KSÜ Tarım ve Doğa Derg 26 (6), 1421-1430, 2023
KSU J. Agric Nat 26 (6), 1421-1430, 2023
https://doi.org/10.18016/ksutarimdoga.vi.1216981

Impact of Different Methods of Wheat Cultivation on the Occurrence of Carabidae Family Representatives (*Carabidae, Coleoptera*)

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ABSTRACT

The aim of this study was to evaluate the impact of different methods of wheat cultivation on the occurrence of Carabidae (Coleoptera, Carabidae). The collection was carried out during a three-year period from 2016 to 2018, on research areas in Borovce, which belong to the Research Institute of Plant Production (VÚRV) in Piešťany. The collection of epigeic material was done in five variants: V1: mulching technique; V2: conventional technique; V3: minimization technique; V4: no-till technique; and ECO: ecological technique. During the three-year period, we obtained 11,362 specimens from eight epigeic groups. Out of all the epigeic groups, the dominant order was Coleoptera with the number of individuals 7593. We addressed the Coleoptera order in more detail. It was represented by six families, of which the *Carabidae* family was dominant. We recorded 6656 specimens from the mentioned family, of which we determined 20 species. The eudominant species were *Pterostichus melanarius* (Illiger, 1798) and *Pseudoophonus rufipes* (DeGeer, 1774) throughout the whole period on all types of variants. Based on the specimens obtained, we calculated the values of dominance, frequency, species similarity of communities, diversity of communities and statistically evaluated the correlation of the impact of meteorological factors and the occurrence of Carabidae.

Zoology

Research Article

Article History
Received : 09.12.2022
Accepted : 08.05.2023

Keywords
Carabidae,
Ecological agriculture,
Pitfall trap,
Pesticides,
Biodiversity

To Cite : Ilko, I., & Peterkova, V (2023). Impact of Different Methods of Wheat Cultivation on the Occurrence of Carabidae Family Representatives (*Carabidae*, *Coleoptera*). *KSU J. Agric Nat 26*(6), 1421-1430. https://doi.org/10.18016/ksutarimdoga. 1216981

INTRODUCTION

The ecology and taxonomy of beetle species is well known. These invertebrates have high demands on the habitat, which they live in, and they are very sensitive to the changes that take place in it. This is also the reason, why they are used as bioindicators of the environment (Rainio and Niemelä, 2003). The diversity and abundance of insect predators in agricultural areas is influenced by the type of agriculture and the presence of natural habitats (Pfiffner and Luka, 2000). Ground beetles such as the Carabidae family feed in agricultural ecosystems on predators, such as ants, aphids, caterpillars or insect eggs (Ekschmitt et al., 1997). The occurrence of this family may reduce some populations of prey in agroecosystems (Edwards et al., 1979; Lang et al., 1999). Due to their sensitive response to pesticides, herbicides, toxic substances and fertilizers, they are used as a model group in ecological studies. Through this group, we monitor changes in the environment, as well as the human environment (Hůrka, 1996). One of the examples of changes in the environment is indicated by the species *Pseudoophonus rufipes* (DeGeer, 1774), which may indicate degrading effects of human activity (Peterkova, 2014). Vician et al. (2018) examined the Carabidae family in the areas with different soil management, and found that the ecological conditions were the most satisfactory. Soil with agri-environmental maintenance contained more macro and microelements, more humus and had a more neutral pH than the conventionally cultivated soil. The occurrence of Carabidae is also affected by the use of agricultural sprays and fertilizers. Multiple studies have shown that the Carabidae family is negatively affected by heavy metals, such as zinc or cadmium, which in *Poecilus cupreus* (Linnaeus, 1758) have affected individuals' size and growth (Ermakov, 2004). The high number of species of Carabidae family may not necessarily indicate the preservation of the ecosystem. In agricultural areas, the number of Carabidae species is usually higher than in undisturbed forest habitats. Therefore, we do not consider the number of species to be decisive, but rather their ecological demands. Preserved ecosystems are dominated by species with higher ecological demands (Bohac, 2007). The Carabidae family belongs to polyphagous species. Due to the predation of invertebrates at different development stages, they play an important role in the formation of organic matter and the circulation of substances in the ecosystem (Vavara, 2010). Deep plowing is one of the agrotechnical techniques that reduce the diversity of Carabidae on arable land (Swaminathan, 2014). The aim of this study was to evaluate the occurrence of Carabidae (Coleoptera, Carabidae) in various methods of wheat cultivation.

