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Otter *Lutra lutra* predation in cyprinid-dominated habitats

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Abstract

Diet composition of otter *Lutra lutra* was quantified by analysis of 2048 spraints collected at half-month intervals concurrently with a one year culture cycle of carp *Cyprinus carpio* in a fish pond area (S.E. Poland) and compared with data on farm stocks. Presence of cultured fish affected the diet composition, carp being the single most important food. The estimated biomass proportion of carp in spraints varied monthly between 15.7 % in June and 78.0 % in March. Carp abundance changes could not explain the seasonal variation in predation pressure. The factors responsible for the seasonal shifts in the use of resources are discussed.

Key-words: *Lutra lutra*, predation, cyprinids, thiaminase, fish-ponds

Introduction

Freshwater populations of the Eurasian otter *Lutra lutra* (Línne, 1758) have suffered a substantial decline in many European countries, this being related to some aspects of human management of aquatic ecosystems (Mason 1989). Although most of the man-made changes are regarded as detrimental to otters, some developments in freshwater habitats dominated by culture-based fisheries may contribute to an increase of food resources. Local strongholds for otter populations have been reported in association with aquaculture sites in central Europe (Macdonald 1995), but the scientific data on the interactions between these populations and farm stocks are lacking. There is a clear need for research on dietary patterns of otters in such man-modified habitats (Mason 1989), even more so because it is suggested that otter numbers are limited by fish populations (Kruuk et al. 1993). In central and eastern Europe aquaculture is dominated by cyprinids, stocked in large earthen ponds, which are very difficult to protect against predators. In Poland only the common carp *Cyprinus carpio* contributes to more than 95 % of the overall aquaculture production and there is growing concern over possible depredation of farm stocks by otters (Dobrowolski et al. 1995).

Cyprinid aquaculture sites create a specific habitat dominated by one prey category for otters. Abundance of food supply is governed by fish culture regime. Moreover, cyprinids exhibit high thiaminase activity, an enzyme that catalyzes the cleavage of thiamine – vitamin B_1 (Harris 1951). The aim of this study was to quantify seasonal variation in otter diet composition at cyprinid fisheries and to gather information on factors influencing the exploitation of farm stocks. The research was conducted in a carp-pond area in south-east Poland.

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Material and methods

Study area

The study areas were the Tyśmienica and Prokop (hereafter Tyśmienica) fish-ponds and adjoining bodies of water situated in the upper and middle regions of the Tyśmienica River 22°50′–52′E, 51°32′–33′N, Lublin Province, S.E. Poland, an area of about 2 400 ha. Tyśmienica valley is covered by grasslands and bounded from the east by coniferous woodlands. Its climate is influenced by continental factors with marked seasonal temperature and percipitation changes.

Semi-intensively cultivated ponds, up to 1 km wide along the Tyśmienica, are managed by two fish-farms, but spatially they constitute one complex. Farming comprised 19 ponds (1 to 18 ha area, 1.0–1.5 m deep) with a total water surface of 127.5 ha, seven of them stocked with 1+ (fish in their second year of life) carp and the others with 0+ (fry) carp. The associated waterflows are up to 5 m wide and up to 1.5 m deep. Because of high bacteriological and organic contamination of the Tyśmienica River the number of fish species has decreased dramatically during the last twenty years (Radwan and Girsztowtt 1994).

Despite the obvious degradation of the Tyśmienica valley, otters are widely reported by local fishermen to have occurred there for many years. During the present research no otter deterrence was undertaken by the fish-farms. American mink *Mustela vison* have not been recorded in the study area.

Farm stocks

As a warm-water species, carp plays a role in the riverine habitats of S.E. Poland only in artificially stocked sites. As otters normally spraint close to their feeding sites (Kruuk 1995), it is most likely that spraints collected in the study area represented prey items consumed at Tyśmienica ponds. However, their ranges may have incorporated other carp farms located up to a few tens of km along the waterways away from Tyśmienica.

