Екол. Зашт. Живот. Сред.	Том	Број	Страна	Скопје
	12	1-2	21 - 30	2009
Ecol. Prot. Env.	Tome	No	pp.	Skopje

SPATIAL VARIATION OF BEETLES (COLEOPTERA) ALONG AN URBAN-RURAL GRADIENT IN THE CITY OF SKOPJE AND ITS SURROUNDING

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ABSTRACT

Prelik D., Gorgievska C.A.,* & Hristovski S. (2009). Spatial variation of beetles (Coleoptera) along an urban-rural gradient in the city of Skopje and its surrounding. Ecol. Prot. Env., Tome 12, No 1/2, 21-30.

The aim of this investigation is to determine the impact of urbanization on beetles (Coleoptera) in three different localities (urban -U, suburban -S and rural-R) along an urban-rural gradient in the city of Skopje and its surrounding, as well as to determine the structure of the community.

The material was collected monthly, during one year period (07.2004–07.2005), by using pitfall traps placed along transect.

Qualitative and quantitative composition as well as seasonal dynamics and spatial variation along the gradient were determined.

The presence of fifteen families was registered: Staphylinidae, Tenebrionidae, Carabidae, Curculionidae, Dermestidae, Cantharidae, Chrysomelidae, Coccinelidae, Elateridae, Histeridae, Scarabaeidae, Silphidae, Anthicidae, Lucanidae, Cerambicidae.

In total, 9.14 ind./trap were found, from which the most abundant were Carabidae (3.03 ind./trap).

Variations of the abundance between different families were noted during the investigation, with highest values in spring-summer period and the lowest in the winter period.

Compared by localities, the abundance did not differ significantly, although the suburban locality had the lowest number of individuals.

Key words: Coleoptera, urbanization, urban-rural gradient

АПСТРАКТ

Прелиќ Д., Ѓорѓиевска Ц.А. и Христовски, С. (2009). Просторно варирање на тврдокрилците (Coleoptera) по должина на урбано-рурален градиент во градот Скопје и неговата околина. Екол. Зашт. Живот. Сред., Том 12, Бр. 1/2, 21-30.

Целта на ова истражување е да се одреди влијанието на урбанизацијата врз тркачите (Coleoptera) во три различни локалитети (урбан – U, субурбан – S и рурален – R) по должина на урбано-рурален градиент во градот Скопје и неговата околина.

Материјалот е колекциониран секој месец, во текот на една година (07.2004 – 07.2005), со помош на ловни замки поставени по должина на трансект.

Одредени се квалитативно-квантитативниот состав, како и просторното и сезонско варирање на тркачите по должина на градиентот.

Регистрирано е присуство на петнаесет фамилии: Staphylinidae, Tenebrionidae, Carabidae, Curculionidae, Dermestidae, Cantharidae, Chrysomelidae, Coccinelidae, Elateridae, Histeridae, Scarabaeidae, Silphidae, Anthicidae, Lucanidae, Cerambicidae.

Во однос на квантитативниот состав, забележани се вкупно 9,14 инд.замка$^{-1}$, од кои со најголема абундантност се издвојуваат тркачите (3.03 инд.замка$^{-1}$).

Во текот на истражуваниот период, забележани се варијации на абундантноста помеѓу различните фамилии, со највисоки вредности во текот на пролетно-летниот период и најниски во текот на зимата.

Следено по локалитети, не е забележана голема разлика во абундантноста, иако субурбаниот локалитет се одликува со најмала бројност.

Клучни зборови: Coleoptera, урбанизација, урбано-рурален градиент

Introduction

Human influence on nature in cities and urban areas causes significant changes in the ecosystem. As a result there is highly modified central part of the city and partly urbanized municipalities (Dickinson, 1996). Central part often contains intact parts which physiognomic are similar to rural parts, but are more polluted, fragmented, wormer, drier and contain exotic species (Gilbert, 1989; Kostel–Hughes, 1995; Kostel-Hughes et al., 1996). Space fragmentation, hunting, reduction of grass surfaces and other changes of the environment cause reduction of species richness, abundance and biomass compared with a rural habitat (Klein, 1989). All of these have influence on species composition. On a global level, urbanization has caused the loss of vast amounts of habitat and caused major modifications of the environmental conditions (Tarvainen et al., 2003).

Today, most people live in and around cities (Douglas, 1992), yet ecological research is focused on rural areas or wilderness (Niemelä, 2000). Urban green areas are, however, important from both an ecological and sociological point of view. Like islands, urban environments contain habitat and species combinations not typically found in the surrounding areas (Frankie and Ehler, 1978). Urban ecological research is also valuable in that these environments can be compared with the surrounding rural environment, thereby improving our understanding of the effect of humans on nature. A way to gauge anthropogenic effects on nature is to study ecosystem structure and function along urban-rural gradients (McDonnell and Pickett, 1990).

Trough examining biotic and abiotic changes along the urban-rural gradients in detail can be evaluated effects of urbanization (McDonnell et al., 1997; Niemelä, 1999, 2000). These gradients from highly populated city core until the ending rural parts reflex the intensive human influence. Such gradients are placed all over the world and obtain sufficient data which comparatively can be analyzed on global level (Niemelä, 2000).

