

## Seasonal exploitation of amphibians by otters (*Lutra lutra*) in north-east Scotland

J.-M. WEBER<sup>1</sup>

*Institute of Terrestrial Ecology, Banchory, Scotland*

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(With 2 figures in the text)

The dietary importance of amphibians to otters was studied in north-east Scotland in 1987. The proportion of amphibians identified in otter droppings varies seasonally and according to the habitat. The consumption of amphibians increases in late winter and spring while they are either hibernating or spawning. Estimations of amphibian population density at spawning sites have been carried out. There is a significant correlation between the availability of amphibians and their consumption by otters. The main amphibian species involved in the diet is the common frog, *Rana temporaria* (60.8%), while the common toad, *Bufo bufo*, represents only 1.7% of the amphibian prey.

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### Introduction

The European otter, *Lutra lutra*, is an endangered species. The freshwater populations are decreasing dramatically throughout Europe (Mason & Macdonald, 1986). Factors such as pollution, persecution, habitat destruction and food availability affect its survival.

To prevent its complete disappearance we need to understand the existing links between otters and those factors. Several studies have indicated that fish dominate the diet (Erlinge, 1967; Jenkins, Walker & McCowan, 1979; Chanin, 1981), but other prey such as birds, mammals, amphibians and invertebrates are also eaten, presumably according to their availability (Lopez-Nieves & Hernando Casal, 1984).

Little is known about predation on amphibians by otters. Fairley (1984) describes this phenomenon in Ireland. In Scotland, Jenkins & Harper (1980) found monthly variation in

<sup>1</sup> Present address: Université de Neuchâtel, Institut de Zoologie, Chantemerle 22, 2000 Neuchâtel, Switzerland

predation on amphibians by otters; however, they did not correlate the dietary importance of amphibians with their availability.

This paper reports the dietary importance of amphibians to otters occupying different habitats and the relationship between consumption and availability of amphibians.

### Study area

The main study area was situated in the drainage of the River Dee, 50 km west of Aberdeen, Scotland. It included two eutrophic lochs, Clarack (*c.* 0.02 km<sup>2</sup>) and Davan (*c.* 0.47 km<sup>2</sup>), one mesotrophic loch, Kinord (*c.* 0.7 km<sup>2</sup>), a permanent marshy area, three small streams, and a major tributary of the lower River Dee. Two of these streams flow directly into the Dee (Monandavan and Tarland Burns). The other flows into Loch Davan (Logie Burn). Monandavan Burn (*c.* 4 km long) passes through temporary wet areas and birch woodland. Tarland (*c.* 8 km) and Logie Burns (*c.* 7.5 km) drain primarily agricultural land (pasture and cereals), spruce plantations and deciduous hedges. An artificial pond (*c.* 1 ha) is present on Logie Burn. The permanent marshy area, Coull Marsh (2.5 ha), is situated 1.5 km west of Tarland Burn. It is surrounded by agricultural land and is partly drained by a network of ditches. The major tributary, the River Feugh, drains primarily agricultural land in its lower reaches and moorland in its upper reaches.

### Materials and methods

A representative 4 km stretch along each stream and river was chosen, and twice each month, from February to December 1987, all the otter faeces ('spraints') found there were collected. All known sprainting sites around the lochs and in the marsh were sampled similarly.

The spraints were analysed as described by Jenkins *et al.* (1979). Fish and amphibian remains were identified with a reference collection, the mammalian hair following Debrot *et al.* (1982), and the feathers according to Day (1966). No quantitative analysis was made. The results of the analysis were expressed as relative frequency of occurrence (% of the total number of prey items). It is generally agreed that this type of analysis introduces a bias in the results, but a bias, although smaller, also occurs in quantitative scat analysis. The entire dropping has to be picked up, and this is not always obvious because the older the spraint, the greater the chance of leaving some remains (*i.e.* scales, small bones) on the sprainting site. Hence the quantitative analysis becomes biased. Furthermore, most of the results found in the literature are expressed in 'frequency of occurrence', so that to compare results between them it is more convenient to use the same analysis. Results were also given by meteorological seasons: spring (March–May), summer (June–August), autumn (September–November) and winter (December–February). No data were collected in January.

