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RURAL SETTLEMENTS AS BIOCENTRES FOR CARABID BEETLES (COLEOPTERA, CARABIDAE) IN AGRICULTURAL LANDSCAPE

VESNICKÁ SÍDLA JAKO BIOCENTRA PRO STŘEVLÍKOVITÉ BROUKY (COLEOPTERA, CARABIDAE) V ZEMĚDĚLSKÉ KRAJINĚ

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ABSTRACT

The biodiversity of carabid beetles was studied using pitfall trapping in two small settlements in the agricultural landscape of southern Bohemia (Central Europe) and in the Vltava housing quarter of České Budějovice. The results were compared with surrounding agricultural landscape. The highest number of carabid species in communities was found in the intensively managed agricultural landscape and in Vltava housing quarter. The number of species was lower in villages but the higher activity of stenotopic carabids was typical for these localities. Ordination of species did not found the distinct difference with exception of three species preferring wet biotopes with clay soils. Ordination of samples reflect the clear difference of samples from the surrounding agricultural landscape and samples from the Vltava housing quarter. Rural settlements are suitable for some stenotopic and protected carabids in monotonous agricultural landscape.

Keywords: rural settlements, management intensity, carabid beetles, communities, agricultural landscape, central Europe

SOUHRN

Byla studována biodiverzita střevlíkovitých brouků ve dvou malých vesnicích a panelovém sídlišti Vltava v okolí Českých Budějovicc. Byla použita metoda zemních pastí. Výsledky byly porovnány s daty získanými v okolní zemědělské krajině. Největší počet druhů ve společenstvech byl zjištěn v intenzivně obhospodařované zemědělské krajině obklopující vesnická sídla a na panelovém sídlišti. Počet druhů byl ve vesnicích nižší, ale charakteristická byla vyšší aktivita stenotopních druhů. Ordinace druhů neprokázala zřejmé rozdíly mezi jednotlivými studovanými lokalitami s výjimkou tří druhů preferujících podmáčené biotopy a jílovité půdy. Ordinace vzorků prokázala jasnou odlišnost vzorků z okolní zemědělské krajiny a sídliště. Vesnická sídla slouží jako biocentra pro některé stenotopní a zákonem chráněné druhy v monotónní zemědělské krajině.

Klíčová slova: vesnická sídla, intenzita managementu, střevlíkovití, společenstva, zemědělská krajina, střední Evropa

DETAILNI SOUHRN

Byla studována biodiverzita střevlíkovitých brouků ve dvou malých vesnicích a panelovém sídlišti Vltava v okolí Českých Budějovic. Výsledky byly porovnány s daty získanými v okolní zemědělské krajině. Pro sběr materiálů byla použita metoda zemních pastí. Pět zemních pastí o průměru 7 cm bylo na sledovaných biotopech od září do října v roce 2004 a od dubna do října v roce 2005. Zemní pasti byly naplněny roztokem ethylenglykolu a vody v poměru 1 : 1. Materiál z pastí byl vybírán každý měsíc od 30. října 2004 po 30 říjen 2005. Pro statistické hodnocení byla použita ordinační metoda [4, 10]. Druhy byly rozděleny do ekologických skupin v závislosti na citlivosti k vlivu člověka [1, 7].

Největší počet druhů střevlíků ve společenstvech byl zjištěn v intenzivně obhospodařované zemědělské krajině obklopující vesnická sídla a na panelovém sídlišti. Pro tyto biotopy s velmi intenzivním managementem byla charakteristická naprostá převaha ubikvistních druhů tolerantních k činnosti člověka. Počet druhů ve vesnicích byl nižší, ale charakteristická byla vyšší aktivita stenotopních druhů. Jednalo se zejména o následující druhy střevlíků: *Carabus intricatus intricatus*, *C. nemoralis nemoralis, C. violaceus violaceus, C. scheidleri scheidleri* a *Cychrus rostratus rostratus.* Pro vesnická sídla byla charakteristická přítomnost zákonem chráněného druhu střevlíka *Carabus scheidleri scheidleri.* Velké druhy střevlíků rodu *Carabus* se vyskytovaly pouze ve vesnických sídlech, s výjimkou druhu *C. violaceus violaceus.* Zajímavá je z ekologického hlediska přítomnost druhu *Cychrus caraboides caraboides*, který je potravně vázán na měkkýše. Je však pravděpodobné, že jsou to migrující jedinci z větší populace žijící na sousedním bývalém vojenském cvičišti.

