora* H' = 2.48, while at the same time the lowest average number of species per relevé was recorded in them. In the root communities, the phytocoenoses *Oxalido-Chenopodietum polyspermi* reached the highest values of the diversity index (H'= 3.10), whereas the community *Galinsogo-Setarietum typicum* was the least diverse (H' = 2.45). In the case of the root communities, the index H' increased with the number of species in the community, while its value was different for cereal crops. This phytocoenosis was characterized by the lowest index H' (the impoverished community from the alliance *Aperion spicae-venti*) and had a rather high total number of species – 92.

The absence of many species characteristic for the associations was translated into a relatively low average number of species per relevé and thus a low value of the diversity index H' in the impoverished communities belonging to the alliance *Aperion spicae-venti*.

Table 1
The species diversity indices for the segetal communities and soil properties

Phytocoenosis	Soil	Soil complex	Number of relevés	Average number of species per relevé	Total number of species	Diversity index H'
Cereal crops					149	
Vicietum tetraspermae typicum	Bw płi, płz A płz, ls F	2, 3, 8, 10	29	23.5	109	2.95
Vicietum tetraspermae with *Vicia grandiflora*	Bw płi, płz, ls F	2, 10	12	27.9	95	2.91
Vicietum tetraspermae impoverished	Bw płi, płz F A płz	2, 10	23	19.9	80	2.87
Vicietum tetraspermae consolidetosum	Bw płz A ls	2, 10	5	25.0	57	2.61
Aphano – Matricarietum typicum	Bw płi, płz F	2, 10	12	21.2	61	2.72
Aphano – Matricarietum with *Vicia grandiflora*	Bw płi, płz A płz	10	9	20.8	59	2.54
Impoverished communities from the alliance *Aperion spicae-venti*	Bw płi, płz, ls F	2, 3, 10	24	16.7	92	2.42
Impoverished communities from the alliance *Aperion spicae-venti,* the form with *Matricaria maritima* ssp *inodora*	Bw płi, płz A płz F	2, 10	12	17.7	77	2.48
Root crops					97	
Echinochloo-Setarietum	Bw płi, płz, ls A płz	2, 10	18	21.6	68	2.75
Oxalido-Chenopodietum polyspermi	Bw płi, płz, ls A płz F	2, 10	15	23.4	78	3.10
Galinsogo-Setarietum typicum	Bw płi, płz A płz F	2, 10	16	18.2	53	2.45
Galinsogo-Setarietum with *Gnaphalium uliginosum*	Bw płi, płz, ls A płz	2, 10	11	22.7	70	2.84

Explanations: Soil: Bw – leached and acidic brown soils; A – pseudopodzolic soil; F – alluvial soils; płz – silts; płi- silt loams; ls- loess. Soil complex: 2 – good wheat soil complex; 3 – defective wheat soil complex; 8 – strong cereal-fodder soil complex; 10 – mountain wheat soil complex.

DISCUSSION

In recent years in Poland, as in the whole Europe, field communities have undergone transformations caused by, among others, the changes in farming practices, which results in their reduced biological diversity [6, 7].

Weed communities accompanying cereal crops in the study area were strongly transformed and simplified; they lacked species characteristics for the associations and this sometimes enabled the determination of only phytosociological units at the rank of community from the alliance *Aperion spicae-venti*. Such phytocenoses were represented by the highest number of relevés from the study area.

The dominance of one or two species causes higher weed infestation, increased harmful competition, and at the same time decreased diversity of agricultural ecosystems [7]. As reported by Trzcińska-Tacik [6], in cereals it is generally *Apera spica-venti,* whereas Stupnicka-Rodzynkiewicz et al. [7]

include it in expansive species. This is also confirmed by the data obtained from the study area where a community from the alliance *Aperion spicae-venti* was identified, characterized by the lowest diversity index H' and a significant dominance of one species, while a large number of relevés is evidence of the expansion of *Apera spica-venti*.

