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SUMMER DIET OF EURASIAN OTTERS IN LARGE DAMS OF SOUTH PORTUGAL

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ABSTRACT **-** Twelve large dams in the Alentejo region (southern Portugal) were surveyed for otter signs from July to September 2002 (dry season). A total of 102 transects (200-600m in length) were conducted on the shores of both lentic systems (reservoirs) and adjoining lotic systems (rivers and streams). All dams had evidence of otter presence. A total of 417 spraints was collected and analysed, resulting in 836 prey items and 33 prey categories. Overall, the American crayfish *Procambarus clarkii* was the most consumed prey (percentage of occurrence, PO = 50.7%), followed by fish (PO = 42.0%). Crayfish dominance was evident in the rivers/streams (PO: 61.6% *vs*. 29.0% for fish) whilst in the reservoirs fish represented 48.4% of consumed prey and crayfish 45.4%. Nevertheless, considering the consumed biomass (PB), fish were more important (overall PB: 70.0%; reservoirs: 69.7%; rivers/streams: 55.4%) than crayfish (36.0%, 30.6% and 44.6%, respectively). The most eaten fish species was the pumpkinseed *Lepomis gibbosus* in both water systems but in terms of biomass carps *Cyprinus carpio* were more important. These two species dominated the fish communities of all reservoirs. Overall, our results support the hypothesis that dams constitute an "attraction point" for otters in terms of water and prey availability, especially during droughts, when Mediterranean lotic systems usually dry up.

Key words: *Lutra lutra*, diet, dry season, dams, Mediterranean ecosystems, Portugal

RIASSUNTO – ***Dieta estiva della Lontra in ampi invasi artificiali del Portogallo meridionale***. Tra luglio e settembre 2002, 12 ampi invasi artificiali situati nella regione dell'Alentejo (Portogallo meridionale) sono stati monitorati per accertare la presenza della Lontra *Lutra lutra*. Complessivamente sono stati effettuati 102 transetti (200-600 m di lunghezza), perlustrando entrambe le rive degli invasi (acque lentiche) e degli adiacenti corsi idrici (acque lotiche). In tutti i corpi idrici esaminati è stata accertata la presenza della Lontra. Tramite l'analisi di 417 feci raccolte, sono state determinate 836 prede e 33 categorie alimentari. I dati sono stati espressi come percentuale di presenza (PO = N° di individui di ciascuna categoria alimentare / N° totale di individui consumati x 100) e biomassa consumata (PB = biomassa di ciascuna categoria alimentare / biomassa totale consumata x 100). Complessivamente, il Gambero rosso della Luisiana *Procambarus clarkii* è risultato essere la specie maggiormente consumata (PO = 50,7%), seguita dai pesci (PO = 42,0%). La dominanza del gambero è stata netta nei corsi idrici adiacenti agli invasi

(PO: 61,6% contro 29,0% per i pesci), mentre negli invasi i pesci hanno rappresentato il 48,4% delle prede consumate e i gamberi il 45,4%. Tuttavia, considerando la biomassa consumata, i pesci sono risultati più importanti (PB: 70,0% della dieta complessiva, 69,7% per gli invasi e 55,4% per i corsi idrici adiacenti) dei gamberi (36,0%, 30,6% e 44,6%, rispettivamente). In termini di frequenza percentuale, il Persico sole *Lepomis gibbosus* è stata la specie maggiormente consumata sia negli invasi sia nei corsi idrici adiacenti, mentre la Carpa *Cyprinus carpio* è risultata predominante in termini di biomassa. Queste due specie sono risultate essere quelle prevalenti nell'ambito delle comunità ittiche degli invasi. In generale, i risultati ottenuti supportano l'ipotesi che gli invasi artificiali, per la disponibilità di acqua e, di conseguenza, di prede, costituiscono un "sito di attrazione trofica" per le lontre, specialmente durante il periodo di siccità, quando i corsi idrici limitrofi sono generalmente asciutti.