Urbanization impact on terrestrial invertebrates was studied in the city of Skopje in 2006/2007. The results on total macrofauna suggested that urbanization has adverse impact (Gorgievska et al. 2008a). Analysis of the ecology of centipedes and millipedes showed highest abundance in the suburban locality (Gorgievska et al. 2008b). The aim of this paper is to determine the impact of urbanization on the structural characteristics of beetles (Coleoptera), their abundance as well as their qualitative and quantitative composition along an urban to rural gradient.

An obstacle confronting many insect-related projects is the overwhelming diversity of species that can be collected (Disney, 1986). As an alternative to sampling all insects, assemblages of select families of beetles representing different ecological or functional roles have been suggested for use as monitoring tools or indicators of environmental change (Kremen et al., 1993). Beetles (Coleoptera) are considered well suited for such purposes as they display a wide range of functional roles (herbivores, predators, fungivores), they are easily sampled through a variety of passive-trapping methods, and good taxonomic information exists for many families (Hutcheson and Jones, 1999).

They represent an integral component of terrestrial fauna yet they have rarely been considered in light of their value as community indicators. They are known to play a number of important roles (pollination, nutrient cycling and predation) in ecosystems and represent a vital food source for other organisms. Although little studied in these settings, the same have the potential to provide a great deal of information regarding urbanization effects on ecosystems.

Area of investigation

The investigations were conducted in the central part of the city Skopje and its surrounding. Climate is presented according to the measurements of Hydro-meteorological Institute - Meteorological station Zajčev Rid, at approximately 270 m altitude. Skopje city and its environment are characterized by moderately cold winters and warm summers. The average annual temperature is 12.0 ^{o}C. The absolute maximal monthly temperatures reach 42.4 ^{o}C (measured in July), while the absolute minimal monthly temperature is -25.6 ^{o}C (January). Maximal mean monthly temperature is 30.0 ^{o}C (August), while minimal mean monthly temperature is -3.6 ^{o}C (January). Days with absolute minimal temperature were recorded during the whole year, with the exception of the summer period, Mean minimal temperatures below zero were appear in January, February and December . The annual number of tropical days is 50, while the annual sum of summer days is 123. Skopje city has 80 frosty days. Skopje is characterized by relatively small amounts of precipitation during the year. The annual sum of precipitation 502 mm, the lowest is in the warmest month of August (29.0 mm), and the highest is during May (60.8 mm). Compared by seasons, autumn is more rainy than spring. The annual relative air humidity is 69% (Filipovski et al. 1996.). Cloudiness as very important climatic factor for the total energetic of biocenosis. Calculated as mean annual cloudiness is 5,4 parts (by the scale of 10) (Živič, 1988).

Arid period was registered during summer months. Semiarid period exists from the second half of May till the end of October (Fig. 1)

Generally, climate is temperate-warm according to temperature, and semi-arid according to humidity (Filipovski et al. 1996.).

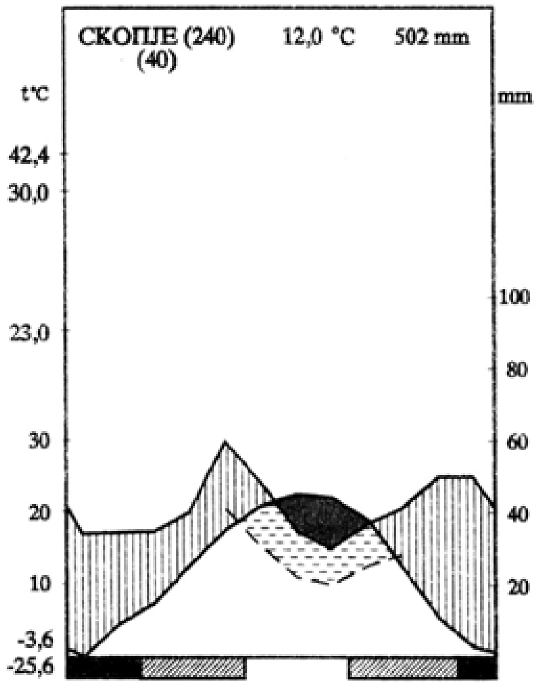

Fig. 1. Climadijagram for the investigation period of 40-years (1951 – 1990) in Skopje city (from Filipovski et al. 1996.)

Сл. 1. Климадијаграм за период од 40 години (1951-1990) во градот Скопје (Филиповски и сор. 1996)

Geological composition is heterogenic. There are almost only clastic sediments, with domination of Tertiary lake and sea sediments (Filipovski et al. 1996).

Characteristics of the investigated localities

A way to investigate the urbanization influence on the environment is to analyze the structure and function of the ecosystem along an urban-rural gradient (McDonnell and Pickett 1990). Urban areas are densely populated, developed and highly urbanized, surrounded with less urbanized areas (Dickinson 1966). According to Shochat et al. (2003), rural areas are residential zones which are not included in the urbanizing plan; suburban areas are those which surround urban parts of the city, with relatively small number of constructing objects (2,5-10 ha) and small amount of green surface (20-50 %); urban areas are the one which are dominated with constructing objects (10 constructing objects /ha). According to Magura et al. (2005), the criteria for urban, suburban and rural areas are the percent of the constructing objects. Namely, this percent in the urban area is 60%, in suburban approximately 30% and in rural area 0%.