Research on otter predation covers a one-year seasonal cycle of carp (0+ and 1+) culture between April 1994 and March 1995, therefore data are presented in this order. The local fisheries' managers provided information on fish supply for each pond. Assessment of carp abundance was based on the data from stocking and restocking operations, and routine net sampling twice a month between June and October. No fishing was undertaken between November and February as the ponds were temporarily frozen. The missing figures were estimated with the help of the fish-farm ichthyologists, assuming a constant mortality rate and weight decrease of young carp during winter.

The term 'farm fish' refers only to carp. The 'unplanned breeding' and the accompanying species in some of the fry ponds: wels *Silurus glanis* and pike *Esox lucius* fry (together 0.7 % of the total fish biomass at harvesting) were not taken into account in the statistical analysis.

Access to ponds was assessed by measuring the ice cover and relating it to the whole pond water surface twice a month between November 1994 and March 1995.

Spraint sampling and analysis

Otter diet was assessed by spraint analysis. Spraints were collected at ponds and along water courses adjoining the ponds. Standard collection routes, totaling about 14 km, were visited twice each month between April 1994 and March 1995. Faecal material was wrapped in individual bags, dried, and washed through a 0.5 mm sieve. Prey remains were identified using a reference collection and existing keys. 'Key bones', the species-specific hard parts that occurred with the greatest frequency in spraints, were used to assess the size of prey items represented in the spraints. They were measured to the nearest 0.5 mm using an ocular micrometer. Key bones comprised pharyngeal teeth structures, maxillae, and dentaries (cyprinids, cobitids); preoperculae, operculae, and jaws (percids); operculae, premaxillae, and dentaries (gasterosteids) and dentaries, articularies, and operculae (other taxa). Measurements from individuals collected in the study area were regressed against original total fish lengths and these against fish fresh masses to produce conversion equations for carp (separately for both age classes) and species dominating in the otter diet. The relationships for less common fishes were taken from the literature, mainly Libois et al. (1987).

Amphibian key bones were ilea, frontoparietale, and jaws while body masses were estimated from a reference collection by adopting three weight classes for each species. Body lengths of crayfish *Astacus astacus* individuals were estimated from chela widths and lengths of the anterior part of cephalothorax with the regressions of Podsiadło and Olech (1994) and length-weight relationship with equations from Stypińska (1978). Since it was often impossible to assess crayfish body length from broken pieces retrieved from spraints, data based on remains of predated crayfishes found on river banks were extrapolated to the entire half-month sample. Bird and mammal remains were assigned to the family level by examining hair and feather characteristics (Day 1966; Brom 1986). Mean weights of the most common species of these families observed at Tyśmienica ponds, taken from Cramp and Simmons (1977) and Myrcha (1969) were applied.

Prey proportions estimation

Prey proportions in the diet were assessed by the method of relative weight percentages with total weight of individuals of a prey category, expressed as a percentage of the total weight of all prey individuals (Bekker and Nolet 1990). The number of individuals of a species represented in a spraint was scored as the highest total of any of the key bones present. Crayfish and bird numbers were defined as the highest totals of any of the identifiable parts present in the whole half-month sample. Insects smaller than 1 cm were considered an effect of secondary ingestion and omitted. Carp fraction in samples was also expressed in terms of frequency of occurrence – the percentage of spraints where a prey category occurred (Bekker and Nolet 1990).

Monthly changes in calorific values of 'averaged' otter food per weight unit were estimated. Relative calorific values of prey categories (Tab. 1) were used combined with data on digestibility (as the percentage of the total ingested food available to the predator as energy). Data on digestive efficiency (50 % for invertebrates, 70 % for fish and 80 % for other vertebrates) were assumed following Beja (1996). Furthermore, prey species were divided into thiaminase-free and thiaminase-active. Data on thiaminase presence were obtained from published reviews (Tab. 1).

Non-parametric tests were used throughout as most of the analyzed variables did not meet the assumptions of normality or homogeneity of variances. The trophic niche breadth was estimated using Levins' measure $B = 1/\Sigma p_i$, where p_i is the percent occurrence of a general prey taxa (Levins 1968).