MATERIAL and METODS

Epigeic material collection was carried out in the form of pitfall traps, which consisted of 700 ml glass container with a bait (soft cheese) in 2016 to 2018 during the given period (March to October) in the crops of a hybrid of *Triticum aestivum x Triticum spelta*. Pitfall traps were placed annually into the winter wheat, whose placing was changed every year as shown on the Figure 1. Pitfall traps placement for the ECO area was not changed in the course of 2016 to 2018. Every research area was marked for the respective option as V1, V2, V3, V4 and ECO. Every trap was marked with a number - for V1 (1-6), V2 (7-12), V3 (13-18), V4 (19-24) and for EKO (1-6). On every research field, six traps were placed - four traps at the ends and two in the middle of the research area. Consequently, the traps were emptied every 24 hours with an instant classification of the material according to a key (Hůrka, 1996; Pokorný, 2002). Same procedure was maintained during the whole research period. We managed to determine the abundance, dominance, species similarity, diversity index and frequency of Carabidae family. Furthermore, we managed to statistically determine the impact of meteorological factors on Carabidae communities. The data collected were recorded every month into a table (Microsoft Excel), which serves as a basis for this work. The statistically processed data were subjected to an analysis in the Statistica Programme, version 12.

Study area

The monitored area is located in the municipality of Borovce, district of Piešťany, falling under the Trnava self-governing region. In terms of landscape structure, Borovce is divided into the agriculture area, forest area and urbanised area. The research areas are located in the mild temperature climate, in the altitude of 167 m above sea level, with an average temperature of 9,2 °C and average annual rainfall of 593 mm (Remenar, 2017). Average wind speed on the monitored area is approximately 4,2 m/s, with the northwest and north flows direction (Mazur and Luknis, 1980).

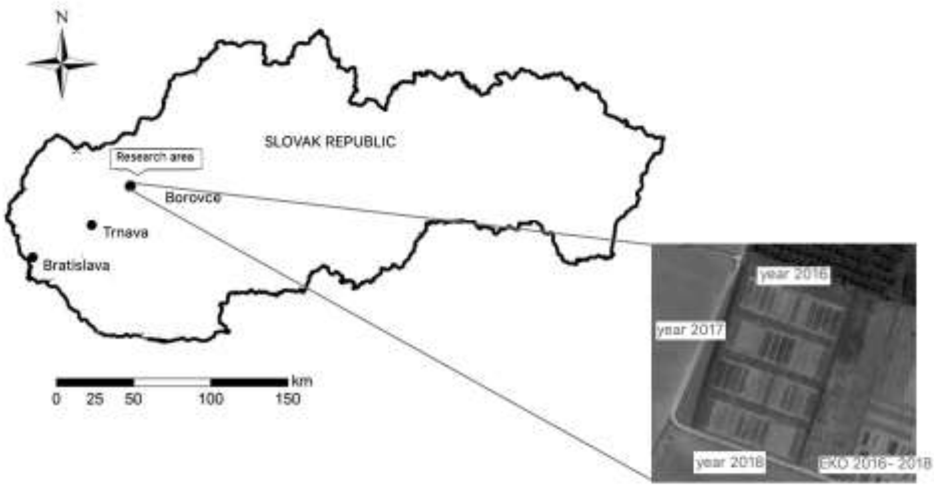

Figure 1 Map of study area – Borovce

RESULTS

Species composition and dominance

During the three-year monitored period, we managed to collect 11 365 specimens from eight epigeic groups and six families. On every monitored area, groups of Coleoptera were present at the eudominant level with the average of 67,26 %, Arachnidae group with the average of 10,66 % and Hymenoptera with the average of 13,29 %. Other epigeic groups were present at a lower level. No epigeic group was present at the dominant level. Group of Larvae was present at the subdominant level with the average of 4,58 %. Groups of Acarina with the average of 1,81 % and Dermaptera with 1,73 % were present at the recedent level. The group of Amphipoda with the average of 0,29 % and Chilopoda 0,44 % were present at the subdominant level. We recorded six families from the beetles collected. On average, families of Carabidae (88,15 %) and Staphylinidae (11,43 %) were present at the eudominant level on all three monitored periods. Other families were present at the subrecedent level - Cerambicidae (0,73 %), Chrysomelidae (0,86 %), Scarabaeidae (0,14 %) and Cicindelidae (0,11 %). In the years 2016-2018, a total of 6656 individuals of the

