AN ATTEMPT AT A METHODICAL SEPARATION OF THE CONCEPTS "SYNANTHROPE" AND "KULTURFOLGER"

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Abstract

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The relation of *Carabidae* and *Staphylinidae* to the man-made habitats is studied on the basis of extensive material of these two model groups. Some methodical approaches of practical separation of the concepts synanthrope and "Kulturfolger" (cultural follower) are shown. The both groups represent in the open landscape and in the urban ecosystems, two types of communities, viz. characteristic for original geobiocenoses and for cultural steppe. The *Sarcophagidae* represent, in the urban ecosystems, the third group of species occurring only in the city. This species group not occurring in the open landscape is to be called synanthropic.

After the attempt at an unambiguous zoocenological definition of the concept of synanthropy (Povolný, 1962) and its international acceptance (e. g. Povolný in Greenberg, 1971; Legner et Poorbaugh, 1972; Legner, Sjogner, Hall, 1974; Tischler, 1975) another attempt was made to differentiate, after a proposal by Tischler (personal communication), the term "synanthrope" from the term "Kulturfolger" (cultural follower) used in the German ecological literature (Povolný, 1963). These two terms are, however, still mixed within one synecological category according to Kélers (1963) opinion, after which the synanthropes are "im weiteren Sinne alle Schädlinge der menschlichen Wirtschaft und Zivilisation". Since the first attempt to differentiate the synanthropes from the "Kulturfolgers" (Povolný, 1963) was based mainly on some deductive contemplations, this paper is another attempt to define these two categories as exactly as possibile from a purely methodical point of view on the basis of two selected model groups of insects, viz. *Sarcophagidae* (*Diptera*) and *Carabidae* (*Coleoptera*). The selection of these two groups for the above purpose is not accidental as it is based on long-term experience of the authors concerning both the autecological and synecological knowledge of the two groups including rich material taken during many year's efforts of field work.

Material and methods

As far *Sarcophagidae* are concerned this family amounts to about 70 specific taxa in Central Europe. Our study is based on 31 619 individuals captured either individually (by netting) in the so called preconnubial aggregations (these are essentially associations of males preparing for mating — see Povolný et Staněk, 1975) during time unit (mostly one hour) or sampled up to a visible decrease of their density (see Povolný et Staněk, 1975). In the agglomeration of the city of Brno where no preconnubial aggregations of *Sarcophagidae* occur this material consisted of specimens taken in normalized fly-traps after Gregor and Povolný (1960).

As for *Carabidae*, this family is represented by more than 500 specific taxa in Central Europe. This study is based on 7136 individuals sampled in the normalized pitfall traps by a routine method described e. g. by Šustek (1976, 1980).

The concrete records of this material and its review are found in the paper by Povolný and Šustek (1981) and they provide a concrete basis for the schematic representations and figures worked out in this paper.

The names and brief characteristics of the individual sampling localities are given besides in the text accompanying the figures and schematic representations.

Results and discussion

As seen from the representation of various species of *Carabidae* in the landscape biocenoses and in differently influenced urban biocenoids of the city of Brno (fig. 1) the species inhabiting originally the cultural steppe and the woodland species penetrate the centre of the city. It is characteristic that the taxocenoses concerned differ from the landscape taxocenoses, first of all, by their impoverished species spectrum in the urban biocenoids approaching the biocenoses of deciduous forests or of the cultural steppe. The next striking phenomenon is a considerable difference in the numeric representation of the individual species in comparison with the landscape taxocenoses. This leads finally to the enormous dominance of only one or two species at simultaneous withdrawal to complete disapperance of all other species. From the qualitative stand-point it is characteristic that the taxocenoses of *Carabidae* in the city differentiate into two groups: The one corresponds essentially to the communities living in the cultural steppe, the other corresponds to the communities of woodland biocenoses. In some instances a diffusion and succesion takes place between these two urban biocenoids depending obviously from the proportion or span of trees (see the centre of the schematic representation, fig. 1).

