Załącznik 3

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4. Indication of the scientific achievement in accordance with Art. 16 paragraph. 2 of the act of 14 March 2003 on Academic Degrees and Titles (Journal of Laws. No. 65, item. 595, as amended.)

a) Title of scientific achievement

"**Impact of management regimes on epigeic spider assemblages in semi-natural mesic meadows**"

b) (author/ authors, title/ titles, year of publication, publishing house, reviewer)

Stańska M. 2019. Impact of management regimes on epigeic spider assemblages in semi-natural mesic meadows. Scientific Publishing House of Siedlce University of Natural Sciences and Humanities, Siedlce, 132 pp.
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Publisher review: dr hab. Maciej Bartos, University professor, University of Łódź

Scientific monograph – according to the scoring system of Ministry of Science and Higher Education – 80p.

c) Discussion of the scientific purpose of the above-mentioned work and the results achieved, together with a discussion of their possible use.

Rationale for the choice of research topic and description of the scientific objective

Biodiversity conservation is one of the most important challenges faced by modern man. Biodiversity is conducive to the proper functioning not only of natural ecosystems but also those used for agriculture to ensuring, inter alia, adequate soil fertility, controlling microclimate and hydrological conditions, maintaining a large number of pollinators, controlling the number of undesirable organisms considered to be pests or neutralizing harmful chemical compounds (Altieri 1999, Foley et al. 2005, Klein et al. 2007, Tscharntke et al. 2007). Consequently, the biodiversity losses may lead to serious problems in agricultural ecosystems, which also translates into substantial financial losses (Carvalheiro et al. 2011).

The intensive agricultural development that has been taking place for decades represents one of the most serious threats to biodiversity worldwide (Tilman et al. 2001). Unfortunately, the main focus and objective of the modern agriculture is to obtain the highest possible yields,

which is to be achieved by using fertilizers and plant protection products on a large scale and in large doses, by carrying out irrigation and drainage of meadows, or by performing various agricultural treatments with great intensity. It also involves the maximum simplification of the environmental structure, resulting in the transformation of small, mosaic agricultural lands into large, homogeneous areas. This leads to the elimination of clumps of trees, field margins, ponds and other similar elements, which until recently have been a permanent feature of agricultural landscapes, contributing to their high biodiversity.

Mesic semi-natural meadows are one of the ecosystems that has been severely affected by the intensification of agricultural production. These habitats, which for many years have been an integral part of Europe's agricultural landscape, are among the richest in terms of flora, and at the same time provide a habitat for many animal species. Unfortunately, the area of semi-natural meadows in Europe has been drastically reduced over the last few decades, both as a result of the intensification of farming and its discontinuation. The decline of their area and the deterioration of their condition are followed by significant impoverishment of the diversity of organisms living there.

The dramatically deteriorating state of the natural environment and the decline of biodiversity in agroecosystems have necessitated drastic measures and systemic solutions in many countries. In Europe, agri-environment schemes (also referred to as agri-environment programmes) are an important tool for supporting the biodiversity in agricultural areas. They were introduced in the European Union in 1992, and in Poland for the first time in 2004 under the Rural Development Programme. The assumption is that agri-environment schemes are to encourage farmers to apply environmentally friendly farming practices, which reconcile the requirements of agricultural production with the need to minimise their adverse impact on the environment.

The financial resources spent on agri-environment schemes in Europe are enormous and in many countries they exceed the amounts spent on nature conservation using other methods. Given such huge expenditure, it is crucial to answer the question of to what extent these schemes support the preservation of biodiversity. The benefits of the schemes and the optimisation of the expenditure are the subject of the ongoing discussion in both the scientific and political spheres. Although research on the effectiveness of the programmes in preserving the biodiversity has been undertaken in Europe almost since their implementation, the results are often inconclusive. Many studies indicate that the programmes have a positive impact on specific groups of organisms, while no positive effect is observed for other groups (Kleijn and Sutherland 2003, Kleijn et al. 2006). As it turns out, the effectiveness of the programmes

depends on many factors, including the type of area in which they are implemented, i.e. the intensity of farming carried out there and the degree of landscape heterogeneity (Batáry et al. 2015). Therefore, it is important to conduct research on various model groups of animals, in areas with varying intensity of farming. This will enable the selection of requirements imposed by individual packages of agri-environment programmes in agriculturally used areas in such a way that they are tailored both to a group of organisms that we particularly want to protect and to a specific place that has to be protected.

Spiders as animals playing an important role in ecosystems are a very good research model. They reach a considerable abundance in almost all terrestrial habitats, including permanent grasslands, where sometimes their densities reach several hundred individuals per square metre (De Keer and Maelfait 1987, 1988). These polyphagous predators feed on a wide range of prey, and a significant part of their diet in agrocenoses consists of various species considered to be pests of crops. This makes them an important element of biological control (Nyffeler and Sunderland 2003). Spiders react dynamically to the transformation of spatial structure of their habitat, which in agrocenoses is caused by agro- and pratotechnical treatments. Therefore, they are often used as bioindicators of environmental changes that occur both as a result of natural processes and human impact (Maelfait and Hendrickx 1998, Diehl et al. 2013, Haase and Balkenhol 2015).

