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Main versus alternative prey of Eurasian otters in an East-European artificial wetland system

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Abstract. The dietary composition of the Eurasian otter (*Lutra lutra*) inhabiting an artificial wetland system, used for aquaculture, was studied over a two-year period in north-eastern Hungary using spraint analyses. Samples were collected on monthly basis along a standard line transect. The main component of the diet was fish, followed by amphibians, birds, insects, mammals, molluscs and reptiles. Except for mammals, we did not find any significant seasonal variation in the composition of prey. Birds were mostly preferred in the first period of the study years, while mammals were dominant in the second one. Most insects were preyed upon in spring, similar to the case of amphibians. Otters did not show any seasonal variation in their trophic niche, most likely due to stable food resource, and the niche breadth was similar between wetland units. The preference for various fish species varied significantly by weight category between fishponds. However, independent of weight and pond categories, pike (*Esox lucius*) was consistently preferred, similar to carp species (*Carassius sp.*) of smaller body mass. Further, we investigated the ratio of economically important fish species against hibernating species by analysing spraints from winter months. We found that, the ratio of economically important species was high; suggesting an optimisation of subsidies for fish-farming.

Key words: diet composition; fishpond; Hungary; *Lutra lutra*; spraint analysis.

Introduction

The Eurasian otter (*Lutra lutra*) is well adapted to a wide range of wetland habitats including ponds, rivers and marine areas, and has a wide distribution range, covering most of Europe, Asia and North-Africa. The species suffered a rapid decline in numbers in the second half of the 20th century due to intensive hunting (Almeida et al. 2012). However, after obtaining status of "strictly protected species of common interest" (Council of the European Community, 1992), the persecution and killing of otters were prohibited and populations started to show a slow recovery. Currently, the species is listed as *Near Threatened* by the 2004 IUCN Red List (Baillie 2004).

Populations in Hungary and other central European countries are stable with some smaller, locally increasing populations (Gera 2007). The Eurasian otter has been protected in Hungary since 1974 and became strictly protected in 1978. Its occurrence depends on food availability, habitat types, degree of human disturbance and other environmental factors, e.g. bankside, water depth and water quality (Kemenes & Demeter 1995). Local population declines may be caused by the degradation of natural wetlands, disappearance of fishponds, illegal hunting and the increasing number of road kills (Mason & MacDonald 2004). In Hungary, otters occupy various types of wetlands with the largest population densities to be observed in fishponds, water reservoirs and backwaters (Gera 2007). The first distribution survey was carried out by Kemenes in 1987-88 (Kemenes 1991). Feeding behaviour of otters occupying fishponds and natural wetlands has been investigated through the application of spraint analyses (Kemenes & Nechay 1990, Lanszki et al. 2001).

Human-wildlife conflicts often arise between humans and large protected vertebrates when they compete for the same biological resources or when wildlife cause damage, especially in case of farmed resources (Kloskowski 1999, Opačak et al. 2004, Vaclavikova et al. 2011). In Hungary, the great cormorant (*Phalacrocorax carbo*) is the primary source of conflict within the aquaculture industry (Kranz 2000). Whereas, the importance of the otter is significantly smaller, especially in case of carp farming. As tense conflicts between nature protection and fish farming are often reported, there is a growing need to quantify the true impact of otters on fish farm resources by studying their feeding ecology (Kemenes & Nechay 1990, Carrs & Parkinson 1996, Sulkava 1996, Lanszki et al. 1999, Lanszki et al. 2001).

Several studies have shown that otter diet is dominated by fish, with considerable amounts of variation (Kemenes 1989, Harna 1993, Baltrūnaité 2006, Remonti et al. 2009, Remonti et al. 2010, Reid et al. 2013). For instance, it was found that in South-East Poland, the dietary composition of otters did not show any significant difference between seasons (Harna 1993). However, results of a Thai survey also indicated that only 37% of otter diet was composed of fish, with a similar consumption of crab (Kanchanasaka 1998). Similarly, extremely low ratio of fish remains were identified in samples by Tumanov & Smelov (1980). In another investigation, otter densities in coastal areas were primarily influenced by seasonal population density of alternative prey taxa (Kruuk et al. 1991). Conversely, a different study using indirect observation showed that otters in Shetland selected larger fish sizes (Kruuk & Moorhouse 1990).

