# Feeding habits of otters living on three moors in the Pannonian ecoregion (Hungary)

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Abstract. Diet composition and feeding habits of Eurasian otters (*Lutra lutra*) living on three moors (Baláta, Nagyberek and Fehérvíz) in Hungary were studied over two years using spraint analysis (n = 199, 503 and 315 samples from the three moors, respectively). The food and presence of otters in the first moderate and second drought year, when the moors dried during the summer period, generally differed. Area-dependent variations in the diet were also found. The primary food source was fish (biomass estimation for the first and second year: Baláta 94.4% and 99.9%; Nagyberek 93.9% and 71.5%; Fehérvíz 66.4% and 82.1%). Most fish (mean: 94.6–99.9%) were small-sized (below 100 g in weight), and the most frequently taken species was *Carassius* spp. On moors, which are dependent on rainfall and ground-water only, during or after periods of drought otters temporarily changed their diet from optimal prey (fish) to sub-optimal prey (e.g., waterfowl) and they often left the habitat entirely. On moors with small canals, during periods of drought otters kept fish as the dominant food source, and weathered out extreme environmental local conditions.

**Key words**: *Lutra lutra*, spraint analysis, diet, fish, drought period

## Introduction

The extent of native moors in the Carpathian basin has changed drastically over the last hundred years, declining to 3% in Hungary, mainly due to drainage (Borhidi & Sánta 1999, Kasza & Marián 2001), or drought periods characteristic to Mediterranean regions (Delibes et al. 2000, Ruiz-Olmo et al. 2001, Clavero et al. 2003). The Eurasian otter, *Lutra lutra* (Linnaeus, 1758) is the top mammal predator on moors, and its feeding habits relate to the habitat conditions (Erlinge 1967, Wise et al. 1981, Chanin 1985, Kruuk 1995). Diverse littoral vegetation, shallow and unpolluted water, and low human influences are favourable for the otter (Mason & Macdonald 1986, Kemenes & Demeter 1995, Kruuk 1995). Otters are able to utilize wide ranges of food resources (Jedrzejewska et al. 2001, Clavero et al. 2003); however fish is the main prey. The otter is food-limited (Carss 1995, Kruuk 1995), and availability of fish and habitat changes (Lanszki et al. 2001) may affect not only the feeding habits (Delibes et al. 2000, Ruiz-Olmo et al. 2001, Clavero et al. 2003), but also the presence of otters (Delibes et al. 2000, Ruiz-Olmo et al. 2002). The diet of otters living on drained marshes and moorland river habitats were studied in northern latitudes (Scandinavia: Erlinge 1967, Devon: Wise et al. 1981), but only during a winter and spring periods on a peat bog in Hungary (Kemenes & Nechay 1990). There is therefore a lack of information about the feeding habits of otters living on moors in Central Europe (Hungary). Unique natural features of these potentially threatened wetlands in the Pannonian ecoregion are floating isles, glacial relics, such as *Comarum palustre, Sphagnum* spp., *Thelypteris palustris*, *Microtus oeconomus*, or subtropical and Mediterranean species, e.g., *Caldesia parnassifolia,* insectivorous *Aldrovanda vesiculosa,* or endemic species, e.g., *Umbra krameri* (e.g., Borhidi & Sánta 1999, Kasza & Marián 2001).

The aim of this two-year study was to establish if there are any differences between the two years and between areas in diet composition, trophic niche breadth and relative spraint density of otters living on moors in a moderate climate, in Hungary.

## Study Areas

The three areas studied are located in SW Hungary and for the purposes of this study the term moor is used to mean a broad area of open land, often high but poorly drained, with patches of heath and peat.

The first moor is the strictly protected Baláta (or BM; 46º19' N, 17º12' E) surrounded by much oak (*Quercetum* communities) and alder swamp wood (*Dryopteridi-Alnetum typicus*). Within the moor there are mire willow scrubs (*Salicetum cinereae*), peat-moss-willow (*Calamagrosti-Salicetum cinereae sphagnetosum*), and large sedge communities (*Caricetum elatae*), reeds (*Scirpo-Phragmitetum*) and rushes (*Scirpo Phragmitetum Typhetosum*). The wetland (174 ha, max. 2.5–3.0 m water depth) is recharged with water only from rainfall and ground-water, and it has no outflow. The moor dried up earlier in extreme years (1948–1950, 1992–1993; Kasza & Marián 2001).

