

## Dynamics of occurrence of dominant species *Pseudoophonus rufipes* (De Geer, 1774) and *Poecilus cupreus* (Linn., 1758) depending on the application of organic matter into the soil

Jana Porhajašová\*, Jaroslav Noskovič, Alena Rakovská, Terézia Čeryová

Slovak University of Agriculture in Nitra, Slovakia

The aim of this work was to evaluate the dynamics of the occurrence of dominant species *Pseudoophonus rufipes* and *Poecilus cupreus*, belonging to the family *Carabidae* (*Coleoptera*), during the years 2004–2009, on the locality Kolíňany, by the earth traps method, which were exposed in the five treatments with application of organic fertilizers: 1<sup>st</sup> treatment- control treatments; 2<sup>nd</sup> treatments – 25 t ha<sup>-1</sup> of the manure; 3<sup>rd</sup> variant – 50 t ha<sup>-1</sup> of biosludge; 4<sup>th</sup> variant – 50 t ha<sup>-1</sup> of the manure; 5<sup>th</sup> variant – 100 t ha<sup>-1</sup> of biosludge. 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*. Altogether there were trapped 105654 exemplars of epigeic groups. From the above mentioned 60396 exemplars belonged to the order *Coleoptera*, of which the family *Carabidae* represented 51932 exemplars. As the dominant species were *Pseudoophonus rufipes* with abundance 39432 exemplars and *Poecilus cupreus* 1560 exemplars. The abundance of *Pseudoophonus rufipes* ranged from 304 to 3384 exemplars, maximum abundance was recorded in 2009 (11868 exemplars) in sunflower crop. Minimum frequency was recorded in 2005 (2920 exemplars) in sugar beet crop. Based on the statistic evaluation the dependence of *Pseudoophonus rufipes* on climate factors was highly significant ( $P < 0.01$ ), dependence of treatment was significant ( $P = 0.05$  to  $0.01$ ) and correlation of *P. rufipes* to other species was insignificant. The abundance of *Poecilus cupreus* was 1560 exemplars, with maximum frequency of 460 exemplars in year 2006 in vegetation with corn for silage, the minimum frequency was recorded in year 2007 in the sugar beet crop, with only 52 ex. Within the multiplicity of variants ranged from absence to 156 exemplars (5<sup>th</sup> treatment, year 2004). The statistic evaluation of species dependence of *Poecilus cupreus* to year, temperature and rainfall was highly significant ( $P < 0.01$ ), the dependence of species to evaluated treatment was insignificant ( $P > 0.05$ ). According to the evaluation of specific identity (58.06 to 78.57 %) the ecosystem can be viewed as a significantly influenced by anthropic activity.

**Keywords:** bioindicators, *Carabidae* family, *Coleoptera* order, organic matter, soil organisms

### 1. Introduction

The cycle of matter and flow of energy in ecosystems is condition of life of all organisms. The care for soil organic matter belongs to the decisive yield factors whit their impact on the physical, biochemical and environmental status of the soil. One of the most important priorities of the sustainability is to prevent the decrease of organic matter in soil due to its management (Pospišil and Ržonca, 2008; Filová and Sytár, 2013). Farmer fertilizers form the basis of sustainable systems and consist of residues of plant and animal origin, improve the agrochemical, physical and biological properties of soil. They have favorable impact on the soil, plants and occurrence of zoo faun. The group of organic fertilizers includes the farmyard manure, slurry, manure, crop residues, compost etc. (Demo et al., 2004). Erichson (1978) considers that organic fertilizers improves the soil structure, increase the vitality and density and creates the favorable

microclimate conditions for zoedaphon, including the family *Carabidae*. Many authors submitted that the impact of organic fertilizers on the occurrence of edaphic groups is indirect, as is known the fact that *Carabidae* migrate, if they are in the open country, in the open soil or scattered vegetation. Löwei et al. (2005) and Rawoth et al., (2004), are of the opinion that the application of organic fertilizers has not materially affected on the occurrence of *Carabidae*, what it shows is significantly contrary to the arguments of the Kromp (1990), who discovered that *Carabidae* prefer the application of organic fertilizers. The positive impact of the application of organic fertilizers on the dominance of high tolerant and expandable species *Pseudoophonus rufipes* found Kabacyk and Wasylik (1978), while other species have disappeared. Irmmler (2003), Booij (1994) adds that the changes in ecological parameters of the species of family *Carabidae* are annual natural climate change and then anthropogenic impacts,