Table 1. Main food categories for otters in the Tyśmienica valley: energy content and thiaminase presence. Mean energy content of crayfish and fish prey after Scherz and Senser (1989), except cobitids (Klejmenov 1962), ictalurids (Feunteun and Marion 1994) and gasterosteids (Massias and Becker 1990); values of other non-fish prey from Griffiths (1977), except mammals (Myrcha 1969). Some data have been recalculated to kJg^{-1} wet weight from the original sources. Data on thiaminase activity after Harris (1951), Tatarskaya et al. (1954) and Ender (1966). If no relevant data for a given species were available from the literature, they were taken from the closest related taxa.

Food items	Energy content (kJg^{-1} wet weight)	Antithiamine activity
Insects	4.53	–
Crayfish	2.95	–
Pike	3.73	+
Carp	5.22	+
Other cyprinids	4.67	+
Cobitids	4.55	+
Ictalurids	4.20	+
Gasterosteids	3.32	+
Percids	3.71	+
Amphibians	4.18	–
Waterbirds	4.43	–
Mammals (soricids)	4.24	–

Results

8437 prey individuals were represented in 2048 spraints. Otters fed primarily on fish, composing more than 90 % of food in all months except in June–September (44.3 %–73.6 %) and January (82.6 %). On an annual basis carp formed 40.8 % of the estimated consumed biomass being the major component in the otter diet during all months (Fig. 1) except June. However, its contribution to otter diet varied from the relatively lowest values in summer (15.7 % by weight and 18.0 % by frequency in June) and in the coldest months, December–January (21.1 %–23.4 % by weight and 17.2 %–19.7 % by frequency) to a peak in March when carp made up 78.0 % of the estimated consumed biomass and was found in 68.6 % of spraints. Monthly estimates of carp use in terms of biomass and frequency of occurrence were similar ($r = 0.92$, $n = 12$, $p < 0.001$).

Percids (ruffe *Gymnocephalus cernua* and perch *Perca fluviatilis*), making up an annual mean of 13.7 % of biomass and cyprinds (mainly gudgeon *Gobio gobio*) with 12.3 % formed the largest proportion of wild fish recorded in the otter diet. Estimates of wild fish proportion ranged from 19.6 % in March to 72.3 %–59.2 % in December–January. Wild fish species represented in spraints were smaller than carp throughout the year. Even in June, when the difference was the smallest, carp was significantly larger (Mann-Whitney U-test; $u = 323.0$, $p < 0.001$). The estimated mean length of wild fish prey was 7.2 ± 2.5 (SD) cm with the median length of 7.0 cm ($n = 5545$). The mean length of carp was 11.4 ± 2.6 cm with the median of 10.9 cm ($n = 1249$).

In summer, crayfish and waterbirds (Podicipedidae, Rallidae) constituted a substantial part of otter food. In June, crayfish was the principal prey species with 22.3 %. Amphibians (frogs *Rana 'esculenta'*, *R. temporaria*, *R. arvalis*) were taken by otters during all seasons, but made a significant contribution only in January reaching 16.5 %. Mammals and insects were of negligible importance (0.01 % on an annual basis).

Carp abundance in terms of biomass varied up to 6.6-fold in the course of the year but these changes were not significantly correlated with estimates of the contribution to the diet of otters in terms of either weight ($r = 0.24$, $n = 12$, $p = 0.44$) or occurrence ($r = 0.16$, $n = 12$, $p > 0.71$; Fig. 2). There was an inverse correlation between proportion of carp in spraints and the extent of ice cover at ponds ($r = -0.79$, $n = 7$, $p < 0.05$ for both biomass and occurrence; Fig. 3), while positive and non-significant relationships were

