Ann. Zool. Fennici 47: 403–410 ISSN 0003-455X (print), ISSN 1797-2450 (online)
Helsinki 30 December 2010

Intensive exploitation of amphibians by Eurasian otter (*Lutra lutra*) in the Wołosaty stream, southeastern Poland

Stanisław Pagacz* & Julia Witczuk

*Museum and Institute of Zoology, Polish Academy of Sciences, Wilcza 64, PL-00-679 Warszawa, Poland (*e-mail: spagacz@miiz.eu)*

Received 22 Feb. 2010, revised version received 14 July 2010, accepted 29 July 2010

Pagacz, S. & Witczuk, J. 2010: Intensive exploitation of amphibians by Eurasian otter (*Lutra lutra*) in the Wołosaty stream, southeastern Poland. — *Ann. Zool. Fennici* 47: 403–410.

Eurasian otters, top predators of freshwater ecosystems, are food limited; thus, species conservation plans should consider local food resources. We used spraint (faecal) analysis to assess diet of otters inhabiting a river in the Polish Carpathians. Although elsewhere in their range otters feed mostly on fish, in our study area amphibians were equally important prey (43% of all prey occurrences, 54% of estimated biomass of consumed prey). Amphibians dominated in the otter diet in winter and spring, and occurred as often as fish in autumn. Only in summer was amphibian occurrence marginal. Typically, two factors explain seasonally high consumption of amphibians: limited fish availability and availability of amphibians gathered to spawn or hibernate. However, factors such as energetic costs of hunting may also cause seasonal changes in otter feeding behavior. Low water temperatures might increase the energetic cost of fishing in cold seasons and force otters to seek an alternative prey. This study raises the possibility that amphibian declines could negatively affect otters in cold, mountainous regions.

Introduction

The Eurasian otter (*Lutra lutra*) is a top predator of freshwater ecosystems. Otters occur through most of Europe, Asia, and North Africa and are found in various semi-aquatic habitats, including lake shores, rivers, small streams, sea coast, and even irrigation ditches. Water pollution caused massive otter declines in Europe in the latter half of the 20th century (Kruuk 2006). Despite their successful recent recovery in many areas (Conroy & Chanin 2002), otters are still considered a species of conservation concern by the European Union (Council Directive 92/43/EEC). Currently, beside water pollution, one of the most serious threats to otters is decline of their food resources (Kruuk 2006). Fish, the primary prey of otters (Mason & Macdonald 1986, Chanin 2003, Kruuk 2006) are negatively affected by over-fishing, pollution and other human caused disturbances (Stone 2003).

Under some conditions alternative prey, usually crustaceans and amphibians may be consumed (Jędrzejewska *et al*. 2001, Clavero *et al*. 2003). The share of these alternative prey items in the diet varies regionally and seasonally (Adrian & Delibes 1987, Weber 1990, Sidorovich *et al*. 1998, Clavero *et al*. 2005, Brzeziński *et al*. 2006). Recent studies indicate that the food niche of otters is affected by habitat structure and stability. Fish dominate in the otter diet in complex and stable habitats — water bodies with diverse microhabitats and small changes in water level. These habitats typically host sizable fish populations. Conversely, in simple or variable habitats, fish availability is often limited (e.g., due to ice cover or droughts) and otters temporally increase predation on alternative prey (Clavero *et al*. 2003, Clavero *et al*. 2008, Remonti *et al*. 2008, Ruiz-Olmo & Jiménez 2009). Because otters are known to be food-limited (Kruuk & Carss 1996, Ruiz-Olmo *et al*. 2001, Kruuk 2006), knowledge of their feeding habits has practical importance for conservation of the species. Our objective was to assess the seasonal variation in otter use of fish and alternative prey, particularly amphibians, in a habitat where both fish and amphibians were available. The study was one component of the research begun in 2008 into otter ecology and population genetics in the Bieszczady Mountains, region of the Carpathian Mountains.

