Biológia, Bratislava, 48/5: 523–533, 1993

Changes in body size structure of staphylinid communities (Coleoptera, Staphylinidae) along an urbanisation gradient

ZBYŠEK ŠUSTEK

Institute of Zoology and Ecosozology of Slovak Academy of Sciences, Mánesovo nám. 2, 851 01 Bratislava, Slovakia

ŠUSTEK, Z., Changes in body size structureof staphylinid communities (Coleoptera, Staphylinidae) along an urbanisationgradient. Biológia, Bratislava, 48: 523–533, 1993.

The body size structure of the staphylinid communitiesis simplier than that of the carabid communities due to the narrowerbody size range of the staphylinids and higher predominance of smallsized species in this family. The local maxima of the polymodal body size distribution of Staphylinidae coincide mostly with the local minima of the body size distribuiton of Carabidae. Besides, the local maxima of the staphylinids are ussually shifted one octave lower. The body size structure of the staphylinids reflects the degree of the anthropogenous pressure on a similar way as that of the Carabids, but five stages of changes in the body size structure distinguished for Carabidae are not so sharply expressed in the staphylinid communities.

Key words: Staphylinidae, urban ecology, body size, competition, anthropic pressure, polymodal distribution.

Body size of an organism represents one of the important properties deciding about its ability to survive in a given type of environment, about the partitioning of the ecological niches and food resources and regulating the competitive reationships between the species. Therefore the body size structure serves as an important characteristics of a community and stays in the focus of attention of both, theoretic (e. g. PIANKA, 1981; GOLIKOV, 1985; LEVINTON, 1982) or field ecologists (e. g. GOSPODAR, 1981; GRUSCHWITZ, 1983; THOMSON, 1986). From the above reasons the body size structure of a community can be also expected to reflect sensitively impacts of several anthropogenous factors (ŠUSTEK, 1983, 1984, 1987). The aim of the present paper is to describe the changes in the body size in the staphylinid communities along an idealized gradient of urbanisation pressure in the cities of Brno and Bratislava and to compare them with the analogous changes in the carabid communities in the same sampling sites.

Material and methods

The beetles were pitfall-traped in the glass jars of the diameter of 95 mm filled with formol. The traps number in each site fluctuated in dependence on the area of individual sites. In the city centre, the traps number was modified according to the local possibilities to hide the traps from the public. One or two traps were in the majority of sites in the city centre. Usually five traps were put in large parks. Traps number in the reference localities in free landscape was determined by the aim for which each locality was primarily studied. The low number of traps in the city interior was compensed by sampling during two or more vegetation periods. The total material consists of 15.150 staphylinids belonging to 210 species.

Body size distribution is expresed by the method proposed by ŠUSTEK (1983) and modified later (ŠUSTEK, 1984). By its help a polymodal curve is obtained. The distribution curve was calculated separately for the binary and quantitative data. If they are expressed in the percentage of the total number of species or individuals, two overlapping curves are obtained. Their overlap can be measured (by proportional similarity in our case) and the degree of similarity of the body size distribution of species, as an offer for the selection,

and of the body size distribution of individuals, as a result of the effect of anthropogenous pressure, competition or of other factor, can be studied. The details of the alghorithm are described by ŠUSTEK (1984 b). The data about body size of each species were taken from the literature (mostly from FREUDE, HARDE, LOHSE 1964, 1974).

Sampling sites and their characteristics

The beetles were collected on 39 localities in both cities. These localities represent all types of the ecosystems occuring in these cities and approximately all degrees of their anthropogenous destruction. Out of it, nine localities in free landscape were choosen as reference localities. Their detailed historical and ecological description is presented by ŠUSTEK (1984 a). The localities are arranged approximately according the degree of their anthropogenous influencing. The localities in Bratislava are in the quarter 7868 of the Data bank of the fauna of Slovakia.

Reference localities: Nesyt - phragmitetum around the fish-pond Nesyt (OBRTEL, 1972), Lednica - natural, regularly inindated *Ulmi Fraxineto populi*, Pavlovské kopce - relatively natural *Fagi Quercetum* (FQ) and *Tiliae Acerenon* (TAc), Boleradice - relatively natural *Fagi-Quercetum*, Báb - tobacco field, Pezinok - maize field, Žemberovce - vineyard, Sereď - small patches of *Salsola cali* on the dump of the nickel leaching rest.

River-side localities in the city interior: Soběšice - moderately influenced phragmitetum around two small ponds near to city margins of Brno, Ráječek - moderately influenced rest of floodplain forest on alluvium of Svitava in Brno-Černovice, Vydrica sanatorium - relatively natural alluvium of Vydrica brook in the recreation zone of Bratislava, close to the State sanatorium in Bratislava - Železná studnička, Vydrica - ZOO, Vydrica - U Slováka, Vydrica - botanical garden - three sites on the banks of Vydrica brook in Bratislava - Mlynská dolina, all moderatelly - strongly influenced, their species spectra strongly influenced by the imigration of the mesohygrophilous species form the surrounding remnants of forests, since 1988 all three localities completly destroyed after construction of the new road, Horský park-creek-wet area around little creek under the northern slope of Horský park in Bratislava, Petržalka - poplar forest - artificial poplar monoculture easterly from the old bridge on Danube bank, Vrakuňa - dead arm - strongly influenced remnants of hygrophilous vegetation on the baks of former meander of Little Danube, Lužánky and Sad J. Kráľa - artificial english parks founded in 1782 - 1785 on the alluvium of Ponávka (Brno) and on former islands between the Danube arms (Bratislava) respectively, both intensively cultivated and frequented by public.

