BIOLÓGIA (BRATISLAVA) 42, 2, 145—156, 1987

# CHANGES IN BODY SIZE STRUCTURE OF CARABID COMMUNITIES (COLEOPTERA, CARABIDAE) ALONG AN URBANISATION GRADIENT

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Šustek, Z., Changes in body size structure of carabid communities (Coleoptera, Carabidae) along an urbanisation gradient. Biológia (Bratislava) 42, 145—156, 1987.

The body size structure of carabid communities reacts rather sensitively on anthropogenous pressure. Five stages of body size distribution can be distinguished in the course of anthropogenous degradation of a community. The atributes of these stages are defined and commented. A prerequisition for more reliable interpretation of body size structure for bioindicative purposes is the precise typization of the communities and paralel analysis of all groups of the same trophical level.

Body size represents one of the properties of an organism determining its ability to live in certain type of environment, its energetical bilance, predisposition for searching for a suitable cover and for passive or active migration. Besides, there exists a relation between body size of a predator and its prey (e. g. Sharova, 1981). Body size decises about the distribution of ecological niches (Hutchinson, 1959) and regulates competitive relations of the species. Due to it, body size is characteristic for the species of different life strategies (r-, K-continuum, Pianka 1981; C-, S-, R-continuum, Grimme 1979; violents, explerents and pacients, Ramenskij, 1938). For the above mentioned reasons, the body size structure has great value for statical characteristics of communities and is in the focus of attention of many authors (e. g. Levinton, 1982; Simberloff, Boecklen, 1981; Gospodar, 1981; Gruschwitz, 1983; Walter, Norton, 1984; Anderbjörn, 1985; Brandl, Topp, 1985; Den Boer, 1977). The above facts make it possible to expect deep changes of body size structure under the pressure of several anthropogenous factors and to use it for bioindicative purposes (Šustek, 1983; 1984a, b). The aim of the present paper is to describe changes in body size structure of carabid communities along an idealized gradient of urbanisation pressure in Bratislava and Brno and, on this basis, to typify tentatively body size structure of carabids in individual stages of community degradation.

## Material and methods

The beetles were collected by pitfall traps with the 6 % formol as a killing and conservation solution. The glass jars of the diameter of 95 mm were used as traps. Number of the traps in each sampling site fluctuated in dependence on the area of individual sites. In the centre of city, traps number was determined by possibilities to hide the traps from the public. One or two traps were in the majority of sites in the town centre. Usually five traps were in large parks. Traps number in the reference localities was determined by the aim for which each locality was primarily studied. The low number of traps in the city centre was compensed by sampling during two or more vegetation periods.

Body size structure is expresed by the method proposed by Šustek (1983) and modified later (Šustek, 1984a). By its help a polymodal cumulative curve is obtained. The distribution curve is calculated separately for binary and quantitative data. So the curves of body size distribution of species and individuals arise. When they are expressed in the percentage of species or individuals totals, their overlap can be measured by a suitable similarity function (proportional similarity in our case). So the degree of disproportion between species body size distribution (as an offer for the selection) and between individuals body size distribution (as a result of common effect of anthropogenous, competitive and other factors) can be measured. The details of the alghorithm are described by Šustek (1984a, b). The data about body size of each species are taken from the literature. The above method is considered to be more objective than the methods based on arbitraly established body size classes (e. g. Gruschwitz, 1983; Gospodar, 1981).

### *Sampling sites and their short characteristics*

The beetles were sampled on 39 localities in both cities. The localities represent all types of ecosystems occurring in both cities and approximately all degrees of their anthropogenous destruction. Besides 9 sampling sites in free landscape were choosen as reference localities. The detailed historical and ecological characteristics are presented by Šustek (1984a). The localities are arranged approximately according to the degree of their antropogenous influencing. The localities in Bratislava are in the quarter 6878 of the conding system of Data basis of fauna of Slovakia.

*Reference localities:* Nesyt — phargmitetum around the pound Nesyt (Obrtel, 1972), Lednice — natural, regurally inundated ulm-ash forest, Pavlovské kopce — relatively natural beech-oak (FQ) and lime-maple (TAc) forests, Boleradice — relatively natural beech-oak forest, Báb — tobacco field, Pezinok — maize field, Žemberovce — vineyard, Sereď — small patches of *Salsola cali* on the dump of rests after electrolytical leaching of nickel.

