painted by Sándor Varga

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DOKTORAL (Ph.D) THESIS

DENSITY, HABITAT PREFERENCE AND FEEDING ECOLOGY OF BADGER (MELES MELES) IN HAJDÚ-BIHAR COUNTY, HUNGARY

Prepared by:
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Debrecen
2007

Tartalomjegyzék

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1. Introduction, goals

The European badger, parallel to the European processions (BEVANGER et LINDSTRÖM, 1995; GRIFFITHS, 1993a, 1993b; GRIFFITHS et THOMAS, 1993; GRIFFITHS et KRYŠTUFEK, 1993; KAUHALA 1995), showed dynamic spread in Hungary since the end of the 1980's (HELTAI et al. 2001; SZEMETHY, 1989; SZEMETHY, 1994; SZEMETHY et HELTAI, 1996, 2001). It appeared and reached significant stock range at areas that earlier were not typical habitats of it (HELTAI et al., 2001; HELTAI et KOZÁK, 2004). This predator not known at several areas before, could give new challenge for nature conservation, and as a fair game mainly for game management professionals (SZEMETHY et HELTAI, 2000; SZEMETHY et al., 2000). At a concrete game management unit or within a unit at a certain area or region, a more detailed survey is necessary, as in connection with any species a correct, ecologically and economically acceptable management could be planned only by a deep analysis (SZEMETHY ET HELTAI, 2000; SZEMETHY ET AL., 2000).

My goals were:

- To investigate the presence and distribution of badgers in Hajdú-Bihar County
- To investigate the population size of badgers in sample areas
- To investigate the habitat preference through of choice of sett place
- To investigate the feeding ecology of badgers use the method of excrements analysis
- To investigate the role of badgers in the predation of ground nesting birds use the method of artificial made nests

2. Materials and methods

2.1. Investigation of sett density

To investigate the sett density I used the method of trail transect (Fig.1.).

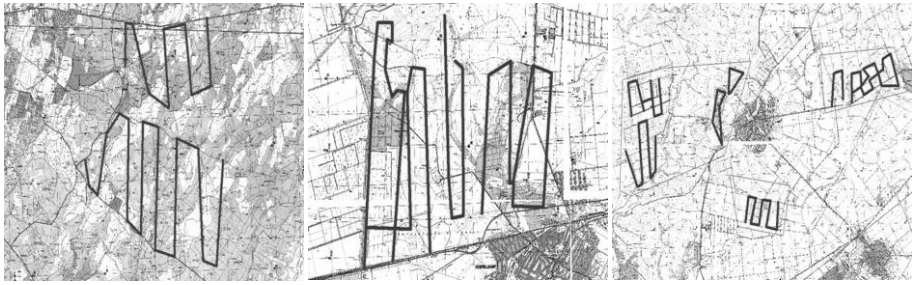

Figure 1. The transects in the sample areas

To get the sett density of the sample area I made a statistical sampling of the data of transects (HELTAI ET KOZÁK, 2004).

2.2. Method of investigation of habitat preference

2.2.1. Regional investigation to measure the role of forestation percent

To get these regional data I used the method of questionnaires.

2.2.2. Investigation of habitat preference

I collected the data of sett places and analyzed the percentage of the several habitat types of the sample areas. I measured the habitat preference by Ivlev-index (IVLEV, 1961):

$P_x=(A-B) / (A+B)$

A = the% of setts in the habitat type

B = the % of that habitat type in the sample area

Px = habitat preference to that habitat type (+1= absolute preference, -1= absolute avoidance)

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2.3. Methods of feeding ecology

2.3.1. Method of excrements analysis

We can collect the excrements of badgers easily because the species use special latrines along the border of the territory and near to the setts as well. The method of analysis of the excrements was made by the method of LANSZKI (2002, 2004). I collected the wastes of 4-4 setts from spring to autumn.

The diet composition was showed by the relative frequency of occurrence (RFO) (LANSZKI, 2002, 2004).

$RFO = 100 * N_i/N$

N_i = number of the taxon in the diet

N = number of all the taxons were part of the diet

2.3.2. Method of artificial made nests

It is impossible to investigate the feeding of eggs to use the method of excrement analysis. To have data I this topic I made the experient with the artificial made nests. I chosed 2-2 inhabited setts of the 2 sample areas. I placed out 6 artificial nest in the direction of the four quarters of the globe 50, 100, 150, 200, 250 and 300 meter far from the sett. To control the experiment data I used 6 random placed artificial nest in every sample area.