As otters are a largely solitary and nocturnal species, their direct observation is generally impossible (Ruiz-Olmo et al. 2001). Consequently, most studies are based on indirect signs of otter presence, such as prey remains, footprints and most often, spraints (Webb 1976, Lanszki 2002, Lanszki & Molnár 2003, Remonti et al. 2011, Kean 2012). However, a limitation of spraint analysis is that often overestimates smaller taxa in the diet and underestimates the number of greater prey items (Lanszki 2002). In the present study, we had two aims: 1) to quantify the dietary composition, and its seasonal variations for otters inhabiting an artificial wetland system inside the largest alkaline steppe national park of Europe; and 2) to test the hypothesis that otters exhibit opportunistic feeding strategy (Reid et al. 2013). We achieved these aims by comparing the composition of spraints collected from fishpond systems with differing degrees of connectivity in moderate climatic conditions of Hungary**.**

Materials and methods

<u>Study area</u>

The study area is located in the central part of the Hortobágy National Park (HNP) and encompasses one of the most important Eurasian otter sites in Hungary. The national park is the largest alkaline steppe in Central Europe covering *ca.* 80000 hectares. Ramsar sites inside the National Park, considered as one of the most important water bird habitats in Europe, encompass 27000 hectares, including the central pond system of the study area. The HNP includes 75 fishponds amounting to 6000 hectares (Table 1.). These fishponds are surrounded by various kinds of habitats including marshes, meadows, grassland and farmlands. The whole area is almost all owned by the state and managed by the Hortobágy Fishfarm CC., applying highly extensive fish-farming technologies adapted to conservation. As the fishpond system is nearly a century old, the majority of the ponds are in different stages of succession into marshes, which explains the importance of the wetland system in maintaining an extremely rich wildlife (Ecsedi 2004). Accordingly, pond vegetation is characterised by reed (*Phragmites australis*), sea clubrush (*Bolboschoenus maritimus*), lesser reedmace (*Typha angustifolia*) and Laxmann's reedmace (*Typha laxmanni*), forming a highly seminatural habitat composition. Floating aquatic vegetation consists basically of water chestnut (*Trapa natans*), fringed water lily (*Nymphoides peltata*) and pondweed (*Potamogeton nodosus*), with sparse occurrences of water lily (*Nymphaea alba*) and yellow water lily (*Nuphar lutea*). Studied ponds are primarily interfered by road traffic at Akadémia, Borsós, Fényes and Gyökérkút and also affected by ecotourism, as well as reed harvesting. The area consists of habitats preferred by other species of conservation concern, such as common crane (*Grus grus*) and lesser white-fronted goose (*Anser erythropus*).

<u>Spraint collection</u>

The diet of otters was investigated applying spraint (faecal) analysis. Spraints were collected once a month, following a standard route reaching every fishpond system of the study area, from January 2005 to January 2007. During data collection 2873 kilometres were covered in 1300 hours (110 km were covered during each survey connecting 33 fishponds). We collected 987 spraints during the study period with the exception of February 2006 due to unfavourable weather conditions.

<u>Preparation of spraints</u>

Spraint analysis was carried out using standard methods recommended by Webb (1976). Accordingly, faecal material was collected in small individual bags, the contents of which were washed afterwards through a sieve of 0.5 mm mesh. In the next step samples were dried and broken up by hand and identifiable prey items were separated. Fish species were identified using a binocular microscope based on characteristic bones such as pharyngeal teeth, operculae, maxillaries, clavicle and scales (Lanszki & Sallai 2006). Prey species were identified using a personal reference collection made especially for this study (skeleton bones and scales) and according to the identification keys of previous studies (Berinkey 1966, Wise 1980, Pintér 1989, Knollseisen 1996, Hájková & Roche 2003). The minimum number of fish occurring in one sample was determined by counting characteristic bones (Lanszki and Körmendi 1996): cleithrum, pharyngeal teeth, opercu-

Table 1. Physical properties of fishpond-systems.

