COMPARATIVE ANALYSIS OF THE SMALL MAMMAL FAUNA OF THE RIVER DRAVA PLAIN REGION. I. SPECIES RICHNESS, DIVERSITY AND BIOMASS BASED ON THE ANALYSIS OF BARN OWL *TYTO ALBA* (SCOP., 1769) PELLETS

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Abstract. A total of 2176 pellets and pellet fragments were analysed, all of which have been collected in 15 human settlements along the river Dráva, during 1996. From these 4335 small mammal specimens were identified. Among the Insectivora, six shrew species belonging to the family *Soricidae* and four insectivorous genera were identified, whereas among the rodents (Rodentia) 12 species were differentiated plus one genus-level (*Apodemus spp.*) identification was made. With the help of abundance data of the small mammal taxa identified from the pellets, a significant saturation curve was found to exist between sample size and number of species. With the increase of pellet number, the number of species did not change considerably. Shannon-diversity and evenness were not sensitive to sample size, but Margaleff's species richness values significantly decreased as the number of pellets increased. As a result of differences in sample sizes, the small mammal communities in only 9 of the settlements were compared using cluster analysis and variance analysis. I concluded from the results that several years of data collection is necessary to clearly describe the small mammal species composition of the studied region.

Keywords: small mammal diversity, species richness, biomass, pellet analysis, Tyto alba

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Introduction

Small mammals have an extremely important role in forming the structures of communities found in natural and seminatural habitats. They were significant objects of production biological research almost thirty years ago. Those studies are especially notable from the aspect of trophic structure analysis, energetics and biomass (Petrusewicz 1975, Petrusewicz and Hannsson 1975, Golley et al 1975). At the same time, other types of synbiological case studies were also produced, such as life history strategies (Gliwicz *et al.* 1968, Bujalska *et al.* 1968, Bujalska 1975, Flowerdew *et al.* 1985), questions of density estimation (Ryszkowski 1971, Smith *et al.* 1971, 1975), as well as the problems of temporal population changes, population regulation and cyclicity (Petrusewicz 1966, Chitty 1967, Krebs 1964).

In the framework of the National Biodiversity Monitoring System introduced recently in Hungary, special attention is focused on small mammal species (Csorba and Pecsenye 1997), since many of them are protected, are included in Red Data Books, and their populations have been thoroughly studied during the past 30 years. The alterations of their densities and community structures as a result of changes in the limiting background variables, indicate any decline in their environment (degradation, fragmentation, urban effects, pollution, etc.). In order to effectively conclude from the changes in small mammal populations and communities, it is necessary to perform synbiological investigation of populations and communities in several habitats or habitat complexes, to describe their spatio-temporal patterns, and analyse the changes in these patterns.

However, because the technical demands of sampling from small mammal populations and the investigation of their life characters (e. g. the use of various trapping techniques, radio telemetry) are pretty expensive, it is common to use indirect sampling, such as pellet analysis, in synphenobiological and ecological research. This method is not objectionable from a conservation aspect, and is a relatively fast way of collecting large amount of occurrence data. For the study of small mammal fauna (status survey, monitoring, diversity estimation) the most appropriate are the pellets of the barn owl (*Tyto alba*), because among the owl species occurring in Hungary this is the one with the widest selection of preys, and also the feeding ecology of this species is well studied (Kalivoda 1994, Csorba and Pecsenye 1997, Mátics 1997, Horváth and Jeney 1998). The relationship between small mammal populations and the feeding of the barn owl has been sought for from various aspects (Bohnsack 1966, de Brujin 1979, Kotler *et al.* 1988, Palotás 1979), and the connection of small mammal abundance and barn owl reproduction has also been studied (Bühler 1964). There has been collected also considerable amount of information on the energetics of the barn owl — small mammal relationship (Ceska 1980, Goszczynsky 1976, Kirkwood 1979). In Hungary, the representativity of pellet analysis as an indirect way of population sampling, and the problem of sample size have been studied mostly from a theoretical approach and based on literature data (Kalivoda 1993, 1994).

The reason the above issues are important from the point of view of indirect monitoring is the fact that owls can be selective: they can prefer some prey species to others. The question is that given such a prey preference and a switching of this attitude, to what extent the species composition appearing in the owl's food is representative of the small mammal fauna of the nearby areas, and samples collected in which period are best for the monitoring of small mammals (Horváth and Jeney 1998). Further, to what extent indices calculated from the basic data of pellet analysis (such as species richness, diversity, biomass) are applicable in following small mammal abundance data and in determining trends.