The main objective of the research described in the monograph presented as a scientific achievement was to understand how the management regimes of semi-natural mesic meadows affects the epigeic spider assemblages. It is also the first work in Poland assessing the effectiveness of agri-environment programme in the protection of the diversity of this group of animals, carried out on extensively used agricultural land.

In addition, the research was designed to assess the impact of mowing on spider assemblages inhabiting the meadows. This common treatment has a negative impact on several groups of animals, especially those less mobile and incapable of escaping invertebrates. Invertebrates, including spiders die as a result of direct impact, i.e. killed during mowing, while some of those that manage to survive migrate from a mown habitat immediately after the plants are cut. Consequently, mowing can lead to a decline in abundance and species richness of spiders (Nyffeler and Breene 1990, Baines et al. 1998, Mazalová et al. 2015).

The objective of the research was also to develop recommendations for agriculture management regarding the use of hay meadows so as to preserve their rich araneofauna.

I carried out my research for three years (2013–2015) on semi-natural meadows belonging to the class of *Molinio-Arrhenatheretea* R. Tx. 1937 and the order of *Arrhenatheretalia* Pawł. 1928. These habitats are of high nature conservation value and, in terms of agriculture, one of the most productive grasslands. The meadows where I collected my samples are located in the Lublin region, which is characterised by high landscape fragmentation and extensive farming, as well as considerable representation of areas with high nature conservation value. Research on the effects of agri-environment schemes in this type of landscape are rarely performed in Europe. In the case of large, intensively used agricultural areas, one can assume with a high probability that imposing certain restrictions on the implementation of specific agricultural treatments brings tangible effects in maintaining high biodiversity. However, the implementation of agri-environment schemes in areas where extensive farming prevails, farms are fragmented and the landscape is very diverse, as in the case of the Lublin region, seems to be disputable. Considering the huge financial expenditure incurred to pay benefits to farmers, a very important question arises about the sense of such measures in this type of areas. The determination to find answers to these questions was one of the reasons for undertaking this research.

Two methodological approaches can be applied in this type of studies. A frequently used method is to carry out an experiment in which the number and timing of cuts are strictly planned, specific doses of fertilizers are applied etc. This approach, however, does not provide a clear answer to the question about the impact of actual farming on assemblages of the studied organisms, where the agricultural treatments performed do not depend to the least extent on the researcher. My research was not based on an experiment, instead it was carried out in the realities of farming typical of the Lublin region. The timing and the number of cuts, the method of mowing and other agricultural treatments were not agreed with farmers using meadows. The only requirements that farmers had to comply with were those resulting from the package or variant implemented under the agri-environment programme.

The research covered four groups of meadows in four management regimes. The first group comprised conventionally used meadows, i.e. meadows used in a way that is typical for the studied region, without any restrictions imposed as to the method, time and the number of cuts. These meadows were mown the earliest among all meadows surveyed in the growing season (the first cut was carried out starting from the end of the third decade of May) and the largest number of times. In addition, some of them were fertilised using small amounts of mineral or organic fertilizers and occasionally grazed by a small herd of cattle outside the sampling period. The remaining groups of meadows were covered by three different packages

and their variants under the agri-environment programme, with different restrictions on the number of cuts and the time of the first cut. The first of these groups encompassed meadows included in “Package 3. Extensive permanent grasslands”, hereinafter referred to as “meadows in extensive package”, where mowing was allowed between 1 June and 30 September, with no more than two cuts per year. The next group comprised meadows included in “Package 4. Protection of endangered bird species and natural habitats outside Natura 2000 areas or Package 5. Protection of endangered bird species and natural habitats in Natura 2000 areas (variants 4.1 and 5.1 Protection of bird breeding habitats)”, hereinafter referred to as “meadows in bird variant”. These variants are primarily aimed at the protection of birds and their habitats, and mowing is allowed from 1 August to 30 September. Only one cut per year is allowed hear. The last group includes meadows included in “Package 4. Protection of endangered bird species and natural habitats outside Natura 2000 areas or Package 5. Protection of endangered bird species and natural habitats in Natura 2000 areas (variants 4.7 and 5.7 Semi-natural mesic meadows)”, hereinafter referred to as “meadows in habitat variant”. The purpose of the two aforementioned variants is to preserve the natural values of semi-natural mesic meadows. Mowing could be carried out from 15 June to 30 September, without destroying the sward and the soil cover, and with no more than two cuts per year. All meadows had to comply with the stipulation to leave 5–10% of the area uncut, each year a different part; no ploughing, rolling or reseeding were allowed either.

Eight study plots were selected in each of the management regimes, where spiders were caught using pitfall traps. In each plot, the material was collected four times a year (from mid-May to late August) during two-week sessions (hereinafter referred to as “sampling periods”).