Forest localities in the city interior: Železná studnička - relatively natural beech - horn - beam forest in the recreation zone of Bratislava, Sitina, Kalvária, Horský park - peek, Horský park - northern slope - forests arisen spontaneously during second half of 19. century from small groups of trees and shrubs between old vineyards, fields and pastures westerly of Bratislava, now isolated as greenery inslands in new part of Bratislava, all of them preserve relatively natural character, Hakenova and Čertova Rokľa - stands of trees and shrubs in two erosive craks in original field in the twenties in a military excercising ground, now transformed into parks in the housign estate Brno-Lesná, Špilberk, southern and northern slope - park founded in 1862 on deforested slopes of old citadela, now physiognomicaly rather similar to a forest, intensively cultivated an frequented by public.

Localities close to the cultural steppe in the city interior: Líšeňská - old apricot orchard on the margins of Brno,

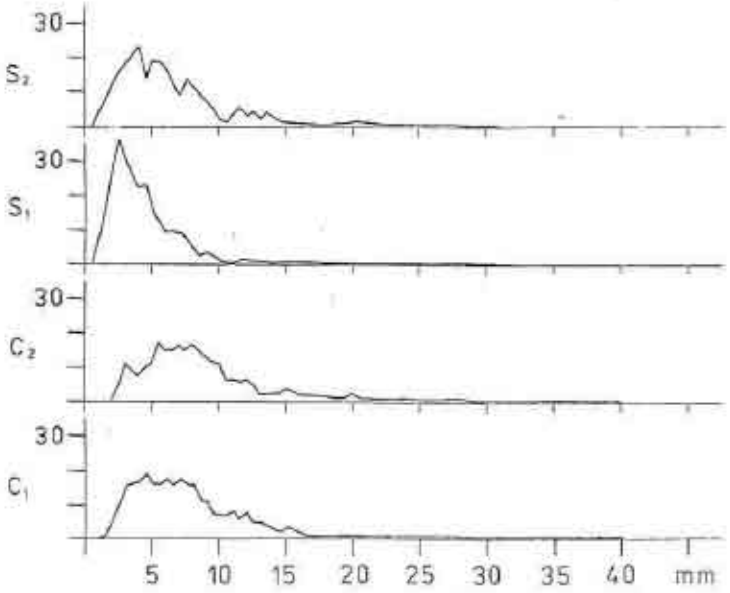

Fig. 1. Comparison of body size disstribution of all Central European staphylinid (S_2) and carabid (C_2) species and of the species constituing potentialy the soil surface communities in the studied cities and in their surroundings (abscisa - body size scale, ordinate - percentage of the species).

