SPATIAL, NUTRITIONAL AND REPRODUCTIONAL INTERACTION BETWEEN DOMESTIC CATS (*FELIS SILVESTRIS* f. *CATUS*) AND WILDCATS (*FELIS SILVESTRIS*)

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1. INTRODUCTION

1.1. Significance of the topic

The wildcat is one of the least known carnivore species in Europe. Mainly observations of animals in captivity (Wolf 1968, Condé and Schauenberg 1969) and investigations of hunted individuals (Schauenberg 1977) were done formerly, because the secret life style of this species. These data gave information on the one hand about the reproduction of the wildcats. On the other hand, Schauenberg (1977) tried to differentiate the wildcat from the domestic cat on anatomical basis.

Field observations could be carried out after the appearance of radio-telemetry. Corbett (1979) in Scotland, Artois (1985) and Stahl et al. (1988) in France investigated the home range of the wildcats in field studies. There were some other telemetry project after them, but the observations were done in few places with few individuals.

On the other hand, laboratory investigations began to explore the hybridization between the wildcats and domestic cats with new genetic techniques.

The wildcat is one of the most endangered carnivore species of Europe (McOrist and Kitchener 1994). This statement is supported by the fact that the Council of Europe made overall reviews about the situation of only two species (lynx and European mink) prior to wildcats. After this in 1992 the Seminar on the Biology and Conservation of the Wildcat (Felis silvestris) was held in Nancy. The participants tried to assess the recent area of the wildcat, the importance of hybridization and the threatened status of the species on the basis of the results of the European researches.

Stahl and Artois (1994) evaluated the recent situation of the wildcat on the basis of the results of the seminar. The major problems were the loss and fragmentation of habitat (cutting of natural forests and monoculture afforestation), the fragmentation of populations linked to habitat alteration, hybridization with the domestic cats, illegal hunting, road kills due to increased traffic and diseases transmitted by domestic cats. The authors suggested:

- to monitor the area and demographic changes of the populations;
- to investigate the effect of the hybridization;
- to map and to protect the potential habitats;
- to suppress the illegal hunting;
- to protect the small, isolated populations and probably the population-substitution of them;
- the extensive researches.

All of these are important, because the wildcat is not a priority taxon in the European research applications (e.g. LIFE Nature) even at the recent time, in spite of the above facts and of the fact that the wildcat is one of animal species of community interest in need of strict protection in the Annex IV. of the Council Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora [92/43/EEC (21.V.1992.)] and in the Appendix II. of the Bern Convention. The researches can establish the stricter, more extensive, even European-level coordinated protection of the taxon.

The domestic cats can cause especially serious problems from the point of the survival of wildcats, because they are widely distributed and these animals use the resources of the human settlements too. Beside the hybridization, this species could be a competitor for the wildcats (Corbett 1979, Hubbard et al. 1992, Clarke and Pacin 2002) and they can transfer diseases to the wildcats (Clarke and Pacin 2002). That is why, it is very important to estimate the effect of domestic cats on the wildcat populations in different habitats taking into account all of the possible standpoints. Thus the protection/management of wildcat population can be sat on the adequate basis.

The wildcat has been protected in Hungary since 1974. It is listed among the currently endangered species in the Red Data Book (Rakonczay 1989). Despite this the investigations about the situation of the wildcat managed by László Szemethy only began in 1987 at the Department of Wildlife Biology and Management of St. Stephen University (formerly Game Biology Research and Education Station). This research group began to study the spatial distribution of wildcats and domestic cats and the intogressive hybridization between them in 1991. Having joined this project I could examine the home ranges and the habitat preferences of these species and the overlaps of their home ranges. From 1997 I could also investigate in cooperation with other researchers the reproduction, the body-condition and diet of the two species in the National Monitoring Program of Carnivores. The same program provided me with the opportunity to study the hybridization of domestic and wildcats based on genetic markers. Beside these projects, I participated in the evaluation of area-mapping and demographic changes based on mail questionnaire surveys. Heltai (2002) reviewed the changes of wildcat population in country-level, which drew attention to the worsening situation of the wildcat and to the deficiencies of the research programs and the protection.

1.2. Purposes

The basic aim of the dissertation is the assessment of the impact of domestic cats on wildcats in natural habitats, thus:

- to estimate the mean size of yearly home ranges;
- to assess the mean overlap of the home ranges of the two taxa;
- to determine the habitat preferences of both taxa;
- to define the diet compositions of the two taxa and that of their hybrids and the diet overlap between wildcats, domestic cats and their hybrids;
- to assess the degree of hybridization in Hungary;
- to evaluate the general size of the area surrounding human settlements that is effected by ranging domestic cats and to prepare a potentially domestic cat-free distribution map of wildcats in Hungary;
- to address management implications.