I assessed the impact of the management regime in meadows on the araneofauna inhabiting these habitats based on the analysis of a number of parameters describing the assemblages of spiders, i.e. abundance, species richness, species diversity, the abundance and the number of species in selected families and functional groups (guilds) as well as groups of species classified as rare. The inclusion of specific families and guilds in the analysis was due to the fact that each spider group had specific environmental requirements, different hunting strategies, dispersion methods, etc., which means that they could react in a very specific way to the pratotechnical treatments carried out in the meadows. In addition, I have analysed the species composition of assemblages under different management regimes. All my analyses were carried out on the basis of four sampling periods.

In order to determine the direct impact of mowing on spider assemblages, I compared the above parameters in unmown meadows with parameters in meadows where mowing was

already performed. I performed these analyses regardless of the management regime implemented in the meadows. I have carried them out separately for the three sampling periods omitting the first period because the cuts were not yet made. In the last two periods, I took into account the time that elapsed from the cut in order to assess whether the impact of mowing on spiders is short- or long-term.

I used generalized linear mixed models (GLMM) to analyse the parameters characterising the spider assemblages and the redundancy analysis (RDA) in CANOCO for Windows 4.5 to determine the impact of the management regime and mowing on the species composition.

I assumed the hypothesis that the management regime would have a significant impact on epigeic spider assemblages, and the analysed parameters would be significantly higher when the intensity of farming is lower, i.e. where fewer cuts are carried out and the first cut is performed later in the growing season. Therefore, these parameters should be lower on conventionally used meadows compared to meadows covered by agri-environment packages. The second hypothesis assumed that mowing would have a negative impact on epigeic spider assemblages, which would result in lower values of the analysed parameters in the case of mown meadows compared to meadows that have not yet been mown.

Results and conclusions

On the basis of a three-year study, during which a total of 31,945 adult spiders belonging to 161 species and 18 families were caught, as well as an analysis of the collected data, I managed to obtain many interesting results concerning the influence of the management regime and the impact of mowing on the epigeic spider assemblages. The most important of them are presented below.

1. The management regime implemented in meadows did not affect spider abundance.
2. Species diversity (expressed as the Shannon–Wiener index) did not differ between the management regimes.
3. The management regime influenced the species richness of spiders. The lowest number of species was recorded in the meadows covered by the habitat variant, whereas the highest number was recorded in the bird variant.
4. The largest number of spider families was found in the meadows covered by the bird variant.

5. The management regime applied in meadows did not affect the abundance of families Tetragnathidae and Lycosidae, but influenced the abundance of family Linyphiidae. Spiders from the latter family were the most abundant in meadows used conventionally, the least numerous in the meadows in the bird variant.
6. The abundance of each of analyzed functional groups (guilds) was similar in meadows under all management regimes.
7. All analyzed parameters were influenced by the period in which the research was carried out. Moreover, in the case of some of the parameters that were not affected by the management regime, its interaction with the sampling period turned out to be significant. This indicated that the management regime affected these indicators only in specific sampling periods. However, this did not apply to the first sampling period, in which no differences were found between the compared regimes except for the number of species belonging to the guild of "ground hunters".
8. The species composition of spider assemblages was similar in all management regimes. The studied meadows were dominated by several abundant species, which are widely distributed, typical inhabitants of open areas: *Pardosa palustris*, *Pardosa pullata*, *Pachygnatha degeeri*, *Pardosa prativaga*, *Erigone dentipalpis* and *Erigone atra*. Despite this, some less numerous species of spiders preferred specific management regimes. *Walckenaeria atrotibialis*, *Zora armillata* and *Ozyptila brevipes* preferred meadows in the bird variant, *Oedothorax apicatus*, *O. fuscus*, *Araeoncus humilis* and *Pachygnatha clercki* preferred conventionally used meadows, while *Agyneta affinis* and *Ozyptila westringi* – meadows in the habitat variant.
9. A total of 29 rare species (469 individuals) i.e. those listed on the “Red list of threatened animals in Poland” or known from less than 20 localities in Poland, were found during the research. Nine species represented by 47 individuals were found on conventionally used meadows, 12 species and respectively 140 and 138 individuals were found in the extensively used meadows and meadows in the habitat variant, and 20 species and 144 individuals were found in the bird variant. A statistically significant difference in the number of individuals and the number of species was found only between the conventionally used meadows and those covered by the bird variant.
10. The mowing did not cause a decrease in abundance, species richness and species diversity of spiders. This was also true for the majority of other parameters characterizing spider assemblages. Lower values on mown study plots compared to uncut plots were observed only in the case of the number of families (in the third sampling period) and the

number of species belonging to the guild of "ground hunters" (in the second sampling period).

11. Spiders from the family Linyphiidae and the guild of "other hunters", which consists mainly of this family, were more numerous in the study plots where the cutting was made (especially when it occurred at least 4 – 5 weeks earlier) compared to the uncut areas.
12. The performing of the cut affected the species composition of the spider assemblages. Some species such as *Walckenaeria atrotibialis*, *Piratula hygrophila* clearly preferred uncut meadows, reaching higher numbers on them, while other species (e.g. *Erigone dentipalpis*) preferred mowed meadows.

