*Mem. Inst. Oswaldo Cruz*, Rio de Janeiro, Vol. *84*, Supl. IV, 441-447 1989

# SYNANTHROPIC TRENDS IN URBAN AND EXTRAURBAN TAXOCENOSES OF SARCOPHAGINAE (DIPTERA) IN THREE CENTRAL EUROPEAN CITIES

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*An attempt has been made to characterize the synanthropic trends in Sarcophaginae of three Central European cities, viz. Brno, Bratislava and Budapest. The polar ordination of both sarcophagine taxa and of their taxocenoses revealed clear-cut trends towards culturophily and synanthropy in the male preconnubial aggregations of Sarcophaginae evidencing that this group of high Diptera represent an excellent model for the study of this phenomenon.*

Key words: Sarcophaginae - synanthropy – culturophily – urban biocenoses – ecology – Central Europe

The aim of this paper is to demonstrate primarily the trend towards the culturophily and, mainly, towards the synanthropy in Sarcophaginae. This trend known for years was analyzed biostatistically to objectivise hidden relations. For this purpose the taxocenoses of (male) Sarcophaginae were sampled in three selected cities of Central Europe (Brno, Bratislava and Budapest) and in their vicinity.

## MATERIAL AND METHODS

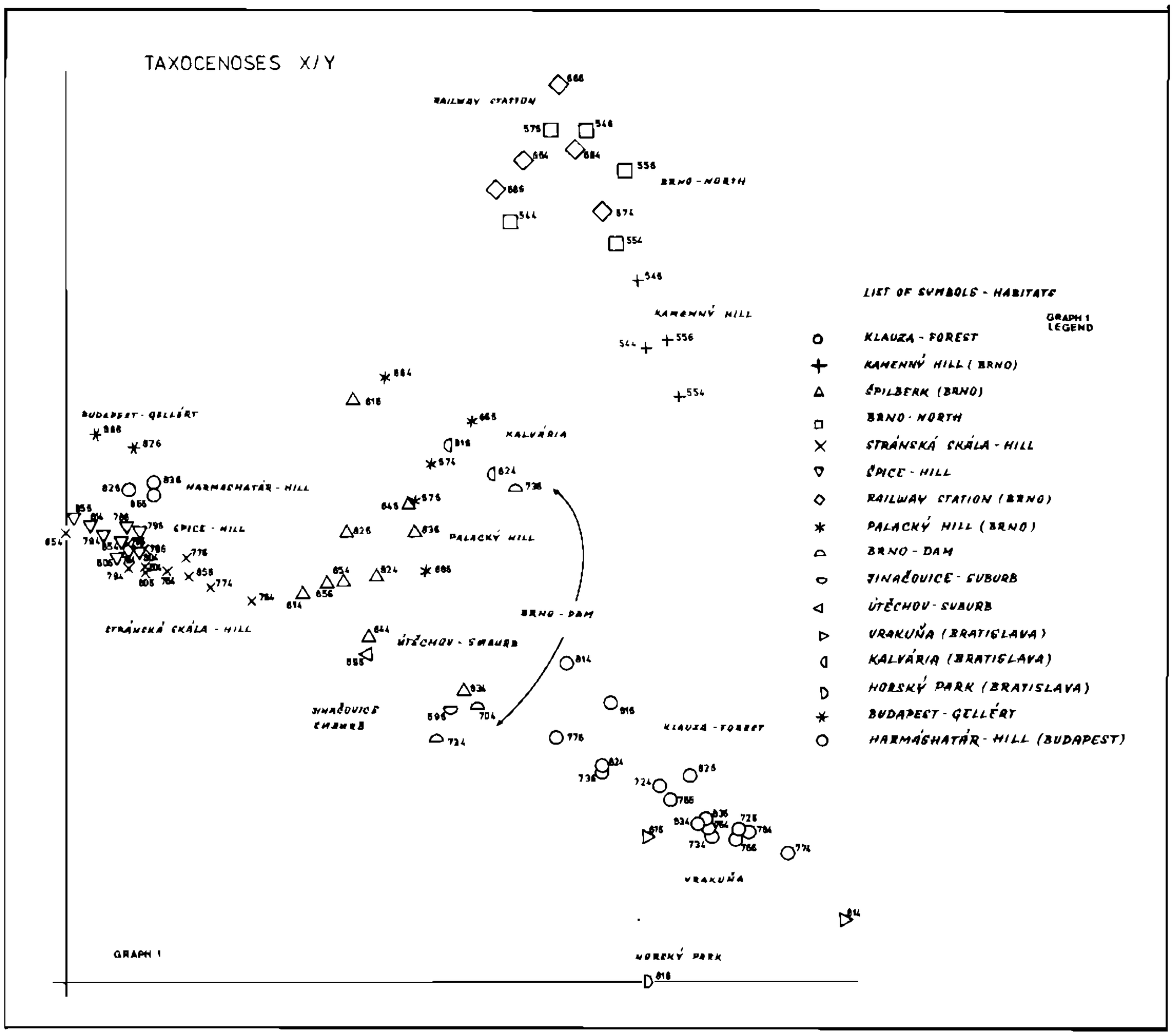
The material on which this paper is based was collected (during the years 1954-1985) in the male preconnubial aggregations (Povolný & Šustek, 1981) in a transsect of habitats including the vicinity (both "natural" and moderately changed habitats) of the above cities, their suburbs and centers. It totals more than 20 thousand individuals belonging to some 50 taxa of some 80 taxa occurring in Central Europe. This material is just a fraction of a date base comprising similar samples taken between the years 1954 and 1989 in 142 individual habitats of the Central European landscape and including about 80 sarcophagine taxa represented by about two hundred and fifty thousand individuals.