Parole chiave: *Lutra lutra,* dieta, stagione secca, invasi di dighe, ecosistemi mediterranei, Portogallo

INTRODUCTION

Optimal habitats for Eurasian otters (*Lutra lutra*) are considered to be water systems with dense riparian cover, low disturbance and good foraging areas with high prey availability (e.g. Kruuk *et al*., 1993; Prenda and Granado-Lorencio, 1995; Beja, 1996). Dams, on the other hand, are considered detrimental to otters and one of the causes of the decline of the species in Europe (Macdonald and Mason, 1984; Foster-Turley *et al*., 1990). One of the consequences of dam construction is the change in prey communities, as fish species adapted to flowing rivers differ from those adapted to large still water bodies (Collares-Pereira *et al*., 2000; WCD, 2000). Moreover, the otter's favourable foraging areas are affected, as dams tend to have steep margins and deep reservoirs, which constrain the fishing ability of otters (Kruuk, 1995). However, the response of otters to changes in fish communities associated with dams has been seldom investigated. Sheldon and Toll (1964), focusing on the North American river otter (*L. canadensis*) in a reservoir in Massachusetts (USA), found that otters were feeding mainly on yellow perch (*Perca flavescens*). At the Furnas dam (Brazil), the diet of the Neotropical otter (*L. longicaudis*) was mostly composed of cichlids (Passamani and Camargo, 1995). Gourvelou *et al.* (2000) examined the feeding habits of the Eurasian otter in a shallow reservoir in northern Greece, where the most important food species were *Lepomis gibbosus*, and *Carassius auratus*.

Mediterranean streams are character-rised by strong irregularities in water flow and, during dry seasons, many dry up and water is retained in few scattered pools (Prenda *et al*., 2001). This reduction in water and prey availability forces otters to concentrate in water patches containing food and cover (e.g. Macdonald and Mason, 1982; Prenda *et al*., 2001). Although reservoirs could be seen as poor otter habitat, due to the frequent and unpredictable water level fluctuations that result in the lack of bank vegetation and consequently of refuges, they could be important for otters, primarily as foraging areas, during the long periods of water shortage (Prenda *et al.*, 2001; Pedroso *et al.*, 2004).

Portugal is considered to have one of the most viable populations of otters in Europe (Macdonald and Mason, 1982; Mason and Macdonald, 1986; Santos-Reis, 1983, Santos-Reis *et al.*, 1995); the species is found throughout the country, inhabiting all types of riverine systems as well as the southwest sea coast (Trindade *et al.*, 1998). This may be a result of the high diversity of wetlands and good habitat conditions found in Portugal (Macdonald and Mason, 1982; Santos-Reis *et al.*, 1995).

Portugal has 92 large dams with a further 15 scheduled for construction in the forthcoming years, many of them located in the south of the country.

The aim of our study is to describe the diet composition of otters in reservoirs and surrounding rivers during the dry season (summer), characterized by rivers and streams of irregular flow.

STUDY AREA

The study was conducted at 12 large dams (defined as having a wall height ≥ 15 m or a wall height between 5-15 m and a reservoir volume greater than three million cubic metres; WCD, 2000) and adjoining rivers/streams in the Alentejo region (South Portugal) during the dry season (July-September) of 2002 (Fig. 1). Four dams (Caia, Vigia, Monte Novo and Lucefécit) are located in the Guadiana basin and eight (Alvito, Odivelas, Pego do Altar, Vale do Gaio, Fonte Cerne, Campilhas, Roxo and Monte da Rocha) in the Sado basin. The Guadiana and Sado are two of the most important rivers in Portugal. Pego do Altar is the oldest dam (1949) and Fonte Cerne the more recent (1997). All were created for irrigation and as water reserves. According to the reservoir size two groups were identified: (i) one with reservoir areas <300 ha - Fonte Cerne, Lucefécit, Vigia and Monte Novo dams, (ii) the other with areas ≥ 300 ha, including the Caia reservoir (1970 ha), the largest one. The climate of the study area is characterised by mild winters and extremely hot summers (Carmel and Flather, 2004).

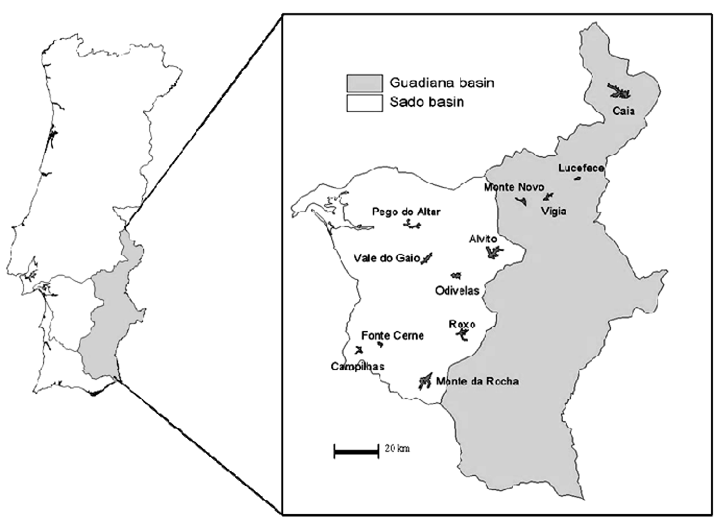

Figure 1 – Large dams surveyed for otter signs in Alentejo region (South Portugal).