*River side localities in the city interior (within administrative border of the city):* Soběšice — moderately influenced phragmitetum around two small pounds in Brno-Soběšice, Ráječek — moderately influenced rest of river side forests in aluvium of Svitava in Brno-Černovice, Vydrica sanatorium — relatively natural aluvium in the recreation zone of Bratislava in the vicinity of State Sanatorium in Bratislava-Železná studnička, Vydrica ZOO, Vydrica pub „U Slováka", Vydrica — botanical garden — three points on the banks of Vydrica creek in Bratislava-Mlynská dolina, all moderately — strongly influenced, their species spectra are influenced by the imigration of species from the surrounding rests of forests, Horský park creek — wet area around the spring of a creek under the northern slope of Horský park in Bratislava, Petržalka poplar forest — artificial poplar monoculture eastern from the old bridge on Danube riverside, Vrakuňa dead arm — strongly influenced banks of rest of original meander of Malý Dunaj, east of Bratislava, Lužánky and Sad J. Kráľa —

artificial english parks founded 1782—1985 in the aluvium of Ponávka (Brno) and on the island between Danube arms, both intensively cultivated and frequented.

*Forest localities in the city interior:* Železná studnička — relatively natural beech-horn beech forest in the recreation zone of Bratislava, Sitina, Kalvária, Horský park peak and Horský park northern slope — forests arised spontaneously during second half of 19. centure from small groups of trees and bushes between old vineyard, fields and pastures west of Bratislava, now isolated as greenery island in the new parts of Bratislava, all preserve relatively natural character, Hakenova and Čertova rokľa — stands of trees and bushes in two erosive craks in original fields turned later in military excercising ground, now changed into parks in the housing estate Brno Lesná, Špilberk southern and northern slopes — park founded 1862 in deforested surroundings of old citadela, today physiognomically rather similar to a forest, intensively cultivated and frequented.

*Localities close to cultural steppe in the city interior:* Líšeňská — old apricot orchard on the margin of Brno, Břenkova — garden in the residencial quarter Brno Černá pole, arised 1927, recultivated 1963—1965, Bajkalská — ruderal site in the new housing estate in eastern part of Bratislava, Hrad — bushes on the ruinas of former quarter Bratislavské Podhradie near Beblavého street, Kraví Hora — week grass belt along a way in the Schrebergarten colony in Brno; Americké nám., Nám. 4. apríla, Kollárovo nám., Prior small and big flowerbed, Medická záhrada, Notre Dam, Nám. SNP, Šafárikovo nám., Uršulínska — all are small patches of grass, sparse trees and bushes on the squares and streets in the centre of Bratislava, all strongly affected by public, domestic animals, traffic and industrial imissions, majority of them arised during first two decenia of 20. centure, all intensively cultivated and frequented, Nám. 28. října — artificial park in Brno arised 1907, today of similar character as above parks in Bratislava.

## Results

In the lowlands (oak to oak beech vegetation tier) of Central Europe, the body size of majority of *Carabidae* concentrates in the left third of its potential distribution scale (fig. 1). Relatively undistinct local maxima of the distribution are in the vicinity of body length of 3; 6—8; 15 and of 20 mm. The modus of the distribution is within the limits of 6—8 mm. With regard to ehe linear scale used in the diagram, the distribution correspond to the log-normal distribution of body size in majority of animals, as established by M a y (1978). Because of relatively small number of species in each community, because of long-normal character of body size distribution and linear scale of abscisa, more distinctly separated peaks corresponding with the above local maxima occure in distribution curves of body size in each concrete community.

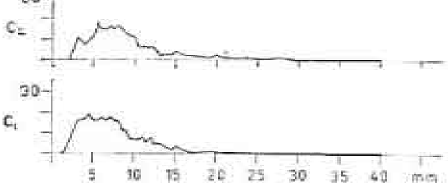


Fig. 1. Body size distribution of all carabids in Central Europe ($C_l$) and in the oak — oak-beech vegetation tiers in Central Europe ($C_o$), abscissa = body size scale, ordinate = percentage of species number in each interval of body size).

In the natural communities of forests and river side formations (fig. 2 and 3), the body size distribution of *Carabidae* takes its whole potential extent, 3--24 mm in river side communities and 3—40 mm in the forest communities. All distributional curves are distinctly polymodal, the large sized species