Material and methods

Study area

The study was conducted along the Wołosaty stream in the Bieszczady Mountains, southeastern Poland (22°40´E, 49°08´N). The study area lies in the temperate continental climate zone and is characterized by cold winters and mild summers. The average temperatures in July and January are 17 °C and –3 °C, respectively. The annual precipitation is 900–1100 mm (Nowosad 1995). Precipitation peaks in July, when 150–170 mm falls as rain, and is minimal in January, when 70 mm falls, usually as snow (Winnicki & Zemanek 2003).

The Wołosaty is a medium size stream (28 km long) with stony bed and fast current. The majority of the drainage basin (118 km^2) is protected within Bieszczady National Park, which is part of the "East Carpathians" International Biosphere Reserve. Stream flow peaks in April. There are two annual periods of low flow from September to October and again from January to February. The stream never dries up but does partially freeze over in winter. Banks are overgrown with trees, primarily alder (*Alnus incana*) and beech (*Fagus sylvatica*). At the upper end of the study area (700 m a.s.l.), the stream is 10 m wide and about 0.2 m deep, whereas at the lower end (540 m a.s.l.) it is 20 m wide and 0.3 m deep. Locally, depth may reach 1.5 m.

The Wołosaty stream contains 13 fish species. The most numerous are Alpine bullheads (*Cottus poecilopus*), brown trout (*Salmo trutta*), and minnows (*Phoxinus phoxinus*) (Kukuła 1999). In terms of biomass, brown trout predominate. A rough estimate of fish biomass in the studied section of the Wołosaty is about 3–4 g m^{-2} (Kukuła 1995). The most common amphibians in the study area are yellow-bellied toad (*Bombina variegata*), common frog (*Rana temporaria*), and common toad (*Bufo bufo*) (Głowaciński *et al*. 1995). The noble crayfish (*Astacus astacus*), also potential prey for otters, occurs only in the lower part of the stream (Kukuła 2000).

From our observations, we know that the Wołosaty is intensively used by otters in all seasons. Along the numerous small tributaries of the main stream, otter tracks and spraints are present up to 800 m a.s.l. (own unpubl. data). The Wołosaty's drainage basin is surrounded by extensive areas of forested mountains, where many similar size or smaller streams, offer comparable habitats for otters.

Field sampling and spraint analysis

We assessed otter diet by analysing spraints (faeces). Otter spraints are easy to find, as they are typically deposited on prominent rocks or logs. Spraints were collected along 10 sampling transects (Fig. 1). Transects, each about 0.2 km long, were located near bridges or other easily accessible sites. The upper transect was placed 10 km from the stream's source, with the lowest at the stream's mouth; the distance between transects was approximately 1.5 km. We collected spraints from February 2008 to November 2009. Based on the time of collection, we assigned them into one of four seasons: spring (April–May), summer (July–August), autumn (October–November), and winter (January–February). Spraints were stored in paper envelopes labeled with date, name of transect and GPS coordinates. Prior to the analysis, spraints were