\***Correspondence:** Jana Porhajašová, Department of Environmental Sciences and Zoology, Faculty of Agrobiolgy and Food Resources, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, e-mail: jana.porhajasova@uniag.sk

such as the application of organic fertilizers. Species of the family *Carabidae*, which are part of the edaphon can be assessed as a species, their presence contributes to increase of insect biodiversity on farmland, because many species are adapted to the occurrence in the agro-ecosystems. Species *Pseudoophonus rufipes* and *Poecilus cupreus* are evidence of the adaptation to the anthropogenic impacts, because their occurrence in the systems affected by human activity is high dominant. *Carabidae* position as the main and important predator of many parasitic species (aphids) in agro-ecosystems devoted Loughridge and Luff (1983). Attention focused on the most abundant species *Pseudoophonus rufipes*, which hibernates in the larval stage or as an adult and during the growing season disposed ever-increasing number of aphids. In the lab found that for the one day they can consume up to 130 individuals *Myzus persicae* (Sulz.). In natural conditions in the production of cereals identify the effect of temperature on their activity. Low night temperature limit in terms of the survival/activities *Pseudoophonus rufipes* was 6 °C. Expressed the opinion the usefulness of species for predation of aphids is dependent on the border limit of temperature during the growing season. It is assumed that organic fertilizers create favorable microclimatic conditions for the occurrence of epigeon, have a positive impact on the accumulation of different species of family *Carabidae*. The positively influenced on the occurrence of many species *Pseudoophonus rufipes*, *Poecilus cupreus*, *Anchomenus dorsalis*, *Brachinus explodens*, *Calathus fuscipes* and many others (Porhajašová et al., 2008). Šťastná and Bezděk (2001) observed a significantly positive impact of agro-technical interventions on the species *Pseudoophonus rufipes*; incubate the late spring and early summer, which lay their eggs during the summer and fall. Bukejs, Balalaikins (2008) watched the species composition and zoogeographical specificities of *Carabidae* in the wheat agrocenosis of Lithuania. They recorded 41 species, which belongs to the 14 genera, with eudominant representative of species *Poecilus cupreus* and *Pseudoophonus rufipes*. Šťastná and Bezděk, Hartman (2001) found in crops of cereals, that for vernal species agricultural engineering in terms of species and numerous representation did not play important role due to a lower representation of numerous species in ground traps (*Poecilus cupreus*, *Anchomenus dorsalis*). To the autumn species (*Pseudoophonus rufipes*, *Pterostichus melanarius*) had impact stubble. The impact of harvesting was not reflected. Porhajašová et al., (2000) classifies species *Pseudoophonus rufipes* to significantly eurytopic, in the agro-ecosystems widespread, inclining to a wetter environment (impact of vegetation cover), in terms of trophic according to developmental stages abreast of herbivore and carnivore. They require sandy-loam wetter

soil with temperature indication favorable habitat, with ability to vertical migration in soil. Kielhorn et al. (1999), Retho et al. (2008), Saska et al. (2007), Varvara (2010) mentioned within the evaluation of the abundance and dominance of species of the family *Carabidae* in agro-ecosystems for clearly dominant species *Pseudoophonus rufipes*, while other species with their occurrence just complement spectrum of species and got epithet expansive representative of the fauna fields. Andersen (1999) added, that prefers particular cultivated soil and is characterized by wide ecological valence and with other species of the family *Carabidae*, as *Poecilus cupreus*, *Pterostichus melanarius* etc., (Kádár and Szentkirályi, 1997; Šustek, 2007) complement that they belongs to species with relatively tight binding to the environment and if environment does not satisfying, they are capable for two or three hours leave the place. Kielhorn et al., (1999) considered the species *Poecilus cupreus* for the typical and dominant occurring mainly in arable soil. On its occurrence has a positive impact application of organic fertilizers.

The aim of this study was to determine the dynamics of the existence of dominant species *Pseudoophonus rufipes* and *Poecilus cupreus* depending on the application of organic fertilizers. On the basis of calculated indicators and indexes evaluate the homeostasis of agro-ecosystems.

## 2. Material and methods

### 2.1 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. In the field were ground traps exposed at the beginning of the growing season, in the monthly intervals have been renewed until the end of the growing season. Invertebrates, 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 abundance and species composition of epigeic communities, the advantage of this method is relatively high efficiency, realizable and financial modesty, which is dependent on the activity of the species.