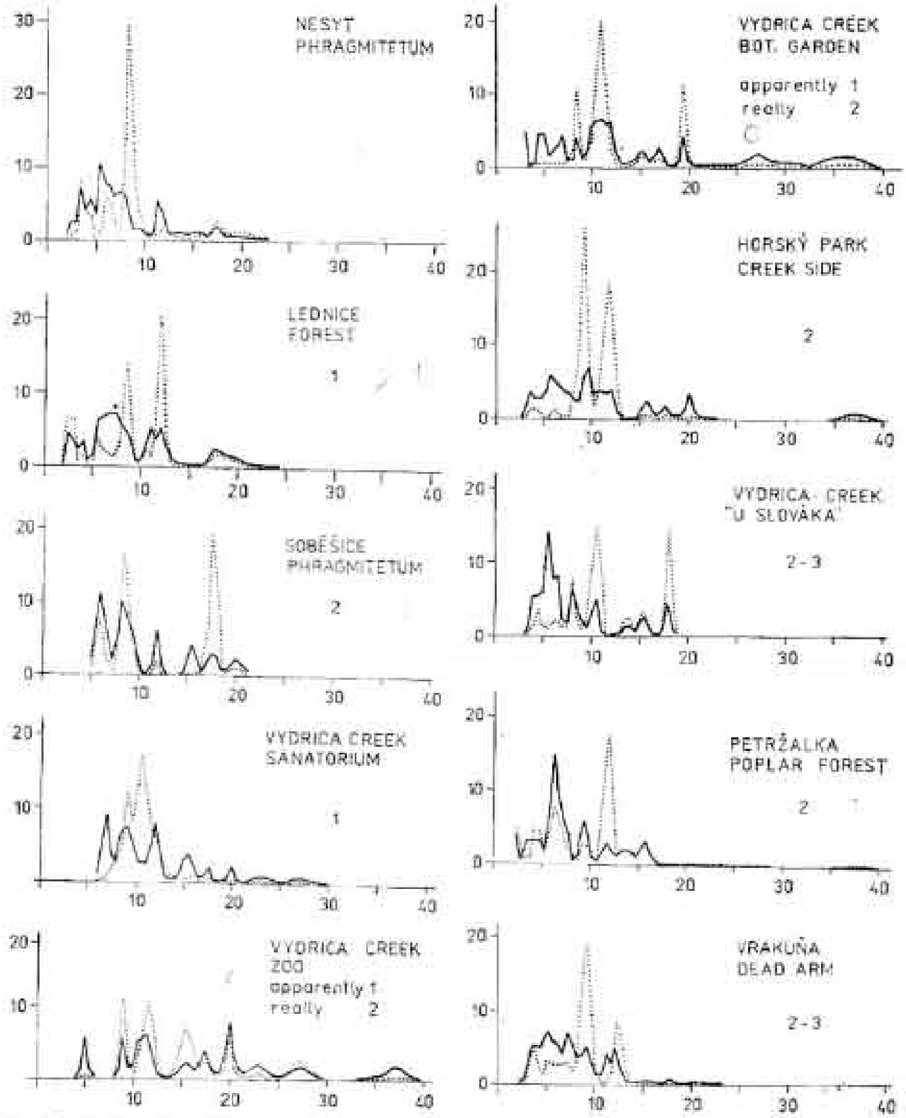


Fig. 2. Body size distribution of species (solid line) and individuals (pointed) in the aluvial communities of *Carabidae* (abscisa = body size scale in mm, ordinate — percentage of species or individuals in each interval of body size, the arabic digits under the name of the locality means the type of distribution to which a curve belonges, 1 = natural communities, 2 = moderately influenced communities, 3 = intermediately influenced communities, 4 = strongly damaged communities), 5 = the most damaged or chronically pionier communities.

are abundant and the curves of species and individuals body size distribution well coincide (overlap 55—70 %, fig. 7). This pattern is preserved in the communities from Mlynská dolina, Železná studnička, Sitina. In Mlynská dolina, it is due to the imigration of large sized species (*Carabus coriaceus* and

