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Landscape ecological analysis of barn owl pellet data from the Drava lowlands, Hungary

HORVÁTH GYŐZŐ., MOLNÁR DÁNIEL, NÉMETH TAMÁS & CSETE SÁNDOR

University of Pécs, Faculty of Sciences; Institute of Biology, Department of Animal Ecology;
H-7624 Pécs, Ifjúság u. 6. Hungary; e-mail: horvath@ttk.pte.hu

HORVÁTH, GY., MOLNÁR, D., NÉMETH, T., & CSETE, S.: *Landscape ecological analysis of barn owl pellet data from the Drava lowlands, Hungary.*
Abstract: Small mammal fauna monitoring in the Drava Lowlands has been done partly by barn owl pellet collecting and analysis. In the present study the correlations between landscape patterns and barn owl food composition (i.e. the indirect representation of small mammal communities) were analysed using an approach how the cummulated data of particular breeding pairs can be interpreted as characteristic for the patch composition of the mosaic landscape considerably larger than the hunting range of barn owls. For landscape ecological analysis CORINE LANDCOVER 1:50.000 mapping categories were applied, based on which natural or semi-natural areas, differing from each other also in their barn owl hunting qualities, were differentiated. Three larger areas along river Drava were investigated: two in the upper reach monitoring zone (Zákány-Porrogszentkirály, and Berzence-Heresznye), and one in the lower Drava reach (Drávaiványi-Szaporca). In the two upper-reach zones the localities differed from the greater scale landscape in less than 30% of the patches, with only 3-5 patches showing significant difference. In the lower reach there was one sampling locality with 6 patches differing from the greater-scale area, although in the entire lower section 33% or less difference was found between patch compositions of the two scales. Based on patch overlap calculations and homogeneity tests it was concluded that small mammal faunal data of the localities can be cumulated and can be evaluated on much larger landscape ecological scales than barn owl hunting ranges.

Keywords: Landscape pattern, small mammals community, pellet analysis, *Tyto alba*

Introduction

The most widely used and, in Hungarian zoological studies, a quite conventional method for general small mammal distribution data analysis and for more detailed presence/absence analysis within particular regions is indirect monitoring using barn owl pellets. This methodology is acceptable from a nature conservation aspect, and is capable of producing masses of abundance data. It allows for both quantitative and qualitative analysis of the distribution patterns of small mammal species, and, by using relative abundance values of various species in the particular samples, it also makes possible to compare small mammal communities of various areas. The monitoring, at various depths, of changes in distribution is essential in all Hungarian mammal species (CSORBA and PECSENYE 1997), thus, in small mammals, the most effective data collecting method in the faunal exploration of the Drava Lowlands has been monitoring that relies on barn owl pellet analysis. Besides distribution monitoring, the small mammal fauna of partic-

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ular habitat complexes can also be analysed, and, using quantitative variables and indices derived from basic regular data, changes in the proportions of taxa as well as their trends can be examined. By means of landscape pattern analysis of habitats along Drava, and by applying GIS, small mammal distribution in the area can be interpreted at a landscape ecological scale as well.

Owls are important top predators of Cetral-European ecosystems, with the barn owl *Tyto alba* (Scop., 1769), strictly protected in Hungary, having special importance due to its role in small mammal faunal studies. Because of its significant role in the food chain, and because its behaviour and habitat are closely associated with humans, there have been several studies focusing on its habits, nesting characteristics, breeding biology and ecology (TAYLOR 1994, MIKKOLA 1983), and feeding ecological studies dealing with the barn owl as a predator provide important data concerning prey species as well. Indirect monitoring based on barn owl pellet analysis provides information about the composition and structure of small mammal communities using the mosaic-pattern hunting areas surrounding particular nesting sites. (SCHMIDT 1973, WIJNANDTS 1984). Habitat patches differing in their sizes determine the local densities of small mammal populations found there, and the higher percentage of small mammals in various patches are represented in barn owl food as well, however these correlations can become clearer if areas analysed are larger (HORVÁTH et al. 2003). River Drava being a green corridor in the south of Hungary, is an important conservation area, with lowland areas along the river being inhabited by dense barn owl populations. Regular pellet collecting has been done in these areas, and their data are used in anlyses of spatial and temporal distribution of small mammals. In the present study monitoring data from the upper river section (Somogy county) are ivestigated together with barn owl pellet data. Correlations were analysed between landscape patterns of barn owl nesting areas and the compositions of small mammal communities shown in barn owl pellets, as well as we looked at statistical differences in the feeding ecology between owls nesting in Drava Lowland areas that differ in their patch compositions. We have performed regular pellect collecting in barn owl nesting areas of the Drava Lowlands, and based on their spatial distributions three larger regions were differentiated. Landscape ecological and small mammal faunal data of these regions were summed and evaluated on a larger spatial scale and on the local hunting area scale as well.

