AUTOREFERAT PROVIDING A DESCRIPTION OF SCIENTIFIC ACHIEVEMENTS

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1. Name and surname: Paweł Sienkiewicz

2. Certificates and scientific degrees:

2003 – doctor in agriculture in the scope of horticulture, Faculty of Horticulture, University of Life Sciences, Poznań; doctoral dissertation title: "The structure of epigeic communities of carabids (Coleoptera, Carabidae) of meadows periodically flooded in the medium Warta valley". Doctoral supervisor: Prof. dr hab. Janusz Nowacki, reviewers: Prof. dr hab. Andrzej Leśniak, Prof. dr hab. Barbara Wilkaniec.

1998 – magister inżynier of forestry, Faculty of Forestry, University of Life Sciences, Poznań; master thesis title: "Structure of epigeic communities of carabids (Carabidae Erichson, 1897; Coleoptera) of forest habitats of Zespół Przyrodniczo-Krajobrazowy - Wiejkowski Las and its area". Supervisor: dr inż. Andrzej Łabędzki.

3. Information on previous employment in scientific units:

From 2/04/2002 to 30/09/2006 – senior technical clerk at the Chair of Entomology and Chair of Environment Protection;
Since 01/10/2006 till now – assistant professor at the Chair of Entomology and Environment Protection.

4. Indication of achievement resulting from art. 16 s. 2 of the act of 14 March 2003 on scientific degrees and scientific title and the degrees and title in art (Dz. U. no 65, s. 595, as amended):

a) Title of scientific achievemnt:

Carabid communities (Coleoptera, Carabidae) of xerothermic grasslands of the eastern edge of Central European Plain

The scientific achievement is a scientific dissertation published as a book within the series of Polish Entomological Monographs.
Publishing reviewers: Prof. dr hab. Oleg Aleksandrowicz, Prof. dr hab. Piotr Tryjanowski.

b) List of publications constituting a scientific achievement:

SIENKIEWICZ P. 2019. Carabid communities (Coleoptera, Carabidae) of xerothermic grasslands of the eastern edge of Central European Plain. Biodiversity – Ecology – Valorisation. Wydawnictwo Uniwersytetu Przyrodniczego w Poznaniu, Polish Entomological Society, pp. **1- 195**.
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c) Description of the scientific aim of the above-mentioned paper and the results along with their possible use:

Introducion *(list of publications quoted are at the end of the Summary)*

The proces of forming the modern-day Poland's wildlife started about 20 thousand years BP, during the last post-glacial period, i.e. soon after the icesheet retreated from its maximum range area (PAWŁOWSKI 1991). The most intensive transformations of flora and fauna took place in the Holocene, at first mainly unaffected by human activity. Significant human impact on the environment, which with time became more and more devastating, started in Europe in the Neolite (MARUSZCZAK 1991). However, the peak of negative human impact on the environment is recorded in modern day (in Poland particularly from the 19th century to 1990s). This was related to a surge in population size. Humans needed more and more area to produce food and protect it, to establish settlements and build roads. The related technological advancement cannot be neglected, pollution emissions, growing amounts of waste, including xenobiotics, the need for energy, which led to exploitation of fossil fuels and cutting down forests. These actions resulted in a loss of biodiversity and habitat fragmentation (PULLIN 2004). The problem has been recently noticed also by politicians (*Convention on biological diversity*) and by nations, who started to appreciate how important it is to protect biodiversity and better know the functional principles of nature. They started actions to protect the habitats we are losing, often also those which resulted from natural forces, e.g. forest fires or floods, the phenomena whose impact has been significantly reduced by humans who protect their interests. Nowadays the existence of those habitats dependes on active protection, which imitates natural processes. Such highly endangered natural habitats in Europe include dry grasslands, and xerothermic grasslands among them (JANSSEN et al. 2016). As they are characterised by a high biodiversity of flora and fauna, they are often described as hotspots of biodiversity (BUTAYE et al. 2005, VALKÓ et al. 2016, WILLEMS 1990, WOODCOCK et al. 2005). This has also been reflected in a recently created EU programme protecting valuable habitats and species called NATURE 2000 (EUROPEAN COMMISION 2013). In Poland the programme protects xerothermic grasslands of *Festuco-Brometea* class (habitat code: 6210), with important orchid habitats as priorities (MRÓZ i BĄBA 2010). It is vital to protect such and similar habitats in order to preserve heterogeneity of the landscape. It is essential if we want to preserve – in time and space – stable species populations, their interactions and opportunities to migrate (FAHRIG i in. 2011). Taking all this into consideration, preserving a proper mosaic character of the landscape in the agricultural matrix becomes a key task for agricultural policy, in order to minimise the results of habitat fragmentation. Such actions should be preceded first of all by an exploration of biological diversity of the most valuable remains of seminatural habitats, which include xerothermic grasslands.

Acknowledging that ground beetles are one of important and frequently studied beetle families, also used as bioindicators (e.g. AVGIN & LUFF 2010, CAMERON & LEATHER 2012, KOIVULA 2011, LAROCHELLE & LARIVIÈRE 2003, RAINO & NIEMELÄ 2003), first such sweeping studies were started to describe the biodiversity of ground beetle (Coleoptera, Carabidae) communities of the north-western concentration of xerothermic grasslands in Poland. It is also the easternmost concentration of such grasslands in Central European Plain. It should be borne in mind that the grasslands neighbouring on agricultural fields are also important refuges for representatives of many Carabidae, which can develop only in places of undisturbed soil environment, where they also find wintering spots and alternative food sources (FAHRIG 2011, HOLLAND 2002, LEE & LANDIS 2002). They are also localities of characteristic xerothermic (xero-thermophilous) carabid fauna (LINDROTH 1949, THIELE 1977, TURIN 2000).

So far the carabid communities of xerothermic grasslands of the north-western Poland have not been comprehensively studied, in spite of their enormous impact as the biodiversity hotspots. This became the impulse for the author to start the studies presented. The study of xerothermic grasslands allowed for their phytosociological diversity resulting from different microclimatic conditions the grasslands occur in. They were divided into stipa - *Festuco-Stipion* grasslands (KLIKA 1931) KRAUSCH

1961 and flowering grasslands - *Cirsio-Brachypodion pinnati* HADAČ et KLIKA 1944 em. KRAUSCH 1961. Also the geographical variety of the grasslands was considered, as the study area covered the areas of the lower Odra and the lower Vistula as well as Toruń-Eberswalde Ice-Marginal Valley, which probably constitutes a chain ecological corridor (PAUL 2010).

Hypothesis and study aim

The main hypothesis of the studies assumed that xerothermic grasslands are an important and diverse habitat for carabid communities (Coleoptera, Carabidae), at the same time different from carabid communities of other open areas.

In order to verify the study hypothesis I achieved the following study aims:

1. checking if xerothermic grasslands of north-eastern Poland inhabited by stenotopic, threatened and rare Carabidae species, which makes their communities possible biodindicators of grassland condition;
2. estabblishing if stipa and flowering xerothermic grasslands are inhabited by various Carabidae communities;
3. checking if Carabidae communities of xerothermic grasslands of the lower Odra and Vistula are similar in terms of species composition and biodiversity, as Toruń-Eberswalde Ice-Marginal Valley was and can still be an ecological corridor for carabid fauna;
4. evaluating the impact of selected habitat parameters on carabid communities characteristic of grasslands. The parameters included: grassland size, surroundings, exposure and slope incline, plant cover and geographical location,
5. checking of the protection state of xerothermic grasslands influence species richness of grassland Carabidae, particularly on the occurrence of stenotopic (xerothermic) species
6. checking of xerothermic grassland communities differ from the communities of the quasi-steppes, i.e. agricultural fields (mostly with crops).

The studies are my original contribution in the knowledge of carabid fauna of Poland and Europe. The studies of xerothermic grasslands also included the species protected by Polish law and were located in selected nature reserves, and the author of the paper obtained relevant permits from state administration bodies.

Discussion of results

Ad.1. Checking xerothermic grasslands of north-eastern Poland inhabited by stenotopic, threatened and rare Carabidae species, which makes their communities possible biodindicators of grassland condition.

The study material I collected included 160 Carabidae species, which constitutes as many 30% carabid species found in Poland and about 2/3 in the region. I reported 136 species from flowering grasslands and 134 from stipa ones. I found numerous stenotopic-xerophile species in the studied xerothermic grasslands. They constituted the core of Carabidae communities. They included the species which can be considered rare and valuable for this part of Europe. Using red lists of endangered species of Germany and Poland (PAWŁOWSKI et al. 2002, SCHMIDT et al. 2016) in classified as such the following species: *Amara curta, A. lucida, A. tibialis, A. tricuspidata, Broscus cephaloters, Calathus cinctus, Cymindis angularis, Harpalus autumnalis, H. calceatus, H. caspius, H. flavicornis, H. hirtipes, H. honetsus, H. modestus, H. serripes, H. servus, H. solitaris, H. xanthopus, Lebia cruxminor, L. cyanocephala, Licinus depressus, Masoreus wetterhallii, Olisthopus rotundatus, Ophonus melletti, O. puncticollis, O. azureus, O. cordatus, O. sabulicola, O. stictus, Panagaeus bipustulatus, Philorizus notatus, Poecilus punctulatus*.

For some rare Carabidae species I also established new range borders in Poland: the north-eastern one for *A. fusca*, *C. angularis*, *H. caspius*, *O. cordatus*, *O. melletti*, the western one for *Laemostenus terricola*, *L. depressus*, *H. autumnalis*, *O. azureus*, *O. laticollis*, *O. sabulicola*, the northern one for *H. flavicornis*.

Also my observations of *Carabus auratus*, so far associated mainly with agricultural crops, are of merit. This species has its eastern range border in Poland and has been expanding its range to the east recently (TURIN et al. 2003). I proved that xerothermic grasslands are important and natural habitats for *C. auratus*, and the grasslands of river valleys favour its dispersion. This can be proven by its frequency in grasslands – almost 90% of the studied habitats and a high share in community structure, on average 67% in flowering and 38% in stipa grasslands. This is why this thermophilous species was classified into xerothermic ones in the dissertation. Anyway, as was proven by LINDROTH (1949) the connection of European Carabidae species with xerothermic habitats should be rather explained with the need for higher development temperatures than low habitat moisture. This fact can influence the distribution of species, which are less xerothermic elsewhere, in xerothermic habitats in the localities with lower mean temperatures. Besides the species closely related to the studied kind of habitats I also found valuable Carabidae species connected to neighbouring habitats mostly alluvial and water edges. Their presence in the grasslands (mostly in very low numbers) most probably results from dispersal power and the related migrations. The factor which affects the migration of species from river valleys can also include the escape from flood waters (SIEPE 1994), however, some species may find good conditions for wintering in the grasslands (ANDERSEN 1968, 2011).