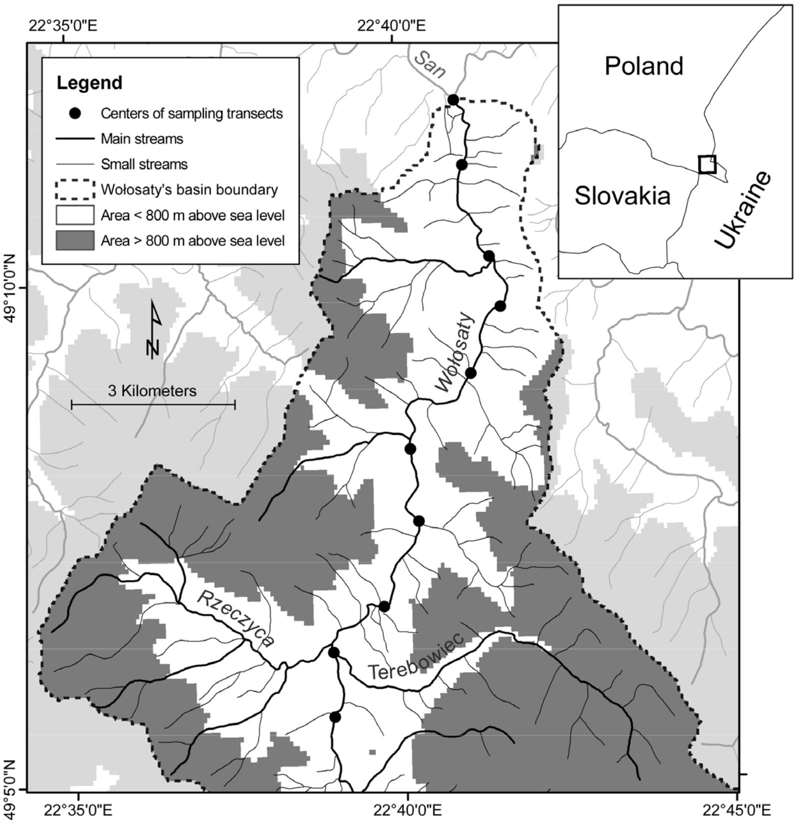

Fig. 1. Locations of sampling transects along the Wołosaty stream, southeastern Poland, where otter spraints were collected in 2008–2009. Area below 800 m elevation constitutes potential otter habitat.

soaked in water with detergent, washed through a 0.5 mm sieve, and air dried. Prey remains were assigned to six categories: fish, amphibians, mammals, birds, insects, and crayfish. Identification of items was based on characteristic features such as shape and color of bones, shape of teeth, or the presence of feathers, fur, or parts of exoskeletons.

We expressed diet composition in two ways. Firstly, we calculated the relative frequency of occurrence [RFO = (number of occurrences of a given prey category)/(number of all occurrences of all prey categories) × 100]. This method may over-estimate the importance of small but frequently occurring prey categories and under-estimate the importance of larger prey with small bones to flesh ratio (Carss & Parkinson 1996, Ciucci *et al*. 1996, Jacobsen & Hansen 1996). Despite its drawbacks, RFO is commonly used to estimate diet composition as it gives a reasonable picture of the relative importance of prey groups in the diet (Erlinge 1968, Carss & Parkinson 1996, van Dijk *et al*. 2007). It is also the simplest method of fecal analysis and permits comparison of diet composition across the many studies which employ this method. Because of the caveats associated with the use of RFO, we also expressed diet composition as a percentage of biomass [PB = (biomass of a given prey category)/(biomass of all prey) × 100]. This method avoids the main limitations of the RFO, as it takes into account both the weight of the prey remains and the proportion of indigestible matter specific to a given type of prey (Litvaitis 2000, Jędrzejewska *et al*. 2001). The biomass of prey is estimated by multiplying the weight of prey remains by a corresponding coefficient of digestibility. The coefficients are typically obtained through feeding experiments with captive animals by calculating the ratio: (weight of prey eaten)/(dry weight of its remains in scats). We used the following coefficients: fish: 25, amphibians: 18, rodents: 9, birds: 12, crayfish: 7 (Fairley *et al*. 1987), and insects: 5 (Lockie 1961). All analyses were conducted separately for each season and sample transect.