Answers were sought to the following questions: (i) are the patch compositions of the larger designated areas similar to the hunting areas of the barn owls, thus can we draw conclusions for the small mammal composition of the entire area, (ii) what are the differences between the Drava sections in their food and patch compositions, (iii) are the differences in patch compositions of the different-scale areas expressed also in the food compositions of barn owls in those areas, or how does patch composition determine the type of small mammal fauna shown during monitoring?

Material and Methods

A total of 17 barn owl nesting locations were selected along river Drava, so that small mammal communities indicated from owl pellets can be analysed based on the landscape ecological investigation of the owls' hunting ranges. Nesting locations were compared based on both owl feeding data and vegetation patch composition.

The first sampling period in the selected nesting sites lasted during the first nesting period, from spring to late June. The second sampling period lasted from August to

November, including any possible second nesting. If pellets were collected several times in a particular nesting area, then their data were treated together within that period.

Small mammal identification was done according to SCHMIDT (1967), ÁCS (1985) és UJHELYI (1994), based on skull characteristics and tooth morphology. Some identification guides differentiate Neomys species - *Neomys fodiens* (Pennat, 1771) and *Neomys anomalus* (Cabrera, 1907) - based on the height of the coronal process of the mandible. Withtin the genus *Apodemus*, we treated the wood mouse *Apodemus sylvaticus* (Linnaeus, 1758), yellow-necked wood mouse *Apodemus flavicollis* (Melchior, 1834) and the pygmy field mouse *Apodemus microps* (Kratochvíl és Rosicky, 1952) together as wood mice (*Apodemus* spp.). The differentiation of the two *Mus* species occurring in Hungary, i.e. the house mouse (*Mus musculus* Linnaeus, 1758) and the gleaner mouse (*Mus spicilegus* Petényi, 1882) from owl pellet skeletal remains is still not totally settled. These two species were then separated based on the upper and lower zygomatic arches (DEMETER 1995, DEMETER et al. 1995). If these were either missing or only mandibles were present, then only the genus was determined (*Mus* spp.). Hereby is a list of taxa that are determined in pellet analyses at non-species lebvels (only small mammals are considered):

Soricidae indet. (any unidentifiable shrew)

Neomys spp. (*Neomys fodiens* or *N. anomalus*)

Apodemus [*Sylvaemus*] spp. (any species belonging to the *Sylvaemus* subgenus - *sylvaticus* or *flavicollis* or *microps*)

Mus spp. (*musculus* or *spicilegus*)

Rattus spp. (*rattus* or *norvegicus*).

For landscape ecological analysis CORINE LANDCOVER 1:50.000 mapping categories were applied, based on which we determined 17 patch categories differing in their qualities from the aspect of barn owl hunting. Using the software ArcView 3.2 the following patch types were established: waters, wet areas (marshes), forests (closed or

Table 1: UTM codes, sample numbers, pellet numbers and prey abundance values for the 17 villages selected