The samples used within the frame of this study were treated and evaluated by means of Detrended Correspondence Analysis (DCA). This ordination method is based on the Principial Component Analysis (PCA) the latter being generalized for non-linear data and adapted for zoocenological studies. The principles of this method were described by Hill (1979) and by Gauch Jr (1982). The diversity and the equitability indices were obtained by the FORTRAN IV programme (Kaesler & Mulvany, 1976a, b). These two programmes (originally due to phytocenology) were joined and modified for zoocenological purposes. This original adaptation (by V. Znojil) of the algorhythms of dating includes the random selection of samples according to a series of numbers and their ordination at a simultaneous separation of synonyms and under continuous completing. The polar ordinations were used to present the trends studied graphically.

## RESULTS AND DISCUSSION

The distribution of species along the first two major ordination axes (Graph 1), obtained by the version of the DECORANA programme employed, shows two clean-cut groups of taxa:

(1) A characteristic cloud of taxa along the X axis, typical of (Ponto) Mediterranean limestone cliffs and loess deposits, as characterized by travertin habitats in the centre of the right-bank Budapest (roughly in the area of Gellért), the wooded slopes of the Harmáshatárhegy (Hill) exposed towards the south-east, and the similar but more northern habitats in the environs of Brno (the Špice Hill and especially Stránská skála Rock). Bratislava lacks similar habitats in its vicinity, but similar or almost identical conditions can be found in the wider region of southern Slovakia, viz., near Štúrovo (Hegyfárok) and Nitra (Kalvária in its center). From the environs of Brno and the




whole of southern Moravia are absent only the pronouncedly south European stenecious species *(Discachaeta cucullans, Parasarcophaga aegyptica, P. jacobsoni)*, the same as the Carpathian endemic species accompanying warm woodland formations of the western Carpathians *(Sarcophaga zumptiana* and *S. moldavica)*. The presence of *Helicophagella novercoides* on the limestones of Budapest (i. e., localities very low in terms of hypsometry) documents their biogeographical proximity to the Mediterranean localities of this species which, more to the north, appears as a heliophilous species accompanying limestone formations lying above the timberline in the Carpathians.

(2) Another clean-cut cloud lies on either side of the Y axis. It can be unequivocally characterized as a taxocenosis of the Central European broadleaved forest, with considerable participation of the thermophilous element *(Parasarcophaga portschinskyi, P. emdeni* and especially *Heteronychia haemorrhoides)*. Thus, the direction from the middle section of the X axis to the right towards the Y axis apparently expresses, on the one hand, a gradient from the Central European south-east, forest-sreppe in character and affected by the Carpathians, towards the Hercynian woodled north-west and, on the other, from the more xeric continental woodless region towards the more mesic and Atlantic transitory territory, as represented by the Bohemian Massif. From the ordination origin diagonally in the direction to the right and upwards, there is a cloud belt which contains three considerably ubiquitous species *(S. variegata, Sarcophaga carnaria, S. subvicina)* and *Heteronychia vagans*. These species can be rather unequivocally characterized as euryecious culturophiles. They are joined by a characteristic group of synanthropic taxa including