Carabidae family was collected in the research areas. Individuals were classified into 20 species. During the research period, we collected 1622 individuals from 19 species on the V1 area. We collected 1432 individuals from 19 species on the V2 research area. We collected 1095 individuals from 14 species on the V3 research area. On the V4 research area, we collected 1576 individuals from 17 species and on the ECO area, we collected 931 individuals belonging to 14 species. During the years 2016 to 2018, the number of species in individual areas fluctuated. The largest number of species was in the variant V1 in all three evaluated years. Eudominant species in all monitored areas during the three-year period were *Pterostichus melanarius* (Illiger, 1798) and *Pseudoophonus rufipes* (DeGeer, 1774). In the research area V1, the species *P rufipes* was significantly eudominant during all three years. The dominance of this species ranged from 39 to 54 %. Another eudominant species on the V1 research area was *P. melanarius*. The dominance of this species during the three-year monitored period ranged from 24 to 36 %. In the research area V2, the species *P. rufipes* and *Pterostichus melanarius* were significantly eudominant in all three monitored years. Their values ranged from 32 to 46 % for *P. rufipes* and 33 to 43 % for *Pterostichus melanarius*. Eudominant species in the V3 research area in the three-year monitored period were *P. rufipes* with the representation from 36 to 43 % and *Pterostichus melanarius* with the representation from 35 to 40 %. The V4 research area was represented by two eudominant species *P. rufipes* and *P. melanarius*. Their values in the three-year period ranged from 33 to 40 % for the *P. rufipes* species and 31 to 38 % for the *P. melanarius* species. In the ECO research area, *P. rufipes* was in the range of 33 to 44 % and *P. melanarius* in the range of 35 to 43 %. Both species occurred as eudominant. Other species were at a lower level on all research areas during the whole monitored period. In Table 1, we evaluate the comparison of the species dominance in the years 2016-2018 in all monitored areas. The table shows that *P. melanarius* and *P. rufipes* were characteristic species during the monitored period for each area in all three years.

Frequency

The highest frequency or recurrence of species of the Carabidae family in the V1 research area was achieved by the *Pterostichus melanarius* (Illiger, 1798) and *Pseudoophonus rufipes* (DeGeer, 1774) species. Based on the frequency, we can consider the *P. rufipes* to be constant, in 2018 on the V1 monitored area even euconstant. The *P. melanarius* species can be considered constant, in 2017 it occurred at the accessory level in the V1 monitored area. The highest frequency in the V2 research area was achieved by the *P. melanarius* and *P. rufipes* species. The data obtained show that the frequency of *P. rufipes* was at a euconstant level in 2018, and in 2016 and 2017 it was at a constant level. In the area V3, the frequency of occurrence of *P. melanarius* and *P. rufipes* was at a constant level during all three monitored years. In the V4 research area, *P. melanarius* and *P. rufipes* occurred at a constant level in the three-year monitored period. In the ECO research area, *P. melanarius* and *P. rufipes* were at a constant level in all three monitored years. The data show that the *P. melanarius* and *P. rufipes* species were constant to euconstant in all monitored areas throughout the observed period. To assess the differences between the individual research areas, we calculated the Sőrensen similarity index of species. The similarity of research areas in 2016 ranged from 86 to 100 %. The ECO research area had the highest similarity in the given year together with the V3 research area - the species similarity reached the value of 100 %. In 2017, the similarity of communities in the research areas was lower than in the previous year, it ranged from 70 to 96 %. In the given year, the ECO research area had the highest species similarity together with the V3 area, reaching the value of 96 %. In the last monitored year, the values of species similarity ranged from 80 to 100 %, similarly to 2016. Also in 2018, the ECO research area achieved the highest species similarity together with the V3 research area. The similarity value between the ECO and V3 area was 100 %. Table 2 shows the results of the Sőrensen similarity index on V1-ECO areas in the three-year monitored period.

Species similarity

The Carabidae community in the research area V1 reached a similarity of 77 to 86 %, in all monitored periods. Year-on-year similarity indices were higher in the research area V2 than in the research area V1. The research area V2 achieved year-on-year differences in species similarity from 81 to 88 %. By comparing the species similarity of Carabidae communities on the research area V3, we found a slight decrease in the value of the similarity index than in the previous variants. Year-on-year similarity indices reached values in the range of 66 to 84 %. The V4 research area achieved similarity indices in the range of 70 to 84 %. By comparing the similarity indices of individual variants, in 2016 and 2017, we found the similarity between the research areas V1 and the area V2, which ranged from 91 to 97 %. The research areas V1 and V2 were located next to each other. Similarity in 2016 and 2017 was also achieved by areas V2 and V4, whose similarity indices were around 91 %. The ECO research area and the V3 research area achieved a very high similarity index in all three monitored periods in the range from 96 to 100 %. Based on a statistical t-test comparison, we assessed the species similarity of research areas V2 and V3 with the ECO area. These areas are managed in a similar way, using deep plowing and shallow tillage. Comparison of the V2 and

