Original Paper

Occurrence of epigeic groups, with emphasis on the families of beetles (Coleoptera) in various types of soil management

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The aim of this study was to assess the occurrence of epigeic groups of animals in five types of soil management. Research areas were marked as V1-EKO, whereas on the V1 area, mulching technology was used, on the V2 area, conventional technology, on V3 area, minimization technology, on the V4 area, no-till technology and the EKO area was managed in an ecological way. A ground pitfall trap was placed in the variety of a hybrid of *Triticum aestivum* × *Triticum spelta* – PS Lubica. The experiment was carried out between 2016 and 2018 in the research areas of the Research Institute of Plant Production in Borovce. In the course of three years, 11,365 specimen from 8 epigeic groups and 6 families were collected. At the eudominant level, Coleoptera and Hymenoptera groups were found in every research area. At the dominant level, Arachnoidea group were found on the V1 research area. and larvae on the EKO research area. The most numerous variant in terms of the number of individuals, but the number of groups also, collected over three years, was variant 1 – mulching technology. This means that shallow tillage, which decreases evaporation, soil loose and eliminates the weeds, is most beneficial to epigeic groups. Based on the statistical evaluation, we were unable to demonstrate the effect of rainfall on the occurrence of groups each year in the compared research areas. On the contrary, we were able to demonstrate the effect of temperature changes on the occurrence of epigeon.

Keywords: epigeic groups, Coleoptera, ecological agriculture, pitfall trap

1 Introduction

Expansion and intensifying of agriculture in the 20th century contributed to the mitigation of poverty in the whole world. Benefits were, however, connected to the ecosystem changes and biodiversity losses at the local as well as global level (Tilman, 1999). According to Scharlemann et al. (2005), agriculture is closely linked to the environment threats and biodiversity loss. Donald et al. (2006) expect doubling of food demand. In the developing countries, an increase of 25% of agricultural land will be needed, in order to meet this demand (Balmford et al., 2005). In addition to an increased demand for food, demand is growing also for the agricultural crops used for the cultivation of industrial material for bioenergetics that provide low-quality habitats (Field et al., 2008, Aratrakorn et al., 2006). Baranová et al. (2015) list the soil edaphone as one of the potential biotope load indicator. In addition to the natural factors, in agroecosystems, man has also strong impact on the land edaphone by his actions such as tillage, crop rotation, use of fertilisers and pesticides etc (Porhajasova, 2019). Harmful effect of agriculture on soil ecosystems and the related biodiversity loss will continue. This is one of the reasons, why the need of agroecosystems and biodiversity protection is gradually recognized (Perrings et al., 2006). Among main principles of modern protection of nature, preservance of maximum possible diversity of ecosystems should be included, and thus the maximum possible diversity of biotopes that can be inhabited by species (Lieskovský et al., 2010). According to Tieman et al. (2015), negative impact of intensive agriculture can be mitigated by a diversity increase of the agricultural land. Soil fauna effects on nutrient and water use efficiencies are also apparent, but diversity effects may be indirect, through effects on soil structure (Brussaard et al., 2007). The aim of this study was to assess the occurrence of

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epigeic groups in the crops of *Triticum aestivum* × *Triticum spelta* hybrid in the different types of land management.

2 Material and methods

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 the years 2016 to 2018 during the given period (from March to October) in the crops of a hybrid of *Triticum aestivum* × *Triticum spelta* – PS Lubica. 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 EKO 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 EKO. 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; Pokorný, 2004). The same procedure was maintained during the whole research period. We managed to determine the abundance and occurrence of epigeic groups of animals in five types of land management. Furthermore, we managed to statistically determine the impact of meteorological factors on the epigeic groups of animals. The data collected were put down every month to a table, which serves as a basis for this work. The statistically processed data were subjected to an analysis in the Statistica Programme, version 12.

2.1 Study area

The monitored area is located in the municipality of Borovce, district of Piešťany, falling under 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 593 mm (Remenár, 2017). Average wind speed on the monitored area is approximately 4.2 m s^{-1}, with the northwest and north flows direction (Mazúr and Lukniš, 1980).