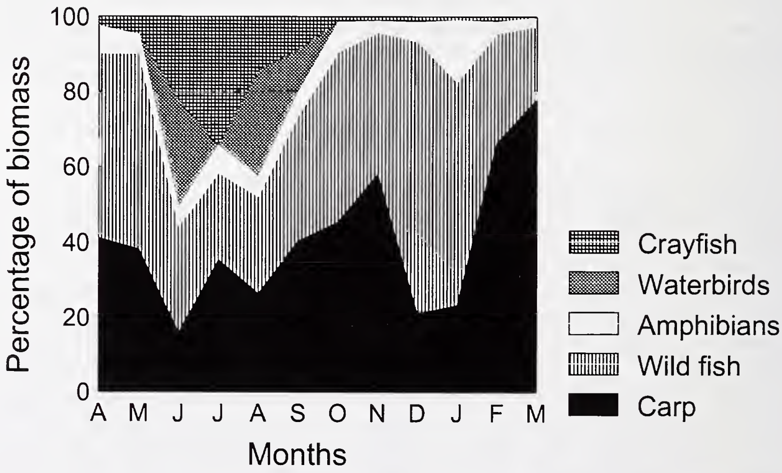

Fig. 1. Monthly variation in the estimated proportion of major prey categories in otter diet in Tyśmienica ponds area, April 1994–March 1995, quantified in terms of weight.

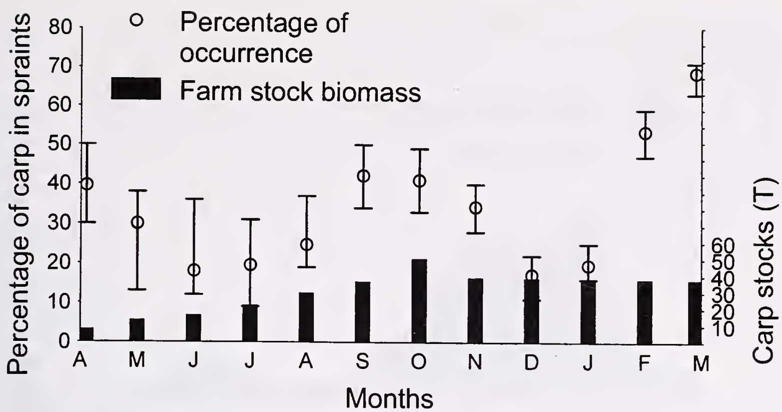

Fig. 2. Frequency of occurrence (with 95 % confidence intervals) of carp in otter spraints and changes in the total abundance of farm stocks in the Tyśmienica fish-ponds, April 1994–March 1995.

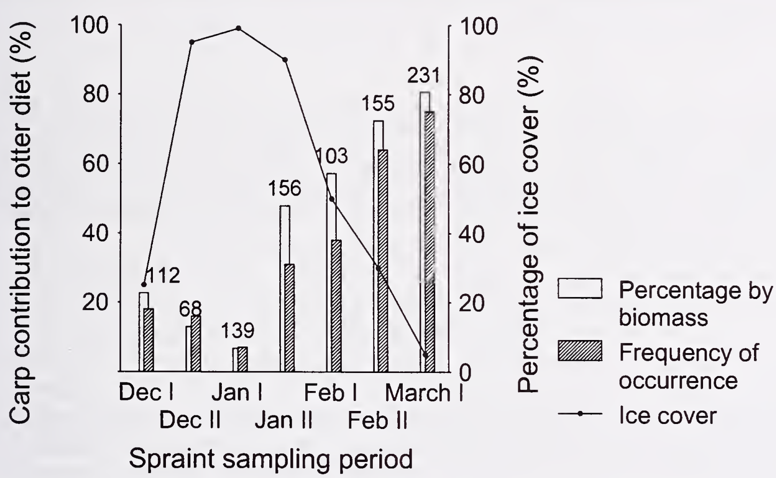

Fig. 3. Mean percentage of ice cover on the Tyśmienica fish-ponds to the total water surface of the ponds in November 1994–March 1995 and variation in the proportion of carp in terms of biomass and frequency of occurrence in otter diet (half-month samples). Numbers over columns are sample sizes.

found for wild fish ($r = 0.57$, $p > 0.18$ and $r = 0.75$, $p > 0.05$, respectively). After exclusion of the data from December–January, the period after establishment of persistent ice cover, the correlations between farm fish abundance and its proportion in otter diet were stronger, but still not significant ($r = 0.61$, $n = 10$, $p > 0.06$ for both methods of diet quantification).

