Winter predation by otter, *Lutra lutra* on carp pond systems in South Bohemia (Czech Republic)

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A b s t r a c t . Otter (*Lutra lutra*) diet was studied by analysing of 180 spraints and 29 partly consumed fish remains found in winter around fishponds in South Bohemia (Czech Republic). The proportion of fish found in spraints was 95.6% of all prey items, roach (*Rutilus rutilus*), topmouth gudgeon (*Pseudorasbora parva*) and common carp (*Cyprinus carpio*) being the most numerically abundant species with 37.3, 21.3 and 19.0% respectively. Carp dominated the diet by mass (47.8%), whilst roach and "other commercial fish species" (predatory and herbivorous fish, tench, *Tinca tinca*) formed 21.8 and 15.3% of total biomass, respectively. Small fish (< 200 mm) predominated in the diet and only 4.0% of all fish found in spraints exceeded 300 mm TL. Large fish remains were very scarce in spraints and were best recorded from uneaten prey remains. The partially eaten remains of carp, pike (*Esox lucius*) and common bream (*Abramis brama*) were found on banks or ice, but most (86%) were carp. The original length of carp corpses ranged between 283 and 530 mm TL, and the proportion of body mass consumed varied between 5.0 – 90.1%. The length of pike remains ranged from 386 to 754 mm TL, of which 84.0% of body mass on average was consumed by otters. The otter diet apparently reflects food availability in fishponds and supply channels. Small water basins with a high stock density can be vulnerable to serious damage especially during the winter period and at such places, where no better accessible source of food is available to otters. However, in many such places simple mitigation measures may be able to reduce otter predation.

Key words: otter diet, spraint analysis, excessive hunting, fish remains

Introduction

The Eurasian otter (*Lutra lutra* L.) is present in more than 60% of the Czech Republic, and according to the Czech Otter Foundation, their numbers were estimated at 1200–1500 individuals in 2005 (Marcela R o c h e , pers. comm.). The largest and strongest otter population in the Czech Republic extends across the large South Bohemia fishpond area (Třeboň and České Budějovice districts), suggesting that fishponds are very attractive habitats for otters. Home ranges of otters in such areas, with numerous densely stocked ponds, can cover only 2.5 km^2 – 3 km^2 (D u l f e r et al. 1996) and otters, along with great cormorant (*Phalacrocorax carbo sinensis*), are considered as the most important fish predator in the Czech Republic (A d á m e k et al. 2007). Financial losses caused by otter predation to recreational and commercial fisheries in the Czech Republic were estimated at 200.78

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million CZK (6.7 million EUR) in 2005 (Czech Ministry of Agriculture 2006). The majority of problems associated with otter predation on fishponds arise in winter months, especially during the period when ponds are ice covered. Openings in the ice and unfrozen inflow parts of overwintering ponds are frequently visited by otters. That such accessible ponds are exposed to increased predation pressure is indicated by fish remains and otter faeces (spraints) here. Partially eaten remains of large fish are regularly found on pond banks or the ice and fishermen believe such predation forms a significant proportion on the total losses to fish production (K r a n z 1998), particularly on small ponds (K u č e r o v á et al. 1999). Futhermore, a survey amongst fisherman in the local study area (Fishery Hluboká) revealed a strong belief, that otters regularly caught more fish than they were able to consume and, on some occasions, they preferred highly valuable commercial fish species to other prey. Serious damage to overwintering fish stocks is also thought to be caused by fish being disturbed by hunting otters (indirect losses), which can lead to weight losses and increasing susceptibility to infections and parasite invasions (A d á m e k et al. 2003).

The proportion of fish in otter diet increases in winter, when many alternative prey sources became unavailable. Common carp is the dominant prey at fishponds in winter. Studies of otter diet at fishponds are based on analyses of faecal samples and are concentrated mostly on ponds stocked with younger carp (A d á m e k et al. 1999, K l o s k o w s k i 1999, R o c h e 2001, A d á m e k et al. 2007). However, these studies do not reveal the extent of large and economically most valuable fish in the diet, because they are either (1) restricted to those ponds holding smaller, young fish or (2) rely on spraint analysis, a method underestimating (or fail to record) the proportion of large fish in the diet of otters. The latter occurs because otter seldom ingest the bones of large fish (see discussion in C a r s s et al. 1990, C a r s s & E l s t o n 1996). Previous work showed that the size of fish eaten by otters as being assessed from uneaten fish remains found near fishponds differed considerably from that determined by spraint analyses in other studies (A d á m e k et al. 2003). Hence complete analysis of otter diet should include examination of both – partly consumed fish and spraints composition.