2.4. Time of investigations and used statistical methods

Objects	Period
Measure of sett density	2003, 2004, 2006
Investigate of habitat preference	2003, 2004
Excrement analysis	2005, 2006
Artificial nest experiment	2006

In the statistical analysis I used Kolmogorov-Smirnov test, χ^2-probe, Pearson correlation, one sample t-test ad independent samples t-probe.

2.5. The sample area

I collected data by questionnaires in 18 game management units. The detailed investigation was carried out in three sample areas wich are represent the significant habitat types of Hajdú-Bihar County: open (Nádudvar), transition (Püspökladány) and forested (Erdőspuszta) habitats (Fig. 2.).

Figure 2. The locality of the sample areas

6. Publications

Publications in the subject of thesis

Papers:

HELTAI, M. és KOZÁK, L. (2004): A borz kotoréksűrűségének felmérése két alföldi területen. Vadbiológia, 11: 83-91

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on the season, according to the seasons it shows changes both at the Erdőspuszta and both at the Nádudvar area.

Thus I can state on the whole that among the affect on artificial nests and the distance of the nests to the badger setts I did not find significant correlation. It means that the badger do not have any preference to the bird eggs.

3. Results

3.1. Results of the sett density investigation

Table 1. Sett density of the sample areas

Area	Inhabited setts/100 ha	All setts/100 ha	Year
Erdőspuszta*	1,07	3,00	2004
Erdőspuszta*	1,00	2,8	2006 a
Erdőspuszta*	1,06	2,77	2006 b
Püspökladány	0,3	0,39	2004
Püspökladány	0,26	0,32	2006
Nádudvar	0,61	0,64	2004
Nádudvar	0,91	0,93	2006

* Significant difference between the inhabited and not habited setts.

From the results of my sett density examinations it can be stated that the estimated sett density values that are not supported by a concrete analysis, given by the professionals of the game management units within a questionnaire survey, are significant ($p=0.05$) lower than the average values that I gained throughout my detailed investigation in case of open and forested habitats. Thus it is statable that the questionnaire survey is a quick and good method for gathering trend featured data, however to gain factual stock data a detailed, even a not complete, but anyway a representative examination is necessary, for which the flexible line transect method that I used is an appropriate method.

Analysing the data of the sample areas of the detailed survey I was given the result that the habitat circumstances ($p=0.05$) significantly affect the sett density values of the open (Nádudvar), transition (Püspökladány) and forested (Erdőspuszta) habitats; significantly less badger live at the open and transition areas than at the forested areas.

The sett density values gained throughout my investigations exceed the values of most detailed surveys processed at the Great Plain (Tab. 1.)

By the statistical analysis, the results of the comparing surveys with two years difference are not differing significantly. The reason of this is the short period between the two surveys, and that the species approached the maximal population range at the sample areas.

All these data strengthen that by nowadays the badger could be considered a predator that owns significant number of individuals and density at those areas of Hajdú-Bihar County where previously it was not particular. The rationally considered management of this species is an actual question in nature conservation and also game management aspects. The data of my detailed survey point also the fact that the more correct judgement of the stock range is not possible by a simple estimation, it needs scientifically established sampling.

3.2. Result of investigation of habitat-preference

The Pearson correlation examination of the data (Fig. 3.) gained by the medium scaled questionnaire survey, according to which the forestation affects the sett density in 38.71% (r = 0,622, p = 0,01).

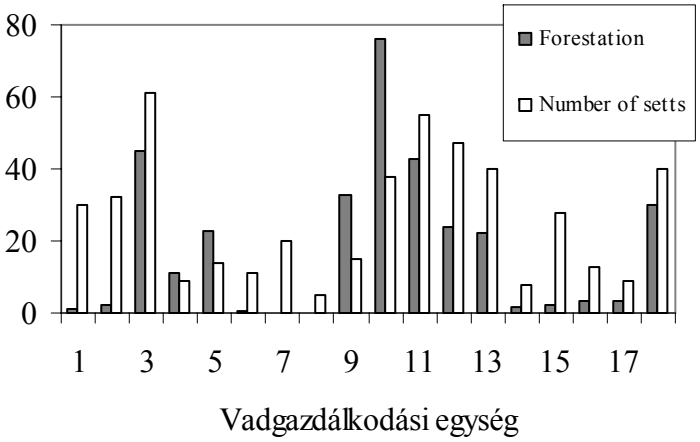

Figure 3. Dta of the forestation and number of setts in the investigated game management units

5. New scientific achievements

Density of badger setts:
My data strengthen that by nowadays the badger could be considered a predator that owns significant number of individuals and density at those areas of Hajdú-Bihar County where previously it was not particular. The sett density values gained throughout my investigations exceed the values of most detailed surveys processed at the Great Plain.
It can be stated by the number of the inhabited setts, that the badger density value at the highly forested Erdőspuszta sample area reached the values of the Transdanubian populations with considerable stock.