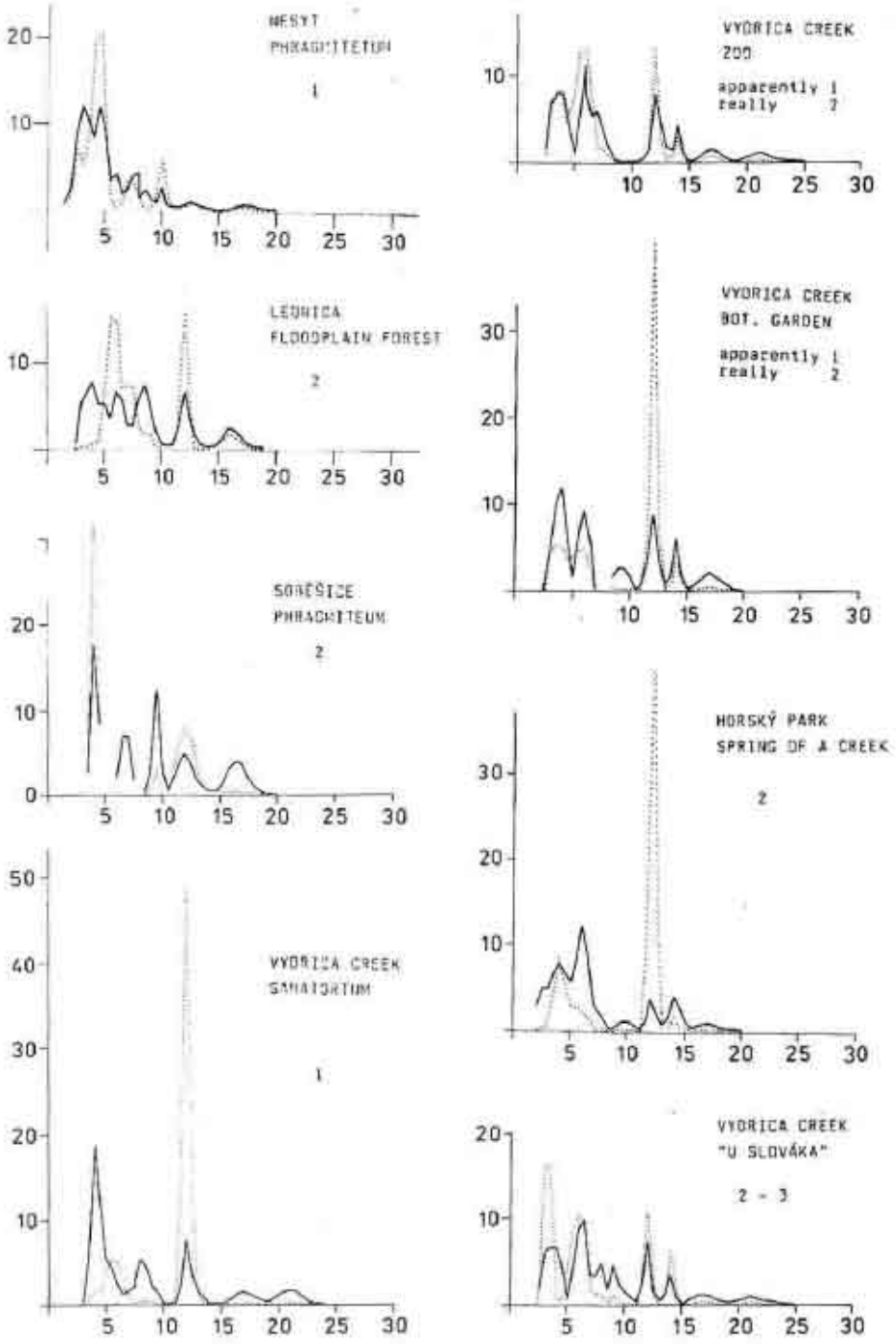

Fig. 2. Body size distribution of species (solid line) and individuals (dotted line) in the alluvial communities of Staphylinidae in reference localities in free landscape (Nesyt, Lednica) and in city interior (other localities), (abscisa - body size scale in mm, ordinate - percentage of species or individuals in each interval of body size, the arabic digits under the locality name means the degree of the anthropogenous pressure on each community, 1 - natural communities, 2 - moderately influenced communities, 3 intermediately influenced communities, 4 - strongly damaged communities, 5 - extremly damaged or chronically pionier communities).

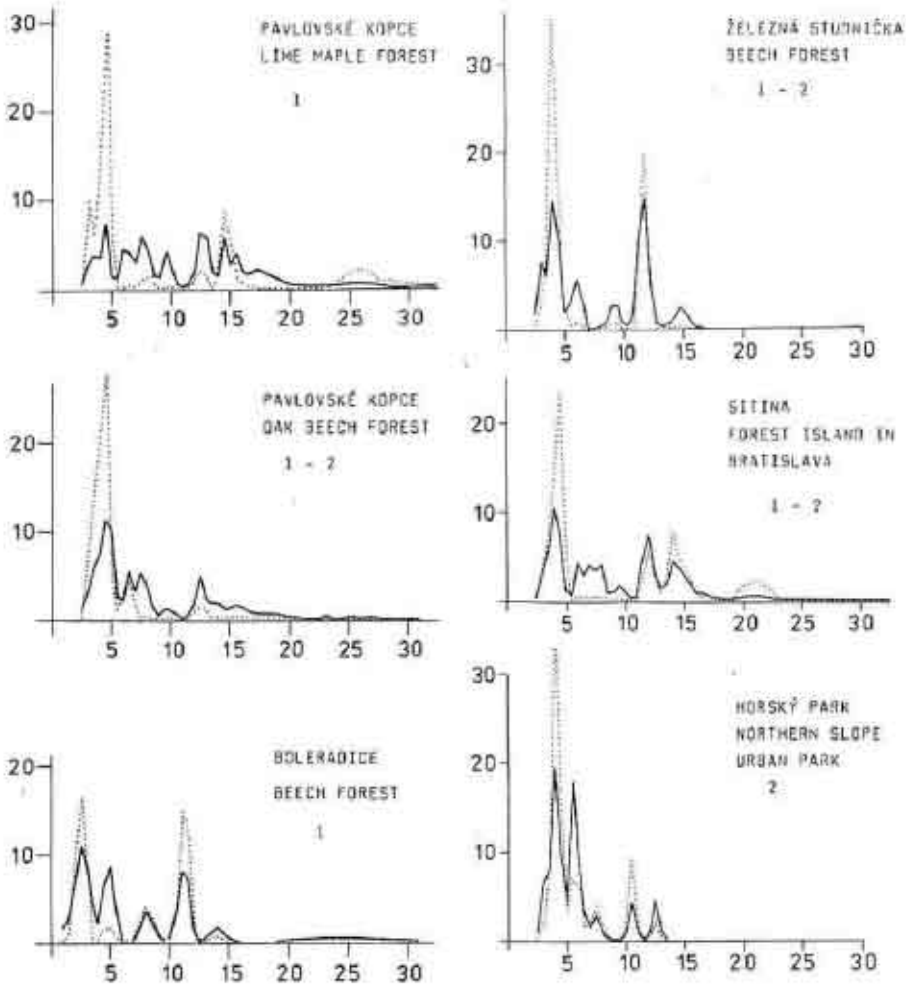

Fig. 3. Body size distribution of Staphylinidae in alluvial communites in city interior (symbols as in Fig. 1).

Břenkova - garden in older residencial quarter of Brno - Černá pole, arisen in 1927, recultivated in 1963 - 1965; Bajkalská - ruderal site in new housing estate in eastern parts of Bratislava, Hrad - shrubs on the ruinas of former quarter Bratislavské Podhradie nearby Beblavého street, Kraví Hora - week grassy strip along a way in a Schrebergarten colony in Brno; Americké nám., Nám. 4. apríla (since 1990 Hlavné nám. square), 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 shrubs on the squares and streets in the centre of Bratislava, all strongly affected by public, domestic animals, traffic and industrial imissions; majority of them arose during first two decenia of 20 century, all intensively cultivated an frequented; Nám. 28. října - artificial park in Brno arisen in 1907, today of the same character as the above parks in the centre of Bratislava.

Results

The body size of all Staphylinids in Central Europe takes the range of 1 - 32 mm (Fig. 1). However, majority of the species concentrates in the interval of 1 - 10 mm and the mode of the distributions moves around the length of 3 mm. The body size of approximately 200 staphylinid species constituing the soil surface communities in the habitats at the lower altitudes corresponding to the oak - oak - beech vegetation tier moves within the same range of 1 - 32 mm, but the body size distribution curve is much more left shifted. Both distributional curves of the staphylinds are much more left-skew in comparison with those of the Carabids (Fig. 1).