The aim of this study was thus to investigate food composition of otters at carp fishponds in winter paying special attention to the proportion of commercial fish species in the diet and their size distribution, utilising both spraint analysis and uneaten fish remains.

Study Area

Otter diet was studied at the České Budějovice fishpond area in South Bohemia (Czech Republic), at fishponds belonging to the Fishery Hluboká Co. The total yearly production of the company amounts to 1,300 tons of fish from more than 300 ponds with a total water surface of 2,660 ha. Common carp (*Cyprinus carpio*) is the main cultured commercial species, supplemented by grass carp (*Ctenopharyngodon idella*), tench (*Tinca tinca*), bighead carp (*Aristichthys nobilis*), silver carp (*Hypophthalmichthhys molitrix*), ide (*Leuciscus idus*), European catfish (*Silurus glanis*), pike (*Esox lucius*) and zander (*Sander lucioperca*). Other non-commercial species present are roach (*Rutilus rutilus*), rudd (*Scardinius erythrophthalmus*), common bream (*Abramis brama*), Prusian carp (*Carassius gibelio*), ruffe (*Gymnocephalus cernuus*) and perch (*Perca fluviatilis*). Topmouth gudgeon (*Pseudorasbora parva*) is a very abundant invasive species in fishponds and pond channels.

Three different locations were chosen for study, being representative otter foraging habitats in the Hluboká fishpond region. The Bezdrev locality included the Zlivský (66 ha) and Bezdrev (433 ha) ponds, their inflow channels and pools below the dams. The Čakov locality was a system of 8 ponds (1.5 to 23 ha), connected by short channels. The Ostrov locality comprised 6 small (0.6 ha) overwintering ponds separated by 4 m wide dams including the Blatec (25.1 ha) and Mlýnský (19.3 ha) ponds. These three locations were not connected directly by channels and the minimum distance between them was at least 10 km. As estimated otter home ranges in similar areas in the Třeboň fishpond area are 3 km^2 (D u l f e r et al. 1996), it was assumed that spraints collected in one location were not the product of meals eaten by otters in other of the two locations. Given the disparity between otter home range size and the distance between sampling localities, likely the present study included spraints deposited by a number of otters, thus minimising the bias associated with the suggestion that individual otters may show variation in foraging behaviour and diet (K r u u k 1995).

Methods

Fresh otter faeces and fish remains were collected regularly three times a month during winter (December 2002 to February 2003) in Bezdrev and Čakov, while collections were made at Ostrov during January and February 2003. All three locations were checked for evidence of otter predation (spraints and fish remains) especially around the inflows to ponds, pools below dams and along water channels between ponds, these areas remain ice-free during the winter and being preferentially visited by foraging otters. Also dams and bank parts of ponds were surveyed for occurrence of otter spraints and fish remains.

Collected spraints were stored separately in plastic bags, then soaked in an enzyme solution Golem Bio (Druchema Prague, CR). After three days, samples were washed thoroughly through a 0.5 mm sieve and dried on filter paper. Fish remains found in spraints were determined to species level using key bones and scales in order of importance – head bones, vertebrae, scales and broken bones, using a reference collection of skeletons and scales, and published keys (L i b o i s et al. 1987, L i b o i s & H a l l e t - L i b o i s 1988, C o n r o y et al. 1993). Roach and rudd were classified together, as well as silver and bighead carps to avoid erroneous species determination due similar bone and scale morphology, and the occurrence of hybrids. The minimum number of individuals was estimated according to paired bones and from size differences between vertebrae or other bones. Original fish length of prey was reconstructed from bones using published correlations according to L i b o i s et al. (1987), L i b o i s & H a l l e t - L i b o i s (1988), M e h n e r (1990) and A d á m e k et al. (2003). When key bones were absent or broken in the sample, fish prey was classified (50 mm category) by comparison to a reference collection. The reference collection of skeletons and scales of local fishes was set up for this purpose, each species being ranked in 50 mm size categories. Scales were not used for fish size reconstruction as, besides other disadvantages described by W i s e (1980), their size differs considerably on different parts of the body and, in case of mirror carp, all scales are of different sizes and shapes. Topmouth gudgeon was classified into one of two 50 mm size categories by comparing with the reference collection, whilst key bones from the other fishes were measured to nearest 0.1 mm where possible. This enabled an exact calculation of original length of fish in 65% cases (except topmouth gudgeon). The size category of remaining 35 % fish was estimated by comparison with the reference collection (Table 1). Non-fish prey were identified as amphibian, bird and mammal using bones, feather and fur remains.