Due to the connection with dry habitats two very rare flightless species attract special attention: *Laemostenus terricola* and *Carabus marginalis*. The former is connected with the presences of mammal burrows, which offer good development conditions in many European countries (GRUTTKE 1994). In Poland and Finland the species is now closely connected with households – it inhabits cellars with earth floor, old buildings and bakeries, although it used to inhabit caves (PAWŁOWSKI 2004, NIEMELÄ 2001). The species site found a long time ago (RUTA 2007) near Byszewice village (Toruń-Eberswalde Ice-Marginal Valley) had been the only proof of *L. terricola* in Poland in natural habitat before. My studies proved that this critically endangered species also occurs in xerothermic grasslands by the Odra (nine sites) and the Vistula (two sites). This means that the ecological conditions in Poland (mainly higher temperatures) of those habitats enable its occurrence away from households, particularly in stopa grasslands it preferred. Besides a relatively high temperaturę I noted numerous animal burrows there. I believe that this species of low dispersal power can be deemed an indicative one for e.g. xerothermic grasslands, which have been least affected by jabitat fragmentation. This claim can be supported by the studies by GRUTTKE (1994), who studied the connection of *L. terricola* with rabbit burrows and found that the species disappeared as the rabbit habitat was destroyed or fragmented.

Carabus marginalis was previously found in coniferous forests of north-eastern Poland. The sites of *C. marginalis* which I discovered in xerothermic grasslands are first of this type in the country. Although this concerns only two grasslands in the Vistula valley ("Góra św. Wawrzyńca" reserve and the area of Gruczno village), this can incite further research of the distribution of *C. margianlis*, which is a rare and legally protected species.

For many species listed in the paper the data confirm their occurrence after many decades or indicate their new sites in the region.

The material which I collected from the grasslands in the Odra and Vistula valleys and Toruń-Eberswald Ice-Marginal Valley helped to evaluate the preservation state through their Carabidae communities and checking if Carabidae communities can be useful in evaluating of those habitats. Apart from species composition analysis I also used ecological groups and Chao-1 and H' and MIB indices.

Based on the differences observed in the parameters of Carabidae communities I found that the condition of their preservation in stipa and flowering grasslands is better in the western sites. This can results from the occurrence of ecological corridors for xerothermic carabid fauna in the landscape and their connection with refuges of this insect group. The grasslands of western Poland seem to be in a better situation in this respect, as a chain of xerothermic and other dry, the so called open habitats runs from the refuge in Turing across Germany to the lower Odra valley (BfN/BMUB 2013).

When it comes to using Carabidae in valorisation of xerothermic grasslands I found that it could be possible particularly if we concentrated on the most valuable community components (valorisation species), including xerothermic species. I used points awarded to species depending on their rarity scale in my analyses. I proved that stipa grasslands are noticeably richer, as we found there more such species on average than in flowering grasslands. Apart from valuable species I also recorded those with wider or different ecological preferences in both those grassland types. The species with wider ecological preferences can probably use xerothermic grasslands as a periodically important locality, e.g. during floods, agricultural works on nearby fields or while wintering. On the other hand, the grasslands did not differ in terms of the total number of valorisation points awarded to valuable species. This is why, although stipa grasslands contribute more to the conservation of xerothermic species, in my opinion flowering grasslands should not be ignored while planning environment conservation on a local scale.
The analyses I performed proved that the valorisation and monitoring of xerothermic grasslands should finally concentrate on xerothermic species, all the more so because these should be the quickest to react to unfavourable changes in the habitat, just as butterflies (ROSIN et al. 2012) or other beetle groups do (MAZUR & KUBISZ 2013). Using the presented study results we can claim that we should report at least average numbers of valorisation points from the grasslands located in north Poland and preserved at least in a satisfactory state. Moreover, when concentrating on the quality and not quantity aspect we simplify the valorisation process and thus can try to perform supravital beetle analyses during spring and autumn peaks of abundance, in this manner reducing the pressure on the habitat.
When looking at the distribution of valorisation points awarded to grasslands we can see that the western ones are definitely higher valued than those in the Vistula valley. However, I reported considerable fluctuations also within archipelagoes, this is why I analysed also the correlation between the valorisation results and the selected habitat factors which I deemed the most significant. I also evaluated the impact of concentration of grasslands in the area on the rare species that inhabit them and I expressed that with the number of grasslands studied in a single UTM square (10 x 10 km).
In my analysis I singled out the Carabidae of the highest preferences for calcium carbonate in soil (calciphilous), and basically requiring a higher heat accumulation (LINDROTH 1949). I proved that this species group was more abundant in grasslands of a larger habitat area, which was not compensated by the incline of grassland-grown slope. Too steep slopes were not advantageous for this Carabidae group. Generally the most important factor for valuable grassland species was the concentration of habitat patches. So for the proper and effective protection of xerothermic grasslands of both types they must constitute as large patches as possible and should be frequent in agricultural landscape, connected with ecological corridor system, which leads to the spreading of xerothermic habitats Carabidae. Otherwise we will gradually lose biodiversity of next unique habitats. The result corresponds with the well-known ecological theory of islands (MACARTHUR & WILSON 2001, VRIES DE 1994) and metapopulation (HANSKI & GILPIN 1991).

Ad.2. Establishing whether stipa and flowering xerothermic grasslands are inhabited by different Carabidae communities.

Stipa and flowering xerothermic grasslands differ in terms of floristic composition (MATUSZKIEWICZ 2012) and their location in landscape. For this reason I assumed that despite many similarities they would differ in their Carabidae species composition. After a comparison of communities from both grassland types I noted the differences which turned out to be statistically significant (NMDS stress=0.19; ANOSIM: $R=0.10$; $p<0.01$) but were so unclear that finally I did not differentiate the Carabidae communities arbitrary based on differences in grassland microclimate. More detailed data on the character of the differences was provided by SIMPER analysis, which yielded dissimilarity index at 83.54%. Taking into consideration the species which particularly prefer a higher content of calcium carbonates in the soil (MÜLLER-MOTZFELD 2004) the following species were more connected with flowering grasslands: *Panagaeus bipustulatus*, *Ophonus puncticollis* and *O. azureus*. The following were more numerous in stipa grasslands: *Cymindis angularis* oraz *Ophonus cordatus*. However, these species were generally not abundant in the grasslands and were never dominants, unlike many other xerothermic carabids.

When examining the Carabidae species which mostly contributed to the differences between the flowering and stipa grassland communities we can see they reflect the microclimatic differences of those habitats, particularly considering the pioneer character of stipa grasslands. This helped me make sure that differentiating the carabid communities of both grassland types is justified. I proved the higher abundance of carabids of wider preferences for the so-called dry grasslands, mesophile medows and fields in flowering grasslands (e.g. *Carabus auratus*, *C. cancellatus*, *Poecilus lepidus*, *P. cupreus*, *Ophonus stictus*, *Amara equestris*, *Harpalus rubripes*, *Microlestes minutulus*) with the exeption of *Pterostichus niger*. It is a forest species which most probably migrated to the grasslands from the neighbouring forests or shrubberies.

The dominants with a high abundance in stipa grasslands included the Carabidae preferring initial habitats with low plant density, namely: *Calathus erratus*, *C. fuscipes*, *Harpalus anxius*, *H. autumnalis*, *H. tardus*, *H. pumilus*, *H. picipennis* and *Harpalus rufipes*, with slightly wider ecological preferences and was not generally frequent in the grasslands. Except the last species mentioned the others prefer loose soil. This is a significant factor, particularly for many species of the genera *Harpalus* or *Ophonus*, as the larvae of many of them live in burrows (LINDROTH 1949, THIELE 1977).

Such a character of differences between Carabidae communities of xerothermic grasslands suggsts a highe stability of species composition of flowering grasslands and instability of stipa grassland species composition, as they are more initial (represent an earlier succession stage). Nonetheless, a nestedness analysis of those communities did not corroborate my assumption. This may result from the isolation of grasslands and the resulting weakening of migration between them (PATTERSON & ATMAR 1986); they additionally take up a comparatively small area and include species of low dispersal power.

The hypothesis of distinct character of stipa and flowering grassland communities, posed at the beginning, can be claimed confirmed. A next point in describing community diversity was the question if the differences in species composition of flowering and stipa xerothermic grasslands are reflected in the structure of ecological groups of Carabidae communities, species richness indices (Chao-1) and biodiversity (H') as well as mean individual biomass (tMIB).

As I proved, the common feature of the studied grasslands was e.g. a significant average share of brachypterous species (about 60% in flowering grasslands and 40% in stipa grasslands). Such an image of the community results from the stabilisation of conditions in most grasslands (SIGMUND and WALTZBAUER 2007, VENN 2016). The habitats unstable by nature and those of initial character are usually dominated by macropterous species (AUKEMA 1995), this is why I could state that from the point of view of xerothermic grasslands protection we should pay attention the habitat stabilisation level, which might mean disadvantageous succession changes, as well as result from insufficient opportunities for migration. The observed significant fluctuations in the proportions between brachypterius and macropterous Carabidae prove different state of the habitats and the excessive representation of this ecological group often resulted from the domination of *Carabus auratus* and *C. cancellatus*.

When it comes to flowering grasslands it can be said that habitat conditions are more stable and consequently the average share of species will low dispersal power is higher, as has been observed before (THIELE 1977).

The xerothermic grasslands I studied were dominated by the Carabidae of the so-called spring breeding type (over 70% on average). It is characteristic of many open habitats, particularly those of loose soil and shortage of water (THIELE 1977). This group also dominates other extreme habitats (KINNUNEN and TIAINEN 1999, SIENKIEWICZ and ŻMIHORSKI 2012, THIELE 1977) as well as less fertile fields (e.g. HURUK 2007, KOSEWSKA et al. 2014). The species of autumn breeding type were usually a minority in the communities during my studies. They are typical of stabilised habitats with not very changeable ecological conditions, eg. Forests (GOBBI & FONTANETO 2008, THIELE 1977).