Name of fishpond- system	Abreviation	Number of ponds	Area size (ha)	Number of wintering ponds	Average water depth (m)
Hortobágy-Halastó	H	10	1720	40	0.6
Akadémia	A	4	110	20	1
Fényes	F	5	230	35	1.6
Gyökérkút	GY	6	385	20	1
Csécs	CS	7	583		1
Borsós	B	1	135		1.2

laria-bones, scapula, maxilla, etc. Amphibians and reptiles were also determined by characteristic bones such as ilea, frontoparietale bones (Böhme 1977, Knollseisen 1996). While avian prey species were identified using feather structure (Brown et al. 1993), the analysing of mammal remains was based on microscopic hair structure (Day 2009). In case of hair remains we excluded the presence of otter hair. Undigested integuments were used to distinguish molluscs and insects. Food remains were divided into the following groups: 1. fish, 2. amphibians, 3. reptiles, 4. birds, 5. mammals, 6. insects, 7. molluscs, 8. other taxa.

We considered fish species as economically valuable (pike *Esox lucius*, grasscarp *Ctenopharyngodon idella*, silver carp *Hypophthalmichthys molitrix,* carp *Cyprinus carpio,* tench *Tinca tinca,* pike-perch *Stizostedion lucioperca*) which were sold after harvesting. Hibernating species were classified based on fish farm data (Halasi-Kovács, Hortobágy, pers. comm. 2006).

Statistical analyses

During the analyses we addressed the following questions: (1) What are the otters' preferences for various prey taxa? (2) How is otter preference weighted between different fish species? (3) What preference is exhibited by otters for fish species of different economic value? (4) Do otters prefer hibernating fish? (5) What is the trophic niche-breadth of otters in our study area? To answer these questions, we applied the following proxies as response variables: we calculated Ivlev's preference index, described below, for (1) each taxa, (2) each fish species, (3) economically valuable fish species, and (4) hibernating fish. Lastly, we calculated (5) the trophic niche breadth, as described below.

First, the minimum number of individual fish in each sample was estimated to evaluate diet composition, trophic niche breadth and relative frequency of occurrence. Trophic niche breadth was calculated according to the methodology suggested by Levins (1968):

$B=1/\Sigma p_i^2$,

where p_i is the relative frequency of occurrence of the i^{th} taxon. Ivlev's index of preference for fish species was applied as follows:

$E_i=(r_i-n_i)/(r_i+n_i)$,

where E_i is Ivlev's preference index, r_i is the percentage frequency of occurrence of the given species in the diet, n_i is the percentage of occurrence frequency of the given species (Krebs 1989).

Secondly, we estimated the fish stock in ponds using data on fish harvests which were closest in time to the respective spraint survey (unpublished dataset of Hortobágy Fishfarm CC.). Fish weight was classified into the following five categories: (1) <50g; (2) 50 – 100g; (3) 100 – 500g; (4) 500 – 1000g; and (5) >1000g.

All data was analysed using bivariate tests with the exception of fish preference, as these were most appropriate given the sample sizes of our data. Since these response variables did not follow normal distribution, we conducted Kruskal-Wallis or Mann-Whitney's U-test depending on the number of grouping categories to assess differences between groups of categorical explanatory variables. In the case of fish preference, we fitted a linear mixed model to control for possible confounding factors such as spatial autocorrelation of the same individuals in the same fishpond system and the non-normality of response data. Accordingly, fishpond system was added as a random factor into the model. During the analyses we performed backward stepwise model selection removing factors with absolute t-values <2.00 (Crawley 2007). All statistical analyses were performed in the R programming environment (R Development Core Team 2009)

Results

Seasonal diet composition

In total, 987 spraints were collected, from which we identified 1552 different prey items. Although the diet was dominated by fish taxa in all seasons (Kruskal-Wallis test, $p<0.001$ for all seasons), the proportion of amphibians and birds, insects, mammals, molluscs and reptiles (ordered in abundance) was relatively high (Fig. 1.). While insects samples were dominated by great diving beetle (*Dytiscus marginalis*), birds were primarily represented by species belonging to *Passeriformes* and *Anatidae*. The single food item belonging to reptiles was a grass snake (*Natrix natrix*). Other food items included plant remains (*Graminae*), gravel and occasionally pieces of paper.