In the natural water-side habitats and in the floodplain forests the body size distribution of the staphylinids takes only a narrow range of 2 - 25 mm (Fig. 2 and 3). It is less than in the natural mesohygrophilous forests or in the open landscape (Fig. 4 - 8). However, the absence of the large sized species of the genera *Ocypus* and *Staphylinus* in the natural alluvial habitats is caused only by the low moisture preference of those species. So, there is nearly no difference between the body size range of the communities in the natural and seminatural habitats. In all studied alluvial communities of Staphylinidae, regardless of the degree of their anthropogenous influencing, the local maxima of the qulitative distribution of the body size lay between the local maxima of the body size distribution of Carabidae coincide with the local minima of Staphilinidae (c. f. ŠUSTEK, 1987). This indicates that the body size distribution of boths predominantly predaceous groups reflects partitioning of their food resources according to the relation of the predator-prey size and natural competition of the representatives of both families.

Similarly as in the carabids, the discordance between the qualitative (potential) and quantitative (realized) body size distribution increases with the increasing anthropogenous pressure on a community. The individual local maxima of the body size distribution of Staphylinidae are mostly shifted at one octave lower than in Carabidae. The degree of the anthropogenous influencing of the studied water-side commu-

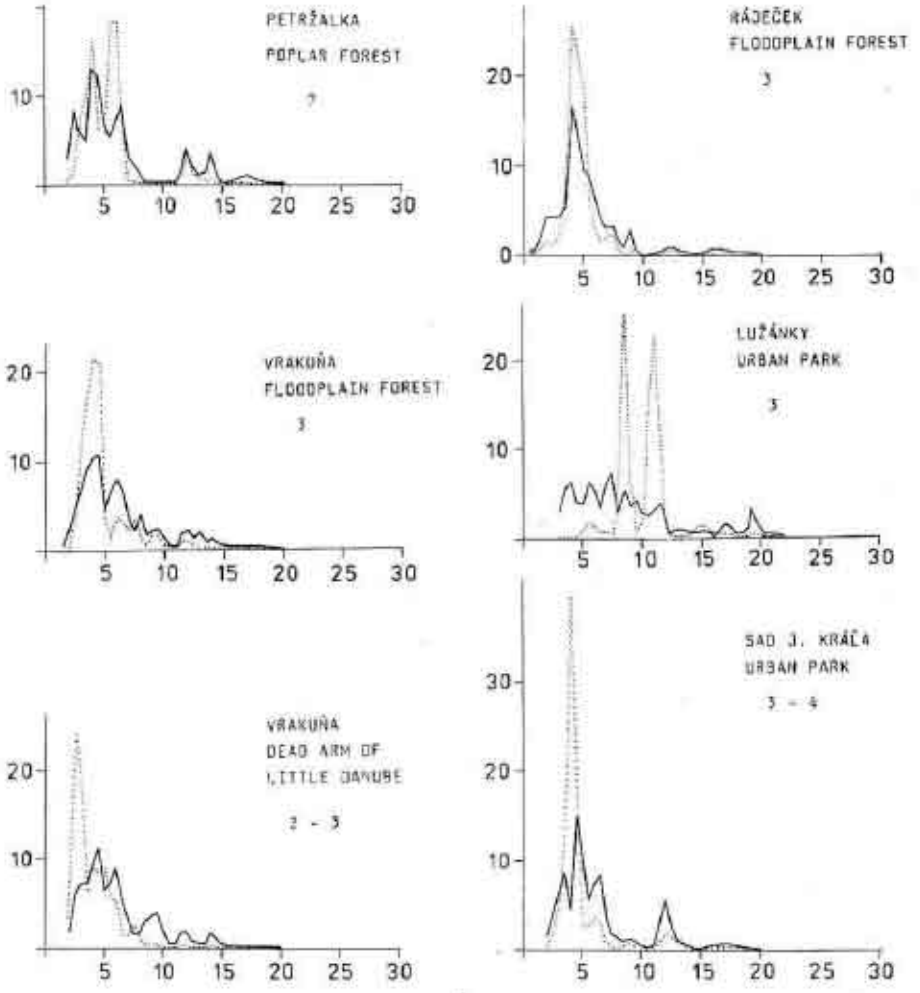

Fig. 4. Body size distribution of Staphylinidae in the mesohygrophilous forest communities in reference localities (Pavlovské kopce, Boleradice) and in city interior (symbols as in Fig. 1).

nities was not so high to there appeare discontinuities of the body size distribution in its local minima (Fig. 2 and 3) or to the body size distribution range be narrower than in the natural communities, so as it can be observed in the following two types of communities (Fig. 4 - 8).

The body size structure of Staphylinidae in the more or less natural or seminatural mesohygrophilous deciduous forests strongly differs from that in the water-side habitats (Fig. 4 and 5). The staphylinid body size fill its whole potential range, hence 1 - 32 mm. This is possible due to the occurrence of *Ocypus tenebricosus* or of its ecological vicariant *Ocypus biharicus*, which are sporadicaly acompanied also by *Ocypus olens* or *Ocypus opthalmicus*. The local maximum nearby ca. 15 mm is missing or it is indicated only in the qualitative distribution. This is caused by the presence or absence of *Philonthus decorus*, which is usually abundant in the floodplain forests or more humid submontaneous forests, but which mostly does not occure in the mesohygrophilous forests at lower altitudes. The local maximum in the range of 2 - 5 mm is always more developed in the mesohygrophilous forests in both, qualitative and quantitative distribution.