2.2 Agritechnical interventions

Mulching technology was used on the V1 research area. In May (7. 5.) a fungicide was applied. Next was a shallow tillage, which decreases evaporation, makes the soil loose and eliminates the weeds. Application of herbicides before the sowing was not carried out in this option. Application of potassium and phosphorus fertilizers was carried out by means of a spreader (10. 10.). Potassium fertilizer was applied at a rate of 7.96 kg ha^{-1} and phosphorus fertilizer at a rate of 6.52 kg ha^{-1}. After the sowing, a liquified potassium fertilizer was applied (12. 10.). Herbicide was applied in April (12. 4.) and was supplemented by a nitrogen fertilizer. Application of insecticide was carried out in June (7. 6.) and harvesting

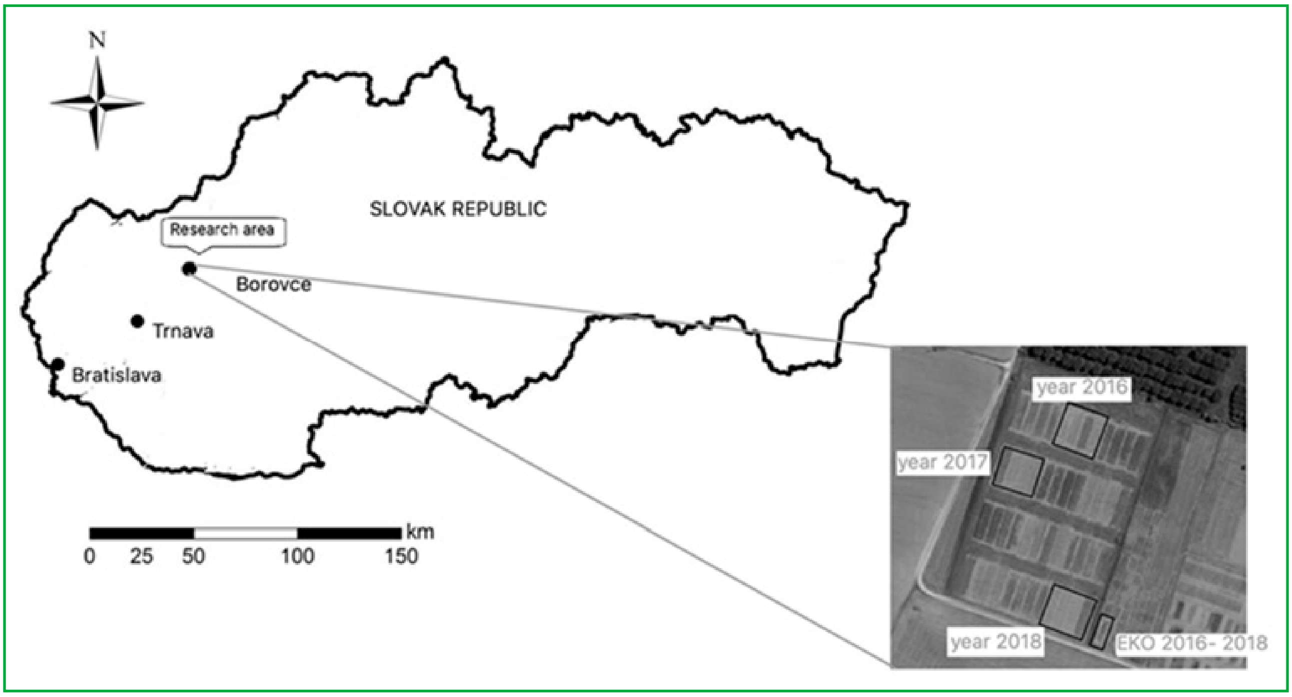

Figure 1 Map of study area – Borovce

in July (18. 7.). Every agrotechnological procedure on this research area was carried out every year, the same date that is referred to in the columns (VÚRV, 2019). Conventional technology was used on the V2 research area. Around 7. 5., a fungicide was applied. Next agrotechnological procedure was the shallow tillage (27. 9.), tillage and field leveling (28. 9.). A herbicide was not applied before the sowing. For the soil cultivation, a deep plough was used and a field leveling afterwards (28. 9.). A universal fertilizer (40 kg ha^{-1}) was applied before the sowing (10. 10.). For the cultivation, heavy disc gates were used. Afterwards, the sowing and field leveling (12. 10.). Fertilization was applied (31. 3.–4. 4.) and the herbicide was applied around (12. 4.–19. 4.) Insecticide was not applied in this option. Harvesting was carried out on (25. 7.). Every agrotechnological procedure on this research area was carried out every year, the same date that is referred to in the columns (VÚRV, 2019). Minimization technology was used on the V3 research area. Around (7. 5.), a fungicide was applied. Next agrotechnological procedure was the shallow tillage (27. 9.), tillage and field leveling (27. 9.). Application of potassium and phosphorus fertilizers was carried out by means of a spreader (10. 10.) in the same dose as on the V1 research area. After the sowing, a liquified potassium fertilizer was applied (1. 10.) in a dose 5 l ha^{-1}. Herbicide was applied in April (12. 4.) and was supplemented by a nitrogen fertilizer. Application of insecticide was carried out in June (7. 6.) and harvesting in July (18. 7.). Every agrotechnological procedure on this research area was carried out every year, the same date that is referred to in the columns (VÚRV, 2019). No-tillage technology was used on the V4 research area. Around (7. 