I did not record significant differences between grassland types in terms of habitat preferences. They were dominated by open-habitat species, just like in many other non-forest habitats and in fields. This species group contained the Carabidae which can be connected with steppe habitats (LINDROTH 1949). The dominant character of this ecological group in dry habitats was also reported by ANDERSEN (2000). He also found a low share of litoral and forest species in such habitats. These two ecological groups also differentiated the flowering grasslands I studied from the stipa ones. A higher share of those species can be attributed not only to the forests and shrubs surrounding the grassland, but with other ecological conditions different for these two grassland types. The key ones can be more shaded ground and accumulation of organic matter, which increases the inflow of biogenes and thus the ability to maintain moisture. This is the result of incorrect habitat protection methods (HABEL et al. 2016) and migration of grass species connected with fresh meadows, as was noted for dry dune grasslands (NIJSEN et al. 2001). The same microhabitat conditions probably result in the differences in the share of Carabidae with various moisture preferences. Hences the reported highe share of higrophilous species in flowering grasslands, with a general dominance of xerothermic species in Carabidae communities of both grassland types. Also their average higher share in stipa grassland cannot be neglected. I also recorded nearly twice more hemizoophagous species in stipa grasslands, most of them also xerothermic ones (KOCH 1989, MÜLLER-MOTZFELD 2004). This is related on the one hand with availability of a rich set of plants preferred by seed-feeding species and loose soil which enables the species of *Ophonus*, *Metophonus* czy *Harpalus* genera maintaining larvae in their burrows (BRANDMAYER 1990, HONEK et al. 2003, KRYZHANOVSKIJ 1983, LINDROTH 1949, THIELE 1977).

Large zoophages were more numerously represented in flowering grasslands (over threefold). This results from a higher share of not exactly forest species, but large predators of open areas: *Carabus auratus* in the west and *Carabus cancellatus* in the east. The differences are reflected in the index of mean individual biomass, which was on average about twice as high in flowering grasslands as in stipa ones and reached about 225 mg. This difference may result from more advances succession stage of flowering grasslands in comparison with stipa ones, just like with changes of this index in succession chain of forest ecosystems (SZYSZKO 1983).

The grasslands did not differ in terms of species richness (Chao-1) and biodiversity (H') indices.

Ad.3. Checking of the Carabidae of xerothermic grasslands of the lower Odra and Vistula are close in terms of species composition and biodiversity, as Toruń-Eberswalde Ice-Marginal Valley has been and can still be an ecological corridor for carabid fauna.

The grassland parameters were greatly changeable within grassland types and location, to be precise: within river valley they were connected with. I described the variety separately for flowering and stipa xerothermic grasslands, as the differences were not the same in character.

Flowering xerothermic grasslands

After my analysis I classified flowering grasslands into two groups (NMDS stress=0.15; ANOSIM: R=0.37; $p<0.001$). One group included the grasslands connected with the Odra valley and Toruń-Eberswalde Ice-Marginal Valley, the other one: the grasslands connected with the lower Vistula. With a SIMPER analysis I defined the species which significantly contributeto the differences with their higher average abundance. As was mentioned before, the communities differed in the abundance of two large predators of the *Carabus igenus*. The dominant of the first group grasslands was *C. auratus*, which increases its range towards the east, on Vistula grasslands it was vicarised by *C. cancellatus*, a species widely spread in Poland (BURAKOWSKI et al. 1973, TURIN & al. 2003). I also observed a higher share of other species connected with xerothermic habitats, which otherwise often occur in fields (np. *Calathus fuscipes*, *Harpalus rufipes*, *Harpalus rubripes*, *Amara equestris*, *Poecilus cupreus*) in flowering grasslands of the Odra valley and Toruń-Eberswalde Ice-Marginal Valley. The rarest species, occurring solely in Odra grasslands, included *Ophonus stictus*. On the other hand, in the Vistula valley a high share of species preferring various xerothermic habitats, but less connected with fields could be seen; the species included *Syntomus truncatellus*, *Microlestes minutulus*, eurytopic *Carabus convexus* and forest *Pterostichus niger*.

Analysing the differences in ecological structure of those communities I showed that flowering xerothermic grasslands by the Odra and Toruń-Eberswalde Ice-Marginal Valley preserved their xerothermic character to a higher extent than those by the Vistula. This can be proven by the proportions of Carabidae ecological groups. I recorded a higher (almost twice higher) share of macropterous species in the grasslands of the first group than in the Vistula grasslands, which were characterised by a higher share of brachypterous species (about 1.5 times). An over twice higher share of carabids of autumn breeding type was reported from the Odra and Toruń-Eberswalde Ice-Marginal Valley grasslands, while the Vistula grasslands yielded a slightly higher, but statistically significant share of spring breeders. The archipelagoes of flowering grasslands also differed in terms of species with different moisture preferences. One of more significant differences was a considerably higher average share of xerothermic species (about 2.5 times) in the grasslands from the Odra valley and Toruń-Eberswalde Ice-Marginal Valley in comparison with the grasslands of the Vistula valley. This can constitute additional proof that the xerothermic grasslands in the western part of the study area are better preserved. Low value of flowering xerothermic grasslands of the Vistula can also be proven by a high share of species with wide moisture preferences, which in disturbed habitats compete with stenotopic species (CZECHOWSKI 1989, LUKA & al. 1998). In terms of trophic structure I recorded a significantly higher share of hemizoophages in the grasslands of the Odra valley, on the other hand, a considerably higher share of large zoophages was reported from the Vistula grasslands. As a result the mean individual biomass is even by 100 mg higher in these grasslands. Flowering grasslands did not statistically significantly differed in terms of species richness (Chao-1) and biodiversity (H') indices, however the first group of grasslands yielded a higher value of average and maximum H' index.

Stipa xerothermic grasslands

A similar analysis was used for stipa grasslands, which helped to classifiy them into three groups (NMDS=0.18; ANOSIM: R=0.46; $p<0.0001$): 1) the grasslands located closer to the Odra valley (the western part of study area), 2) the grasslands located on the edge of Toruń-Eberswalde Ice-Marginal Valley (two isolated plots near Gorzów Wielkopolski), 3) the grasslands located on the edges of the Vistula valley. The differences in species composition of Carabidae partly corroborate the results obtained for flowering grasslands and prove a better preservation state of carabid fauna in the grasslands located in western Poland. The average share of brachypterous species, typical of more stable habitats, was definitely higher for the stipa grasslands of the Vistula and unusually high (78.11% on average) for the isolated plots in Toruń-Eberswalde Ice-Marginal Valley, while macropterous species dominated in the grasslands by the Odra. All the plots reported a higher average share of spring breeders (much higher when comparing the isolated grasslands with those by the Odra). No significant differences were noted in the shares of species with various habitat preferences, again with the exception of the grasslands of Toruń-Eberswalde Ice-Marginal Valley, where the share of forest species was higher on average.

When it comes to moisture preferences the communities of Toruń-Eberswalde Ice-Marginal Valley were slightly different from stipa grasslands, however, in some respects they were closer to those of the Odra. It could be seen that Carabidae communities of the Vistula grasslands were characterised by a significant share of species with wide moisture preferences, with an about twice lower average share of xerothermic species. Consequently, the grasslands from the Odra are characterised by an average higher share of hemizoophages, although the difference is statistically insignificant in comparison with the grasslands from the Vistula. Isolated stipa grasslands are considerably poorer in this ecological group. The share of small zoophages in the grasslands of the Odra valley was also higher on average than in the other grasslands, which is typical of labile habitats in their earlier succession stages or those subjected to periodic pressure (SIENKIEWICZ i ŻMIHORSKI 2012). On the other hand, the share of large zoophages in the communities increased to the east. Due to a high abundance of *C. auratus* its highest share was recorded in stipa grasslands in the Ice-Marginal Valley. This was also reflected in the mean individual body mass index (tMIB), which on average reached 75 mg in the Odra valley, almost 170 mg in the Vistula valley and about 340 mg in isolated grasslands. The Carabidae communities of stipa xerothermic grasslands did not differ in terms of species richness index (Chao-1), while Shanon-Wiener biodiversity index (H') was on average higher in the Odra grasslands; next came the grasslands of the Vistula and the least diverse were the isolated ones. A fall in biodiversity may in this case result from habitat fragmentation, which negatively affect the opportunities of species migrating between populations (HANSKI i GILPIN 1991).

A characteristics of Carabidae communities of stipa and flowering xerothermic grasslands is completed with their zoogeographical profile. Both habitats yielded a significant share of components of Western-Palearctic range (about 46% and 32% on average, with extreme cases when this group was a dominant one). Among them I found the species connected with warm regions of North Africa and Asia Minor, such as: *Amara fusca*, *Calathus cinctus*, *C. fuscipes*, *Carabus auratus*, *Harpalus caspius*, *H. flavicornis*, *H. honestus*, *Olisthopus rotundatus*, *Ophonus laticollis*, *Ophonus sabulicola* and *Panagaeus bipustulatus* (KOCH 1989, MÜLLER-MOTZFELD 2004,). They are characteristic for European xerothermic grasslands, just as equally well-represented group of Euro-Siberian species (almost 40% and over 45% respectively, sometimes vastly dominant in communities). The xerothermic species recorded during study include: *Cymindis angularis*, *Harpalus serripes*, *H. servus*, *Licinus depressus*, *Ophonus cordatus*, *Poecilus punctulatus*. Another significant group included the species of wide range, i.e. Trans-Palearctic. Their share in communities, however, was lower (about 12% and 19%). The widest range group, i.e. Holarctic species, reached 1.6% in flowering grasslands and slightly over 2% of stipa grassland communities. The grassland types differed in terms of the share of Euro-Siberian species, whose share was about 1.5 times higher in the flowering grasslands, usually closer to Asian steppes in their Carabidae composition (VENN and MATALIN 2014). In stipa grasslands over 1.5 times higher share of Trans-Palearctic species was recorded.