Monthly changes in the calorific value of otter food per weight unit were inversely correlated with fluctuations in the proportion of thiaminase-free prey ($r = -0.85$, $n = 12$, $p < 0.001$; Fig. 4). June–August was the period of the lowest calorific content of the otters' food (the calorific equivalent of an 'average' digested 1 g dropped below 3.0 kJ), while the proportion of thiaminase-free prey was highest then, ranging from 41.4 % to 55.7 % of the consumed biomass. The energetic intake per 'digested' prey weight unit was greatest in February–March and November, when it reached 3.4 kJg^{-1}. In these months the proportion of thiaminase-free prey was the lowest, ranging from 2.4 % to 4.4 %.

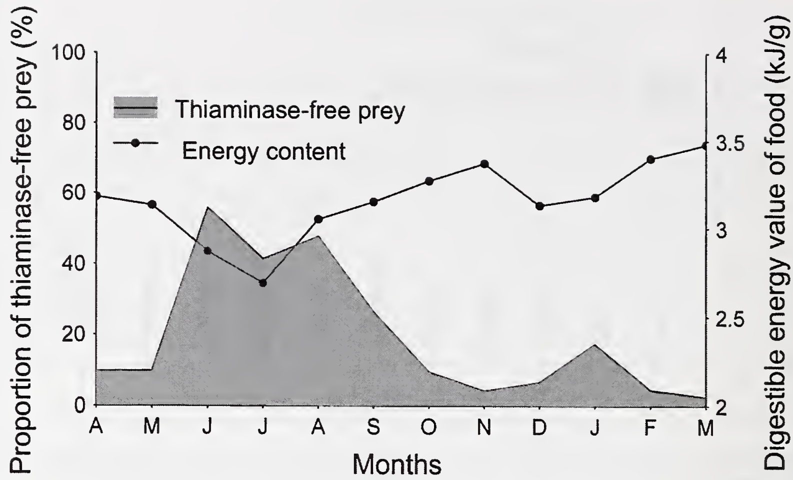

Fig. 4. Monthly variation in the digestible calorific value of otter 'average' food per weight unit and the proportions of thiaminase-free prey between April 1994 and March 1995.

The trophic niche breadth varied throughout the year, otters specializing most in summer (Levins' B falling from 5.0 in June to 3.6 in August) with another low in March (B = 4.9) while a wider range of items was eaten in December (B = 8.8) and January (B = 9.2). The total biomass of farm fish was not significantly correlated with diet breadth (r = 0.40, n = 12, p = 0.20).

Discussion

Assessing the proportion of prey categories in otter diet on the basis of faeces analysis must be regarded with caution. Carss and Parkinson (1996) and Jacobsen and Hansen (1996) pointed out some potential difficulties. The severest problem is the lack of statistical independence of the data following errors in estimation of the number of fish recorded per spraint and the number of droppings containing the remains of individual items. The applied recording procedure was chosen as a compromise between these demands. Identifying several different prey structures increases the likelihood of scoring a prey category (Cottrell et al. 1995), while the probability of recording a single item repeatedly, as may be common when using scales and vertebrae for quantifying prey number (Jacobsen and Hansen 1996), was minimized.

The present results show that cultured stocks constitute an important food resource for otters. However, since carp fraction in the otter diet declined with the increasing proportion of ice cover at ponds, the advantages of using the additional food resource in the period of an ecological 'bottleneck' were reduced. Presumably better access to water under ice was provided at rivers, while water inlets were occasionally the only unfrozen places in the ponds.

Farm fish was not taken in proportion to abundance. In April 41 % of the estimated otter diet consisted of carp, but only 26 % in August, despite the stock enhancement by a factor of 3.9. These considerations lack comparisons with the relative abundance of alternative prey, as neither good density estimates nor data on seasonal changes in otter ranges were available. Still, information provided by the local fishermen indicate that the fish productivity of the Tyśmienica at its upper and middle reaches was poor and variations in wild fish abundance did not balance the changes in artificial food resources created by the vast pond complexes. This view gains some support from the fact that wild fish prey was markedly smaller than carps retrieved from spraints.

A series of carp vulnerability periods related to fish culture regime may be responsible for these seasonal disproportions. Predation at carp farms may increase during stock translocations, as cultured fishes are more vulnerable when under stress associated with transport (Olla et al. 1994). Fishes are also left unprotected due to lowering the water table during the few days of drawing down the ponds at harvests or restocking. In the study area these operations took place in March–April and September–October, and the proportion of carp in otter diet was relatively high in these months. Bad condition of carp after wintering may contribute to the peak of its exploitation in February–March.