5.), a fungicide was applied, and the herbicide was applied before the sowing (29. 9.). Application of potassium and phosphorus fertilizers was carried out by means of a spreader (10. 10.) in the same dose as on the V1 research area.. After the sowing, a liquified potassium fertilizer was applied (12. 10.) in a dose 5 l ha^{-1}. Nitrogen fertilizer was applied (4. 4.) followed by an application of herbicide (12. 4.). Application of insecticide was carried out in June (7. 6.) and the harvesting in July (18. 7.). Every agrotechnological procedure on this research area was carried out every year, the same date that is referred to in the columns (VÚRV, 2019). The area occurs in the area of maize production and climatic region (KT 2) with land BPEJ 0139002 – chernozem. This type of soil represents medium-heavy soil with a humus content of 1.8–2 g kg^{-1}. The groundwater is located at a depth of approximately 15 m. The reaction of the soil (pH) is in the range of 5. 5–7. 2. Table 1 shows the pesticide products that were used on the V1-V4 research areas.

Table 1 Pesticide products used on the V1-V4 research areas

Sprayings used	RoundupFlex – 2.3 l ha^{-2}
	Mustang forte 1 l ha^{-1}
	Lontrel 0.3 l ha^{-1}
	Trichomil 2 l ha^{-1}
	Fung. CAPALO 1.4 l ha^{-1}
	Fung. ZAMÍR 40 EW 1.0 l ha^{-1}
	Decis 50EW0,15 l ha^{-1}

Agrotechnological operations provided in the Tables 2 and 3, for the year 2016 and 2017, were used on the EKO research area. In 2018, the EKO option was cancelled.

Table 2 Overview of agrotechnical operations in 2016 (VÚRV, 2019)

Agrotechnical interventions	Date	
Tillage and rolling	23. 9. 2015	x
Soil cultivation after tillage and rolling	2. 10. 2015	x
Soil cultivation before sowing, rolling and sowing	13. 10. 2015	x
Application of foliar fertilizers	1. 4. 2016	
Application of bio fungicides	20. 4. 2016	x
Application of foliar fertilizers	28. 4.2016	
Application of bio fungicides	19. 5. 2016	x
Application of foliar fertilizers	23. 5. 2016	
Application of foliar fertilizers	30. 5. 2016	
Application of bio fungicides	1. 6. 2016	x
Harvesting by a combine harvester	12. 7. 2016	x

Table 3 Overview of agrotechnical operations in 2017 (VÚRV, 2019)

Agrotechnical interventions	Date	
Tillage and rolling	25. 9. 2016	x
Soil cultivation after tillage and rolling	2. 10. 2016	x
Soil cultivation before sowing, rolling and sowing	12. 10. 2016	x
Application of foliar fertilizers	10. 4. 2017	
Application of bio fungicides	28. 3. 2017	x
Application of foliar fertilizers	26. 4. 2017	
Application of bio fungicides	11. 5. 2017	x
Application of foliar fertilizers	18. 5. 2017	
Application of foliar fertilizers	30. 5. 2017	
Application of bio fungicides	2. 6. 2017	x
Harvesting by a combine harvester	12. 7. 2017	x