Ordinace druhů neprokázala zřejmé rozdíly mezi jednotlivými studovanými lokalitami s výjimkou tří druhů preferujících podmáčené biotopy a písčité půdy. Ordinace vzorků prokázala jasnou odlišnost vzorků z okolní zemědělské krajiny a sídliště.

Nejvyšší podíl ubikvistních druhů (90 %) byl zjištěn v zemědělské krajině v okolí vesnických sídel. V panelákovém sídlišti dosahoval podíl ubikvistních druhů 97 %. Nižší podíl ubikvistních druhů byl zjištěn ve vesnicích: v Bavorovicích 93 % a v Pohorovicích (87 %). Nižší zastoupení ubikvistních druhů indikuje menší antropogenní vliv a příznivější prostředí pro stenotopní druhy. Vesnická sídla proto mohou sloužit jako biocentra pro některé stenotopní a zákonem chráněné druhy v monotónní zemědělské krajině.

INTRODUCTION

Carabid beetles are one of the most studied insect families. They are also one of the most diverse families, the latest count of the central European fauna revealed more than 600 species [e.g. 6]. They play an important role in the pest control as both

specialist and generalist in their feeding habits. Carabids can have an impact on pest population that is economically significant for farmers [5]. The intensive agriculture with enhanced using of pesticides in the past period resulted in the decline of populations of some species (e.g. *Carabus auratus* in the Western Europe)[12]. The sustainable agriculture can enhance the activity of carabids [e.g. 5]. The structure of carabid communities and the spatial distribution of carabids is affected by the landscape character [11]. The higher frequency of stable natural habitats (e.g. heathlands, forests and woodland) and semi-stable and semi-natural habitats (e.g. hedges, field boundaries and other interstitial habitats) increased the species number and activity and is perspective from some sensitive and stenotopic species.

It is a great number of papers dealing with the landscape ecological studies using carabids [e.g. 5]. We have relatively low knowledge about the carabid communities in small rural settlements on the other side [e.g. 3]. The study of the effect of land use on the carabids of six villages in south and north Bohemia with the different intensity of man management documented that the more intensive management support the number of carabid species. The number of species in particular villages did not depend on the size of the settlement. The classification and ordination of carabid beetle communities in particular sites in villages and in the surrounding fields demonstrated the dissimilarity of field communities from other sites.

The aim of our study was to test the hypothesis that the small settlements can serve as a perspective biotope for carabids in relatively monotonous agricultural landscape.

RESEARCH SITES AND METHODS

Stand and site characteristics

Four localities were studied in the vicinity of České Budějovice in Southern Bohemia. The localities differ by the intensity and type of management character. The localities are situated in an altitude 412-450 m a.s.l. Mean annual temperature was 10.0 °C, annual precipitation was 450 mm. The characteristic of studied localities is the next:

1. Vltava housing quarter in České Budějovice. An area built up with block of flats in the 1970s and 1980s. Green structures are represented by regularly mown meadows, decorative shrub and trees under park arrangement, tens of older remnant trees, vegetation along the road network. The target plant assemblages are based on the species *Quercus robur – Acer* sp. typical new district founded in 80th years of the last century on the previous meadow on the shore Vltava River. The housing quarter is characterized by the high impact of trampling.

2. Bavorovice by České Budějovice. The historical village with preserved green. The historical houses prevailed above some new buldings situated to the margin of village. The surrounding of village is created by gardens, meadows and field.

