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ORIGINAL ARTICLE

Diet of the otter *Lutra lutra* inhabiting a forest stream in SW Poland

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Abstract
Diet of the otter inhabiting a forest stream in SW Poland was studied in order to show the impact of the otter on fish and other aquatic animals. The diet was examined by means of spraint analysis. A total of 157 spraints were collected from 14 sites, and 605 prey items were extracted. Fish comprised the staple diet. It was supplemented by frogs, birds, small mammals and invertebrates. Fish were represented by at least 23 species belonging to seven families. Two families Cyrinidae and Percidae dominated the fish component of the diet (together 70.1%). The most numerous fish species consumed were *Perca fluviatilis* (24.1%) and *Rutilus rutilus* (12.1%). The otter diet was most diversified in the coldest months of the year (November-April; B = 10.0-10.5), and least in the warmest months of the year (July-August; B = 5.7). The niche breath was wider in 2006 (B = 12.2), compared with 2007 (B = 20.4). However, only the proportions of *Gobio gobio* and *Esox lucius* were statistically different in those two years compared. This study confirms previous findings that the otter is a generalist piscivorous predator hunting opportunistically on locally and seasonally most common fish species, mainly of low economic importance.

Keywords Diet · Seasonal variation · Year-to-year variation

Introduction

Once rare and declining, the otter *Lutra lutra* (L., 1758) began to expand in Poland. Its increase in numbers coincides with the occupation of small river courses and fish ponds, regarded as its suboptimal habitats (Romanowski 2006). As a result of this expansion, the species is today widespread and relatively common throughout Silesia, SW Poland (Kopij 2016). It inhabits not only the Oder, the largest river in this region, but also all its tributaries (rivers of the II order), and some rivers of the III orders (e.g. Ścinawa Niemodlińska, Biała, Czerna). Opportunistic foraging habits enable it to colonize also man-modified habitats, such as channels, larger fish-ponds (e.g. near Niemodlin), and water reservoirs (e.g. Nyski and Otmuchowski).

The otter is recognized as one of the top piscivorous predators in freshwater ecosystems, and thus has the potential to play an important role in the functioning of these ecosystems. The diet varies in different localities, different habitats and different seasons of the year (Jędrzejewska et al. 2001; Krawczyk et al. 2016).

Although the otter diet has been thoroughly studied in Europe (Jędrzejewska et al. 2001; Clavero et al. 2003; Krawczyk et al. 2016), it is not well known from the suboptimal habitats of small rivers colonized recently. From Poland, such data are available only from small water courses in agricultural landscape (Krawczyk et al. 2011). The aim of the present study is to determine the diet composition and its changes on the monthly and annual basis of otters inhabiting forest streams.

Materials and methods

Spraints were collected from 14 sites located on the Czerna Wielka River. It is III order rivulet, a tributary of the Bóbr River (II order), which in turn is a tributary of the Odra River (I order). The Czerna Wielka River is 72 km long and its drainage area is 949 km^2. Its spring is located in Izerskie Upland at 283 m a.s.l. (51°38 × 02´´ N, 15°0.18´´21´´ E) and its confluence with the Bóbr River is located in Żagań town at 92 m a.s.l. (51°11 × 06´´ N, 15°13 × 30´´ E). The river flows mainly through an extensive forests dominated by Scots pine *Pinus sylvestris*.

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The diet composition was determined through spraint content analysis. The spraints ($n = 158$) were collected throughout all seasons from 16 to 2005 to 2 July 2007 in 14 sites on the Czerna River between Węgliniec and Żagań (Table 1). Analysis followed the standard procedure (Krawczyk et al. 2011). In a laboratory the spraints were individually soaked and washed through 0.5 mm mesh sieve to retrieve clear prey items, which were subsequently dried and sorted. Identification of prey items was aided with a stereomicroscope (10×). Prey items were identified by fragments of vertebrate bones (operculum, pharyngeal teeth, vertebrae, mandibles, ileum, and frontoparietale), fish scales, mammal hairs and teeth, avian feathers and arthropod exoskeletons. Fish were identified down to species level, amphibians and crustaceans down to the genus level, while all other prey to the class or order level. Prey items were identified by comparing them with a reference collection and using the following keys: Brylińska (1991); Kołodziejczyk and Koperski (2000). Characteristic bones and scales were used to determine the number of individuals of a given prey taxon within a spraint. Duplicate bones or differences in size of particular bones/scales were sufficient to distinguish the presence of more than one individual within a given prey taxon.