TABLE I

Ecological characteristic of sampling sites

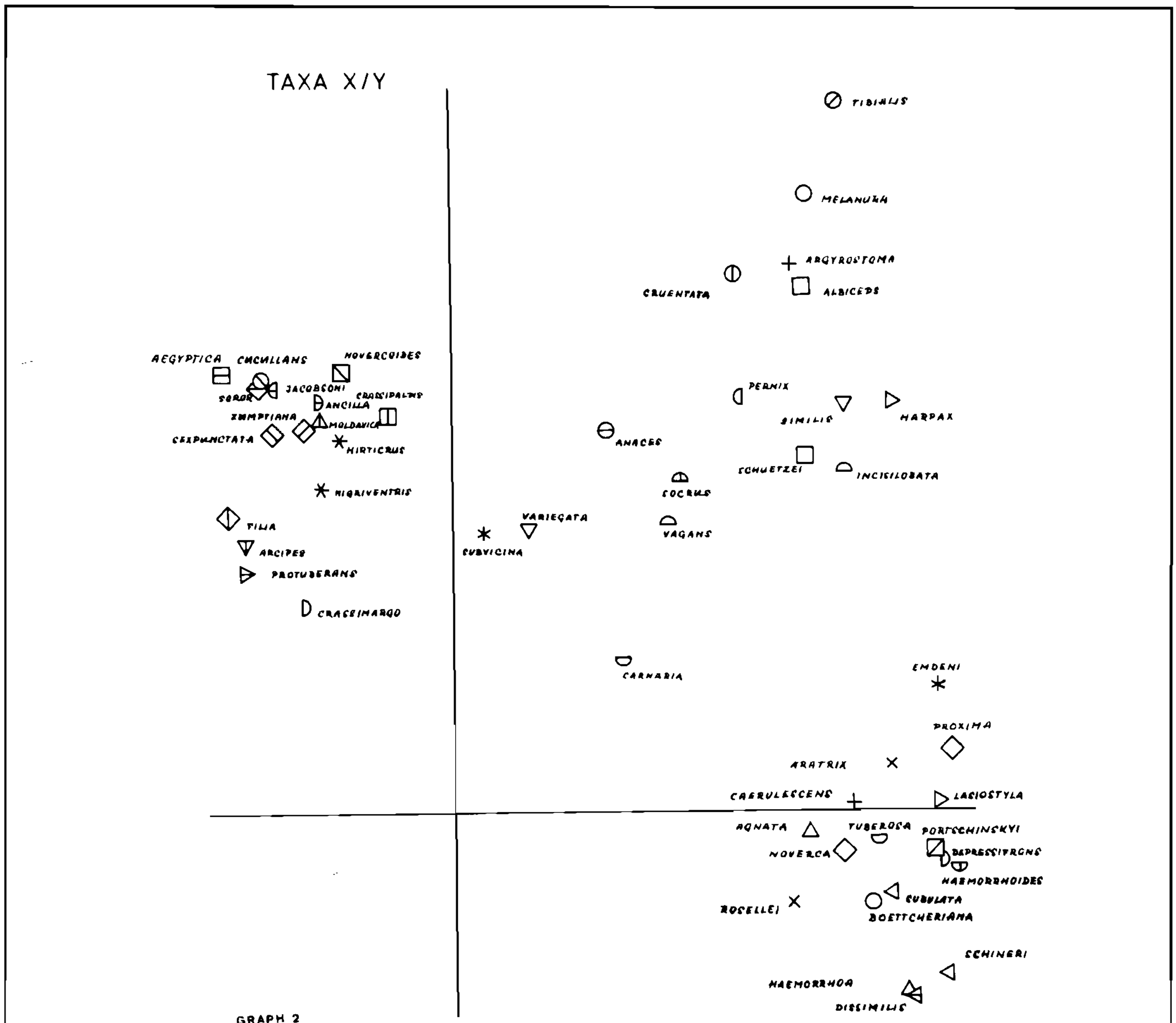
| Habitat | Precipitations above 1 mm days | Total sunshine hours | Clear days number | Summer days hours | Winter days number | Snow cover days number | January ϕ temperature | July ϕ temperature | Annual ϕ temperature |
|---|---|---|---|---|---|---|---|---|---|
| Klauza/Forest | 90 | 1900 | 55 | 50 | 35 | 50 | −0.4 | 19 | 9.2 |
| Kamenný Hill/Brno | 100 | 1900 | 55 | 50 | 35 | 50 | −2.3 | 18 | 8.5 |
| Špilberk Hill/Brno | 100 | 1900 | 55 | 50 | 35 | 50 | −1.6 | 18.7 | 8.7 |
| North Suburb/Brno | 100 | 1900 | 55 | 50 | 35 | 50 | −1.2 | 19.1 | 8.8 |
| Stránská skála Rock/Brno | 100 | 1900 | 55 | 50 | 35 | 50 | −1.4 | 18.2 | 8.7 |
| Hostěrádky Hill/Brno | 100 | 1900 | 55 | 50 | 35 | 50 | −1.3 | 18.9 | 8.9 |
| Railwaystation/Brno | 100 | 1900 | 55 | 50 | 35 | 45 | −0.2 | 19.2 | 9.0 |
| Palacký Hill/Brno | 100 | 1900 | 50 | 50 | 35 | 50 | −1.9 | 18.8 | 8.6 |
| Dam/Brno | 100 | 1850 | 50 | 48 | 35 | 50 | −2.0 | 18.7 | 8.3 |
| Jinačovice Suburb/Brno | 100 | 1850 | 50 | 48 | 40 | 50 | −2.1 | 18.1 | 8.4 |
| Útěchov Suburb/Brno | 100 | 1850 | 50 | 48 | 40 | 55 | −2.3 | 17.6 | 8.1 |
| Kalvária Hill/Bratislava | 100 | 1900 | 55 | 50 | 35 | 45 | −1.1 | 18.9 | 9.4 |
| Horský Park/Bratislava | 100 | 1850 | 55 | 48 | 40 | 50 | −1.7 | 18.3 | 9.1 |
| Vrakuňa Suburb/Bratislava | 95 | 2000 | 55 | 55 | 30 | 40 | −2.7 | 19.0 | 9.9 |
| Harmáshatár Hill/Budapest | 80 | 2150 | 60 | 65 | 30 | 40 | −0.3 | 20.1 | 10.1 |
| Gellért Hill/Budapest | 75 | 2200 | 65 | 70 | 25 | 35 | −0.1 | 21.2 | 10.6 |