As for the taxocenoses of *Sarcophagidae* (fig. 2) the obvious differentiation of three groups of species follows, as seen from a comparison between the landscape and the city. The first group corresponds essentially to the woodland taxocenoses. If in some instances the representatives of the arboreal taxocenoses penetrate the biocenoses of the cultural steppe, they never reach important population densities as they do not establish themselves there. Concerning the other group (corresponding to the taxocenoses of the cultural steppe) their representatives reach important densities only in the typical habitats, and only their ecologically most tolerant

representatives penetrate the woodland associations and urban associations as well. Their population densities remain limited in both cases. The third clearly differentiated group of *Sarcophagidae*, which is comparatively numerous only in the urban agglomeration or in its centre, are the obvious synanthropes. These species penetrate the biocenoses of the cultural steppe comparatively seldom or as individuals and they are practically absent from natural woodland habitats. It follows from the comparison betwen figs. 1 and 2 that among both the *Carabidae* and *Sarcophagidae*, as model groups, there exist species capable of existing in the closest neighbourhood of man. But only within the frame of *Sarcophagidae* there follows a selection of species strictly confined to man, i. e. the synanthropes. Within the *Carabidae* and *Sarcopha-*

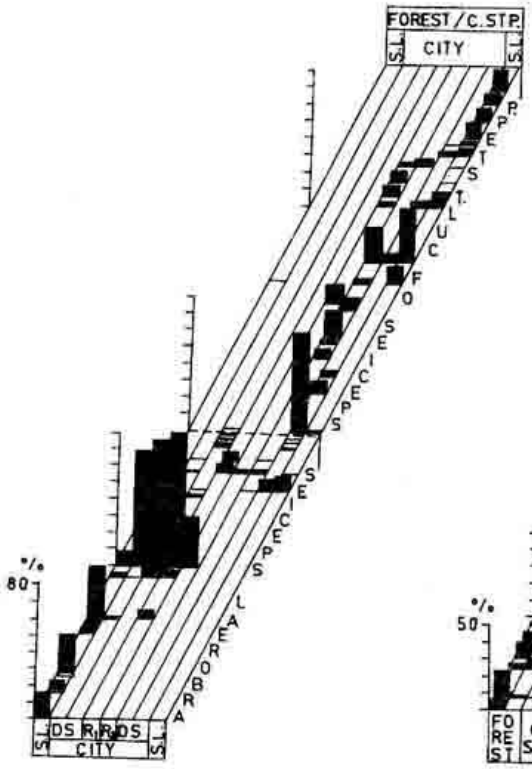

Fig. 1. Quantitative structure of the *Carabidae* associations in the landscape and in the city centre of Brno. S. L. — surrounding landscape. DS. — biocenoids. R_1 — renewing associations of the adjacent cultural steppe. R_2 — renewing associations of a forest.

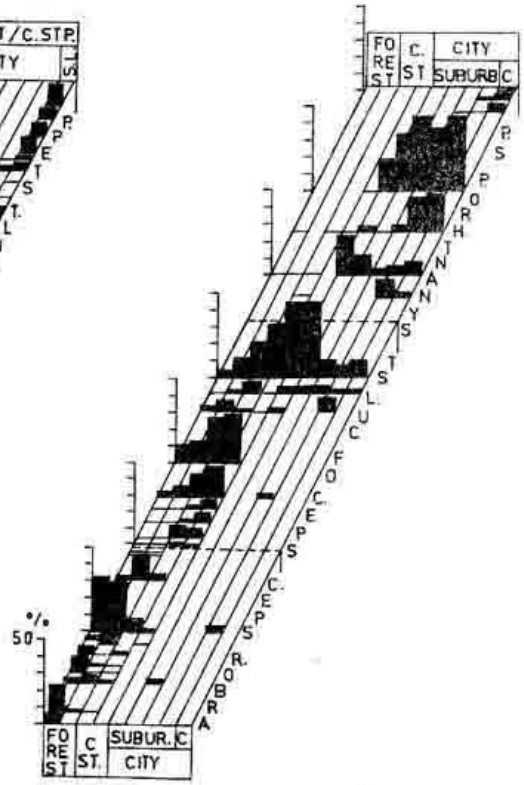

Fig. 2. Quantitative structure of *Sarcophagidae* associations in their taxocenoses of forest, cultural steppe, of suburbs and of city centre of Brno. C. ST. — cultural steppe. C. — centre.