The frequency of prey occurrence in sites (FO) was calculated as the percentage of sites, where the given prey taxon was present. The frequency of prey occurrence in spraints (FS) – as the percentage of spraints, where a given taxon of prey was present. The frequency of occurrence of prey items (FP) refers to the number of prey items of a given prey taxon in relation to the total number of all prey items extracted from all spraints, and was also expressed in percentages.

The Levins's index (Levins 1968) was used to calculate the niche breath:

$$B = 1/\sum p_i^2$$

where B is the Levins's measure of niche breadth and p_i is the proportion of each food category consumed by otters. Species in the case of fish, and classes in the case of all other prey were used as food categories. Spearman's rank correlation test was used to check for relationships between the monthly and year-to-year occurrence of particular fish families while x^2-test was used to compare otter diet composition in the year 2006 and 2007.

Results

Fish comprised the staple food of the otter. It was supplemented by frogs, birds, small mammals and invertebrates. Fish were represented by at least 23 species belonging to seven families. Two families, Cyrinidae and Percidae, dominated the fish component of the diet (together 70.1%). The most numerous fish species consumed were *Perca fluviatilis* L., 1758 (24.1%) and *Rutilus rutilus* (L., 1758) (12.1%). Relatively numerous (each with > 5%) were also *Cottus gobio* L., 1758 (7.6%), *Gasterosteus aculeatus* L., 1758 (6.9%), *Gymnocephalus cernus* (L., 1758) (5.8%), *Gobio gobio* L., 1758 (5.3%) and *Esox lucius* L., 1758 (5.0%). Amphibians were represented exclusively by frogs (Ranidae), while invertebrates by mussels (Mollusca: Bivalvia), crayfishes (Crustacea: Decapoda: *Astacus* spp.) and insects (Table 2).

The otter diet was most diversified in the coldest months of the year (November-April; B = 10.0-10.5), and least diversified in the warmest months of the year (July-August; B = 5.7). Its average values were found in spring (May/June; B = 7.5) and autumn (September/October; B = 7.9) (Fig. 1). The contribution of two main fish families: Cyprinidae and Percidae in the diet of the otter was high (70.1% of all prey items). The proportion of percids was higher than cyprinids in the warmer months of the year (May-July), while the proportion

Table 1 Number of spraints collected at particular sites on the Czerna River

Date↓/Site→	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	Total
16.05.2005		1		1						3			2	2	9
24.09.2005			1			1	2	2		2	1		1	1	11
02.12.2005	2	1	1		2	3	3			1	1			1	15
24.02.2006	1	1	2		2	3	1	4	2	1	1	1	1		20
31.03.2006		1	1	3	1					3	3		2	3	17
28.05.2006		1			1		1	1	1	2		1	1	2	11
13.09.2006						1				1	1			2	5
09.12.2006		1	1	3	4	3				3	5	1	2	2	25
08.02.2007		1		2	1			1		1	2	2	1	1	12
05.04.2007	3	1		3		1		3	1	3	1		1	3	20
02.07.2007	2	1		2	1	4		1		1				1	13
Total	8	9	6	14	12	16	7	12	4	21	15	5	11	18	158