2. MATERIAL AND METHODS

2.1. Study area

Our study wildcats were radio-tracked in the field site of the Department of Wildlife Biology and Management of St. Stephen University in Babat, which is located 3 km northeast of the city between 1990 and 1993. This nearly 2000 ha large area is a part of the Gödöllő-hills. The altitude is between 130 and 450 m a.s.l. This site is a traditional habitat of the wildcats, and permanent part of the wildcat area (Szemethy 1989). The formerly large population has already decreased (Szemethy and Heltai 1996), although considering the features of the given area - extensive forests, human interference is localized to small parts of the area - it is a suitable habitat for the wildcats. However, the area strongly worsened by this time due to the clear-cuts and to the human invasion.

2.2. Capture, immobilization, marking

The animals were caught with box-traps. The traps were checked in the morning every day. Hellabrunn-mixture diluted 2.5x in a dose of 0.06 ml/body weight (kg) (Wiesner and Hegel 1985) was used for immobilization at first. Later a new tranquillizer (Xilazin HCl:Ketamin HCl=2:5) was used in a dose of 0,1 ml/body weight (kg). A total of 16 wildcats and 19 domestic cats were captured during 13759 trap nights. The animals were marked with radio-collars.

2.3. Radiotelemetry

Two methods were used to localize the animals:

1./ Direct tracking:

We track the animals until we saw them without disturbance or we localized them from two different places during a short time period. The point at which these bearings intersect on the map gives the localization of the animal (Amlaner and Macdonald 1980). The fixes were marked on a 1:10000 scale map, which gives immediately the coordinates of the localization. The date, time, the activity of animal and the quality of the radio signal were recorded. The changes of signal strength indicate the activity. If the signal did not change, we assume that the individual did not move. The advantages of this method are the more precise localization and the observer can get an idea about the animal and its environment. However, it requires a lot of time and work and the researcher can easily disturb the animal.

2./ Tracking from towers:

We used the topographic triangulation method. The direction of the signal was determined from two different towers with protactor at the same time. The zero point of the bevel was given by the signal of a transmitter with known coordinates. The directions of the individual radio-collars were compared with this zero point. The bearings from the two towers measured at the same time determined the localization of the animal. The two towers have known coordinates, of course. The researchers do not get direct information about the animal and the localization is less precise, but the animals are not disturbed and the measuring is more effective. The mean precision of this method was a 0,1 ha error polygon.

2.4. Home range estimation

The home ranges were estimated by two methods on the basis of the localizations, using the software Tracker 1.1. (Camponotus AB, Sweden). The convex polygon method (White and Garrott 1990) connects the outermost points. The 10 % extreme points were not taken into account in the case of the 90 % convex polygon. It is widely used, most of the authors give the home range size by this method, because it is very simple and it can be compared with the literature. However, it may include large unused areas. The Kernel-method (Worton 1989), which assesses the home range on the basis of point density, is more accurate. The core areas were estimated also by the Kernel-method, but at the 60 % level. The overlaps between the home ranges (90 % Kernel method) and between the core areas calculated using the software Tracker, afterwards these areas were compared to the whole territory of the two animals:

overlap % = 100*area of the overlap/(area of one animal + area of the other animal – area of the overlap).

The home range fidelity was calculated in the same way, but in this case the home ranges of one animal from two different years were used.

2.5. Habitat preference

The habitats of the study area were classified into 11 categories. The relative frequency of these areas was estimated using 3700 random points. The distributions of the localization and the random points were compared by Π^2 test. The habitat preferences were calculated using Ivlev's electivity index (Ivlev 1961) for all habitats:

$$\mathbf{P_x=A-B/A+B}$$

where: **A**= relative frequency of the localizations of an animal in a given habitat;
B= relative frequency of the random points in the same habitat;
$\mathbf{P_x}$= habitat preference (from +1 to -1).

The same indices were calculated for the edges of habitats (100 m buffer zone) and for the human disturbed areas. Bonferroni-intervals were used to test the accuracy of the preferences (Byers et al. 1984):

$$\mathbf{p_i-Z_{\forall/2k}/p_i(1-p_i)/n\#p_{i0}\#p_i+Z_{\forall/2k}/p_i(1-p_i)/n}$$

where: p_i= the relative frequency of occurrence of the cats in each habitats;
$\forall$= significance level (0,05);
k= number of habitats;
$Z_{\forall/2k}$= the upper standard normal table value corresponding to a probability tail area of $\alpha/2k$,
n= the total number of cat localizations;
p_{i0}= the theoretical relative frequency of occurrence in each habitats.