gidae as far as their next two groupings are concerned it is obvious from the quantitative representation of such forms coexisting in an open landscape and in the anthropobiocenosis that the immediate neighbourhood of man does not offer them optimum conditions — they are "Kulturfolgers" (cultural followers).

Such clean-cut qualitative differentation of species confined to the anthropobiocenosis and of species confined to the secondary habitats of man-made biocenoses (cultural steppe, cultural forest) indicates the necessity to differentiate also the terms of synanthropes and "Kulturfolgers" as two ecocenological categories. Such a differentiation of these two categories presumes a qualitative and quantitative analysis of the representation of species concerned in various types of habitats.

The schematic representation of the differentiation of the taxocenoses studied as model groups (figs. 1 and 2) claims considerable space and can be substituted by a more laborious but schematically easier method of association analysis (figs. 3 and 4) based on the application of the index of species similarity (IJ) and on the index of dominance identity (IR). In these two figures a classification is performed of:

1. the taxocenoses of *Carabidae* of the Brno agglomeration accomplished by the selected taxocenoses of deciduous forest, cultural steppe and lowland forest existing in the surroundings of Brno and
2. the taxocenoses of *Sarcophagidae* of the Brno agglomeration accomplished by the analogical taxocenoses of the cultural steppe and of forests.

As far as the *Carabids* are concerned, an obvious differentation is visible from the two dendrograms into associations of the lowland forest, of the deciduous forest and of the city parks on one hand, and the associations of the cultural steppe and of the gardens of the city on the other. The seeming separation of a fragmentary taxocenosis from the square of Náměstí 28. října is obviously due to the limited material of this strictly urban habitat. The transfer of the taxocenosis of the southern slope of the Spielberg-Castle (which is found in the dendrogram after the qualitative indices by Jaccard —IJ— among the taxocenoses corresponding to the cultural steppe) to the associations of the woodland character is a consequence of a secondary developing span of the trees and it manifests itself especially by the dominance of the forest *Carabid Abax ater*, as seen also in fig. 1. In fig. 3 a similar differentiation is observed as described in connection with fig. 1.

In fig. 4 (*Sarcophagidae*) there follows from both dendrograms (IJ and IR) that there exists also a clean-cut differentiation of associations of the more or less natural biocenoses and associations of the city of Brno. In the dendrogram after IR there are moreover differentiated associations of the forest and the (cultural) steppe, which are not clearly differentiated in the dendrogram after IJ. This is obviously due to the fact that in the two taxocenoses of the Pavlovské vrchy — Hills studied (Klauza — a forest and Děvičky — a forest steppe) the purely territorial neighbourhood of these two habitats and the flight activity of *Sarcophagidae* results in a mutual mingling of species. A very interesting differentiation of the taxocenoses of *Sarcophagidae* takes