Table 2 Diet of the otter in the Czerna River

Prey taxon	FO		FS		FP	
	N	%	N	%	N	%
PISCES					566	(93.6)
Esocidae					(30)	(5.0)
Esox lucius	12	85.7	30	19.0	30	5.0
Cyprinidae					(257)	(48.8)
Abramis brama	3	21.4	3	1.9	3	0.5
Alburnus alburnus	6	42.9	8	5.1	10	1.7
Barbatula barbatula	9	64.3	15	9.5	20	3.3
Barbus barbus	2	14.3	2	1.3	2	0.3
Blicca bjoerkna	4	28.6	1	0.6	4	0.7
Carassius carassius	8	57.1	12	7.6	25	4.1
Cyprinus carpio	9	64.3	13	8.2	15	2.5
Cyprynidae spp.	11	78.6	25	15.8	25	4.1
Gobio gobio	10	71.4	43	27.2	32	5.3
Leucaspius delineatus	7	50.0	10	6.3	14	2.3
Leuciscus cephalus	1	7.1	1	0.6	1	0.2
Leuciscus idus	1	7.1	1	0.6	1	0.2
Rhodeus sericeus	1	7.1	1	0.6	1	0.2
Rutilus rutilus	14	100.0	39	21.7	73	12.1
Scaradinius erythrophthalmus	6	42.9	7	4.4	10	1.7
Tinca tinca	10	71.4	17	10.8	21	3.5
Cobitidae					(6)	(1.1)
Cobitidae spp.	2	14.3	2	1.3	4	0.7
Cobitis taenia	1	7.1	1	0.6	1	0.2
Missgurnus fossilis	1	7.1	1	0.6	1	0.2
Gadidae					(4)	(0.7)
Lota lota	3	21.4	4	2.5	4	0.7
Gasterosteidae					(42)	(6.9)
Gasterosteus aculeatus	14	100.0	37	23.4	42	6.9
Percidae					(181)	(29.9)
Gymnocephalus cernua	10	71.4	31	19.6	35	5.8
Perca fluviatilis	14	100.0	96	60.8	146	24.1
Cottidae					(46)	(7.6)
Cottus gobio	12	85.7	33	20.9	46	7.6
AMPHIBIA (Ranidae)	8	57.1	10	6.3	10	1.7
AVES	1	7.1	2	1.3	2	0.3
MAMMALIA (hairs)	1	7.1	2	1.3	1	0.2
MOLLUSCA	1	7.1	1	0.6	1	0.2
INSECTA	7	50.0	13	8.2	13	2.1
CRUSTACEA (*Astacus* sp.)	7	50.0	12	7.5	12	2.0
Total	14	100.0	158	100.0	605	100.0

FO - frequency of distribution in 14 sites, FS– frequency of distribution in 158 spraints, FP – frequency of distribution in 605 prey items

of cyprinds was higher than percids in colder months of the years (September-April). The proportion of *G. gobio* was not correlated with the proportion of *P. fluviatilis* ($R^2 = 0.044$), *R. rutilus* ($R^2 = 0.001$) and *E. lucius* ($R^2 = 0.085$), while the proportion of *P. fluviatilis* was correlated with the proportion of *R. rutilus* ($R^2 = 0.696$), and not correlated with the proportion of *E. lucius* ($R^2 = 0.169$); proportion of *E. lucius* was correlated with the proportion of *R. rutilus* ($R^2 = 0.352$).

The niche breath was wider in 2006 (B = 12.2), compared with 2007 (B = 20.4). However, only the proportion of *G. gobio* and *E. lucius* were statistically different in those two years (Fig. 2).

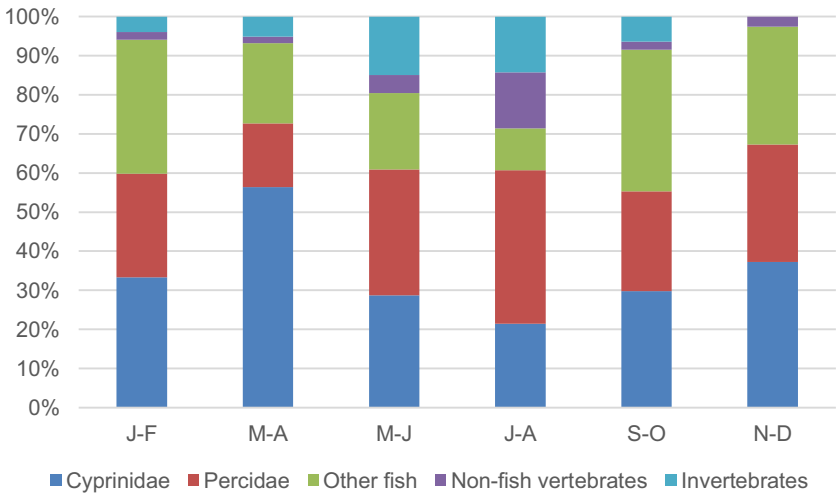

Fig. 1 Month-to-month variation in the main prey categories in the diet of the otter in the Czerna River