Table 1 Comparison of species dominance in 2016-2018 on the monitored areas (ED- eudominant, D- dominant, SD- subdominant, R- recedent, SR- subrecedent)

Species	V1			V2			V3			V4			EKO		
	2016	2017	2018	2016	2017	2018	2016	2017	2018	2016	2017	2018	2016	2017	2018
Amara aenea	SD	SD	SD	SD	SD	SD	SD	D	SD	SD	D	SD	SD	D	SD
Amara aulica	D	SD	SD	D	D	SD	D	R	SD	D	D	SD	D	R	SD
Amara communis	D	D	SD	D	D	SD	D	D	D	D	D	D	D	D	D
Amara familiaris	SR	SR	SR	R	SR	SR	SR	SR	R	R	R	SR	SR	SR	R
Bradycellus caucasicus	SR	SR	SR	SR	SR	SR	SR	R	SR	SR	SR	SR	SR	R	SR
Brachinus crepitans	SR	SR	R	SR	SR	SR	R	SR	R	SR	SR	SR	R	R	R
Cicindela campestris	SR	SR	SR	SR	SR	SR	R	SR	SR	SD	SR	SR	R	SR	SR
Harpalus affinis	SR	SR	SR	SR	SR	R	SR	SR	SR	SR	SR	SD	SR	SR	SR
Harpalus hospes	SR	SR	SR	SR	R	SR	SR	SR	SR	SR	R	SR	SR	SR	SR
Lebia chlorocephala	SR	R	R	SR	SR	SR	SR	SR	R	SR	SR	SR	SR	SR	R
Nebra brevicollis	SR	SR	R	SR	SR	R	SR	SR	SR	SR	SR	R	R	R	SR
Ophonus rupicola	SR	SR	SR	SR	SR	SR	SR	SR	SR	SR	SR	SR	SR	SR	SR
Poecilus cupreus	R	SR	SR	SD	SR	SR	SR	SR	SR	SD	R	R	SR	SR	SR
Pseudoophonus rufipes	ED	ED	ED	ED	ED	ED	ED	ED	ED	ED	ED	ED	ED	ED	ED
Pterostichus incommodus	SR	SR	SR	SR	SR	SR	SR	SR	SR	SR	SR	SR	SR	SR	SR
Pterostichus melanarius	ED	ED	ED	ED	ED	ED	ED	ED	ED	ED	ED	ED	ED	ED	ED
Pterostichus niger	SR	SR	SR	SR	SR	SR	SR	SR	SR	SR	SR	SR	SR	SR	SR
Pterostichus nigrita	SR	SR	SR	SR	SR	SR	SR	SR	R	SR	SR	SR	SR	SR	R
Pyrrhocoris apterus	SR	R	R	SR	SR	SR	R	SR	SR	SR	R	R	SR	SR	SR
Zabrus tenebrioides	SR	R	R	SR	SR	R	SR	SR	SR	R	SR	SD	SR	SR	SR

Table 2 Results of the Sőrens similarity index on V1-ECO areas throughout the three-year monitored period

Locality	V1/2017	V1/2018	V2/2016	V2/2017	V2/2018	V3/2016	V3/2017	V3/2018	V4/2016	V4/2017	V4/2018	EKO/2016	EKO/2017	EKO/2018
V1/2016	86,49	86,49	91,89	97,3	84,21	81,25	75	84,85	88,89	83,33	80	81,25	72,73	84,85
V1/2017	-	77,78	77,78	94,44	75,68	77,42	70,97	68,75	74,29	85,71	70,59	77,42	68,75	68,75
V1/2018	-	-	77,78	88,89	86,49	70,97	70,97	87,5	74,29	74,29	82,35	70,97	68,75	87,5
V2/2016	-	-	-	88,89	81,08	83,87	77,42	81,25	91,43	85,71	76,47	83,87	68,75	81,25
V2/2017	-	-	-	-	86,49	77,42	77,42	81,25	85,71	91,43	82,35	77,42	75	81,25
V2/2018	-	-	-	-	-	75	75	84,85	77,78	77,78	85,71	75	72,73	84,85
V3/2016	-	-	-	-	-	-	84,62	74,07	86,67	80	82,76	100	81,48	74,07
V3/2017	-	-	-	-	-	-	-	66,67	80	80	82,76	76,92	96,3	66,67
V3/2018	-	-	-	-	-	-	-	-	77,42	70,97	80	74,07	64,29	100
V4/2016	-	-	-	-	-	-	-	-	-	70,59	84,85	86,67	77,42	77,42
V4/2017	-	-	-	-	-	-	-	-	-	-	84,85	80	77,42	70,97
V4/2018	-	-	-	-	-	-	-	-	-	-	-	82,76	80	80
EKO/2016	-	-	-	-	-	-	-	-	-	-	-	-	81,48	74,07
EKO/2017	-	-	-		-	-	-	-	-	-	-	-	-	64,29