There was no seasonal variation in fish preference. Whereas, bird remains were found mostly in spring and summer samples (5.56%), and bones and hairs of mammals were more frequent in autumn and winter seasons (3.53%). Otter preference for insects was dominant in spring. In the case of

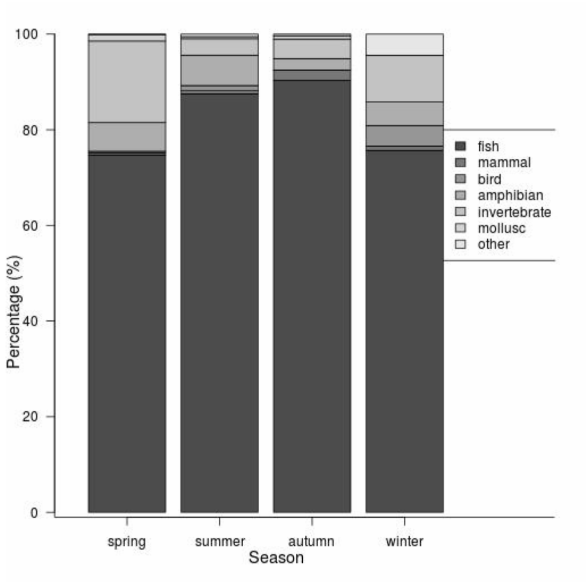

Figure 1. Seasonal diet composition of otters (*Lutra lutra*) in Hortobágy National Park, Hungary, inferred from 987 spraint samples collected monthly from around the fishponds between 2007-2009.

the Csécs fishpond system – as a singular occurrence – greater than 70% composition was found in January 2005. However, during the other months this ratio was less than 33%.

With the exception of mammals, we did not find any significant seasonal variation in the composition of these taxa (Kruskal-Wallis test, $p > 0.155$ for all cases). Although mammals consisted only a relatively small proportion of the diet (0.1-2%), the preference for this group significantly differed between seasons (Kruskal-Wallis chi-squared = 12.692, df = 3, $p < 0.001$, Table 2).

Trophic niche breadth

A broader spectrum of food sources for otters is accompanied by greater trophic niche breadth (Table 3). In this case, otters did not show any seasonal variance in trophic niche breadth related to fish dominance (Kruskal-Wallis-test, χ^2=5.897 df=3, p=0.117). The difference between pond systems was not significant (Kruskal-Wallis-test, χ^2=1.134 df=4, p=0.889, Table 2).

Fish preference

Although we found no difference in fish preference between fishpond systems (Kruskal-Wallis test, χ^2=3.778, df=4, p=0.437), weight category exhibited a significant effect (Kruskal-Wallis test, χ^2=78.6, df=28, p<0.001). Pike was consistently preferred (t=3.696) in every study area independent from weight categories. Similarly, carps (*Carassius sp.*) weighing less than 100g and between 100-500g were often preyed upon. Otters also consumed pike-perch weighing less than 1000g in large proportion (t=2.345). A strong fluctuation was observed for pike-perch preference between 500-1000 g and *Carassius sp.* between 100-500g. Interestingly, otters avoided common carp (t=-6.297) and silver carp between 50-100 and 500-1000 g (t=-4.516). Similarly, fish in weight categories 3, 4 and 5 were also not preferred.

The economical importance of fish species found in our samples is shown in Table 4. Economically important fish species were dominated by common carp, silver carp, tench and pike (Table 5.).

While the relative frequency of common carp belonging to the weight category 1 was high in winter and spring, Silver carp was found in winter and autumn most frequently. Remains of pike were present in large quantities in spraints. Otters primarily consumed pike-perch in summer and autumn, but the ratio of this species was lower than that of the previous species.