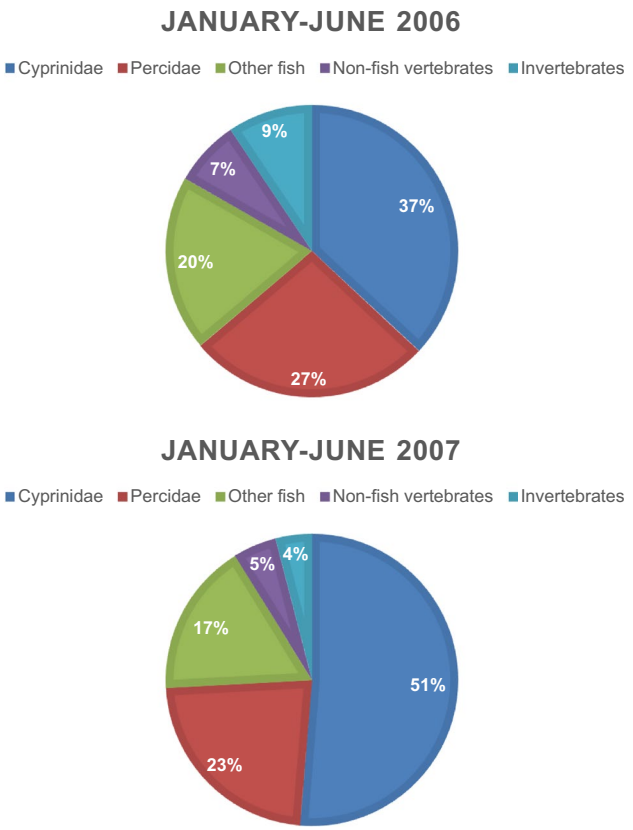

Fig. 2 Proportion of main prey categories in the diet of the otter in the Czerna River in 2006 and 2007

Discussion

The major finding of this study is that the diet of the otter inhabiting a small river in an extensive woodland was strongly dominated (> 90%) by fish. In terms of the biomass, the diet was almost exclusively (> 99%) composed of fish. In Poland and other countries in Eastern Central Europe, the proportion of fish in the otter diet ranged from 35 to 96% (Table 3). A similarly high proportion of fish in the otter diet (c. 90%) was recorded in fish ponds only (Table 3). Outside Eastern Europe, the proportion of fish ranged from 44% (S Italy) to 79% (Greece), being exceptionally high (96%) only in NE Spain (Acra and Prigioni 1987; Ruiz-Olmo et al. 1989; Sulkava 1996; Gourvelou et al. 2000; Remonti et al. 2008; Smilordo et al. 2009; Breust 2021; Gladitsch 2022). Based on published data of 29 diet studies carried out across Europe, Krawczyk et al. (2016) calculated that fish comprised on average 72% of all prey items and 75% of the biomass. There were more fish in the diet in standing than in flowing water; and more in wetlands than in farmlands and woodlands. However, our results do not support this generalization.

Among fish, the two most important species in otter diet in this study were *P. fluviatilis* (24.1%) and *R. rutilus* (12.1%). In other sites ($n = 10$) in Poland, two most numerous fish species recorded in otter diet varied from site to site. In overall, the species most often consumed were *G. gobio* (recorded in six sites) and *G. aculeatus* ($n = 3$). *R. rutilus, P. fluviatilis* and *E. lucius* were recorded in two sites, whereas *Lota lota* L., 1758, *Salmo trutta* L., 1758, *Rhodeus sericeus* Pallas, 1776, *Barbatulla barbatulla* L., 1758 and *Phoxinus phoxinus* (L., 1758) were recorded only in one site (Harna 1993; Jędrzejewska et al. 2001; Brzeziński et al. 2006; Krawczyk et al. 2011; Kłoskowski et al. 2013).

In other European countries (data from 33 sites in 19 countries), two most numerous fish species recorded in the diet were *Carassisus* spp. (*C. auratus* L., 1758, *C. carassius* (L. 1758), *C. gibelio* (Bloch, 1782) ($n = 9$ sites), *Cottus gobio* ($n = 9$ sites), *Salmo trutta* ($n = 7$), *Rutilus* spp. (*R. rutilus, R. rubilio* (Bonaparte, 1837) ($n = 4$) *Anguilla anguilla* (L., 1758) ($n = 4$), *Barbus* spp. (*B. barbus* L., 1758, *B.*

Table 3 Proportion of main prey groups in the diet in Poland and other East European countries