METHODS

1. Sampling sites and spraint collection

At each dam, we established a series of 200m long transects for collecting otter spraints and/or prey remains, extended to 600m whenever no otter signs had been found previously (Macdonald, 1983; Prenda *et al.*, 2001). A total of 102 transects were conducted (76 along the reservoirs and 26 along the adjoining rivers/streams). A single survey campaign was performed.

2. Spraint and data analysis

Fish remains were identified using keys for scales and specific bone structures (Baglinière and Le Louarn, 1987; Elvira, 1988; Prenda and Granado-Lorencio, 1992; Conroy *et al.*, 1993; Prenda *et al.*, 1997). American crayfish (*Procambarus clarkii*) remains were identified using the exoskeleton pieces (Freitas D., unpubl. data), while amphibians and reptiles were identified by specialists using characteristic remains (e.g. scales for reptiles). For birds we used feathers (Brom, 1986), whilst for mammals hair and teeth were considered (Debrot *et al.*, 1982). Whenever possible, prey remains were identified to the species level. The minimum number of individuals consumed was calculated by counting, measuring and matching paired skeleton/exoskeleton pieces. A maximum of 30 spraints was analysed per sampling site and, whenever this number was exceeded, a random procedure was followed to select sub-samples. (Sokal and Rohlf, 1995). This was the case for many reservoirs but not for rivers/streams. To convert the length of specific fish bones and *P. clarkii* exoskeleton pieces found in scats into total length of individual prey and this into weight consumed, we used regression equations (Prenda and Granado-Lorencio, 1992; Prenda *et al.*, 2002; Freitas D., unpubl. data). Results were expressed as percentage of occurrence ($PO_{(item\ A)}$ = total number of individuals of prey item A consumed / total number of individuals consumed x 100) and for fish and *P. clarkii*, the main otter preys, also as percentage of biomass ($PB_{(itemA)}$ = total biomass of prey item A / total biomass of all prey categories x 100). Trophic niche breadth was calculated using Simpson (BS) index of diversity (Sokal and Rohlf, 1995). Yates' χ^2 correction for continuity (Simpson *et al.*, 1960) was used to check differences in otter diet between lotic and lentic systems. We assumed that the prey recorded in sprints collected in a particular water body were caught in the same water body. The influence of reservoir size on BS and on each main prey class consumption was inferred using Spearman's correlation coefficient, r_s (Sokal and Rohlf, 1995).

3. Prey availability

Prey availability was assessed on the basis of visual qualitative estimates of the abundance of fish and *P. clarkii*, the main prey for otters in Mediterranean habitats (e.g. Beja, 1991 and 1996; Ruiz-Olmo *et al.*, 2001; Clavero *et al.*, 2003 and 2004, Ruiz-Olmo *et al.*, 2005). This visual estimation, although methodologically limited due to its subjectivity, has been used for assessing different ecological variables (e.g. potential refuges, marking sites, human disturbance) in other otter studies (e.g. Beja, 1992; Prenda *et al.*, 2001). The diversity of fish inhabiting the reservoirs is low, with most using the margins of these aquatic systems (Ferreira and Godinho, 1994), allowing for easy observation. To reduce bias the same observer collected all field data. The abundance classes were: absence, scarce, frequent, abundant and highly abundant (see Ruiz-Olmo *et al.*, 2005). Data from the Regional Agriculture Department, gathered in fishing competitions (Ferreira *et al.*, 1999), were available, although not from the same time frame as this study, and were used to complement field data in terms of the species inventory. Ferreira *et al.* (1999) presented ten years of fish data gathered during fishing competitions for several dams, including the ones in this study. Although these data are not recent, in the last decade the fish community has maintained a considerable stability in terms of species composition and relative abundance, a consequence of being composed mostly of exotic species (Ferreira *et al.*, 1999). This suggests that the current situation of the fish community may not differ from the last available data (1997 for 9 of the 12 dams). Nevertheless, these data were only used as an indicator of the otter prey community. According to Ferreira *et al.* (1999), in 1997 the diversity of the fish community in these reservoirs was fairly low, including *Chondrostoma willkommii*, *C. polylepis*, *Squalius pyrenaicus*, *S. alburnoides*, *M. salmoides, Cyprinus carpio, L. gibbosus*, *C. auratus* and from one to five species of barbel (*Barbus bocagei, B. sclateri, B. comiza, B. steindachneri* and *B. microcephalus*), which fishermen were not able to distinguish. The most abundant species - *M. salmoides, C. carpio, L. gibbosus* and *C. auratus -,* are exotic, suggesting a low ecological interest of the fish community. According to the same authors, *C. carpio* dominated in five dams (Vale do Gaio, Roxo, Odivelas, Caia and Alvito) and *L. gibbosus* in four (Pego do Altar, Monte Novo, Lucefécit and Vigia).