Some studies have shown that the harmfulness of a weed community with a simplified composition can be even greater than that of more diverse communities [7, 15–17]. In the opinion of some researchers [4,6], greater species diversity of segetal weeds, with their small numbers, promotes better and more stable yields – therefore it is very beneficial. It is a proven fact that a large number of weed species in a field is not tantamount to reduced yield, since quite often their total cover is small [18].

Ever greater importance is now attached to the maintenance of biodiversity, since the presence of weeds in an agricultural ecosystem affects the quantitative relations between plant species and the diversity of other living organisms, among others, insects and birds. Rich agrophytocenoses are a manifestation of biodiversity that has now become a highly valued quality of agricultural areas [4].

Production intensification, changes in agricultural technology, *inter alia*, the widespread use of herbicides, changes in grain cleaning technology and sowing technology all cause a simplification of the floristic composition and structure of companion vegetation as well as the loss of archaeophytes from these communities [19]. According to Rola and Rola [20], the use of herbicides significantly reduces the numbers of weeds but not their diversity, although the long-term use of the same herbicides at high rates can lead to complete elimination of certain species from a particular ecosystem.

The present study shows that there are relationships between the biological diversity index and the number of species in a weed community. This study found that the biodiversity of the segetal flora increased with the number of species. Similar results have been obtained by Wanic et al. [17], Trąba and Ziemińska-Smyk [8], Skrzyczyńska and Ługowska [21]. Worth noting are the lower values of the index H' for the impoverished communities compared to the well-developed ones, which is confirmed by the results of the study of Trąba and Ziemińska-Smyk [8]. The present study also confirmed this.

The association *Galinsogo-Setarietum* predominated in root crops of the study area; it is widespread in Poland and develops most frequently in allotment gardens and in garden crops [14]. Patches of the community *Gnaphalium uliginosum* deserve attention. The change in the species composition of the flora towards a higher proportion of hygrophilous species can perhaps be explained by the location of some fields near the river valley and the high level of groundwater. The phytocoenosis *Galinsogo-Setarietum* from the buffer zone area in the Roztocze National Park has also been described by Trąba and Ziemińska-Smyk [8], while Anioł-Kwiatkowska and Dajdok [22] have characterized it as the ruderal form of the association *Echinochloo-Setarietum*.

CONCLUSIONS

1. The value of the Shannon-Wiener diversity index H' ranged between 3.10 and 2.42. In cereal crops, the association *Vicietum tetraspermae typicum* reached the highest value (H'=2.95) and the impoverished community from the alliance *Aperion-spicae venti* the lowest value (H'=2.42), whereas in root crops these were respectively *Oxalido-Chenopodietum polyspermi* (H'=3.10) and *Galinsogo-Setarietum typicum* (H'=2.45).
2. A total of 149 species were found in all cereal crops; the highest number was recorded in the community *Vicietum tetraspermae typicum* (109 species), while the lowest one in *Vicietum tetraspermae consolidetosum* (57 species). 97 species were found in root crops; the largest number in *Oxalido-Chenopodietum polyspermi* (78 species) and the lowest number in *Galinsogo-Setarietum typicum* (53 species).
3. Worth noting are the much lower values of the Shannon-Wiener index H' for the impoverished communities compared to the well-developed ones.

Acknowledgments

I would like to thank the anonymous reviewers for their many valuable comments and suggestions on this paper.