Table 1. Key bones used to estimate the original length (TL) of prey fishes recorded in spraints and their contribution to all reconstructed remains.

	Key bones					Proportion of individuals (N) for which length reconstruction was based on		
						Computation	Estimation (ref. collection)	
Species	**Praeoperc.**	**Pharyngeal teeth**	**Dentary**	**Maxillary**	**Vertebrae**	**%**	**%**	**Total (n)**
Carp		2	3	7	57	69	31	100
Roach & Rudd		55			86	72	28	196
Perch	6				27	66	34	50
Common bream		1	1	7		41	59	22
Pike							100	8
Zander							100	7
Bighead & Silver carp							100	2
Prusian carp							100	1
Tench		1				100	0	1
Grass carp							100	2
Ruffe							100	1
Topmouth gudgeon							100	112
Total	6	59	4	14	170	65	35	502

Fish remains partly consumed and found on banks or ice were weighed and total length or head length was measured wherever possible. In many cases only the head or part of the body had been left and in such cases, original length was estimated from head length: total length. regression equations for carp (TL=71.54+3.91xHL, n = 70, r = 0.92) and pike (TL = 31.56+3.61xHL, n = 23, r = 0.99) derived from a reference measuring of fish from ponds within the study area.

Original weight of fish prey was calculated from total length (TL) (Appendix 1). Reference fish for the calculation of exponential equations were obtained from spring pond harvesting in order to minimize any seasonal variances in fish weight. A maximum bulk of 500 g was used for quantification of the fish biomass consumed by otters, when the total weight of an individual prey fish was identified as exceeding this value (R o c h e 2001). Mean ranges of each 50 mm size category were used for reconstruction of original weight in cases when exact TL was impossible to assess. Biomass of non-fish prey was not determined exactly, but was based on the average weight of prey types in the study area (amphibian 15g, bird 20g, mammal 300g).

Only commercial fish species are included in the available information about fish stocks in particular locations and these data were obtained from the local fish farm company. Ivlev´s selectivity coefficient E (J a c o b s 1974) was applied for the evaluation of food (prey) electivity:

$$E = (r - p)/(r + p),$$

where r = percentage of certain prey item taken by predator, p = percentage of that prey item available.

Thus a value of E = 0.00 means that consumption of a particular food item corresponds to its occurrence, whilst $-1 < E < -0.01$ and $0.01 < E < 1$ indicate negative selection (less consumption than expected) and positive selection of a particular food item, respectively.

Simpson´s diversity index D was used to assess the diversity of prey within otter diet at particular locations:

$$D = N (N - 1)/\sum n (n - 1),$$

where N = the total number of all prey individuals of all species recorded, n = the total number of prey individuals of a particular species. High D values mean that the diet consists of species taken in comparable quantities, whilst low D values mean that the diet consists of many species but only a few of them form the majority.

All figures for fish length are presented as total length (TL). The diet composition is presented either as a relative abundance or as biomass of prey species in all collected spraints. Fish species with abundance < 4 % were classified as “other” category or divided into “other commercial” and “other non-commercial” fish species categories.

Results

Altogether 29 fish remains and 180 spraints were analysed from winter period 2002/2003. In total 525 prey items were recorded from spraints, 502 (95.6%) of them fish and 23 (4.4%) non-fish prey. From 12 fish species found in spraints only 5 of them – roach, topmouth gudgeon, common carp, perch and common bream – were registered in higher numbers. Other species were scarce in the diet (<4 % by abundance). Roach was the most abundant