3. Pohorovice by Vodňany. Small village with older houses and smaller agricultural buildings. The small gardens are situated by all houses. The village is surrounded by fields from three sides. The one direction of the village is represented by a mown meadow.

4. Agricultural landscape surrounded studied settlements. It is represented by fields, meadows and gardens on the border of studied settlements.

Sampling and data analysis

The method of pitfall trapping was used for the collection of carabid beetles. A row of five pitfall traps (diameter 7 cm) was exposed in each locality at September – October 2004 and April – October 2005. Pitfall traps were filled with a mixture of ethylene glycol. The material from the traps was collected every month up to 30 October 2004 and 30 October 2005.

Ordination analysis by the DCA method [4, 10] was made. The degree of human impact was be studied by finding of frequency of species of different ecological groups [7, 1]. For this, the species were divided into groups groups as follows:

- Group R1 (relic species) includes species remaining from communities of past period, e.g. species with arcto-alpine, boreo-montane and boreo-alpine occurrence, inhabiting mainly mountains and peatbogs, or only occurring in remains of forests stands, which because of their high species diversity resemble recent climax forests.

- Group R2 (specialists) encompasses species of both natural and managed forests.

- Group E (generalists or ubiquitous species) comprises eurytopic species that successfully occupy deforested sites and are also found in areas strongly affected by man.

The method of ecological analysis of beetle communities [1] was used for evaluating of community structure particularly. Various characteristics (frequency of ecological groups according to their relation to the naturalness of biotopes, frequency of species with summer and winter activity of imagos, proportion of winged species, various body size groups, thermo- and hygropreference and geographical distribution) were used during this analysis. Increased influence of man was found to bring about an increase in the frequency of eurytopic species, an increase in the frequency of species with summer activity of imagos, and decrease in the proportion of species with winter activity of imagos. One peak in seasonal activity of staphylinids was found in biotopes with increased influence by man in contrast to two peaks in seasonal activity in semi-natural habitats. Furthermore, an increase was also seen in the proportions of winged species and individuals possessing a higher migrating ability, large body size (size Groups IV and V after [1]), species with higher temperature and lower moisture preferences, and species with an area of occurrence wider than

Europe. A decrease in the number of life forms was accompanied by a decrease in the beetle community index. More extensive human activity was also shown to bring about an alternation of the sex ratio.

RESULTS

Carabid beetle communities on studied plots

The number of species found in all studied plots was 23. The number of occurred species was different in studied plots (Table 1). The highest number of species was found in agroecosystems and Vltava housing quarter (17 species in both localities). These localities are characterized by very intensive management. The both rural settlements have the lower number of carabid species in their communities (15 and 14 respectively). It is evident that the higher number of carabid species is not an indicator of less intensive management.

There are mainly ubiquitous species in all studied localities (Table 1). Five species (*Carabus intricatus intricatus*, *C. nemoralis nemoralis, C. violaceus violaceus, C. scheidleri scheidleri* and *Cychrus rostratus rostratus* belong to species with higher claims on the biotopes. The presence of the protected species after Czech law *Carabus scheidleri scheidleri* in rural settlements is surprising. The great species of the carabid beetles from genus *Carabus* occur mainly in rural settlements with exception of *C. violaceus violaceus.* The presence of trophic specialist *Cychrus*

Table 1. Activity of carabid beetles in rural settlement, Vltava housing quarter and in the surrounding agroecosystems (fields, meadows, gardens). E – ubiquitous species, R2 (specialists) - encompasses species of both natural and managed forests.
Tabulka 1. Aktivita střevlíkovitých brouků ve vesnických sídlech, panelovém sídlišti Vltava a v okolní zemědělské krajině (pole, louky, zahrady). E – ubikvistní druhy, R2 (specialisté) - zahrnují druhy vyskytující se v polopřirozených nelesních biotopech a v člověkem neovlivněných i umělých lesních biotopech.