Based on the cartographic data (Markovski and Gorin, pers. comm.) for the position of the investigated area, and the appropriate phytocenological analyzes (Kostadinovski, pers. comm.), gradient was placed starting from:

1. Urban locality (U): highly disturbed urban area - the area that is nearest to the swimming poll ”Карпош“ and the Military Hospital. The same is placed in the central part of the city, at the right site of the River Vardar, at the altitude of 252 m, covering the surface area of 1,38 hectares. The frequency of traffic is very intensive, and near by is a constructing object. Also this is part of the city where air pollution is very high. Trees are absent in this locality. Phytocenosis belong to the class of Chenopodietea Br.-Bl. 1952, order Chenopodietalia Br.-Bl. (1931) 1936, alliance Hordeion Br.-Bl. (1931) 1947, as well as parts of other alliances and orders of the same class and parts of communities of grazed habitats.

2. Suburban locality (S). Less disturbed suburban area - the area which almost identically reflects the characteristics of the suburb zone, meaning part which is at appropriate distance from the city center; where urbanization and air pollution are less intensive. The same is named as suburb locality (S) and it is placed near the municipality Madžari and grocery market**.** This locality is placed at the left site of the River Vardar, at the 234,6 m altitude with surface area of 0,788 hectares. The trees are rare, only at the periphery of the biotope. The transects are placed at the quite diverse vegetation surface, with fitocenosis which belong to few classes of ruderal vegetation, such as: Polygono arenastri-Poetea annuae Rivas-Martinez 1975 corr. Rivas-Martinez et al. 1991, Stellarietea mediae Tx. et al. 51, Artemisietea Lohm. et al. 51 et Galio-Urticetea Passarge et Kopecky 69 (Matvejeva, 1982; Čarni et al., 1997, 2002).

3. Rural locality (R). Undisturbed rural area - rural locality (R) is placed nearest to the village Mralino and the road Skopje-Veles, at about 24 km distance from the Skopje city.

This locality is placed at the left site of the River Vardar, at the altitude of 227 m and with surface of 5,1 hectares. Trees are rare and surround the biotope. Although there is some transformation to sinantropic vegetation, the vegetation in this locality belongs to the class of meadow community Molinio-Arrhenatheretea R. Tx. 1937 em. R. Tx. 1970, order Arrhenatheretalia R. Tx. 1937, alliance Cynosurion R. Tx. 1947, Communities are developed on habitat which is used for grazing, which prevents the development of this vegetation to a typical meadow community.

Along the gradient (in all three localities), similar phytocenological composition was noticed (especially between suburban and urban locality), represented with ruderal vegetation.

Material and methods

The investigation was conducted monthly (July 2004-July 2005), by using pitfall traps. Pitfall traps is the usual method for sampling epigean insects. This method is not the most appropriate for direct estimation of absolute true density, but it is useful to compare population size and community structure in space and time (Dent & Walton 1997; Duelli et al. 1999; Perner & Schueler 2004; Grez, et al. 2004).

Within each locality, three transects were randomly placed, each transect line was approximately 50–100 m apart, and at each 10 pitfall traps were placed, 10 m apart. In total, there were three localities, 9 transects and 90 traps. Each pitfall trap consisted of plastic cup, which was placed flush with the surface of the soil. The pitfall traps were half filled (200 ml) with formalin - vinegar solution, in 1:7ratio, which acted as killing and preserving agent of the catch. Plastic roofs were placed at each trap, a couple of centimeters above, to prevent dilution of preservative from the rain water.

During the investigation, temperature and humidity of soil surface (0-5 cm) were also measured.

Collected beetles were analyzed ecologically and taxonomically, classified to families. Qualitative and quantitative compositions as well as structural characteristics of different families of order Coleoptera were determined:

- the abundance as ind.·trap^{-1} of different families of Coleoptera, their seasonal dynamics, spatial variation and dominance, calculated by the formula of Balogh (1958):

$$D = \frac{a_i}{\sum_{i=1}^{n} a_i} * 100$$

where: **n** is number of families, $\mathbf{a_i}$ –number of individuals from the **i** - family, while $\sum_{i=1}^{n} a_i$ is the total number of individuals of Coleoptera.

According to Balogh (1958), families that are present with more than 10% of the individuals are dominant, from 5-9,9% are subdominant, from 1-4,9 % are recendent, less than 1% are subrecendent.

Further statistical analysis was performed by using BRODGAR program.

Results and discussion

During the investigation in Skopje Valley, qualitative and quantitative composition, seasonal dynamics of different families, as well as spatial variation of beetles between three different localities were analyzed.

Tab.1. Qualitative composition of Coleoptera along an urban-rural gradient in the city of Skopje and his surrounding

Таб. 1. Квалитативен состав на Coleoptera по должина на урбано-рурален градиент во градот Скопје и неговата околина

Class INSECTA
- Order COLEOPTERA
  - fam. Carabidae
  - fam. Histeridae
  - fam. Silphidae
  - fam. Staphylinidae
  - fam. Lucanidae
  - fam. Scarabaeidae
  - fam. Dermestidae
  - fam. Cantharidae
  - fam. Elateridae
  - fam. Coccinelidae
  - fam. Anthicidae
  - fam. Tenebrionidae
  - fam. Cerambycidae
  - fam. Chrysomelidae
  - fam. Curculionidae

The abundance of beetles was higher during autumn and spring-summer period (with maximal value in June and July 2005) with the exception for the Chrysomelidae and Curculionidae which had increased abundance in autumn–winter period.