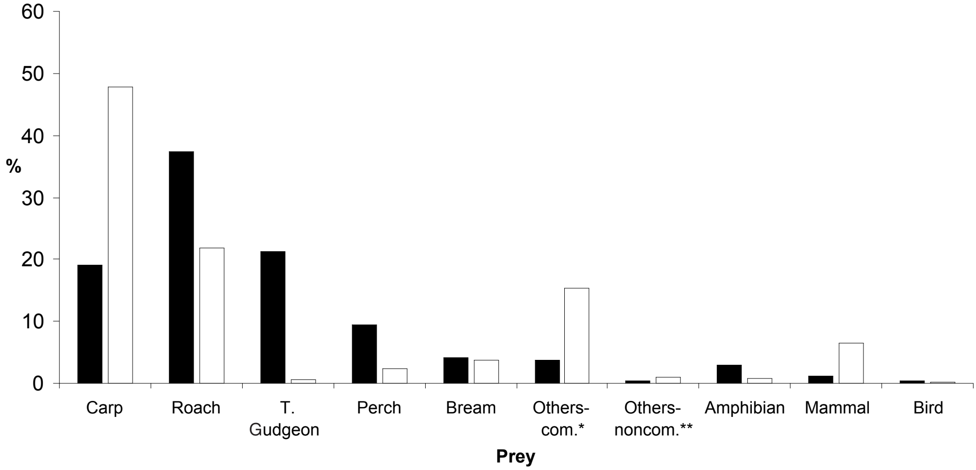

Fig 1. Proportion (numerical ■ and by mass □) of individual prey items recovered in otter spraints. Notes: * Others-commercial = pike, zander, bighead and silver carp, tench; ** Others-noncommercial = Prusian carp, ruffe.

species in the diet (37.3%), being ranked second in terms of estimated biomass (21.8%). Topmouth gudgeon was the second most abundant species (21.3%), but formed only 0.6% of diet by mass. Carp was ranked third in the diet by abundance (19.0%) but formed by far the highest estimated biomass (47.9%) of all prey items. Other fish species with high abundance in otter diet were perch (9.5%) and common bream (4.2%), but the estimated mass of these species was low (2.4 and 3.8%, respectively). Other commercial species found in the spraints represented 3.8% of all prey items (abundance) and 15.3% (biomass). Of these, pike had a relative abundance of 1.5% but comprised relatively large fish and so formed 10.5% of estimated total biomass, and small zander representing 1.3 and 0.8% of the diet by abundance and biomass respectively.

Silver carp, grass carp and tench were represented by relatively few specimens, of which only silver carp was important in biomass (3.5%). Species classified as other non-commercial fishes had only a minor contribution to overall diet (0.4%), and were

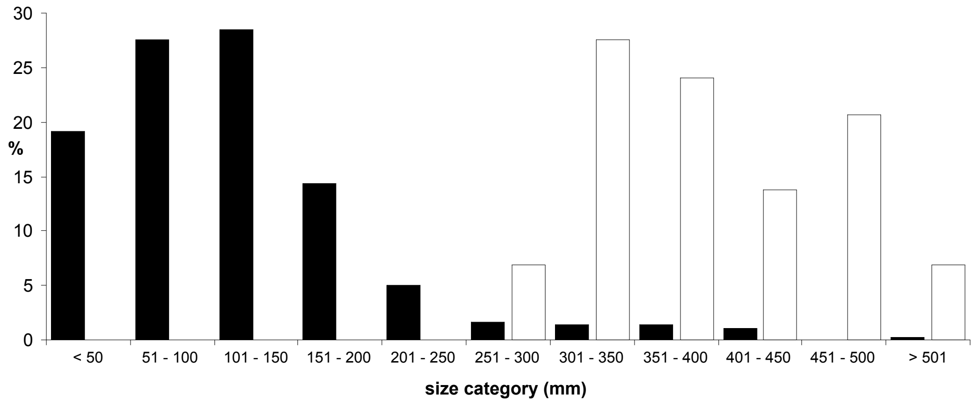

Fig. 2. Distribution of prey fish size (50 mm categories) estimated from spraints ■ and uneaten prey remains □ (TL, mm).

represented by ruffe and Prusian carp. Non-fish prey were represented by amphibians (2.9 and 0.8%), mammals (1.1 and 6.4%) and birds (0.4 and 0.1%) in abundance and biomass respectively (Fig. 1).