Another possible reason for the shifts in carp use by otters is meeting of nutrient and energy requirements at different seasons. Even 20 % carp proportion in the diet can evolve clinical signs of thiamine deficiency in river otters *Lutra canadensis* after a long period (Aulerich et al. 1995). Consumption of thiaminase-containing food by Tyśmienica otters exceeded the above value by far throughout the year. Seasonal changes in the use of energy-rich prey coincided with inverse shifts in consumption of nutritionally valuable (thiaminase-free) food. In summer water temperatures are relatively high and some thiaminase-free prey types become available, whereas otters face hardship in winter as food requirements increase with decreasing water temperature (Kruuk 1995) and fish accessibility is restricted by ice cover. Shifts in prey choice, governed by a combined effect of seasonal food availability and its nutritional value, result in a balanced diet when it is averaged over long periods, but not in particular feeding periods (Westoby 1978). Although otters fed raw carp reject this food after a few days (S. Sikora, pers. comm.), clinical symptoms of thiamine defficiency in captive animals are considerably delayed in time, dependent on the degree of thiamine deprivation and fat content in the diet (Geraci 1974; Aulerich et al. 1995). Thus, under natural conditions switching to foods higher in thiamine may occur at longer intervals and thus produce a seasonal pattern. Still, spraint analysis allows no conclusions on the feeding behaviour of individual otters.

Despite the presence of densely stocked ponds, a partial shift to non-fish food was apparent in summer. The same predation pattern was stated on the basis of a relatively small spraint sample (n = 74) in the study area a year later, in June–July 1995. In July 1995 crayfish constituted over half of the estimated otter diet by weight (J. Kloskowski, unpubl.). Similar dietary shifts were demonstrated in other eutrophic habitats of temperate Europe (Erlinge 1967; Wise et al. 1981) and interpreted as response to changes in fish dispersion and motility. However, carp stocks were regulated by transfers independent of natural seasonal population dynamics. Dispersion in densely stocked ponds was restricted. Moreover, in summer many carps were observed being torpid close to the water surface, probably due to temporal oxygen drops and were an easy prey for otters. By contrast, crayfish was rare in the canalised and polluted waterflows of the region (Radwan and Girsztowtt 1994). In addition to the mentioned possible nutritional benefits, crayfish importance in the otter summer diet may be attributed to its increased activity in this period (Erlinge 1967). Preference for some alternative prey may have important implications for integrative management of aquatic habitats adjoining the fish farms, but its reasons have to be clearly determined.

More information is needed on diet composition at individual levels and long-term numerical responses of otters to changes in prey availability in conditions of patchily distributed monocultured fish supply. Considering the magnitude of cyprinid culture in central and eastern Europe and thriving otter populations in some parts of this region

(Brzeziński et al. 1996), further progress to elucide the factors influencing otter depredation of farm stocks may contribute to mitigation of large scale conflicts with aquacultural policy.

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Zusammenfassung

Beuteerwerb des Fischotters Lutra lutra in von Weißfischen dominierten Habitaten

Die Nahrung des Fischotters in einem Teichgebiet in Südostpolen wurde quantitativ untersucht, indem insgesamt 2048 Losungen, zweimal monatlich parallel zum alljährlichen Nutzungsmuster einer Karpfenzucht gesammelt und analysiert wurden. Die Zusammensetzung der Nahrung wurde mit Daten über den Fischbesatz verglichen. Die Präsenz der Karpfenbestände beinflußte die Zusammensetzung der Nahrung mit Karpfen als dem wichtigsten Bestandteil. Der Biomasseanteil von Karpfen an der Gesamtnahrung variierte von 15.7 % im Juni bis 78.0 % im März. Die Änderungen des Angebotes an Karpfen konnten die jährliche Variation der Prädation nicht erklären. Die für die jahreszeitlichen Verlagerungen in der Ressourcennutzung verantwortlichen Faktoren werden diskutiert.

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