ECO areas in 2016 is shown in Fig 1. The graph also shows that the difference in the occurrence of Carabidae in these areas is not statistically significant (p = 0.491730).

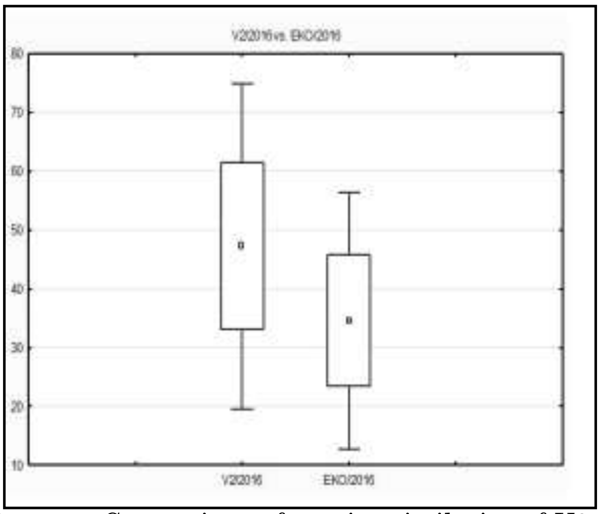

Figure 1. Comparison of species similarity of V2 and ECO research area in the monitored year 2016

By comparing the V2 and ECO areas in 2017, we reached the same result (p = 0.334654). Fig 2 shows a comparison of the species similarity of the research area V2 and ECO in 2017.

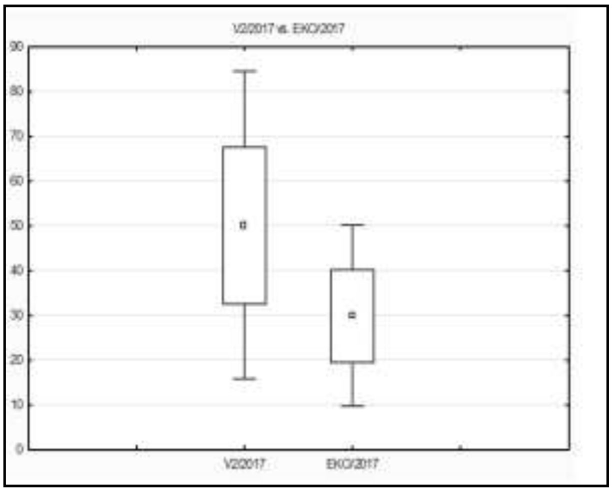

Figure 2 Comparison of species similarity of V2 and ECO research area in the monitored year 2017

Even in 2018, we did not notice a statistically significant difference between the V2 and ECO areas (p = 0.350437). Fig 3 shows a comparison of the species similarity of the research area V2 and ECO in 2018.
We also compared the V3 and ECO areas in individual years with the same test. Even by comparing these areas, we did not find statistically significant differences. In 2016, the value of evidence was (p = 0.726472), in 2017, we recorded the value of evidence (p = 0.701478) and in 2018, the value of the t-test was (p = 0.774668). These results fully correspond to the results of the Sőrensen similarity indices.