Small fish (< 200 mm) predominated (89.4%) in the diet assessed from spraints. The highest proportion was formed by size categories 51 – 100 mm (27.5% of individuals) and 101 – 150 mm (28.5 %, Fig. 2). Only 4 % of all fish found in sprints exceeded 300 mm TL – this size category was dominated by carp followed by pike, silver carp and roach. The highest contribution to the 100 – 200 mm size category comprised carp and roach, whilst topmouth gudgeon and roach dominated size categories below 100 mm. Mean original TL of carp found in spraints was 185 mm. The weight distribution of fish prey was similar to that for length, where 88.3% of consumed fish weighed < 100 g and 3.4% of fish exceeded 500 g. Carp (416 mm, 1242 g), pike (450 mm, 722 g) and silver carp (>600 mm, min. 2937 g) were the largest commercial species prey items.

Despite the relatively consistent proportions of roach and carp at the three study locations, dietary patterns were significantly different (Fig. 3). Topmouth gudgeon was captured in very high numbers at Čakov, whilst all other fish species recorded in spraints here were represented by only few individuals. The situation was similar also at Ostrov, where only small individuals of topmouth gudgeon and perch were captured in higher proportion. A different picture arose from analysis of otter diet at Bezdrev. Carp and roach were found in similar numbers to the other locations, but the proportion of common bream and all other fish species was considerably higher. Most commercial species found in spraints came from Bezdrev, whilst numbers of topmouth gudgeon were very low there. Also 13 out of 17 fish that exceeded the weight of 500 g were all found at Bezdrev. Simpson´s index of diversity calculated for fish prey also indicate the highest diversity in Bezdrev (D = 4.57) and very low diversity at Čakov and Ostrov (D = 3.25 and 3.33, respectively).

Comparison of the composition of commercial fish species present in the stock at fishponds to that recorded in otter diet did not show very significant differences (Table 2). Carp was by far the most abundant species in both stock and prey and its proportion in the

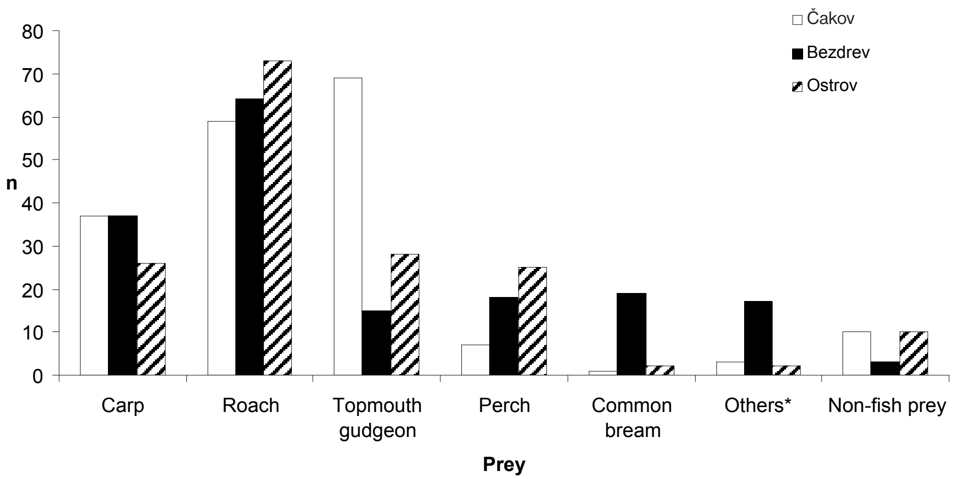

Fig. 3. Comparison of prey abundance (proportion assessed from spraints) at three study locations, different dietary compositions were recorded at each ($X^2 = 105.59$, df = 12, $P < 0.001$). Notes: * Others = pike, zander, bighead and silver carp, tench, Prusian carp, ruffe.

Table 2. Proportions and Ivlev´s index of selectivity (I_V) of commercial fish stocked in the three study locations and their proportion as recorded from fish remains in spraints. Note: Figures are presented as total water surface and stock of all ponds within each location. Percentage figures were calculated only for commercial species currently held in each location.