If the p_{i0} falls in the calculated interval, then the difference is not significant, while if it is under the interval, then significant preference, or if it is above the interval, then significant avoidance can be stated.

2.6. Estimation of the potentially clear wildcat areas

The distribution area of the wildcats was assessed by Szemethy (1989), Szemethy and Heltai (1996) and Heltai (2002) using mail questionnaire surveys among the hunting estates between 1988 and 2001. The positive answers were summarized from each year on a map, using the software ArcView 3.1 (ESRI, USA). It gives the potential distribution area of the wildcats in Hungary. The distribution of the hybrids was represented in the same way.

The distance between the capture place and the home of a domestic cat (based on radiotelemetry) was measured on a 1:10000 scale map of the study area. There was a representative distance, till the domestic cats strayed from the human settlements.

The human settlements of Hungary was buffered with this typical distance of straying cats, and then the potential distribution map of wildcats was compared with this map and with the distribution map of the hybrids, using the software ArcInfo 3.5 (ESRI, USA).

The analysis used the Overlay module. The positive answers (tracks, scats, dens, used hollow trees, carcasses and sightings of living animals) were selected, afterwards the maps of each year were connected using the UNION command and the boundaries of these hunting estates were merged using the DISSOLVE command. The direct distance effect of the domestic cats from the settlements was estimated using the BUFFER command. The polygons of buffered areas and those of the occurrences of hybrid cats were intersected with the potential distribution map of the wildcats using the ERASECON command, and thus we get the map of the clear wildcat areas.

2.7. Assessment of reproduction rate and body condition

The samples were collected from the study areas of the National Monitoring Program of Carnivores (Szemethy and Heltai 2002). The domestic cats (236 specimen) were captured or hunted, the hybrids (25 specimen) and the wildcats (20 specimen) were found as carcasses. The reproduction rate of domestic cats and hybrids (83 domestic cat and 10 hybrid females) was estimated by counting placental scars. The nutritional condition was assessed by the kidney fat index (Harder and Kirkpatrick 1994). Only the reproduction rate of the hybrids and domestic cats could be compared using the Mann-Whitney U-test, because we had not got enough wildcat females. The body condition of the three groups was contrasted using the Kruskal-Wallis test.

2.8. Investigation of hybridization using genetic markers

The sample individuals were collected from the study areas of the National Monitoring Program of Carnivores. The sample sizes of each group in the Italian investigation were: 23 domestic cats, 17 hybrids and 6 wildcats. Walnut sized muscle and kidney tissues were collected and preserved in 96 % ethanol. The genetic examinations were carried out in the laboratory of the Istituto Nazionale per la Fauna Selvatica by Dr. Ettore Randi and Massimo Pierpaoli in Italy within the frameworks of a Europe-wide project about the wildcat hybridization. The method is reviewed shortly here the details are described by Pierpaoli et al. (2003).

Total DNA was extracted from tissues using guanidinium-silica (Gerloff et al. 1995). Twelve microsatellites, originally isolated in the domestic cat (Menotti-Raymond et al. 1999), were amplified by polymerase chain reaction and analysed using protocols described by Randi et al. (2001). The exact classification of the cat samples was carried out by factorial correspondence (FCA, Benzécri 1973) and Bayesian cluster analyses, using the software Structure (Pritchard et al. 2000).

2.9. Diet analysis

The sample individuals were collected from the study areas of the National Monitoring Program of Carnivores. The sample sizes were: 264 domestic cats, 30 hybrids and 22 wildcats, respectively. The feeding habit of the cats was investigated by analysis of stomach and faeces collected from the rectum at the Kaposvár University by Dr. József Lanszki. The method is reviewed shortly here the details are discussed by Lanszki (2002). The domestic cats were classified into three regional groups: Transdanubia, between the Danube and Tiscia and Transtiscia. Prey determination was performed on the basis of skull bones, dentition (Schmidt 1967, März 1972, Görner and Hackethal 1987, Újhelyi 1989) and hair characteristics (Debrot et al. 1982, Teerink 1991) in the case of mammals.

The determination was performed on the basis of feather and skull bones (Brown et al. 1993) in the case of the birds, scales and bones (Dely 1983) in the case of the reptiles, bones (Paunovic 1990) in the case of the amphibians, scales, skull bones and gullet teeth (Pintér 1989, Knollseisen 1996) in the case of the fishes. Invertebrates were identified from their integuments (Móczár 1969). The plants, especially the corns were identified on the basis of the work of Soó and Kárpáti (1968).

To calculate diet composition and trophic niche overlap from the relative frequencies of diet taxa, the minimum number of food items identified from the stomachs and faeces were taken into account. The percentage relative frequency was calculated as follows:

100x(number of specimen of the given taxon)/(number of specimen of all taxa).

