IMPACT OF APPLICATION OF ORGANIC FERTILIZERS ON BIODIVERSITY AND SPATIAL STRUCTURE OF FAMILIES COLEOPTERA IN SOUTHWESTERN PART OF THE SLOVAK REPUBLIC

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Abstract: *The aim of this work was to evaluate the dynamics of the occurrence of families of order Coleoptera, during the years 2005 and 2006, on the locality Kolíňany, by the earth traps method, which were exposed in the five treatments with application of organic fertilizers: 1st treatment- control variant ; 2nd treatment - 25 t.ha-1 of the manure ; 3rd treatment - 50 t.ha-1 of biosludge; 4th treatment - 50 t.ha-1 of the manure; 5th treatment - 100 t. ha-1 of biosludge. Every year traps in different crops were exposed: 2005– Beta vulgaris and 2006 - Zea mays. During two-years period was within five treatments obtained 25, 616 ex of epigeic individuals. In the year 2005 we obtained 13,744 ex and in the year 2006 the number amounted 11,872 ex. From the stated number of obtained epigeic groups we focus as the dominant group – Coleoptera, which has been determined to individual families. In the year 2005 Coleoptera represented 5,600 ex and in the year 2006 it was 6,496 ex. With respect to evaluation of the year and crop can be concluded that the more appropriate climate and habitat conditions provided the year 2006 with crop of Zea mays. On the basis of the cumulative abundance of families Coleoptera together 15 families was determined. Within the 1st treatment, during two-year period, was obtained occurrence of 7 families, with the number of individuals 2,228 (2005 – 940 ex, 2006 – 1,288 ex), within the 2nd treatment was identified 12 families, with number of exemplars 1,894 (2005 – 1,680 ex, 2006 2,144 ex), in the 3rd treatment occurred 9 families, with total number 1, 736 ex (2005 – 616 ex, 2006 – 1,120 ex), within the 4th treatment was obtained 10 families, with number of 2, 316 ex (2005 – 944 ex, 2006 – 1,372 ex), in the last 5th treatment occurred 11 families, with 1, 992 ex (2005 – 1,420 ex, 2006 – 572 ex). Based on the assessment of dominance of determinate families can be conclude that families Carabidae and Staphylinidae recorded eudominant representation and families Silphidae dominant representation. Other families (Anthicidae, Coccinelidae, Elateridae, Ptiliidae and others) confirmed the occurrence less than 2%, their presence was at recendent respectively subrecendent representation. On the basis of calculated indexes farming system can be evaluated as a homeostatically balanced providing present zoo faun with topical and trophic conditions.*

Key words: *agroecosystems, biodiversity, Coleoptera, Slovak Republic*

INTRODUCTION

The term biodiversity is understood as diversity and variability of all living organisms, but also diversity of ecosystems. Biodiversity is understood as complex set of genes, species and ecosystems in a given geographical area. Human always affect natural ecosystems, but in recent year has increased the impact of human activity on agro-ecosystems (input of industrial and organic fertilizer to the soil, application of pesticides, realized agrotechnics etc.) primarily on biological diversity of present zoocoenoses. PORHAJAŠOVÁ (2011) states that Zooedaphon communities are one of the most diversified components of the soil fauna. With the wide range of taxonomic groups, families and species with specific adaptations to soil microhabitats and different sensitivity to environment stress may be present

groups used for further study of monitoring the impact of natural and anthropogenic disturbance to the soil environment. Richness of order Coleoptera is according to LENGERKEN AND HANNS (1983) in soil environment influenced by many factors eg: soil characteristics, degree of humidity, altitude, application of industrial resp. organic fertilizers, present vegetation, impact of year with climatic factors such as rainfall, temperature etc. Examples of families who prefer shading and humidity of the environment are the families Curculionodae, Cantharidae and Nitidulidae. Known are findings of Blažek, PAVLÍČEK (1986), ANDERSEN, ELTUN (2000), PORHAJAŠOVÁ, ŠUSTEK (2011), that increase in abundance of families Formicoidae means reducing in abundance of species of the dominant families Carabidae a Staphylinidae (order Coleoptera), it in extreme cases resulting in their disappearance form the locality. Known is that the aggregation of individual types of families with the same demands on the environment et. the humidity environmental conditions, which is typical for species of the family Carabidae and Staphylinidae. To evaluate the dominance of the families of order Coleoptera occurring in natural ecosystems respectively agro-ecosystems act as dominant families Carabidae, Staphylinidae and Silphidae, which despite of the strong anthropic pressure, long term isolation and impact of surrounding epigeic groups preserve their species spectrum and they are not sensitive to pollution and negative impacts to the environment and what is important plays in ecosystems many important functions (PORHAJAŠOVÁ, 2011; ANDERSEN, ELTUN, 2000). Biodiversity with their presence in ecosystems complemented other families of order Coleoptera. These are Scarabaeidae, Cryptophagidae, Anthicidae, Coccinelidae, Curculionidae, Histeridae and many others. By PORHAJAŠOVÁ (2011) despite of their low abundance they ensure the smooth running of ecosystems. By PETŘVALSKÝ (1997) the functionality of all types' ecosystems depends on the climatic and edaphic factors. Listed makes the species composition, structure and evolution of cenosis. If is biocenosis stable, energy and information flows between the trophic segment. Difficult trophic relationships are realized in the soil not only by dominant group of microbiocenosis, but also by present zooedaphon with populations of herbivorous, carnivorous, saprophagous and coprophagous forms.