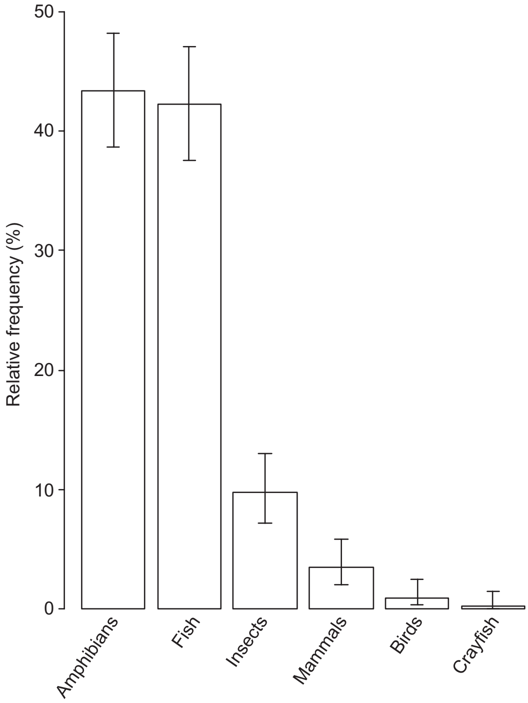

Fig. 2. The relative frequency of occurrence (RFO) of prey groups in Eurasian otter (*Lutra lutra*) spraints from the Wołosaty stream (Poland); RFO = [(number of occurrences of a given prey category)/(number of all occurrences of all prey categories) × 100], number of spraints = 284, number of prey items = 431; error bars represent 95% confidence intervals for binomial sampling distribution.

Statistical computations were performed and figures created with the program R (R Development Core Team 2009). As suggested by Carss and Parkinson (1996), we present RFO values together with 95% confidence intervals for binomial distribution.

Results

We collected and analyzed 284 spraints. Spraints were frequently encountered at all transects. Amphibians and fish were dominant and equally important prey of otters, constituting 43% and 42% of all prey occurrences, respectively (Fig. 2). Similarly, in the biomass analysis amphibians accounted for 54%, and fish 44% of estimated prey biomass.

There was a clear seasonal pattern in otter diet (Fig. 3). In winter and spring, the frequency of occurrence of amphibians (RFO = 54% and 59%, respectively) was significantly higher than that of fish (32% and 22%, $\chi^2 = 35.1$, df = 3, $p < 0.001$). The pattern was similar for percentage of biomass (amphibians PB = 66% and 69%, fish PB = 33% and 28%, $\chi^2 = 156$, df = 3, $p < 0.001$). Conversely, fish were the staple diet of otters (RFO = 80%, PB = 93%) in summer, when amphibians occurred only occasionally (RFO = 9%, PB = 5%). In the autumn, both prey groups contributed equally to the diet (RFO about 40%

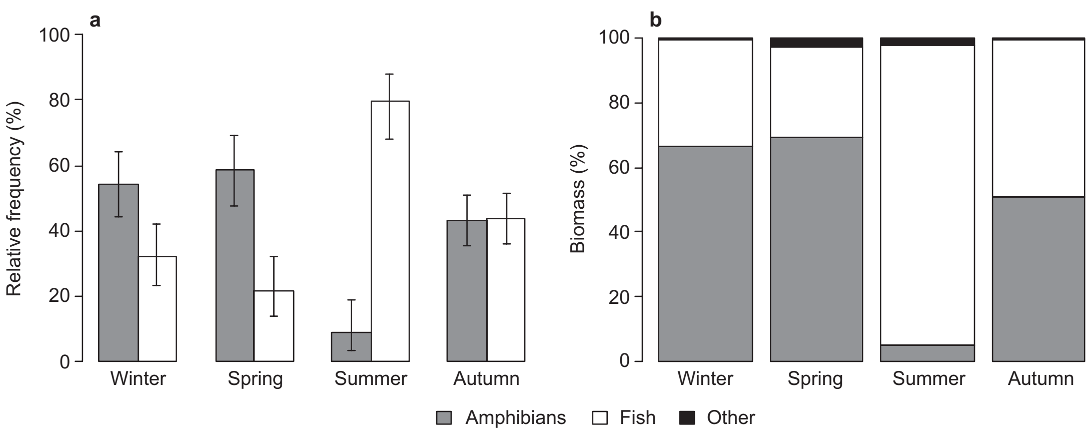

Fig. 3. (**a**) The relative frequency of occurrence of amphibian and fish remains, and (**b**) the estimated percentage of biomass of main groups of prey in Eurasian otter (*Lutra lutra*) spraints from the Wołosaty stream (Poland) across seasons. Number of spraints: winter: 65, spring: 55, summer: 61, autumn: 103.