Every amphibian spawning site in each spraint sampling area was recorded and numbers of egg clumps laid in the water were estimated as an index for the population of frogs. Toads, however, were simply recorded as present or absent, because their eggs were difficult to spot and spawning sites were usually in deeper water than those of frogs.

To test the results, chi-square tests and, when sample size was small, Fisher exact probability tests (Siegel, 1956) were used. To compare prey classes and location, reciprocal averaging (Hill, 1973) was used. This method is rather similar to the principal components analysis (PCA), but is more specific to the analysis of contingency tables. Its main advantage over the PCA is to ordinate simultaneously observations and variables (here the locations represent observations and prey classes represent variables), giving a unique scatter diagram. Thus the interpretation of the diagram is much easier. The set of points may be interpreted as a map, where the proximities represent resemblances. The variables are situated closer to the observations for which the frequency is important than to the other observations.

## Results

### *Occurrence of amphibians in the diet*

A total of 919 spraints was collected (Table I). Fish dominated the diet in every area. Amphibians were of secondary importance and mammals (lagomorphs only), birds and insects were taken occasionally by otters (Table II).

The lowest relative frequency of occurrence of amphibians in spraints occurred in the Feugh area (13% of the diet). That proportion increased in the loch areas (15–20%) and along the small streams (20–25%). The differences, however, were statistically non-significant (except between the River Feugh and Monandavan Burn) (Table III).

Consumption of amphibians was statistically more frequent in Coull Marsh and Logie Burn (47% and 37% of the items were amphibian remains) (Table III).

### *Seasonality of predation on amphibians*

The overall diet figures must, however, be considered cautiously because there were seasonal variations in the consumption of amphibians (Table IV).

In Coull Marsh, otters were exploiting amphibians mainly in late winter and in spring, when amphibians were available. In summer when amphibians were absent, otters had apparently deserted the marsh, since no evidence of their presence (tracks, spraints) was found (Table V).

In the Feugh area, amphibians occurred in almost 30% of the spraints during spring. That proportion fell below 3% during the other seasons. These differences were statistically significant (Table V). In Loch Davan and Loch Kinord, the otters fed more on amphibians during spring than in summer and in autumn (Table V). There, winter predation was also important. In Loch Clarack, although there were no significant differences, the frequency of occurrence of amphibians in the spraints was higher in spring and in winter.

Along the small streams, the seasonality of predation on amphibians was less obvious. The frequency of occurrence of amphibians in the diet was also fairly important in summer and in autumn, especially along Logie Burn (Table IV). However, the consumption of amphibians was higher in spring.

TABLE I  
*Spraints collected in different habitats in 1987*

	Clarack	Coull	Davan	Feugh	Kinord	Logie	Monandavan	Tarland
February	3	19	24	28	21		15	7
March	20	28	28	17	38		10	6
April	4		28	11	33	7	17	2
May	6		12	12	19	2	5	5
June	2		8	11	19	1	1	4
July			20		16	1	9	6
August			11	5	17	2	6	7
September	2		24	10	22	1	9	10
October	5	7	27	10	24	7	11	16
November	14		27	15	16	3	12	14
December	3		16	11	10	8	10	2
Total	59	54	225	130	235	32	105	79

TABLE II

Prey consumed by otters in different habitats for 1987. *N*, number of prey items; %, relative frequency of occurrence

	Clarack		Coull		Davan		Feugh		Kinord		Logie		Monandavan		Tarland	
	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%
Fish	54	73.0	48	51.6	223	79.9	112	68.7	212	76.0	31	63.3	98	75.4	76	75.2
Amphibian	12	16.2	44	47.3	45	16.1	21	12.9	53	19.0	18	36.7	29	22.3	18	17.8
Mammal	1	1.3	1	1.1	1	0.4	24	14.7	2	0.7	0	0.0	2	1.5	4	4.0
Bird	2	2.7	0	0.0	5	1.8	3	1.8	8	2.9	0	0.0	1	0.8	2	2.0
Insect	5	6.8	0	0.0	5	1.8	3	1.8	4	1.4	0	0.0	0	0.0	1	1.0
Total	74	100.0	93	100.0	279	100.0	163	100.0	279	100.0	49	100.0	130	100.0	101	100.0

TABLE III

Comparison ( $\chi^2$ ) of the proportion of amphibians in the diet of otter in different habitats