Base on the above the aim of this work was to evaluated the biodiversity of families of order Coleoptera in agro-ecosystems affected by the application of organic fertilizers.

MATERIAL AND METHODS

Adopted method of collection

For the collection of epigeic materials a method of ground traps was used. We placing the open jar of glass (1 liter) into the soil and it is a trap for animals with surface activity. Ground traps during the whole growing season (March – October) were exposed and have been renewed in the monthly intervals. Invertebrates (rarely vertebrates), which move on the surface of the soil, fall into the jar with preservative fluid 4% formaldehyde. Obtained biological material was determined in the appropriate taxonomic categories on the Department of Environment and Zoology. This method is used for determine qualitative and quantitative composition of epigeic communities.

Characteristics of locality

The experiment was carried out on the locality Kolíňany, located near the city of Nitra. Cadastral area falls to the climatic region MT2 (temperate warm, slightly moist), with the sum of temperature 2 200 – 2 500 °C with a probability of dry growing season 15-30%, with an average annual temperature of air 7-8°C, with an average rainfall of 550-700mm. Monitored territory belongs to the maize production area with the flat terrain, with 87% of degree of plowing and 8% of permanent grassland (ŠPÁNIK et al., 2000).

Organization of the experiment was as follow: the experimental area for each crop included 4 ways of fertilization with organic fertilizers (farmyard manure and bio sludge in specific doses and intervals) and unfertilized control (Table 1). Each level of fertilization was 3 shots of drill at 6m with length of 100m →18 x 100 = 1800m^{-2}. Organic fertilizer only in the middle 6m waist was applied. Marginal two straps were insulating. Various dosages of organic fertilizers were from each other separated by 12m wide insulating areas (at 6m from each variant). Area of one crop was 0.9ha (5x18=90m wide x 100m long). Within crop rotation annually was selected, in which the ground traps were placed, the 2004 Sunflower (*Helianthus annuus*), the 2005 sugar beet (*Beta vulgaris*), the 2006 maize for silage (*Zea mays*).

Table 1

Doses of organic matter on the individual treatments

Treatments	*Doses of organic matter on the individual variants*
1. treatment	*unfertilized control*
2. treatment	*25 t.ha^{-1} farmyard manure*
3. treatment	*50 t.ha^{-1} bio sludge*
4. treatment	*50 t.ha^{-1} farmyard manure*
5. treatment	*100 t.ha^{-1} bio sludge*

Data analysis

For analysis of data were used and calculated: abundance, dominance and faunistic similarity by Jaccard (I_A), identity of dominance by Rennkonen (I_D) and degree of diversity by Shannon-Weaver (d) (LOSOS et al., 1984).

RESULTS AND DISCUSSIONS

During the two year period 2005 – 2006 were together in the 5th treatments collected 25,616 exemplars of epigeic component of individuals. Of this number 12,096 exemplars was form the order Coleoptera, which was subsequently determined for individual families, which was aim of the work. Coleoptera was in the year 2005 represented by 5,600 ex and in the year 2006 were collected 6,496 ex, all of which belong to 15 families. To evaluate the impact of year it can be state that in the year 2006 higher abundance was found, which is possibly associated with present vegetation (Zea mays) and climatic conditions, referred influenced qualitative and quantitative composition of the monitored populations. Evaluation of monitored years, treatments and representation of present epigeic groups presented Table 2 and 3. Dominant families during both years was family Carabidae, which represented in the year 2005 was 63.86% (3,576 ex) and in the year 2006 was 67.19% (4,364 ex), family Staphylinidae with dominance in first year of 20.07% (1,124 ex) in second year 18.22% (1,184) and family Silphidae with dominance 5.23% (293 ex) in first year and in second year 9.54% (620 ex). That corresponds with the findings of ANDERSEN AND ELTUNA (2000), CHABERT AND BEAUFRETON (2005) who considered the dominant family Carabidae from the view of the existence in biotopes for predators who hunt various insects, their larvae, earthworms, mollusks and some species are herbivorous too, only a small part are pets of agricultural crops, thereby in nature involved in maintaining of biological balance. PORHAJAŠOVÁ AND ŠUSTEK (2011) states on the basis of the results that the families Carabidae and Staphylinidae are in mutual negative correlation, which is clearly linked with similar requirements to habitat and family Staphylinidae negative response to implemented agronomic practices in agricoenose. The presence of other families for example Coccinelidae, Cryptophagidae, Scarabaeidae and other with their occurrence confirmed lower representation at the level recendent respectively