and PB about 50% each). As expected, the importance of minor prey items, particularly insects, was overestimated by the RFO method relative to the PB method. Insects accounted for 10% of prey occurrences but only for 0.4% of prey biomass. They usually constituted a minor part of spraint (i.e., one or two individual insects) and only two spraints were entirely composed of insect remains. Insects are often found in spraints but it is difficult to distinguish whether they were eaten by otters or were incidentally ingested (Mason & Macdonald 1986). Most of the insects we detected were stonefly (Plecoptera) larvae, a common prey of brown trout and alpine bullhead (Holmen *et al*. 2003, Hesthagen *et al*. 2004), so it is probable that the insects were ingested together with fish alimentary tracks. Mammals, birds, and crayfish represented together only 5% of prey occurrences, and 1% of prey biomass. We did not find any spatial pattern in prey occurrence across the river length.

Discussion

The importance of amphibians

The high frequency of amphibians in the otter diet is the most striking finding of our research. Although elsewhere otters feed mainly on fish (Mason & Macdonald 1986, Chanin 2003, Kruuk 2006), in our study area, amphibians were equally important prey. Amphibians dominated in the otter diet in winter and spring and contributed equally with fish in the autumn. Summer was the only season when amphibians were consumed less frequently than fish.

Intensive otter predation on amphibians and the seasonal switch in otter diet are typically explained by two factors, which are not mutually exclusive. Firstly, otters may switch from fish, the preferred prey (Erlinge 1968), to an alternative food if fish availability is seasonally limited (Clavero *et al*. 2003). For example, otters in northeastern Scotland travelled 3.5 km overland to a marsh where they could prey on hibernating frogs when winter fish became unavailable (Weber 1990). Otters in central Finland (Sulkava 1996) also increased their use of amphibians in winter when fish density declined in rivers at the same time that ice-cover on lakes prevented otters from entering the water. Secondly, during cold seasons amphibians, gathered in shallow streams to hibernate or spawn, are a readily accessible food source. In many areas, increased predation on amphibians coincides with amphibians' spawning and hibernation periods (Weber 1990, Clavero *et al*. 2005, Britton *et al*. 2006). However, other factors may contribute to seasonal changes in otter feeding behavior. Otter prey choice and rate of predation upon alterative prey may depend on the balance in energy gain and expenditure associated with fishing *versus* hunting of alternative prey. This balance is affected not only by prey abundance, but also by factors such as prey congregations, prey mobility, seeking time, energetic value of prey, and energetic costs of hunting of a given prey. Low water temperatures in cold seasons increase the energetic costs of fishing and might cause otters to minimize time in this activity. Using captive otters, Kruuk *et al*. (1994) experimentally demonstrated that the main energetic cost of fishing results from the need to maintain body temperature at low water temperatures. If otters find fishing in cold water — particularly at a time of lower fish availability — to be energetically inefficient, they would be likely to seek alternative prey. Hunting groups of hibernating frogs in small, shallow tributaries is likely less energetically demanding than fishing. The low calorific value of amphibians relative to fish (Nelson & Kruuk 1997) could be counteracted by the fact that when an aggregation of amphibians is found, they constitute a substantial meal. Catching birds or mammals would generally be more difficult and less profitable.

A few authors have reported relatively intense seasonal predation on amphibians by Eurasian otter inhabiting small woodland rivers, montane streams, and lakes that completely freeze over (Harna 1993, Sulkava 1996, Sidorovich *et al*. 1998, Jędrzejewska *et al*. 2001, Brzeziński *et al*. 2006, Remonti *et al*. 2008, Smiroldo *et al*. 2009). However, the frequency of amphibians in otter spraints in our study area is the highest reported for temperate climates (Table 1). In fact, this is one of the first reports of otters seasonally using amphibians at higher rates than fish. Other studies report that Eurasian otters consume amphibians at relatively high rates (~30%–40%), but

Table 1. Seasonal diet studies of Eurasian otter (*Lutra lutra*) that report intensive exploitation of amphibians in temperate areas. For purpose of comparison, the frequency of occurrence reported in Sidorovich *et al.* (1998) and Jędrzejewska *et al.* (2001) were recalculated to relative frequency of occurrence [(number of occurrences of a given prey category)/(number of all occurrences of all prey categories) × 100]. F = fish, A = amphibians.