Country	Numerical percentage (relative occurrence) of prey items			Number of prey items	Source
	Fish	Other verteb.	Inverte-brates		
W Poland, small river in farmland	64	11	25	153	Krawczyk et al. (2011)
NE Poland, Biebrza and Wissa	c. 83	c. 10	c. 7	171	Skierczyński and Wiśniewska (2010)
NE Poland, lowland rivers	59	15	26	6466	Brzeziński et al. (2006)
E Poland, upland river	80	19	1	1004	Brzeziński et al. (2006)
E Poland, fish ponds	c. 90	c. 5	c. 5	8437	Kłoskowski (2000)
SE Poland, mountain stream	43	46	11	431	Pagacz and Witczuk (2010)
SE Poland, small mount. streams	63	15	22	1687	Harna (1993)
SE Poland, mountain river	89	6	5	559	Brzeziński et al. (2013)
SE Poland, mountain rivers	79	21	0	4243	Brzeziński et al. (2006)
S Poland, fish ponds	c. 90	c. 10	0	344	Wiśniowska (2006)
SW Poland, small river in woodland	94	2	4	605	This study
NE Czech Rep., mountain streams	c. 68	c. 22	c. 10	894	Polednik et al. (2004)
S Czech Rep, fish ponds	96	4	0	525	Kortan et al. (2007)
Latvia	32	44	24	263	Ozolins et al. (1998)
Belarus	c. 60	c. 25	c. 15	2832	Sidorovich (2000)
Hungary	c. 80	c. 6	c. 14	811	Kemens and Nechay (1990)
Hungary, post mortem	62	31	5	327	Lanszki et al. (2015)
SW Hungary	c. 88	c. 7	c. 5	1151	Lanszki and Molnar (2003)
SE Romania	35	43	22	118	Bouroş and Murariu (2017)
SE Bulgaria	62	14	24	1673	Georgiev (2006)
N Greece	79	16	5	207	Gourvelou et al. (2000)

cyclolepis Heckel, 1837, *B. graellsi* Steindachner, 1866, *B. plebejus* Bonaparte, 1839) ($n=4$), *Esox lucius* ($n=4$); *Pseudorasobora parva* (Schlegel, 1842) ($n=4$); *Perca fluviatilis* ($n=3$); in two sites: *Chondrostoma* spp. (*C. genei* Bonaparte, 1837, *C. taxostomus* Vallot, 1837), *P. phoxinus, G. aculeatus, Ictalurus nebulosus* (Lesueur, 1819) and *Cyprinus carpio* L., 1758. Three other fish species were recorded in one site only: *Scardinus erythrophthalmus* (L., 1758), *Luciobarbus sclateri* (Guenther, 1868), *Lepomis gibbosus* (L., 1758) (Webb 1975; Bekker and Nolet 1990; Kemens and Nechay 1990; Libois 1995; Sulkava 1996; Gourvelou et al. 2000; Lanszki and Molnar 2003; Polednik et al. 2004; Britton et al. 2006; Georgiev 2006; Preston et al. 2006; Kortan et al. 2007; Lanszki et al. 2007, 2009, 2010, 2015; Bauer-Haas et al. 2014; Sittenthaler et al. 2019; Breust 2021; Macforlane 2021).

The proportion of two main fish families in the otter diet, Cyprinidae to Percidae, was 1 : 0.6 in this study, and its overall contribution to the otter's diet (79%) was the highest ever reported from Poland. In other sites in Poland, the proportion ranged from 1: 0.2 to 1 : 3.5, but the overall contribution to the diet was nowhere higher than 67% (Table 4). In the Netherlands, it was 1 : 0.7 (Bekker and Nolet 1990); S Sweden 1 : 0.5 (Erlinge 1967); Denmark 1 : 0.4; (Erlinge and Jansen 1981); UK (Devon) 1 : 0.2 (Wise et al. 1981); UK (N Ireland): 1 : 0.2 (Preston et al. 2006); U. K.: 1: 0.2 (Britton et al. 2006); 1 : 0.2; N Germany (Schleswig-Holstein) 1 : 0.1 (Breust 2021; S Italy: 1 : 0.05 (Remonti et al. 2008); C Italy: 0.02 (Arca and Prigioni 1987); Austria 1: 0.03 (Gladitsch 2022), NE Spain: 1 : 0.00 (Ruiz-Olmo et al. 1989); Portugal: 1 : 0.00 (Novais et al. 2010).