	Nesting sites	UTM codes	Number of samples	Number of pellets	Total number of individuals
Upper reach	1. Zákány	XM52	3	299	747
	2. Gyékényes	XM52	3	42	118
	3. Porrogszentkirály	XM52	4	339	1017
Middle reach	4. Berzence	XM62	2	39	116
	5. Somogyudvarhely	XM61	2	130	410
	6. Vízvár	XM70	3	48	157
	7. Heresznye	XM70	1	38	152
Lower reach	8. Drávafok	YL18	6	196	409
	9. Drávaiványi	YL18	2	14	45
	10. Zaláta	YL27	3	136	406
	11. Nagycsány	YL28	5	150	415
	12. Piskó	YL27	5	115	306
	13. Vejti	YL37	6	162	422
	14. Vajszló	YL38	5	130	294
	15. Páprád	BR68	7	184	305
	16. Cún	BR77	2	72	160
	17. Szaporca	BR77	3	112	328
	Total		62	2206	5807

open, dry or wet deciduous forests, as well as coniferous forests and forest plantations), natural and degraded grasslands, shrubby areas, unvegetated open areas, ploughlands, perennial cultivated plants (vineyards and orchards), agricultural areas with various types of cultivation, artificial surfaces (artificial, non-agricultural vegetated areas and urban areas). Two areas were selected in the upper Drava monitoring areas (between Zákány-Porrogszentkirály, and Berzence-Heresznye, respectively), whereas in the lower section only one larger area was chosen (Drávaiványi-Szaporca). The local landscape ecological analysis of the hunting areas was done on the basis of the patch composition in a 2 km radius around the nesting sites, whereas for the greater-scale analysis of the particular Drava section we used the patch composition of the area bordered by the attingents of 10 km radius circles around nesting sites and by the line of the Drava. As part of lanscpe ecological analysis, the patch diversity values of the entire river section areas were calculated, and the comparison of sampling localities and larger-scale areas was done by G-tests and patch overlap calculatioons (Schoener-index).

In the case of all 17 places, the analysis of barn owl food composition was done using the cumulated data from pellet samples collected in 2002 (Table 1). For comparing small mammal proportions at various river sections homogeneity tests (G-test) were applied. Any correlation between habitat patches that were found to be occurring in considerably different rates within the various sampling areas and the abundance of their characteristic small mammals were tested using regression analysis.

Results

Regarding patch composition, the three Drava sections and the cumulation of their sampling localities were found by G-tests to be homogenous, with only one case of significant difference on the lower and middle section, and two patches with significant difference in the upper section. Patch overlap values also showed high degree of similarity in all three comparisons (lower section: 0.82; middle section: 0.74; upper section: 0.73).

The statistical analysis of patch compositions of the three greater areas revealed higher patch overlap between the upper and middle sections (0.85), whereas these two areas were more different from the lower region in respect of their patch distributions, thus smaller overlap values were obtained (0.64 and 0.62). Based on G-tests the upper and

Table 2: Homogeneity G-test of patch compositions in the various Drava reaches

Patch type	p_i (total reach)	p_i (total reach)	G-values
	Upper reach	Middle reach	
Mixed agricultural areas	9.49	2.23	4.84*
	Middle reach	Lower reach	
Marshes	**0.18**	4.36	4.77*
Dry closed deciduous forest	**46.87**	19.63	11.50***
	Upper reach	Lower reach	
Mixed agricultural areas	9.49	2.66	4.06*
Dry closed deciduous forest	**39.08**	19.63	6.57*
Forest plantation	3.58	11.51	4.38*

***: $p < 0.001$; ** : $p < 0.01$, *: $p < 0.05$

Table 3: Homogeneity G-test of cumulated pellet samples in the various Drava reaches

Prey taxa	p_i (total reach)	p_i (total reach)	G-values
	Upper reach	Middle reach	
M. arvalis	46.81	29.58	3.92*
	Middle reach	Lower reach	
S. araneus	19.88	4.27	10.94***
M. arvalis	29.58	55.63	8.09**

***: $p < 0.001$; ** : $p < 0.01$, *: $p < 0.05$

middle sections were significantly different in one, the lower and middle in two, and the lower and upper in three patch types (Table 2). When food composition was analysed, there were less clear differences than expected between the three river sections. However, significant differences i.e. inhomogeneity occurred in the ratios of the common vole, the most preferred prey animal of the barn owl. This may be due to different small mammal availabilities related with patch composition differences in the various Drava sections. Another significant difference was found in the common shrew, a protected insectivorous small mammal of indicator significance, playing an important role in rating areas with different landscape patterns (Table 3). When data from nesting localities of one of the Drava sections were compared with data for the entire length, more significant results were obtained both in patch composition and in small mammal distributions of their corresponding habitat patches. In patch composition analysis only those patch types were emphasized among significant ones that were habitats of significantly different prey taxa in that sample. This revealed correlation between the most frequent