3 Results and discussion

During the 3 years monitored period, we managed to collect 11,365 individuals from 8 epigeic groups and 6 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% a nd 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. 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. On V1 research area, between 2016 and 2018, Coleoptera (67.72%) and Hymenoptera (14.21%) groups were eudominant. Dominant group was the Arachnidae group (9.81%). Subdominant was the larvae (4.32%). Acarina (1.61%) and Dermaptera (1.70%) groups were present at recedent level. Chilopoda and Amphipoda were present at the subrecedent level. On V2 research area, between 2016 and 2018, Coleoptera (64.52%), Hymenoptera (15.63%) and Arachnidae (11.26%) were eudominant. No dominant groups were present on the V2 area between 2016 and 2018. Subdominant were larvae (4.36%) and group Acarina (2.03%), group Dermaptera (1.53%) was present at the recedent level. Groups of Chilopoda (0.4%) and Amphipoda (0.3%) were present at the subrecedent level. On V3 research area, between 2016 and 2018, Coleoptera (68.50%), Hymenoptera (11.76%) and Arachnidae (11.03%) were eudominant, No dominant groups were present on the V3 area between 2016 and 2018. Subdominant groups on the V3 area was larvae (4.10%), Dermaptera (1.80%) and Acarina (1.90%) were present at the recedent level. Groups of Chilopoda (0.66%) and Amphipoda (0.23%) were present at the subrecedent level. On V4 research area, between 2016 and 2018, Coleoptera (66,80%), Hymenoptera (12.66%) and Arachnidae (11.13%) were eudominant. No dominant groups were present on the V4 area between 2016 and 2018. Larvae (4.83%) was the subdominant. Groups of Dermaptera (1.96%) and Acarina (1.86%) were present at the recedent level. Groups of Chilopoda (0.50%) and Amphipoda (0.23%) were present at the subrecedent level. Between 2016 and 2018, on EKO research area, Coleoptera (68.73%), Hymenoptera (12.26%) and Arachnidae (10.06%) were eudominant. Larvae (5,26%) were dominant on the EKO area between 2016 and 2018. Subdominant group was not present on the EKO area. Groups of Dermaptera (1.76%) and Acarina (1.56%) were at the recedent level. Groups of Chilopoda (0.26%) and Amphipoda (0.06%) were present at the subrecedent level. Percentage of epigeic groups of animals on the monitored area is shown in the Figure 2.

From the beetles collected, we recorded 6 families. In the Figure 3, percentage of Coleoptera on the monitored area is shown. At the eudominant level, families of Carabidae (88.15%) and Staphylinidae (11.43%) were present in average in 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%). On the V1 research area, Carabidae (86.06) and Staphylinidae (13.60%) were present at the eudominant level. Other families were present at the subrecedent or no level – Cerambicidae (0.20%), Chrysomelidae (0.00%), Scarabaeidae (0.13%) and Cicindelidae (0.00%). On the V2 research area, Carabidae (85.86%) and Staphylinidae (13.40%) were present at the eudominant level. Other families were present at the subrecedent or no level – Cerambicidae (0.00%), Chrysomelidae (0.16%), Scarabaeidae (0.30%) and Cicindelidae (0.26%). On the V3 research area, Carabidae