The following food taxa were used: small mammals; hares; carcasses; birds; domestic animals; other vertebrates; invertebrates; plant matter.

Trophic niche breadth was calculated in accordance with Levins (Krebs 1989): $B = 1/\sum p_i^2$, where p_i = the relative frequency of occurrence of the *i*th taxon; and standardized across food taxa: $B_A = (B-1)/(n-1)$, rating from 0 to 1. To study the possible trophic competition between cat groups, niche overlap estimation was applied. Niche overlap was calculated by means of the Renkonen index (Krebs 1989) $[P_{jk} = [\Sigma n(\text{minimum } p_{ij}, p_{ik})]x100]$, where P_{jk} = percentage overlap between two cat groups (*j* and *k*); p_{ij} and p_{ik} = proportion accounted for by the *i*th food taxon (i.e., resource) in the diet of the cat *j* and *k* group (the minimum means that the smaller value should be used); n = the number of food taxa (of the eight categories listed above).

Distribution of prey body weight in the diet of cats was determined in accordance with Clevenger (1993): < 15 g; 15-50 g; 51-100 g; 101-300 g; > 300 g. Prey classification on the basis of zonation (characteristic level of occurrence or the physical stratification where a species is most active) was performed according to Gittleman's published data on predators (1985) (1: terrestrial and terrestrial but sometimes arboreal, 2: arboreal and arboreal but sometimes terrestrial, and 3: aquatic). Prey species were classified on the basis of their typical environment associations (1: human-linked, 2: wild, and 3: mixed). Household food was not listed in the group, only the prey.

Hierarchical cluster analysis (UPGMA method) was used with Pearson correlation and Euclidean distance to compare data of diet composition recorded at different cat groups. The χ^2 test was applied for distribution analysis of the diet composition; prey consumption on the basis of weight, zonation and environment association of prey of the different cat groups. SPSS (Green et al. 1997) statistic program was used for processing data.

3. RESULTS

3.1. Home range size, overlap between the home ranges and home range fidelity

The mean home range size of the male wildcats was 515 ha, while that of the females 397.7 ha. The size of their core areas were 132.86 ha and 59.62 ha, respectively. The mean size of the home range of male domestic cats was 131.8 ha, while that of the females 325.25 ha. The size of their core areas were 10.2 ha and 66.1 ha, respectively. Mici (female domestic cat) used larger area, than some of the female wildcats (Viki, Szerénke) or some of the male cats (Tom, Pukk). Her space use was similar to the wildcats. She lived far away from the human settlements and she occupied Tom's former home range partly from Viki. The overlap between the home ranges of males was the most extent (21.05 %). The overlap was 15.23 % between males and females, while it was 6.66 % between females. The female wildcats seemed to exclude the male domestic cats from their home ranges (Lisa – Oriza: 0.05 %, Viki – Oriza: 3 % overlap). However, they respected the home ranges of female domestic cats. Lisa (wildcat) avoided the frequently used areas of Zsuzsi (domestic cat), and she occupied these territories, when Zsuzsi died. The overlap between the two core areas was only 1.2 % before Zsuzsi died, and afterwards it raised to 38 % of the total core area, but it was 82.1 % of the core areas of Zsuzsi. Thus Lisa occupied nearly the total area, which she avoided earlier.

The male wildcats crossed also the home ranges of female domestic cats during their roaming. The home ranges of Tom and Ábrahám overlapped significantly with the home range of Zsuzsi, although the core areas did not touch each other. This supports the idea that the males reached the area of Zsuzsi only during their roaming. Although the overlap considering the total home ranges was small, because the home ranges of the males were very large (Ábrahám – Zsuzsi: 2.83 %, Tom – Zsuzsi: 10.53 %), but this overlap was 42.1 and 56.7 % part of the area of Zsuzsi, respectively.

The core areas overlapped only in a small-scale. Thus the larger overlaps are due to the overlaps of the edges, and the central parts were used exclusively.

The home range fidelity was the least in the case of Ábrahám (27.36 % overlap), he changed his territory considering the small overlap between the core areas. The females had strong fidelity (51.15 % overlap) considering the large overlap of the core areas.

3.2. Habitat preference

Comparing the distribution of the localizations of the cats with that of the random points significant difference could be demonstrated. The wildcats preferred the pine and oak forests, the shrubs and the meadows. They avoided the locust and alder forests. The wildcats avoided also the human disturbed areas, like the cultivated fields, gardens and human settlements. However, in this latter case the avoidance was not significant.

The domestic cats used randomly the pine and oak forests and the bushes. They also avoided the locust forests, but preferred the alder patch. Moreover they also preferred significantly the meadows. Some parts of the disturbed areas – the cultivated fields and gardens – were avoided also by the domestic cats, but the human settlements were preferred.