subrecendent reperentation. Despite of their low abundance it must be concluded that the presence of the smaller populations contributes to the biodiversity of agroecosystems and with their presence ensure the smooth running of ecosystems.

Table 2

Occurrence of families of order Coleoptera on the locality Kolíňany in the year 2005 (in the crop *Beta vulgaris*)

	1.treatmet		2.treatment		3.treatment		4.treatment		5.treatment		Total	
Families	∑	%	∑	%	∑	%	∑	%	∑	%	∑	%
Anthicidae	20	2.13	20	1.19	36	5.84	4	0.42	32	2.25	112	2.00
Carabidae	612	65.11	1,148	68.33	360	58.45	372	39.41	1,084	76.34	3,576	63.86
Coccinelidae	-	-	-	-	4	0.65	-	-	-	-	4	0.07
Curculionidae	-	-	4	0.24	-	-	-	-	-	-	4	0.07
Cryptophagidae	48	5.11	20	1.19	20	3.25	32	3.39	76	5.35	196	3.50
Dermestidae	-	-	4	0.24	-	-	-	-	-	-	4	0.07
Histeridae	-	-	20	1.19	-	-	-	-	-	-	20	0.35
Chrysomelidae	20	2.13	-	-	16	2.59	32	3.39	12	0.84	80	1.43
Liodidae	-	-	4	0.24	-	-	-	-	-	-	4	0.07
Nitidulidae	-	-	-	-	-	-	16	1.69	-	-	16	0.28
Ptiliidae	-	-	-	-	-	-	-	-	4	0.28	4	0.07
Scarabaeidae	44	4.68	28	1.67	16	2.59	55	5.83	20	1.41	163	2.93
Silphidae	8	0.84	228	13.57	4	0.65	45	4.76	8	0.56	293	5.23
Staphylinidae	188	20.0	204	12.14	160	25.98	388	41.11	184	12.97	1,124	20.07
Total	940	100	1,680	100	616	100	944	100	1,420	100	5,600	100

Table 3

Occurrence of families of order Coleoptera on the locality Kolíňany in the year 2006 (in the crop *Zea mays*)

	1.treatmet		2.treatment		3.treatment		4.treatment		5.treatment		Total	
Families	∑	%	∑	%	∑	%	∑	%	∑	%	∑	%
Anthicidae	-	-	4	0.18	4	0.36	-	-	4	0.69	12	0.18
Carabidae	992	77.02	1,516	70.71	620	55.36	832	60.64	404	70.65	4,364	67.19
Coccinelidae	-	-	4	0.18	4	0.36	8	0.58	8	1.39	24	0.37
Cryptophagidae	-	-	16	0.75	8	0.71	8	0.58	-	-	32	0.49
Dermestidae	4	0.31	8	0.37	-	-	-	-	-	-	12	0.18
Elateridae	-	-	4	0.18	-	-	4	0.29	4	0.69	12	0.18
Chrysomelidae	8	0.62	12	0.57	-	-	8	0.58	-	-	28	0.45
Liodidae	-	-	4	0.18	-	-	-	-	72	12.59	76	1.17
Nitidulidae	-	-	-	-	4	0.36	8	0.58	-	-	12	0.18
Scarabaeidae	36	2.79	12	0.57	12	1.07	60	4.38	-	-	120	1.85
Silphidae	80	6.21	284	13.25	36	3.21	220	16.04	-	-	620	9.54
Staphylinidae	168	13.05	280	13.06	432	38.57	224	16.33	80	13.99	1,184	18.22
Total	1,288	100	2,144	100	1,120	100	1,372	100	572	100	6,496	100