The obtained results indicated only moderate differences between assemblages of epigeic spiders inhabiting the meadows under different management regimes. They concerned only a few of the analyzed parameters, and in the case of part of remaining parameters, the impact of the management regime was observed only in some sampling periods. It is worth to emphasise that the spider assemblages did not differ in the first period when the meadows had not been mown yet. In the three other periods, significant differences between the spider assemblages were observed. This indicates that the management regime is a factor that, to some extent, affects the araneofauna of meadows (mainly through the mowing regime), but it is a short-term impact that does not diversify spider communities in a permanent way. After finishing the cutting, the resulting differences disappear and the assemblages become similar.

Moreover, in the case of most parameters, different for the analysed groups of meadows, their values were not arranged from the least to the most intensive gradient. In general, meadows covered by the agri-environment programme, especially in the extensive package and the habitat variant, did not show higher values of parameters characterising the assemblages of spiders compared to conventionally used meadows. This indicates that the restrictions imposed by these two management regimes, e.g. delaying the first cut until 1 and 15 June respectively, and leaving unmown fragments of meadows as refugia, do not have a significant positive effect on the assemblages of epigeic spiders.

I observed a certain positive impact on spiders only in the case of meadows covered by the bird variant, which was characterised by the most rigorous restrictions as to the date of mowing (allowed only from 1 August), as well as the lowest number of cuts. It is possible that the combination of these two factors is the best way to protect the diversity of spiders, as indicated also by other authors (Cizek et al. 2012, Lafage and Pétillon 2014).

It seems that spiders may be negatively affected by the concentration of cuts on multiple plots in one period of the growing season, as was the case for the habitat variant where the lowest number of spiders was found. This is consistent with the results of other researchers, who have shown that time-synchronized cuts, especially when carried out over large areas, have a negative impact on communities of arthropods (Cizek et al. 2012).

The second hypothesis, assuming a negative impact of mowing on epigeic spider assemblages, was not confirmed. Mowing did not cause a decline in the abundance, species richness and species diversity of spiders and most of the other analysed parameters, although it did affect the composition of spider assemblages. On the mown plots I observed larger numbers of spiders from the family of Linyphiidae and from the guild of "other hunters". I can assume that mainly these spiders colonize in a short time the mown area from adjacent habitats and thereby eliminate the potential decrease in abundance, number of species and species diversity.

My research has shown that the implementation of agri-environment packages has a moderate effect in supporting the diversity of spiders in areas with extensive farming and in a fragmented landscape, as is the case of the Lublin region. This may be due to the existence of many natural refugia (e.g. field margins, clumps of trees), where spiders can hide after mowing and from where they can migrate to recolonise the mown areas. Secondly, the high fragmentation of the landscape, reflected in a large number of small areas of agricultural land, makes it much less likely to carry out cuts synchronised in time and space. Usually, many independent meadow owners do not mow their meadows at the same time, which gives the spiders an opportunity to escape into uncut areas. Thirdly, in addition to mowing, agricultural activity in meadows is carried out in a moderate way which probably results in a less destructive effect of the mowing operation on spiders.

In the case of the surveyed area, preservation of the current farming practices, with a possible delay in mowing, seems to be a sufficient measure to protect the biodiversity of epigeic spiders. However, on the basis of the results of the research conducted, several recommendations for agricultural management practices can be established, the implementation of which can contribute to the preservation of high diversity of ground-dwelling spiders on hay meadows. These are:

1. delaying the first cut until August in the case when unique assemblages of spiders or the rare species are to be protected,
2. ensuring the availability of refugia – both natural e.g. in the form of field margins, or created by leaving unmown fragments of meadows if there is lack of natural ones,

3. performing no more than 1 – 2 cuts during the growing season,
4. providing a varied pattern of cuts in time and space.

However, it should be borne in mind that the development of comprehensive recommendations for the conservation of biodiversity in mesic meadows should take into account the results of research on other groups of organisms occurring in this type of habitats.

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5. Other scientific and research achievements.

In 1995 I graduated from the University of Agriculture and Pedagogy in Siedlce (nowadays Siedlce University of Natural Sciences and Humanities) with a Master's degree in Biology. My master thesis entitled: "Influence of temperature, manganese and iron on bacteriocin-producing strains of *Yersinia enterocolitica*" was prepared in the Department of Microbiology under the supervision of prof. dr hab. Kazimierz Bukowski. During my studies, in addition to microbiological interests, I developed my zoological interests, being a member of the Student Ornithological Circle and taking part in field trips and scientific camps. After graduation I was employed in the Department of Zoology, where I started working as a member of a team of scientists studying biology of various bird species and ecological processes taking place in primeval forests of the Białowieża Forest.

Starting research in the Białowieża Forest, I realized that this is one of the most interesting natural forest areas in Poland, but closer acquaintance with this fascinating forest confirmed me in the belief that it can be an excellent object of multidirectional research. Therefore, for many years I have associated my scientific work with this place.