The dynamics shows similar distribution along the gradient, without significant differences in abundance between localities. The only exception is the dynamics in S in spring 2005 when lower values were recorded and maximal values was reached one month later (in July 2005) compared to U and R (Fig. 2.).

In average, 9.14 ind.·trap^{-1} were registered for the whole gradient. In R, there were in 10.34 ind.·trap^{-1}, in S - 7.34 ind.·trap^{-1} and in R - 9.75 ind.·trap^{-1}.

Compared by localities, families Carabidae, Histeridae, Dermestidae, Cerambicidae, Curculionidae, Scarabaeidae, Staphylinidae, reached higher values in rural locality, while Silphidae and Chrysomelidae in suburban and Cantharidae, Coccinelidae and Anthicidae in urban locality. Representatives of the family Elateridae had the lowest abundance in rural locality (Fig. 3, 4, 5).

In total, 9861 (9,14 ind./trap) individuals from 15 families were collected across the urban-rural gradient in Skopje City (Tab. 1). Community structure of the suburban site was substantially different from urban and rural sites. This site yielded lowest number of individuals (2637), while rural site had the highest number (3718 individuals). Carabidae was the most abundant family with 33.2% of the total catch, followed by Tenebrionidae (17.00%), Staphylinidae (14.2%) and Dermestidae (11.0%)

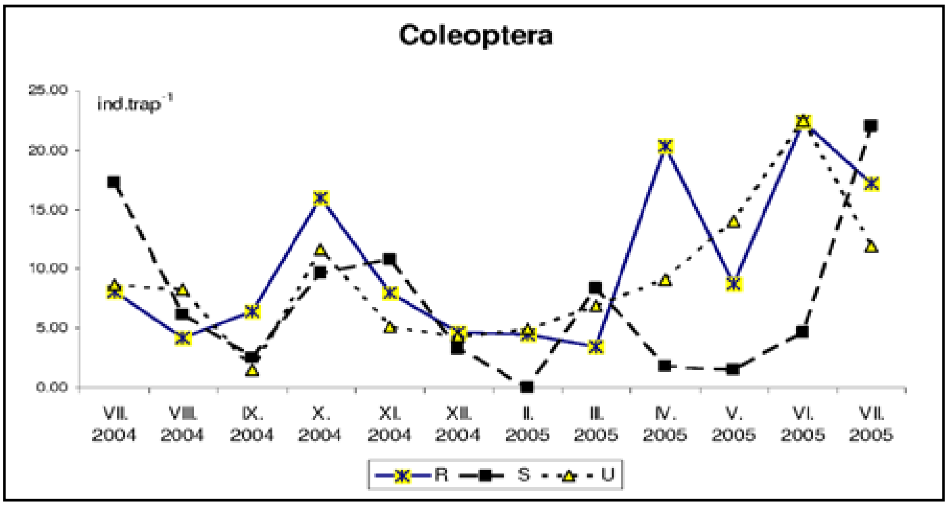

Fig. 2. Seasonal dynamics of Coleoptera along an urban-rural gradient in Skopje city
Сл. 2. Сезонска динамика на Coleoptera по должина на урбано-рурален градиент во градот Скопје

Tab. 2. Relative abundance and participation of different families of Coleoptera along the gradient
Таб. 2. Релативна абундантност и процентуално учество на одделните фамилии од редот Coleoptera по должина на градиентот

Coleoptera	R			S			U		
	инд.·замка$^{-1}$ ind.·trap-1	Доминантност Dominance		инд.·замка$^{-1}$ ind.·trap-1	Доминантност Dominance		инд.·замка$^{-1}$ ind.·trap-1	Доминантност Dominance	
Carabidae	3.42	33.08	D	2.54	34.60	D	3.14	32.21	D
Histeridae	0.20	1.93	R	0.15	2.04	R	0.13	1.33	R
Silphidae	0.16	1.55	R	0.87	11.85	D	0.39	4.00	R
Staphylinidae	1.90	18.38	D	0.93	12.67	D	1.06	10.87	D
Lucanidae	0.00	0.00		0.00	0.00		0.00	0.00	
Scarabaeidae	0.20	1.93	R	0.11	1.50	R	0.03	0.31	SR
Dermestidae	2.08	20.12	D	0.21	2.86	R	0.71	7.28	SD
Cantharidae	0.01	0.10	SR	0.01	0.14	SR	0.02	0.21	SR
Elateridae	0.19	1.84	R	0.52	7.08	SD	0.53	5.44	SD
Coccinelidae	0.01	0.10	SR	0.01	0.14	SR	0.05	0.51	SR
Anthicidae	0.04	0.39	SR	0.17	2.32	R	0.41	4.21	R
Tenebrionidae	0.98	9.48	SD	1.20	16.35	D	2.49	25.54	D
Cerambycidae	0.51	4.93	R	0.13	1.77	R	0.14	1.44	R
Chrysomelidae	0.15	1.45	R	0.29	3.95	R	0.17	1.74	R
Curculionidae	0.49	4.74	R	0.20	2.72	R	0.48	4.92	R
Вкупно Total	10.34			7.34			9.75		

(Tab. 3). Besides the family Carabidae, Staphylinidae was also dominant in all three localities.