The second moor is the strictly protected Nagyberek (or NM; 45º59' N, 17º33' E), again surrounded by much oak and alder swamp woods. The extent of aquatic habitats can reach nearly one hundred hectares (max. 1.7 m water depth) in wet years and then it connects with the entrance of a small stream.

The third moor is part of the large protected area of Fehérvíz (or FM; 46º38' N, 17º32' E); due to extensive drainage it has greatly decreased in the past. Currently, only regulated canals connect the wetlands to Lake Balaton. The typical communities of this area are alder swamp woods, reeds, rushes and mire willow scrubs, with large sedge communities. The area of the moor habitat (without woods and on higher relief mesophyl rich fens or meadows) is 85–90 ha (max. 2.0 m water depth).

The most abundant fish in the littoral region of moors (Z. Sallai, unpubl. data from electrofishing) was the *Carassius auratus*. Besides this, other common fish were *Lepomis gibbosus*, *Pseudorasbora parva* in the BM and NM and *Scardinius erythrophthalmus* in the FM. The climate is continental, and the mean temperature during the two years studied was -2.3±1.3 ºC and 0.4±1.0 ºC in winter (independent samples t-test, $t = 1.65$, $P = 0.173$), and 20.8±0.4 ºC and 23.1±0.6 ºC in summer (independent samples t-test, $t = 3.04$, $P < 0.05$). The mean monthly rainfall was 76.7±26.9 mm and 38.4±10.6 mm (independent samples t-test, $t = 0.51$, $P = 0.617$), and the underground water level in summer, measured on the Baláta (E. Mezei, unpubl. data) was 910.0±37.8 mm and 163.3±160.3 mm (independent samples t-test, $t = 4.45$, $P < 0.05$), in the two years respectively. Temperature and rainfall were measured by the Hungarian Meteorological Service. The moors dried up in summer 2003 (except the permanent streams of FM) and only the autumn rainfall restored the water levels.

Otter spraints were also collected during the dry period. The first year of the study (from June 2002 to May 2003) was termed "moderate", and the second year (from June 2003 to May 2004), including the drought of summer and autumn, was termed "drought", because of differences in abiotic conditions.

## Methods

Diet composition was investigated by spraint (otter faeces) analysis. Samples were collected every six weeks between June 2002 and May 2004. Spraints were soaked in water and then washed through a sieve and dried. All recognizable prey remains were separated. Fish species were identified by microscope from scales and bones, e.g. pharyngeal teeth, operculae, maxillaries (e.g. Knollseisen 1996, detailed by Lanszki & Molnár 2003). Fish weight categories were recorded on the basis of comparative measurement of our reference fish bones, according to the following categories: below 100, 100–500 or above 500 g. Other remains of food species consumed by otters were identified by microscope from characteristic skeletal remains, teeth, hair, feathers and integuments (e.g., März 1972, Brown et al. 1993, and personal reference collections). All dry prey remains were weighed and multiplied by coefficients of digestibility (summarized by Jedrzejewska & Jedrzejewski 1998), to obtain an estimate of the percentage fresh weight (biomass) of food consumed. Trophic niche breadth (B index) was calculated in accordance with Levins: $B = 1/\sum p_i^2$, where $p_i$= is the percentage biomass of a given taxon (Krebs 1989). The following five prey taxa were used in the B index calculations: mammals, birds, reptiles with amphibians, fish and invertebrates.