REFERENCES

1. Liro A. Programy rolnośrodowiskowe – Instrument ekologizacji gospodarki rolnej IUCN – The World Conservation Union. Fundacja IUCN Poland. WWF Światowy Fundusz na Rzecz Przyrody. Warszawa, 2002. (in Polish)
2. Warcholińska A.U. (ed.), Ginące i zagrożone gatunki flory segetalnej. / Endangered and threatened species of segetal flora. Acta Univ. Lodz. Folia Bot. 1996; 13: 1–277. (in Polish)
3. Warcholińska A.U. Właściwości zagrożonych segatalnych roślin naczyniowych Polski. / Features of threatened segetal vascular plants in Poland. Acta Univ. Lodz., Folia Bot. 1998; 13: 7–14. (in Polish)
4. Dobrzański A., Adamczewski K. Wpływ walki z chwastami na bioróżnorodność agrofitocenoz. / The in-

fluence of weed control on agrophytocenosis biodiversity. Postępy w Ochronie Roślin/ Progress in Plant Protection 2009; 49 (3): 982–995. (in Polish)

5. Siciński J.T. Gatunkowa różnorodność biologiczna chwastów segetalnych i jej zagrożenia w Polsce. / Biological species diversity of segetal weeds and its threats in Poland. Acta Univ. Lodz., Folia Bot. 2001; 16: 73–86. (in Polish)
6. Trzcińska-Tacik Znaczenie różnorodności gatunkowej chwastów segetalnych. / Importance of field weed species diversity. Pamiętnik Puławski, 2003; 134: 253–262. (in Polish)
7. Stupnicka-Rodzynkiewicz E., Stępnik K., Dąbkowska T., Łabza T. Różnorodność zbiorowisk chwastów w uprawach zbóż w Beskidach. / Diversity of cereal crops weed communities in the Beskidy Mountains. Fragm. Agron. XXI, 2004; 4(84): 45–54. (in Polish)
8. Trąba Cz., Ziemińska-Smyk M. Różnorodność florystyczna zbiorowisk chwastów w uprawach roślin okopowych otuliny Roztoczańskiego Parku Narodowego. / Floristic diversity of weed communities in the root crops of the Roztocze National Park buffer zone. Pamiętnik Puławski, 2006; 143: 195–206. (in Polish)
9. Ratyńska H., Boratyński A. Czynna ochrona roślin i zbiorowisk segetalnych i ruderalnych. / Active protection of segetal and ruderal plants and vegetation. Przegląd Przyr. XI, 2000; 2–3: 43–56. (in Polish)
10. Ziaja M. Flora segetalna Doliny Strugu w woj. podkarpackim. / The segetal flora of the Strug River valley in Podkarpackie Voivodeship. Acta Sci. Pol., Biologia 2004; 3(2): 77–100. (in. Polish)
11. Pawłowski B. 1972. Skład i budowa zbiorowisk roślinnych oraz metody ich badania. [W:] Szata roślinna Polski. W. Szafer, K. Zarzycki (red.) PWN, Warszawa 1: 237–269. (in Polish)
12. Krebs H.J. Ekologia. PWN, Warszawa, 2001. (in Polish)
13. Mirek Z., Piękoś-Mirkowa H., Zając A., Zając M. Flowering plants and pteridophytes of Poland: A checklist. Kraków: W. Szafer Inst. Bot. Pol. Acad. Sci., 2002.
14. Matuszkiewicz W. Przewodnik do oznaczania zbiorowisk roślinnych Polski. Vademecum Geobotanicum, Wyd. Nauk. PWN, Warszawa, 2002. (in Polish)
15. Rola H. Zjawisko konkurencji wśród roślin i jej skutki na przykładzie wybranych chwastów występujących w pszenicy ozimej. Wyd. IUNG Puławy, 1982; R 139: 64. (in Polish)
16. Adamiak E., Zawiślak K. Zmiany w zbiorowiskach chwastów w monokulturowej uprawie podstawowych zbóż i kukurydzy. [W:] Ekologiczne procesy w monokulturowych uprawach zbóż. UAM, Poznań: 1990; 33–61.
17. Wanic M., Jastrzębska M., Kostrzewska M.K., Nowicki J. Analiza zbiorowisk chwastów za pomocą wybranych wskaźników biologicznych. / Analysis of weed communities using selected biological indicators. Acta Agrobot. 2005; 58(1): 227–242. (in Polish)
18. Dostatny D.F., Małuszyńska E. Skład gatunkowy chwastów podczas wegetacji i w materiale ze zbioru w uprawach ekologicznych i konwencjonalnych. / Floral composition of weeds during the vegetation and in seed material on the organic and conventional field. Pamiętnik Puławski, 2007; 145: 43–59. (in Polish)
19. Żyszkowska M., Paszkiewicz-Jasińska A. Różnorodność florystyczna zbiorowisk użytków zielonych i gruntów ornych Pogórza Złotoryjskiego. / Floristic diversity of grassland communities and arable lands in the Złotoryja Foothill. Water-Environment-Rural-Areas. 2010; T. 10 4 (32):307–318. (in. Polish)
20. Rola H., Rola J. Pozytywne i negatywne aspekty stosowania herbicydów w uprawach rolniczych w Polsce w latach 1950–2000. / Positive and negative aspects of herbicide application in agricultural crops in Poland (1950–2000). Progress in Plant Protection / Postępy w Ochronie Roślin 2001; 41(1): 47–57. (in Polish)
21. Skrzyczyńska, J., Ługowska M. Dominacja gatunków i bioróżnorodność zbiorowisk agrocenoz ziemniaka Doliny Środkowej Wisły. / Species domination and biodiversity in weed communities of agrocenoses of the Middle Vistula Valley. Zesz. Prob. Post. Nauk Rol., 2008; 530: 105–115. (in Polish)
22. Anioł-Kwiatkowska J., Dajdok Z. Roślinność wschodniego Krańca Równiny Oleśnickiej. I. Zbiorowiska naturalne, półnaturalne i antropogeniczne. Acta Univ. Wrat. Prace Bot. 1993; 55: 5–100. (in Polish)