CK	16.08	0.01	0.28	0.11	5.46	0.67	0.00
	++	-	-	-	+	-	-
CL	35.57	35.26	27.56	1.06	14.28	18.03	
	++	++	++	-	++	++	
DN	0.62	0.61	10.11	1.89	0.06		
	-	-	++	-	-		
FG	2.34	12.73	3.90	0.85			
	-	++	+	-			
KD	6.72	0.42	0.01				
	++	-	-				
LB	3.12	5.47					
	-	+					
MN	0.46						
	-						
TB							

CK, Clarack; CL, Coull; DN, Davan; FG, Feugh; KD, Kinord; LB, Logie; MN, Monandavan; TB, Tarland

-, insignificantly different; +, significantly different (0.05 >  $P$  > 0.01); ++, significantly different ( $P$  < 0.01)*Amphibian species involved in the diet*

A total of 240 spraints contained amphibian bones (Table VI). Common frog (*Rana temporaria*) remains were identified in 146 spraints (60.8%) while common toad (*Bufo bufo*) remains were identified in only four spraints (1.7%). It was not possible to identify the amphibian remains in 90 spraints (37.5%), because of the absence of characteristic bones such as jaw, femur or bones of the pectoral girdle.

Although they were present in the area, no palmate newts, *Triturus helveticus*, were identified in the spraints.

TABLE IV

*Seasonal relative frequency of occurrence of amphibians (%) in otter diet in different habitats. N, number of amphibian remains. Total number of prey items in parentheses*

	Clarack		Coull		Davan		Feugh		Kinord		Logie		Monandavan		Tarland	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Spring	9 (37)	24.3	28 (51)	54.9	24 (92)	26.1	19 (64)	29.7	31 (117)	26.5	7 (15)	46.7	8 (37)	21.6	7 (21)	33.3
Summer	0 (2)	0.0	0 (0)	0.0	3 (47)	6.4	0 (17)	0.0	6 (53)	10.9	1 (5)	20.0	2 (15)	13.3	3 (21)	14.3
Autumn	2 (27)	7.4	1 (8)	12.5	6 (87)	6.9	1 (36)	2.8	7 (68)	10.3	4 (15)	26.7	7 (38)	18.4	6 (48)	12.5
Winter	1 (7)	14.3	15 (34)	44.1	12 (53)	22.6	1 (46)	2.1	9 (39)	23.1	6 (14)	42.8	12 (39)	30.8	2 (11)	18.2

TABLE V

*Seasonal differences in amphibian consumption by otters in different habitats (Fisher exact probability test)*

	Clarack	Coull	Davan	Feugh	Kinord	Logie	Monandavan	Tarland
Spring/summer	1.00000	1.00000	0.00588*	0.02052*	0.02809*	0.60268	0.70389	0.27716
Spring/autumn	0.10035	0.05232	0.00059*	0.00124*	0.01334*	0.44972	0.77917	0.05257
Spring/winter	0.67324	0.38011	0.69390	0.00026*	0.83272	1.00000	0.43932	0.44138
Summer/autumn	1.00000	1.00000	1.00000	1.00000	0.99999	1.00000	0.41527	1.00000
Summer/winter	1.00000	1.00000	0.02681*	1.00000	0.15943	0.60268	0.30154	1.00000
Autumn/winter	1.00000	0.12709	0.00939*	1.00000	0.09369	0.44972	0.29136	0.63476

\*, significantly different

TABLE VI

*Amphibians as proportion of the number of prey items (%) in otter spraints from different habitats. N, number of prey items*

	Clarack		Coull		Davan		Feugh		Kinord		Logie		Monandavan		Tarland	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Frog	4	33.3	40	90.9	25	55.6	12	57.1	29	54.7	8	44.4	18	62.1	10	55.6
Toad	0	0.0	0	0.0	0	0.0	0	0.0	2	3.8	0	0.0	2	6.9	0	0.0
Unidentified	8	66.7	4	9.1	20	44.4	9	42.9	22	41.5	10	55.6	9	31.0	8	44.4
Total	12	100.0	44	100.0	45	100.0	21	100.0	53	100.0	18	100.0	29	100.0	18	100.0

*Amphibian populations*

Spawning frogs were distributed differently depending on habitat. In Lochs Davan and Kinord, they were clumped primarily in marshy areas. There were estimated to be 800 individuals on 7 ha (114/ha) and 400 on 4 ha (100/ha), respectively. In Loch Clarack, the frogs were distributed in patches along the grassy banks, but in smaller numbers (164 individuals on 2.7 ha (60/ha)). Toad spawning sites were found in Lochs Kinord and Clarack.