Spraint survey methods are the most available techniques for studying or monitoring otters, but their value and reliability have been widely discussed and criticized (e.g., Kruuk & Conroy 1987, Conroy & French 1991). Although no simple correlations between otter numbers and spraint numbers have been found (Kruuk et al. 1986), some authors suggest that such "relative spraint densities" can potentially be used as indicators of changes in otter population densities, between years and areas, using the same sampling methods over time (Jefferies 1986, Mason & Macdonald 1987, Reuther et al. 2000). To compare areas and years, the D index, as relative otter spraint density index was used, expressed by the number of seasonally collected (eight seasons, two collections per seasons combined) otter spraints per one km line transect (unity standard route). Individual spraint samples were collected alongside the wetlands of moors (willow, sedge, rush and canal if available), on 1.47 km standard route at the BM (n = 199 samples), 1.76 km along the NM (n = 503) and 2.26 km along the FM (n = 315). During the two year study, terrestrial carnivores (Lanszki 2005a) and small mammal communities (Lanszki 2004) were also examined in ecozones and adjacent habitats, e.g., in meadows and nearby forests. However, during the study, otter signs (footprints and spraints) were not found outwith the moors. Therefore the standard routes (transects given above) alongside the wetlands of moors were only used in the calculations of relative otter spraint density index (Table 1).

The $\chi^2$ test was used for distribution analysis for the diet composition (possible six categories: mammals, birds, reptiles with amphibians, fish, invertebrates and plant matter) of the otters living in the various habitats, and year-dependent analysis of the diet. Paired samples t-test was applied to test the effect of year on fish (primary) or non-fish (secondary) food consumption (% of biomass); and to evaluate the effect of year in trophic niche breadth (B index) and relative otter spraint density (D index). One-way analysis of variance (ANOVA, LSD post-hoc test) was applied for the evaluation of the consumption of five main food taxa, furthermore trophic niche breadth values and D indices among areas. The SPSS 10 for Windows (1999) statistical package was used for the processing of the data obtained.

## Results

### Feeding habits

The distribution of different food items in the diet of otters living on BM significantly differed between the first and second years ($\chi^2 = 30.91$, df = 4, P < 0.001). However, the difference in fish consumption (paired samples t-test, t = -3.03, P = 0.094, Table 1) or summarized non-fish diet (t = 3.03, P = 0.094) was not significant between the years. The primary food source was fish (Fig. 1a). The principal fish prey of the otters (in all three areas) was *Carassius* sp., mainly the non-native *Carassius auratus gibelio* (Table 2). In the non-fish diet (Table 3), the most important items were anurans (mainly *Rana* kl. *esculenta*).

The diet of otters living on the NM differed between years on the basis of six food items ($\chi^2 = 888.94$, df = 5, P < 0.001). The dominant food source generally was fish (Fig. 1b). In

**Table 1.** Year-dependent mean fish consumption (% of biomass), trophic niche breadth (B index) and relative spraint density (D index) of otters living on moors in Hungary. B: Levin's index, D index: based on the number of seasonally collected (eight seasons, two collections per seasons combined) otter spraints per one km line transect, mean ± s.e., paired samples t-test, * P<0.05.

| Moors | Fish diet (%B) | | Niche-breadth (B) | | Relative spraint density (D) | |
|---|---|---|---|---|---|---|
| | 1st year | 2nd year | 1st year | 2nd year | 1st year | 2nd year |
| Baláta | 94.4±2.3 | 99.2±0.7 | 1.12±0.05 | 1.02±0.02 | 24.8±5.4 | 9.0±4.1* |
| Nagyberek | 93.9±3.6 | 71.5±17.8 | 1.13±0.08 | 1.42±0.18 | 59.2±12.2 | 12.2±1.1 |
| Fehérvíz | 66.4±4.6 | 82.1±8.7* | 2.00±0.12 | 1.46±0.26 | 17.9±5.3 | 16.9±8.3 |

**Table 2.** Number of items (N) and percentage biomass of various fish species consumed by otters living on moors in Hungary (data for two years pooled). +: occurring in proportions lower than 0.05%. Empty cells mean that the given item was not detected.