Locality	Abundance (%)			Biomass (%)	
ČAKOV (65 ha / 8 ponds)	Stock	Prey	I_V	Stock	Prey
Carp	55.87	94.87	+ 0.26	86.69	96.03
Grass carp	1.07	-	- 1.00	2.6	-
Pike	0.36	2.56	+ 0.75	1.65	1.84
Tench	35.59	2.56	- 0.87	8.84	2.13
Ide	7.12	-	- 1.00	0.22	-
BEZDREV (499 ha / 2 ponds)					
Carp	98.61	71.15	- 0.16	77.73	64.9
Grass carp	0.41	1.92	+ 0.34	8.09	0.17
Pike	0.17	13.46	+ 0.98	0.53	25.16
Zander	0.29	9.62	+ 0.85	3.15	1.02
Bighead & Silver carp	0.46	3.85	+ 0.25	8.4	8.74
Wels catfish	0.06	-	- 1.00	2.1	-
OSTROV (48 ha / 8 ponds)					
Carp	98.97	96.3	- 0.01	97.21	97.2
Pike	0.28	-	- 1.00	1.23	-
Zander	0.07	3.7	+ 0.96	0.2	2.8
Bighead & Silver carp	0.09	-	- 1.00	1.23	-
Ide	0.6	-	- 1.00	0.13	-

diet corresponded with its stocking density – Ivlev´s index of electivity ranged from –0.16 to +0.26. At Čakov and Bezdrev, pike was found more often in the diet than in the stock (I_V +0.75 and +0.98 respectively). Zander was a positively selected prey at Bezdrev and Ostrov (I_V +0.85 and +0.96, respectively). Tench was stocked in a higher proportion than its estimated proportion in the diet at Čakov (I_V –0.87).

The remains of 29 fish partly consumed by otters were found on the bank or ice cover during the sampling period. Of these, 25, 3 and 1 individuals were carp, pike and common bream, respectively. All corpses were found at Bezdrev, near the ice opening at its inflow, on the bank of the dam and below the dam around the pool. Most of the remains (79 %) were found close to the inflow channel or pool. In 12 cases (41.3%), only part of the flank and viscera of the fish were consumed, from other corpses the front part of the body or mostly only the head was left uneaten. The original reconstructed total length and weight of carp from these uneaten remains ranged between 283 and 530 mm TL (mean = 398 ± 71 mm, n = 25) and 366 – 2677 g (mean = 1191 ± 654 g, n = 25) respectively (Table 3). Otters consumed

Table 3. Estimated mean original sizes of fish remains left by otters and proportions consumed.

		Mean original size		Proportion consumed (%)		
Species	n	TL (mm)	W (g)	Min.	Max.	Mean
Carp	25	398	1191	5	90.1	47.3
Pike	3	529	1534	81.8	85.9	84.0
Common bream	1	300	341	61.9	-	61.9

at least 102 g (5.0%) and up to 1709 g (90.1%) of the estimated original fish biomass. Mean weight of the consumed part of carp was 453 ± 392g (47.3%). Only the heads of pike were found left uneaten by otters, and their original length and weight ranged from 386 to 754 mm TL (529±197 mm, n = 3) and 428 to 3493 g (1534±1701 g), respectively. Almost the same proportions (84.0%) of the body mass were consumed from all 3 individual pike. One remain of common bream with an estimated original size of 300 mm and weight of 341 g was found on the bank, the otter had consumed 61.9% of its body mass. For all fish remains, the mean proportion of the consumed part of the body was 529 ± 603 g, which represents 51.6 % of the estimated body weight on average.

Discussion

The diet of otters living near fishponds within the study area did not differ considerably from the findings at other fishpond localities. Carp was the dominant food item in fish ponds stocked with one-year old carp in S.E. Poland, forming 23.4% of food biomass in winter, with mean length of 114 mm (K l o s k o w s k i 1999). Another study carried out in South Bohemia showed that small carp dominated otter diet across an area covering several ponds and the river Malše, representing 52 % of total biomass. The highest proportion of carp in otter diet was registered in winter and spring, 61 and 66% respectively (A d á m e k et al. 1999). R o c h e (2001) also showed the highest proportion of carp in the otter diet in another fishpond study (South Bohemia, Třeboňsko). Carp formed 57 and 67% of the diet in abundance and biomass in winter. Roach (21%) and perch (17%) were other species numerous in abundance but contributing very little to biomass. Other fish, including commercial species, formed only 1% of biomass of all prey items in winter. Also B o d n e r (1995), K n o l l s e i s e n (1995) and K u č e r o v á (1997) found that carp predation rose to high levels in winter period. In cold months, when otters have the highest energy demand and access to other sources of food is limited, carp became very profitable prey because it is easy to catch during their winter resting period (R o c h e 2001). All of the above mentioned studies reported strong dominance of small carp in otter diet, where none or very few individuals exceeded TL of 300 mm. However, the study areas were mostly restricted to carp ponds with one-year-old stock, and therefore it was not possible to describe the whole range of fish prey size taken by otters. The present study covered 18 ponds with a total water surface area of 612 ha. Although 95% of the commercial fish stock was smaller than 200 mm, the whole range of fish size classes was available to otters. Mean original TL of carp (185 mm) found in spraints was higher than in previous studies and also a higher proportion of commercial fish larger than 300 mm TL was recorded in otter diet in the present study.