In our study, most fish preyed by otter were small-sized species, i.e. *B. barbatula, Cobittis taenia* L., 1758, *C. gobio, G. gobio, G. aculeatus, Leucaspius delineates* Heckel, 1843, *Misgurnus fossilis* (L., 1758), *R. sericeus*. They comprised 32.7% of all fish consumed. They have no economic value. Also *P. fluviatilis* (25.8%) is of low economic value, often regarded by freshwater fishery as a strong competitor and predator of fish species of high economic importance (Brylińska 1991). Fish of economic value preyed upon by the otter were in most cases of small sizes (5–15 cm). In other places in Poland, small-sized fish constitute a bulk of the otter's diet. Only in the upper Biebrza River, relatively high predation on *Lota lota*, and high proportion *of Salmo trutta* in some streams in the Carpathians Mts. have been reported (Harna 1993; Jędrzejewska et al. 2001; Brzeziński et al. 2006, 2013; Krawczyk et al. 2011; Kłoskowski et al. 2013). In other European countries, also small-sized, elongated, economically indifferent fish species predominated in the diet (*G. aculeatus, Barbus* spp., *Cottus* spp., Cobitiidae). However, some fish of high economic value were also reported almost everywhere, e.g. *A. anguilla, S. trutta* and *E. lucius* (Webb 1975; Bekker

Table 4 Proportion of Cyprinidae and Percidae in the diet of the otter in Poland

Place	Percentage fish	Percentage Cyp. Perc.	Proportion Cypr.: Perc.	Source
Tanew River, E Poland	80	7	1:3.5	Brzeziński et al. (2006)
San River, SE Poland	73	27	1:1.5	Brzeziński et al. (2013)
Białowieża Forest, NE Poland	51	23	1:0.8	Jędrzejewska et al. (2001)
Artificial channel, W Poland	64	32	1:0.8	Krawczyk et al. (2011)
Czarna Hańcza River, NE Poland	57	25	1:0.4	Brzeziński et al. (2006)
San River, SE Poland	82	30	1:0.3	Brzeziński et al. (2006)
Bieszczady, SE Poland	63	30	1:0.3	Harna (1993)
Biebrza River, NE Poland	61	36	1:0.2	Brzeziński et al. (2006)
Canal-river system, E Poland	87	67	1:0.02	Kłoskowski et al. (2013)
Czerna River, SW Poland	94	79	1:0.6	This study

and Nolet 1990; Kemens and Nechay 1990; Libois 1995; Sulkava 1996; Gourvelou et al. 2000; Lanszki and Molnar 2003; Polednik et al. 2004; Britton et al. 2006; Georgiev 2006; Preston et al. 2006; Kortan et al. 2007; Lanszki et al. 2007, 2009, 2010, 2015; Bauer-Haas et al. 2014; Sittenthaler et al. 2019; Breust 2021; Macforlane 2021). In our study, as in other aquatic habitats in Europe, the size of fish preyed by the otter is positively correlated with the size of fish dominating in these habitats (Libois and Rosoux 1991; Brzeziński et al. 2006, 2013; Krawczyk et al. 2011).

In our study, seasonal variations recorded in the diet of otter reflect seasonal variation in the abundance and availability of the prey. *E. lucius, C. carassius, C. carpio* and *G. gobio* are more available in winter/spring month, while *B. barbatula, C. gobio, G. cernus, P. fluviatilis, R. rutilus* are more common in summer months. Frogs are more available in winter and spring as they overwinter in the river mud, while in spring they spawn. Crayfish and insects are most common in summer. Results obtained from other parts in Poland show that, in habitats with a small number of fish species, like this in our study, the diet of the otter is less diverse than in rich habitats. The diet composition is, however, more stable (Brzeziński et al. 2006).

It has been shown that the otter diet is more diverse in less stable environment, where non-fish prey are more often preyed upon (Ruiz-Olmo and Jimenez 2008; Dettori et al. 2022). In our study, as in many other European habitats, alternative vertebrate prey other than amphibians, played a little role. In most places, reptiles, birds, mammals did not contribute separately more than 10% of the otter diet (Jędrzejewska et al. 2001).

Amphibians (especially Ranidae and *Bufo bufo* (L., 1758)) are often preyed upon by the otter throughout the species' European range (Fairley 1984; Lizana and Perez Mellado 1990; Weber 1990; Pikulik and Sidorovich 1996; Jędrzejewska et al. 2001; Sidorovich and Pikulik 1997; Smiroldo et al. 2019; Polednik et al. 2004; Clavero et al. 2003; Garcia-Diaz and Ayres 2010; Ayres and García 2011; Parry et al. 2015; Zalewska et al. 2020). Amphibians are especially important in winter when fish availability is reduced. Amphibians, often hibernating in river muds, may be in winter easily accessible. At least 20 amphibian species were identified in the otter diet, which comprised 35% of European species.

