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Original Paper

Coleoptera families fluctuation depending on the organic fertilizers application

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The aim of this work was to evaluate the impact of application of defined doses of organic fertilizers (manure and bio sludge) to the occurrence of family of Coleoptera fauna, during six years period of 2004–2009. Experiment was carry out on the locality Kolíňany, by earth traps method, which were exposed in the five treatments (1st treatment – control treatments; 2nd treatments – 25 t ha^{-1} of the manure; 3rd treatment – 50 t ha^{-1} of bio sludge; 4th treatment – 50 t ha^{-1} of the manure; 5th treatment – 100 t ha^{-1} of bio sludge). Each year the traps were exposed in different crops: 2004 – *Helianthus annuus*; 2005 – *Beta vulgaris*; 2006 – *Zea mays*; 2007 – *Beta vulgaris*; 2008 – *Hordeum vulgare*; 2009 – *Helianthus annuus*. Altogether there were trapped 60,406 exemplars of Coleoptera fauna, that according taxonomic point of view belonging to the 16 families. The year, temperature and precipitation had positive impact on the incidence of families in the year 2009, when we obtained 18,436 ex and in the year 2008, when we found 15,201 ex. Abundance of exemplars during other studied years was significantly lower. The impact of year on an occurrence of families showed significant influence ($P = 0.05–0.01$) for families Anthicidae, Chrysomelidae, Cryptophagidae, Elateridae and Staphylinidae. The statistical evidence was not reflected (P >0.05) for families Carabidae, Coccinelidae, Curculionidae, Dermestidae, Histeridae, Lathridiidae, Liodidae, Nitidulidae, Ptiliidae, Scarabaeidae and Silphidae. Impact of temperature and precipitation recorded evidence for families Anthicidae, Chrysomelidae, Elateridae, Staphylinidae. Other families showed no statistically evidence of impact of temperature and precipitation. The most favorable conditions for evidence of families of Coleoptera fauna were as follows: 1st treatment – control treatment (13,574 ex), 3rd treatment – 50 t ha^{-1} of bio sludge (13,318 ex), 2nd treatment – 25 t ha^{-1} of the manure (12,286 ex), 5th treatment – 100 t ha^{-1} of bio sludge (10,904 ex) and 4th treatment – 50 t ha^{-1} of the manure (10,324 ex). Eudominant representation within all treatments and years showed the family Carabidae, with dominance from 95.53% to 98.32%. Compared similarities the values of species identity by Jaccard (I_A) ranged from 75.00 to 100.00% and values of identity of dominance (I_D) ranged from 93.71 to 97.58%. We can conclude that realized anthropogenic inputs does not negatively affect occurrence of present geobiocoenosis.

Keywords: biodiversity, bio sludge, Carabidae, epigeic group, family, manure

1 Introduction

The soil edaphon is an important component of biocoenosis, reflects the burden on biotopes and is an important bio-indicator of environmental quality. Presence of Coleopterofauna in natural and artificial biocoenosis plays an important role, which is related to the huge number of species and mainly with their great abundance. Mutual relationships between species and their dependence on the environment are multiple and very complex (Petřvalský et al., 2007). Results from studies of epigeic components of individuals with an emphasis on order Coleoptera, according to Schwerk and Dymitryszyn (2015) showed that diversification of biotopes and its environmental characteristics are important particularly in terms of diversity of species. Order Coleoptera is represented by 166 families, in Central Europe it is 108 families, with huge abundance of species. The most numerous and economically the most important families in ecosystems Carabidae, Staphylinidae, Cerambycidae, Elateridae, Curculionidae, Histeridae and other are found. All of them are possible in a way described as economically important species. Abundance of order Coleoptera in ecosystems is given by the ration between the soil characteristics, the degree of humidity, altitude and by presence of vegetation. For example the moist and shaded biotopes favored species of families Curculionidae, Cantharidae, Nitidulidae (Lengerken and Hanns, 1983). Nietupski et al. (2015) states that factors influencing species composition, of almost always dominant family Carabidae, are mainly way of land uses, variability of environmental conditions, environmental moisture and impact of surrounding habitats. Varvara (2010), Gongalsky and Cividanes (2008) considered as critical

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factors temperatures, soil type, sufficient amount of food, completion, then any changes in ecological factors in ecosystems are real. Boháč (2005) considered that the environment influenced the shape of body for example species living under the bark (family Cucujidae) have narrow, flat body, species inhabiting the soil (family Staphylinidae) have very slim and narrow body, etc. Povolný and Šustek (1985) investigated synanthropy of individuals of populations of Carabidae and Sarcophagidae. For families Sarcophagidae occurs in anthropobiocoenoses to the selecting of set strictly synanthropic species with varying intensity of strict bonds to human settlements, in case of Carabidae that set do not exists because the individuals of this families stay within the boundaries strictly bound to torsos of green vegetation. Porhajašová and Šustek (2011) state that he overgrowth of Formicoidae causes the reduction in frequency of species of Carabidae and Staphylinidae, which in extreme cases can lead to their disappearance from the locality. According to Thomas et al. (2002) intensive farming with the use of pesticides and industrial fertilizers has negative effect to the population of Coleoptera faun and sustainable agriculture creates favorable conditions for its existence.