Country/ type of habitat	Relative frequency of occurrence (%)								*n*	Source
	Winter		Spring		Summer		Autumn			
	F	A	F	A	F	A	F	A		
Poland										
Mountain stream	32	54	22	59	80	9	44	43	284	This study
Mountain streams	57	40	58	39	62	36	52	46	214	Brzeziński *et al.* 2006
Mountain streams	70	15	54	29	61	7	63	12	379	Harna 1993
Woodland streams			33*	19			38	45	396	Jędrzejewska *et al.* 2001
Belarus										
Lakes and rivers	60	31	47	39	42	24	57	40	641	Sidorovich *et al.* 1998
Finland										
Lakes and rivers	64	25	71	10	75	3	70	15	1506	Sulkava 1996

* Results were pooled by authors for spring–summer and autumn–winter.

with only one exception (Jędrzejewska *et al.* 2001), otters use of fish exceeded their use of amphibians in all seasons. Together, these studies highlight the importance of amphibians for otter populations living in habitats with relatively low fish availability.

Conservation implications

The relatively pristine habitats in the Carpathian Mountains host stable otter populations that may be important for the species' persistence. These populations could serve as a source for recolonization of lowland populations following a catastrophic event (e.g., accidental river pollution). Immediately, the presence of quality, high-elevation habitats likely serves to maintain connectivity between otters on the north and south sides of the range.

Given that otters typically prefer fish when fish are available, the presence of large amounts of amphibians in the diet may indicate that habitat is sub-optimal. Based on a literature review, Chanin (2003) suggests that otters can survive and breed if the biomass of fish is above 10 g m^{-2}. In many streams permanently inhabited by otters in the Bieszczady Mountains, fish biomass is as low as 2–3 g m^{-2} (Kukuła 1995). Otters in these and other locations with similarly low fish biomass may depend on amphibians for survival. Effective otter conservation will require a more complete understanding of the spatial and temporal dynamics of prey switching by otters and the effects of alternative prey, particularly amphibians, on otter survival and reproduction. Informed by such research, local prey populations might be effectively manipulated to improve the quantity, quality, and temporal availability of otter food resources. For example, otter conservation plans might incorporate activities to support amphibian populations such as protecting amphibian spawning and hibernation sites. Additionally, such research would shed light on the possible impacts of amphibian declines (Stuart *et al*. 2004) on otter populations.

Acknowledgements

We are grateful to Suzanne Griffin, Joanna Gliwicz and two anonymous reviewers for helpful comments on the manuscript, Suzanne Griffin for improving English of the manuscript, and Krzysztof Madej for assistance in the field. The study was funded by the Polish Ministry of Science and Higher Education (grant number N N304 080935).

References

Adrian, M. I. & Delibes, M. 1987: Food habits of the otter

(*Lutra lutra*) in two habitats of the Doñana National Park, SW Spain. — *Journal of Zoology, London* 212: 399–406.

Britton, J. R., Pegg, J., Shepherd, J. S. & Toms, S. 2006: Revealing the prey items of the otter *Lutra lutra* in South West England using stomach contents analysis. — *Folia Zoologica* 55: 167–174.

Brzeziński, M., Romanowski, J., Kopczyński, Ł. & Kurowicka, E. 2006: Habitat and seasonal variations in diet of otters, *Lutra lutra* in eastern Poland. — *Folia Zoologica* 55: 337–348.

Carss, D. N. & Parkinson, S. G. 1996: Errors associated with otter *Lutra lutra* faecal analysis. I. Assessing general diet from spraints. — *Journal of Zoology, London* 238: 301–317.

Chanin, P. 2003: *Ecology of the European otter*. — Conserving Natura 2000 Rivers Ecology Series no. 10, English Nature, Peterborough.