An important issue it to define to what extend the carabids used or still use the studied spatial layout of xerothermic grasslands for migration (mainly dispersion). A closer look at a zoogeographical profile of Carabidae communities in local aspect reveals that the grasslands located in the east of the study area and along Toruń-Eberswalde Ice-Marginal Valley are characterised with a considerably higher share of Western-Palearctic species. This can be explained with their use of Brandenburg-Pomeranian migration route (MAZUR & KUBISZ 2013), which even now can help the migration of fauna from the refuges in Turing through a network of xerothermic habitats in Germany (BfN 2013, MÜLLER-MOTZFELD 2004). The xerothermic grasslands of the lower Vistual were distinct because of their share of Euro-Siberian species, which in turn suggest that their carabid fauna migrated along the Podole route. Such a variety of zoogeographical profile might mean that Toruń-Eberswalde Ice-Marginal Valley is no longer a functional migration route for Carabidae. Based on studies of selected groups of clearly xerothermic beetles it was supposed in some publications that while migrating from the south along the

Vistula valley the insects encountered a filter, which hindered their passage along the mid-Vistula valley. Thus a conclusion was drawn that the fauna of the area could have been supplied latitudinally along the Noteć valley (MAZUR & KUBISZ 2013). Looking at the distribution of Carabidae the most closely connected with xerothermic grasslands of Central European Plain it can be deemed that this migration route was not particularly often used. This seems to be confirmed by some of my studies' results which complete literature data published so far. For example *Olisthopus rotundatus* and *Ophonus cordatus* are often found in the upper Vistula and lower Odra valleys, while they have no sites in the lower Vistula valley. On the other hand, *Calathus cinctus* has its sites in central Poland, in north west and by the lower Odra and lower Vistula. *Laemostenus terricola* mainly occurs in the south of Poland (the upper and lower Vistula valley), but also in the lower Odra and Vistula valleys and also in one site in Toruń-Eberswalde Ice-Marginal Valley (RUTA 2007). *Amara fusca* occurs mainly in the west of the country, including the lower Odra valley. *Harpalus caspius* is an exceptionally rare species previously reported from the upper and middle Vistula and one site from the lower Odra valley. *Harpalus flavicornis* was reported from the lower Odra valley and by the Noteć (ahead Bydgoszcz Canal). *Ophonus azureus*, *Licinus depressus* and *Cymindis angularis* occur in the uplands of the south-eastern and central Poland as well as in several sites along all the study area. Thus it is not clear (although it seems logical) whether Toruń-Eberswalde Ice-Marginal Valley was an important migration route for carabids from the lower Odra and lower Vistula valleys. I suppose that this bridge is more frequently used now, which can be proven by expanding range of *Carabus auratus* e.g. along Toruń-Eberswalde Ice-Marginal Valley. Apart from that some xerothermic species can find their refuges and migrate through highly urbanised areas (VENN i in. 2013), which obviously did not exist in the past.
In order to evaluate if Carabidae on the edges of study area now use Toruń-Eberswalde Ice-Marginal Valley as an ecological corrider it might be helpful to study communities ecological structures. The differences in these structures, presented in the paper, lead to a conclusion that the communities fomed in different ways.

The results I obtained show the exected impact of migration routes on Carabidae communities structure. The fact that in terms of zoogeography and ecology this fauna varies depending on the region may confirm that Toruń-Eberswalde Ice-Marginal Valley is not a significant migration route for the carabids of Odra and Vistula grasslands, as was suggested earlier. This might be connected with human activities, which resulted in disappearance of many xerothermic habitats on the edge of Toruń-Eberswalde Ice-Marginal Valley. The river-free fragment of the Ice-Marginal Valley before the construction of Bydgoszcz Canal might have been a migration filter just like the one in the Vistula valley (MAZUR & KUBISZ 2013). There could have been more such filters, e.g. the broads at the Warta rivermouth or the areas east of Santok village, where more wood grew until modern times (BREYMAYER 1991). I believe it would be good to apply genetic research to solve this problem.

Ad.4. Evaluating the impact of selected habitat parameters, such as grassland size, surroundings, slope exposure and incline, plant cover density and geographical location, onto Carabide communities characteristics.

The differences between grassland types within their regions are added to habitat factors which affect grassland microclimate and the possibility that the grassland will be inhabited by fauna less connected with xerothermic habitats. The changing character of those conditions makes xerothermic grasslands sometimes considerably varied in terms of species composition in particular patches. Using the information on grasslands which I gathered in field studies I checked if factors such as exposure, habitat area, slope incline, distance from the river, the degree of surroundings diversity and the percentage of plant covered area as well as geographical location (longitude and latitude) affect Carabidae communities. It was important because they directly influence ecological conditions of the grassland itself, i.e. moisture, temperature, organic matter accumulation, insolation, the richness of ecological niches etc. An RDA analysis proved that the Carabidae of xerothermic grasslands reacted differently to those habitat factors and could be indifferent to some of them. Below I present the most significant results of my studies in terms of grassland types functioning.

Flowering xerothermic grasslands

The habitat area, geographical location and distance from the river turned out to be significant for shaping Carabidae communities of flowering xerothermic grasslands.

Along with the increase of studied grasslands area the share of low-dispersal power (brachypterous) species decreased, while the share of dimorphic ones increased. Macropterous Carabidae did not react to an increase in the area, as they are better adapted to open areas (THIELE 1977). The decreased share of brachypterous species along with the decrease of grassland area should be deemed advantageous, as a high share of this group in communities means an excess stability of ecological conditions (VENN 2016), i.e. progressing ecological succession which results from improper grassland protection, e.g. stopping extensive use or removing shrubs or animal grazing (HILL et al. 2004, WURTH 2004).

A larger grassland area favoured the occurrence of xerothermic species, i.e. those connected with open areas, tolerating high temperatures and a low habitat moisture. It should be noted that the group which decreased its share in a community was eurytopic one (both in terms of habitat and moisture preferences). Thus the community became more specialised with the growth of grassland area. This can also have consequences for the protection of xerothermic grasslands and may mean that too small patches of habitats can easily lose their characteristic faun, like other environmental islands (MCARTHUR and WILSON 2001). Additionally the adverse impact of water edge zone intensifies there (HANSKI i GILPIN 1991). This thesis can additionally be corroborated by the positive response of hemizoophages and small zoophages to an increasing area. The first group includes many species typical of xerothermic grasslands. On the other hand, the share of large zoophages falls as the area increases. Larger grassland patches were also characterised by a higher species richness index (Chao-1).

A larger distance of a flowering grassland from the river was favourable for the occurrence of brachypterous species, while the species of higher dispersal power responded negatively. This may indicate lack of connection between such grasslands and migration corridors which naturally formed on river valley edges and consequently with a faster degradation of carabid fauna of such grasslands.

Carabidae classified as spring breeders also increased their share as the distance from the river increased, which is interesting, as the grasslands further form hydrogenic habitats could have been expected to yield a similar share of this ecological group and in the neighbourhood, where grasslands can be used by the species escaping adverse conditions in flooded terraces (ANDERSEN 1968). This might be the effect of escape from fields and green crop areas, described before (CLAßE & al. 1993, HOLLAND 2002). Nonetheless for many grassland species the spring and early summer may also turn out to be better due to moisture conditions (LINDROTH 1949). The grasslands farther from the river were characterised by a higher share of open habitat species. However, I did not find that factor to condition the occurrence of xerothermic species. Along with the distance of the river the share of large zoophages increased, too, and consequently the mean individual biomass (tMIB). The further from the river, the higher was also the species richness index (Chao-1).

The share of xerothermic species was also connected with geographical location of the grassland, as it increased to the south and west. Chao-1 also increased to the west. This also corroborates an earlier observation that the grasslands located by the Odra are characterised by better preserved carabid fauna than those by the Vistula.

Stipa xerothermic grasslands

Carabidae communities of stipa xerothermic grasslands responded to factors such as slope exposure and incline, percentage of plant cover, changeability of grassland surroundings and latitude. It is a set of different factors than those which were significant for flowering grasslands, which results from different conditions in which stipa xerothermic grassland form.

One of more significant factors is the percentage of grassland area covered by plants. The excess plant cover changes the grassland character and indicates a progressing ecological succession (HABEL et al. 2019, NIJSEN et al. 2001, SIGMUND and WALTZBAUER 2007, TROST 2004). This results in an increased share of brachypterous species in the community. Also the share of autumn breeders increases, as they are more frequent in the habitats of more stabilised ecological conditions. A larger plant cover does not help maintain xerothermic species and small zoophages, either. Consequently the mean individual biomass increases (tMIB). An equally important factor turned out to be geographical location. Stipa grasslands are subject to milder conditions to the north due to stronger influence of sea climate, which can explain the observed fall in the share of the species characteristic of xerothermic grasslands (the share of xerothermic species falls and the share of species with wide moisture preferences increases, also the share of brachypterous species is higher, and the share of open habitat species falls). A larger slope incline was advantageous for Carabidae communities of stipa grasslands (a higher temperature, quicker loss of water, slope erosion). This was expressed in a higher share of macropterous and hemizoophagous species. However, no impact of this parameter on xerothermic species was found, although the factor should have had an impact, judging by intuition. A key factor for stipa xerothermic grasslands was also slope exposure. As predicted, the ecological structure of Carabidae groups was better formed on slopes of south-western and southern exposure. Such grassland could be expected to have a higher share of macropterous species and those preferring xerothermic habitats. Such exposure also favours hemizoophagous species.

According to the concept of "spatial landscape heterogeneity" (FHARIG i in. 2011) diverse grassland surroundings can be expected to influence species richness and biodiversity, however, my research revealed that this factor on a local scale, in immediate surroundings of the habitat patch did not always favourably affected Carabidae communities structure. When other habitats appeared in grassland area (e.g. forests or shrubberies), the share of brachypterous and forest species increased (a large group of forest species are brachypterous species), as did the share of autumn breeders, whose higher share is not typical of dry habitats, either. With a small area of habitat patches it is probably a and edge effect (HANSKI and GILPIN 1991). I also noted an increase in the share of xerothermic species with a fall of hemizoophagous ones. On the other hand, xerothermic species may use nearby shaded habitats in the hardest drought (LINDROTH 1949), which I clearly recorded in the case of *Carabus auratus* (unpublished material). It is significant that diverse grassland surroundings could have influenced a lower value of species richness of grassland communities (Chao-1).

Ad.5. Checking if the protection of xerothermic grasslands influences species richness of grassland Carabidae, particularly the occurrence of stenotopic (xerothermic) species.

Introduction of legal protection, which should be an active one, targeted at maintaining the appropriate stage of succession, is important for xerothermic Carabidae of flowering grasslands. I proved that legally protected flowering grasslands were characterised by a higher share of open areas and xerothermic species. This means that conservation actions started recently on unprotected grasslands (BARAŃSKA 2014, BĄBA 2004) should greatly improve the structure of their Carabidae communities. A higher mean individual biomass of species reported from protected grasslands may come as a surprise; this could be the effect of a change in the approach to the protection of xerothermic grasslands in recent years (BARAŃSKA 2014), as opposed to leaving the grasslands as they were, which had happened before (KUŚKA 1981, 2006). I recorded a clear impact of legal protection only in flowering grasslands as a rule, which can be explained by the fact that most stipa grasslands described in the paper was already protected. Besides, stipa grasslands are more often subjected to active protection, even if they are not legally protected yet.