Most of the 15 families were recorded in all three localities, although certain families were more abundant in one or the other locality. R was dominated by Carabidae (33.08%), Dermestidae (20.12%) and Staphylinidae (18,38%). S was dominated by Carabidae (34.60%), Tenebrionidae (16.35%) and Staphylinidae (12.67%). U was dominated by Carabidae (32.21%), Tenebrionidae (25.54%) and Staphylinidae (10.87%) (Tab. 2). High presence of Silphidae and Chrysomelidae was specific for S, Dermestidae, Staphylinidae, Cerambycidae, Histeridae and Scarabaeidae for R Tenebrionidae, Anthicidae and Coccinelidae for U.

Some of them experienced irregular increases and declines in abundance in response to soil temperature and humidity (Fig. 7).

Tab. 3. Relative abundance and participation of different families of Coleoptera along the gradient, compared by months

Таб. 3. Релативна абундантност и процентуално учество на одделните фамилии од редот Coleoptera по должина на градиентот, следено по месеци

USR-gradient	Carabidae	Histeridae	Silphidae	Staphylinidae	Lucanidae	Scarabaeidae	Dermestidae	Cantharidae	Elateridae	Coccinelidae	Anthicidae	Tenebrionidae	Cerambycidae	Chrysomelidae	Curculionidae
VII. 2004	4.27	0.23	1.48	0.89	0.01	0.16	0.98	0.00	0.79	0.00	0.10	2.18	0.08	0.03	0.13
VIII. 2004	2.29	0.01	0.07	0.28	0.00	0.07	0.99	0.01	0.31	0.00	0.06	1.81	0.13	0.06	0.13
IX. 2004	2.21	0.00	0.01	0.36	0.00	0.02	0.04	0.00	0.08	0.00	0.09	0.44	0.00	0.16	0.08
X. 2004	7.19	0.01	0.01	3.79	0.00	0.00	0.13	0.00	0.21	0.01	0.14	0.24	0.00	0.21	0.48
XI. 2004	4.27	0.01	0.01	2.64	0.00	0.00	0.01	0.00	0.09	0.00	0.23	0.04	0.00	0.39	0.27
XII. 2004	1.83	0.03	0.00	1.07	0.00	0.03	0.00	0.00	0.14	0.01	0.16	0.01	0.00	0.16	0.62
II. 2005	0.68	0.04	0.00	0.89	0.00	0.00	0.01	0.00	0.10	0.00	0.18	0.03	0.00	0.34	0.86
III. 2005	1.08	0.03	0.01	1.42	0.00	0.03	0.09	0.00	0.47	0.01	0.84	0.08	0.00	0.86	1.28
IV. 2005	2.20	0.40	0.58	1.88	0.00	0.07	2.33	0.04	0.82	0.06	0.32	0.96	0.43	0.06	0.26
V. 2005	1.67	0.20	1.02	0.70	0.00	0.16	1.29	0.03	0.53	0.13	0.07	1.54	0.51	0.06	0.17
VI. 2005	3.08	0.56	0.37	0.84	0.00	0.34	2.84	0.00	0.92	0.03	0.23	5.28	1.71	0.07	0.23
VII. 2005	5.60	0.38	2.12	0.78	0.00	0.48	3.28	0.02	0.51	0.01	0.03	6.06	0.28	0.03	0.18
relative abundance	**3.03**	**0.16**	**0.47**	**1.29**	**0.00**	**0.11**	**1.00**	**0.01**	**0.41**	**0.02**	**0.20**	**1.56**	**0.26**	**0.20**	**0.39**
dominance	**33.2**	**1.7**	**5.2**	**14.2**	**0.0**	**1.2**	**11.0**	**0.1**	**4.5**	**0.2**	**2.2**	**17.0**	**2.9**	**2.2**	**4.3**
	D	**R**	**SD**	**D**		**R**	**D**	**SR**	**R**	**SR**	**R**	**D**	**R**	**R**	**R**