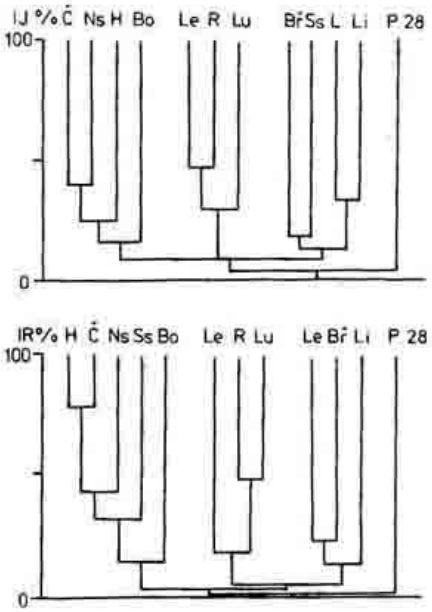

Fig. 3. Similarity dendrograms of associations of *Carabidae* studied in the centre of Brno and in selected biocenoses of a landscape. IJ — Jaccard's index. IR — Renkonen's index. The forest biocenoses and biocenoids: Č — Park of Čertova rokle, Ns — Northern slope of the Spielberg-Castle, H — Park in the Hakenova Street, Bo — *Quercetum faginum* (2nd vegetation tier) at Boleradice. The cultural biocenoses and biocenoids: Bř — a garden in the Břenkova Street, Ss — southern slope of the Spielberg-Castle, L — lucerne field at Troubsko, Li — a garden in the Líšeňská Street, P 28 — a park in the "Square of 28th October". Biocenoses and biocenoids of the lowland forest: Le — *Aceretum ulmi* at Lednice. R — a lowland forest at Ráječek near Brno. Lu — a park of Lužánky in Brno.

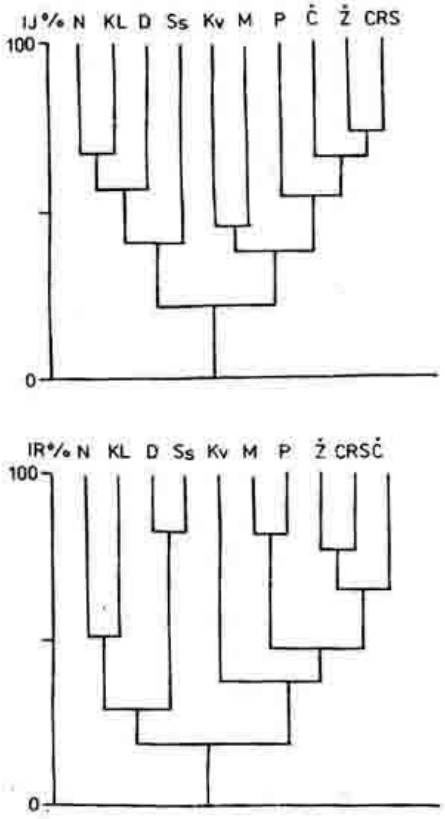

Fig. 4. Similarity dendrograms of the associations of *Sarcophagidae* studied in the centre of Brno and in selected biocenoses of a landscape. IJ — Jaccard's index. IR — Renkonen's index. N — Nejdek, a lowland forest (*Acretum ulmi* near Lednice). KL — Klauza, a warm deciduous forest (*Carpini quercetum*). D — Děvičky, a well preserved forest steppe. Ss — Stránská skála, a steppe on the margin of the city of Brno. Kv — Kamenný vrch hill, a pathway on the margin of a recreation deciduous forest with numerous gardens. M — Medlánky, gardens at the margin of a suburb. P — Palackého vrch hill, gardens in a suburb. Č — Černá pole — a yard with neighbouring gardens in a suburb. Ž — Židenice, a yard of a suburb housen. CRS — Central Railway Station, a ramp.

place in the city centre of Brno, in the frame of which we may observe, even in the dendrogram after IJ, the grouping of the aggregations of the Kamenný vrch hill and Medlánky situated in the margin of the city. The next subgroup is formed by the aggregations of the suburbs Černá pole, Židenice and of the central railway station of Brno, situated in the city centre, or in densely built-up parts of the city. This differentiation is even more distinct in the dendrogram based on the dominance identity after Renkonen (IR) making it possible to compare the aggregations studied after the quantitative representation of species. In the case of the relatively natural associations there differentiate clearly the taxocenoses of forest habitats (Nejdek and Klauza) from the taxocenoses of relict steppes (Děvičky and Stránská skála) irrespective of their penetration by some vagile species of the territorially close habitats. In the city centre, too, there is obvious the differentiation between the aggregations of the centre margin and its inside. A comparison of both dendrograms (IJ and IR) shows the mutual approach of the aggregations of the margin of the city centre. In this way the associations of the Medlánky and the Kamenný vrch hill (after the separation of the taxocenosis of the Kamenný vrch hill strongly influenced by forest species) approach mutually forming a subgroup (not existing in the dendrogram after IR, the indication of which is, however, visible there, on the other hand, from the association of the taxocenosis of the Palackého vrch hill to the associations of the densely inhabited parts of the city).