Różnorodność gatunkowa zbiorowisk upraw zbożowych i okopowych w gminach położonych w dolinie rzeki Strug w województwie podkarpackim

Streszczenie

W ostatnich latach szczególnego znaczenia nabrały badania flory segetalnej i agrocenoz, gdyż są ważnym elementem w ochronie bioróżnorodności. Ocenę stanu flory segetalnej wykonano na podstawie badań prowadzonych w latach 1998–2002 na polach uprawnych czterech gmin położonych w dolinie rzeki Strug, w woj. podkarpackim. Badania wykonano w uprawach okopowych oraz zbożowych. W pracy określono ogólne bogactwo gatunkowe oraz średnią liczbę gatunków w zdjęciu fitosocjologicznym. Przy określaniu różnorodności gatunkowej zbiorowisk posłużono się wskaźnikiem różnorodności Shannona-Wienera (H'). W obrębie upraw zbożowych największym bogactwem gatunkowym odznaczało się zbiorowisko *Vicietum tetraspermae typicum* – 109 gatunków, a najmniejszym *Vicietum tetraspermae consolidetosum* – 57 gatunków, zaś w uprawach okopowych największą różnorodność osiągnął zespół *Oxalido-Chenopodietum polyspermi* – 78 gatunków, najmniejszą *Galinsogo-Setarietum typicum* – 53 gatunki. W zbiorowiskach

zbożowych zanotowano łącznie 149 gatunków chwastów, zaś w okopowych 97. Wartości indeksu ogólnej różnorodności Shannona-Wienera (H') mieściły się w granicach od 3,10 do 2,42. Największą wartością wskaźnika Shannona-Wienera (H') wyróżniały się fitocenozy *Oxalido-Chenopodietum polyspermi, Vicietum tetraspermae typicum, Vicietum tetraspermae* wariant z *Vicia grandiflora,* a najmniejszą zespół *Galinsogo--Setarietum typicum* oraz zbiorowiska kadłubowe ze związku *Aperion spicae-venti.*

Handling Editor: Elżbieta Weryszko-Chmielewska