Based on published results of 29 studies carried out in Europe, Krawczyk et al. (2016) calculated that frogs constitute on average 17% of biomass and 13% of RFO in the diet of the otter. The proportion of amphibians increased from west to the east. Smiroldo et al. (2019) on the basis of 64 European studies on the otter diet from 20 countries revealed that amphibians comprise from 0 to 43% of all prey items, in most studies – more than 15%, e.g. 43% in the Wołostaty Stream in Bieszczady Mts., SE Poland (Pagacz and Witczuk 2010); 39% in the Lovat River, NE Belarus (Sidorovich 2000); 30–34% in Latvia (Ozolins et al. 1998); 24–36% in Georgia (Gorgadze 2013); 25% in Hungary (Lanszki et al. 2015); 24% in E Romania (Bouroş 2014); 16% in N Germany (Breust 2021).

Very low contribution of frogs in our study indicates that amphibians are rare in small rivers flowing through woodlands dominated by pine plantations. In another small river in almost pristine stage in the Białowieża Forests, Jędrzejewska et al. (2001) reported frogs as comprising 58% of all prey items. Also in small artificial channels in an extensively managed farmland, frogs comprised an important prey (16%; Krawczyk et al. 2011).

In Europe, the proportion of invertebrates and other non-fish prey in the otter diet shows a longitudinal trend, i.e. the proportion increases southwards (Clavero et al. 2003). Wherever decapods (Crustacea: Decapoda) are abundant they comprise an important component of the otter diet (McFadden and Fairley 1984; Beja 1996; Ruiz-Olmo et al. 1998; Sidorovich 2000; Jędrzejewska et al. 2001; Georgiev and Stoycheva 2006; Dettori et al. 2022). In inland waters in Europe, they are represented in the otter diet by *Astacus astacus* L., 1758, *Pontastacus leptodactylus* (Eschscholtz, 1823), *Austropotamobius pallipes* (Lereboullet, 1858), *Procambarus clarkia* (Girard, 1852), *Potamon ibericum*

(Bieberstein, 1808), *P. fluviatile* (Herbst, 1758), *Pachygrapsus marmoratus* (Fabricius, 1787) (Chanin 2003; Georgiev 2006; Remonti et al. 2008; Dettori et al. 2022). Their contribution in the otter diet may range from 0 to 48% (Chanin 2003; Dettori et al. 2022), being higher in the coast than inland habitats, and in summer than in winter (Ruiz-Olmo and Jimenez 2008; Dettori et al. 2022).

Most studies in Poland do not report mussels (Mollusca: Bivalvia) in the otter diet (Harna 1993; Kłoskowski 2000; Jędrzejewska et al. 2001; Brzeziński et al. 2006, 2013; Wiśniowska 2006; Pagacz and Witczuk 2010). None were recorded even in rivers well known for the abundance of unionid mussels (Brzeziński et al. 2006). Kłoskowski et al. (2013) recorded only one unionid specimen out of 1465 prey items retrieved from 478 spraints in river-channel systems in E Poland. Also in this study only single mussel was reported. However, predation by the otter on the mussels has been reported by Kopij (2011) and Krawczyk et al. (2011). Through direct field observations Kopij (2011) reported relatively high predation on the threatened *Anodonta cygnea* (L., 1758) in a fish-pond in SW Poland, while Zając (2014) using telemetry recorded such case in a small water reservoir in S Poland. It appears that in places where mussels are abundant, like in some fish-ponds, water reservoirs and larger rivers, they may constitute an important component in the otter diet (Georgiev 2006; Kopij 2011; Zając 2014), although their remnants are poorly represented in spraints.

This study confirms previous findings (Lanszki et al. 2007, 2009; Jędrzejewska et al. 2001) that the otter is a generalist piscivorous predator, hunting opportunistically on locally and seasonally most common fish species, mainly of low economic importance.

Author contribution K. Szymczyk: collection of the material and prey identification; G. Kopij: prey identification, data analysis, literature review, writing the manuscript.

Declarations

Ethical approval Not applicable.

Conflict of interest None.

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