Table 4: Homogeneity G-test of pellet samples and patch compositions in the various nesting localities and in complete Drava reaches

Reaches	Nesting sites	Prey taxa / patch types	pi (total reach)	pi (given nest site)	G-values
Upper reach	Zákány	*M. arvalis*	46.81	21.02	10.06**
		crop field	14.85	1.76	11.79***
	Gyékényes	*C. glareolus*	3.77	0.00	5.23*
		Apodemus spp.	12.65	3.39	5.69*
		dry closed deciduous forest	39.08	0.00	54.18***
		wet closed deciduous forest	13.63	0.00	18.89***
Middle reach	Berzence	*S. araneus*	19.88	0.86	21.58***
		C. glareolus	3.47	0.00	4.81*
		dry closed deciduous forest	46.87	0.00	64.98***
		M. arvalis	29.58	58.62	9.74**
		crop field	13.31	63.73	35.89***
		mixed agricultural areas	2.23	11.55	6.91**
	Heresznye	*Apodemus spp.*	9.10	0.00	12.62***
		dry closed deciduous forest	46.87	0.00	64.98***
Lower reach	Vajszló	*S. araneus*	4.27	13.95	5.41*
		dry closed deciduous forest	19.63	49.29	13.19***
		forest plantation	11.51	24.11	4.56*

***: $p < 0.001$; ** : $p < 0.01$, *: $p < 0.05$

prey taxa (*M. arvalis, Apodemus* spp. and *S. araneus*) and their most characteristic habitat patches (ploughland, broad-leaved forests). As suggested by G-tests, the relative frequency of the typically forest-dwelling small mammal *C. glareolus*, found at lower proportions in the samples, is also determined by the ratios of closed, dry deciduous forests. Thus, in these species the relative frequency calculated for a particular Drava section differed from values obtained for certain localities, whic is because of the fact that the habitat patches typical of these species differed significantly too when locaities and larger-scale areas were compared (Table 4).

The relative proportions of *C. glareolus* and *S. araneus* in the Drava sections were noted as characteristic for forest patches; and relative proportions of M. spicilegus és a *C. suaveolens* as characteristic for natural grasslands. When patch ratios and the relative frequencies of these species were charted together, it suggested that relative prey species abundance in the food of the owls depends on the extent of the characteristic small mammal habitats.(Figure 1-2). The correlations obtained by homogeneity tests were then tested with regression analysis too, to reveal significant correlation between relative frequencies of habitat patches and that of the particular species, in the case of *M. arvalis, Apodemus* spp., and *C. glareolus* (Figure 3-5). As patch proportions grew, relative frequencies of wood mice (*Apodemus* spp.) and common vole increased with an exponential curve, whereas for the bank vole significant linear correlation was found, showing that as the proportions of forested patches grew, the abundance of this species in the owl pellets also increased. When relationships between landscape ecological parameters and small mammal community parameters derived from pellet data were analysed in the case of localities, significant correlation was found between patch diversity and prey species number, meaning that the number of species indicated by pellets is in linear correlation with patch diversity (Figure 6).