Comparing figs. 3 and 4 we may see, similarly as in figs. 1 and 2, that among the *Carabidae* there differentiate groups of associations typical of the biocenoids of the city centre, the species composition of which is analogical to the corresponding biocenoses of the landscape. As for *Sarcophagidae* a similar differentiation is observed but additionally there selects a group of true synanthropes characteristic of the city centre. The method of association analysis makes it consequently possible to differentiate, in a distinct and instructive way, both mathematically and schematically, the synanthropic and the non-synanthropic species and species associations existing in an anthropobiocenosis.

The synanthropic and non-synanthropic species associations can be in ambiguos cases differentiated also by the analysis of their quantitative structure, as demonstrated by figs. 5 and 6. Fig. 5 shows the quantitative structure of three *Carabidae* associations originating from three similar biocenoses corresponding to the conditions of the second (2.) vegetation tier in the city centre of Brno and Ždánský les (Boleradice). The *Quercetum faginum* of Boleradice representing a well preserved, locally very original association on the margin of Brno and the northern slope of the Spielberg-Castle is a secondary renewing forest association. The gradual anthropic pressure on these associations becomes manifest in that whereas in Boleradice the abundances of the individual species are minimal, the association of the Čertova rokle park is dominanted by a single abundant species the other species withdrawing to the very limits of registrability. At the same time, the species spectrum of this

purely abiotically similar biocenoid is impoverished. It seems to be obvious that anthropic pressure on the Čertova rokle park (exerted e. g. by its being turned to a park, by its continuous maintenance, utilization for recreation, influence of industrial emissions and exhalates, etc.) manifests itself by the decreased abundance of practically all ecologically less tolerant species up to their complete disappearan-

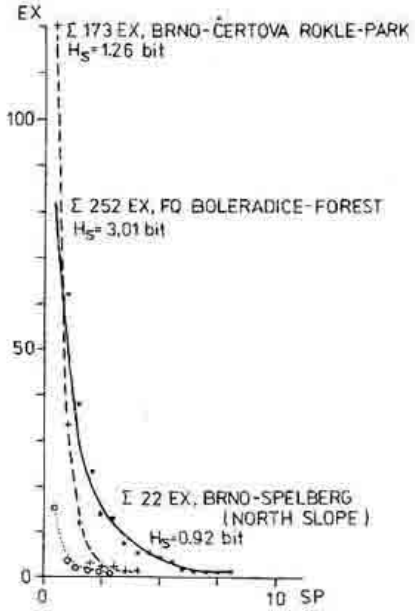

Fig. 5. Quantitative structure of the taxocenoses of *Carabidae* in a *Quercetum faginum* of Boleradice, in the park of Čertova rokle of the suburb of Brno and in the park of the northern slope of the Spielberg-Castle. Hs — units of entropy characteristic of the quantitative structure of animal association. Ex — number of individuals. Sp — number of species.