Along the streams, however, frog spawning sites were scarce. In the Feugh area, only three sites were found. Two were very small (six and 12 individuals) and situated in a temporary body of water near the stream. The other (154 individuals) was in a permanent pond, where toads were also present. The surface covered by the spawning site was about 1 ha. There were few frog spawning sites along Tarland and Monandavan Burns. On Tarland Burn, only one site was found, in a small temporary pond (64 individuals), while on Monandavan Burn three sites were situated in temporary bodies of water (18, 16 and 98 individuals on 1.5 ha (88/ha)). No toad spawning sites were found in either area. On Logie Burn, there were two frog spawning sites. One was in wet pasture (16 individuals), the other in an artificial pond (c. 1 ha) situated close to the stream (174 individuals). There, toads were numerous.

In Coull Marsh the frogs were distributed uniformly. There were estimated to be approximately 1200 reproducing adult frogs on 2.5 ha (480/ha). No toads were present.

*Comparison of otter diet, location and amphibian populations*

Was the predation on amphibians associated with a particular location?

TABLE VII

Number of amphibian items found in otter spraints collected during spring in each area, associated with amphibian populations. (Numbers of other prey items used for the reciprocal averaging analysis are also given)

Area	POPU: Amphibian density (indiv./ha)	AMPH: Amphibian prey items	Other prey items		
			FISH	MAMM	BIRD
Coull (CL)	480	28	22	1	
Clarack (CK)	60	9	25	1	1
Davan (DN)	114	24	67		1
Feugh (FG)	172	19	27	15	2
Kinord (KD)	100	31	80		5
Logie (LB)	190	7	8		
Monandavan (MN)	88	8	29		
Tarland (TB)	64	7	12	1	1

Abbreviations in capitals are those used on Fig. 1

This analysis (reciprocal averaging<sup>1</sup>) considered only the proportion of various prey items found in spraints collected during the spring when amphibian populations were estimated (Table VII). Insects were not included because of their very small relative frequency of occurrence.

<sup>1</sup> The proportion of variability absorbed by the factors corresponding to the axis is, respectively for the three axes, 75.8%, 19.7% and 4.5%.

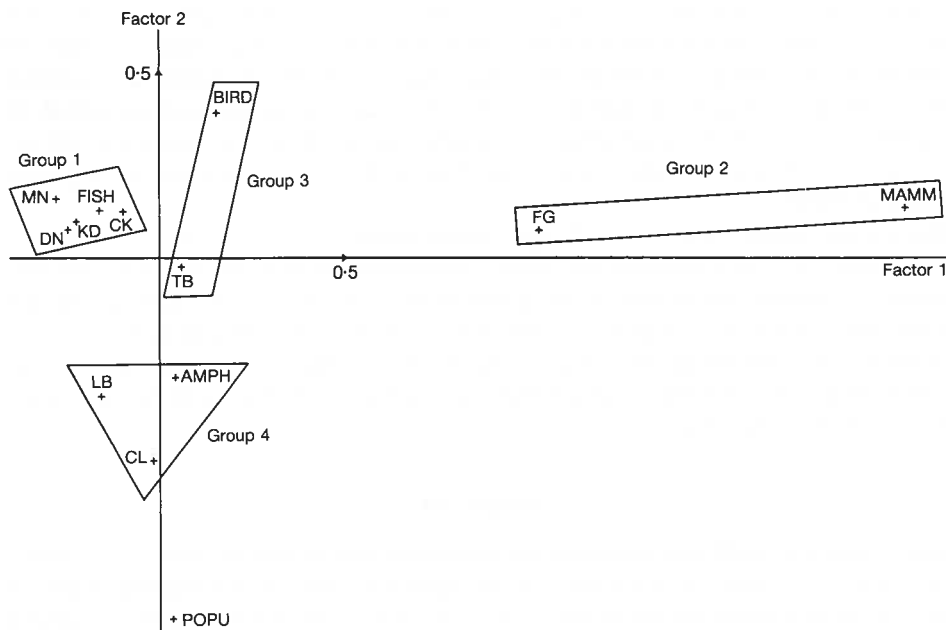


FIG. 1. Reciprocal averaging ordination of locations and prey classes (for explanation and abbreviations, see text).