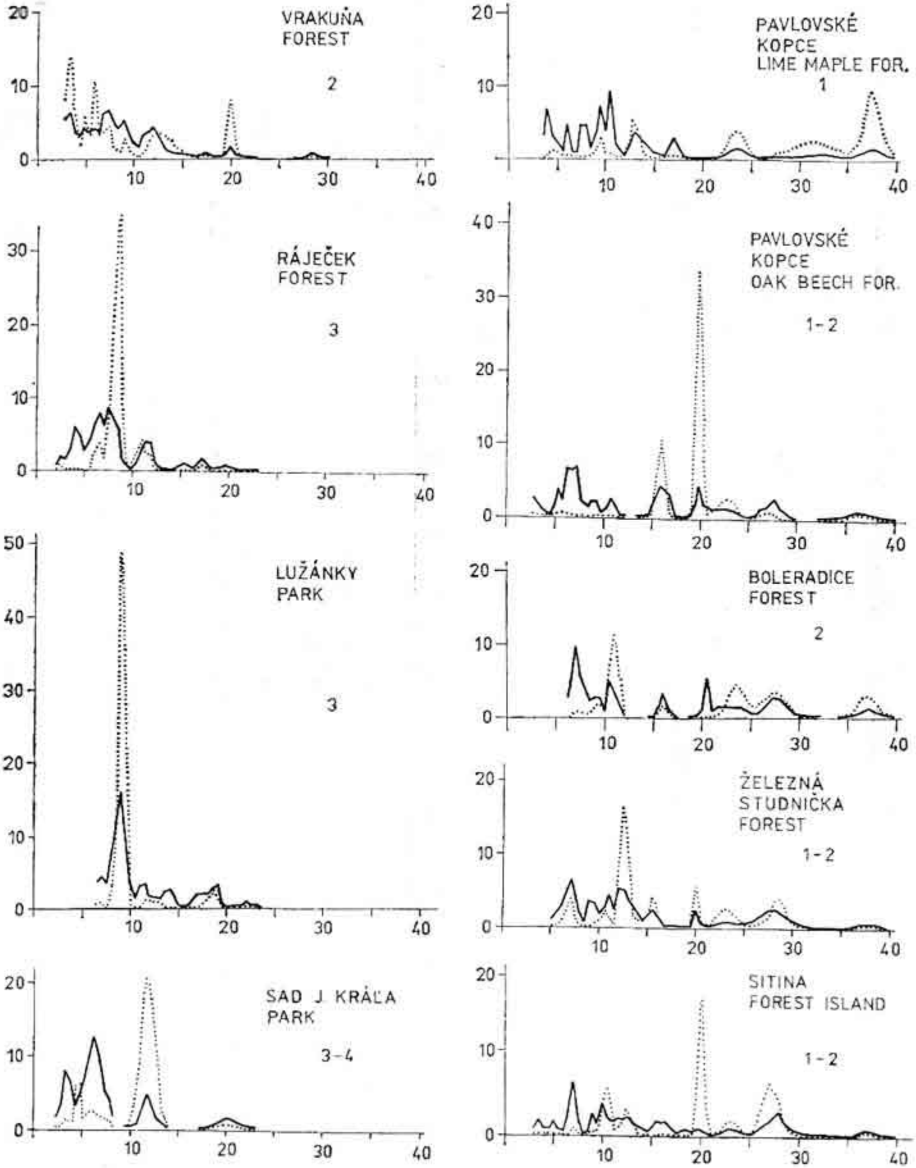


Fig. 3. Body size distribution of species and individuals in aluvial (Vrakuňa — Sad J. Kráľa) and forest communities (Pavlovské kopce — Sitina). (Symbols as in fig. 2.)