### 2.2 Site characteristics

The experiment was carried out on the locality Koliňany, located 10 km northeast from the city of Nitra. Cadastral area falls to the climatic region MT2 (temperate warm, slightly moist), with the sum of temperature 2200–2500 °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 550–700 mm. 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).

The experimental area for each crop included 4 variants of fertilization with organic fertilizers (farmyard manure and bio sludge in specific doses and intervals) and unfertilized control (tab. 1). Each level of fertilization was 3 shots of drill at 6 m with length of 100 m → 18 × 100 = 1800 m<sup>2</sup>. Organic fertilizer only in the middle 6 m waist was applied. Marginal two straps were insulating. Various dosages of organic fertilizers were from each other separated by 12 m wide insulating areas (at 6 m from each variant). Area of one crop was 0.9 ha (5 × 18 = 90 m wide × 100 m 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*), the 2007 sugar beet (*Beta vulgaris*), the 2008 spring barley (*Hordeum vulgare*), the 2009 sunflower (*Helianthus annuus*).

**Table 1** Doses of organic matter on the individual treatments, in the years 2004–2006

Variants	Dose of organic fertilizer
1 variant	unfertilized control
2 variant	25 t ha <sup>-1</sup> farmyard manure
3 variant	50 t ha <sup>-1</sup> bio sludge
4 variant	50 t ha <sup>-1</sup> farmyard manure
5 variant	100 t ha <sup>-1</sup> bio sludge

### Data analysis

For analysis of data were used and calculated abundance, dominance and faunistic similarity by Jaccard (IA), (Losos et al., 1984). Due to uniform distribution of statistical data the data transformations were used – Kruskal-Wallis nonparametric test (Vrábelová and Merkechová, 2001).

### 3. Results and discussion

Functionality of individual types of terrestrial ecosystems is mainly dependent on edaphic and climatic factors of habitat which makes the species composition, structure and evolution of biocenosis. In addition the above mentioned factors important role in agro-ecosystems play anthropogenic interventions such as input of organic and inorganic fertilizers, application of pesticides, tillage and more. All the above mentioned interventions represent risk for present edaphic groups and result in decreasing of frequency (Porhajašová et al., 2013; Baranová et al., 2013; Petřivalský, 1993). In regard to the monitored species *Pseudoophonus rufipes* and *Poecilus*

*cupreus* with their occurrence indicates the degree of the burden and exploitation of agro-ecosystems, respectively of the environment.

Final evaluation must be based on the total number of collected individuals. On the basis of the cumulative abundance can be concluded that the in six-year period totally 105 654 ex of epigeic individuals was obtained as follows: 2004 – 19 048 ex, 2005 – 13 744 ex, 2006 – 11 872 ex, 2007 – 8 404 ex, 2008 – 27 042 ex, 2009 – 25 544 ex was occurred. The most abundant were *Coleoptera*, *Araneida*, *Collembola*, *Opiliona* and others, which significantly contributed to the biodiversity of habitat. As dominant acted *Coleoptera*, which recorded throughout the file during the six-year period represented 60 396 ex, what is the 57.16 %. Within the *Coleoptera* the specific families were determined. Significantly dominant family was family *Carabidae*, which totally recorded 51 932 ex, what representing from the order *Coleoptera* – (2004 – 8 232 ex, 2005 – 3 576 ex, 2006 – 4 364 ex, 2007 – 4 808 ex, 2008 – 13 108 ex, 2009 – 17 844 ex). Compared the variations of number of species of the family *Carabidae* throughout the period depending on the application of organic fertilizers fluctuated as follows tr. 1 – 11 926 ex, tr. 2 – 10 468 ex, tr. 3 – 11 516 ex, tr. 4 – 8 508 ex., tr. 5 – 9 514 ex. On the base of the cumulative abundance the favorable treatment was the first treatment, i.e. control treatment and tr. 3, where the dose of 50 t ha<sup>-1</sup> of bio sludge was applied. On the based of the above mentioned results can be concluded, that the occurrence of treatments was almost equal. Significant differences were noted by the growing crops, the most suitable was Sunflower, which in terms of the humidity, temperature and shading create the best conditions. Climatic factors are crucial for the occurrence of species; trophic competition was also significant. This is in conformity with the findings of Porhajašová et al. (2008).

On the border of dominance was also family *Staphylinidae* (With dominance of 5.91 % i.e.) Presence of other families such as *Silphidae*, *Anthicidae*, *Curculionidae* and other recorded recedent respectively subrecedent representation.