The region Erdőspuszta is well inhabited by badgers. This strong population could function like a root population in the inhabitation of the open areas.

Habitat preference:
By the results of my examinations on the quality of the vegetation and the rate of the vegetation cover I can state that the cognition of these environmental factors indicates the appearance and the accidental spreading of these species only partly because however the preference of the forested areas in case of a bigger region is statable but the settlement of the badger in open and forested habitats could be that sized that need interference from both game management or nature conservation aspect.

According to the forest preference it is contradictious result according to the international data that I found not avoidance but stronger than medium preference (P_x=0,62) to the coniferous forests at the Erdőspuszta habitats.

Feeding ecology:
Analysing the feeding data of the two sample areas I found that the food composition of the badgers is significantly ($p<0.01$) dissimilar in the different seasons, viz. the food composition depends

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The Table 2. and the Figure 4. show the data of the habitat types of the investigated sample areas.

Table 2. A mintaterületeken az összevont élőhely-típus kategóriák aránya

Habitat type	% in Erdőspuszta	% in Püspökladány	% in Nádudvar
Forest	55	16,1	0,5
Open	42	75,9	87,9
Wetland	2	3,2	10,8
Urban area	1	4,8	0,8

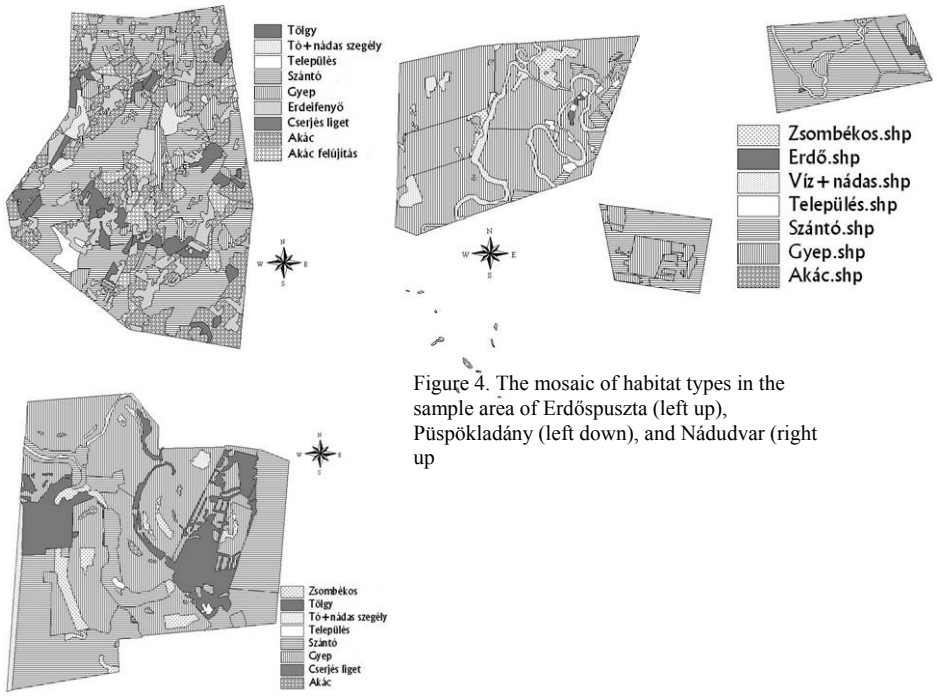

Figure 4. The mosaic of habitat types in the sample area of Erdőspuszta (left up), Püspökladány (left down), and Nádudvar (right up