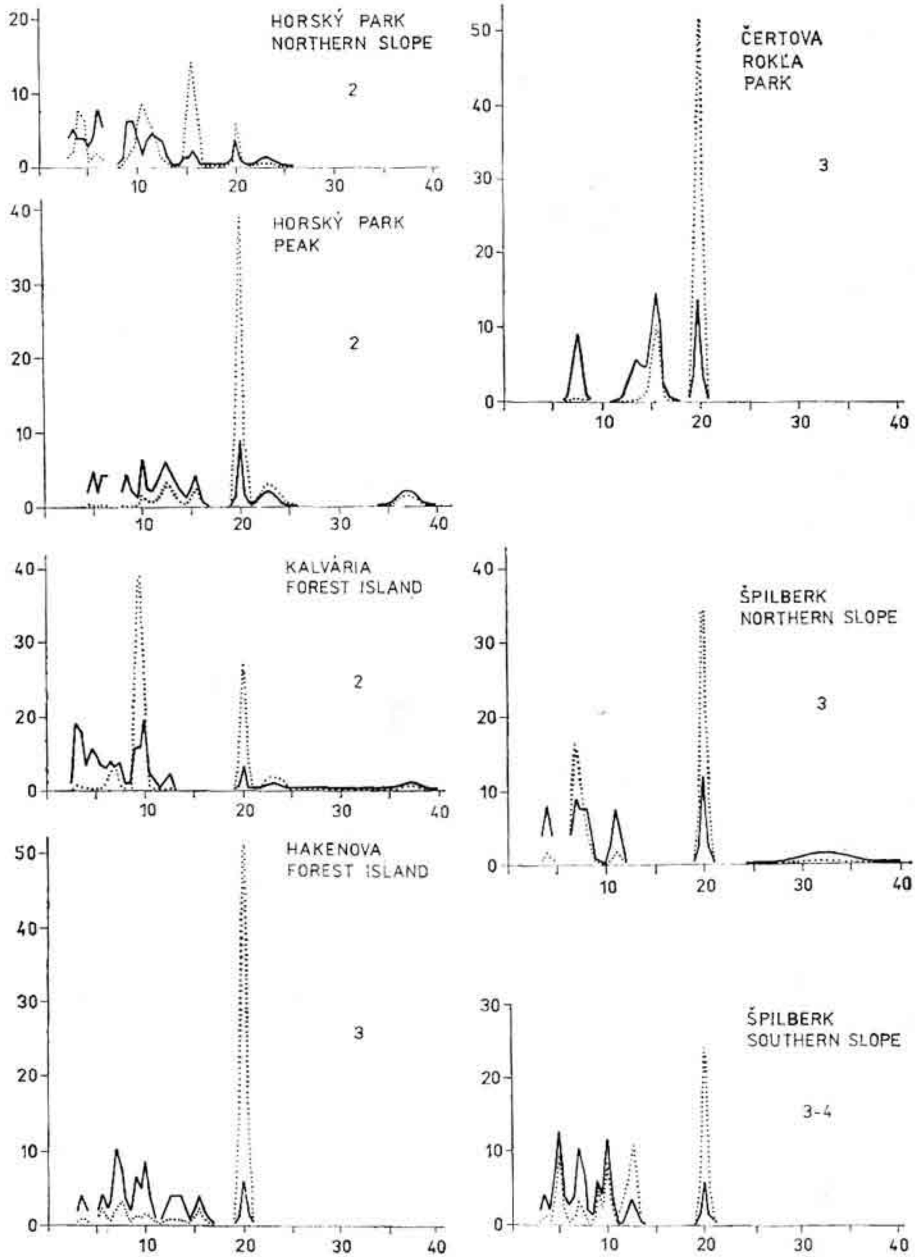


Fig. 4. Body size distribution of species and individuals in forest communities. (Symbols as in fig. 2.)

Carabus nemoralis from surrounding). In the community from Boleradice, Horský park and Kalvária the distributional curves are brooken in local minima. It is partly due to low troficity of these siliciferous ecosystems and due to resulting low abundance and in the communities from the interior of Bratislava also due to increasing anthropogenous preasure.