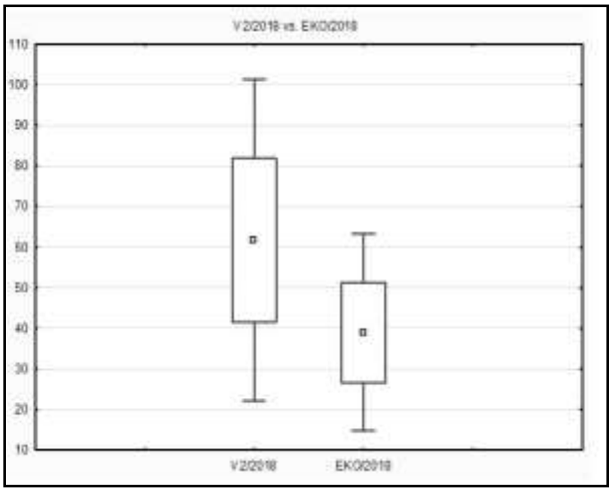

Figure 3 Comparison of species similarity of V2 and ECO research area in the monitored year 2017

Diversity index

In the V1 research area, the diversity index reached 1.63 bits in 2016, 1.42 bits in 2017 and 1.45 bits in 2018. In the V1 research area, the community reached the limit of ecological carrying capacity in 2017 and 2018, in 2016 the community was ecologically balanced. The average value of the diversity index for the research area V1 was 1.51 bits. Based on the average value, we can conclude that the community in the research area V1 was ecologically balanced. The number of individuals in the research area V1 was 505 in 2016. In 2017, the number increased to 611 and in 2018, it decreased again to 506 individuals. The change in the diversity index in 2016 could be due to an increase in the number of species that year. The diversity index on the V2 research area reached 1.58 bits in 2016, in 2017 the value was 1.51 bits and 1.51 bits in 2018. The average value of the diversity index on the V2 research area is 1.53 bits, which indicates ecological balance of the community. The V3 research area reached a diversity index of 1.50 bits in 2016, 1.42 bits in 2017 and 1.47 bits in 2018. The average value of the diversity index for the V3 research area is 1.47 bits. The community in the V3 research area was on the verge of ecological carrying capacity. In the V4 research area, the values of the diversity index were at the level of 1.69 bits. Based on the average value of the diversity index for the V4 area, we can consider the community to be ecologically balanced. The values of the diversity index of the ECO research area reached 1.49 bits in 2016, 1.43 bits in 2017 and 1.50 bits in 2018. In the ECO research area, the Community reached the limit of ecological carrying capacity during the three-year monitored period. The average value of the diversity index for the ECO research area is 1.47

bits. Based on the average value, we can conclude that the community in the ECO research area reached the limit of ecological carrying capacity. Fig 4 shows the values of the diversity index in the V1-ECO research areas in the observed period 2016 to 2018.

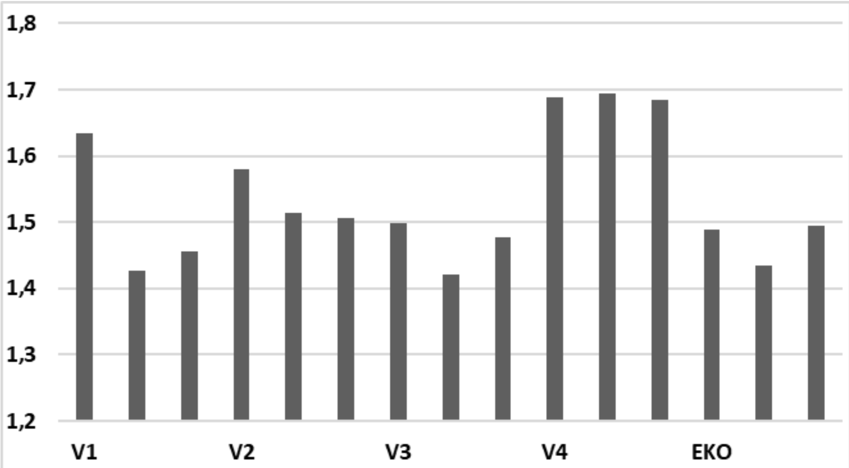

Figure 4 Values of the diversity index on research areas V1-ECO in the monitored period 2016 - 2018

Impact of Meteorological Factors

In 2016, the occurrence of Carabidae species correlated with temperature in the research area V2, V3, V4 and ECO. The correlation between the occurrence of Carabidae and temperatures was highly statistically demonstrated for the area V2 ($p = 0.000$), the area V3 ($p = 0.000$), the area V4 ($p = 0.001$) and the research area ECO ($p = 0.000$). Another factor we assessed was the total rainfall. In 2016, on all monitored areas, the total rainfall did not correlate with the occurrence of the Carabidae family. In 2017, the temperature correlated with the occurrence of the Carabidae family in the research area V2 ($p = 0.001$), the area V3 ($p = 0.000$), the area V4 ($p = 0.001$) and the ECO research area ($p = 0.000$). The influence of temperature on the abundance of the Carabidae family was highly demonstrated in the observed year in the areas V2, V3, V4 and ECO. The occurrence of Carabidae did not correlate with the total rainfall on any of the monitored areas. The correlation of the occurrence of Carabidae with the temperature in 2018 was positive in the area V1 ($p = 0.010$). The correlation of the abundance of Carabidae with temperature was statistically significant in the monitored area V1. The effect of rainfall on the occurrence of Carabidae did not mutually correlate.

