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Twenty years have passed...

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The author presents a view on his own publications on carabid beetles published in the period 1959-1994. Even though they were lacking – according to contemporary standards - proper statistical elaboration, the results presented there can be useful for present investigators. As an example, it is shown that one trying to study biodiversity of carabid beetles in a site, should base his estimates on recognition of population density of each species, and repeat the estimates during a few years.

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INTRODUCTION

When I started to work for the Institute of Ecology, Polish Academy of Sciences (in 1958) I was impressed, like many of my colleagues, with the disputes concerning population dynamics: Nicholson (1933) and his followers on one side and Andrewartha and Birch (1954) on the other. Therefore, my primary research on carabid beetles was focused on the attempt to estimate density of carabid populations (Grüm 1959, 1971), and their spatial distribution (Grüm 1962, 1965, 1971, 1973a). Late 60-ties of the past century brought a new challenge due to the participation of the Institute of Ecology in the International Biological Programme. The data on density of carabid populations had to be complemented by estimates of reproduction (Grüm 1973b), mortality (Grüm 1975), growth rate (Grüm 1973d) and energy flow (Grüm 1973c, 1976, 1978). My last attempts to carabid studies were aimed mostly on dynamics of species forming a guild (Grüm 1986).

Since 1986 I have not sampled carabid beetles, and my last paper related to carabids appeared in 1994 (Grüm 1994). The above mentioned facts give me a time-lapse necessary for more objective look (less biased by emotions) at my achievements.

VALID OR NOT?

When I started my scientific carreer no one of my colleagues and tutors paid attention to statistical elaboration of the sampled data. There was, however, a common demand: the sample size had to be numerous and "reliable", i.e., repeated in two or better three or even four consecutive years. This was a reasonable attitude in the period of absence of personal computers. Nowadays, however, easy available statistical programs (see e.g., statistics.altervista.com) and PC's can be used to verify differences between even smaller ("less reliable") samples.

As a consequence of availability of statistical data elaboration, most of my papers published in 60-ties and 70-ties, nowadays would be rejected by professional journals. The reason of the rejection would, perhaps, be unsatisfactory statistical elaboration of the presented empiric data.

I do not, however, plan to recalculate all the data used in my publications, though in some of them – considered by me the most important – I did that. For instance, I postulated (Grüm 1971) that all individuals of *Carabus arcensis* stay only for a short time at the peripheries of the local population, and contrary to that, some of them exhibit longer period of residency in the center of the local population area. The applied non-parametric statistic showed that at the peripheries (the verge between wet *Carici-elongatae Alnetum* and dry *Pino-Quercetum*) population density is lower than that in the center of the local population area, located in *Pino-Quercetum* (Tab. 1). The same statistic provides evidence of shorter time of residence at the peripheries than that found in the center of the population area (Tab. 1).

The above example leads me to the conclusion that reliable empiric data are of important value, resistant to the time pass.

CONTEMPORARY TOPICS

The most common topics in ecology change with time (although not as frequently as female fashion!), and I mentioned a few, like population ecology, bioenergetics, and community ecology. My impression is, that nowadays biodiversity can be considered as one of the most important goals.

Carabid biodiversity seems to be worthy of precise studies, as these beetles are considered to be important bioindicators (Heidemann 1955, Szyszko 1979). In my opinion estimates of species richness - or more sophisticated analyses relaying on application of such indices like Shannon-Veawer - if based only on one sampling method, for instance, often applied Barber pitfalls, can provide unreliable results.

The results of sampling carabids with pitfalls evidently depend on population density and individual mobility, expressed in distance passed by an individual in a time unit. And that distance varies from species to species, and as a rule large individuals, like *Carabus* are more mobile than those of small body dimension, like *Pterostichus* (Grüm 1981). Besides, some small-body beetles can avoid pitfalls, or climb up their walls. Therefore, pitfalls do not allow for proper recognition of quantitative proportions between all the carabid species inhabiting a sampling site.

The proper solution seems to be estimation of population density of the carabid species inhabiting a site. In order to perform this goal one must apply different methods of sampling, adjusted to the species in question. My method of population density estimation (Grüm 1971) can be used for density estimation of *Carabus* and large *Pterostichus* (like *P. niger*), and with some modification (isolation of areas ranging from 1 to 3 m^2) to smaller epigaeic carabids (Grüm 1981). However, it seems to be useless for such species, like *Notiophilus*, *Bembidion* and others of similar body size. In the latter case soil samples would, perhaps, deliver estimates of population density.

Unfortunately, it is not enough to properly recognize proportions between population densities of the species existing in a site and a given year to provide realistic estimate of the species richness and biodiversity. Another important phenomenon in this respect is different course of multiannual changes in population dynamics of the co-existing species: the years of peak numbers are rarely concurrent (Grüm 1986). As a consequence, estimates of biodiversity – e.g., Shannon-Veawer indices – vary greatly in a site during consecutive years, and a negative correlation is seen between the estimates of biodiversity and the total catch of the species (Grüm 1986). Modelling of the negative correlation shows that it is the result of independent course of multiannual fluctuation of population size of the species in question, and moreover, the concur-

Table 1. *Carabus arcensis*: differences between optimal and suboptimal sites in catch size (even pitfall numbers and trapping period) and the time needed to recapture all marked individuals, tested with Wilcoxon matched pairs test. Catch size: $p<0.05$, time: $p<0.05$.

		Optimal site (*Pino-Quercetum*)		Suboptimal site (*Alnetum* edge)	
Year	Period	Catch size	Time (days)	Catch size	Time (days)
1964	Early	22	3	16	2
1964	Late	10	2	7	1
1965	Early	13	3	11	2
1965	Late	14	3	10	2
1966	Early	21	5	7	2
1966	Late	18	8	4	2

rent fluctuations do not result in any correlation between Shannon-Veawer indices and the total catch size (Grüm 1986).

The emerging conclusion is that to characterize biodiversity of carabid community in a site one has to, apart from making population density estimates, consider making samples for a number of years if reliable estimates are needed.

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