The wildcats seemed to have more localization in the edges of the open and closed habitats. The distribution of wildcat localizations differed significantly from the random, and they preferred the 50 m wide edge habitats, while avoided the inner parts. The domestic cats did not show significant preference for this habitat.

3.3. The potentially clear wildcat areas

The free-ranging domestic cats can diverge from human settlements as far as 2 km. The potentially clear wildcat areas based on the map of human settlements of Hungary buffered with this distance are the inner, undisturbed forests of the Northern and the Transdanubian Middle-

Altitude Mountains, the forests of Somogy-hills and the floodplain of Dráva, Tiscia and Körös rivers. Similar areas were traced out the intersection map of the distribution of hybrids and wildcats. There may be some clear populations in the mountains, but we got larger areas in Somogy- and Zala-hills, while less clear habitats were in the Great Plain.

3.4. Estimation of reproduction rate and body condition

The reproduction rate of the domestic cats was larger, than that of the hybrids. The mean nutritional condition of the three groups did not differ.

4.5. Hybridization

The Bayesian cluster analysis classified the cat samples into 6 categories. The first three groups were the wildcats, the 4th group was the hybrids, the 5th group was the African wildcats (*Felis silvestris lybica*) and the 6th group was the domestic cats. Our domestic cats were assigned to the 6th group squarely, but the wildcats were ranked only partially into the wildcat groups, they were classified in part as domestic cats, which showed the mixed genotypes. There were 12 admixed individuals, which could not be assigned exclusively to the domestic or to the wildcat clusters. The references were clear domestic cats and wildcats from Europe.

The concordance between the morphological and genetic identification was large in the case of domestic cats and hybrids (domestic cats in the 1st group 100 %, in the 2nd group 86 %, in the hybrid group 100 %). However, the wildcat classification was problematic (43 % concordance).

3.6. Feeding ecology

3.6.1. Diet composition, niche-breadth and niche-overlap

Small mammals formed dominant component of the diet of feral domestic cats. Hare was present in all of the regions but its amount was not significant. Although birds mean a secondarily important prey, the most favoured quarries from birds were the small perching birds, their occurrence was not frequent in the diet. Domestic animals were consumed rarely, and household food was found at low levels in the diet too.

The wildcat bases its diet also upon small mammals. The wildcat consumed most frequently lagomorphs. However, the second most heavily consumed item was birds, but it was more significant than in the case of the domestic cats. They preyed on mainly small perching birds. Carcasses were rarely in the diet of the wildcats (roe deer – 1 case), but domestic animals and household food were not found in their diet.

The primarily important component of the diet of hybrids was also small mammals. Lagomorphs were present more frequently in the diet than in that of feral domestic cats. The second most heavily consumed item was birds (mainly small perching birds and pheasant), but their consumption was already significant percentage. Domestic animals (poultry) and carcasses (roe deer) were found in 1-1 case.

Plant material, essentially of the grass family was consumed by each group, but grape, pear and vegetables also occurred in the diet of the domestic cats.

The wildcats and the hybrids assigned to one cluster, while the domestic cats formed another group, even this group could be divided into subgroups.

Hybrid cat has the broadest standardized trophic niche (B_A = 0.21), occurring 14 different prey and 2 plant taxa. Breadth of niche was dependent on different regions (Transdanubia: B_A = 0.16, between Danube and Tiscia: B_A = 0.07 and Transtiscia: B_A = 0.19) in the case of feral domestic cat, having the narrowest trophic niche in general (B_A = 0.11). In its diet 28 prey and 4 plant taxa occurred. Trophic niche breadth of wildcat (B_A = 0.13) can be found between hybrid and feral domestic cat, consuming 11 prey and 1 plant taxa. Each group can be described with a relatively narrow trophic niche.

Trophic niche overlap between wild and hybrid cat was high, 83%. Trophic niche overlap between wild and feral domestic cat was medium high, 77% for all the feral domestic cat groups examined, and 73% in the case of Transtiscian group (examining in the same habitat). Similarly, medium high trophic niche overlap was found between the hybrid cat and feral domestic cat, 79% for all the feral domestic cat groups examined, and 70% in the case of Transtiscian group (examining in the same habitat).

3.6.2. Characteristics of prey items (weight, zonation, environment association)

Among the cats examined in the diet of the smallest feral domestic cat (2.98 ± 0.06 kg, mean ± S.E.; n = 258 measured) occurred more frequently prey with a smaller size (smaller than 50 g), while the bigger wildcat (4.97 ± 0.49 kg; n = 9) and hybrid cat (4.44 ± 0.15 kg; n = 30) more frequently consumed larger preys (larger than 300 g)

Preys of feral domestic cats more frequently belonged to the group of terrestrial animals, while hybrids and wildcats often consumed arboreal preys.