Discussion

One of the most important results of our study is that although otters primarily feed on fish in extensive fish-farms, the presence of alternative prey plays a decisive role in the diet selection of otters. This indicates the importance of applying extensive methodology in fish-farming in sustaining

Table 2. The presence of alternative prey taxa in diet of otters.
(A- Akadémia, B- Borsós, CS- Csécs, F- Fényes, GY- Gyökérkút, H- Hortobágy-Halastó)

		Prey taxa					
		fish	mammal	bird	amphibian	insect	mollusc
F/2005	spring	74.07	-	3.70	12.03	10.20	-
	summer	89.84	-	3.70	6.46	-	-
	autumn	94.74	3.50	-	1.76	-	-
	winter	89.70	-	1.40	2.36	5.13	-
F/2006	spring	90.40	-	-	3.93	5.66	-
	summer	85.86	-	-	10.43	3.70	-
	autumn	93.93	1.51	-	1.51	3.03	-
	winter	100.00	-	-	-	-	-
CS/2005	spring	24.10	-	-	5.00	70.80	-
	summer	86.36	2.25	-	6.80	2.25	-
	autumn	97.96	0.90	-	-	1.13	-
	winter	77.96	3.53	-	2.30	16.20	-
CS/2006	spring	83.35	5.55	-	-	5.55	5.55
	summer	85.00	-	-	8.33	6.66	-
	autumn	91.90	-	-	3.36	2.38	-
	winter	93.15	-	-	2.65	4.20	-
GY62005	spring	70.80	-	-	8.35	20.85	-
	summer	68.09	5.53	5.56	11.10	5.56	4.16
	autumn	90.00	3.33	-	3.33	-	3.34
	winter	36.70	-	50.00	5.00	6.65	-
GY/2006	spring	80.56	-	-	19.43	-	-
	summer	95.56	-	-	3.33	-	1.10
	autumn	83.03	1.85	-	4.41	8.83	1.88
	winter	84.21	5.26	-	5.26	5.26	-
H/2005	spring	67.25	-	-	10.83	10.13	10.73
	summer	91.66	-	-	3.03	1.35	-
	autumn	91.93	2.55	-	0.73	3.03	1.76
	winter	86.40	-	-	10.20	3.40	-
H/2006	spring	89.96	-	-	8.26	1.75	-
	summer	76.90	-	3.70	8.50	9.20	-
	autumn	82.06	1.40	0.50	2.25	13.75	-
	winter	94.60	-	-	4.05	1.35	-
A/2006	spring	82.95	-	-	4.15	12.90	-
	summer	69.45	-	-	18.05	12.50	-
	autumn	93.26	0.98	-	4.76	-	-
	winter	100.00	-	-	-	-	-
A/2006	spring	100.00	-	-	-	-	-
	summer	100.00	-	-	-	-	-
	autumn	84.50	5.10	-	1.76	8.60	-
	winter	95.45	2.27	-	2.27	-	-
B/2005	spring	66.66	-	-	-	33.30	-
	summer	100.00	-	-	-	-	-
	autumn	-	-	-	-	-	-
	winter	-	-	-	-	50.00	-
B/2006	spring	-	-	-	-	-	-
	summer	-	-	-	-	-	-
	autumn	-	-	-	-	-	-
	winter	50.00	-	-	25.00	25.00	-

otter populations.

Otters showed a wide trophic spectrum in the study area, consuming at least 18 fish species, aquatic invertebrates, birds, reptiles, amphibians and small mammals. In this work we demonstrated that fish consumption decreased during winter, while the importance of alternative prey taxa increased. This observation indicates that a wide variety of alternative food items might contribute to enhanced survival rates of young otters.

Table 3. Values of niche breadth for otters in HNP, as calculated from prey taxa (A- Akadémia, B- Borsós, CS- Csécs, F- Fényes, GY- Gyökérkút, H- Hortobágy-Halastó).