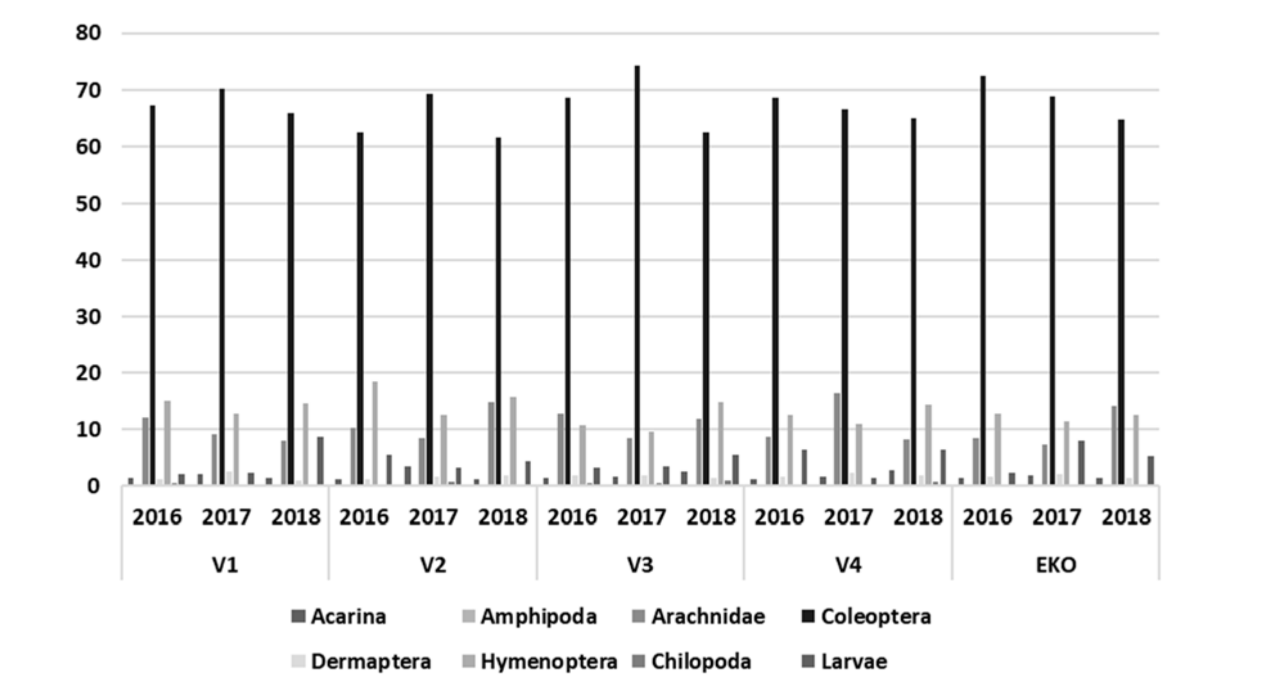

Figure 2 Percentage of epigeic groups of animals

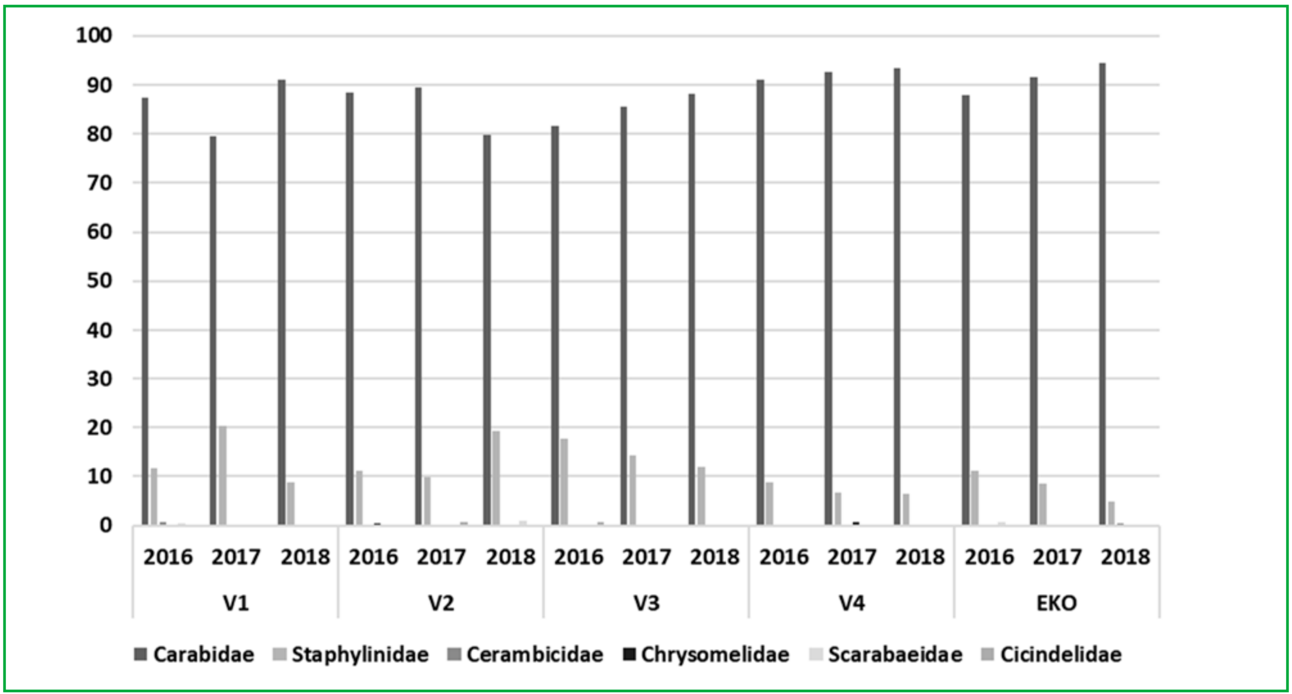

Figure 3 Proportion of beetle families (%)

(85.10%) and Staphylinidae (14.60%) were present at the eudominant level. Other families were present at the subrecedent or no level – Cerambicidae (0.00%), Chrysomelidae (0.06%), Scarabaeidae (0.00%) and Cicindelidae (0.23%). On the V4 research area, Carabidae family (92.40%) was present at the eudominant level. Staphylinidae family (7.33%) was present at the dominant level. Other families were present at the subrecedent or no level – Cerambicidae (0.00%), Chrysomelidae (0.20%), Scarabaeidae (0.00%) and Cicindelidae (0.06%). On the EKO research area, Carabidae family (91.33%) was present at the eudominant level. Staphylinidae family (8.23%) was present at the dominant level. Other families were present at the subrecedent or no level – Cerambicidae

(0.16%), Chrysomelidae (0.00%), Scarabaeidae (0.26%) and Cicindelidae (0.00%).

Ivanič Porhajašová et al. (2018) list the Coleoptera order as dominant in almost all kinds of ecosystems, including agroecosystems. Data collected by us confirmed the dominance of the Coleoptera order (7,593 individuals). Presence of this order contributes to the increased biodiversity of agroecosystems, and simultaneously serves as food source for other vertebrates and invertebrates. We determined 6 families from the Coleoptera order, with a dominant presence of Carabidae family (6,656 individuals). We collected 6656 individuals of this family during the monitored period. Number of individuals on each research area ranged from 931 to 1,622 individuals. The lowest number of individuals was recorded on the EKO research area and the highest on the V1 area. Melnychuk et al. (2003) also did not record statistically important differences