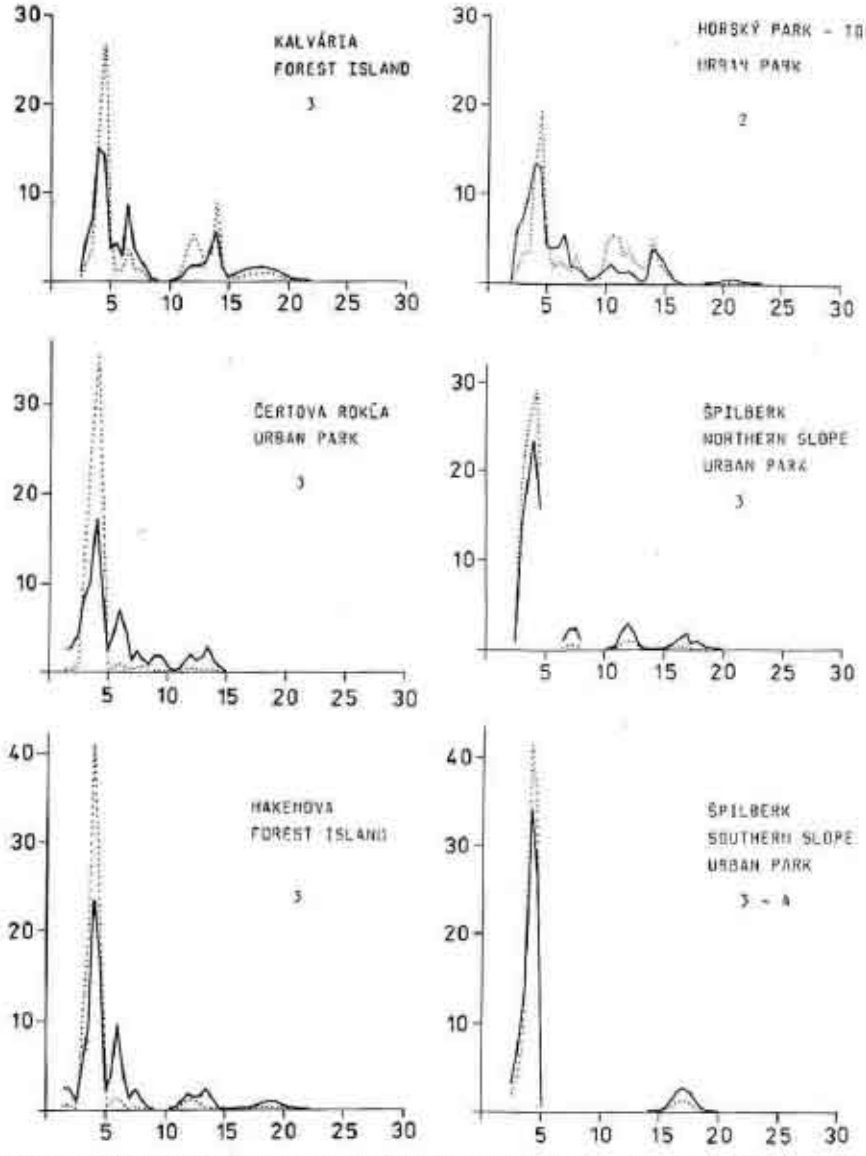

Fig. 5. Body size distribution of Staphylinidae in the mesohygrophilous forest communities in city interior (symbols as in Fig. 1).