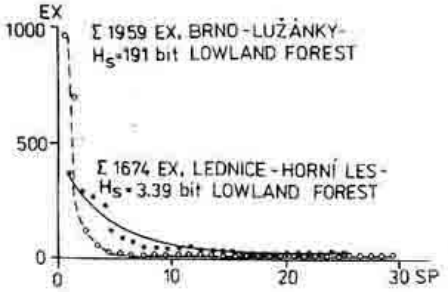

Fig. 6. Quantitative structure of taxocenoses of *Carabidae* in a lowland forest at Lednice (*Aceretum ulmi*) and in the park of a former lowland forest in Lužánky. Hs — units of entropy characteristic of the quantitative structure of an animal association. Ex — number of individuals. Sp — number of species.

ce. The association as a whole is, thus, represented by a few or, in extreme cases, a single species occupying all niches of the habitat after having reached high densities.

This is evident from the fact that the sum of abundances of this is dominant species and of the other surviving and withdrawing species equals the values observed in the natural association of Boleradice. If this anthropic pressure continues or if its intensity increases, the abundance of this only tolerant species finally decreases and consequently the total abundance of the taxocenosis decreases, too. This decrease in the abundance of the associations studied results in its seeming, that is, secondary

levelling, so that the corresponding curve representing the structure of the taxocenosis is getting flat, as is the case in the natural biocenoses, shown by Šustek, 1980. This trend is obvious from fig. 6, demonstrating the quantitative structure of natural associations of a lowland forest and of a lowland forest turned into a park. Analogically as in fig. 5 the strong increase in the abundance of two ecologically tolerant species in the park of Lužánky resulted in a decrease of all other members of this taxocenosis. The species spectrum in this secondarily changed habitat of a lowland forest appears to be a little richer than in a natural lowland forest and also the sum of abundances of all species is somewhat higher.

These phenomena, resulting from figs. 5 and 6 can be generalized or idealized in that associations of a landscape (irrespective of being primary or secondary) react at first by quantitative changes, first of all by a decrease in total abundance while preserving their species spectrum. In the next stage of such changes the decrease in the total abundance is accompanied by the impoverished species spectrum. This trend culminates in the decrease in the abundance of the surviving species which approach the limits of their registration. The original and the final stage of this sequence of changes is characterized by a flat curve demonstrating the quantitative structure of dominance. The transitive or intermediary stages of this development are characterized by a steep curve due to the abundance of tolerant species and by the simultaneous withdrawal of the less tolerant forms.

If the association studied and situated in the neighbourhood of an urban agglomeration is characterized by a low sum of abundances, by a steep curve representing its quantitative structure and by a low number of species frequently occurring in a non-urbanized landscape, one can be sure that non-synanthropic species accompanying a secondary cultural steppe (or "Kulturfolger") are concerned.

The sequence of synanthropic species in these cases cannot be percepted, since they occur only in the immediate neighbourhood of human settlement or in its centre (as seen in fig. 2) being virtually absent from non-urbanized landscape.

These contemplations lead us back to fig. 4. It is obvious that according to the situation, ecological or spatial relation to the human settlement, also non-synanthropic species may play a certain role in the corresponding taxocenoses. This phenomenon manifests itself in the corresponding dendrograms by that the association with a certain portion of non-synanthropic species associate themselves with the synanthropically influenced taxocenoses on gradually lower levels. This is clearly seen in Fig. 4 (IJ), where the marginal aggregations of the suburbs of Černá pole, Palackého vrch hill, Medlánky and Kamenný vrch hill gradually associate themselves with the aggregations of Židenice and the central railway station of the city centre dominanted by synanthropic species. A similar trend is observed also in fig. 4 (IR). It shows that as the associations approach the margins of a city, their relations realize on still lower levels.

As for *Sarcophagidae* it is impossible to exclude, especially in long-term samplings, that a more or less wide spectrum of species will be found, since also accidental immigrants will be sampled. Such cases become more numerous especially during hot midsummer days when individual flies follow the air currents of the summer thermics and so they occur far away from their habitats in which only they can establish themselves ecollogically. Such cases must be excluded on the basis of concrete knowledge of their autecology, mainly of the trophical relations of the individual species, and by stressing the statistical significance (the dominance identity) of the material sampled.