Month	B (niche breadth)				
	Study area				
	F	CS	GY	H	A
1	1.450	1.960	1.000	-	-
2	1.330	1.580	0.017	1.160	1.450
3	1.240	2.000	0.040	1.350	1.210
4	2.060	1.600	0.020	1.810	1.690
5	1.930			3.030	
6	1.580	1.740	0.037	1.330	2.270
7	1.170		0.013	1.160	
8	1.000	1.000	1.400	1.080	1.250
9	1.000	1.000	1.000	1.220	1.330
10	1.360	1.740	2.080	1.080	1.130
11	-	1.060	1.00	1.160	1.000
12	1.000	1.220	-	1.420	-
13	-		-	-	-
14	-	1.120	-	1.000	1.000
15	1.250		0.625	1.380	1.000
16	1.000	1.000	0.440	1.350	1.000
17	1.440	2.080	1.000	1.000	-
18	1.20	1.000	1.000	2.560	1.000
19	1.000	2.270	1.000	1.360	1.000
20	2.000	1.110	0.750	1.380	1.580
21	1.000	1.370	1.000	1.420	1.000
22	1.510	1.110	0.530	1.880	1.780
23	1.000	1.130	1.170	1.750	1.560
24	1.000	1.190	0.710	1.260	1.200

Table 4. Average rate (%) of economical important fish species in spraints.

Pond system	1.year	2.year
Fényes	63.17	47.63
Csécs	62.64	36.53
Halastó	48.30	49.84
Akadémia	43.27	32.48
Gyökérkút	52.63	48.61

Overall, fish was the dominant group in the otters' diet independent of area, season and year. This finding is in line with previous studies documenting that otter diet tends to follow the variation in the relative abundance of prey types (Kruuk 1995, Lanszki et al. 2000, Lanszki & Széles 2006, Remonti et al. 2010). Conversely, our result that seasonal differences in the proportion of mammals in the diet is small is in contrast with those of other investigations were mammal consumption was found to be predominant in summer (Sulkava 1996, Baltrünaité 2006, Lanszki & Sallai 2006).

Birds were preyed upon more frequently in the summer months, probably consisting of young individuals hatched in the breeding season, similar to the results of other studies (Kloskowski 1999, Baltrūnaité 2006, Lanszki & Sallai 2006). In the case of amphibians, our results show differences: in several areas more frequent occurrence was found in spring and in summer (Lanszki & Körmendi 1996, Lanszki & Molnár 2003, Baltrünaité 2006), while in other studies the winter season was preferred (Kloskowski 1999, Prigioni et al. 2006, Pagacz 2010) (Table 2.) These results can be associated with amphibian breeding season which has high intra-specific variation in timing. Sulkava (1996) has also indicated that amphibian breeding season is important for otters. Pagacz (2010) proposed that limited fish availability and hibernating period could explain seasonally high consumption of amphibians. Crustaceans are known as an additional food source for otter in Europe (Chanin 2003). In contrast to other studies we didn't find any crustacean remains (Lanszki & Molnár 2003, Georgiev & Stoycheva 2006, Prigioni et al. 2006, Preston et al. 2007). Otter predation on snakes was reported by Prigioni et al. (2006), mainly in summer. High levels of predation on insects have been noted during spring months compared to other seasons, independent of fishpond system and year. In previous studies, the remains of water beetles were identified mainly in samples of autumn and summer months (Lanszki & Körmendi 1996, Tarsoly 1999). Molluscs, reptiles and plant remains formed a minor component of collected spraints.

Niche breadth did not differ significantly between seasons. This is possibly due to easily accessible fish stocks all the year round and the vicinity of neighbouring pond systems and canals. It might further imply that, if habitat started to be become unfavourable (for example, as a result of drainage), animals did not have to shift to alternative prey taxa. During winter, the presence of wintering ponds ensures a stable food source for otters. Consequently, otters did not have to leave their territory to obtain food, as ice-free patches of water are always available even in harsh winter weather. Thus, the significant increase of diet spectrum breadth was not detectable in contrast to other studies (Lanszki & Molnár 2003). However, this index has almost doubled in spring because of increasing proportion of other prey taxa. This process paralleled the decline in fish availability, as reported by Lanszki & Körmendi (1996).