those which, in the wild, are adapted to faeces (such as *Thyrsocnema incisilobata*), up to those which, being classical synanthropes, can occur in heavily stressed urban ecosystems or pseudo-ecosystems, in extreme cases even in the "concrete desert" *(Bercaea cruentata, Parasarcophaga argyrostoma).* In this connection, two taxa deserve particular attention, viz. *Parasarcophaga crassipalpis* and *P. tibialis*. These two species are typical of the warmest and driest situations of the European Pontomediterranean Region where they produce high population densities, especially on seashores as consumers of dead marine animals washed ashore, or waste materials and faeces in recreation areas. They may be accidentally conveyed more to the north by transportation (cf. the finding of *Parasarcophaga tibialis* at the main railway station in Brno), without becoming established.

It may be stated in general that the oblique cloud belt extending from the ordination origin to the right and upwards distinctly indicates the trend from ubiquitous towards culturophilous and markedly synanthropic species.

The ecological characteristies of sampling sites appear in Tables I and II.

A similar picture is provided by Graph 2, in the middle section of the X axis, by the distribution of taxocenoses from the habitats under study. The two Budapest habitats (Harmáshatárhegy and Gellért) are approached by analogical formations of Brno (Stránská skála Rock and the Špice Hill), whereas localities with woodland cover (Klauza, Vrakuňa and Horský Park) are found on the bottom right above the X axis. The scatter of the Klauza locality is due to the fact that in 1979 its biocenosis was considerably altered and destabilized by the destruction of natural vegetation which was replaced by a horse chestnut plantation grown for gamekeeping purpose – an intervention returning Moravian nature far behind feudalistic relations of man towards nature. Such localities as municipal parks (Špilberk) or recration woods, suffering from heavy recreational traffic (Palácký Hill, Kalvária in Bratislava), occupy a transitional zone between the two clean-cut groups of relatively preserved habitats or those affected by culturophilous species only. The remarkable scatter of plots for the Brno Dam Lake is due to the fact that during summer (i. e. at the time of recreation) its sarcophagine taxocenosis is much more markedly affected by the presence of synanthropic species than it is during an earlier aspect when it resembles the taxocenosis of the surrounding woodland. The top cloud on the right comprises strongly destabilized habitats in the center of Brno