Ad.6. Checking if xerothermic grassland communities differ from the communities of quasi-stepppes, i.e. fields (mostly with grain crops).

Other open habitats can constitute temporary habitats for xerothermic fauna. According to the data from resources this can concern mainly grain crops, often neighbouring on grasslands (HOLLAND 2002, THIELE 1977), particularly because some fauna inhabiting xerothermic grasslands also occurs in Asian fields, particularly in steppe areas (BESPALOV et al. 2017, VENN and MATALIN 2014). For this reason I compared the xerothermic grassland Carabidae communities with a number of fields, in the latter case on the basis of my own unpublished materials and literature data. After the analysis I found that these communities are not really close in species composition of their Carabidae (ANOSIM: $R=0.48$; $p<0.001$). This was also proven by dissimilarity index of communities in both ecosystem types, which reached over 92% (SIMPER analysis). I suppose this is the result of the diminishing number of species, including carabids, in fields, which has been noted in Europe for years (HOLLAND and LUFF 2000). It is also expressed in a significantly higher biodiversity index (H') species richness index (Chao-1) on the studied xerothermic grasslands than on fields. The differences are even greater considering the fact that the studied xerothermic grasslands turned out to be an important habitat for 44 species. The species reached a higher abundance than in fields or else they were not found in fields at all. Thus I corroborated the working hypothesis that xerothermic grasslands are habitats clearly distinct from fields. They are then an important and indispensable element ensuring a higher biodiversity also in agricultural landscape.

Summary

The studies I conducted proved that natural and semi-natural refuges, i.e. xerothermic grasslands of the studied part of Central European Plain, are an exceptional area for a number Carabidae species. It is necessary and important to maintain these habitats in landscape to preserve biodiversity. I conformed the hypothesis that xerothermic grasslands of north-eastern Poland are still a habitat for stenotopic, rare and endangered Carabidae species and that their communities can be bioindicators of grassland condition. Grassland condition first of all enables the occurrence of the most valuable components, i.e. xerothermic species. It was proven that stipa and flowering grasslands are distinct, although overlapping Carabidae communities. The communities in grassland types differ depending on the region, and Toruń-Eberswalde Ice-Marginal Valley is not and perhaps has never been a route of intensive species migration between grassland concentration in the lower Odra valley and lower Vistula valley. The fauna of both regions could have encountered a filter in the form of comparatively scarce xerothermic grasslands on its edges. It seems that the modern distribution of anthropogenically formed habitats can enforce the role of Ice-Marginal Valley as a migration route.

The communities quality, species composition and ecological structure of grassland Carabidae communities depend on many habitat factors. More significant and important for grassland protection include the area, incline and exposure of the slope, plant cover and concentration of similar habitats in the area. The hypothesis on the importance of legal protection for the quality of Carabidae communities was confirmed only partly – for flowering grasslands. This probably results from the fact, that most studies stipa grasslands is already legally protected. Apart from that the manner of protection is significant. Also the hypothesis on a distinctiveness between xerothermic grassland Carabidae communities and field communities.

Possibilities to apply study results

The study results, particularly knowledge of the occurrence of xerothermic (stenotopic) species, can be used in valorisation of xerothermic grasslands. The described current state of grassland Carabidae communities and the factors affecting their quality can be applied in planning environment conservation and valorising the activities targeted at maintaining xerothermic grasslands in agricultural landscape as important components of preserving biodiversity within sustainable development. A wide analysis of xerothermic grassland Carabidae communities helped ascertain that the following are necessary to protect their carabid fauna:

a) including possibly large grassland patches with legal protection, also by increasing the protection rank of the sites already protected and increasing their area;
b) maintaining planned active protection on those sites;
c) as a priority protect the grassland sets on river valley edges;
d) reconstruct the network of ecological corridors which enable fauna and flora migration.

In order to better protect stipa xerothermic grasslands also the following can be suggested:

a) not allowing excessive plant density, leave patches of bare soil (e.g. by extensive grazing);
b) concentrate protective actions on grasslands of medium and higher slope incline and south-western and south exposure, without leaving the grasslands of other parameters, which still can be locally valuable refuges of xerothermic carabid fauna.

5. Presentation of other scientific and research achievements with the elements of the scientific curriculum

My scientific interests started at an early school age, when encouraged by my family I began my first entomological collection. My interest increased, boosted by contacts with the scientific community of the University of Life Sciences in Poznań (formerly University of Agriculture) and Adam Mickiewicz University. In secondary school I began to participate in the works of Polish Entomological Society, concentrating my research on beetles (Coleoptera), particularly on the carabid family (Carabidae). The areas of particular interest to me – concentrating mainly on beetles (sometimes also arachnids and other insect groups) are faunistic and zoogeographical features, conservation of biodiversity, ecology, invasive species, connections between carabids with gregarines (Protista: Gregarinasina) as internal parasites of invertebrates and, in the last 10 years, the opportunity of applying pro-environmental methods in organic farming in its broad meaning. My scientific work includes the following areas:
1) Faunistic research and biodiversity and its protection, with particular focus on beetles.
2) Alien and invasive species, their distribution and elements of ecology.
3) Carabids in ecosystem's trophic structure and other areas of Carabidae ecology.
4) Preserving biodiversity in agricultural landscape.
5) Connections between the carabids (Carabidae) and gregarines (Gregarinasina).

Ad. 1. <u>Faunistic research and studies of biodiversity and its protection, with particular focus on beetles</u>

This area of my research, conducted together with other scientists and entomology enthusiasts, includes five more specialised topics.
The first one is the study of the distribution of selected groups of beetles (Coleoptera) with special focus on carabids (Carabidae) and selected groups of true bugs and arachnids. In my publications on this subject, I presented a number of new data on their main taxa in Poland, thereby extending the knowledge of their distribution. Most papers concerned rare species, whose distribution is sometime still

insufficiently studied. This in turn leads to problems with their protection. Additionaly, this research helped to fill gaps in the knowledge of species ecology. During faunistic studies, I managed to find new species in Poland, namely *Ophonus diffinis* Dej. (Coleoptera, Carabidae), a new species for Bulgaria: *Pachycarus ceaneus* (Dej.) (Coleoptera, Carabidae), and a new one for Ukraine: *Polichus Connexus* (Geofr.) (Coleoptera, Carabidae). One of my significant achievemens in this area was creating a summary of the distribution and creating a key to determine the species of the genus *Triplax* (Coleoptera, Erotylidae), and report a new species for Poland: *Atheta strandiella* (Brundin) (Coleoptera, Staphylinidae), which is a stenotope on well-preserved high peat bogs.
Publications on the list: **A. 13, D. 1, D. 2, D. 4, D. 6, D. 7, D. 8, D. 9, D. 10, D. 12, D. 13, D. 19, D. 21, D. 26, D. 28, D. 35, D. 36, D. 38, D. 42, D. 48, D. 39** and most peer-reviewed scientific messages listed at the end of the dissertation.

Another area of my research was biodiversity characteristics of selected groups of invertebrates (mainly beetles) inhabiting the areas of surface conservation methods where applied. Most of these studies relate to cultural landscapes dominated by the agrocenoses. The studied landscape components were important for the protection of its richness. In this way, I described selected groups of beetles of Biedrusko Protected Landscape Area, now part of NATURA 2000 programme. A number of my publications in this regard concern the occurrence of beetles in NATURA 2000 - the Rogalin Warta Valley, where I studied and described beetles (mainly Carabidae), meadows, old river bed edges and tree clumps in an extensively used agricultural landscape, and also, together with UAM scientists - the meadows and fragments of forests of "Krajkowo" nature reserve.
Within cooperation with the Museum of the First Piasts at Lednica and UMCS, I also described the communities of spiders and harvestmen of selected habitats of Lednicki Landscape Park. My research also covered some nature reserves, providing valuable and first-time data on many species of beetles and arachnids, confirming the importance of such residual natural and semi-natural habitats for preserving the biodiversity at a regional level. I also investigated selected strict protection areas in Wielkopolski and Świętokrzyski National Parks.
Publications on the list: **D. 5, D. 11, D. 16, D. 17, D. 22, D. 31, D. 39, D. 40, D. 43, D. 45, D. 46, D. 57, D. 61, D. 62.**

The third area of my studies focused on selected protected or endangered species of insects and arachnids and resulted in two chapters in the Polish Red Book of Animals, describing the species of beetles: *Caroathobyrrhulus tatricus* Mroczkowski and *Rhysodes sulcatus* (F.). Separate publications summarised and provided new information on the distribution and ecology of the following taxa: Coleoptera: *Velleius dilatatus* (F.), Araneae: *Atypus* spp., *Eresus kollari* Rossi.
Publications on the list: **A. 1, D. 20, D. 27, D. 63, D. 64.**
The fourth area of my research is related to practical issues, primarily a description of the monitoring methods of *Rhysodes sulcatus* as part of the National Monitoring of the Environment, the development of which was possible after a study on the distribution of this species in Poland. This monitoring, which resulted in creating the method, was commissioned by PAS Institute of Nature Conservation. The conservation practices were also subject of a paper on protected dendrophilous beetles of Western Poland, which discusses issues related to threats to species, their protection, monitoring and compensation of losses from economic activities.
Practical aspects also concern methods of inventories and, although this is a broader area, it is of particular importance to protected areas, directly linked to the study of biodiversity. I contributed to two publications on this topic, one on the use of soil traps in pine forests with a thick forest floor and the other on the possibility (or rather the impossibility) of making a full inventory and the role of models which help evaluate and compare the species richness. The paper highlighted aspects such as labour and

time consumption as well as the amount of the material collected. The latter factor, if inventory efforts were to be intensified, could prove destructive to local habitats. It is therefore important to optimise the amounts of sampling during inventories.
Publications on the list: **A. 10, D. 41, D. 52, D. 58.**

The fifth group of issues in my publication concerns forest ecosystems and the influence of humans on their components. In cooperation with the Department of Forest Entomology of Poznań University of Life Sciences I analysed the impact of anthropogenic and climatic factors on the diversity of the Carabidae of continental and sub-Atlantic fresh pine bores. Another, slightly separate issue, was an analysis of the impact of forest management on game animals as part of forest biodiversity.
Publications on the list: **D. 56, D. 59, D. 60.**