Species	Vltava housing quarter	Bavorovice village	Pohorovice village	Agroecosystems
Agonum muelleri (Herbst, 1784), E	-	5	-	-
Amara aenea (De Geer, 1774), E	26	-	-	15
Amara familiaris (Duftschmid, 1812), E	18	-	-	3
Bembidion lampros (Herbst, 1784), E	-	-	-	5
Calathus fuscipes (Goeze, 1777), E	74	11	33	28

Calathus melanocephalus (Linnaeus, 1758), E	7	-	-	-
Carabus granulatus granulatus (Linnaeus, 1758), E	-	21	39	32
Carabus hortensis hortensis Linnaeus, 1758, R2	7	11	29	2
Carabus intricatus intricatus Linnaeus, 1761, R2	-	-	5	-
Carabus nemoralis nemoralis O. F. Müller, 1764, R2	5	19	39	2
Carabus scheidleri scheidleri Panzer, 1799, R2	-	15	35	2
Carabus violaceus violaceus Linnaeus, 1758, R2	7	-	-	-
Clivina fossor (Linnaeus, 1758), E	-	3	-	2
Cychrus caraboides caraboides (Linnaeus, 1758), R2	4	-	-	-
Harpalus affinis(Schrank, 1781), E	58	13	5	8
Harpalus rubripes (Duftschmid, 1812), E	98	90	27	18
Nebria brevicollis (Fabricus, 1792), E	63	24	24	5
Platynus assimilis	21	9	7	-
Poecilus cupreus (Linnaeus, 1758), E	85	93	159	285
Poecilus versicolor (Sturm, 1824), E	30	51	97	5
Pseudoophonus rufipes (De Geer, 1774), E	52	36	28	46
Pterostichus melanarius (Illiger, 1798), E	51	70	75	119
Trechus quadristriatus (Schrank, 1781), E	5	-	-	4
Sum	484	471	602	581

caraboides caraboides eating snails is very interesting in the Vltava housing quarter. It is possible that this species migrated from the territory of the army exercising ground situated close to the Vltava housing quarter.

Ordination of species

Ordination diagram of species for studies localities (Fig. 2) shows, that the majority of species is situated in the center of axis. Three species are situated outside from this main cluster. It is *Bembidion lampros* populating the initial successional stages often bar soil in fields. The other two species situated separately are *Clivina fossor* and *Agonum muelleri.* These hygrophylic species prefer the clay substrate. Mentioned results document the uniformity of carabid community in agricultural landscape included villages. The community comprises both generalists (e.g. *Amara aenea*, *Poecilus cupreus*, *Pseudoophonus rufipes*) and specialists (e.g. *Cychrus caraboides* and *Carabus violaceus*).

Classification of plots

Classification of plots by the Ward method (Fig. 1) illustrate three distinct groups of samples. The first it is the group of specific samples from the village Bavorovice and Vltava housing quarter. The activity of adults from this samples are from May to August mainly (summer breeding species). The second distinct group is represented by samples from spring and autumn sampling data. This group is more homogenous in all localities. We think that the autumn breeding species prevail in these samples. The third distinct group is from summer sampling data (May-August). This group is most heterogenous.

Ordination of samples

Ordination of samples reflect the clear difference of samples from the surrounding agricultural landscape and samples from the Vltava housing quarter Fig. 3. The samples from villages are very close and particularly overlapping. The greatest difference between localities was found during the sampling in April and May 2005. The samples from the Vltava housing quarter are separated from other samples. The samples from agricultural landscape are in the intermediary position between Vltava housing quarter and villages.

The human effect on beetle communities

The ecological structure of beetle communities discovered by the pitfall trapping in studied localities plots differed very distinctly. The stenotopic species of the Group R1 was not found. The frequency of ubiquitous carabid specimen (Group E) was the highest (about 90 %) in the surrounding agroecosystem in the vicinity of settlements. The frequency of ubiquitous specimen was very high in the Vltava housing quarter (97 %). The frequency of these eurytopic specimen was lower in villages (93 % in Bavorovice and 87 % in Pohorovice). The lowest frequency of ubiquitous species and highest frequency of anthropotolerant species indicate the more suitable conditions for carabid beetles.