Preference for economically valuable fish species, independent from season and area,- was

Table 5. List of fish species of high (HE), indifferent (IE) and without economic (NE) value.

Fish species	Weight categories				
	<50g	50-100g	100-500g	500-1000g	>1000g
grass carp (*Ctenopharyngodon idella*)	HE	HE	HE	HE	HE
silver carp (*Hypophthalmichthys molitrix*)	HE	HE	HE	HE	HE
common carp (*Cyprinus carpio*)	HE	HE	HE	HE	HE
tench (*Tinca tinca*)	HE	HE	HE	HE	HE
common bream (*Abramis brama*)	IE	IE	IE	IE	IE
common rudd (*Scardinius erythrophthalmus*)	IE	IE	IE	IE	IE
Carassius sp.	NE	NE	NE	NE	NE
northern pike (Esox lucius)	HE	HE	HE	HE	HE
European perch (*Perca fluviatilis*)	NE	NE	NE	NE	NE
ruffe (*Gymnocephalus cernuus)*	NE	NE	NE	NE	NE
topmouth gudgeon (*Pseudorasbora parva)*	IE	IE	IE	IE	IE
asp (*Aspius aspius*)	IE	IE	IE	IE	IE
pike-perch (Stizostedion lucioperca)	HE	HE	HE	HE	HE
brown bullhead (*Ameiurus nebulosus*)	NE	NE	NE	NE	NE
pumpkinseed sunfish (Lepomis gibbosus)	NE	NE	NE	NE	NE
Sunbleak (Leucaspius delineatus)	IE	IE	IE	IE	IE
bleak (Alburnus alburnus)	IE	IE	IE	IE	IE

prominently high. This is likely due to the fact that otters living on extensive cultivated fishponds were studied where the proportion of economically valuable fish is significantly higher to those of natural water systems. Preference for pike is similar to the findings of other studies (Lanszki et al. 2001, Lanszki 2002, Lanszki & Sallai 2006). While Lanszki et al. (2001) showed that preference for small pike-perch was year-and area-dependent in fishponds, in Hortobágy, otters avoided pike-perch weighing more than 1000g because they are more difficult to capture. Remains of small-sized pike-perch were frequently found in spraints, however. Pike and prussian carp occurred in samples from all habitat types. The former species was included in the input in both years in all pond systems. Similar to other results, there was no indication of a preference neither for perch, pumpkinseed sunfish (*Lepomis gibbosus*), European catfish, tench nor for grass carp. Furthermore, otters did not consume common carp in large proportions, which has been observed in other carp-dominated areas in Central Europe (Kloskowski 1999, Lanszki et al. 2001, Lanszki & Sallai 2006). This is probably due to extensive fish farming technology in our area. Similar to the results of Lanszki and Körmendi (1996), common carp predation was present more frequently in winter and spring, but in our case only silver carp consumption was relatively high.

The results of otters' preference for hibernating species is an important issue for fish farming, as otters during hunting may disturb hibernating fish with slow metabolism. Therefore, the availability of alternative prey might decrease the chance of disturbing fish species during hibernation.

In Hungary, several factors limit the protection and future population increase of otters: destruction of habitats, increasing density of roads and poaching (Gera 2007). Presence and survival of this species basically depend on diet quality. In our case there is a further remarkable aspect: the study area is protected and at the same time fish farming is in operation on an extensive scale. Our results show that artificial fishponds also play an important role in providing otter habitats, although human-wildlife conflicts between the strictly protected otter and fish farmers are constant occurrences and may remain a concern.

As Hungarian laws do not permit compensation for damages attributed to otters, we recommend carrying out similar investigations promoting the elaboration of subsidies. In this way, effective otter conservation will involve cooperation between various ministries, fish farmers and conservation biologist. Our work provides substantial information on how to elaborate legislative tools for agri-environmental schemes which can help to support a self-sustainable otter population.

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