Several studies have been produced about barn owl pellet collecting and analysis (Fenyősi 1994, Horváth 1995, Purger 1998, Horváth 1998), which are faunistic summaries of various time intervals, with no attention to parameters derived from basic data and the relationships between them.

The aim of the present study is to analyse the relationships between derived community-ecological and feeding ecological characteristics obtained from the abundance data in pellets collected during a span of a year, and to compare the small mammal faunas of the sample areas.

Material and methods

Pellet samples and identification

The present study elaborates on the results of analysis of pellets collected in 15 human settlements along the river Dráva in 1996. Sampling, accordingly, covered the lower river section in Somogy county, and its entire section in Baranya county. The settlements of the collection sites were numbered from the east to the west. Thus the first sampling site is Tótokföldje (Old) in Baranya county, whereas the last one is Péterhida in Somogy county. Church towers as potential barn owl nesting sites were visited monthly from the beginning of the year, and were frequented as long as fresh pellets suggesting the presence of owls were found. There were no successful nestings in the belfries of the subject villages in 1996; in most of the cases fresh pellets found during the period between April-June originated from owls left without a pair. In the case of Péterhida, Szentborbás (2) and Tótokföldje, pellets were collected in abandoned farm buildings and old, uninhabited houses. The number of collections and the amount of the collected material (i. e. the number of pellets) varied among the 15 sites; these are summarized on a UTM-grid in the order of collection sites, in Table 1. The collected material included whole pellets as well as pellet fragments/debris in many cases. This is important to note because prey lists were compiled based on whole pellets only as well as on whole pellets plus pellet debris.

Taxonomic identification was done on the basis of skull characteristics and dentition (Schmidt 1967, Ács 1985, Ujhelyi 1994). The *Neomys* species (*Neomys fodiens* Pennant 1771, and *Neomys anomalus* Cabrera 1907) were differentiated by measuring the height of the corona-process of the mandible; if this was unfeasible, only the genus was identified (*Neomys sp.*). The wood mouse (*Apodemus sylvaticus* Linnaeus 1758), the yellow-necked wood mouse (*Apodemus flavicollis* Melchior 1834) and the pygmy field mouse (*Apodemus microps* Kratochvíl and Rosicky 1952) were categorized commonly as wood mice (*Apodemus spp.*) The house mouse (*Mus musculus* Linnaeus 1758) was differentiated from the gleaner mouse (*Mus spicilegus* Petényi 1882) on the basis of the length proportions of the upper and lower zygomatic arches (Demeter 1995, Demeter *et al.* 1995); when these were missing from the skull or only a mandible was found, only the genus was indicated (*Mus sp.*).

Remains of both the rare ship rat (*Rattus rattus* Linaeus 1758) and the invasive house rat (*Rattus norvegicus* Berkenhout 1769) were discovered in the pellet samples. In cases when the skeletal material was insufficient for the exact differentiation of these two species, only the genus was indicated (*Rattus sp.*) Accordingly, evaluation was performed on the basis of a total of 23 small mammal taxa.

Statistical methods

When the collected material was summed up, only the whole pellets were brought into the analysis. The first important basic information was the number of pellets, a variable expressing the size of the sample and affecting its representativity. Thus, as a first step, regression analysis was applied for the relationship between number of pellets and number of species. Community indices were then calculated from the abundance data of samples with totalized pellet numbers, such as Shannon-Wiener diversity

$$H(S) = -\sum_{i=1}^{S} p_i \ln p_i ,$$

and evenness

$$J = \frac{H}{\ln S},$$

where p_i is the proportion of the i-th species in the sample, H is diversity, and S is the number of species (Pielou 1975), and species richness based on Margaleff's index

$$d = \frac{S-1}{\ln N}$$

(Magurran 1988) where S is the number of species identified from the pellets, and N is the number of

Table 1. Pellet collection sites along river Dráva, with dates of collection, number of pellets and prey taxa