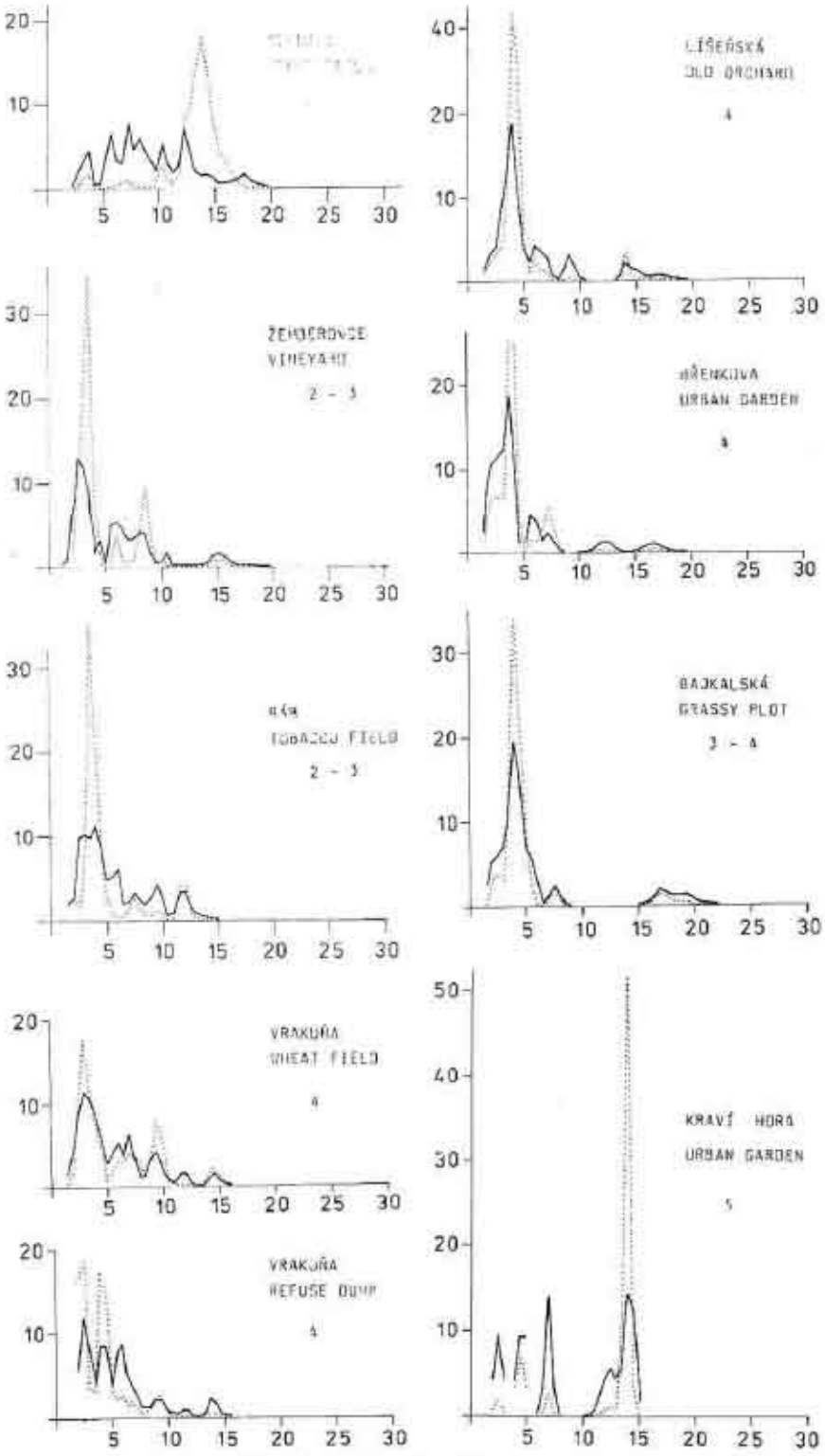

Fig. 6. Body size distribution of Staphylinidae in open landscape (s. c. cultural steppe) in reference localities (Pezinok, Žemberecovce, Báb) and in city interior (symbols as in Fig. 1).

It is due to high abundance of the species couple *Omalium rivulare* and *Oxytelus sculpturatus*, which represent a constant component of the staphylinid communities even in many strongly anthropogenously influenced habitats in the city interior. In the natural conditions, this local maximum is created also by *Lathrobium atrocephalum*. Only rarely (in Boleradice and in Železná studnička, Fig. 4) the local maxima of the body size distribution of Staphylinidae coincidates with those of Carabidae (c. f. ŠUSTEK, 1987). However, the strongly different body form of the representatives of both families indicates that there will be only a small overlap of their ecological niches. When compared with the carabids, the body size distribution of the staphylinid communities does not change so far along the studied urbanisation gradient. More significant changes appeare only in two strongly affected communities on the slopes of Špilberk in Brno (Fig. 4). Similarly as in the carabids, the distributional curve becomes discontinuous in its local minima and the body size distribution does not take the whole potential range. The large sized species *Ocypus tenebricosus* or *Ocypus biharicus* disappeare from the anthropogenously affected communities. Their large body size coincides with unability to fly and, consequently, with the reduced dispersal power. Therefore the large body size of *Ocypus tenebricosus* and *O. biharicus* plays probably only a secondar role, as it is indicated by their flying congeners *Ocypus olens* and *Ocypus opthalmicus*.

In the reference localities in the arable land (Fig. 6), the body size disstribution of staphylinids takes the range of 2 - 22 mm or 2- 15 mm respectively. The actual body size range is strongly dependent on the presence of some species of the genus *Staphylinus* (mostly *S. caesareus*, 17 - 22 mm and *S. chalcocepha-*