Conclusions

Spatial heterogeneity is one of the most essential factors determining processes in populations and communities. The effect of heterogeneity is seen mostly in landscapes and habitats transformed by humans (KOZAKIEWICZ 1983). In respect of the Drava reaches subject to barn owl pellet collecting and analysis as part of small mammal indirect monitoring, landscape ecological analyses showed that among the three studied areas the one in the lower section was considerably different from the two areas in the upper reach. When interpreting the results, it has to be noted that the proportions of wet forest patches were considerably higher and those of ploughlands were lower in the upper Drava section. An important finding was the significant difference in the frequency of marshy areas in the lower (Baranya county) section. These results clearly indicated landscape ecological differences between the various Drava reaches, and, accordingly, differences occurred also in the compositions of their small mammal communities as shown by owl pellets. The results obtained are remarkable because due to seasonal differences in the hunting strategy of the barn owl, and due to the presence of prey preferences, i.e. to density-dependent hunting, the over-representation or under-representation of certain species can considerably influence small mammal abundance values obtained from pellets. Selective predation is studied in the barn owl (COLVIN and MCLEAN 1986, DICKMAN et al. 1991, TAYLOR 1994), but there are no data showing how much significance prey selection has in comparing data of various temporal and spatial scales, in relation to small mammal availability expected on the basis of mosaic habitat patches.

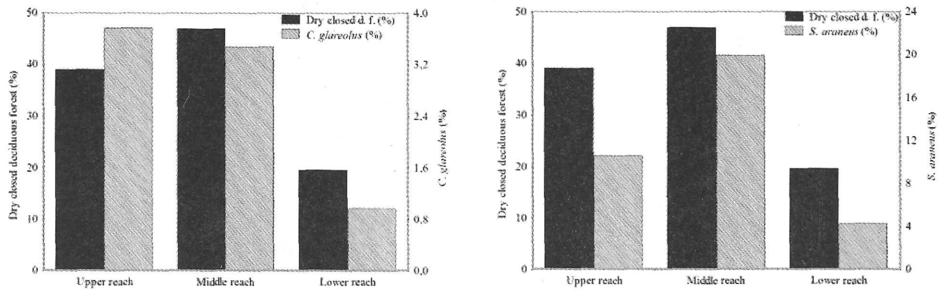

Fig. 1. Relationship between the proportions of dry, closed forests as potential habitats, and *C. glareolus* / *S. araneus* relative frequencies in the three studied Drava reaches

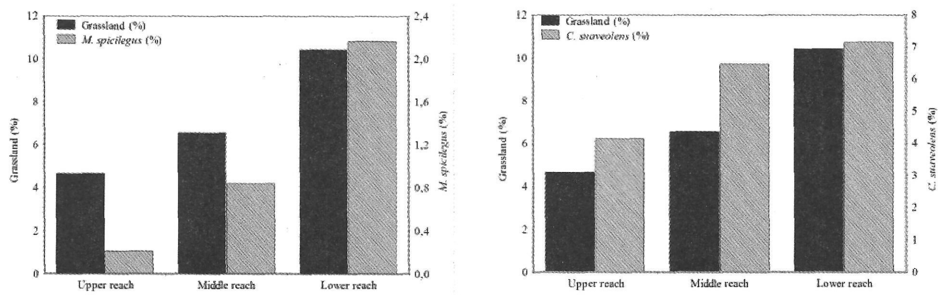

Fig. 2. Relationship between the proportions of natural grasslands as potential habitats, and *C. suaveolens* / *M. sipcilegus* relative frequencies in the three studied Drava reaches

Based on patch patterns the area designated in the lower Drava section was significantly different from the two regions selected in the upper reach, although this difference could not be statistically proved. As seen from the homogeneity tests, among species that differed significantly in their percentages in the the entire reaches, it was the common shrew that had similarly high G-values for its habitat, i.e. for closed, dry forests. As shown by G-tests performed in order to compare patch compositions and prey compositions of barn owl hunting areas and the corresponding Drava reaches, in the case of several nesting locations the proportions of both certain patyh types and their characteristic small mammals differed significantly from values obtained for the larger-scale areas. These relationships are seen primarily in species that are heavily preyed upon by the barn owl. We have shown in our earlier investigations that the sizes of various habitat patches within the hunting range of the barn owl often determines the frequency values of small mammals calculated from pellets, which can be proved by regression analysis (HORVÁTH et al. 2003). In most cases, the correlations between proportions of patch types and prey species having striking homogeneity-test G-values could be clearly shown by regression analysis in the present study, too, consequently, barn owl pellet