DISCUSSION and CONCLUSION

In the three-year monitoring period, we recorded 11,362 specimens of epigeic groups of animals in the research areas of the Research Institute of Plant Production (VÚRV) in Borovce. Individual species were classified into eight epigeic groups. Porhajasova et al. (2007) report the Coleoptera order as dominant in almost all types of ecosystems, including agroecosystems. The data obtained by us confirmed the dominance of the Coleoptera order (7593 individuals), the presence of this order contributes to the increased diversity of agroecosystems, and at the same time, serves as a food source for other invertebrates and vertebrates. Out of the Coleoptera order, we determined six families, of which the family Carabidae (6656 individuals) had a dominant representation. During the three-year period, we collected 6656 individuals of this family. The number of individuals in the individual research areas ranged from 931 to 1622 species. We recorded the lowest number of individuals in the ECO research area and the highest in the V1 area. Melnychuk et al. (2003) also did not note statistically significant differences in the number of individuals, when comparing commercial and ecological agriculture systems. During all three years of the monitored period, we recorded two significantly eudominant species, *P. melanarius* and *P. rufipes*, in all research areas. The dominance values of these species ranged from 32 to 54 % during the monitored period. Twardovski et al. (2006) state that the impact of intensive agriculture does not negatively affect the presence of dominant species *P. melanariu*s and *P. rufipes*. Other species were observed as recurrent or subrecedent, which fully corresponds to the data obtained by us. Kos et al. (2011) identified *P.melanarius* and *P. rufipes* as the most common species in maize fields in three locations in Croatia. The data obtained by us suggest a positive effect of intensive agriculture on the predominance of *P. melanarius* and *P. rufipes*. We also conclude that intensive agriculture has a negative effect on the abundance of other species of the *Carabidae* family. Lacko-Bartosova et al. (2005) came to similar conclusions. Rusch et al. (2013) assessed the dominance of *Carabidae* in agroecosystems in Sweden before and after the introduction of a pesticide risk reduction programme. No different species composition of the community was demonstrated, but differences in species dominance and community functional composition were demonstrated. The data obtained by us did not confirm the differences in the dominance of species in ecological and conventional agriculture, which could be caused by the surrounding agricultural areas with conventional agricultural management and the termination of the ECO research area in 2018. Vician et al. (2010) identified eudominant species of *P. melanarius* and *P. rufipes* on different management of agricultural areas, without observing significant differences in dominance. By evaluating the frequency of occurrence of individual species, we conclude that the *P. melanarius* and *P. rufipes* species were constant during the three-year monitored period. The probability of occurrence of these species was 30 to 43 %, the occurrence of other species was accessory or accidental with low abundance, which could be related to their migratory ability from the surrounding country or accidental occurrence. Indices of species similarity of individual variants in 2016 and 2017 reached similarity between the research areas V1 and V2, which ranged from 91 to 97 %. The similarity in the occurrence of Carabidae could be due to the proximity of research areas and the migratory ability of individuals. In 2016 and 2017, similarity was also achieved on the areas V2 and V4, whose diversity indices were around 91 %. The highest similarity of 96-100 % was achieved during all three monitored periods on the research areas V3 and ECO. Based on the findings, we can assume that the V3 and ECO research areas provided very similar conditions for Carabidae, which may be related to the agrotechnological procedures used. These results were also confirmed by a comparison of the above areas using a t-test, whereas we showed no statistically significant difference between the areas in any year. Our finding corresponds with the finding of Melnychuk et al. (2003), who also did not find statistically significant differences in the number of individuals in their study when comparing commercial and organic farming systems. Gallardo et al. (2011) argue that disturbed ecosystems are characterized by a lower value of species similarity. The diversity index is used to assess the species diversity of Carabidae. Petřvalský (1993) considers as ecologically balanced communities those, whose value of the diversity index is in the range of 1.51-2.0 bits. Communities above 2.0 bits are considered environmentally stable. The values obtained by us in the three-year monitored period ranged from 1.42 to 1.69 bits. Based on this, we can conclude that none of the monitored research areas represented an ecologically stabilized community. The low value of the diversity index could be caused by agrotechnical interventions. Sustek et al. (2011) monitored the Žitavský lúh Reservation, calculating a species diversity index of 2.5092, which represents a highly stabilized ecosystem. Horakova et al. (2005) monitored the Carabidae family in the areas of the Moravian Karst Protected Landscape Area and found that the least anthropogenically affected areas were characterized by the highest index of species diversity, which represented a value of about 2.90 bits. On the V4 monitored research area, the value of species diversity reached the value of 1.69 bits, representing the highest value of all monitored areas. It follows that the no-till technique used in the V4 research area could have had a positive effect on the species diversity of Carabidae communities. Kosewska et al. (2014) dealt with the impact of various agricultural techniques on the occurrence of Carabidae in Poland. They concluded that plowing negatively affects the species variability of Carabidae, with zoophagous and medium-sized species predominating. The data we found also showed a negative impact of plowing on the diversity of Carabidae. The low diversity on the ECO variant could be caused by plowing, while we did not have a research variant with no-till management in ecological agriculture. Based on the evaluated data, we found that the temperature was positively correlated in individual areas with the abundance of the family of Carabidae. The data also show that the impact of total rainfall did not correlate in any of the monitored years and in any research area. The effect of temperature on the abundance of Carabidae was statistically significant in 2018 ($p = 0.010$) and highly statistically demonstrated in 2016 ($p = 0.000$-0.001) and 2017 ($p = 0.000$-0.001).