RESULTS

All dams had evidence of otter presence, only 13.7% of transects giving negative results (14.5% in reservoirs and 11.5% in rivers/streams). A total of 681 otter signs were found. Of these, 417 spraints were analysed resulting in 836 prey items, belonging to 33 categories (Tab. 1).

Overall, the American crayfish was the most common prey (PO = 50.7%), followed by fish (PO = 42.0%). In rivers/streams *P. clarkii* clearly dominated (61.6% *vs.* 29.0% for fish) the otter diet, whilst in the reservoirs fish represented 48.4% of the consumed prey and *P. clarkii* 45.4%. Nevertheless, considering the total consumed biomass, fish was more important (overall PB: 64.95%; reservoirs: 69.4%; rivers/streams: 55.4%), followed by *P. clarkii* (overall: 35.1%; reservoirs: 30.6%; rivers/streams: 44.6%), even considering that fish biomass is underestimated when compared with *P. clarkii,* since unidentified fish (most probably carp *C. carpio*) were excluded from PB calculations.

The most consumed fish species was the pumpkinseed (*L. gibbosus*) (PO = 13.8% in both water systems) but in terms of biomass, *C. carpio* was more important (reservoirs: 55.8%; rivers/streams: 41.3%). This cyprinid species contributed the largest biomass in overall terms (51.2%), being surpassed by *P. clarkii* only for rivers/streams.

Comparing otter diet between rivers/streams and reservoirs significant differences emerged for fish, which were more consumed in the reservoirs (χ^2 = 29.39; P<0.001), and crayfish, which were preyed more frequently along rivers/streams (χ^2 = 20.16; P<0.001).

Focusing on the dam reservoirs and analysing the results in terms of occurrences, *P. clarkii* was more important in six reservoirs (Alvito, Fonte Cerne, Odivelas, Monte da Rocha, Roxo and Monte Novo)

Table 1 - Percentages of occurrence (PO) and biomass (PB) of otter prey categories in Alentejo (N = number of individuals).

	Total (N = 836)			Reservoirs (N = 560)			Rivers/streams (N = 276)		
Prey Categories	N	PO	PB	N	PO	PB	N	PO	PB
Procambarus clarkii	424	50.7	35.05	254	45.4	30.55	170	61.6	44.57
Insects	28	3.3	-	13	2.3	-	15	5.4	-
Odonata	4	0.5	-	1	0.2	-	3	1.1	-
Coleoptera	4	0.5	-	2	0.4	-	2	0.7	-
Hymenoptera	1	0.1	-	1	0.2	-	0	0.0	-
Unidentified insect	19	2.3	-	9	1.6	-	10	3.6	-
Fish	351	42.0	64.95	271	48.4	69.36	80	29.0	55.38
Lepomis gibbosus	115	13.8	8.35	77	13.8	7.62	38	13.8	9.87
Micropterus salmoides	41	4.9	2.50	29	5.2	2.39	12	4.3	2.74
Unidentified Centrarchids	11	1.3	-	8	1.4	-	3	1.1	-
Squalius alburnoides	10	1.2	0.75	9	1.6	1.10	1	0.4	0.02
Chondrostoma polylepis	4	0.5	0.68	4	0.7	1.00	0	0.0	-
Barbus bocagei	3	0.4	1.37	2	0.4	1.34	1	0.4	1.43
Barbus sp.	6	0.7	-	6	1.1	-	0	0.0	-
Cyprinus carpio	42	5.0	51.22	35	6.3	55.82	7	2.5	41.32
Unidentified Ciprynids	70	8.4	-	62	11.1	-	8	2.9	-
Gambusia holbrooki	36	4.3	0.08	28	5.0	0.09	8	2.9	0.06
Unidentified fish	13	1.6	-	11	2.0	-	2	0.7	-
Amphibians	18	2.2	-	9	1.6	-	9	3.3	-
Triturus sp.	1	0.1	-	0	0.0	-	1	0.4	-
Unidentified Urodela	1	0.1	-	1	0.2	-	0	0.0	-
Pelobates cultripes	2	0.2	-	1	0.2	-	1	0.4	-
Rana perezi	9	1.1	-	5	0.9	-	4	1.4	-
Unidentified Anura	1	0.1	-	0	0.0	-	1	0.4	-
Unidentified Amphibians	4	0.5	-	2	0.4	-	2	0.7	-
Natrix sp.	8	1.0	-	7	1.3	-	1	0.4	-
Birds	3	0.4	-	2	0.4	-	1	0.4	-
Anseriformes	1	0.1	-	1	0.2	-	0	0.0	-
Passeriformes	1	0.1	-	1	0.2	-	0	0.0	-
Unidentified birds	1	0.1	-	0	0.0	-	1	0.4	-
Mammals	4	0.5	-	4	0.7	-	0	0.0	-
Mus sp.	1	0.1	-	1	0.2	-	0	0.0	-
Unidentified mammals	3	0.4	-	3	0.5	-	0	0.0	-