The aim of this paper was to investigate the effects of different doses of organic fertilizers to the diversity of order Coleoptera, with an emphasis on the evaluation of the families belonging to this order.

2 Materials and methods

2.1 Characteristics of locality

The experiment was realized at the locality of Kolíňany, with coordinates 48° 21´ 41´´ north west latitude and 18° 12´ 37´´ east west Jongitude. Locality is part of flat maize production area, the climatic region is moderately warm and slightly wet, with sum of temperatures 2 200–2 500 °C, with average annual air temperature 7–8 °C and average rainfall 550–700 mm (Špánik et al., 2000). The average monthly temperature was ranged from 9.6 to 11.4 °C during the whole research period and the amount of monthly precipitation varied from 507.1 to 633.0 mm during the whole research period (Repa and Šiška, 2004; Šiška and Čimo, 2006; Weather condition of the years 2007, 2008, 2009).

2.2 Characteristic of experiment

The experiment was realized during the years 2004–2009, on the locality Kolíňany, by the method of earth traps exposed in the five variants with application of organic fertilizers, as follows:

- 1st variant – control;
- 2nd variant –25 t ha^{-1} of the manure application;
- 3rd variant – 50 t ha^{-1} of bio sludge;
- 4th variant – 50 t ha^{-1} of the manure;
- 5th variant – 100 t ha^{-1} of bio sludge.

Every year the traps were exposed in different crops: 2004 – *Helianthus annuus*; 2005 – *Beta vulgaris*; 2006 – *Zea mays*; 2007 – *Beta vulgaris*; 2008 – *Hordeum vulgare*; 2009 – *Helianthus annuus*.

Area of one crop was 0.9 hectares (5 × 18 = 90 m wide × 100 m length). Area of whole experiment was 3.6 hectares. The experiment was located along the field airport, 50 meters form field path, by the long strips method.

Collections of epigeic material were realized by earth traps method. The method is based on the location of the open glass jar into the soil (1L – filled up to 1/3 by fixative solution of 4% formaldehyde), with aim to obtain individuals with surface activity. Earth traps were exposed within the crops and treatments during the growing season (April to October). Obtained biological material was taken off in monthly intervals, earth traps were subsequently renewed and in terms of the department was this material determinate.

For the data analysis were used and calculated: abundance, dominance and faunistic similarity by Jaccard (I_A) and identity dominance by Rennkonen (I_D). Obtained results were statistically evaluated, the file did not have uniform distribution, even after use of transformations, so we used nonparametric Kruskal-Wallis test (Vrábelová and Markechová, 2001).

3 Results and discussion

During the six-years period by a method of ground traps, within five variants of collected 60,406 individuals of Coleoptera fauna from a taxonomic point of view pertaining to 16 families, the number of which within individual variations ranged from 12 to 15. The composition, structure and occurrence of biocenoses are dependent on edaphic and climatic factors that determine the functionality of terrestrial ecosystems. In addition to the factors mentioned, an important role in agro-ecosystems are also played by anthropogenic interventions by which we understand the effects of crops being cultivated, inputs of inorganic, in our case, organic fertilizers (farmyard manure and bio sludge), application of pesticides, tillage and other factors. Many from the above mentioned interventions for the present edaphic groups mean a risk and their occurrence is manifested in particular by decreasing their multitude (Porhajašová et al., 2013; Porhajašová et al., 2014; Baranová et al., 2013; Vician et al., 2015).