Site of sampling	UTM code	Yearly number of collection	Date of collection [1996]	Number of pellets / collection	Total number of pellets	Number of prey taxa
1. Tótokföldje (Old)	BR97	4	04. 01. 06. 20. 07. 27. 08. 31.	70 152 233 27	482	18
2. Gordisa	BR87	1	06. 20.	31	31	13
3. Matty	BR87	1	02. 24.	47	47	13
4. Kovácshida	BR87	5	02. 24. 03. 25. 04. 29. 06. 20. 09. 28.	6 21 4 36 2	67	10
5. Szaporca	BR77	5	02. 24. 03. 25. 04. 29. 05. 25. 06. 20.	14 3 89 8 2	116	15
6. Cún	BR77	5	02. 24. 03. 25. 04. 29. 05. 25.	67 67 55 4	193	19
7. Tésenfa	BR77	1	07. 27.	176	176	17
8. Kisszentmárton	BR67	4	02. 24. 04. 29. 05. 25. 06. 30.	48 39 11 11	109	17
9. Majláthpuszta	BR77	1	03. 25.	42	42	13
10. Vejti	YL37	3	02. 24. 03. 25. 04. 29.	26 15 15	56	16
11. Piskó	YL27	3	02. 24. 03. 25. 04. 29.	17 11 19	47	16
12. Zaláta	YL27	1	06. 29.	21	21	13
13. Drávasztára	YL17	1	06. 29.	8	8	5
14. Szentborbás(1.,2.)	YL08	1/1 2/1	09. 03. 09. 03.	6 48	54	13
15. Péterhida	XL98	1	07. 31.	79	79	18
Σ		61		2176	1528	216

individuals. Knowing the average body weight of the various species (von Knorre 1973, De Brujin 1979, Görner-Hackethal 1987, Ács 1985, März 1987), two feeding-ecological parameters were calculated from the samples with a given number of pellets, the following way:

- prey number in a pellet [*PN*]:

$$PN(specimens) = \frac{\text{number of prey items found}}{\text{number of pellets}}$$

- biomass eaten in a pellet [*BEP*]:

$$BEP(g) = \frac{\text{totalized body weight of prey items}}{\text{number of pellets}}$$

Then the relationships between the number of pellets and the three community characteristics (diversity, evenness, species richness), and between the two feeding-ecological parameters and the community characteristics were analysed using regression analysis.

Because sample sizes (number of pellets and number of collections) varied, the abundance values of various species in the different villages were standardized for 100 pellets:

$$\text{relative abundance} = \frac{\text{abundance} \times 100}{\text{number of pellets} \times \text{number of collections}}$$

where samples with fewer than 50 pellets were left out from the calculations. Based on these relative abundances, 9 settlements were compared using cluster analysis, where Chekanowski-index and the group average method were applied. Then the sampling sites were compared using the Kruskal-Wallis test of ANOVA. The program packages NuCoSA 1.05 (Tóthmérész 1993, 1996, 1997), BioDiversity (Lambshead *et al.* 1995), and Toxstat (Gulley *et al.* 1990) were used for these calculations.

Results

From the material collected in 1996 in 15 settlements along the river Dráva a total of 2176 pellets and pellet fragments were processed (Table 1.), and 4335 small mammal specimens were taxonomically identified. Among the Insectivora, six shrew species belonging to the family Soricidae and four insectivorous genera were identified, whereas among the rodents (Rodentia) 12 species were differentiated plus one genus-level (*Apodemus spp.*) identification was made. 1130 specimens belonged to the order Insectivora, out of which only one individual was a mole (*Talpa europaea* Linnaeus 1758), while the remaining were members of the Soricidae family.

Based on data from the whole pellets, a saturation curve (r = 0.8) was obtained for the correlation between number of pellets and number of prey taxa (Fig. 1). From this it appears that the number of species shows considerable variation up to a value of around 100 pellets beyond which the increase in the number of prey taxa is quite insignificant.

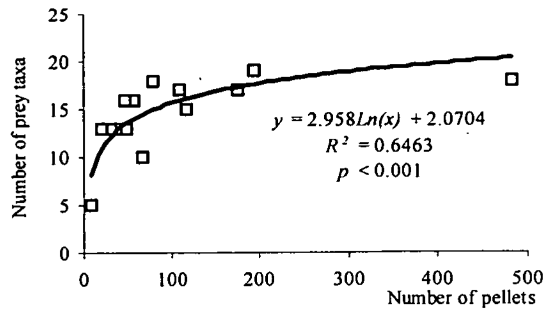

Fig. 1 Correlation between number of pellets and number of prey taxa, based on the entire sample.