At the beginning, my scientific interests focused on the invertebrate fauna that inhabits the nests of birds nesting in holes. It was an interesting research problem for me, especially that high numbers of parasites in nests force birds to produce special defence mechanisms. The effect of my research were two publications. In the first paper, the results of research on

the infestation by fleas of the nests of secondary hole-nesters in the Białowieża National Park were presented (IIA18*). They indicated that the number of infested nests and the number of fleas in nests of collared and pied flycatchers, as well as marsh tits occupying natural holes, were very low, different from results obtained in other areas. The nests of flycatchers nesting in nest boxes and tits in the holes, but on the area with nest boxes, were characterized by very high levels of infestation, similar to those reported by other authors, from areas outside the Białowieża Forest. The study indicated that data obtained in areas with nest boxes should not be referred uncritically to areas without boxes, and that a high infestation of birds' nests should not be seen as a species feature. The second paper concerned the occurrence of Gamasina mites in the nests of secondary hole-nesters – the collared and pied flycatchers (IID28). A total of 12 species were found, one of which turned out to be new to the whole Białowieża Forest, three new for the Polish part of the Forest, and several were recorded for the first time in bird nests.

Moreover, cooperation with the team of ornithologists during the research conducted in the Białowieża Forest resulted in a publication on small mammals found in natural cavities and nest boxes occupied by the collared and pied flycatchers (IIA17). As it turned out, mammals inhabited cavities and nest boxes more often in managed forests than in primeval stands in the Białowieża National Park. Probably the attractiveness of nest boxes for mammals increases in the managed forests due to the lack of natural cavities. The results of the study showed that the role of small mammals in the ecology of reproduction of secondary hole-nesters was underestimated in ornithological studies.

In the course of my work, my scientific interests focused on spiders. These interests were certainly based on the fact that in the Department of Zoology, where I was employed, there was a team of arachnologists, headed by Prof. dr hab. Marek Żabka. It was the inspiring cooperation with Prof. Marek Żabka, and later with Prof. dr hab. Wojciech Staręga that defined the profile of my further professional work and made spiders the main object of my scientific interests.

Although the Białowieża Forest has long been a very attractive place of research for every naturalist, it did not receive a comprehensive study of the araneofuna. Therefore, in 1998, I started research on spider assemblages inhabiting the deciduous forests of the Białowieża Forest, which became the basis for my doctoral thesis. I received funds to conduct this research as a grant awarded by the State Committee for Scientific Research (Grant no. 6P04G01417). Doctoral thesis entitled "Spider fauna (Araneae) of selected types of deciduous forests in the Białowieża Forest" prepared under the supervision of prof. dr hab. Wojciech

Staręga I defended in 2003 at the Faculty of Biology of Adam Mickiewicz University in Poznań. The material collected intensively for four years using various methods allowed me to analyze several important issues. I have compared spider fauna in terms of species diversity and dominance structure in various habitats and microhabitats, taking into account the developmental stages of stands in typical oak-lime-hornbeam forests. One of the analysed problems was also the assessment of the influence of anthropopressure on spider assemblages occurring in selected types of deciduous forests (oak-lime-hornbeam forest, alder carr and riparian forest). On the basis of the obtained results I formulated recommendations for forest management concerning the protection of endangered and rare species of spiders and their environments.

The rich material collected during the research allowed me to prepare a number of publications. The subject of two of them were the spiders of alder carrs – marshy forests with a characteristic mosaic, the hummock-hollow structure. Natural fluctuations in the water level contribute to the considerable dynamics of the communities of organisms in this habitat, which makes them a very interesting object of research. Unfortunately, changes in water relations and drainage of many areas lead to the degradation and disappearance of this type of forests in Europe. In addition, due to the swampy nature, these forests are hardly available and quite rarely become the object of arachnological research, and if any, the material is usually collected only on hummocks, omitting hollows where water stagnates for the most part of the year. The first paper concerned assemblages of epigeic spiders in the alder carrs in Eastern Poland (IID26). The unique hummock-hollow structure in the forest floor, which characterized alder carrs, should promote the occurrence of specific spider fauna there. On the basis of the conducted research, it was not possible to distinguish a group of species that could be considered characteristic for alder carrs. On the other hand, comparison of the fauna of the primeval alder carr and alder carr under human impact showed that despite the similarities in the species composition and the dominance structure, species diversity of spiders in the primeval forest located in the Białowieża National Park was higher than in the managed forest.

Another paper was devoted to the comparison of the araneofauna inhabiting the hummocks and hollows in the primeval alder carr in the Białowieża National Park (IIA6). In this publication, the influence of vegetation structure and humidity on the number of individuals and spider species occurring in this type of forest was analysed. As expected, the hummocks were characterized by greater species richness and species diversity in comparison to the hollows. It was shown, however, that some species (*Oedothorax gibbosus* and

Oedothorax retusus) clearly preferred hollows, reaching several times higher numbers there than in the hummocks. The studies did not prove the influence of vegetation structure on the abundance and species richness of spiders, whereas a positive effect on spiders was found in the case of humidity. An important conclusion of the study is that the research, in which the material is obtained only from hummocks, do not reveal the real structure and dynamics of spider assemblages in alder carrs. In order to know the full structure, the material should be collected in both microhabitats – on the hummocks and in the hollows.