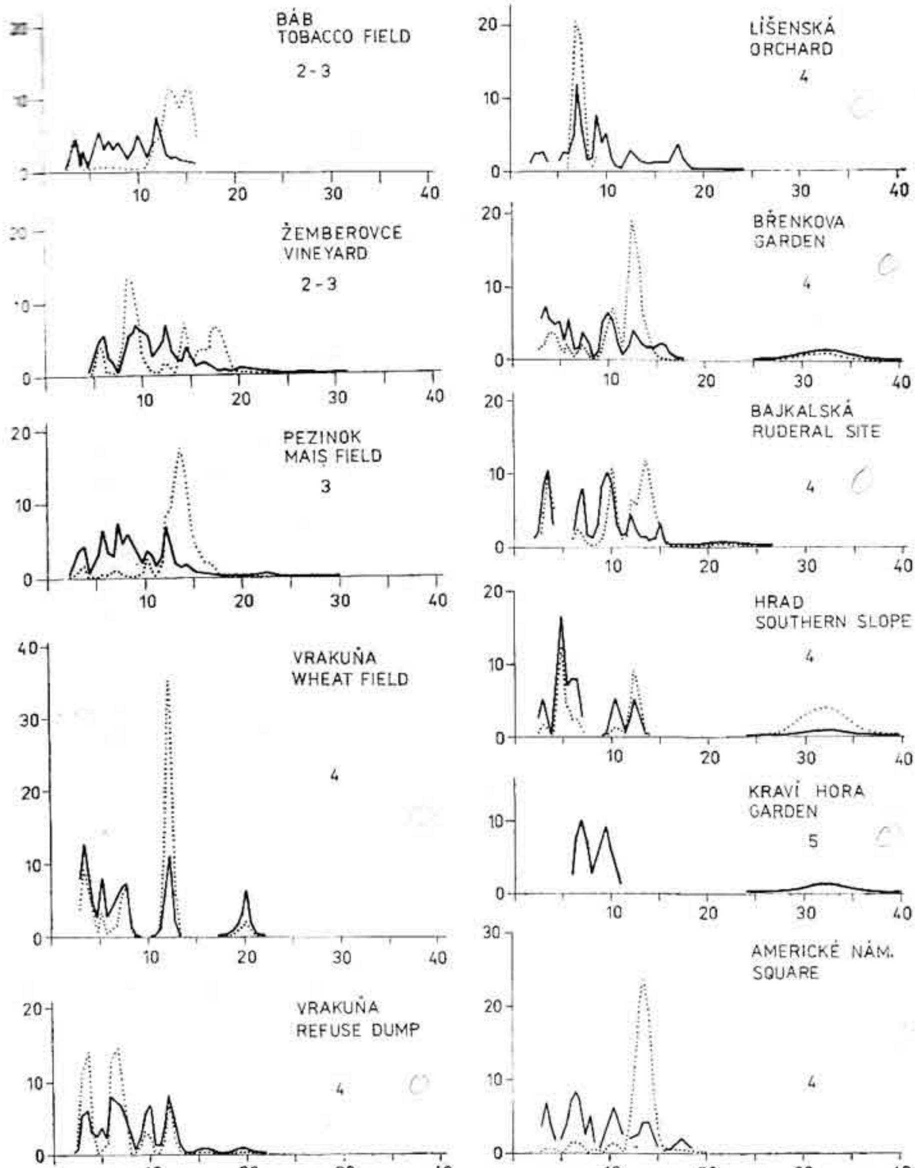


Fig. 5. Body size distribution of species and individuals in carabid communities of cultural steppe. (Symbols as in fig. 2.)

In the communities exhibiting higher degree of influencing (Ráječek, Lužánky, Sad J. Kráľa, Hakenova, Čertova rokľa — fig. 3 and 4) the distributional curves do not take their potential extent, the individuals concentrate strikingly in an only peak, the overlap of both distribution curves sinks on 30—50 %. The same pattern is typical for all reference communities from the

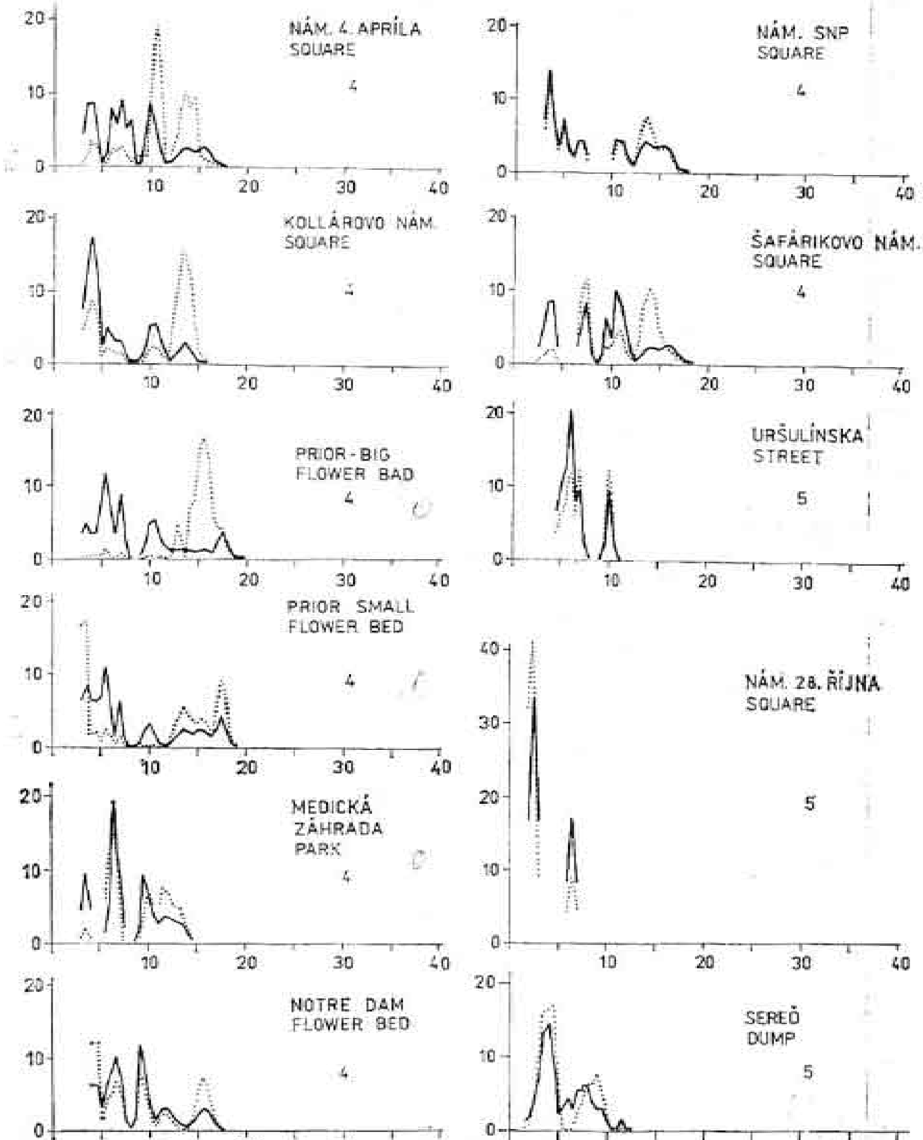


Fig. 6. Body size distribution of species and individuals in carabid communities of cultural steppe. (Symbols as in fig. 2.)