GRAPH 2

LIST OF SYMBOLS - TAXA

GRAPH 2 – LEGEND

| | | |
|---|---|---|
| ○ HEL. MELANURA | ▽ PAR. SIMILIS | ◠ PIERR. SOCRUS |
| + ROB. CAERULESCENS | ◇ HET. PROXIMA | ◔ HET. HAEMORRHOIDES |
| △ HEL. AGNATA | ✳ PAR. EMDENI | ◁ HET. DISSIMILIS |
| □ KRAM. SCHUETZEI | ◠ HET. VAGANS | ▷ PAND. PROTUBERANS |
| × HEL. ROSELLEI | ◒ PAR. TUBEROSA | ◫ PAR. CRASSIPALPIS |
| ▽ SARC. VARIEGATA | ◁ HET. SCHINERI | ⊟ PAR. AEGYPTICA |
| ◇ HEL. NOVERCA | ▷ PAR. HARPAX | ⊘ PAR. TIBIALIS |
| ✳ SARC. SUBVICINA | ◖ RAV. PERNIX | ⊘ DIGC. CUCULLANS |
| ◠ THYRS. INCISILOBATA | ◗ HEL. CRASSIMARGO | ◖ PAR. JACOBSONI |
| ◒ SARC. CARNARIA | ✳ HEL. HIRTICRUS | ◗ HET. ANCILLA |
| ◁ BELL. SUBULATA | □ PAR. PORTSCHINSKYI | |
| ▷ SARC. LASIOSTYLA | □ BELL. NOVERCOIDES | |
| ◗ HET. DEPRESSIFRONS | ◐ BERC. CRUENTATA | |
| ✳ PIERR. NIGRIVENTRIS | ⊖ KRAM. ANACES | |
| ○ HET. BOETTCHERIANA | ◈ SARC. ZUMPTIANA | |
| + PAR. ARGYROSTOMA | ◈ ARACH. SEXPUNCTATA | |
| △ HET. HAEMORRHOA | ◬ SARC. MOLDAVICA | |
| □ PAR. ALBICEPS | ▽ SIC. ARCIPES | |
| × PAR. ARATRIX | ◈ PIERR. SOROR | |
| | ◈ HET. FILIA | |

TABLE II

Ecological characteristic of sampling sites

| Habitat | Longitude | Latitude | Elevation metres | Vegetation tier | Geol. formation |
|---|---|---|---|---|---|
| Klauza/Forest | 16°38'36" | 48°41'55" | 320 | 1 | Jurassic Limestone |
| Kamenný Hill/Brno | 16°33'12" | 49°10'49" | 315 | 3 | Gabro |
| Spilberk Hill/Brno | 16°36'04" | 49°11'39" | 250 | 2 | Uralitic Diabas |
| North Suburb/Brno | 16°38'26" | 49°12'06" | 220 | 2 | Aluvium |
| Stránská skála Rock/Brno | 16°40'50" | 49°11'29" | 310 | 1 | Jurassic Limestone |
| Hostěrádky Hill/Brno | 16°47'12" | 49°07'19" | 350 | 1 | Tertiary sea sediments |
| Railwaystation/Brno | 16°36'48" | 49°11'27" | 205 | 2 | Aluvium |
| Palacký Hill/Brno | 16°34'46" | 49°13'23" | 340 | 2 | Diabas/Granodiorite |
| Dam/Brno | 16°30'00" | 49°14'55" | 250 | 2 | Granodiorite |
| Jinačovice Suburb/Brno | 16°31'05" | 49°15'40" | 325 | 3 | Granite-Gneis |
| Útěchov Suburb/Brno | 16°37'43" | 49°17'20" | 450 | 3 | Granodiorite |
| Kalvária Hill/Bratislava | 17°06'00" | 48°09'40" | 260 | 2 | Metamorphic layers |
| Horský park/Bratislava | 17°03'30" | 48°10'00" | 260 | 2 | Metaperhic layers |
| Vrakuňa Suburb/Bratislava | 17°13'20" | 48°09'15" | 130 | 1 | Aluvium |
| Harmáshatár Hill/Budapest | 19°07'58" | 47°32'19" | 320 | 1 | Tertiary limestone cliff |
| Gellért Hill/Budapest | 19°07'41" | 47°31'16" | 245 | 1 | Thermal Travertinite |