Ad. 2. Alien and invasive species – their distribution with elements of ecology.
Today, invasive animal and plant species are considered one of the major threats to biodiversity. During my research in Poland, I was the first to find an invasive species of harvestmen (Arachnida, Opiliones), namely *Odiellus Guiara* (Bosc), which, as shown by further studies, after invading other countries in western Europe expands its range to the east. Another studied invasive species of harvestman, which in recent years has been greatly expanding its range, was *Lacinius Dentiger* (C. L. Koch), whose new sites were found in great numbers. Both species turned out to expand their range not only through synanthropic habitats, they were also reported from natural habitats. Toruń-Eberswalde Ice-Marginal Valley turned out to be an important dispersion route through a network of thermophile habitats on its edges. Also latitudinal layout of railway can also favour their migration.
Another interesting aspect associated with the occurrence of alien species was genetic research conducted on Central European population of *Gryllus campestris* L.(Orthoptera, Gryllidae). During the study carried out by an interdisciplinary team we detected a DNA introgression of a related Mediterranean species, namely *G. bimaculatus* De Geer. In Europe the species is sometimes accidentally released from breeding places. Such hybrids were known from laboratory experiments; an adverse effect on native species (which is endangered e.g. in Germany) includes a behavioural change in mating period, which in turn weakens reproductive opportunities. This may result in a faster extinction of the native species, particularly when coupled with the main threat, i.e. agriculture (especially plant protection substances). Genetic introgressions between invertebrates is the threat rarely mentioned in the context of alien species.
Other issued discussed in my publications is the functioning of invasive invertebrates on newly invaded areas in the context of the "enemy release hypothesis" (ERH), according to which parasites less often attack alien species. Withi this in mind I conducted a study on a population of invasive ladybugs *Harmonia axyridis* (Pall.), caught in mid-field wind farm from communities preparing for winter. A visual inspection and a dissection of the beetles were made for the presence of gregarines, fungi, nematodes and phorethic mites. The observed low or zero infestation of the population by these groups of parasites confirmed this theory, although H. *axyridis* has been present in Polish fauna for more than 10 years.
Publications on the list: **A. 3, A. 4, D. 18, D. 24, D. 25.**

Ad. 3. Carabids in ecosystem trophic structure and other studies in Carabidae ecology
The carabids, a very important family because of their abundance, for years have constituted a model group in ecological research, aimed at understanding how an ecosystem works and how it reacts to anthropogenic and natural disturbances. Due to their role as predators and plant seed feeders, they are an important group of insects that support the control of pests and weeds. In order to understand the functioning of the Carabidae in the trophic network better and to contribute to the knowledge of the size

of their ecological niches, studies with stable nitrogen and carbon isotopes have been conducted. I was member of an interdisciplinary and international team chaired by Marcin Zalewski, D.Sc.. The results of our research helped to better understand the role and trophic position of Carabidae in ecosystems, show the complexity of those correlations within meta-populations, between populations, and between the characteristics such as sex and dispersal power, which in Carabidae is associated with the development of wings. Isotope-aided studies helped to make the following discoveries:
-the trophic structure of the carabids consists of three food guilds which partially overlap;
-guilds feed on different trophic floors using different sources of carbon;
-the beginning of the trophic chain is in dead matter in the saprophages guild, which had not been known before;
-the species mostly feed on 2-3 trophic levels, which results in the overlap of ecological niches (except the genus *Pterostichus*);
-the survey, which covered 18 islands on Mamry and Wigry lakes and two mainland areas, helped to compare many meta-populations and consequently to find significant diversity of trophic ecological niches within the meta-populations. This means performing various functions on a local scale and wide niches on a regional scale;
-when examining Polish and Russian populations of the same Carabidae species in terms of differences in the feeding niches between sexes the differences (albeit subtle) were actually found; in this respect females also displayed differences before and after laying eggs (in the spring-laying species);
-winged specimens were characterized by a wider ecological niche from the wingless ones.
The results also show that the hypothesis of the trophic theory of island biogeography (Holt 2010, Gravel and others 2011) does not fully explain the results obtained in extensive research and should be reconsidered. Research on the intricate Carabidae trophic systems coupled with research of other trophic levels (plants and arachnids) helped to verify the hypothesis of trophic island biogeographical theory to a wider extent. Combining distribution aspects of communities with their position in ecosystem trophic structure enabled to corroborate the model according to which the rotation of species in space (β-diversity) decreases ad trophic levels increase.
In the study of the trophic dependencies of Carabidae, thanks to the collaboration with Prof. Bernard Staniec of UMCS, I also had the opportunity to compare the occurrence of the beetles of the genus *Dyschirius* (Carabidae) with trophically associated (source of food) beetles of the genus *Bledius* (Staphylinidae). Apart from the new sites of many species, 9 species of the genus *Dyschirius* were found to be associated with 18 species of their potential victims in the region. For the species *Dyschirius globosus* (Herbst) it was first information about the occurrence of the genus *Bledius* in colonies. For several other species their co-existing species were found. In cooperation with IUNG in Puławy, I also gathered material consisting of various Carabidae species common in fields to investigate their diets with DNA, however, the samples are still being processed.
Other issues combining ecology and farming in river valleys included research of Carabidae communities of periodically flooded meadows farmed to a various extent, also the impact of flooding on those communities. There I proved a significant impact of floods on community qualitative and quantitative aspects, as their lack negatively affects the communities by changing their species composition. It leads to disappearance of stenotopic species and homogenization of the habitat.
Research with my participation, which concerned the importance of Carabidae dispersal power in the colonisation of islands on Mamry and Wigry lakes, led to a discovery that wingless, dimorphic and winged species differ in their capacity to colonise islands, i.e. create permanent populations. Due to this relations between species and habitat depend on their dispersal power. The results contribute to the knowledge of carabid colonisation of islands.
Publications on the list: **A.2, A.5, A.7, A.8, A.9, A.11, a.12, D.44, D.47.**

Ad. 4. Preserving biodiversity in agricultural landscape.
The functioning of Carabidae and other invertebrates in the agricultural landscape are closely related to the achievements I attributed to my other areas of interest. In this part I included my work closely related to pro-environmental (so-called ecological) approach to agriculture, which fosters higher biodiversity; I also described its benefits, i.e. ecosystem services. I have been more involved in this area for the last few years. The topics I deal with in the papers written with other scientific centres is the application of floral belts as a refuge and a source of beneficial species supporting agricultural production. Further papers on this subject, the results of a research project commissioned by the Ministry of Agriculture and Rural Development (project no 6 on the list) are being prepared. Other papers concern best practices in farming which favour biodiversity by using farming know-how and leaving of refuge habitat. Thus the knowledge about biodiversity can be used in agricultural landscape.
Moreover, I was appointed contractor (through a tender) in three projects commissioned by the Ministry of Agriculture and Rural Development on the use of basic substances and micro-organisms in organic potato and tomato cultivation; namely I assessed the effects of these treatments on epigeic Carabidae as useful fauna components. The results have so far been presented only at conferences and publications are under preparation.
Publications on the list: **D.3, D.15, D.50, D.50a, D.51, D.54, D.55.**

Ad. 5. Correlations of carabids (Carabidae) with gregarines (Gregarinasina).
Gregarines belong to widespread internal parasites, mainly attacking invertebrates. They usually do not pose a fatal threat to their hosts, but may weaken their vital functions and, by damaging epithelium in their gastrointestinal tract, create an opportunity of infections by other, more virulent microorganisms. Exception are schizogregarines, are usually lethal to their hosts. Concerning a possible effect of gregarines on carabid communities, I started cooperating with Prof. Jerzy J. Lipa from IOR-PIB. Following a scientific internship, where I studied research techniques and recognizing gregarines, I became manager of the grant awarded in the contest of Scientific Research Committee, titled "Dynamics and intensity of carabid (Coleoptera, Carabidae) infestation by gregarines (Sporozoa, Gregarinomorpha) in forests and agrocenoses (GRANT no 0787/P01/2006/30) ". It also resulted in several scientific papers. The studies covered the carabids of forests, meadows, and farmland with various moisture. It was proven that habitat type was more important for gregarines than its moisture level. Also a much higher prevalence in forest communities was found, while the fewest were found in crops. These findings may be important, because gregarine pattern of occurrence might be similar to other ecological insect groups, including pests. Therefore, the role of gregarines in controlling farmland pests can be questioned. The studies also proved gregarine dependence on their hosts' general nutritional preferences. The infestation usually affected most strongly and most frequently large zoophages, while few gregarines occurred in small zoophages, and the fewest were found in hemizoophages. Thus the feeding pattern affects the occurrence of gregarines in their host.
During the studies I found gregarines in two carabid species considered to be crop pests. The species of parasites are also new to Polish fauna. A pest of cereal crops, i.e. *Zabrus tenebrioides* (Goeze), was found to hots *Gregarina vizri* Lipa. In comparison with the data from Russia, the studied Polish population of *Z. tenebrioides* yielded a significantly higher level of *G. Vizri* infestation (12% and 42%). This means that this parasite can significantly affect the occurrence of its host, which is the most serious Carabidae pest in Poland. The other Carabidae species is common in *Harpalus rufipes* (deg.) and can cause economic losses especially in strawberry fields (it is more often treated as pest in the east of Europe). It was also found to be host for the gregarine *Clitellocephalus ophoni* (Tuz. et. Orm.) in Poland. However, it was only detected in 1% of the population, while in total only 8% individuals were found to be attacked by gregarines. Therefore, in this case the role of gregarins in the pest control is doubtful.

For the most common gregarines of the genus *Actinocephalus* and *Ancyrophora,* I conducted a preference analysis concerning host and seasonal dynamics analysis. It was interesting due to the fact that the gregarines of these types do not coexist in one individual and differ in body size. The results helped to reveal such preferences: *Actinocephalus* preferred large hosts, and *Ancyrophora* rather medium ones. The intensity of prevalence was also seasonal, and at the same time the gregarines differed in their pattern of occurrence: *Actinocephalus* occurred most numerously in spring and summer, and *Ancyrophora* in summer and autumn.

The research of gregarines of Poland's carabids was also presented in a faunistic aspect, by comparing own and resources data with a list of studied Carabiedae and their pests.

Research of gregarines and Carabidae correlations and other groups of invertebrates will continue in experiments planned for the future.

Publications on the list: **D.14, D.30, D.32, D.33, D.37**.

Other publications

My papers published in peer-reviewed journals include a wide-ranging historical study of the Polish Entomological Society (**D.34**), review of a monograph relevant to research on Carabidae and providing valuable information on the ecology of species and their distribution in Switzerland (**D.29**) and a number of non-listed publications, namely reports from the meetings PTEnt. board as well as conferences organized by the Society. I also co-authored a monograph chapter on hortitherapy, focusing on fauna (**D.53**).