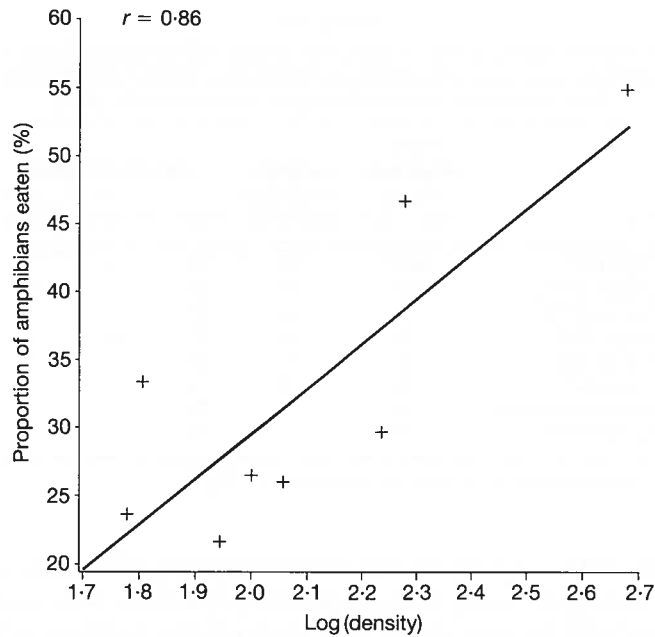


FIG. 2. Relationship between the proportion of amphibians eaten by otters during the spring (%) and amphibian availability (log density).

The graph shows the existence of four groups, formed with locations, all associated with a prey class (Fig. 1). Group 1, defined by the lochs (DN, KD, CK) and Monandavan Burn (MN), is associated with fish. Group 2 contains only the Feugh (FG), and is associated with mammals (MAMM). Group 3 contains Tarland Burn (TB). Although this area is not associated with any particular prey class, it shows some affinity with birds on the third axis, but values are very low. Finally, Group 4 contains Coull (CL) and Logie Burn (LB). Both these areas are associated with amphibians (AMPH).

Is this situation related to the availability of amphibians?

This question may be addressed by using 'amphibian density' (POPU) (Table VII) as a supplementary variable. Inspection of the graph (Fig. 1) shows that the population density of amphibians also lies within Group 4, the area associated with amphibians in spraints.

Furthermore, by correlating the proportion of amphibians identified in spraints collected during the spring to the density of amphibians in each area, we find a significant correlation:  $r=0.86$  ( $d.f.=6$ ,  $P<0.01$ ) (Fig. 2).

### Discussion

The diet of otters in north-east Scotland has been described by Jenkins *et al.* (1979) and Jenkins & Harper (1980). The results of the present study agree with these earlier findings. Fish remained the main prey. In most areas mammals and birds were only occasional prey, never exceeding 4% of items. These results are similar to those of Chanin (1981) and Adrian & Delibes (1987) amongst others. In the Feugh area, however, mammals occurred more often (14.7%). Jenkins *et al.* (1979)



found a similar proportion around the Dinnet lochs in 1976. They thought otters might have been compensating for a scarcity of eel, their usual prey. We do not know if this was happening in the River Feugh. Mammals were only consumed by otters in late winter-early spring. It is possible that salmonids were scarce at that time.

Insects also occurred in the diet but it is not known if they were consumed directly or if they originated from fish eaten by otters. Small insects, such as Trichoptera, were therefore not considered as otter's prey and only large beetles, such as *Dysticus* sp., were counted, which in any case were seldom found.