…ds (Báb. Pezinok and Žemberovce), (fig. 5). It can be observed also in the …al" community from beech-oak forest from Pavlovské kopce (fig. 3). …ll more influenced communities are characterized by the curves brooken in …al minima between lower octaves (Vrakuňa wheat field, Americké nám., …m. 4 apríla, Prior big flower bed, fig. 5). In this phasis, a peak appears ex…nally in the interval 30—40 mm. It is caused by the occurrence of *Carabus*

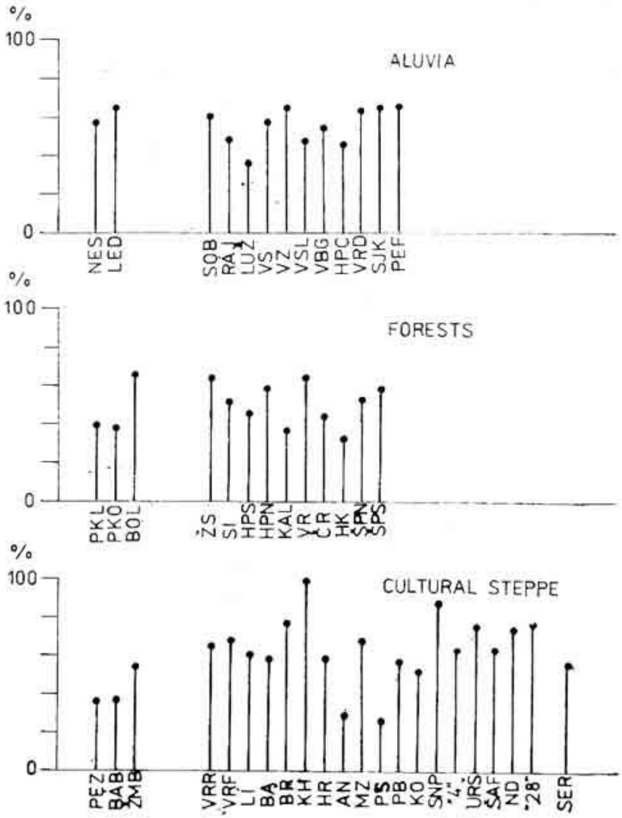


Fig. 7. Overlap (in %) of distributional curves of the body size of species and individuals (NES — Nesyt, LED — Lednice, SOB — Soběšice, RÁJ — Ráječek, LUŽ — Lužánky, VS — Vydrica, sanatorium, VZ — Vydrica ZOO, VSL — Vydrica, U Slováka, VBG — Vydrica, botanical garden, HPC — Horský park, creek, VRD — Vrakuňa, dead arm, SJK — Sad J. Kráľa, PEF — Petržalka, poplar forest, PKL — Pavlovské kopce, lime maple forest, PKO — Pavlovské kopce, oak-beech forest, BOL — Boleradice, ŽS — Železná studnička, SI — Sitina, HPS — Horský park, summit, HPN — Horský park, northern slope, KAL — Kalvária, VR — Vrakuňa, forest, ČR — Čertova rokľa, HK — Hakenova, ŠPN — Špilberk, northern slope, ŠPS — Špilberk, southern slope, PEZ — Pezinok, BÁB — Báb, ŽMB — Žemberovce, VRR — Vrakuňa, ruderal site, VRF — Vrakuňa, field, LÍ — Líšeňská, BA — Bajkalská, BŘ — Břenkova, KH — Kraví hora, AN — Americké nám., MZ — Medická záhrada, PB — Prior, big flower bed, PS — Prior, small flower bed, KO — Kollárovo nám., SNP — nám. SNP, „4" — nám. 4. apríla, URŠ — Uršulínska, ŠAF — Šafárikovo nám., ND — churche Notre Dam, in Bratislava, „28" — nám. 28. října, SER — Sereď. (Other symbols as in fig. 2.)

*intricatus*, which seems to be well adapted to the life in suburban areas of central European cities [Praha, Brno, Bratislava].

The communities from small greenery areas in the town centre have very contracted distributional curves. The curves are brooken even in each local minimum and the overlap of species and individuals distributional curves increases secondarly on even 90—100 %. This is a manifestation of high equitability in such communities [Kraví hora]. This pattern is exhibited in the communities from Notre Dam, Uršulínska, Kraví hora and in reference community from Sereď (fig. 6). In the most destroyd communities are present only two separated peaks. There are continuous intergradation between types of body size distribution during antropogenous degradation of communities.