(the main railway station; old periphery in the north of Brno) and a gardenerś colony at the very edge of the town (Palacký Hill), heavily affected by the presence of synanthropic taxa (developing in wastes, faeces of household animals, particularly dogs, etc.). The fact that this cloud does not comprise the taxocenosis of the travertine cliff in the right-bank Budapest (whose position above that of Harmáshatárhegy indicates that it is affected by synanthropic species) is apparently due to two causes: 1) The method employed did not permit to discover in Budapest a preconnubial aggregation of males in the centre of the intra-urban area, such as was the case in Brno (the main railway station). It is known, however, from such intra-urban habitats as the slaughter-house of Budapest (Gregor & Povolný, 1960) that its sarcophagine taxocenosis would include only a few highly synanthropic taxa (e. g. *Helicophagella melanura*, *Bercaea cruentata*, *Parasarcophaga argyrostoma*, *P. crassipalpis*, *P. albiceps*) and in this case such habitat would be undoubtedly placed in or among the cloud of strongly changed habitats (such as Railway station of Brno). 2) Because of latitude, such taxa as, e. g. *Parasarcophaga crassipalpis* may produce non-synanthropic (free-nature) and synanthropic (urban) populations. A similar problem is encountered with a number of species of subtropical origin or strongly thermophilous ones (especially taxa of the subgenus *Liosarcophaga*, e. g. *P. tibialis*, *P. dux*, *P. aegyptica*), which have secondarily invaded warmer regions along the Danube River and its tributaries only after they had become arid due to the deforestation in historical times. It may be stated in general that even in this case the slightly destabilized localities are ordinated diagonally between the arms of the ordination axes whereas the disintegrated habitats with clean-cut synanthropic taxocenoses are isolated in the upper right corner.

As far as the indices of species diversity and equitability are concerned, the respective values indicate that species diversity is fairly high in relatively little distrubed localities. This is generally true of other insect and animal groups in that region. This disintegration of Central European broadleaved woodland, having begun in the early Middle Ages (and long before in the Mediterranean) and resulting in the losening of the vegetation cover in extensive regions, has importantly contributed to the invasion of the members of the thermophilous element from the European south-east. This may have even resulted in a secondary fusion of extrazonal

TABLE III

Shannon's diversity (D) and equitability (E) indices normalized by random selection of 100 individuals from groups of samples with special regard to seasonal aspects (4 = late spring aspect, 6 = top summer aspect)

| Habitat | Code | D | E | n | Habitat | Code | D | E | n |
|---|---|---|---|---|---|---|---|---|---|
| Klauza/Forest | 724 | 2.249 | 0.827 | 418 | Palacký Hill/Brno | 686 | 1.590 | 0.677 | 230 |
| | 726 | 2.082 | 0.784 | 304 | Hostěrádky/Hill/Brno | 784 | 1.750 | 0.791 | 251 |
| | 734 | 2.167 | 0.742 | 274 | | 786 | 1.569 | 0.745 | 943 |
| | 736 | 2.270 | 0.806 | 351 | | 794 | 1.660 | 0.841 | 897 |
| | 764 | 1.989 | 0.749 | 465 | | 796 | 1.423 | 0.736 | 1350 |
| | 766 | 1.702 | 0.697 | 896 | | 804 | 1.656 | 0.796 | 592 |
| | 774 | 1.859 | 0.742 | 389 | | 806 | 1.595 | 0.823 | 1983 |
| | 776 | 2.062 | 0.802 | 524 | | 814 | 1.810 | 0.840 | 129 |
| | 784 | 1.821 | 0.717 | 532 | | 854 | 1.546 | 0.799 | 232 |
| | 786 | 2.080 | 0.773 | 534 | | 856 | 1.615 | 0.792 | 1137 |
| | 814 | 1.735 | 0.806 | 556 | Špilberk Hill/Brno | 814 | 1.914 | 0.708 | 259 |
| | 816 | 1.605 | 0.707 | 777 | | 816 | 1.793 | 0.866 | 144 |
| | 824 | 1.849 | 0.753 | 423 | | 824 | 2.097 | 0.805 | 286 |
| | 826 | 2.002 | 0.786 | 116 | | 826 | 2.165 | 0.821 | 306 |
| | 834 | 1.681 | 0.701 | 330 | | 834 | 2.122 | 0.834 | 226 |
| | 836 | 1.639 | 0.672 | 502 | | 836 | 1.871 | 0.821 | 145 |
| Gellért Hill/Budapest | 826 | 2.113 | 0.113 | 211 | | 854 | 1.885 | 0.735 | 100 |
| | 866 | 1.909 | 0.770 | 510 | Stránská skála Rock/Brno | 764 | 1.590 | 0.780 | 187 |
| Harmáshatár/Budapest | 826 | 1.893 | 0.730 | 312 | | 774 | 1.573 | 0.707 | 527 |
| | 836 | 1.758 | 0.714 | 393 | | 776 | 1.594 | 0.716 | 315 |
| | 866 | 1.686 | 0.641 | 274 | | 784 | 1.696 | 0.754 | 384 |
| Dam/Brno | 704 | 1.795 | 0.708 | 137 | | 786 | 1.471 | 0.731 | 722 |
| | 734 | 1.613 | 0.655 | 163 | | 794 | 1.670 | 0.795 | 927 |
| | 736 | 1.589 | 0.671 | 220 | | 796 | 1.528 | 0.820 | 1471 |
| North Suburb/Brno | 556 | 1.721 | 0.828 | 556 | | 804 | 1.629 | 0.762 | 943 |
| Kamenný Hill/Brno | 546 | 2.208 | 0.897 | 187 | | 806 | 1.604 | 0.786 | 1521 |
| | 556 | 2.343 | 0.913 | 101 | | 854 | 1.626 | 0.808 | 213 |
| Útěchov Suburb/Brno | 696 | 2.052 | 0.790 | 144 | | 856 | 1.348 | 0.794 | 355 |
| Vrakuňa Suburb Bratislava | 814 | 1.205 | 0.510 | 301 | | | | | |