My research in the Białowieża Forest also included the spider fauna inhabiting tree trunks, taking into account its changes in the following months of the year in various types of deciduous forests (IIA2). The trunks turned out to be a habitat rich in spiders – a total of 43 species were found there. For some of them (*Amaurobius fenestralis*, *Anyphaena accentuata*, *Segestria senoculata*, *Neriene montana*), regularly recorded on the trunks during the entire study period, this is a typical place of living. For other spider species, trunks are a temporary or accidental habitat and overwintering place.

I also dealt with the issue of the spatial distribution of spiders with different body sizes in the multi-layered habitat of primeval forest (IIA5). Body size is one of the most important attributes of living organisms, and knowledge of spatial distribution patterns of co-occurring species with different body sizes can contribute to the understanding of many ecological processes. In my work, I analyzed the distribution of spider species of various sizes in selected forest microhabitats: ground, herbaceous vegetation, tree trunks and leaves. The study showed that the ground layer was dwelled by species of the smallest size, while larger species inhabited herbaceous plants and leaves, and the largest trunks. In the paper, I discussed several potential mechanisms that may be responsible for such a pattern of the spatial distribution of species. These include microclimatic conditions (i.e. temperature, humidity), predation (mainly from birds) and nutritional value of spider prey. A very probable cause of differences in the size of spider species between the ground layer and other microhabitats is the complex structure of the litter layer creating many potential niches, which can be occupied by a large number of species of small size.

An important aspect of my work was also research on rare and endangered species in the Białowieża Forest (IID13, IID17, IID25). These studies proved that the forest was an important refuge for such species. Out of 245 species that I revealed during the research conducted there, 20 were species listed on the "Red list of threatened animals in Poland", and 11 were species known from less than 20 localities in our country. In total, about 13% of all collected species were classified as rare species, of which almost half were species with

northern ranges, for which the Białowieża Forest was an important refugium. Especially marshy forests - alder carrs and ash-alder forests were particularly rich in rare species.

As a specialist dealing with spider fauna I also cooperated with the Forest Research Institute in preparation of the results of monitoring studies conducted in the Białowieża Forest. These studies showed the natural fluctuations in abundance and species composition of spider assemblages (IID23).

My interests in the distribution of spiders in forests continued with my involvement in research conducted on a large geographical scale on spiders in the canopies of primary forest trees of the boreal zone (IIA10). These studies showed that the abundance, taxonomic and functional diversity of arboreal spiders decreased with latitude, most likely due to the increasing pressure of predators (birds) in this gradient. Coniferous tree species were characterized by a higher abundance and diversity of spiders than deciduous ones (birches). However, the decline in the abundance and taxonomic diversity of arboreal spiders along the geographical gradient did not differ between coniferous and deciduous species. On the other hand, the decline in the functional diversity of spiders with latitude was more pronounced on birches than on conifers. Moreover, euryphagous spiders showed a stronger decline in abundance and taxonomic diversity with latitude than more specialised steno- and oligophagous spiders.

Since 2003 I have been involved in cooperation with the Ecological Research Centre of the Polish Academy of Sciences within the framework of a project devoted to the ecology of the Mazurian Lake District islands (grant ordered no. PBZ-KBN-087/P04/2003). The result of this cooperation was a series of papers on various ecological problems, which were analyzed using, among others, spiders as a model group (IIA1, IIA11, IIA15, IIA16).

One of these problems concerned the co-occurrence patterns of species. On the one hand, the co-occurrence of species occupying a similar niche is less likely than that of species occupying different niches. On the other hand, there is a theory that species with similar ecological requirements should co-occur more frequently than the random probability of co-occurrence suggests. The study was conducted on spider assemblages inhabiting two island complexes: one on Wigry Lake and the other on Nidzkie, Bełdany and Mikołajskie Lakes (IIA15). As a result of the study, both aggregated and random co-occurrence of species of the same genus and a significant tendency to segregate species between genera were found. It was also shown that species of the same genus react similarly to important environmental variables.

In the project it was also investigated the impact of anthropogenic disturbances caused by the presence of tourists on islands on the abundance, species richness and patterns of co-occurrence of spider species (IIA16). On the basis of the research, it was possible to state that certain disturbances in the structure of spider assemblages may indicate factors negatively affecting the ecosystem. These disturbances are visible much earlier than it is possible to identify changes in species richness and abundance of analysed communities. The effects of the research may certainly be applied in the protection of biodiversity.