| Fish species | Baláta | | Nagyberek | | Fehérvíz | |
|---|---|---|---|---|---|---|
| | N | %B | N | %B | N | %B |
| *Carassius* spp. | 172 | 77.3 | 692 | 90.1 | 60 | 17.6 |
| *Cyprinus carpio* | | | | | 8 | 2.8 |
| *Ctenopharyngodon idella* | | | | | 1 | 0.1 |
| *Tinca tinca* | 4 | 1.0 | 7 | 0.8 | 4 | 0.4 |
| *Scardinius erythrophthalmus* | | | 1 | 0.1 | 10 | 2.2 |
| *Rutilus rutilus* | 9 | 2.7 | 1 | 0.1 | 11 | 1.8 |
| *Alburnus alburnus* | | | 5 | 0.3 | 117 | 17.0 |
| *Rhodeus sericeus* | | | 3 | 0.1 | 3 | 0.3 |
| *Leucaspius delineatus* | 1 | + | | | | |
| *Gobio* spp. | | | | | 2 | 0.2 |
| Other small Cyprinidae | 1 | 0.1 | 24 | 0.9 | 6 | 0.4 |
| Unidentified Cyprinidae | 24 | 6.0 | 14 | 0.6 | 30 | 6.3 |
| *Misgurnus fossilis/Cobitis taenia* | 16 | 2.4 | | | 1 | 0.1 |
| *Lepomis gibbosus* | 31 | 4.3 | 10 | 0.3 | 55 | 14.0 |
| *Perca fluviatilis* | | | 2 | + | 32 | 6.1 |
| *Gymnocephalus cernuus* | | | | | 6 | 0.5 |
| *Ictalurus nebulosus* | 2 | 0.1 | 2 | 0.3 | 27 | 6.3 |
| *Esox lucius* | 1 | 0.1 | | | 9 | 2.8 |
| Unidentified fish | 16 | 1.8 | 17 | 1.1 | 16 | 1.6 |

**Table 3.** Non-fish diet of otters living on moors in Hungary (*fish and non-fish items together, for abbreviations see Table 2).

| Food items | Baláta | | Nagyberek | | Fehérvíz | |
|---|---|---|---|---|---|---|
| | N | %B | N | %B | N | %B |
| Mammalia | 1 | + | 8 | 0.1 | 27 | 4.8 |
| Passeriformes | 6 | 0.8 | 9 | 0.3 | 1 | 0.1 |
| Waterfowl | | | 10 | 1.1 | 4 | 2.5 |
| Colubridae | | | 7 | 0.2 | 1 | + |
| Anura spp. | 22 | 3.3 | 88 | 3.6 | 51 | 7.7 |
| *Astacus* spp. | | | | | 68 | 4.4 |
| Other Invertebrata | 31 | 0.1 | 78 | 0.1 | 36 | 0.2 |
| Plant matter | | | 7 | 0.1 | 7 | 0.1 |
| No. of spraints | 199 | | 503 | | 315 | |
| Items* | 337 | | 985 | | 593 | |

the first, moderate year the proportion of fish (Table 1) was not significantly higher (paired samples t-test, $t = 1.56$, $P = 0.217$), and consumption of non-fish food lower ($t = -1.56$, $P = 0.217$), as compared to the period of drought. In both cases, however, the difference was biologically meaningful. During the drought summer (and the following winter) otters consumed more amphibians and less fish than in the first year (Fig. 1b). Extreme bird consumption was found in the spring of 2004, when the bird source (70%), especially *Fulica atra* (32.4%) and anserine birds (21.2%) were the most important.

The diet of otters living on the FM differed between years ($\chi^2 = 313.51$, df = 5, $P < 0.001$). Fish consumption (Table 1) was lower in the moderate, than in the drought year (paired samples t-test, $t = -3.36$, $P < 0.05$), while the non-fish diet was more important in the moderate year, compared to the drought one ($t = 3.36$, $P < 0.05$). The primary food source was also fish (Fig. 1c); in the non-fish diet anurans and small mammals were important.

### Area-dependent variations in diet

The diet of otters living on the three different areas varied significantly ($\chi^2 = 83.96$, df = 10, $P < 0.001$). The area-dependent differences arose mainly from the dissimilarity of the summarized secondary food taxa (e.g. birds, amphibians) (ANOVA, $F = 6.71$, $P < 0.01$) and not directly from consumption of the primary fish ($F = 2.84$, $P = 0.082$). Otters living on the NM consumed significantly more birds ($F = 8.20$, $P < 0.05$) than those living on the BM and FM, and otters living on the FM consumed more mammals ($F = 9.20$, $P < 0.05$) and more invertebrates ($F = 3.67$, $P < 0.01$) than otters living on the BM and NM. No area-dependent difference was found in consumption of amphibians and reptiles ($F = 2.59$, $P = 0.100$).