in number of individuals in comparing the commercial and ecological agriculture system. Table 4 shows the results of correlations of the occurrence of beetle families in individual areas in the monitored years. The table shows that in every year the occurrence was statistically significantly correlated in all areas, where various types of standard agrotechnical interventions were used. The only exception was the EKO area, where the beetle individuals occurred statistically differently. These results support the findings of Gallé et al. (2018) who conclude that the organic management in agroecosystems increases structural biotope composition. Thanks to this, it provides greater food sources, which correlates with the number, as well as the average size of individuals. Diehl et al. (2016) conclude that the presence of weed in the ecological management of wheat cultivation supports density and diversity of Carabidae family occurrence through recource-mediated effects, such as increased availability of food derived from weeds (eg seeds and pollen) and herbivorous prey. Weeds also contribute to this effect by changing the microclimate. The authors further determine that the presence of weeds in organically farmed wheat fields increases the density and diversity of carabide activity and needs to be integrated into the future nature conservation management strategies.

Another factor that affects the occurrence and abundance of epigeic groups is the change in abiotic factors. We compared the abundance of representatives of beetle families depending on the change in temperature and rainfall in the monitored months of each year and the monitored areas according to the type of farming. Based on the statistical evaluation, we were unable to demonstrate the effect of rainfall on the occurrence of groups each year in the compared research areas.