Throughout my habitat preference examinations I stated that the lack of the considerable vegetation cover, namely the forest habitat does not impede the appearance of the badger at a certain habitat. Thus I experienced that the badger showed quite minor preference (P_x=0,11 and P_x=0,06) to the open habitats at the area of Püspökladány and Nádudvar, while it avoided the open areas at the Erdőspuszta region (Fig. 5.). Considering forests at the Erdőspuszta territory I found medium, only P_x=0,30 preference values. All these facts and the total avoidance of these waterlogged forest plots of these latter areas support the statement that the sheltering forest habitat is only one factor in choosing the place for the setts. Pedology and hidrology features could have dominant role and according to literature data (KRUUK ET PARISH, 1982; DA SILVA ET AL., 1994) the presently not examined feed supply characteristics that affect the rate of the home territory could also own an important factor in some cases also. This result of mine coincides with those British literature data that emphasise besides the vegetation characteristics the significance of the geological features in choosing the habitat (SOUTHERN, 1964).

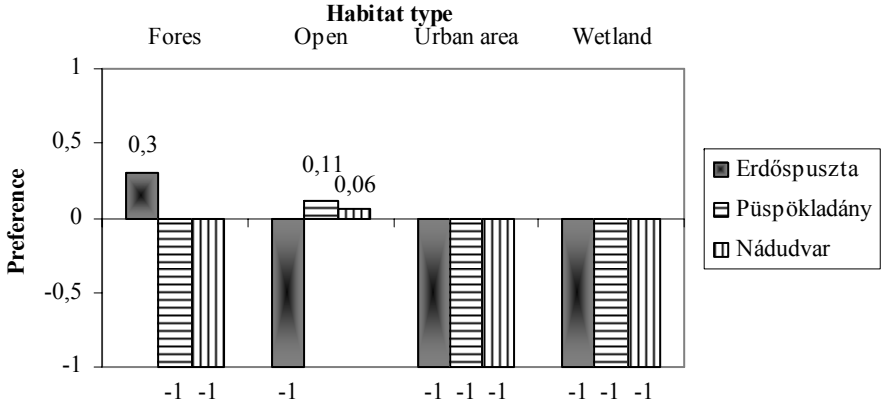

Figure 5. Habitat preference in the sample areas with aggregated habitat types

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The rate of egg decrease due to the days elapsed, both in case of experimental and both of control artificial nests is increasing (Fig. 12.). By the evaluation of the certain experiments in case of three experimental formations I found significant linear and in one case medium strong correlation, while considering the control nests all but one cases showed linear relation between the days elapsed and egg decrease. By this the inhabitants of the badger warrens could have an expected affect on the egg decrease. However, the statistical survey on the rate of the affect on the experimental formation and on the control artificial nests with independent-samples T test did not strengthen this expectation. Namely I did not find significant difference between the two data bases at a p=0.05 significance level.

Thus I can state on the whole that among the affect on artificial nests and the distance of the nests to the badger warrens I did not find significant correlation, viz. I had to reject my H_0 hypothesis on that. The reason of this could be presence of other predators, like Red fox, European polecat, stray cat, or Wild boar, Hooded crow, European magpie as species with a role in robbing the nests or other species also. According to this, however the badger endangers the eggs and still flightless nestlings of the birds nesting on the ground, this effect is not exclusive, it is added to the affect of other bird's-nesters and the nearness of the warren does not increase the frequency of robbing the nests.

By the cumulated data of the sample areas it can be stated that the species shows medium preference (P_x=0,41) to the forested habitats against the open ones (Fig. 6.). This result from the detailed examination strengthens the experiences of the correlation examination of the data gained by the medium scaled questionnaire survey, according to which the forestation affects the sett density in 38.71%.