With respect to a summary evaluation of the influence of the year on the occurrence of an epigeic animal element, the total number of collected individuals (60,406 individuals), across the individual years were obtained the following numbers of individuals, 9,372 in the year 2004, 5,600 individuals in the year 2005, 6,496 individuals in the year 2006, 5,292 individuals in the year 2007, 15,201 individuals in the year 2008, 18,436 individuals in the year 2009. From the results achieved it is obvious that in determining the impact of climate characteristics in increasing abundance during the years of study were taking their share mainly climatic factors, increasing monthly average temperatures and decreasing average values of total monthly rainfalls during the growing season, as evidenced by past years of monitoring (2008 and 2009). More expressive differences found in the years of observation were, however, affected by crops being cultivated, with the most convenient crops being *Helianthus annuus* and *Hordeum vulgare*, which in terms of humidity, temperature, shading and suitability of trophic preference have created the best convenient microclimatic conditions in the habitat, which can be compared with the results obtained by Porhajašová et al. (2014), Peterková (2014), Varvara (2010), who in the case eudominant species of carabidofauna (*Pseudoophonus rufipes* and *Poecilus cupreus*) recorded almost identical results, because the family Carabidae has shown a significantly eudominant representation. Gongalsky and Cividanes (2008) consider a limiting factor for the occurrence of population Coleoptera fauna also the given microclimatic conditions of the habitat, which are a reason for spatial variation in agrocenosis population.

Statistical evaluation of the impact on the incidence of the families was significantly manifested ($P = 0.05$ to 0.01) for families Anthicidae, Chrysomelidae, Cryptophagidae, Elateridae and Staphylinidae. The statistical significancy was not manifested ($P > 0.05$) in the family Carambicidae, Coccinelidae, Curculionidae, Dermestidae, Histeridae, Lathridiidae, Liodidae, Nitidulidae, Ptiliidae, Scarabaeidae and Silphidae. In evaluating a year impact have played an important role also climatic factors, namely, temperature and rainfalls. The influence of temperature and rainfalls has been coincidently recorded as significant in the families Anthicidae, Chrysomelidae, Elateridae, Staphylinidae. No stastistical significance of the influence of climatic factors of temperature and precipitation has been confirmed by other families. When evaluating the treatments effect on the occurrence of coleopterofauna families on the basis of results of abundance and family dominance (Table 1 to 5) the most convenient treatment is the first variant – control variant (13,574 individuals and the third variant 50 t ha^{-1} of bio sludge (13,318 individuals) followed by the second variant 25 t ha^{-1} of the manure (12,286 individuals). Nearly coincidental coleopterofauna representation was exhibited by the fifth variant – 100 t ha^{-1} of bio sludge (10,904 individuals) and the fourth variant – 50 t ha^{-1} manure application (10,324 individuals). Eudominant representation showed only family Carabidae, the occurrence of which varies from 95.53 to 98.32% in all treatments (Table 6), whose presence, according to Kujawa et al. (2006), is important, since they are acting as predators of many pests in agrocenoses and as the first arthropocoenoses colonize the new environments. Woodcock et al. (2010) found that Carabidae showed a big dependence on the landscape structure, which is related to their high mobility required to transfer for a source of food. Another from a numerously occurring families in agrocenoses is

Table 1 Abundance and dominance of the order Coleoptera families, on the locality Kolíňany, 1st control variant

Years	2004		2005		2006		2007		2008		2009	
Family	Σ	%	Σ	%	Σ	%	Σ	%	Σ	%	Σ	%
Anthicidae	16	0.64	20	2.13			12	0.79	10	0.31	4	0.10
Carabidae	2204	86.09	612	65.11	992	77.02	1468	96.58	2818	85.24	3832	96.28
Coccinelidae							16	1.05				
Cryptophagidae			48	5.11					14	0.43	4	0.10
Dermestidae	4	0.15			4	0.31	8	0.53	2	0.06		
Elateridae	4	0.15							142	4.29	12	0.31
Chrysomelidae	4	0.15	20	2.13	8	0.62						
Lathridiidae	12	0.47					4	0.26	6	0.18	4	0.10
Nitidulidae									8	0.24		
Scarabaeidae	24	0.95	44	4.68	36	2.79			2	0.06		
Silphidae	184	7.18	8	0.84	80	6.21	12	0.79	164	4.96	72	1.81
Staphylinidae	108	4.22	188	20.00	168	13.05			140	4.23	32	0.81
Total	2560	100	940	100	1288	100	1520	100	3306	100	3960	100

the family Staphylinidae, within the second, third and fourth variant it recorded a dominant representation, in the incidence was ranging from 5 to 10%. Within the framework of the first and fifth variant the occurrence was only 2 to 5% ie at the level of subdominance (Table 6). The families Carabidae and Staphylinidae are characterized by coincidental demands on the environment, however, in the case of correlation relations, we could not confirmed this fact. Eudominant family Carabidae recorded a highly significant correlation only to the family of Lathridiidae and significant relationship to the family of Silphidae, which can be explained by similar demands on the environment, because they are shade-loving and hydrophilic. The occurrence of other families recorded representation only at the level of subrecedent representation, lower than 1%.