Summary and information on other achievements

My research in the main topics and other, less extensive studies helped me to write 140 papers, including: 13 in JCR journals, 49 in journals from "B" list of MNiSW, 3 monographs (including scientific achievement; one monograph was also translated into English), 11 chapters in monographs (two in English, one translated into English) and 64 other publications (scientific news, reports, popular articles), many of which I am the first and leading author. The number of points of MNiSW according to the list of scientific journals from the year of issue is **743.5** (including 80 as a scientific achievement) and an IF summary is **16.38**. The number of publication quotes by the Web of Science is **45**; by Scopus – **69**. At the Web of Science, the value of Hirsch index is 4, at Scopus it is 5.

My achievements also include reports and communications presented at national and foreign conferences. I took an active part in 21 national and 8 international conferences, where I delivered 8 papers in English and 12 in Polish, and I presented the results of the survey in the form of posters.

I was the organizer or co-organizer of 2 international conferences and 14 national ones. I have reviewed 25 scientific publications (11 for international journals and 14 for national ones). Within acquiring research funds, I was managed a grant was awarded in a KBN competition on the dynamics and intensity of carabid (Coleoptera, Carabidae) infestation by gregarines (Sporozoa, Gregarinomorpha) in various habitat types and I took part in 4 other projects awarded under the MRiRW competitions.

I have done numerous studies, most of which were scientific in nature and led to creating documentation for various conservation purposes. As a result, I was also an expert in monitoring NATURA 2000 species.

As part of scientific activities, I have been deeply engaged in the activities of the Polish Entomological Society, where I am now Secretary General in the Board and member of the editorial team of peer-reviewed "Entomological News" magazine, published by the society. I am also a member of the European Dry Grassland Group and Klub Przyrodników.

For my scientific activity, I obtained four rewards from the vice-Chancellor of the University of life Sciences in Poznań, two for organizational activities. I was awarded the "Bronze Cross of Merit of Poland" and the "Golden Badge of Polish Entomological Society".

In addition to conducting classes in numerous subjects, I prepared the curriculum and managed some subjects for students of levels 1 and 2. I have used my academic achievements in teaching students. I was also the supervisor of 4 master thesis and 11 engineer papers, as well as an supplementary supervisor of a doctoral thesis. I have popularised science by writing popular articles, giving presentations, and conducting workshops for students of different levels, I have given radio and television interviews and I have co-created events university. I have also been active in my faculty's activities by participating in various organisational bodies, and above all in the Council of the Faculty and the Education Quality Team at the Faculty of Landscape Architecture.

References

ANDERSEN J. 2000. What is the origin of the carabid beetle fauna of dry, anthropogenic habitats in western Europe? Journal of Biogeography, 27: 795–806.

ANDERSEN, J. 1968. The effect of inundation and choice of hibernation sites of Coleoptera living on river banks. Norsk Entomologisk Tidsskrift, 15: 115-133.

ANDERSEN, J. 2011. Hibernation sites of riparian ground beetles (Coleoptera, Carabidae) in Central and Northern Norway. Norwegian Journal of Entomology, 58, 111–121.

AUKEMA B. 1995. The evolutionary significance of wing dimorphism in carabid beetles (Coleoptera, Carabidae). Research in Population Ecology, 37(1): 105-110.

AVGIN S. S., LUFF M. L. 2010. Ground beetles (Coleoptera: Carabidae) as bioindicators of human impact. Munis Entomology & Zoology, 5(1): 209-215.

BARAŃSKA K. 2014. Podręcznik najlepszych praktyk ochrony kseroterm. CKPŚ, Warszawa.

BĄBA W. 2004. The species composition and dynamics in well-preserved and restored calcareous xerothermic grasslands (South Poland). Biologia (Bratislava), 59(4): 447-456.

BESPALOV A. N., DUDKO R. Y., LYUBECHANSKII J. J. 2017. Population of carabid beetles (Coleoptera, Carabidae) in the central part of the Baraba forest steppe (South-West Siberia). Eurasian Entomological Journal, 16(3): 283-293.

BfN/BMUB 2013: Nationaler Bericht Deutschlands nach Art. 17 FFH-Richtlinie, 2013; basierend auf Daten der Länder und des Bundes. Datengrundlage: Verbreitungsdaten der Bundesländer und des BfN. Access: 03-01-2019, URL: www.bfn.de.

BRANDMAYR T. Z. 1990. Spermofagous (Seed-eating) Ground beetles: First Comparision of the Diet and Ecology of the Harpaline Genera Harpalus and Ophonus (Col., Carabidae). (pp. 307-315) [in:] STORK N. E. (ed.): The Role of Ground Beetles in Ecological and Enviromental Studies. Intercept Ltd., Andover, Hampshire, UK.

BREYMAYER 1991. 3.9. Ekosystemy. (pp. 159-176) [in:] STARKEL L. (ed.): Geografia Polski – środowisko przyrodnicze. PWN Warszawa.

BURAKOWSKI B., MROCZKOWSKI M., STEFAŃSKA J. 1973. Chrząszcze – Coleoptera. Biegaczowate – Carabidae, część 1. Katalog Fauny Polski, XXIII, 2, Warszawa.

BUTAYE J. ADRIAENS D., HONNAY O. 2005. Conservation and restoration of calcareous grasslands: a concise review of the effects of fragmentation and management on plant species. Biotechnology, Agronomy, Society and Environment, 9(2): 111–118.

CAMERON K. H., LEATHER S. R. 2012. How good are carabid beetles (Coleoptera, Carabidae) as indicators of invertebrate and order richness? Biodiversity & Conservation, 21: 763-779.

CLAßE A., KAPFER A., LUICK R. 1993. Einfluß der Mahd mit Kreisel- und Balkenmäher auf die Fauna von Feuchtgrünlanden. Untersucht am Beispiel von Laufkäfern, Heuschrecken und Amphibien. Naturschutz und Landschaftsplanung, 25(6): 217-220.

CZECHOWSKI W. 1989. Carabid beetles (Coleoptera, Carabidae) of moist meadows on the Mazovian Lowland. Memorabilia Zoologica, 43: 141-167.

EUROPEAN COMMISSION 2013. Interpretation Manual of European Union Habitats, version EUR 28. URL: http://ec.europa.eu/environment/nature/legislation/habitatsdirective/docs/.

FAHRIG L., BAUDRY J., BROTONS L., BUREL F. G., CRIST T. O., FULLER R. J., SIRAMI C., SIRIWARDENA G. M., MRTIN J.-L. 2011. Functional landscape heterogeneity and animal biodiversity in agricultural landscapes. Ecology Letters, 14: 1010-112.

GOBBI M., FONTANETO D. 2008. Biodiversity of ground beetles (Coleoptera: Carabidae) in different habitats of the Italian Po lowland. Agriculture, Ecosystems and Environment, 127: 273–276.
GRAVEL D., MASSOL F., CANARD E., MOUILLOT D., MOUQUET N. 2011. Trophic theory of island biogeography. Ecology Letters,14: 1010–1016.
GRUTTKE H. 1994. Investigation on the ecology of Laemostenus terricola (Coleoptera, Carabidae) in an agricultural landscape. (pp. 145-151) [in:] K. DESENDER, M. DUFRENE, M. LOREAU, M. L. LUFF & J.-P. MEALFAIT (eds): Carabid Beetles: Ecology and Evolution. Kluwer Academic Press, Dordrecht.
HABEL J. C., SEGERER A., ULRICH W., TORCHYK O., WEISSER W. W., SCHMITT T. 2019. Butterfly community shifts over two centuries. Conservation Biology, 30(4):754-762.
HANSKI I. & Gilpin M. 1991. Metapopulation dynamics: brief history and conceptual domain. Biological Journal of the Linnean Society, 42: 3–16.
HILL B. T., BEINLICH B., BECK L. 2004. Reaktionen der Laufkäferzönose eines brachgefallenen Kalk-Ackers auf extensive Schweinebeweidung. Angewandte Carabidologie, Supp. III: 3 - 15.
HOLLAND J. M., LUFF M. 2000. The effects of agricultural practices on Carabidae in temperate agroecosystems. Integrated Pest Meneagment Revievs, 5: 109-129.
HOLLAND J. M. 2002. Carabid beetles: their ecology, Survival and use in agroecosystems. (pp. 1-40) [in:] J. M. HOLLAND (ed.): The Agroecology of carabid beetles. Intercept, Andover, UK.
HOLT R.D. 2010. Towards a trophic island biogeography: reflections on the interface of island biogeography and food web ecology. (pp. 143–185) [in:] LOSOS J.B., RICKLEFTS R.E (eds): The Theory of Island Biogeography Revisited. Princeton University Press.] Princeton.
HONEK A., MARTINKOVA Z., JAROSIK V. 2003. Ground beetles (Carabidae) as seed predators. European Journal of Entomology, 100: 531-544.
HURUK S. 2007: Analiza struktur i aktywności polnych zgrupowań biegaczowatych (Carabidae, Coleoptera) na wybranych typach gleb. Wyd. Akademii Świętokrzyskiej, Kielce.
JANSSEN J.A.M., RODWELL J.S., GARCÍA CRIADO M., GUBBAY S., HAYNES T., NIETO A., SANDERS N., LANDUCCI F., LOIDI J., SSYMANK A., TAHVANAINEN T., VALDERRABANO M., ACOSTA A., ARONSSON M., ARTS G., ATTORRE F., BERGMEIER E., BIJLSMA R.-J., BIORET F., BIŢĂ-NICOLAE C., BIURRUN I., CALIX M., CAPELO J., ČARNI A., CHYTRÝ M., DENGLER J., DIMOPOULOS P., ESSL F., GARDFJELL H., GIGANTE D., GIUSSO DEL GALDO G., HÁJEK M., JANSEN F., JANSEN J., KAPFER J., MICKOLAJCZAK A., MOLINA J.A., MOLNÁR Z., PATERNOSTER D., PIERNIK A., POULIN B., RENAUX B., SCHAMINÉE J.H.J., ŠUMBEROVÁ K., TOIVONEN H., TONTERI T., TSIRIPIDIS I., TZONEV R. and VALACHOVIČ M. 2016. European Red List of Habitats Part 2. Terrestrial and freshwater habitats. Publications Office of the European Union.
KINNUNEN H., TIAINEN J. 1999. Carabid distribution in a farmland mosaic: The effect of path type and location. Annales Zoologici Fennici, 36(3): 149-158.
KOCH K. 1989: Die Käfer Mitteleuropas. Ökologie. 2: 1-440.
KOIVULA M. 2001. Carabid beetles (Coleoptera, Carabidae) in boreal managed forests - meso-scale ecological patterns in relation to modern forestry. Academic dissertation, March 2001. University of Helsinki, Faculty of Science, Department of Ecology and Systematics, Division of Population Biology.
KOSEWSKA A., SKALSKI T., NIETUPSKI M. 2014. Effect of conventional and non-inversion tillage systems on the abundance and some life history traits of carabid beetles (Coleoptera: Carabidae) in winter triticale fields. European Journal of Entomology, 111 (5): 669–676.
KRYZHANOVSKIJ O. L. 1983: Žestkokrylye (Rhysodidae, Trachypachidae, Carabidae) T. I, v. 2, Fauna SSSR 128. Nauka Leningrad.
KUŚKA A. 1981. Uwagi o ochronie rezerwatów stepowych na Śląsku. Chrońmy Przyrodę Ojczystą , 37(3): 62-64.
KUŚKA A. 2006. Ochrona prawna wybranych stanowisk kserotermicznych na Górnym Śląsku i Jurze Krakowsko-Częstochowskiej i jej wpływ na zmiany w koleopterofaunie. Wiadomości Entomologiczne, 25 (Supl.) 2: 121–130.
LAROCHELLE A., LARIVIÈRE M.-C. 2003. A Natural History of the Ground-Beetles (Coleoptera: Carabidae) of America north of Mexico. Pensoft, Sofia-Moscow.
LEE J.C., LANDIS D. A. 2002. Non-Crop Habitat Management for Carabid Beetles (pp. 279-303) [in:] J. M. HOLLAND (ed.): The Agroecology of carabid beetles. Intercept, Andover, UK.
LINDROTH C.H. 1949. Die fennoskandichen Carabidae. Eine tiergeographisce Studie. 3. Allgemeiner Teil. – Göteborgs Kungl.: Vetenskaps-och Vitterhets-Samhalles, 4: 1–911.