All of the cat groups preyed mainly (more than 70%) on wild animals. In the diet of wildcat prey associated with human settlements did not occurred, also occurred rarely in the diet of hybrid cat (1 chicken), while it was responsible for one fifth of prey in the diet of feral domestic cats.

The wildcats and the hybrids ranked to one class, while the domestic cats formed another group on the basis of the characteristics of prey items.

3.7. New scientific results

Based on the data evaluated, the following new scientific results have been achieved:

1. I estimated the home range size of the wildcats (Felis silvestris) and domestic cats (Felis silvestris f. catus) – male wildcats: 515 ha, females: 397.7 ha; male domestic cats: 131.8 ha, females: 325.25 ha, and the size of the core areas (male wildcats: 132.86 ha, females: 59.62 ha; male domestic cats: 10.2 ha, females: 66.1 ha) in a typical wildcat habitat. I assessed the overlaps between the home ranges (male-male: 21.05%, male-female: 15.23%, female-female: 6.66%) and the home range fidelity (males: 27.36%, females: 51.15%) for each sex. I stated the wildcats do not exclude the domestic cats from their home ranges. The domestic cats able to immigrate into the wildcat population in natural habitats. On the other hand, male wildcats may visit the free-ranging female domestic cats during the reproduction period.

2. I defined the potentially “clear” wildcat areas in Hungary. Potential wildcat reserves can be traced out on the basis of this map and other former results.

3. I determined the habitat preferences of wildcats and domestic cats. The wildcats prefer the thick forests (pine, oak) and the shrubs neighbouring open meadows. The domestic cats prefer the human settlements, the open meadows and other habitats with rich food supply.

4. I proved the hybridization between the wildcats and domestic cats in Hungary. This phenomenon can be shown even in the potentially clear wildcat areas (floodplain forests of Tiscia River).

5. I estimated the diet composition, trophic niche-breadth (wildcats: B_A=0.13, domestic cats: B_A=0.11, hybrids: B_A=0.21), niche-overlap (wildcat-domestic cat: 77%, wildcat-hybrid: 83%, domestic cat-hybrid: 79%) of the wildcats, feral domestic cats and their hybrids. I

described the characteristics of the prey items based on their weight, zonation and environment association. I stated trophic overlap between the wildcats and domestic cats based on these results.

4. DISCUSSION AND PROPOSALS

The home range size of the male wildcats in our study area was similar to the French (Stahl et al. 1988, Artois 1985) and West-Scottish (Daniels et al. 2001) results, while it was smaller in East-Scotland (Corbett 1979), and larger in Switzerland Liberek (1996), or in West-Scotland (Scott et al. 1993). The home range size of the females was the same according to other researchers. The home range sizes of the wildcats in our study site were further from Corbett's results (1979), because the diet of the wildcats in Hungary contained mainly small mammals, contrary to East-Scotland, where the main prey item was rabbits. According to the other authors, the home range size differed between the sexes. Tom's home range size was in accordance with that of Corbett's resident individuals (1979). These animals were dominant. Tom was probably dominant over Ábrahám based on their movement pattern (Biró et al. in press). Lisa had larger home range, than that of the males in general. She wandered some times across the M3 motorway from her regular area. Similar phenomenon was found by Liberg and Sandell (1988) in the case of female domestic cats.

There was a frequently used part of the home range (core area), from where the owner excluded other cats (territoriality, see Corbett 1979). The females guarded their home range from each other more strictly, than from the males. It appears that our cats exhibited a pattern of intrasexual territoriality displayed by other asocial felids (Kleimann and Eisenberg 1973, Ferreras et al. 1997, Stander et al. 1997). The males were more tolerant. They used their home ranges not only in space, but also in time (Corbett 1979, Daniels et al. 2001). According to Daniels et al. (2001) the home range fidelity of females was stronger.

The domestic cats used smaller areas, than the wildcats, as it was found in East-Scotland (Corbett 1979). Oriza and Pukk (males) had larger home ranges, than Zsuzsi, however, Mici had the largest area (Biró et al., in press). It can be explained on the one hand by the density and distribution of females (Turner and Mertens 1986, Weber and Dailly 1998), on the other hand Mici was a feral individual and not a straying cat. Apps (1986) in South Africa, Liberg (1980) in Sweden, and Turner and Mertens (1986) in Switzerland found similar home range sizes. These cats were mainly farm cats, except in the Dassen-island (Apps 1986). These animals do not require such a large home range, than the wildcats, because they are smaller and they can use also the food resources of the human settlements (Liberg and Sandell 1988). There was not such a hierarchic system among the females in Babat, like in Sweden (Liberg 1980), or in Switzerland (Turner and Mertens 1986), because the density of the domestic cat population was low, however, the food resources were abundant and concentrated (see the goose farm). That is why these domestic cats were solitary, like the wildcats.