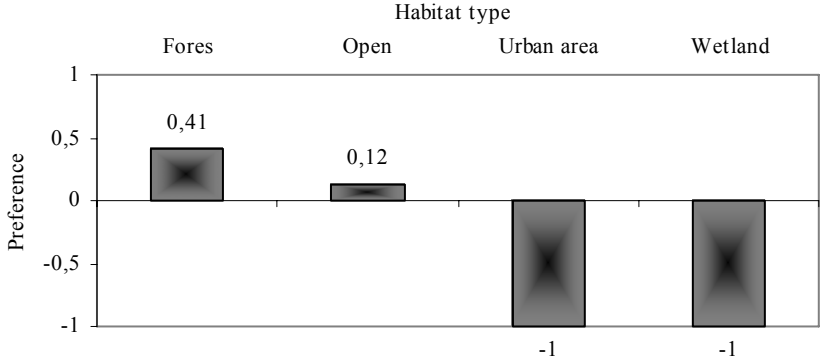

Figure 6. Habitat preference with cumulated data of the three sample areas

For the evaluation of the preference of different forest types by forestation indicators (forestation %, and the variety of forest types) the Erdőspuszta sample area afforded the opportunity. According to the forest preference it is contradictious result according to the international data (NEAL et CHEESEMAN, 1996) that I found not avoidance but stronger than medium preference (P_x=0,62) to the coniferous forests at the Erdőspuszta habitats (Fig 7.). In the British case the badgers chosen for sett place the coniferous forest only without a better solution and in these cases they chose mainly the forest fringes. In case of the Norway pine forests of the Erdőspuszta I found the setts also close to the fringes or it is typical at this area that a forest fragment from Norway pine is that small sized that the whole of the forest could be considered as fringes. Besides, the habitats of these forests are markedly dry, warm sand areas that are perfect for sett digging.

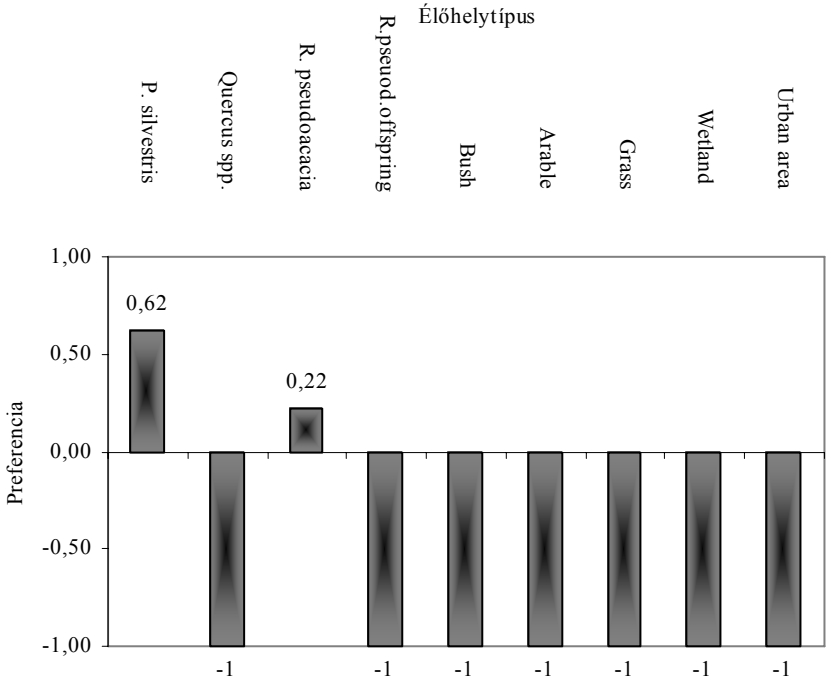

Figure 7. Habitat preference of badger in Erdőspuszta with 9 habitat types.

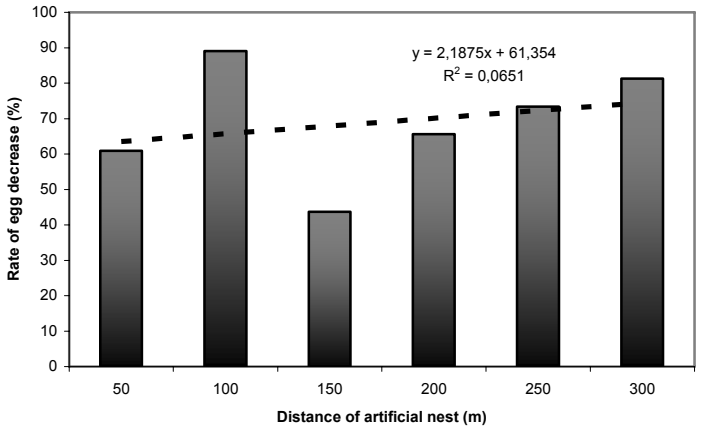

Fig 11. Rate of egg decrease in the experiment made in Nádudvar (n=384)