When Shannon-diversity and evenness were plotted against the number of pellets, no significant correlations were found (Figs 2-3). The value of diversity can be quite variable up to 100 pellets, which is, of course, influenced not only by lower or higher values of the number of species, but it is also influential whether or not the barn owl prefers certain preys to others, because the higher relative frequency of a preferred prey animal reduces the diversity of its sample. Evenness is less variable in this range of pellet number. A sample of low number of pellets, collected once in a given period provides little information about the prey choice of an area and about the hunting strategies of the owls. One reason of the greater evenness values may be that the frequencies of the few specimens identified from a small sample are quite similar, and another possibility is that in spring when the density of the common vole (*Microtus arvalis* Pallas 1779) is still low, barn owls feed on a greater variety of prey which fact results in an increased evenness of the sample.

In the case of samples with low pellet numbers, species richness values are generally much higher than at greater pellet numbers. The value of species richness shows significant exponential decrease as the number of pellets grow (r = 0.947). Margaleff's index of species richness is much more sensitive to the number of pellets determining sample size, than diversity or evenness. Its main reason is that in the species richness formula abundance appears in the denominator, and because abundance grows linearly with the number of pellets, species richness values calculated from a sample of few pellets containing less specimens will be much lower than with a sample of high number of pellets.

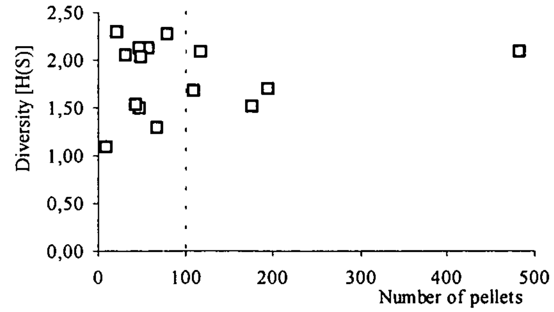

Fig. 2 Shannon-diversity as a function of number of pellets.

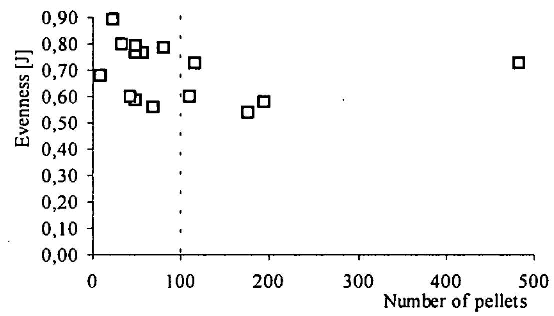

Fig. 3 Evenness as a function of number of pellets.

No significant correlation was found when BEP and PN were tested for relatedness with the community characteristics. The values of the two feeding-ecological indices show moderate variation, since these are indices that level off differences in sample sizes, thus in a comparison with the community parameters, there is no mathematically describable significant correlation between the analysed variable-pairs.

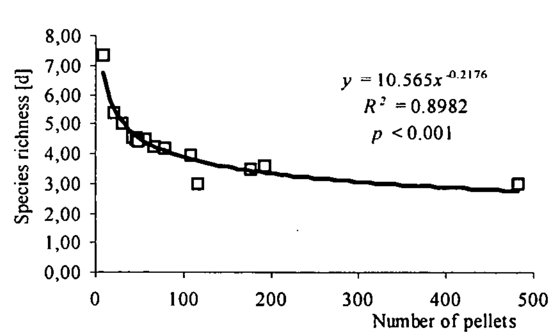

Fig. 4 Correlation between number of pellets and Margaleff-index.

Collection sites with samples larger than 50 pellets were compared based on their relative abundances. The cluster analysis separated two main groups between which there is a relatively great distance (Fig. 5). The smaller cluster on the right is more uniform, with the two villages in Somogy county clearly separated and with the species composition of only one sampling site in Baranya county showing similarity to them. In the other cluster there are samples from county Baranya only, but this one is not as uniform as the other. The small mammal composition obtained for Vejti (7) is especially different from the rest of the collecting sites in Baranya.