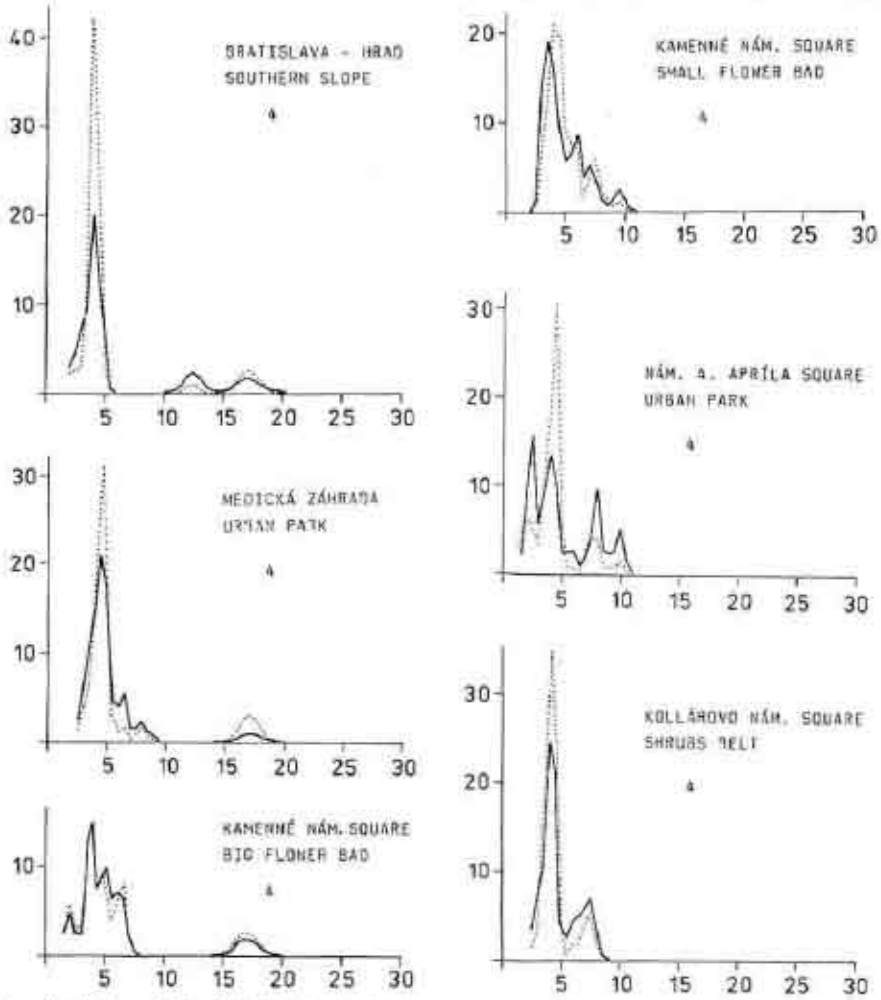

Fig. 7. Body size distribution of Staphylinidae in open landscape (s. c. cultural steppe) in the city interior (symbols as in Fig. 1, Nám. 4. apríla square (overnamed on the Hlavné námestie square since 1990).

ies, 13 - 19 mm), which usually prefer more natural habitats. The qualitative body size distribution is polymodal in these communities, while the quantitative distribution tends to create an only high peak more than in the carabids (c. f. ŠUSTEK, 1987). The peak in the interval of 2 - 5 mm is created by the species of the genera *Tachyporus, Oxytelus* and *Omalium*, the peak around the lenght of 15 mm by *Philonthus fuscipennis*.

The body size distribution of the staphylinid communities in the suburban areas (Fig. 6) takes still the same range as in the reference localities, but it is discontinuous and more expresively concentrated in an only peak in the interval 2 - 5 mm. The proportional similarity of the qualitative and quantitative distribution is high. The same pattern is preserved also in the communities from the more natural habitats in the city interior

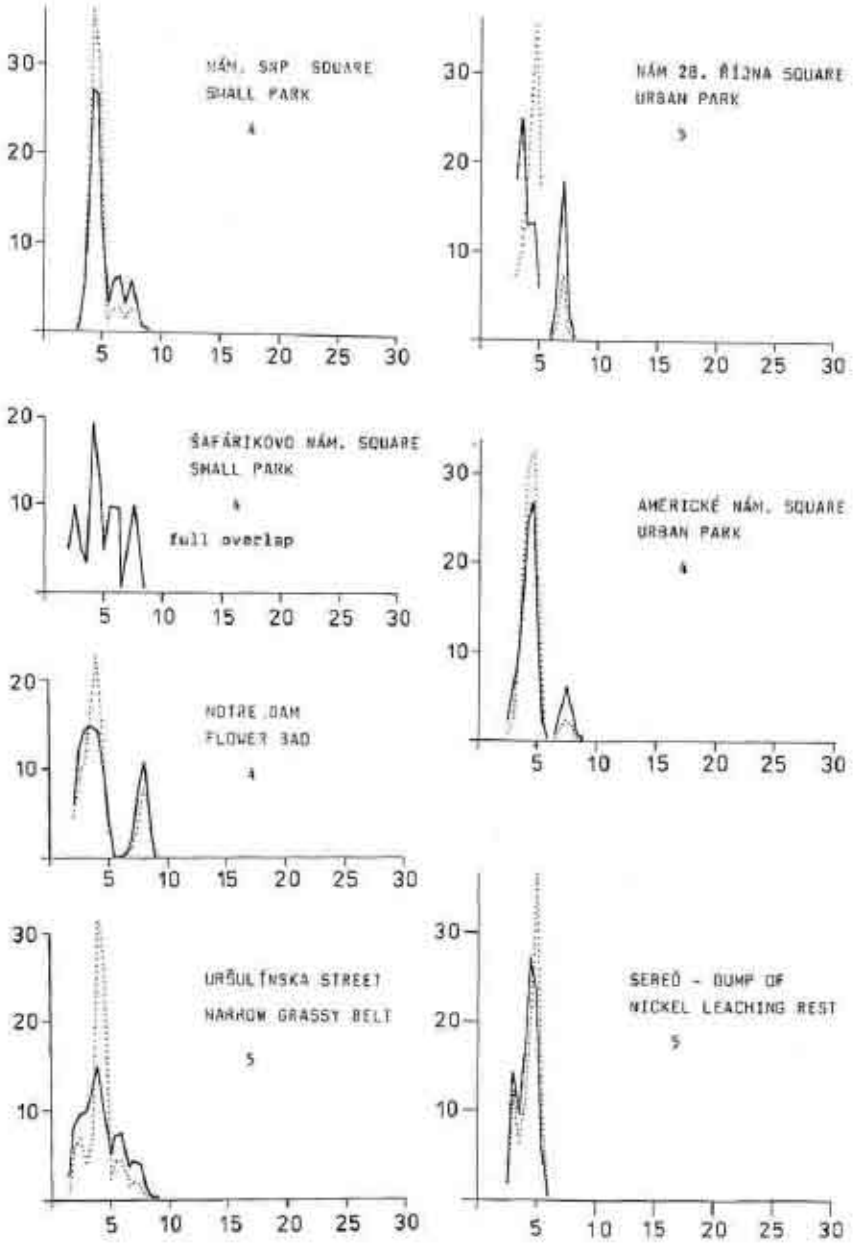

Fig. 8. Body size distribution of Staphylinidae in open landscape (s. c. cultural steppe) in the city interior and in an extremly unfavourable habitat in free landscape (Sereď), (symbols as in Fig. 1).