LUFF M. L. 2002. Carabid assemblage organization and species composition. (pp. 41-80) [in:] J. M. HOLLAND (ed.): The Agroecology of carabid beetles. Intercept, Andover, UK.

LUKA H., WALTHER B., DURRER H. 1998. Die Laufkäferfauna (Coleoptera, Carabidae) des Naturschutzgebietes "Petite Camargue Alsacienne" (Elsass, F). Mitteilungen Entomologischen Gesellschaft Basel, 48(3): 99-140.

MACARTHUR R. H., WILSON E. O. 2001. The theory of island biogeography. Princeton, N.J, Princeton University Press.

MARUSZCZAK H. 1991. Wpływ rolniczego użytkowania ziemi na środowisko przyrodnicze w czasach historycznych. (pp. 190-205) [in:] L. STARKEL (ed.): Geografia Polski – środowisko przyrodnicze. PWN Warszawa.

MATUSZKIEWICZ W. 2012. Przewodnik do oznaczania zbiorowisk roślinnych Polski. PWN, Warszawa.

MAZUR M., KUBISZ D. 2013. Distribution and migration of xerothermic beetles (Coleoptera) in the Vistula River valley. Monografie Fauny Polski, Vol. 26 [in polish].

MRÓZ W., BĄBA W. 2010. Murawy kserotermiczne. (pp. 119-129) [in:] W. MRÓZ (ed.): Monitoring siedlisk przyrodniczych. Przewodnik metodyczny. Część I.

MÜLLER-MOTZFELD G. 2004. Xerotherme Laufkäfer in Deutschland – Verbreitung und Gefärdung. Zeitschrift für Angewandte Carabidologie, Suplement III: 27-44.

NIEMELÄ J. 2001. Carabid beetles (Coleoptera: Carabidae) and habitat fragmentation: a reviev. European Journal of Entomology, 98: 127-132.

NIJSSEN M., ALDERS K., VAN DER SMISSEN N. ESSELINK H. 2001. Effects of grass-encroachment and grazing management on carabid assemblages of dry dune grasslands. Proceedings of the Section Experimental and Applied Entomology of the Netherlands Entomological Society, 12: 113-120.

PATTERSON B. D., ATMAR W. 2000. Analyzing species composition in fragments. Bonner Zoologische Monographien, 46: 9-24.

PAUL W. 2010. Szlaki holoceńskich migracji roślin kserotermicznych na ziemie Polski – przegląd ustaleń i hipotez oraz perspektywy badań. (pp. 55 – 65) [in]: H. RATYŃSKA, B. WALDON (eds.), Ciepłolubne murawy w Polsce – stan zachowania perspektywy ochrony. Wydawnictwo Uniwersytetu Kazimierza Wielkiego. Bydgoszcz.

PAWŁOWSKI J. 1991. Przemiany fauny od pleniglacjału do czasów współczesnych. (pp. 159-176) [in:] L. STARKEL (ed.): Geografia Polski – środowisko przyrodnicze. PWN Warszawa.

PAWŁOWSKI J. 2004. CR *Aechmites terricola* (HERBST, 1784), Ordo: Coleoptera/Chrząszcze, Familia: Carabidae/Biegaczowate. (pp. 97-98) [in:] Z. GŁOWACIŃSKI, J. NOWACKI (eds.): Polska czerwona księga zwierząt. Bezkręgowce. Instytut Ochrony Przyrody PAN, Kraków Akademia Rolnicza, Poznań.

PAWŁOWSKI J., KUBISZ D., MAZUR M. 2002. Coleoptera – Chrząszcze. (pp. 88-110) [in:]: Z. (ED.): Czerwona Lista Zwierząt Ginących i Zagrożonych w Polsce. Instytut Ochrony Przyrody PAN, Kraków.

PULLIN A. S. 2004. Biologiczne podstawy ochrony przyrody. Wydawnictwo Naukowe PWN.

RAINIO J., NIEMELÄ J. 2003. Ground beetles (Coleoptera: Carabidae) as bioindicators. Biodiversity & Conservation, 12: 487-506.

ROSIN Z. M., MYCZKO Ł., SKÓRKA P., LENDA M., MOROŃ D., SPARKS T. H., TRYJANOWSKI P. 2012. Butterfly response toenvironmental factors in fragmented calcereous grasslands. Journal of Insects Conservation, 16: 321-329.

RUTA R. 2007. Chrząszcze (Insecta: Coleoptera) kserotermicznych Wzgórz Byszewickich w Dolinie Noteci. Nowy Pamiętnik Fizjograficzny, 5(1-2): 49-106.

SCHMIDT J., TRAUTNER J., MÜLLER-MOTZFELD G. 2016. Rote Liste und Gesamtartenliste der Laufkäfer (Coleoptera: Carabidae) Deutschlands. 3. Fassung, Stand April 2015. Naturschutz und Biologische Vielfalt, 70(4): 139-204.

SIENKIEWICZ P., ŻMIHORSKI M. 2012. The effect of disturbance by river flooding on the ground beetles (Coleoptera, Carabidae). European Journal of Entomology, 109(4): 535-541.

SIEPE A. 1994: The „Flooding Behaviour" of Carabid Beetles (Coleoptera: Carabidae) in River Floodplains: Ecological and Ethological Adaptations to Periodic Inundations – I: Swimming. Zoologische Jahrbücher. Abteilung für Systematik, Geographie und Biologie der Tiere, 12: 515 – 566.

SIGMUND E., WALTZBAUER W. 2007. Diversität epigäischer Laufkäfergemeinschaften (Carabidae, Coleoptera) in einem Steinbruch unter Berücksichtigung von Sukzessionaspekten (Bad Deutsch – Altenberg, WÖ). Verhandlungen der Zoologisch-Botanischen Gesellschaft in Österreich, 144: 1-20.

SZYSZKO J. 1983. State of Carabidae (Coleoptera) fauna in fresh pine forest and tentative valorisation of this environment. Warszaw Agricultutal University Press, Warszawa.

THIELE H.U. 1977. Carabid beetles in their environments. a study on habitat selection by adaptations in physiology and behaviour. Berlin–Heidelberg–New York.

TROST V. 2004. Differenzierung der Carabidenfauna von mitteldeutschen Xerothermhabitaten mit besonderer Berücksichtigung Sachsen-Anthals. Angewandte Carabidologie, Supp. III: 95-114.

TURIN H. 2000. De Nederlandse loopkevers. Verspreiding en Oecologie. (Coleoptera: Carabidae). Nederlandse Fauna 3. Nationaal Natuurhistorisch Museum Naturalis, KNNV Uitgeverij, Utrecht.

TURIN, H., PENEV, L. & CASALE, A. 2003. The genus Carabus in Europe. A synthesis. Pensoft, Sofia and European Invertebrate Survey, Leiden.

VALKÓ O., ZMIHORSKI M., BIURRUN I., LOSS J., LABADESSA R., VENN S. 2016. Ecology and conservation of Steppes and Semi – Natural Grasslands. Hacquetia, 15(2): 5-14.

VENN S, MATALIN A. 2014. Carabid beetles of the Russian Steppe. Bulletin of the European Dry Grassland Group, 23: 21-23.

VENN S. 2016. To fly or not to fly: Factors influencing the flight capacity of carabid beetles (Coleoptera: Carabidae). European Journal of Entomology, 113: 587-600.

VENN S. J., KOTZE D. J., LASSILA T., NIEMELÄ J. K. 2013. Urban dry meadows provide valuable habitat for granivorous and xerophylic carabid beetles. Journal of Insect Conservation, 17:747–764.

VRIES DE H. H. 1994. Size of habitat and presence of ground beetle species. (pp. 253-259) [in:] K. DESENDER, M. DUFRENE, M. LOREAU, M. L. LUFF, J.-P. MEALFAIT (eds): Carabida Beetles: Ecology and Evolution. Kluwer Academic Press, Dordrecht.

WILLEMS J. H. 1990. Calcareous grasslands in Continental Europe. (pp. 3–10) [in:] S.W. HILLIER, D.H.W. WALTON, D.A. WELLS (eds.): Calcareous Grasslands Ecology and Management. Bluntisham Books, Bluntisham, UK.

WURTH C. 2004. Auswirkung einer 13järigen extensiven Beweidung auf die Laufkäferfauna von pannonischen Trockenrasen im Naturschutzgebiet "Hundsheimer Berge" (Niederösterreich). Angewandte Carabidologie, Supp. III: 59-66.