Ciucci, P., Boitani, L., Pelliccioni, E. R., Rocco, M. & Guy, I. 1996: A comparison of scat-analysis methods to assess the diet of the wolf *Canis lupus*. — *Wildlife Biology* 2: 37–48.

Clavero, M., Prenda, J. & Delibes, M. 2003: Trophic diversity of the otter (*Lutra lutra* L.) in temperate and Mediterranean freshwater habitats. — *Journal of Biogeography* 30: 761–769.

Clavero, M., Prenda, J. & Delibes, M. 2005: Amphibian and reptile consumption by otters (*Lutra lutra*) in a coastal area in southern Iberian Peninsula. — *Herpetological Journal* 15: 125–131.

Clavero, M., Prenda, J., Blanco-Garrido, F. & Delibes, M. 2008: Hydrological stability and otter trophic diversity: a scale-insensitive pattern? — *Canadian Journal of Zoology* 86: 1152–1158.

Conroy, J. W. H. & Chanin, P. R. F. 2002: The status of the Eurasian otter (*Lutra lutra*). — In: Dulfer, R., Conroy, J., Nel, J. & Gutleb, A. C. (eds.), *Proceedings VIIth International Otter Colloquium*: 24–48. IUCN Otter Specialist Group Bulletin 19A (special issue).

Erlinge, S. 1968: Food studies on captive otters *Lutra lutra* L. — *Oikos* 19: 259–270.

Fairley, J. S., Ward, D. P. & Smal, C. M. 1987: Correction factors and mink faeces. — *Irish Naturalists' Journal* 22: 334–336.

Głowaciński, Z., Profus, P. & Fijał, J. 1995: Herpetofauna Bieszczadów Polskich i jej ochrona. — *Roczniki Bieszczadzkie* 4: 264–270.

Harna, G. 1993: Diet composition of the otter *Lutra lutra* in the Bieszczady Mountains, south-east Poland. — *Acta Theriologica* 38: 167–174.

Hesthagen, T., Saksgård, R., Hegge, O., Dervo, B. & Skurdal, J. 2004: Niche overlap between young brown trout (*Salmo trutta*) and Siberian sculpin (*Cottus poecilopus*) in a subalpine Norwegian river. — *Hydrobiologia* 521: 117–125.

Holmen, J., Olsen, E. M. & Vøllestad, L. A. 2003: Interspecific competition between stream-dwelling brown trout and Alpine bullhead. — *Journal of Fish Biology* 62: 1312–1325.

Jacobsen, L. & Hansen, H.-M. 1996: Analysis of otter (*Lutra lutra*) spraints: Part 1: Comparison of methods to estimate prey proportions; Part 2: Estimation of the size of prey fish. — *Journal of Zoology, London* 238: 167–180.

Jędrzejewska, B., Sidorovich, V. E., Pikulik, M. M. & Jędrzejewski, W. 2001: Feeding habits of the otter and the American mink in Białowieża Primeval Forest (Poland) compared to other Eurasian populations. — *Ecography* 24: 165–180.

Kruuk, H. 2006: *Otters: ecology, behaviour, and conservation*. — Oxford University Press, New York.

Kruuk, H., Balharry, E. & Taylor, P. T. 1994: Oxygen consumption of the Eurasian otter *Lutra lutra* in relation to water temperature. — *Physiological Zoology* 67: 1174–1185.

Kruuk, H. & Carss, D. N. 1996: Costs and benefits of fishing by a semi-aquatic carnivore, the otter *Lutra lutra*. — In: Greenstreet, S. P. R. & Tasker, M. L. (eds.), *Aquatic predators and their prey*: 10–16. Fishing News Books, Oxford.

Kukuła, K. 1995: Ichtiofauna Bieszczadzkiego Parku Narodowego i problemy jej ochrony [Ichthyofauna of the Bieszczady National Park and problems of its protection]. — *Roczniki Bieszczadzkie* 4: 123–142. [In Polish with English summary].

Kukuła, K. 1999: Ichthyofauna of the upper San drainage basin. — *Archives of Polish Fisheries* 7: 307–319.