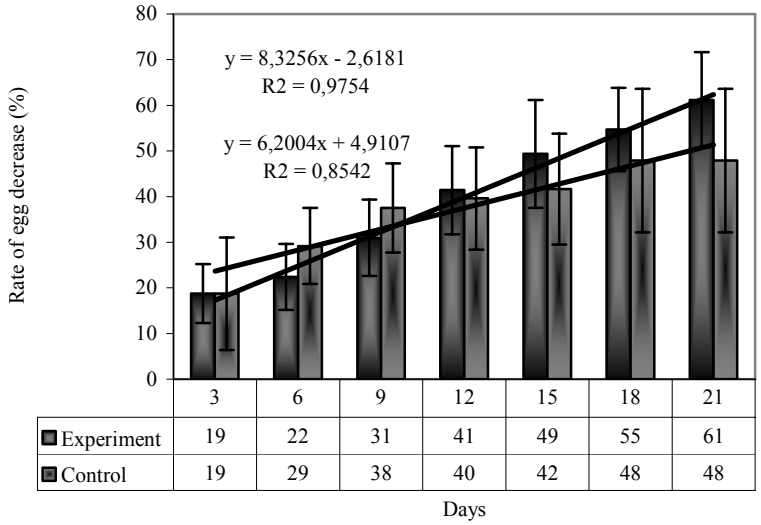

Figure 12. The rate of egg decrease in the 21 day of experients

did not find significant relation between the affect on artificial nests and the distance of the nests to the warrens. The result of the four experimental formations at the Nádudvar sample area is similar (Fig 11.) and the R^2 value by the summarized data is very low, viz. I did not find significant correlation between the affect on artificial nests and the distance of the nests to the warrens. Summarizing the results (Fig. 12.) of the two sample areas it is statable that however the rate of the egg decrease declines accordingly to the distance to the badger warrens, but there is no significant correlation between the two variables.

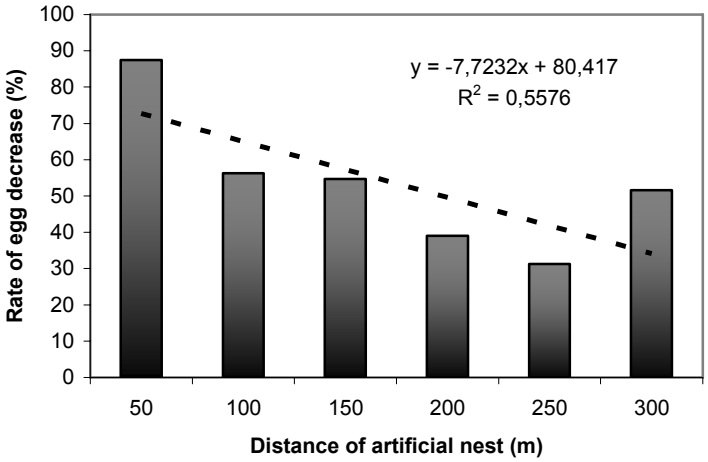

Figure 10. The rate of egg decrease in Erdőspuszta (n=384)

5.3. Results of investigation of feeding ecology

5.3.1. Excrement analysis

By the data of the waste analysis of the feeding examinations (Fig. 8.), the consumption of the invertebrates was dominant (80,3%) in the spring period at the Erdőspuszta sample area, but the bird consumption could be considered also significant (9,6%). In the summer period the food composition is more balanced. The importance of the invertebrates increased (52,3%), but it is still predominantly important and the small mammal consumption became secondarily significant (33,9%). For the autumn period from the second half of the summer, the increasing plant food became dominant (80,9%) which meant the consumption of maze and forest fruits (blackthorn, albespine) mainly. The secondarily important group was of invertebrates (11,7%) and the small mammal capture also occurred (6,4%).