However, Mici had such a home range in size, like the wildcats, even larger in some case, and it got wedged in the home ranges of the wildcats. Liberg (1980) in Sweden, Jones and Coman (1982) in Australia, and Konecny (1983) in the Galapagos-islands found similar home range sizes in the case of feral domestic cats. It supports the idea that the domestic cats can survive in natural habitats without human aid. However, they can use the resources of human settlements. The feral domestic cats adapt to the social system and behaviour of the wildcats, increasing the risk of hybridization and the population fragmentation. The risk of hybridization increases also with the low wildcat population density, because the male wildcats visit the female domestic cats under such circumstances, even in the human settlements (Corbett 1979, French et al. 1988).

According to Raimer and Schneider (1983), Artois (1985), Stahl et al. (1988), and Corbett (1979), the wildcats preferred the thick forests (deciduous and evergreen) and the shrubs for hiding and resting, but they used the open meadows for hunting (Biró et al. in press). The significant preference for the edge habitats supports this idea, because they occupy this borderland, thus they can change between the open and closed habitats easily. They avoided the human settlements. The wildcats do not like the human disturbance. According to Genovesi and Boitani (1993) and Stahl et al. (1988), the wildcats are active only at night in disturbed areas, while they are active also daylight in other places.

The domestic cats preferred the human settlements, because three of our four cats lived close to the human settlements. According to Jones and Coman (1982), Fitzgerald and Karl (1986), and Daniels et al. (2001), the feral domestic cats use similar habitats, like the wildcats. It might be true in the case of Mici in our study site, because she occupied the former home range of Tom. Moreover the domestic cats also preferred the open meadows, where they could hunt. Our diet analysis of feral domestic cats supports this idea, because the main prey item was the common vole. According to Liberg (1984), even those domestic cats hunt, which live in farms and eat mainly household food. The free-ranging domestic cats preferred the areas with high prey density, like the alder patch in Babat, or the sand dunes in East-Scotland (Corbett 1979), where the rabbits lived.

Considering the wandering distance of free-ranging domestic cats, there are just a few potentially “clear” wildcat areas in Hungary, where they can find their preferred habitats (undisturbed thickets with neighbouring open meadows). If we take into account the feral cats, the situation worsens. These animals are independent from the human settlements, and their home ranges can get wedged in the home ranges of the wildcats, which may fragment the wildcat population. The wildcats, the domestic cats and their hybrids can be certainly classified using genetic markers, while it was doubtful using morphologic marks. The admixed Hungarian samples support the statement of Stahl and Artois 1994, that the hybridization is one of the most important threat for the wildcat populations (Pierpaoli et al., 2003). The weak concordance between the genetic and morphologic identification of wildcats means a serious problem for the experts, who wants to protect the wildcat against the domestic cats. Especially, the feral domestic cats may have tabby pelage and they behave like a wildcat in natural habitats (Daniels et al. 2001). A national genetic/distribution database has to be established and operated based on the certain genetic identification. It should contain the trapped and classified individuals (from blood samples). According to Daniels et al. (2001), where the wildcat density is high and the occurrence of hybrids and domestic cats is scarce, wildcat reserves can be established strictly preventing the immigration of these two latter groups. Strong live-trapping is needed in the potential habitats. On the other hand, the trapped animals can be identified. The wildcats with clear genotype can breed in captivity and the new individuals can be used for population substitution later (Nowell and Jackson 1996).

The diet composition of the wildcats in Hungary was close to the results of Condé et al. 1972, Hewson 1983, Kožená 1990, Fernandes 1993 and Tryjanowski et al. 2002, where the rabbit density was low. The small mammals, especially the voles were the main prey item. The second most heavily consumed item was birds, mainly small perching birds. Consumption of carcasses was scarce similarly to the results of Hewson (1983), or Tryjanowski et al. (2002). The relative frequency of plant matter was not so high, than in the study of Kožená (1990) in Slovakia. The wildcat did not eat domestic animals or household food.

The small mammals, especially the voles dominated the diet of the feral domestic cats too, but it contained also domestic animals and household food, thus also these feral cats use the resources of the human settlements (Fitzgerald 1988). Heidemann and Vauk (1970), Heidemann (1973), and Spittler (1978) got similar results from the stomach contents of feral cats in Germany. Liberg (1980) found, that even the farm cats, which only sometimes straying, changed to more extent hunting, if a prey species appeared in their areas in high density. Spittler (1978) found a positive relationship between the distance from the human settlement and the consumption rate of natural prey items. It meant mainly small mammals, but if this resource became limited, they could eat birds in a larger proportion (Heidemann and Vauk 1970). Thus the domestic cats can compete with the wildcats for the natural food resources. Because the domestic cats can use the resources of the human settlement too, they may have advantage during a period of food scarcity.