Another of the analysed problems concerned changes of β-diversity at different trophic levels on the islands of Lake Wigry, and the study included not only spiders but also plants and herbivorous, omnivorous and predatory ground beetles (IIA1). The results showed that on larger islands the proportions of predators and habitat generalists are lower than on smaller islands. Moreover, environmental niches and niche overlap were the highest in predators. Variability in environmental niche width among species increased at higher trophic levels.

During the research conducted on the islands of Lake Wigry, a rare spider species in Poland, *Emblyna brevidens*, was found and a paper concerning this species was published (IID20). This species associated with wetlands and sunny habitats is known from individual sites in several European countries.

In my professional work I also participated in research on various ecological issues related to metabolism and its relation to body weight and density of organisms in which spiders were used as a model group (IIA9, IIA12, IID12).

In 2005 I completed a two-month internship in the team of Prof. David Wise (University of Kentucky, Lexington, USA) conducting multidirectional ecological research, that main research object were spiders. During the internship, I took part in field and laboratory research performed by the members of the team of Prof. David Wise, and I also participated in classes with students and scientific seminars.

Along with the research described above, I was involved in the work on the diversity of invertebrates in the nature reserves located in the South Podlasie Lowland: "Dębniak", "Stawy Broszkowskie" and "Stawy Siedleckie". This type of faunistic and faunistic-ecological studies provides many valuable data on the distribution, species richness and diversity of organisms, which may be the basis for the application of appropriate conservation methods in a given area. This is particularly important for groups such as spiders, as knowledge of the distribution and habitat preferences of particular species remains scarce. Research on spiders and diplopods in the "Dębniak" forest reserve provided knowledge on the diversity of fauna in the dominant habitats of this reserve and resulted in the preparation of two scientific

publications (IID15, IID18). The issue of spider diversity in the nature reserves "Stawy Broszkowskie" and "Stawy Siedleckie" also turned out to be interesting. Both these pond complexes were characterized by a large diversity of habitats, which favored rich fauna and flora and there was a concentration of species with extremely different environmental preferences on a relatively small area. The reserves proved to be a refuge for 15 rare and endangered species of spiders included in the "Red list of threatened animals in Poland", some of which are associated with wetland habitats (*Tetragnatha reimoseri*, *Pardosa sphagnicola*, *Marpissa radiata*) and some are species that prefer dry and sunny habitats (*Pellenes tricuspidatus*, *Alopecosa schmidti*) (IID1, IID10, IID14, IID16, IID21).

The problem of protection of rare and endangered spider species was not new to me, because while preparing the description of the jumping spider – *Philaeus chrysops* for the Polish Red Data Book of Animals, I became interested in the threats to this group of animals in Poland (IID24).

I also conducted research on biodiversity as a contractor in the project on habitat diversity and biodiversity of selected arthropod groups in the Bug river valley (Grant No. N304 113 32/4128 from the Ministry of Science and Higher Education). The choice of such a study place was determined by the fact that the Bug river is one of nine rivers of key importance for the preservation of biodiversity in Europe. It is a great object allowing to recognize the influence of environmental factors and mutual dependencies in the groups of the studied organisms and to determine their role in shaping biodiversity of a large river valley ecosystem of natural character. A good introduction to the work on the project was the preparation of two review publications on spiders of the Mazovian Lowland (IID27) and the Bug river valley (IID22).

The rich arachnological material collected within the project became the basis for several publications, in which I was a co-author. One of them was devoted to the diversity of centipedes (Chilopoda) in different types of habitats in the Bug river valley, which also reported on about one new species for Polish fauna *Lithobius dudichi* (IIA8). In the next paper, I described the impact of the habitat type and its complexity on the size of two species of spiders belonging to the family Lycosidae - *Alopecosa cuneata* and *Alopecosa pulverulenta* (IIA3). The study showed that both species reached larger body sizes in habitats with more complex vegetation structure, which may have been caused by selective pressure from predators, mainly birds choosing larger specimens of spiders. Among the species collected in the Bug river valley, there were also spider species new to Polish fauna, and data concerning two of them (*Glyphesis taoplesius* and *Walckenaeria incisa*) were published (IIA4, IID9).

In addition to the mainstream of my research, I have also joined in the behavioral studies on the methods of hunting of *Yllenus arenarius*. The goal was to check whether the increased visibility of spiders on the background affects the effectiveness of their hunting (IIA13). It turned out that the color of the background had a significant impact on jumping distance, approaching speed and predatory success. On the light background, cryptically colored spiders attacked from closer distances, approached prey with faster speed and hunted more effectively than on the dark one.

In 2011, I started work on a project entitled: "Protection of species diversity of valuable natural habitats on agricultural lands on Natura 2000 areas in the Lublin Voivodeship", carried out in partnership with the Institute of Soil Science and Plant Cultivation - State Research Institute in Puławy, and co-financed within the Swiss-Polish Cooperation Programme. Since 2012 as a supervisor (coordinator) from Siedlce University of Natural Sciences and Humanities (project partner), for over five years I was responsible for the implementation of a part of the project concerning research on spider diversity in selected types of habitats on agricultural lands. The most important issues implemented by the arachnological team included: study and protection of spider species diversity on valuable natural habitats on agricultural lands, analysis of the impact of measures applied in the agri-environment programme on the diversity of spiders, creation of a basis for spider monitoring in agricultural areas and preparation of recommendations for changes in the agri-environment programme to protect the species diversity of spiders. The project was carried out in the Lublin Voivodship, which is characterised by the predominance of small farms, high fragmentation and the mosaic agricultural landscape and a significant share of areas of high nature value. Studies on the effects of agri-environment programmes in this type of landscape are rare in Europe.