Discussion

The diversity of carabid beetles was studied in rural settlement in Czech Republic [3]. It was found that the diversity of carabid beetles was higher in villages with more intensive management. It was assumed, that rural settlement can serve as a biocentrum for beneficial arthropods including carabid beetles in a simple agricultural landscape. This result was supported by our study in south Bohemian villages.

It is evident, that the number of carabid species does not predicate about the quality of biotope or the intensity of management. It is often approved by many authors [e.g. 5] that in intensively managed fields is the higher number of species than in the surrounding landscape. Our results approved this fact – the highest number of carabid species was found in the agricultural landscape. The ubiquitous species prevailed there. The number of species found in villages was lower but the activity of specialist (e.g. *Carabus intricatus intricatus*, *C. nemoralis nemoralis, C. violaceus violaceus, C. scheidleri scheidleri* a *Cychrus rostratus rostratus*) was higher. The protected species *Carabus scheidleri scheidleri* was a typical species occurring in villages. The great *Carabus* species were discovered in villages only with an exception of *C. violaceus violaceus.* The presence of carabid species *Cychrus caraboides caraboides* which is specialist eating molluscs is surprizing in Vltava housing quarter. We are thinking that specimen of this species are a part of the stable population living in the past military area beside of Vltava housing quarter.

The role of semi-stable and semi-natural habitats as hedges, field boundaries is generally known [e.g. 11]. The main importance of these habitats is in overwintering or aestivation places. The larvae of carabids used these habitats as a biotope during its development too. The role of small rural settlements is not so often discussed. Our results support the idea, that the heterogenous environment of villages support the diversity of carabids. Some specialists use this environment as the hibernating place (see the similarity of carabid assamblages from villages in early spring). The communities of carabids from small villages differ from communities of surrounding agricultural landscape and housing quarter. It seems that gardens, shrubs, flower-beds, solitary trees, grass plots are suitable biotopes for some stenotopic and even protected species. The mosaic of these biotopes with different microclimatic characteristics (e.g. soil moisture, organic matter content) has the main effect on heterogeneity of environmental conditions in small villages [3]. It is known that small elevations formed by plants and their rests by the forceless management in agricultural biotopes play the positive role as the shelter for epigeic beetles [2, 8, 9]. All mentioned characteristics create optimal condition for mesophilous carabid species which were found in small villages (e.g. great species of the genus *Carabus*).

The migration possibilities of ground beetles are relatively great [e.g. 11]. The small villages can serve as steps for carabid beetles living in agricultural landscape and play the important role for species living in metapopulation structure. This is supported by our results showing the greater activity of carabid species from villages during spring and autumn.

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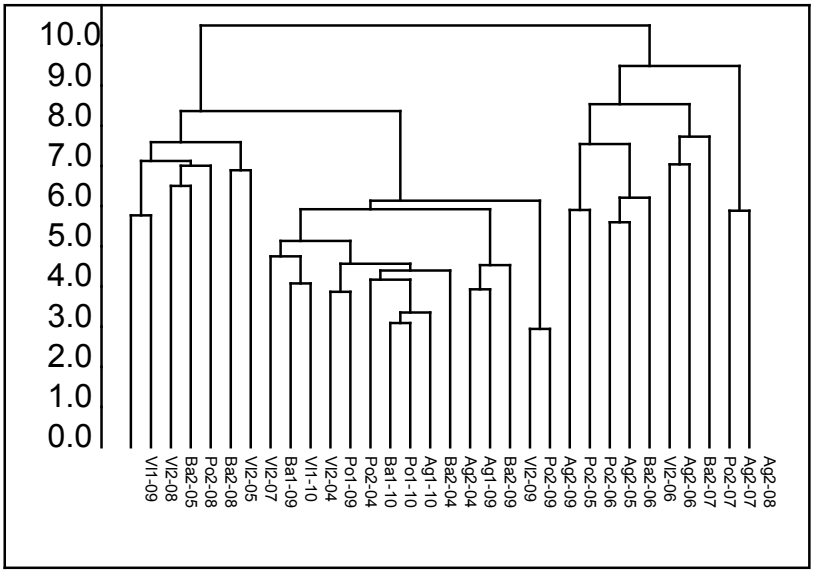