Kukuła, K. 2000: Występowanie raka szlachetnego *Astacus astacus* L. w zlewni grórnego Sanu [Occurence of noble crayfish *Astacus astacus* in the San River headwaters]. — *Parki Narodowe i Rezerwaty Przyrody* 19.3: 103–106. [In Polish with English summary].

Litvaitis, J. 2000: Investigating food habits of terrestrial vertebrates. In: Boitani, L. & Fuller, T. K. (eds.), *Research techniques in animal ecology: controversies and consequences*: 165–190. Columbia University Press, New York.

Lockie, J. 1961: The food of the pine marten *Martes martes* in West Ross Shire, Scotland. — *Proceedings of the Zoological Society of London* 136: 187–195.

Mason, C. F. & Macdonald, S. M. 1986: *Otters: ecology and conservation*. — Cambridge University Press, Cambridge.

Nelson, K. & Kruuk, H. 1997: The prey of otters: calorific content of eels (*Anguilla anguilla*) and other fish, frogs (*Rana temporaria*) and toads (*Bufo bufo*). — *IUCN Otter Specialist Group Bulletin* 14: 75–80.

Nowosad, M. 1995: Zarys klimatu Bieszczadzkiego Parku Narodowego i jego otuliny w świetle dotychczasowych badań [Outlines of climate of the Bieszczady National Park and its buffer zone in the light of previous studies]. — *Roczniki Bieszczadzkie* 4: 163–183. [In Polish with English summary].

R Development Core Team 2009: *R: A Language and Environment for Statistical Computing*. — R Foundation for Statistical Computing, Vienna.

Remonti, L., Prigioni, C., Balestrieri, A., Sgrosso, S. & Priore, G. 2008: Trophic flexibility of the otter (*Lutra lutra*) in southern Italy. — *Mammalian Biology* 73: 293–302.

Ruiz-Olmo, J. & Jiménez, J. 2009: Diet diversity and breeding of top predators are determined by habitat stability and structure: a case study with the Eurasian otter (*Lutra lutra* L.). — *European Journal of Wildlife Research* 55: 133–144.

Ruiz-Olmo, J., López-Martín, J. M. & Palazón, S. 2001: The influence of fish abundance on the otter (*Lutra lutra*) populations in Iberian Mediterranean habitats. — *Journal of Zoology, London* 254: 325–336.

Sidorovich, V., Kruuk, H., Macdonald, D. W. & Maran, T. 1998: Diets of semi-aquatic carnivores in northern Belarus, with implications for populations changes. — In: Dunstone, N. & Gorman, M. (eds.), *Behaviour and ecology of riparian mammals*: 177–189. Symposia of the Zoological Society of London no. 71, Cambridge University Press, Cambridge.

Smiroldo, G., Balestrieri, A., Remonti, L. & Prigioni, C. 2009: Seasonal and habitat-related variation of otter *Lutra lutra* diet in a Mediterranean river catchment (Italy). — *Folia Zoologica* 58: 87–97.

Stone, R. 2003: Freshwater eels are slip-sliding away. — *Science* 301: 221–222.

Stuart, S. N., Chanson, J. S., Cox, N. A., Young, B. E., Rodrigues, A. S. L., Fischman, D. L. & Waller, R. W. 2004: Status and trends of amphibian declines and extinctions worldwide. — *Science* 306: 1783–1786.

Sulkava, R. 1996: Diet of otters *Lutra lutra* in central Finland. — *Acta Theriologica* 41: 395–408.

van Dijk, J., Hauge, K., Landa, A., Andersen, R. & May, R. 2007: Evaluating scat analysis methods to assess wolverine *Gulo gulo* diet. — *Wildlife Biology* 13 (Suppl. 2): 62–67.

Weber, J.-M. 1990: Seasonal exploitation of amphibians by otters (*Lutra lutra*) in north-east Scotland. — *Journal of Zoology, London* 220: 641–651.

Winnicki, T. & Zemanek, B. 2003: *Nature in the Bieszczady National Park*. — Bieszczady National Park, Ustrzyki Dolne.