The diet of otters in the winter period in studied fishpond areas apparently reflects the food availability in ponds and channels. Čakov and Ostrov are systems of small ponds, connected by narrow and shallow channels. Otters use these water bodies for movement between feeding sites but also feed on small fish there, which reflects their high proportion in the diet. At Bezdrev, otters also use inflow and outflow channels, particularly in cold months, when ponds are covered by ice: up to 8 otters were seen at the inflow channel here in one night (J. Š i n d e l á ř , pers. comm.). This channel is about 2 m wide and 1 m deep and was stocked with older-age fish categories for sport fishing. Also the pool below the dam was stocked with bigger carp for fishing. Fish remains indicated high usage of these places by otters. A d á m e k et al. (2003) also found, in their study of fish remains left by otters, most corpses (71%) along the supply channel to the fishpond. In this study carried out in the Vodňany fishpond system (South Bohemia), 80% of fish remains were carp (376 to 683 mm TL), from which otters consumed on average 27% of body mass. Most of the fish remains found at Bezdrev were also carp, but relatively more body mass was consumed in comparison with the previous study.

Hunting behaviour and possible explanations of surplus killing has been described by Erlinge (1968). This author observed otters in captivity, and discovered that replete individuals occasionally continued their hunting, having captured and left some prey in the water or on land. Large fish were more frequently rejected than small specimens, which might be influenced by the body surface, as the large scales are more difficult to cut. This behaviour was especially observed in young otters, which spend more time hunting and playing with the prey. Trials with different fish species offered to otters showed that slow moving species or fish with reduced swimming ability were caught first and that fish were caught in relation to their ability to escape. Feeding trials with the same fish species of different size showed that size of fish had less influence on the choice of prey than its mobility. Erlinge (1968) supposed that when easily-caught food is available in a relatively small basin, the probability that otters kill more fish than they eat is higher. Also Carss et al. (1990) found that considerable numbers of adult male salmon may be killed by otters in the spawning period, when they are highly vulnerable to otter predation crossing shallow parts of the river. However, these authors found no evidence of surplus killing, i.e. killing prey without eating it, by wild otters and suggested that otter predation was related to prey availability.

In cold water during the winter resting period, many fish species reduce their metabolism, thus their motility and ability to escape from predators. When ponds are ice covered, carp may gather near holes cut in the ice enabling gas exchange between air and water. Such places become highly visited by otters in the cold months, when otter´s food resources are reduced, and at this time they tolerate the presence of other individuals within their home range (Kranz 1995, Foerster 1996). Small wintering ponds, where fish have limited space to escape, can be particularly exposed to heavy predation pressure by otters. Bodner (1998) found that ponds where most uneaten prey fish remains were found were significantly smaller than other ponds. More than one fish´s remains was usually found around unfrozen places. This suggests that either more than one otter (or family) was feeding there, or that fish abundance is very high there and fish are easy to catch at low energy cost.

A relatively higher proportion of larger fish was found in the diet as assessed from spraints than compared to the studies from other fishpond regions, but small fish (<200 mm) still predominated in the diet. The importance of small fish in the diet could be overestimated but more likely their presence was caused by a higher abundance in the environment, both in the ponds and in the channels. Young cultured fish have a higher natural mortality rate, and the proportion of fish in substandard conditions vulnerable to predation may be higher (Temple 1987). Furthermore, young fish may not possess a fully developed ability of predator avoidance (Olla & Davis 1989).

Although it is not possible to compare directly diet composition assessed from spraints and fish remains, the present study shows clearly that spraint analysis can underestimate the proportion of larger fish in the diet of otters (Fig. 2). Only 7 individual carp exceeding 500 g were identified from spraints at Bezdrev locality, whilst 23 carp corpses exceeding this weight were found there. On the other hand, more pike remains were found in spraints than those found left partly uneaten, and remains of silver carp (>500 g) were not found at all.