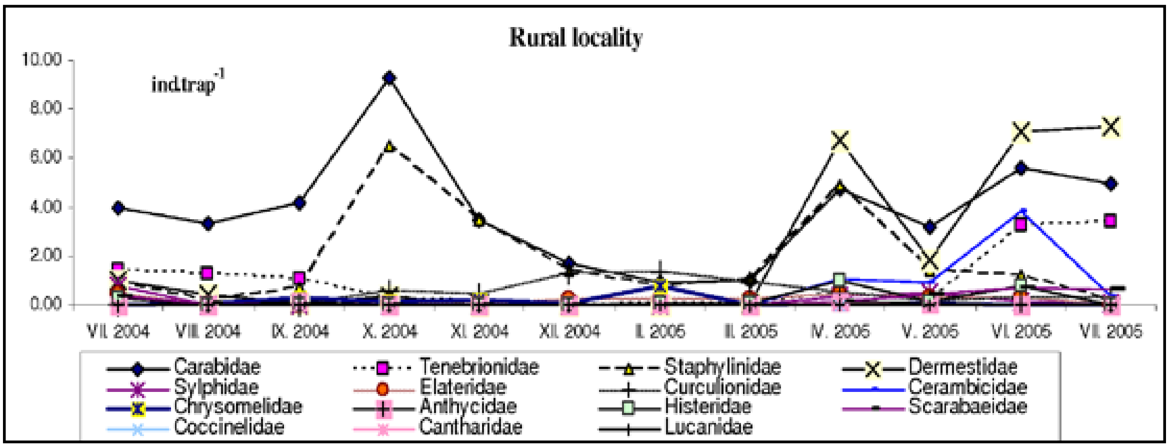

Fig. 3. Seasonal dynamic of coleopteran families in rural locality

Сл. 3. Сезонска динамика на одделните фамилии од редот Coleoptera во руралниот локалитет

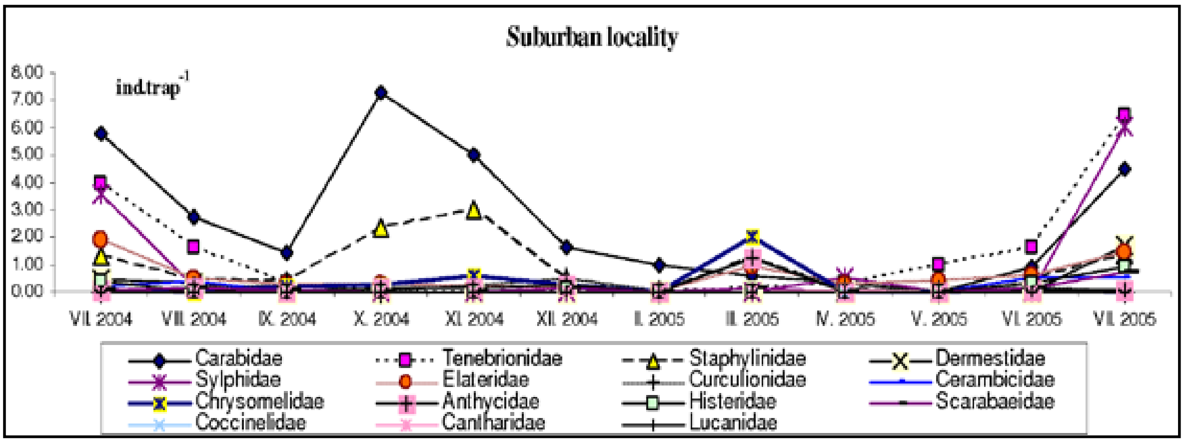

Fig. 4. Seasonal dynamic of coleopteran families in the suburban locality

Сл. 4. Сезонска динамика на одделните фамилии од редот Coleoptera во субурбаниот локалитет

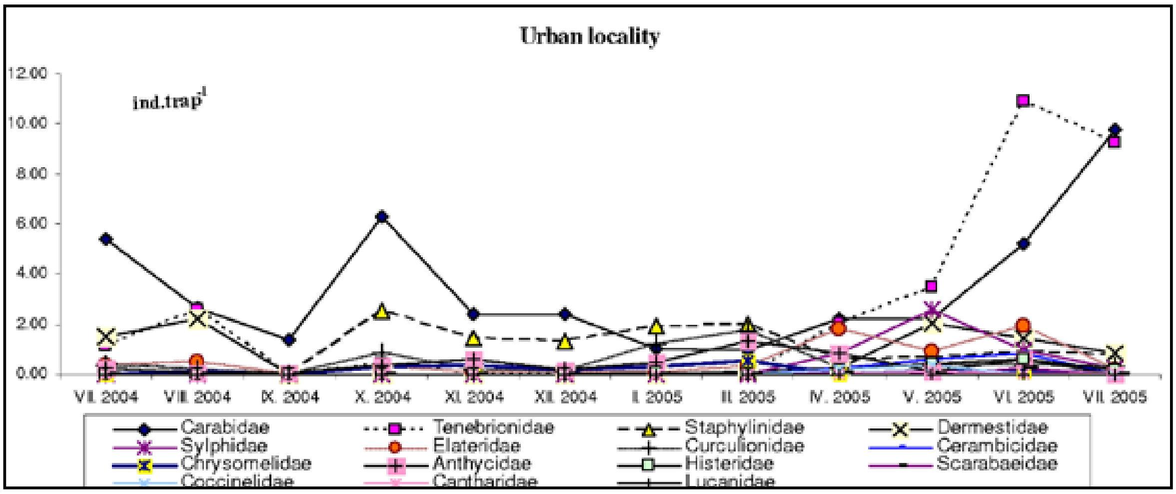

Fig. 5. Seasonal dynamic of coleopteran families in urban locality
Сл. 5. Сезонска динамика на одделните фамилии од редот Coleoptera во урбаниот локалитет