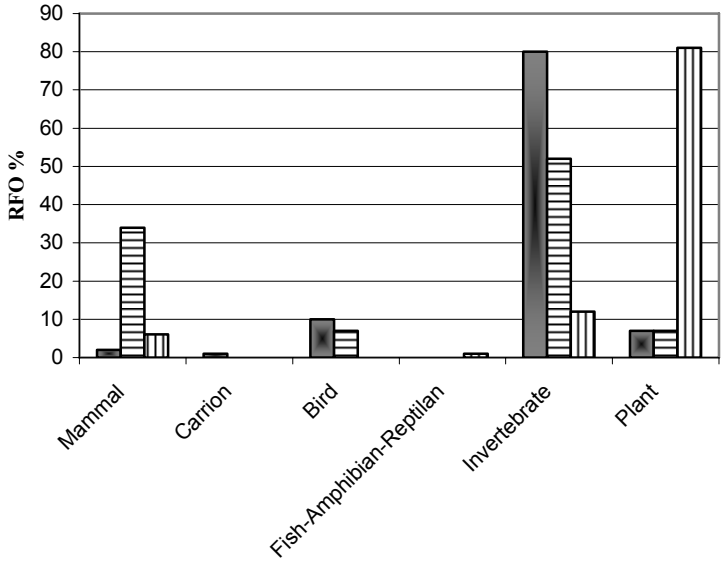

Figure 8. Diet composition in Erdőspuszta

During the spring period, in the food of the badgers of the Nádudvar sample area (Fig. 9.) also the consumption of the invertebrates is the dominant (77,3%), while the mammal (9,6%) and bird (7,3%) eating is secondary. In the summer period the consumption of the invertebrates is decreasing (43%), but the rate of the vegetal nutriments is on the increase (23,6%), the small mammal (15%) and bird (8,4%) intake is still considerable, and the frequency of fish eating (7,2%) is the same as of mammals and birds. During autumn vegetal nutriments become dominant (89,1%) at this area also.

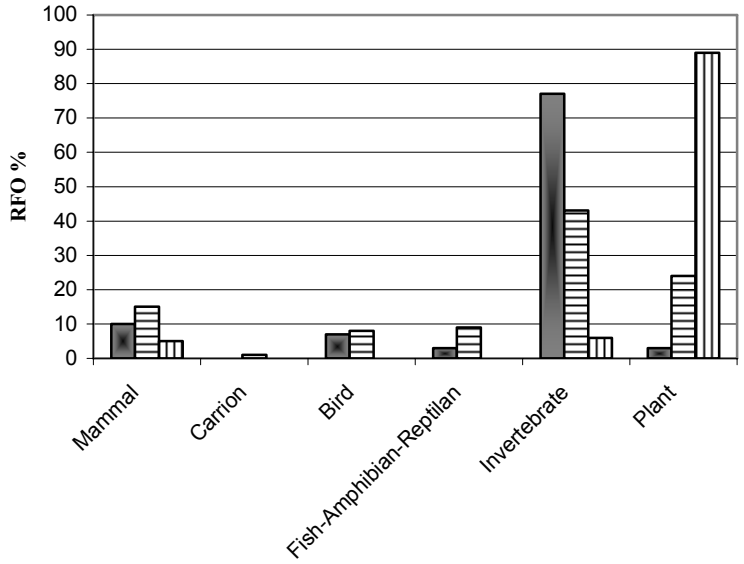

Figure 9. Diet composition in Nádudvar

Analysing the feeding data of the two sample areas I found that the food composition of the badgers is significantly ($p<0.01$) dissimilar in the different seasons, viz. the food composition depends on the season, according to the seasons it shows changes both at the Erdőspuszta and both at the Nádudvar area. Comparing the results of

the certain seasons the difference between the two sample areas in the spring period is not significant at a $p=0.05$ significance level, but at a $p=0.1$ level the difference is significant. The food composition experienced in the summer period differed significantly ($p<0.01$), while due to the dominancy of plant eating during the autumn period, there is no significant difference between the food composition of the two sample areas. In case I compared the two sample areas by the annual food composition, the difference was significant. All these confirm that the food composition of the badger could significantly differ due to the various habitat features, namely the species act as an opportunist accordingly to areal facilities. The utilization of the fish carcase as a food source appearing due to human affect at the Nádudvar sample area indicates the great adaptability of the badger.

5.3.2. Results of artificial nest experiment

Throughout my feeding ecology examinations I was not able to measure appropriately the volume of egg consumption of the badger. To test this I made artificial nest experiments.

Several species could capture the eggs and nestlings. In most cases (67%) during my examinations with sand-trap method I did not succeed to identify the species consuming the eggs. However I applied artificial nests, due to the low number of identified cases I was not able to reveal significant dissimilarity among the different predator species. From the identified cases the badger in 7%, fox in 4%, and boar in 6%, other mammal in 6% and bird in 10% was the perpetrator. According to these results it cannot be stated in case habitat types of the Great Plain represented by my sample areas, which species is the most important from the potential bird's-nesters.

I measured the value of egg consumption according to the presence of badgers, in case of both sample areas near to 2-2 inhabited badger setts, in two repeat. The egg decrease data according to the distance measured in 4 experimental formations shows considerable deviation at the Erdőspuszta sample area, a linear trend cannot be fit on the results (Fig. 10.). The R^2 value by the summarized data is medial, the correlation is not significant, viz. I