(Bratislava, Medická záhrada, Bratislava - Hrad, Fig. 7). The body size distribution of staphylinids in several small grassy plots and flower beds in the city centre or in the extremly unfavorable condiditons on the damp of the nickel leaching rest in Sered (Fig. 7 and 8) is contracted on the range of 2 - 10 or even 2 - 8 mm and the quantitative distribution tends to create a single peak. The communities are extremly poore in species and individuals and they consist mostly of few individuals of *Omalium rivulare, Oxytelus tetracarinatus, Ox. sculpturatus, Drusila canaliculata* and *Xantholinus linearis*. Due to the small species number, the body size distribution is discontinuous even in the narrow range of 2 - 10 mm. Also in these chronicaly pionier communities the local maxima tend to be shifted at one octave lower than in Carabidae (c. f. ŠUSTEK, 1987). The pattern of the body size structure as such is, however, very similar to that in Carabidae in the same sampling plots.

Discussion and conclusions

The body size structure of Staphylinidae exhibits striking changes along the studied urbanisation gradient and, in the more preserved forest habitats also in dependence on the substrate trophicity. These changes have generally the same character as in the carabids (ŠUSTEK, 1987), but they are not so expressive. This is caused by the generally narrower range of body size distribution in staphylinids. There are no species longer than 32 mm, the interval between 25 - 32 mm is occupied only by four species, two of which are rare and other two species, *Ocypus tenebricosus* and *Ocypus biharicus*, do not use to occur together in one place. Due to it, majority of the staphylinid communities is formed even in the natural condition by the species, the size of which does not exceed 25 mm. In the carabid communities such a state corresponds often already to the moderately affected communities (especially in the mesohygrophilous forests). Further, the deciding part of the staphylinids concentrates within the body size range of 2 - 16 mm. This scale of the body size disstribution corresponds already to the considerably affected carabid communities. Besides it, the size (and weight) of carabids and staphylinids of the same body length differs sometimes considerably due to the different body form. A slight negative correlation of the abundance of carabids and staphylinids in majority of habitats and the above analyses indicate that the carabids are superior to the staphylinids in the partitioning of the resource niches. So the staphylinids can occupy only those niches which are not occupied or can not be occupied by the carabids and some other small soil surface predators. Therefore the staphylinids can not form, in regard to the body size, so richly structurized communities as the carabids do.

In spite to the above facts, the five patterns of the body size distribuiton distinguished earlier (ŠUSTEK, 1987) for the carabids can be generally found also in the staphylinids. The first pattern, typical of the natural or completly regenerated communities in the habitats with high trophicity is characterized by continuous polymodal curves taking the whole potential body size range. Second pattern is typical for the moderately influenced communities or for the natural communities in the habitats with a lower trophicity. It is characterized by the discontinuous distributional curves in the local minima before the highest octaves. The third pattern is characteristic for the intermediately influenced communities. The distributional curves do not take the whole potential body size range, the existing part of the curves remains continuos. The fourth pattern is characteristic by the contracted distributional curve, brooken in the local minima. The fifth pattern is typical by the distributional curves consisting of only two or one isolated peak. It occurs in the most damaged or chronically pionier communities. In comparison with the carabids the above five patterns are distinguishible more in the qualitative body size distribution. The quantitative distribution tends to create a single expressive local maximum earlier than the quantitative distribution of body size of the carabids. The reasons of it have been discused above.

References

FREUDE, H., HARDE, K. W., LOHSE, G. A., 1964, 1974: Die Käfer Mitteleuropas, Vol. 4 and 5, Krefeld, 264 pp., 381 pp.

GOSPODAR, U., 1981: Statik und Dynamik der Carabidenfauna einer Trümerschutt-Deponie in Berlin (West). Thesis, Freie Universität Berlin, Berlin 225 pp.

GRUSCHWITZ, M., 1983: Populationsökologische Untersuchungen zur räumlichen Differenzierung von Carabiden in einer Biotopmosaik. Thesis, Rheinische Fridrich-Wilhelm-Universität zu Bonn, Bonn, 181 pp.

GOLIKOV, A. N., 1985: Ob izmenenijach razmerov i prodolzhitelnosti zhizni organizmov v procese evolutsii.- Zhurn. obshch. biol. **46**: 771-777.

LEVINTON, J. S., 1982: The body size-prey size hypothesis: The adequacy of body size as a vehicle for character displacement.-Ecology **63**: 689-872.

OBRTEL, R., 1972: Soil surface Coleoptera in a reed swamp.- Acta sci. nat. Acad. sci. Bohem. Brno, **6**, 9, 35 pp.

PIANKA, E., 1981: Evolutsionnaya ekologiya, Mir, Moskva, 399 pp.

ŠUSTEK, Z., 1983: The comparison of the Carabidae and Staphylinidae (Ins. Col.) in the selected geobiocoenoses of Pavlovské kopce hills during the years 1971-1981.-Biológia, Bratislava **38**: 105-115.

ŠUSTEK, Z., 1984a: Bioindicative properties of Carabidae and Staphylinidae in the Central European cities. (In Slovak).- PhD. thesis, Inst. of Experimental Biol. and Ecol. CBES, Slov. Acad. Sci., Bratislava, 360 pp.

ŠUSTEK, Z., 1984b: Bioindicative role of the body size structure of a community.-Ekol. kooperatsiya, p. 17-19. (In Russian).

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

THOMSON, J., 1986: Trend surface analysis of spatial patterns of tree size, microsite effects, and competitive stress.-Can. Journ. For. Ecol. **16**: 279-282.

Received September 17, 1992