Within the family *Carabidae* 36 species were occurred during the six-year period. Eudominant specie was *Pseudoophonus rufipes*, its occurrence was more or less stable, occurs annually on all variants. It can be evaluated as expansive representative of fauna fields.

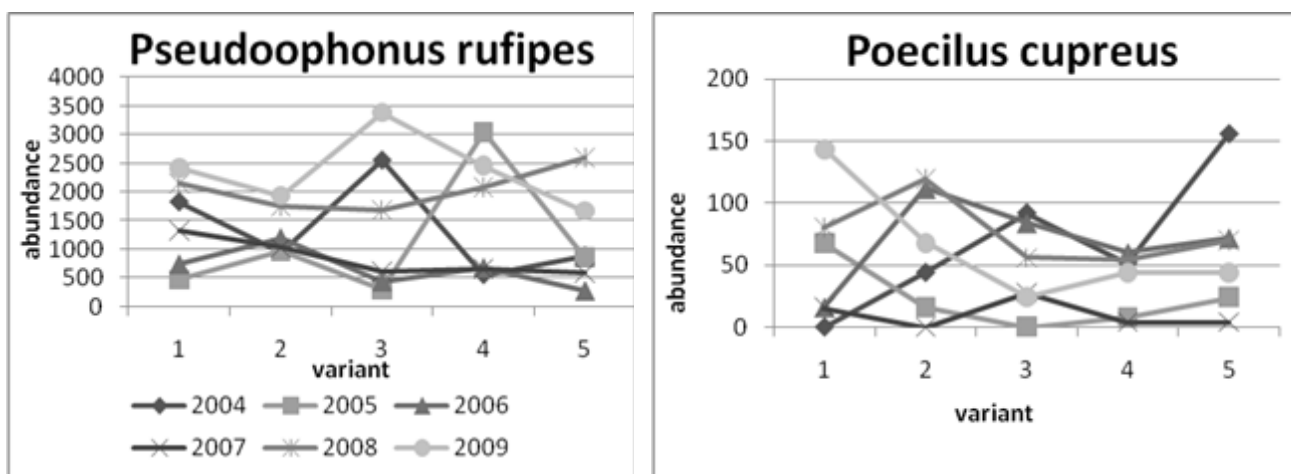
Based on the numerous of individuals within variants its frequency ranged from 304 ex (3<sup>rd</sup> and 4<sup>th</sup> variants in 2005) with a dose of 50 t.ha<sup>-1</sup> bio sludge and 40 t.ha<sup>-1</sup> of manure to 3384 ex (3<sup>rd</sup> variant in 2009), which was applied dose of 50 t.ha<sup>-1</sup> of bio sludge (fig. 1). When we assessing the abundance during the monitored years the maximum incidence in the year 2009 was recorded, where the frequency has reached 11 868 ex,

the minimum incidence 2 920 ex in the year 2005 was recorded (fig. 1). To evaluate variations throughout the period almost identical representation were recorded: tr. 1 – 8 952 ex, tr. 2 – 7 852 ex, tr. 3 – 8 978 ex, tr. 4 – 6 756 ex and var. 5 – 6 894 ex. Total abundance during the years and variations amounted to 39 432 ex, representing a 75.93% of representation of family *Carabidae*. Kielhorn et al., (1999), Retho et al. (2008), Saska et al., (2007) reported in agro-ecosystems as the dominant species *Pseudoophonus rufipes*, which prefers mainly cultivated soil and has wide ecological valence and with other species as *Poecilus cupreus* belongs to the species with tight binding to the environment and this corresponds with the obtained results. Other species with their occurrence just complement the richness spectrum of species (Andersen, 1999). To evaluate the effect of dose of organic fertilizers can be application assessed positively, in particular have been improving the soil structure, vitality of crops, creating favorable topical and trophic conditions for the present species, including the climatic factors, as was confirmed in our case. Irmiler (2003) however believed that the impact of fertilization on the occurrence of species of the family *Carabidae* is non-significant and he considers as determinative habitat conditions. On the basis of the Kruskal-Walis test for the dependent of species depending on the year, variation, precipitation, temperature, repetition *P. rufipes* can be assessed as follows, dependence of specie depending on the year, temperature and precipitation is high significant ( $P < 0.01$ ), the dependence of species from the variant is significant ( $P = 0.05-0.01$ ) and dependence of species from the recurrence is non-significant ( $P > 0.05$ ). Correlation of specie *P. rufipes* and *P. cupreus* was non-significant, but also in relation to other species has been recorded significant dependence. This can be explained by the dominant species is very abundant, ubiquitous and highly expansionary, because it has low correlation

relative to other species, it is called "Classification of neutral type", which is not conditional upon the occurrence of other species.