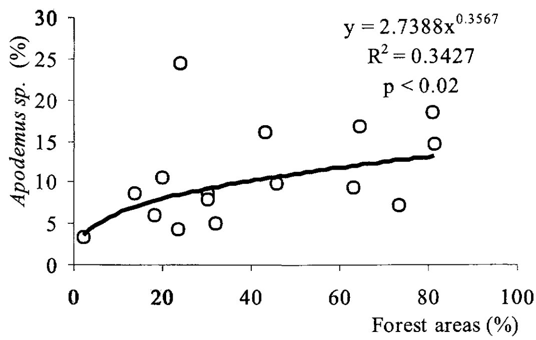

Fig. 3. Correlation between the proportions of wooded areas and *Apodemus* sp. relative frequencies

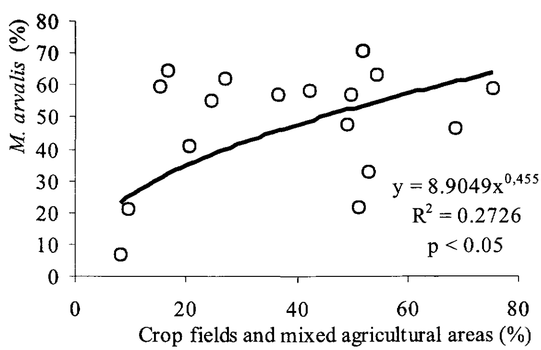

Fig. 4. Correlation between the proportions of ploughlands / mixed use areas and *M. arvalis* relative frequencies

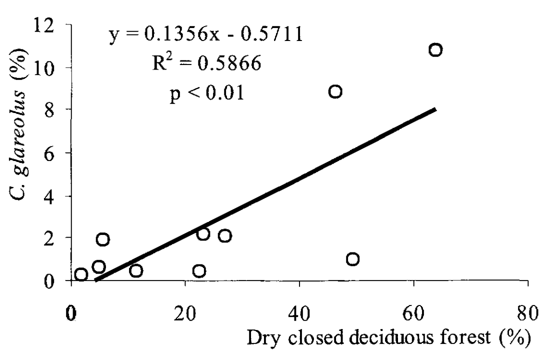

Fig. 5. Correlation between the proportions of dry, closed forest and *C. glareolus* relative frequencies

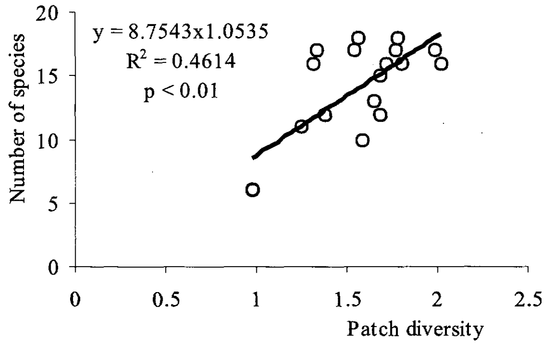

Fig. 6. Correlation between patch diversity and species number

analysis is applicable for the landscape-scale characterization of small mammal communities and their habitat vegetation patches.

In our earlier study we also looked at how prey diversity changed in relation to certain distinguished patches. Patches that are less optimal for the barn owl cause lower species diversity, which was expressed in the case of local hunting areas mostly by the higher rate of inner areas of human settlements. Thus it was concluded that in settlements with higher proportions of inner areas the small mammal community shown from pellets is less diverse. Another important relationship was revealed for forest patches, too: as the percenmtage of this patch type grew, species diversity followed an exponential function (HORVÁTH et al. 2003). As patch size grows, its perimeter grows at a smaller rate, but in this patch it is the perimeter, i.e. the edge zone that acts as potential hunting area for the owl, where, by preying upon forest species, its prey composition becomes wider. As forest size grows, the number of species that can be caught will not grow further, meaning that in patch with a certain ratio of area/perimeter all the potentially hunted species will be represented in the food. Larger forest patches than this size will not cause higher species diversity; it is rather the smaller, separated forest fragments that can be beneficial for the barn owl, as these are the ones that have higher area/perimeter ratios, i.e. larger forest edge proportions. A correlation revealed in the present study for bank vole occurrence in the Drava sections has provided new information for the evaluation of forest patch proportions. Similarly to the issue of diversity, it was presumed that there is exponential or logarithmic correlation between the frequency of the bank voles and increasing numbers of forest patches, meaning that above a certain amount of forest the quantity of bank voles indicated by pellets will not be considerably higher, due to the fact that the barn owl does not hunt in closed forests. However, a linear correlation occurred between wooded areas and relative abundance values of this species, which suggests that a higher fragmentation of forests along river Drava means a high ratio of perimeter/area providing higher chances for the owls to successfully hunt for bank voles inhabiting forest edges.