Within the framework of the Project, several important publications were prepared, which I was a co-author. These include the "Code of good agricultural practices supporting biodiversity" (IID7). This book addressed to scientists and farmers alike, discussesed in detail the impact of various farming practices conducive to preserve the biodiversity of many groups of organisms and to protect their habitats. As there is a need to check the effectiveness of the agri-environment programme implemented in our country, the Project proposed the methodology of the development of a system for the monitoring of agri-environment programme biodiversity results for various groups of organisms (IID3, IID4, IID5). The implementation of the project also coincided with the implementation of the new edition of the agri-environment programme (currently agri-environmental-climate measure) for the

years 2014-2020 in our country and the results of our work served to create recommendations for changes in this programme. There were also given recommendations concerning the protection of invertebrates, including spiders (IID6). This practical dimension of the research in which I took part was of particular importance to me because it enabled me to use the results of my research work in an application way.

On the basis of the rich data collected as part of the project, results regarding plant diversity, orthopterans and rare species of spiders in cereals were published (IID2, IID11). In addition, part of the data became the basis for my scientific monograph on the impact of management regimes on epigeic spider assemblages in semi-natural mesic meadows, which is presented in detail above as a scientific achievement.

Very helpful in the implementation of the project was a month-long internship in 2011 at the University of Bern in Switzerland, where the team of ecologists worked who studied the impact of agricultural practices and the effects of the agri-environment programme on the diversity of selected groups of organisms, including spiders. The cooperation, which was established, significantly influenced my research conducted within the project, as well as allowed me to prepare two scientific publications, of which I was a co-author (IIA4, IIA7). In the first paper, it was shown that an important factor which positively affects the number of planthoppers, leafhoppers and spiders on extensively used meadows in Switzerland is the delay of the first cut. However, it was not found that leaving uncut fragments in meadows as a refuge had a positive effect on these two groups of animals (IIA7). The second paper concerned the possibility of establishing a sustainable way of using mountain and subalpine meadows by testing the effect of fertilization and irrigation on the ground-dwelling invertebrates - spiders and beetles (IIA4). It showed that spiders reached their highest abundance at a moderate level of intensification, while beetles reached their highest abundance at a high level of intensification. However, the effect of management intensification on species richness and β- diversity of spiders and beetles was not proved.

To sum up, throughout my career I have been involved in various research topics, but my scientific interests focused mainly on the influence of natural and anthropogenic factors on the diversity of selected groups of organisms, especially spiders. I was also interested in research problems related to the distribution of organisms in the habitat. Apart from ecological research, I was also involved in faunistic research, appreciating its importance for providing basic data on the occurrence and environmental preferences of species or their ranges. This is particularly important in the case of spiders, of which knowledge is still rather scarce. My research was both basic and application-oriented. In my scientific activity, I

established cooperation with other specialists from Poland and abroad. I also obtained funds for the implementation of the research projects. As a result, I participated in five projects financed from external sources (non-university) and gained experience working in teams both as a contractor and supervisor. At each stage of my professional career, I paid great attention to the education of young people, engaging students in scientific cooperation, which resulted in master's theses, bachelor's theses and common publications. I presented and discussed the results of my research gained in the course of my scientific activity at international and national scientific conferences. During my scientific career, I have acquired knowledge, skills and experience that allow me to plan and conduct field and laboratory research and publish their results.

In the future, I plan to continue my research on the topics I have dealt with so far, including the practical application of research results in the protection of biodiversity in natural and anthropogenic habitats.

* A list of the literature cited in this part of Autoreferat is given in Appendix 4. A list of published scientific or creative professional papers and information on didactic achievements, scientific cooperation and popularization of science, in the tables in points II A and II D.

Załącznik 3

Summary of my scientific activity:

Total number of scientific papers: 46

– before doctorate: 5

– after doctorate: 41

Number of papers published in JCR-listed journals: 18

– before doctorate: 1

– after doctorate: 17

Number of other papers: 28

– before doctorate: 4

– after doctorate: 24

Total impact factor of publications, according to the year of publication: 29,027

– before doctorate: 1,353

– after doctorate: 27,674

Total number of points (according to the scoring system of Ministry of Science and Higher Education) according to the year of publication: 622

– before doctorate: 28,5

– after doctorate: 593,5

Number of conference presentations: 26

– before doctorate: 5

– after doctorate: 21

Number of citations according to the Web of Science: 106

Hirsch index, according to the Web of Science: 5

Marzena Stańska