Table 2 Abundance and dominance of the order Coleoptera families, on the locality Kolíňany, 2nd variant

Years	2004		2005		2006		2007		2008		2009	
Family	Σ	%	Σ	%	Σ	%	Σ	%	Σ	%	Σ	%
Anthicidae	36	2.60	20	1.19	4	0.18	12	0.93	6	0.25	12	0.36
Carabidae	1188	85.84	1148	68.33	1516	70.71	1216	95.00	2172	89.38	3228	95.85
Coccinelidae					4	0.18			4	0.16		
Curculionidae	4	0.29	4	0.24								
Cryptophagidae	12	0.87	20	1.19	16	0.75	8	0.63	8	0.33	12	0.35
Dermestidae			4	0.24	8	0.37			2	0.08	4	0.12
Elateridae	12	0.87			4	0.18			44	1.81	8	0.23
Chrysomelidae	12	0.87	20	1.19	12	0.57						
Lathridiidae							8	0.63	2	0.08	4	0.12
Liodidae			4	0.24	4	0.18						
Nitidulidae	4	0.29							6	0.25		
Ptiliidae							8	0.63	2	0.08	4	0.12
Scarabaeidae	20	1.44	28	1.67	12	0.57			4	0.16	16	0.47
Silphidae	20	1.44	228	13.57	284	13.25	24	1.87	90	3.71	56	1.67
Staphylinidae	76	5.49	204	12.14	280	13.06	4	0.31	90	3.71	24	0.71
Total	1384	100	1680	100	2144	100	1280	100	2430	100	3368	100

Table 3 Abundance and dominance of the order Coleoptera families, on the locality Kolíňany, 3rd variant

Years	2004		2005		2006		2007		2008		2009	
Family	Σ	%	Σ	%	Σ	%	Σ	%	Σ	%	Σ	%
Anthicidae	28	0.79	36	5.84	4	0.36	8	0.94	8	0.31	8	0.17
Carabidae	3124	88.65	360	58.45	620	55.36	756	89.15	2216	84.01	4440	97.12
Coccinelidae	20	0.57	4	0.65	4	0.36			2	0.08		
Cryptophagidae	40	1.14	20	3.25	8	0.71	12	1.41	12	0.45	8	0.17
Dermestidae									2	0.08	4	0.09
Elateridae	4	0.11							30	1.13	8	0.17
Chrysomelidae	20	0.57	16	2.59					4	0.15		
Lathridiidae	8	0.23							2	0.08	8	0.17
Nitidulidae					4	0.36			6	0.22		
Scarabaeidae	20	0.57	16	2.59	12	1.07			4	0.15	20	0.44
Silphidae	152	4.31	4	0.65	36	3.21	44	5.19	202	7.65	40	0.88
Staphylinidae	108	3.06	160	25.98	432	38.57	28	3.31	150	5.69	36	0.79
Total	3524	100	616	100	1120	100	848	100	2639	100	4572	100

Table 4 Abundance and dominance of the order Coleoptera families, on the locality Kolíňany, 4th variant

Years	2004		2005		2006		2007		2008		2009	
Family	∑	%	∑	%	∑	%	∑	%	∑	%	∑	%
Anthicidae	32	4.10	4	0.42					14	0.51	4	0.11
Carabidae	644	82.56	372	39.41	832	60.64	712	79.46	2428	88.55	3520	98.32
Coccinelidae	4	0.51			8	0.58	4	0.45				
Curculionidae	8	1.03							2	0.07		
Cryptophagidae			32	3.39	8	0.58	48	5.36	10	0.36	4	0.11
Dermestidae									2	0.07	4	0.11
Elateridae	16	2.05			4	0.29			46	1.69	4	0.11
Chrysomelidae	8	1.03	32	3.39	8	0.58			2	0.07	4	0.11
Lathridiidae							16	1.79	4	0.14	4	0.11
Nitidulidae			16	1.69	8	0.58			8	0.29		
Scarabaeidae	8	1.03	55	5.83	60	4.38			30	1.09		
Silphidae	12	1.54	45	4.76	220	16.04	20	2.23	112	4.09	20	0.57
Staphylinidae	48	6.15	388	41.11	224	16.33	96	10.71	84	3.07	16	0.45
Total	780	100	944	100	1372	100	896	100	2742	100	3580	100

Table 5 Abundance and dominance of the order Coleoptera families, on the locality Kolíňany, 5th variant