Based on patch overlap calculations and homogeneity tests of patch composition, small mammal faunal data of smaller localities can be cumulated and, in the case of our sampling areas along river Drava, can be evaluated on landscape ecological scales much larger than the actual hunting ranges of barn owls.

Acknowledgement

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A Dráva menti gyöngybagoly köpetekből nyert adatok tájökológiai elemzése

HORVÁTH GYŐZŐ, MOLNÁR DÁNIEL, NÉMETH TAMÁS és CSETE SÁNDOR

Dél-Magyarországon a Dráva folyó természetvédelmi szempontból jelentős ökológiai zöldfolyosónak tekinthető és a folyó menti sík területen nagyobb sűrűségű regionális gyöngybagoly-állomány fészkel. A térségben rendszeres köpetgyűjtést folytatunk, amely alapján a kisemlősök elterjedésének tér-időbeli viszonyait monitorozzuk. Jelen tanulmányban a tájmintázat és a gyöngybagoly táplálék-összetétele közötti összefüggéseket vizsgáltuk abban a megközelítésben, hogy az egyes költőpárok adatainak összesítése mennyiben vonatkoztatható a gyöngybagoly zsákmányolási körzeténél lényegesen nagyobb mozaikos táj foltösszetételére. A tájökológiai elemzéshez a CORINE LAND-COVER 1:50.000-es térképezési kategóriákat alkalmaztuk, amely alapján a gyöngybagoly vadászata szempontjából is eltérő minőségű természetes, vagy természetközeli területeket különítettünk el: vizek (álló és folyóvizek), vizenyős területek (mocsarak), erdők (lombos és tűlevelű erdők), természetes gyepek, természetközeli rétek, átmeneti erdős-cserjés területek, növényzet nélküli és kevés növényzettel fedett nyílt területek. A kategorizálás másik csoportjában az antropogén területeket vettük figyelembe: szántóföldek, állandó növényi kultúrák (szőlők, gyümölcsösök), legelők, vegyes mezőgazdasági területek, mesterséges felszínek (mesterséges nem mezőgazdasági zöld területek és urbanizált területek). A Dráva mentén három nagyobb területet elemeztünk, a Dráva felső szakaszának monitorozási terültén kettő (Zákány-Porrogszentkirály, illetve Berzence-Heresznye), míg az alsó Dráva szakaszon egy szakaszt jelöltünk ki (Drávaiványi-Szaporca). A vadászterületek lokális tájökológiai elemzését a költőhelyek körüli 2 km-es sugarú kör területének foltösszetétele alapján végeztük, míg az adott Dráva szakasz nagyobb léptékben történő vizsgálatához a költőhelyek körüli 10 km-es sugarú körök érintői és a Dráva vonala által határolt terület foltösszetételét használtuk fel. A Dráva legfelső két szakaszán a lokális területek a foltok kevesebb, mint 30 %-ában különböztek a nagyobb léptékű tájhoz viszonyítva, mindössze 3-5 folt esetén volt szignifikáns különbség. Az alsó szakaszon volt olyan lokális mintahely, ahol 6 folt aránya különbözött szignifikánsan a nagyobb területtől, de a teljes szakaszt tekintve 33 %-os, vagy ennél kisebb különbséget kaptunk a két térbeli skálán vett foltösszetétel között. A foltátfedés számítás és a homogenitás tesztek alapján a lokális területek esetén kapott kisemlős faunisztikai adatok összegezhetők és a baglyok vadászterületeinél lényegesen nagyobb tájökológiai skálán is értékelhetők.