Fish consumed by otters in all three areas were generally small sized, below 100 g (mean % biomass, BM 99.9%, NM 94.6% and FM 96.6%), and fish larger than 500 g were not recognized. No area-dependent difference was found in the distribution of fish weight ($\chi^2 = 4.02$, df = 2, $P = 0.134$).

### Trophic niche breadth and relative density of spraints

The trophic niche, related to the fish dominance in the diet of otters living on moors, was characteristically narrow (Table 1). The differences were not significant between the years

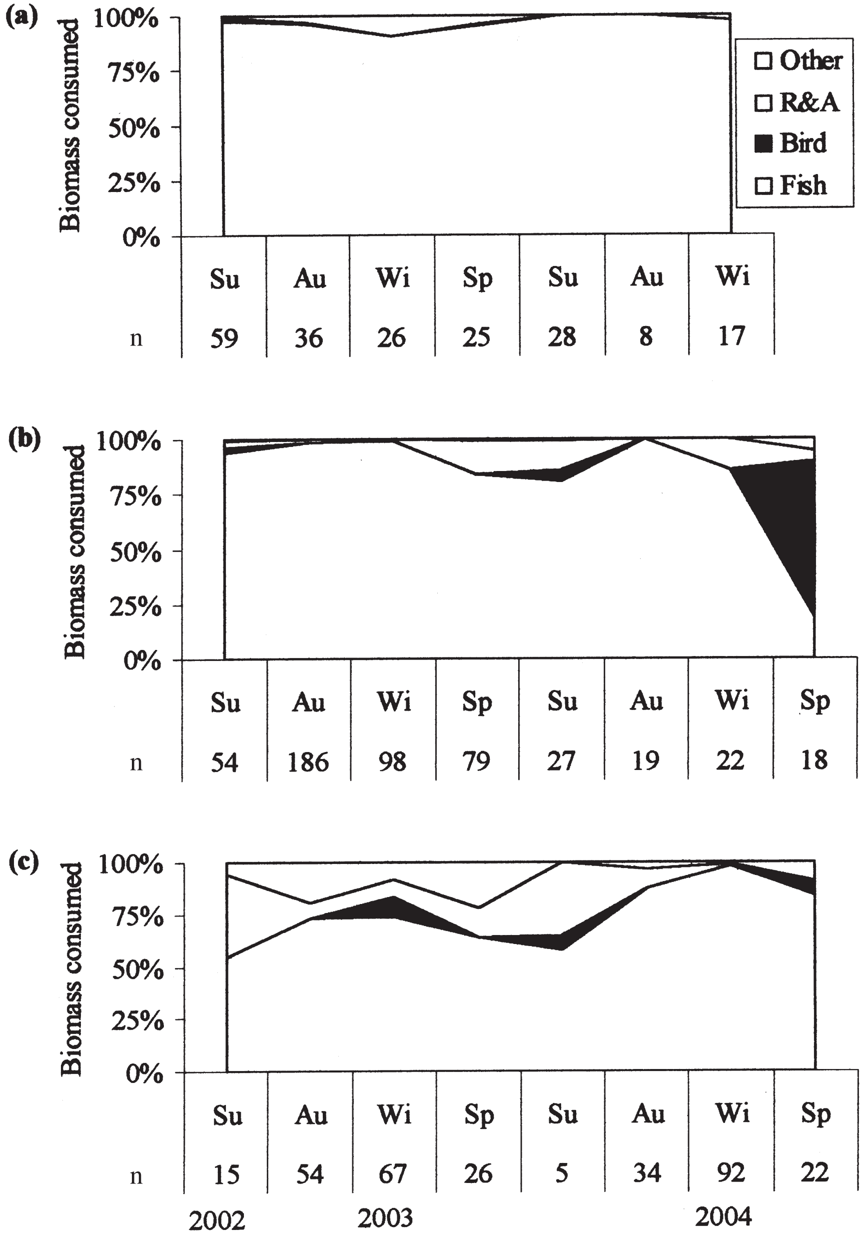


**Fig. 1.** Seasonal diet composition changes of otters living on three moors in the Pannonian ecoregion, Hungary, between summer of 2002 and spring of 2004. Moors: (a) Baláta (or BM), (b) Nagyberek (or NM) and (c) Fehérvíz (or FM); n: seasonal number of spraints, R&A: reptiles and amphibians together. No otters were present on BM from winter 2004.