Table 4 Correlations of the occurrence of families on each area in the monitored years

	2016 V1	2017 V1	2018 V1	2016 V2	2017 V2	2018 V2	2016 V3	2017 V3	2018 V3	2016 V4	2017 V4	2018 V4	2016 EKO	2017 EKO	2018 EKO
2016 V1	1,0000 p= ---	,2481 p=,520	,2289 p=,554	,8866 p=,001	,3654 p=,333	,0973 p=,803	,7967 p=,010	,3414 p=,369	,1852 p=,633	,7008 p=,035	,3639 p=,336	,4135 p=,269	,6311 p=,068	,6322 p=,068	,7371 p=,023
2017 V1		1,0000 p= ---	,5969 p=,090	,6118 p=,080	,9803 p=,000	,5514 p=,124	-,1040 p=,790	,9883 p=,000	,4346 p=,242	,2886 p=,451	,9813 p=,000	,6247 p=,072	,9034 p=,001	,5056 p=,165	,3045 p=,426
2018 V1			1,0000 p= ---	,3871 p=,303	,5670 p=,111	,9689 p=,000	-,1421 p=,715	,5871 p=,097	,8615 p=,003	,0916 p=,815	,5716 p=,108	,9256 p=,000	,5902 p=,094	,1821 p=,639	,6663 p=,050
2016 V2				1,0000 p= ---	,7268 p=,027	,2925 p=,445	,6564 p=,055	,7025 p=,035	,2144 p=,580	,8044 p=,009	,7249 p=,027	,5572 p=,119	,8695 p=,002	,8447 p=,004	,6030 p=,086
2017 V2					1,0000 p= ---	,5320 p=,140	,0487 p=,901	,9980 p=,000	,3850 p=,306	,4708 p=,201	,9999 p=,000	,6450 p=,061	,9329 p=,000	,6637 p=,051	,3140 p=,411
2018 V2						1,0000 p= ---	-,2291 p=,553	,5496 p=,125	,8514 p=,004	,1198 p=,759	,5364 p=,137	,9163 p=,001	,4875 p=,183	,1993 p=,607	,5318 p=,141
2016 V3							1,0000 p= ---	,0140 p=,971	-,2486 p=,519	,7020 p=,035	,0459 p=,907	,0273 p=,944	,2662 p=,489	,5793 p=,102	,3295 p=,387
2017 V3								1,0000 p= ---	,4123 p=,270	,4252 p=,254	,9987 p=,000	,6526 p=,057	,9320 p=,000	,6198 p=,075	,3257 p=,392
2018 V3									1,0000 p= ---	-,0189 p=,961	,3910 p=,298	,8884 p=,001	,4199 p=,260	-,0098 p=,980	,6816 p=,043
2016 V4										1,0000 p= ---	,4658 p=,206	,3703 p=,327	,5005 p=,170	,9562 p=,000	,2085 p=,590
2017 V4											1,0000 p= ---	,6483 p=,059	,9337 p=,000	,6578 p=,054	,3182 p=,404
2018 V4												1,0000 p= ---	,6681 p=,049	,4137 p=,268	,6889 p=,040
2016 EKO													1,0000 p= ---	,6458 p=,060	,5840 p=,099
2017 EKO														1,0000 p= ---	,1688 p=,664
2018 EKO															1,0000 p= ---

This result was influenced by the fact that the average total rainfall in the monitored years was not statistically significantly different ($p \geq 0.05$). On the contrary, we were able to demonstrate the effect of temperature changes on the occurrence of epigeon. The temperature in 2018 differed statistically significantly from the temperatures in 2016 and 2017, which also significantly affected the occurrence of epigeic groups. Röder et al. (2017) also showed that temperature is a significant predictor of the occurrence of most epigeon species.

4 Conclusions

During the three-years period, we monitored the occurrence of epigeic groups of animals in five types of land management. During the three-year period, we obtained 11,365 individuals from 8 epigeic groups and 6 families. At the eudominant level, the Coleoptera and Hymenoptera groups were present in all research areas. At the dominant level, the group Arachnidea occurred in the V1 research area and larvae in the EKO research area. The effects of temperature and farming method was statistically significant on the occurrence of epigeic groups of animals.

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