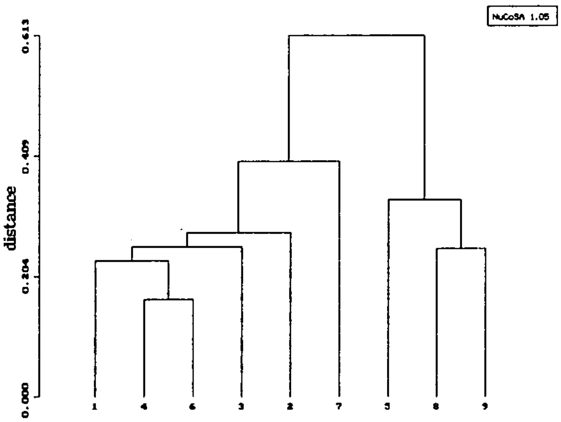

Fig. 5 Comparison of the small mammal communities found in the selected 9 settlements, using cluster analysis and Chekanowski-index. 1: Tótokföldje, 2: Kovácshida, 3: Szaporca, 4: Cún, 5: Tésenfa, 6: Kisszentmárton, 7: Vejti, 8: Szentborbás, 9. Péterhida .

The variance analysis of relative abundance values did not reveal significant difference between any of the sampling sites (H = 12.125, *NS*) from which result it seems likely that in order to be able to demonstrate any slighter difference between the small mammal communities of the various areas much larger amount of data is necessary, which can be obtained only by means of a long-term monitoring program.

Discussion

As part of the National Biodiversity Monitoring System, small mammal monitoring based on country-wide owl pellet collection is planned to be introduced in the form of a separate sub-project. Therefore it would be extremely important to find out how the samples collected in a given period but with varying pellet numbers should be standardized, and from the abundance data of the identified prey species what sort of derived data are applicable for the comparison of samples collected in different times and at different locations. The present paper elaborates on one year's data of a region. From the experience gained during the collections in that year it appeared that it was extremely difficult to fulfill the regularity requirement of monitoring in the study area which follows the course of river Dráva, and to reach every nesting site within a pre-set time interval. The amount of pellets that could be collected regularly from a given nesting site was strongly influenced by how the birds used the site, i. e. whether the church tower was used only as a resting site, a pairless owl occupied the building, or a successful nesting (perhaps a second nesting, too) could be recorded at that place. For this reason the number and size of the samples collected at the 15 villages showed great variation. Based on our results it appeared that the number of species identified from the pellets did not grow further when the number of pellets reached 100 in a sample. Kalivoda (1994), when dealing with the problems of sample size and representativity, concluded that sample sizes of around 200 were appropriate, and even with samples much greater than that only very limited increase could be expected in the number of species. Based on his results, sample sizes of 50 to 100 quite well approximate the number of taxa obtained from greater samples.

From among the three community characteristics, diversity and evenness appeared to be more applicable derived data, for their values were not affected considerably by sample size. However, Margaleff's species richness index proved to be very sensitive to sample size; it is not advisable to calculate it in the case of samples with highly varying number of pellets. PN and especially BEP are appropriate indices for describing feeding rhythms. The values of BEP are determined by the entire food base as a whole, it is not sensitive to the relative frequencies of the various species. It is well in line with the population growth of small mammals in autumn, and it is affected also by the nesting time and nesting rhythm of the owls.

Our regular pellet collecting along river Dráva provides a general idea of the composition of the small mammal faunas around the sampling sites, even after only one year. It is a contribution to the knowledge about the fauna of the southern part of Baranya county along river Dráva with important distribution data, which supplements earlier, sparse data from this county (Schmidt 1969, 1972, 1974, 1975), as well as more detailed surveys having done here (Horváth 1994, 1995, 1998). The first finding to be noted among the processed data is the list of the frequent species. If a comparison is made with results obtained on the Dráva lowland between 1985 and 1994 (Horváth 1995), it appears that at present the most frequent *Microtus* genus is not followed by *Sorex*, but instead the next most frequent species are *Crocidura* and *Apodemus*. This change may be related with the fact that pellet collection sites of those investigations and the present study only partly overlap. Because of the variation of sample sizes, small mammal communities of only 9 of the 15 villages were compared. Relative abundance, a parameter corrected for differences in sample sizes and abundance, was used as input for the cluster analysis, which proved to be appropriate for performing the multivariate statistical procedure. As a surprising result, the two settlements in Somogy county appeared to be in considerable separation, with Tésenfa, a village in Baranya being most similar to them. However, conclusions can only be made with precaution, because variance analysis did not indicate any significant difference. Therefore it remains a question how notable (if any) statistically provable difference can be expected between the small mammal communities recorded in an indirect way of sampling on the spatial scale of areas along river Dráva. Can the variation in climate, terrain and vegetation occurring along this scale cause differences in the composition of small mammal faunas? To what degree the demonstrable results are determined by food preference and density-dependent predation in the owls? In order to be able to answer these questions a successful monitoring and the analysis of data from a number of years are necessary.

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