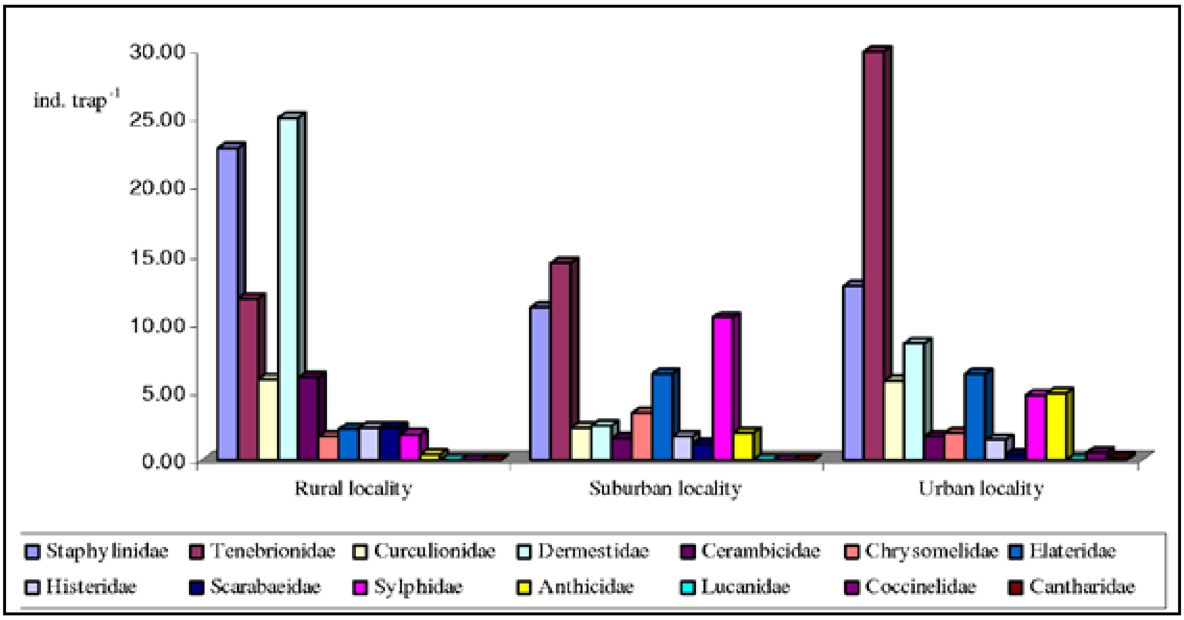

Fig. 6. Relative abundance of different families of Coleoptera compared by localities (B)
Сл. 6. Релативна абундантност на одделните фамилии од редот Coleoptera, следено по локалитети (B)

U was characterized by smaller-sized coleopteran families (Anthicidae, Coccinelidae), while large-sized species were recorded in R (Fig. 6. B).

These families, whose species have small dimensions, like Anthicidae, are probably more tolerant to disturbance. As it was previously discussed about carabid species by Ishitani et al. (2003), this may be because small-sized species are more often winged than large sized species, and therefore small species are more mobile than large species and can colonize and decolonize ephemeral and unstable habitats more easily. However, it is evident that there is a complex interaction between size, trophical structure and wing-development. In order to study these relationships in detail, exact information about these ecological characteristics of the species is required. Further ecological investigations on lower taxonomical level are necessary to develop and test more explicitly the effects of urbanization on beetles abundance and species richness, across urban-rural gradients (Peters 1991).

Urbanization did not have a markable effect on coleopterans community structure. As expected, R had the highest abundance. However, the abundance in U was higher than in S. Possible explanations are the specific conditions in the investigated localities. Trampled site was chosen for S which bordered by a motorway and a railway and it is characterized by a industrial building, houses and gardens. U was placed in „undisturbed“ meadow which seems it was large enough to sustain high abundance of beetles. Further elaboration of urbanization effect on species level might reveal greater significance of habitat impact for some species and urbanization for the others.

For example, cities with a strong difference in human disturbance between urban areas and the surrounding rural environment will most likely have significant differences in community structure of some beetles, especially carabids which are thought to be good environmental indicators (Ishitani 1996; Niemelä 1996; Lovei and Sunderland 1996; McGeoch 1998; Rainio and Niemelä 2003).

Furthermore, the gradient from urban to rural is not likely to be a simple, unimodal gradient reflecting human population numbers and the associated levels of disturbance in green areas only, but rather a complex one where many factors (temperature, moisture, edaphic factors, pollution etc.) interact (McDonnell 1993; Ishitani et al. 2003). These factors, together with possible changes in species interactions along the gradient, are likely to be different in different cities, which could lead to differences in beetle response across the different urban-rural gradients (Ishitani et al. 2003).

Possible explanation for the generally weak distinction along the localities is that beetles are not influenced much by the habitat disturbance that characterizes suburban and urban habitats. For these insects, urban areas may be large and undisturbed enough to retain higher number of individuals despite habitat fragmentation, as was expected. Another reason may be that the location for sampling points on the gradient could have a strong effect on patterns observed (Niemellä et al. 2002). According to McDonnell (1993), two types of gradients have been described in nature: simple gradients and complex ones. For example, it is easy to show that there is a simple, unimodal gradient in human population numbers from low in rural to high in urban environments. It is, however, more difficult to interpret the complex gradients of several possibly interacting factors (temperature, moisture, edaphic factors, pollution gradients) associated with the human population gradient but which are the actual drivers for beetle responses (McDonnell 1993). Such factors interacting with specific combinations of species along the gradient will likely influence the beetle community in a more complex way than indicated by the simple human population gradient (Niemellä et al. 2002).