On the basis of the cumulative abundance of present families of order Coleoptera (Table 4) we can evaluate the impact of treatments as follows. In term of abundance it seen as the best second treatment with application 25 t ha^{-1} of farmyard manure (3,824 individuals), 4. treatment with application 50 $t.ha^{-1}$ of farmyard manure (2,316 individuals), followed by the 1. treatment as unfertilized control, without application of organic matter (2,228 individuals), 5. treatment with application 100 $t.ha^{-1}$ of bio sludge (1,992 individuals) and 3. treatment with application 50 $t.ha^{-1}$ of bio sludge (1,736 individuals). Clearly it can be concluded that the application of farmyard manure positively influenced the occurrence of present epigeic groups,

but must be take into account the primary effects such as the climatic factors of habitat, present vegetation but also interaction, migration and activity of the populations.

Table 4

Cumulative abundance of families of order Coleoptera, during the years 2005 and 2006

	1.treatmet		2.treatment		3.treatment		4.treatment		5.treatment		Total	
Families	∑	%	∑	%	∑	%	∑	%	∑	%	∑	%
Anthicidae	20	0.89	24	0.63	40	2.30	4	0.17	36	1.81	124	1.02
Carabidae	1,604	71.99	2,664	69.66	980	56.45	1,204	51.98	1,488	74.69	7,940	65.64
Coccinelidae	-	-	4	0.10	8	0.46	8	0.34	8	0.40	28	0.23
Curculionidae	-	-	4	0.10	-	-	-	-	-	-	4	0.03
Cryptophagidae	48	2.15	36	0.94	28	1.61	40	1.73	76	3.81	228	1.88
Dermestidae	4	0.18	12	0.31	-	-	-	-	-	-	16	0.13
Elateridae	-	-	4	0.10	-	-	4	0.17	4	0.20	12	0.09
Histeridae	-	-	20	0.52	-	-	-	-	-	-	20	0.16
Chrysomelidae	28	1.26	12	0.31	16	0.92	40	1.73	12	0.60	108	0.88
Liodidae	-	-	8	0.21	-	-	-	-	72	3.61	80	0.65
Nitidulidae	-	-	-	-	4	0.23	24	1.04	-	-	28	0.23
Ptiliidae	-	-	-	-	-	-	-	-	4	0.20	4	0.03
Scarabaeidae	80	3.59	40	1.05	28	1.61	115	4.96	20	1.01	283	2.34
Silphidae	88	3.95	512	13.39	40	2.30	265	11.46	8	0.40	913	7.55
Staphylinidae	356	15.98	484	12.66	592	34.10	612	26.42	264	13.25	2,308	19.08
Total	2,228	100	3,824	100	1,736	100	2,316	100	1,992	100	12,096	100

Table 5

Values of species identity by Jaccard /I_J/ and identity of dominance by Rennkonen /I_D/

Treatments	I_J /%/	I_D /%/
1.-2.	61.54	89.38
1.-3.	70.00	79.76
1.-4.	63.64	78.66
1.-5.	58.33	90.29
2.-3.	57.14	74.44
2.-4.	64.28	78.67
2.-5	58.33	85.92
3.-4.	90.00	85.58
3.-5.	81.82	75.53
4.-5.	75.00	69.48

Similarity of present populations/zoocoenoses within each treatment expresses Jaccard number (I_J). From the calculated values it is clear that the similarity of treatments respectively examined Zoocoenoses ranges from 57.14 to 90.00%, the highest consensus within 3.-4. treatment was found, probably because of the proximity of the treatments (Table 5). Listed is according to Porhajašová (2011) influenced by abiotic as well as biotic factors such as intraspecies and interspecies relations which vary according to environmental conditions. More decisive way of comparing of populations is use index identity of dominance by Rennkonen (I_D), which ranged from 69.48% to 90.29% and confirms the similarity of surveyed sites with applying all biotic and abiotic factors (PORHAJAŠOVÁ et al., 2008).

When evaluating the stability of monitoring sites / treatments was calculated diversity index (d) which taking into account the overall state of biocenosis and homeostatic abilities of agroecosystems (Table 6). From the calculated index, which ranges from 0.95345 (5. treatment) to 1.31768 (4. treatment) it is clear that in terms of self-regulation is habitat fully functional. When we comparing it with index of diversity in natural ecosystems (Nature Reserve Alluvium Žitavy) in which reached diversity index value of 2.8709 is to be noted that anthrorpic pressure contributes to lowering the quality of ecosystems (PORHAJAŠOVÁ et al., 2014).