(paired samples t-test, t = 3.30, 2.77 and 2.71, P = 0.081, 0.069 and 0.073, in the three areas respectively). Significantly wider trophic niche values were found on the FM (ANOVA, BM: 1.07±0.03, NM: 1.27±0.11 and FM: 1.73±0.16, F = 8.13, P < 0.01).

The difference between areas in relative otter spraint density (Table 1) was not significant (ANOVA, F = 1.96, P = 0.166). In the drought year, there was a tendency for lower D index values to be found on the BM (paired samples t-test, t = 4.27, P < 0.05) and NM (t = 2.77, P = 0.069), than in the moderate year. No otter presence was found on the BM from the end of winter 2004.

## Discussion

Besides the principle fish food, many other types of food item were found in the diet of otters living on moors in Hungary, indicating the otters' ability for diverse hunting techniques (Chanin 1985, Mason & Macdonald 1986, Kruuk 1995). Under certain sub-optimal circumstances (e.g. long period of drought) otters may have to increase their home range size (Erlinge 1968); they may also have to forage in different habitats and under extreme conditions to shift fish to sub-optimal prey, e.g. invertebrates, amphibians and birds (Carss 1995, Kruuk 1995, Jedrzejewska et al. 2001, Ruiz-Olmo et al. 2001, Clavero et al. 2003).

The diet composition of otters differed between areas and these differences could be caused by numerous factors. The water level of enclosed moors, surrounded for example by forests (as BM and NM in this study) depends basically on rainfall and underground water levels, while the extended wetland (as FM) is connected by canals to other freshwater sources. The habitat differences (within moors), especially in periods of drought, may cause substantial differences in fish food supply (Delibes et al. 2000, Lanszki et al. 2001, Ruiz-Olmo et al. 2001). In the drought year, consumption of amphibians increased on the FM, and otters changed their prey from fish to birds on the NM. High fish consumption during and after drought in wetlands may influence the necessity to migrate (Dulfer et al. 1998, Delibes et al. 2000, Ruiz-Olmo et al. 2001, 2002) between moors and farther wetlands. Otters left the unfavourable habitat or used it only occasionally, as indicated by the lower otter spraint density indices. The strictly protected *Aythya nyroca*, is the second most frequent nesting waterfowl on the NM (L. Fenyősi, pers. com.) and evidence from nests destroyed by a predator suggest that this may be predated by otter, similar to the most frequent *Anas platyrhynchos*, or to the less frequent *Fulica atra*, which were also identified in the diet of otters. The trophic niche breadth values, in contrast with Mediterranean areas where such values were increasing (Delibes et al. 2000, Ruiz-Olmo et al. 2001, Clavero et al. 2003), remained narrow on Pannonian moors. It seems that otters utilize a narrow range of food resources or even totally deplete them before leaving the area (Delibes et al. 2000), in which case the drying out of the wetland also plays an important role.

Relative otter spraint density values on the moors studied were low, ca. 10% that of other freshwater areas which are abundant in fish (Lanszki 2005b), using similar methods. Our results support experiences in Mediterranean areas, where due to the long period of drought increasing otter migration was found (Ruiz-Olmo et al. 2001). However, radio-tracking can give more information about otter migrations (Erlinge 1968, Dulfer et al. 1998).

In conclusion, area-dependent and year-dependent variations in the general diet of otters living on three moors in Hungary were found. On moors, which are dependent on rainfall and ground-water only, during or after periods of drought, otters may temporarily change their diet from optimal fish prey to sub-optimal prey, however the primary food source was generally small sized fish (most frequently the non-native *Carassius auratus gibelio*) in the drought year, too. On these moors otters left the unfavourable habitat (as on BM from winter 2004) or their presence was only occasional (as on NM) as shown by the relative otter spraint density indices. On moors with small canals as permanent aquatic habitats (as on FM), during periods of drought, otters kept fish as the dominant food source, and weathered out extreme environmental local conditions with less intensive migration.

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