Fig. 1. Classification of carabid beetles samples by Ward´s method with a quadrate of Eucledian distance as a degree of dissimilarity. Species are presented as a logarithmic transformation of the number of specimen (x = log n+1). V – Vltava housing quarter, Ba – Bavorovice, Po – Pohorovice, Agr – surrounding agricultural landscape. 1 – year 2004, 2 – year 2005, months of data sampling are written by roman number.
Obr. 1. Klasifikace střevlíkovitých brouků Wardovou metodou. Druhy jsou prezentovány v logaritmické transformaci počtu jedinců (x = log n+1). V – sídliště Vltava, Ba – Bavorovice, Po – Pohorovice, Agr – okolní zemědělská krajina. 1 – rok 2004, 2 – rok 2005, měsíce odběru vzorků jsou označena číslicemi.

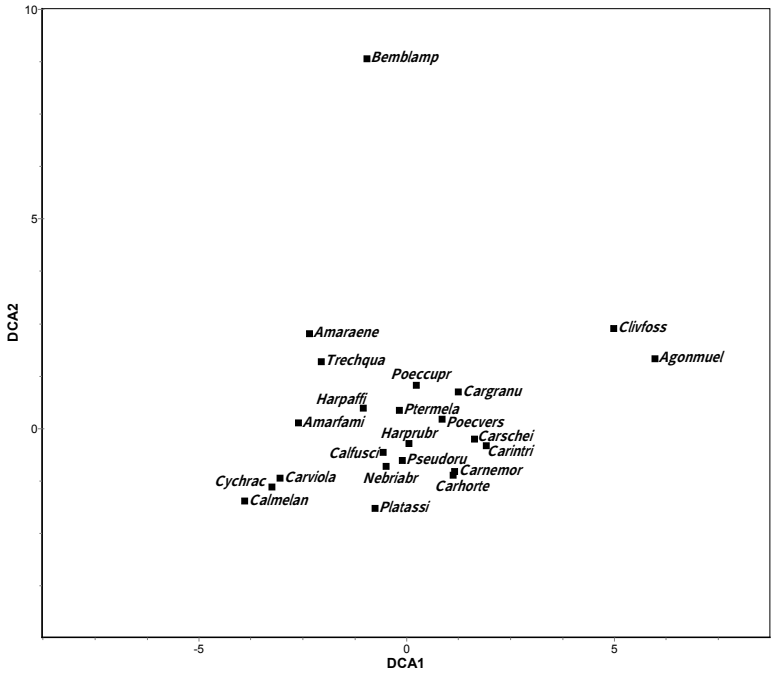

Fig. 2. Ordination of species by DCA method. Abbreviations of carabid species are constructed from the beginning of the genus and species name – see Table 1.
Obr. 2. Ordinace druhů metodou DCA. Zkratky druhů střevlíků jsou tvořeny počátečními písmeny názvů rodu a druhu – viz. Tabulka 1.