Considerable differences in values D and E in the woodland of Klauza are especially characteristic of its disintegration. 54 = 86 successive years of sampling. n = number of individuals

islets of thermophilous post-glacial flora and fauna to form more extensive units. In this way the original largerly woodland character of the Eurosiberian forest belt in its broadleaved western European facies was enriched by the thermophilous element. This trend was continued in a far-reaching spreading of culturophiles and finally also synanthropic species, a number of which (especially the seemingly ubiquitous *Sarcophaga* spp. as well as *Heteronychia vagans*, *Ravinia pernix* of the culturophilous species; *Parasarcophaga argyrostoma*, *Bercaea cruentata* and numerous *Liosarcophaga* spp. of the synanthropic ones) have markedly shifted their northern or north-western limits and, in the case of the synanthropic species, insular urban populations strictly confined to more extensive human agglomerations have been produced.

It appears forthermore that unpremeditated agricultural and forestry management may result in significantly decreased species diversity indices. Thus, for example, in the late 1970ies the natural vegetation of the Klauza in the Pálavské vrchy Mts. (South Moravia) was replaced by a horse chestnut monoculture to provide a source of chestnuts as a food for mouflons and wild goat kept there as game animals. Since 1979, the sarcophagid taxocenosis of that area has been considerably destabilized, which has become apparent, among other things, in the decreased values of species diversity (especially the parasitoids of moluscs and insects decreased or disappeared only the species of *Sarcophaga* s. str. – parasitoids of worms preserving low densities). In a similar way, a lowland forest has been extensively devastated in the area of the south-eastern outskirts of Bratislava near the village of Vrakuňa. It has appeared that while most characteristic taxa have survived in its taxocenosis, only *Sarcophaga lasiostyla* (a parasitoid of earth-worms) has been able to maintain sig-

nificant numbers, while remaining species occur either at low densities or only accidentally and quite unpredictably (see also values of D and E and Table III). This phenomenon has also become apparent in a low level of equitability (E).

Two phases may be, thus, observed in man-introduced changes of biocenotic equilibrium: 1) The first phase is due to the change of the natural vegetation cover and it results in the spread of culturophilous species. 2) The second phase follows in human habitats (mainly agglomerations) proper and it results in the spread of synanthropic taxa.

## CONCLUSIONS

It has become apparent that material of male sarcophagids, collected from their preconnubial aggregations, is a very suitable model to reveal culturophilic and synanthropic trends in so-called urban ecology of wider Central European region, and probably elsewhere, and that the application of ordination methods enables these trends to be very clearly graphically demonstrated.

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