The proportion of fish remains found may represent only a part of captured prey, because most of the remains may be secondarily consumed by other predators until the next day and only frozen fish remains can last a longer time. Nevertheless the total number of remains found was relatively low when compared with the area of study. A d á m e k et al. (2003) found 24 fish corpses during two winter periods and B o d n e r (1998) and K r a n z (1998) concluded that leaving uneaten prey remains was a rare event. However, this conclusion meets with strong disagreement of many fishermen, who have negative experience with otters which depleted nearly all fish stock from their pond during the winter period. Cases often report at least one otter-killed fish found at the bank or ice almost every day. All these cases were reported by private owners of small ponds situated in areas where very few other sources of food appeared to be available to otters in the winter period. The results of this study did not prove that otter predation had serious impact to the fish stock. Just few partially eaten fish remains were found at one out of three study localities only. About 40% of carcases can be undoubtedly classified as a case of excessive hunting, where otters eat only a small part of the body mass and, judging from the fact that in such cases usually more carcases were found at once, most likely continued in hunting. All fish remains were found near small ponds or channels with high stock density. The results of this study, as well as studies of other authors (E r l i n g e 1968, B o d n e r 1998, A d á m e k et al. 2003), indicate that the extent of damage to fish stocks depends on size of the pond and stock density. In the case of a large fishery enterprise this kind of predation does not seem to cause higher financial loses. However, particular small water basins with high stock density can be threatened by serious damage to the fish stock, especially during the winter period, where no other potential source of food is available.

The proportion of larger fish in otter diet reported in the present study is higher than in studies based on spraint analysis alone. Nevertheless small fish (<200 mm) still predominated in the diet and in particular small non-commercial species were captured in very high numbers. Larger commercial fish species were captured occasionally but assessing their proportion accurately meets methodological limitations. Of commercial fish species, only carp was caught in higher numbers than expected from its density in the pond stock. Pike and zander are often believed to be a preferred prey for hunting otters by many fishermen. However, this idea was not confirmed in the present study, although Ivlev´s index of electivity showed a higher proportion of pike and zander in the diet than in the stock. Proportions of these species, both in the stock and in the diet, were too low in comparison with the abundance of carp to provide an objective comparison: a more detailed analysis of the fish stock (including non-commercial fish species from ponds and channels) would be needed for a valid comparison. In fact, as less than 20 individuals of these species were recorded in the diet of otters, so they cannot be considered as a preferred food item.

Understanding of otter feeding behaviour can help predict damage caused to fish stock at ponds. Together with information about the size of ponds, fish stock composition and density it is possible to predict those places highly vulnerable to otter predation. Prevention of damage on such ponds is the only way of reducing of financial losses. Whenever possible, preventive measures, such is stocking the most vulnerable and valuable fish in less vulnerable ponds or preventing otters entering the pond, should be applied. Wire or electric fences have certain limitations, but the most vulnerable small-sized ponds should be relatively easy to protect.

A c k n o w l e d g e m e n t s

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Appendix 1. Regression equations used for the reconstruction of original weight from TL (mm).

Species	Regression	TL min.	TL max.	n	r
Carp	$W = 6.19 \times 10^{-6} \times TL^{3.17}$	42	486	159	0.99
Roach & Rudd	$W = 9.14 \times 10^{-7} \times TL^{3.51}$	34	313	94	0.99
Perch	$W = 1.85 \times 10^{-6} \times TL^{3.38}$	55	350	33	0.99
Common bream	$W = 6.02 \times 10^{-6} \times TL^{3.13}$	80	460	45	0.99
Pike	$W = 3.44 \times 10^{-6} \times TL^{3.13}$	146	630	33	0.98
Zander	$W = 4.52 \times 10^{-6} \times TL^{3.13}$	141	542	53	0.99
Bighead & Silver carp	$W = 5.92 \times 10^{-6} \times TL^{3.13}$	158	630	24	0.99
Prusian carp	$W = 7.0 \times 10^{-6} \times TL^{3.21}$	217	420	8	0.99
Tench	$W = 4.22 \times 10^{-6} \times TL^{3.21}$	92	355	33	0.99
Grass carp	$W = 3.24 \times 10^{-6} \times TL^{3.21}$	109	660	18	0.99