Table 6

Results of diversity index (d) within the individual treatment

	1. treatment	2. treatment	3. treatment	4. teratment	5. treatment
d	0.96777	1.00623	1.07829	1.31768	0.95345

CONCLUSIONS

During the two years period 2005 and 2006 was on the locality Kolíňany by earth traps method collected 25,616 exemplars of epigeic components of individuals. Dominant representation showed order Coleoptera (12,096 exemplars). The aim of the study was to determine the order Coleoptera on individual families and determine the impact of the application of organic fertilizers on the occurrence of these families. Dominant families during both years were families Carabidae with 67.19% representation, Staphylinidae with 18.22% representation and family Silphidae with 9.54% representation. Other families such as Coccinelidae, Cryptphagidae, Scarabaeidae and other noted lower, recendent respectively subrecendent representation. Following the evaluation of the impact of treatment – specified doses of organic fertilizers can be evaluated 2. and 4. treatment as treatments with the highest abundance, that the application of farmyard manure can be evaluated in terms of favorable affect on the incidence of epigeic groups as positive. Based on the calculated indexes can be monitored agroecosystem with the application of defined doses of organic fertilizers in term of self-regulation and homeostatic ability assessing as fully functional.

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BIBLIOGRAPHY

1. ANDERSEN, A. – ELTUN, R. 2000. Long-term developments in the carabid and staphylinid (*Coleoptera, Carabidae and Staphylinidae*)fauna during conversion from conventional to biological farming. In: J. Appl. Entom. No. 124. 2000. pp. 51-56. ISSN 0931-2048.
2. BLAŽEK, R. – PAVLÍČEK, T. 1986. Bioindikace ekologické rovnováhy zemědělsky využívané krajiny s použitím čeledi střevlíkovití (Coleoptera, Staphylinidae). Práca SVOČ, Univerzita J.E. Purkyně – PF. 1986. 44 s.
3. CHABERT, A. – BEAURETON, CH. 2005. Impact de Quelques culturales sur les *Carabes, Araignees, Staphylins*. In: AFPP- 7e Conference Internationale sur les ravageurs en agriclture Montpellier. 2005. pp. 1-10.
4. LENGERKEN, V. – HANNS, V. 1983. Biologie der Tiere Deutschlands-*Coleoptera*. Entomologický ústav ČSAV. Praha. 1983. 40 s.
5. LOSOS, B. – GULIČKA, J. – LELLÁK, J. – PELIKÁN, J. 1984. Ekologie živočichů. SPN Praha, 1. vydanie, 1984. 300 s.
6. PETŘVALSKÝ, V. 1997. Vybrané populácie živočíchov ako indikátor zaťaženia ekosystémov. In: Zb. z medzin. vedec. konf. „Cudzorodé látky v životnom prostredí". 1997. s. 133–137.

7. PORHAJAŠOVÁ, J. – PETŘVALSKÝ, V. – ŠUSTEK, Z. - URMINSKÁ, J. – ONDRIŠÍK, P. – NOSKOVIČ, J. 2008. Long-termed changes in ground beetle (*Coleoptera: Carabidae*) assembleges in a field treated by organic fertilizers. In: Biologia-Section Zoology. Vol. 63. No. 6. 2008. pp. 1184–1195. ISSN 1336-9563.
8. PORHAJAJŠOVÁ, J. 2011. Vplyv aplikácie organických hnojív na Priestorovú štruktúru bezstavovcov s dôrazom na čeľaď *Carabidae*. In: Habilitačná práca. 2011. 133 s.
9. PORHAJAŠOVÁ, J. – ŠUSTEK, Z. 2011. Priestorová štruktúra spoločenstiev bezstavovcov s dôrazom na čeľaď *Carabidae* v prírodnej rezervácii Žitavský luh. Vedecká monografia. 77s. ISBN 978-80-552-0578-6.
10. PORHAJAŠOVÁ, J. – NOSKOVIČ, J. – RAKOVSKÁ, A. – TOBIAŠOVÁ, E. 2014. Dynamics of occurrence of dominant species *Pseudoophonus rufipes* (De Geer, 1774) at Hordeum sativum, var. Annua and Hordeum sativum, var. Biennis. In: RJAS. Vol. 46, No. 2, 2014. pp.290-296. ISSN 2066-1843
11. ŠPÁNIK, F. – ŠIŠKA, B. – TOMLAIN, J. – REPA, Š. 2000. Ukazovatele agroklimatickej rajonizácie poľnohospodárskej výroby na Slovensku v podmienkach klimatickej zmeny. In: Štúdia SBKS SAV XVII. Roč. 15. 2000. 54 s. ISBN 80-7137-885-0.