Based on the dominance and cumulative abundance of species of the family *Carabidae* the dominant occurrence of *Poecilus cupreus* was recorded too. This corresponds with the situation in other agro-ecosystems. *P. cupreus* is typical and dominant occurring mainly on arable land which is consistent with the observed results. Indicated mesophilic nad mezoxerofil species may as numerous also found in peatlands of nature reserve situated in the city (Nietupski et al., 2008).

When assessing the abundance of species *Poecilus cupreus* we recorded abundance of 1560 ex. During the years its abundance was: year 2004 – 344 ex; year 2005 – 116 ex; year 2006 – 460 ex; year 2007 – 52 ex; year 2008 – 380 ex; year 2009 – 324 ex. Based on the foregoing, the particular the year 2007 was in terms of the occurrence extremely low, which may be explained by that the growing crops were sugar beets, which requires more intensive agro-technical interventions than other crops, and these interventions may lead to some reduction of individuals of the study population, similarly in the year 2005 was abundance only 116 ex and again the growing crop was sugar beet. Kielhorn et al., (1999) consider that the species *P. cupreus* is typical and dominant occurring mainly on the arable land, its occurrence has a positively impact the application of organic fertilizers. Within each variant during the six-year period the occurrence was recorded: var. 1 – 324 ex, var. 2 – 360 ex, var. 3 – 284 ex, var. 4 – 222 ex, var. 5 – 370 ex. It can be stated that the presence within variants was close to balance. Its occurrence, depending on the variations during the years ranged from 0 (absence at the first variant in the year 2004, at the third variant in the year 2005, at the second variant in the year 2007). Its maximum abundance of 156 ex at the fifth variant in the year 2004 was recorded (fig. 1).



**Figure 1** Abundance of species *Pseudoophonus rufipes* and *Poecilus cupreus* on the individual variants during the years 2004–2009 in the Koliňany sites

After Kruskal-Wallis test dependence of species on the year, temperature and precipitation, was a high significant ( $P < 0.01$ ), dependence on the variation in the case of *P. cupreus* was non-significant ( $P > 0.05$ ), as well as the dependence of species from recurrence. No relation between occurrence of other species was found. The species *Poecilus cupreus* can be evaluated as a species of field agro-ecosystems, species eurytopic, preferring no shaded habitats of fields, ruderal and meadow.

It can be stated that species *Pseudoophonus rufipes* and *Poecilus cupreus* but also other present groups of individuals indicative by representation topical and trophic environmental conditions. Acting as part of the complex mechanisms, respond to the negative changes and inputs in the soil systems including the transport of pollutants and land management.

To determine the similarity of species composition of compared variations during the whole monitored period the similarity index was used. Calculated values of specific identity within the monitored and compared variants presented in table 2. From the calculated values can be concluded that the similarity of variants and watched zoocoenoses ranged from 58.06 (1<sup>st</sup> and 5<sup>th</sup> variants) to 78.57 (3<sup>rd</sup> and 5<sup>th</sup> variants). The calculated results are real for the agro-ecosystem the strongly influenced by man. On the species composition of populations is largely applied the vegetation cover, abiotic factors of environment but also is applies biotic factors i.e. intraspecies and interspecies relations, which vary according to environmental conditions.

**Table 2** Results of species identity index according to Jaccard ( $I_A$ )

Variants	$I_A$	Variants	$I_A$
1 to 2	63.64	2 to 4	58.82
1 to 3	67.86	2 to 5	62.85
1 to 4	58.62	3 to 4	74.07
1 to 5	58.06	3 to 5	78.57
2 to 3	66.66	4 to 5	75.00

#### 4. Conclusions

Obtained epigeic groups, including the dominant species *Pseudoophonus rufipes* and *Poecilus cupreus* reflect the stability of the community and especially the conditions of monitored habitat where meet together abiotic, biotic environmental factors and anthropogenic inputs, which are fixed by dose of organic fertilizer, manure and bio-sludge. The application of organic fertilizers definitely does not harm population of epigeic groups but positively affects their frequency. Finally, we can evaluate that the present of populations are in a continuous state of flux, we meet with natural phenomena natality and mortality

of individuals, present species are spatially active that could by explain the fluctuations in population levels.

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