Conclusions

1. The families *Carabidae* and *Sarcophagidae* selected as model groups for a differentiation of the terms "synanthrope" and "Kulturfolger" show different reactions upon the anthropobiocenosis.
2. Although in both of them a trend to form two groupings of species (corresponding to the biocenoses of the cultural steppe and of forests in a landscape) can be observed in the urban geobiocenoids, within the frame of the *Sarcophagidae* there exists, especially in the centre or even in completely vegetationless habitats of a city, a distinct group of synanthropic species which are more or less strictly confined to the anthropobiocenosis.
3. Contrary to the landscape biocenoses, considerable numeric differences can be observed in the taxocenoses of the urban geobiocenoids resulting finally in a high abundance of a few or of just one species occupying all adequate niches whereas the remainging species withdraw up to complete disappearance. The gradual pressure of anthropic influences results in a decrease in the abundance of the surviving species which finally comprise also species having a wide ecological tolerance.
4. As for *Carabidae*, the composition of their taxocenoses in the city centre depends on the original character or on the changes of the vegetation cover biocenoids or in its remainders to which they are restricted.
5. The mentioned differentiation of the studied taxocenoses can be methodically represented in various ways, viz., either by a tridimensional scheme or by a more laborious but schematically simpler association analysis based on the indices of species identity (IJ) or dominance identity (IR).
6. The associations of synanthropic or non-synanthropic species can be differentiated by the analysis of their quantitative structure, that is, by the values of their entropy. A relatively flat curve is then characteristic of undisturbed taxocenoses, because the differences of the abundances of the individual species are small. In disturbed biocenoses the curve gets steeper due to the increase in the dominance of a few species and the withdrawal of the others. In the strongly changed biocenoids the curve becomes flattened due to the decrease in the total abundance of the taxocenosis studied.

7. As the synanthropic species do not occur in the nonurbanized landscape or they are present there very accidentally, it is virtually impossible to follow a similar sequence in the non-synanthropic species. The values of entropy resulting from the analysis of the quantitative structure of taxocenoses neighbouring with the human habitation based on species frequently occurring in the non-urbanized landscape bear a clear evidence that a complex of non-synanthropic species was concerned, comprising "Kulturfolgers", especially in those cases when curves are steep. Consequently, the category of synanthropic species consists of forms which were obviously subject to long term selection pressures by the anthropobiocenosis or anthropobiocenoses which resulted in their considerable cosmopolitism independent of their geographical origin and present distribution.

8. Irrespective of the usefulness of these graphical and mathematical methods for the representation of the population structure and of other problems of the qualitative and quantitative composition of the taxocenoses, it remains necessary to confront all such conclusions with concrete knowledge of the autecology, ethology and the other purely bionomical aspects of the individual species so as to prevent any one-sided interpretation of statistical phenomena without respecting the biological substance of these manifestations in animal populations.

Translated by author

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Povolný D., Šustek Zb., **K metodike oddeľovania pojmov "Kulturfolger" a "synantrop".**

Autori sa zaoberajú definovaním a oddelením pojmov „synantrop" a „Kulturfolger", ktoré sa veľmi často zamieňajú a ich koncepcia až na niektoré citované práce je ešte nevyjasnená. Svoje závery zakladajú na štúdiu zloženia spoločenstiev modelových skupín hmyzu (*Diptera — Sarcophagidae, Coleoptera — Carabidae* a *Staphylinidae*) v prírodných ekosystémoch a v ekosystémoch kultúrnej stepi a miest.

Поволны Д., Шустек З., **К методике отделения понятий «Культурфолгер» и «синантроп».**

Авторы занимаются определением и отделением понятий синантроп и «Культурфолгер», которые очень часто заменяются и которых концепция – кроме некоторых цитируемых работ – не была пока объяснена. Свои выводы основывают на изучении сообществ модельных групп насекомых (*Diptera – Sarcophagidae, Coleoptera – Carabidae* и *Staphylinidae*) в природных экосистемах и в экосистемах культурной степи и крупных городов.