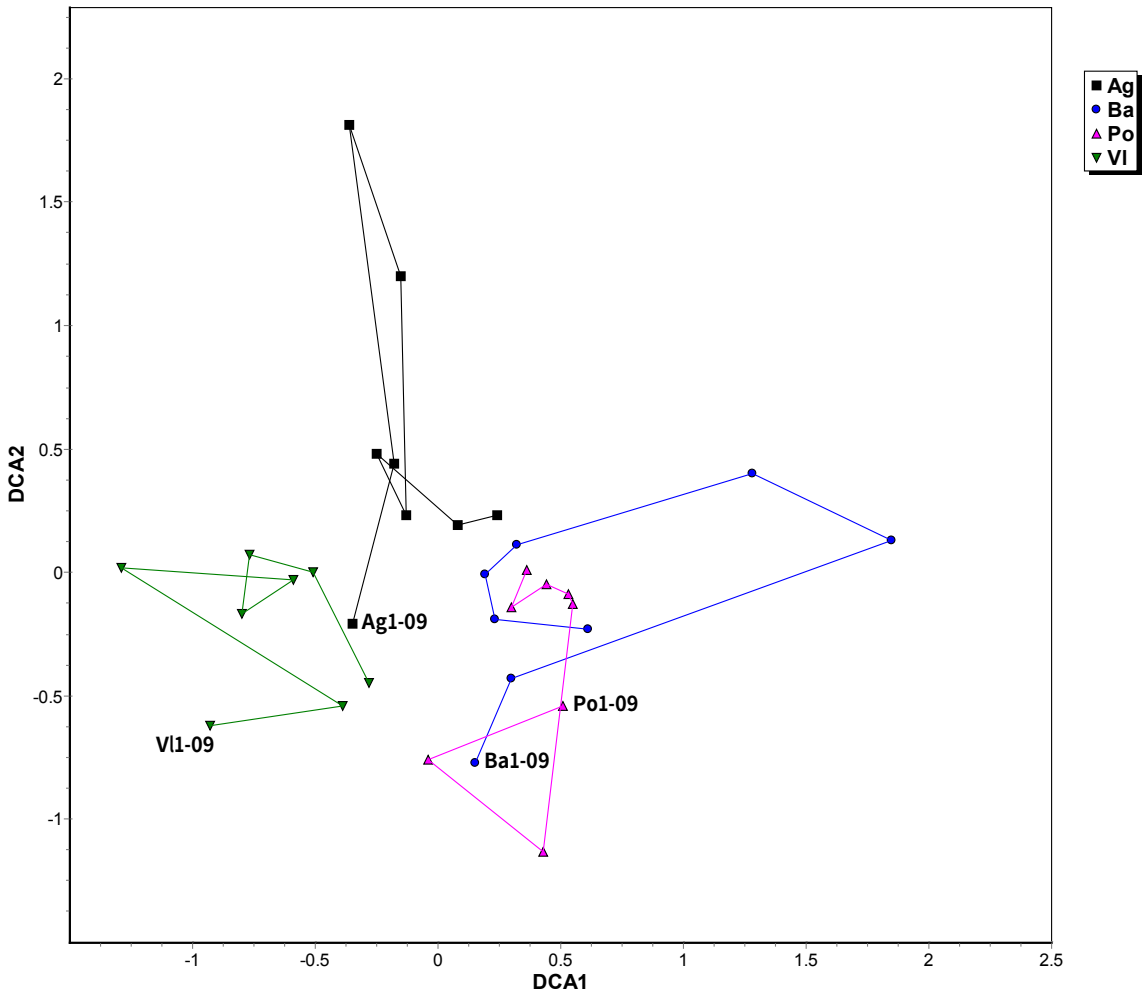

Fig. 3. Ordination of samples by DCA method. The samples from the same localities are connected. Samples of the first collecting (September 2004) are indicated by the name Vl – Vltava housing quarter, Ba – Bavorovice, Po – Pohorovice, Ag – surrounding agricultural landscape.
Obr. 3. Ordinace vzorků metodou DCA. Vzorky z jednotlivých lokalit jsou spojeny. Vzorky prvního odběru (září 2004) jsou označeny následovně: Vl – sídliště Vltava, Ba – Bavorovice, Po – Pohorovice, Ag – okolní zemědělská krajina.