Years	2004		2005		2006		2007		2008		2009	
Family	∑	%	∑	%	∑	%	∑	%	∑	%	∑	%
Anthicidae	8	0.72	32	2.25	4	0.69			24	0.58	8	0.27
Carabidae	1072	95.37	1084	76.34	404	70.65	656	87.70	3474	85.06	2824	95.53
Coccinelidae					8	1.39	4	0.53	6	0.15		
Cryptophagidae	8	0.72	76	5.35			32	4.28	30	0.74	4	0.14
Dermestidae	4	0.35										
Elateridae									34	0.83	4	0.14
Histeridae					4	0.69						
Chrysomelidae			12	0.84					2	0.05		
Lathridiidae							4	0.53	6	0.15	8	0.27
Liodidae					72	12.59					8	0.27
Nitidulidae	4	0.35							24	0.59		
Ptiliidae			4	0.28								
Scarabaeidae			20	1.41					10	0.24		
Silphidae	12	1.07	8	0.56			40	5.35	306	7.49	72	2.43
Staphylinidae	16	1.42	184	12.97	80	13.99	12	1.61	168	4.12	24	0.81
Total	1124	100	1420	100	572	100	748	100	4084	100	2956	100

Based on of Kruskal-Wallis test, no variant effect on the occurrence of a family has been manifested at all, all values were insignificant. This is with agreement of Chabert and Beaufreton (2005), who state that the family Staphylinidae and Carabidae has no negative respond respond to agronomic practices implemented in agrocenosis and their abundant occurrence is on cultivated land. By their occurrence other families have confirmed subrecedent representation, by which they have contributed to the agro-system biodiversity and by their presence they ensure the ecosystem functioning.

Table 6 Comparison of dominance of Coleoptera families within the years and variants

	1st variant	2nd variant	3rd variant	4th variant	5th variant
Anthicidae					
Carabidae					
Coccinelidae					
Cryptophagidae					
Curculionidae					
Dermestidae					
Elateridae					
Histeridae					
Chrysomelidae					
Lathridiidae					
Liodidae					
Nitidulidae					
Ptiliidae					
Scarabaeidae					
Silphidae					
Staphylinidae					

eudominant >10%; dominant 5–10%; subdominant 2–5%; recedent 1–2%; subrecedent <1%

Table 7 Values of species identity by Jaccard (I_A) and identity of dominance by Rennkonen (I_D)

Variants	I_A (%)	I_D (%)	Variants	I_A (%)	I_D (%)
1.–2.	80.00	96.43	2.–4.	86.66	95.15
1.–3.	100.00	97.09	2.–5.	93.33	96.10
1.–4.	92.31	93.97	3.–4.	92.31	95.67
1.–5.	80.00	97.58	3.–5.	80.00	97.04
2.–3.	80.00	97.05	4.–5.	75.00	93.71

The values of the generic identity according to Jaccard (I_A) have been calculated on the basis of the identified summary values within the frame of individual variants. Years of observations have not been taken into account in the calculations. From the calculated values it can be stated that faunistic similarity of compared variants ranged from 75.00 to 100.00% (Table 7), which demonstrates similarities of variants and the creation of convenient conditions for the present zoo fauna.

On the basis of dominance of the present families was calculated identity dominance index (I_D), whose values ranged from 93.71 to 97.58% (Table 7). From the calculated values of both indices it follows mutual similarity between variants, which is related to the application of all the abiotic and biotic factors. Based on the results it can be stated that in the composition of populations are in a large extent applied abiotic environmental factors, vegetation cover, but also the effect of biotic relations, intra- and inter generic and these are dependent on environmental conditions Porhajašová et al. (2009). Just species richness of cenosis is a consequence of the diversity of life opportunities in the studied territory and it can be reduced by abundance or lack of any of the biotic, abiotic, or anthropogenic effects. Calculated values can be compared with the values in natural ecosystems, but also in the agroecosystems, where we meet with a relatively high values of dominance identity, which range from 70 to 80% (Kvasničák and Drdul, 2004; Porhajašová et al., 2009).

4 Conclusions

Biodiversity of coleopteran fauna populations is a consequence of diversity of vital opportunities in the monitored territory and it can be reduced by abundance or lack of any of biotic, abiotic, or anthropogenic effects. Present geobiofauna reflects the stability of the community and is a proof of suitability of environmental conditions including inputs in the form of specified doses of organic fertilizer (farmyard manure and bio sludge), which in no way negatively affect the population monitored. Slight fluctuations in the frequency are caused by natural phenomena such as natality and individuals mortality, a constant migration of present individuals, eg. in consequence of trophic preference, or their natural space and activities, respectively.

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