After fish, amphibians were the most important prey of otters in the study area. They represented 13 to 47% of the whole diet. These results differ from the conclusion of Mason & Macdonald (1986) that amphibians are not frequently eaten by otters in northern Europe. This is true for some areas; for example, on a study in south-west England, Chanin (1981) concluded that amphibians were negligible in the otters' diet (0.5%). It was found that amphibians were very scarce on the same study area (Wise, Linn & Kennedy, 1981). However, Erlinge (1967) demonstrated in Sweden that the proportion of amphibian remains in spraints could vary according to the habitat. In highly eutrophic lakes, surrounded by agricultural land, amphibians made up only 0.2% of the diet of otters, whereas this proportion reached 30% in streams flowing through wetland. This latter habitat is likely to contain more amphibians than the former. Thus the frequency of occurrence of amphibians in the diet is clearly related to their availability. In our study area, in habitats where amphibians were abundant such as Coull Marsh and Logie Burn, the consumption of amphibians was statistically higher than elsewhere.

It is difficult to compare the results of the present study with those of Jenkins *et al.* (1979) and Jenkins & Harper (1980) because they did not quantify amphibians in the diet of otters, although they did find a monthly variation in their occurrence. They found most amphibian remains in spraints collected in April, November and December, which generally agrees with the observations reported here.

The seasonality of predation on amphibians by otters may be directly related to amphibian reproductive and movement patterns. Otters prey on amphibians mainly when they congregate for either hibernation or spawning. Frogs in high population densities are easy prey for otters (Erlinge, 1967). This was obvious in areas, such as Coull, Logie Burn or the lochs, where amphibians gathered from October to April, hibernating and spawning in the same sites.

After spawning the amphibians left the water and most of them moved to the nearby woodlands, where otters did not usually forage (pers. obs.). Therefore the resulting lower numbers of amphibians in aquatic habitats might explain the decrease in their consumption by otters during the summer and in early autumn.

Such an intensive seasonal exploitation of amphibians may also result from a scarcity of usual prey. Eel, *Anguilla anguilla*, was the main prey of otters in the study area (mainly in the lochs area). During cold months, eels are less active and remain buried in the mud for much of the time (Jenkins *et al.*, 1979). Although other fish (e.g. perch, *Perca fluviatilis*) are available, otters do not appear to prey much on them (Weber, unpubl.) and therefore have to look for other prey. In Coull Marsh, otter tracks observed in the snow during the winter indicated that the animals were visiting the marsh from a small loch 3.5 km away. Such overland travels were also noticed by Green & Green (1980). Furthermore, the absence of signs of otters' presence in Coull Marsh during the summer may mean that they visited the marsh mainly to feed on amphibians which were only present in winter months.

Only two anuran species occur in the study area. Common frogs constituted the major part of

amphibian prey (61%), whereas toads represented less than 2% of the diet. Fairley & McCarthy (1985) found in Ireland that otters were not preying on breeding natterjacks, *Bufo calamita*, even though they were at high density. In Spain, where there is a greater diversity of amphibians, otters mainly fed on *Rana* species (Lopez-Nieves & Hernando Casal, 1984; Adrian & Delibes, 1987). Erlinge (1968) showed in an experimental food preference study that otters ate all offered prey but toads. A similar preference has been observed with two captive individuals (Weber, unpubl.). One otter was able to eat toads by skinning them, but they were never completely eaten. The other individual ate the first offered toad without skinning it but it was regurgitated within a few minutes. Both individuals ate frogs without any difficulty. The poisonous dermal secretion of the toad could be an important factor for otters in amphibian selection.

According to Jenkins *et al.* (1979), toads are less likely to be present in spraints than frogs, because they are often only partly eaten. Several toad carcasses were found in the Kinord area during the spring. Usually only the viscera and sometimes the limbs were missing; the head and the skin were always present. Although many of these toad carcasses were found near sprainting sites they may not have been killed by otter but perhaps by mink, *Mustela vison*, or fox, *Vulpes vulpes*, since both occur in the study area. It is also possible that a single otter had learnt to skin toads and was responsible for all the carcasses found. Circumstantial evidence for this is that almost no toad carcasses were found in the same area in 1988, although many toads were present (H. Kruuk, pers. comm.).

Amphibians, then, are an important prey for otters in north-east Scotland. During winter and spring when usual prey like eel is less available, otters have to find alternatives and amphibians gathered for hibernation and spawning during that time are easy prey. Exploitation of amphibians, mainly frogs, by otters is directly related to their abundance. Nowadays amphibian populations are decreasing throughout Europe as suitable habitats are destroyed for economic purposes (Arnold & Burton, 1978). Hence the disappearance of this food supply might adversely affect otter survival.

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