The sequence of the changes in body size structure from natural communities untill the chronically pionier ones indicates simplification of trophical relations in a community, limitation of the competition and the highly occasional character of the completly destroyed communities. On the basis of historical data, the communities in the process of degradation and regenerations exhibit very similar patterns of body size distribution in certain stages of both processes. Consequently, it is possible to postulate that the degradation and regeneration of a community are in their idealized form symetrical each to other.

## Discussion and conclusions

The body size structure exhibits in the urbanisation pressure gradient striking changes, which can be used for the bioindication. In carabids, it seems that five typical patterns of body size distribution can be defined in the course of degradation of a community which represent idealized points in a continuum between natural and fully damaged communities. First pattern is typical for natural or completly regenerated communities in suitable production conditions. It has mostly continuous, polymodal distributional curves occupating the whole potential body size scale. Both curves have high overlap. Second pattern is typical for moderately influenced communities or for natural communities in bad production conditions. It is characterized by broken distributional curves before the highest octave. Third pattern is characteristic for intermediately influenced communities, the distribution curves do not take the whole potential body size scale, individuals concentrate into the only peak, the overlap of the curve of species and individuals is low. The fourth pattern is characteristic by contracted, frequently brooken distributional curves and secondarly by the high overlap of species and individuals curve. It occurrs in the strong damaged communities. Finaly, the fifth pattern is typical by distribution curves consisting of one or two separated peaks. It occurrs in the most damaged or chronically pionier communities.

Small body size seems to be favorizing the carabids in unfavourable conditions and suitable for passive migration. However, there is a synergisms of nearly obligate ability of small carabids to fly. Contrary, the large sized species are mostly apterous and they mode of life (walking epigeobionts, Sharova, 1981) exposes them to several dangerous factors. So, the situation is inverse as in small mammals (cf. Angerbjörn, 1985). The presence or absence of a peak in distributional curves of carabids is determined also by competitive pressure of other predaceous groups, especially Staphylinids and spiders in small carabids and *Soricidae* in large sized *Carabus spp.* It can be observed especially in Staphylinids, which compense the absence of a peak in distribution curves of Carabids (Šustek, 1984a). Presentation of such examples, however, exceeds the extent of this paper. So, taking in count all groups on the same trophical level in analyses of body size structure can prevent difficulties in the interpretation of the result (e. g. only one genus — Brandl, Topp, 1985). It is evident, that unfavourable life conditions (low trophicity and primar production etc.) can have similar effects on body size distribution as anthropogenous factors. Due to it, a precise typification of the communities is desirable for more reliable interpretations of body size structure (and of other community characteristics) in the bioindication.

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ZMENY VO VEĽKOSTNEJ ŠTRUKTÚRE BYSTRUŠKOVITÝCH (COLEOPTERA, CARABIDAE) V GRADIENTE URBANIZAČNÉHO TLAKU

Zbyšek Šustek

Veľkostná štruktúra spoločenstiev bystruškovitých reaguje veľmi citlivo na zmeny v intenzite antropogénneho tlaku. V priebehu antropogénnej degradácie spoločenstva možno rozoznať päť štádií zmien vo veľkostnej štruktúre. Vlastnosti týchto piatich štádií sa v práci podrobne definujú a komentujú. Konštatuje sa potreba presnej typizácie spoločenstiev v rôznych podmienkach ako základný predpoklad na spoľahlivú interpretáciu veľkostnej štruktúry na bioindikačné účely. Ďalším predpokladom je aj súčasné sledovanie veľkostnej štruktúry ostatných skupín živočíchov, ktoré stoja na tej istej potravovej úrovni.

Došlo 16. 12. 1985

ИЗМЕНЕНИЯ В СТРУКТУРЕ ЖУЖЕЛИЦ ПО РАЗМЕРАМ ТЕЛА (COLEOPTERA, CARABIDAE) В ГРАДИЕНТЕ УРБАНИЗАЦИОННОГО НАЖИМА

Збышек Шустек

Структура сообществ жужелиц по размерам тела реагирует очень чувствительно на изменения в интенсивности антропогенного нажима. В течение антропогенной деградации сообщества можно отличить пять стадий изменений структуры по размерам тела. Свойства этих пяти стадий в настоящей статье подробно определены и комментированы. Констатируется потребность точной типизации сообществ в разных условиях как основная предпосылка для надежной интерпретации структуры по размерам тела для биоиндикационных целей. Дальнейшей предпосылкой является также современное исследование количественной структуры остальных групп животных, которые находятся на том же уровне питания.