CONCLUSION and RECOMMENDATIONS

The aim of this work was to evaluate the occurrence of brassicas in different wheat cultivation methods, focusing on the determination of individual brassicas species. We collected epigeic material during a three-year period between 2016 and 2018, in research plots in Borovce, which belong to the Research Institute of Plant Production (RIPP) in Piešt'any. The collections were carried out within 5 variants of the research plots: V1: mulching technique; V2: conventional technique; V3: minimization technique; V4: no-till technique and ECO: ecological technique with ploughing using the earth trap method, using bait, with 24-hour emptying.

During the 3-year study period, we collected 11362 specimens, from eight epigeic groups. Of all epigeic groups, Coleoptera were dominant (7593 specimens). The order was represented by six families, of which the family Carabidae was dominant. We recorded 6656 specimens from the aforementioned family, from which we determined 20 species. In all study plots, we recorded two strongly eudominant species, *P. melanarius* and *P. rufipes*, over the three-year study period. The permanence of occurrence of these species was 30-43%, while the occurrence of the other species was accessory or accidental with low abundance, which could be related to their migratory ability from the surrounding landscape or accidental occurrence.

The highest species similarity of the bryozoan community, 96-100%, was recorded in all three study periods at study plots V3 and EKO. Based on the findings, we can conclude that research plots V3 and research plot EKO provided very similar conditions for sedges, which may be related to the agrotechnological practices used. The species diversity of the sedge communities in the research plots we monitored was highest in plot V4, with a value of 1.69 bits. Which means that the no-till technique used in research plot V4 positively influences the species diversity of sedge communities in the agroecosystem.

The data obtained by us can serve as a baseline material for the detection of species diversity in different wheat cultivation methods in organic farming with subsequent comparison with the data obtained by us. The seasonal dynamics increased in the month of May, which corresponds to the developmental cycle of the brassicas. Individual research plots reached their maximum values in the months of June-August. The decrease in values occurred in the months September-October, which is related to the survival of imagoes and the appearance of overwintering stages. From the evaluated data, we found a positive correlation of temperature in the individual plots with the abundance of the bryozoan family. The data also showed that the effect of rainfall was not correlated in any of the years studied. The effect of temperature on bryophyte abundance was statistically significant in 2018 and highly statistically demonstrated in 2016 and 2017.

Evaluating the results of our work, we conclude that the no-till technology is the most suitable wheat cultivation method in terms of promoting the diversity of brassica species. Of the plots studied, the highest similarity was achieved by abundance in plots V3 and EKO, in these plots deep tillage with subsoiling was used and also for this reason the abundance of sedges as well as their species diversity was lower. The organically cultivated area was used only with ploughing and for this reason we could not evaluate the abundance of sedges in the no-till variant, without the use of chemical preparations. We recorded the highest abundance and diversity in plot V1, where mulching is used to aerate the soil, this confirms the assumption that the no-till technology is more acceptable for sedge populations.

Researchers' Contribution Rate Declaration Summary

The authors declare that they contributed equally to the article.

Conflict of Interest Declaration

The authors declare that there is no conflict of interest between them.

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