Conclusion

1. The presence of fifteen families of the order Coleoptera was registered.
2. In average, 9.14 ind.$\cdot$trap^{-1} were registered for the whole gradient. In R, there were 10.34 ind.$\cdot$trap^{-1}, in S - 7.34 ind.$\cdot$trap^{-1} and in R - 9.75 ind.$\cdot$trap^{-1}.
3. The abundance of beetles was higher during autumn and spring-summer period.
4. The dynamics showed similar distribution along the gradient, with higher values reached in rural locality.

In general, there was a minor trend of a higher abundance in the rural locality, which would suggest that urbanization might have even negative effect on beetle abundance.

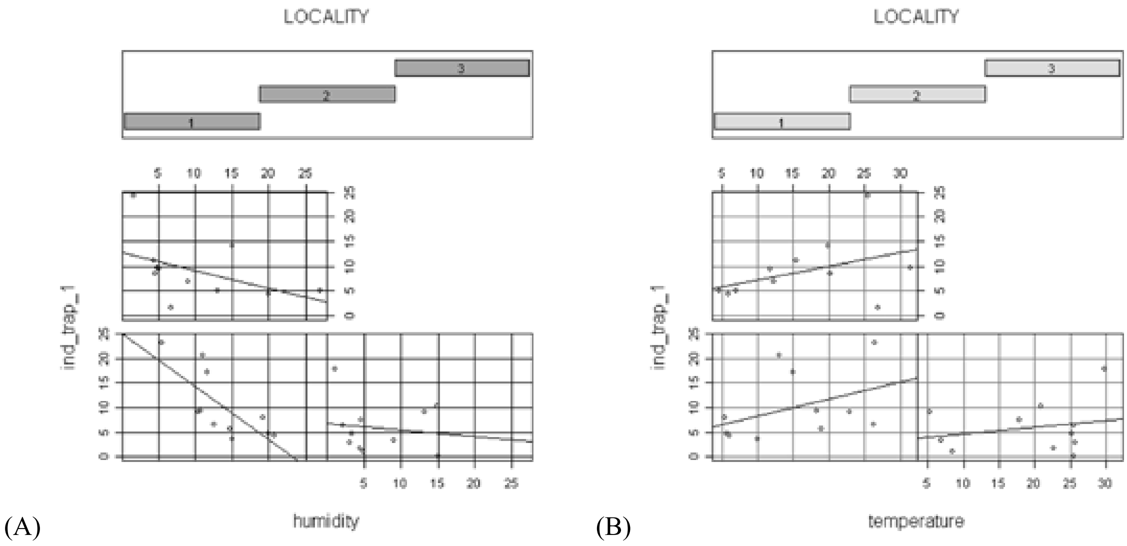

Fig. 8. Coplots for relative abundance as function of soil humidity and soil temperature, conditional on locality (1- rural locality; 2- suburban locality; 3 – urban locality)

Сл. 8. Coplot дијаграми за релативната абундантност како функција од влажноста и температурата на почвата, зависно од локалитетот (1 – рурален локалитет; 2 – суббурбан локалитет; 3 – урбан локалитет)

Evaluation of how these families of beetles respond to the urbanization process should provide insight into how their respective habitats are affected.

Acknowledgments:

We thank Borislav Guéorguiev for the help during the phase of species identification and his constructive suggestions.

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ПРОСТОРНО ВАРИРАЊЕ НА ТВРДОКРИЛЦИТЕ (Coleoptera) ПО ДОЛЖИНА НА УРБАНО-РУРАЛЕН ГРАДИЕНТ ВО ГРАДОТ СКОПЈЕ И НЕГОВАТА ОКОЛИНА

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Резиме

Тврдокрилците претставуваат составен дел на едафонот. Имаат голема улога во функционирањето на екосистемот и се важен извор на храна за другите организми. Преку проучување на нивното однесување може да се одреди влијанието на урбанизацијата врз екосистемот.

Целта на ова истражување е да се одреди влијанието на урбанизацијата врз тврдокрилците во три различни локалитети (урбан-У, субурбан – С и рурален – Р) по должина на урбано-рурален градиент во градот Скопје и неговата околина, а воедно и да се одреди структурата на заедницата.

Материјалот е колекциониран месечно, во текот на една година (07.2004 – 07.2005), со помош на ловни замки поставени по должина на градиентот. При тоа, одредени се квалитативно-квантитативниот состав, сезонската динамика и просторните промени по должина на градиентот.

Регистрирано е присуство на петнаесет фамилии (Staphylinidae, Tenebrionidae, Carabidae, Curculionidae, Dermestidae, Cantharidae, Chrysomelidae, Coccinelidae, Elateridae, Histeridae, Scarabaeidae, Silphidae, Anthicidae, Lucanidae и Cerambicidae) со вкупна бројност од 9,14 инд./замка.

При истражувањето забележани се варијации на абундантноста помеѓу фамилиите, со највисоки вредности достигнати во пролетно-летниот и најниски во зимскиот период од годината. Споредено по локалитети, абундантноста на одделните фамилии од редот Coleoptera нема значителни разлики.