The diet of the hybrids was similar to that of the wildcats, and they did not eat domestic animals and household food. They were also closer to the wildcats, than to the domestic cats based on the characteristics of the prey items. The wildcats and the hybrids formed one group and the domestic cats another cluster based on the diet composition, the weight, zonation and environment association of the prey. However, there were similarities between the two groups and there were variances also among the domestic cats in different regions of the country. The diet of the domestic cats is more variable, and they use more diverse resources, than the wildcats. However, the trophic niche overlaps were medium high (70-80 %) between the wildcats and the domestic cats referring to a possible trophic competition between them. The domestic cat, which occurs in higher density, may be a serious competitor for the wildcat during a period of food scarcity or in areas with limited food resources (Corbett 1979, Daniels et al. 2001). It can increase mainly the mortality of juveniles. It is especially dangerous, because the wildcats breed rarer, and thus they may have fewer kittens in a year, than the domestic cats. On the other hand, the domestic cats are as successful as the wildcats in the natural habitats in the hunting and in the surviving. The similar body condition of the cat groups proves this statement. It shows the strong competitive capacity of the domestic cats. The domestic cat population increases more rapidly, than the wildcat population due to their higher increment rate, and decreasing the survival chances of the wildcats the domestic cats can be the winner of the competition. Moreover the wildcats are food specialist. Our results are in concordance with those of Liberg (1984), or Fitzgerald (1988), who found the domestic cats mainly generalists and opportunists were, while the wildcats although could eat many kinds of prey items, but they were selective predator in a given habitat (Gil-Sánchez et al. 1999). The wildcats cannot find alternative prey so easily, like the domestic cats.

Summarizing these facts we can conclude, that the domestic cats are really significant threatening factor for the wildcat population also in Hungary:

- The increment rate of the domestic cat population is higher, because they can breed several times in a year, thus they have more kittens, and so they may have quantitative advantage.
- The domestic cats use the same habitats in natural areas, like the wildcats. They can get wedged in the social system of the wildcats, fragmenting the wildcat population. Direct competition for the territories can be established.
- The wildcats, which occur in lower population density meat the domestic cats more frequently during the reproduction period, increasing the risk of hybridization. Especially, if there are many feral cats live among the home ranges of wildcats, because the males will not roam great distances to the female wildcats in this case.
- There may be trophic competition between them due to the similar diet composition. The domestic cats are in advantage in this competition, because they can use the resources of human settlements. Thus the domestic cats have probably better reproduction rate and better survival rate.
- The lethal diseases transferred the domestic cats to the wildcats worsen this situation.

Because of these threatening factors and because of the continuous decrease of the Hungarian wildcat population (Heltai 2002) we propose the following nature protection, wildlife management, and animal health–care implications in order to preserve the wildcats:

1. Establishment of wildcat reserves in those potentially „clear” areas where human settlements and thus domestic cats are farther than 2 km and where no hybrids were detected. Moreover preferred wildcat habitats (undisturbed thickets with open meadows) need special attention inside these areas. These reserves cannot be smaller, than 100 km^2 (Stahl and Artois 1994).
2. Intensive live-trapping have to be carried out in these areas to catch domestic cats, and to prevent their immigration. The trapped wildcats can be genetically classified using blood samples. The animals have to be ear-tagged in order to follow their survival. Daniels et al. (2001) suggested similar solution in Scotland.
3. Some of these „clear” wildcats can breed in captivity for subsequent population substitution (Nowell and Jackson 1996). Moreover a sperm bank can be established for latter breeding projects.
4. The trapped domestic cats have to be eradicated from the reserves. The number of domestic cats per household has to be limited at neighbouring human settlements (3-5 km), and these

cats have to be sterilized. The people living in these areas will more likely accept the neutering than the removal (Ash and Adams 2003). However, the neutering programs alone have low efficiency (Castillo and Clarke 2003), and do not prevent the immigration of domestic cats to the natural habitats, the trophic competition nor the transmission of diseases. That is why, the strict protection of wildcat reserves from the immigration of domestic cats is crucial for the survival of the wildcat population in Hungary.

5. Beside of these programs we have to improve nature-like forest management and we have to decrease human disturbance (e.g. forest clear–cuts). The traffic system has to be developed so that roads do not cross the protected areas or if they do several bio-bridges have to be built over the road to protect the animals from the ever increasing traffic (Stahl and Artois 1994).

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