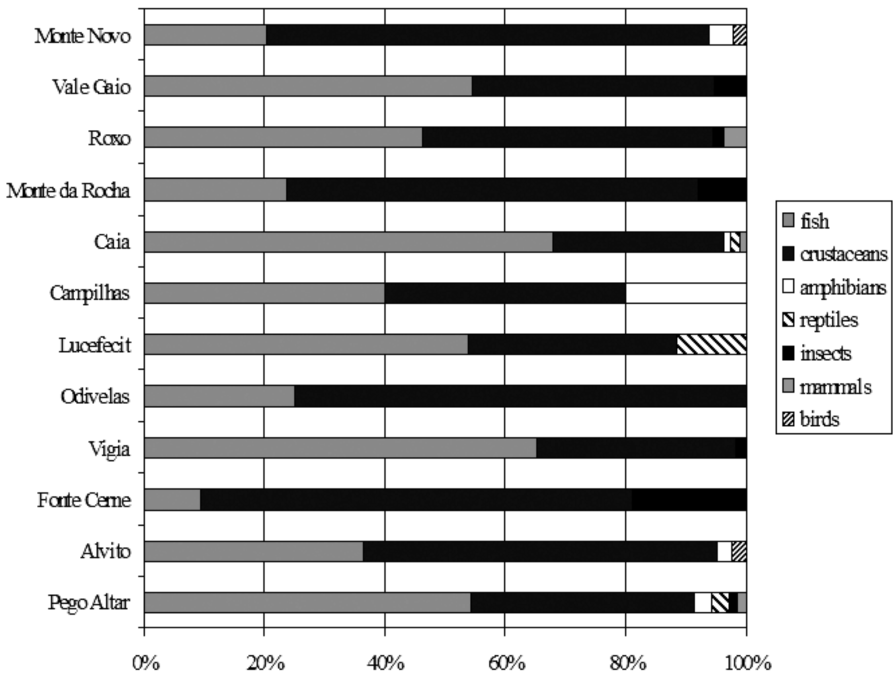

Figure 2 - Percentages of occurrence (PO) of otter prey categories in Alentejo large reservoirs.

and fish in four (Pego do Altar, Vigia, Caia and Vale do Gaio) (Fig. 2). Both prey categories resulted in PO> 20.0% in all reservoirs with the exception of fish for Fonte Cerne. Amphibians were also an important resource in the Campilhas reservoir (PO = 20.0%) and reptiles in Lucefécit reservoir (PO = 11.5%) (Fig. 2).

P. clarkii attained higher PB values in seven reservoirs (Pego do Altar, Alvito, Fonte Cerne, Odivelas, Lucefécit, Vale do Gaio and Monte Novo) and fish in five (Vigia, Campilhas, Caia, Monte da Rocha and Roxo) (Fig. 3). The decisive contribution of *C. carpio* biomass to the total fish biomass was confirmed.

Trophic niche values varied between 0.133 (Monte Novo reservoir) and 0.682 (Lucefécit reservoir) (Fig. 4).

Correlations between reservoir size and BS, as well as reservoir size and consumed prey classes (fish, crayfish, mammals, birds, reptiles, amphibians), were not significant (r_s varied from 0.206, P=0.52, to 0.68, P=0.15, N=12).

On the whole, visual surveys confirmed the available data on fish species abundance (Ferreira *et al.*, 1999) with fish classified as “highly abundant” or “abundant” in 7 reservoirs (Vale do Gaio, Vigia, Caia, Lucefécit, Pego do Altar, Campilhas and Roxo), all with more then 40% of fish in overall

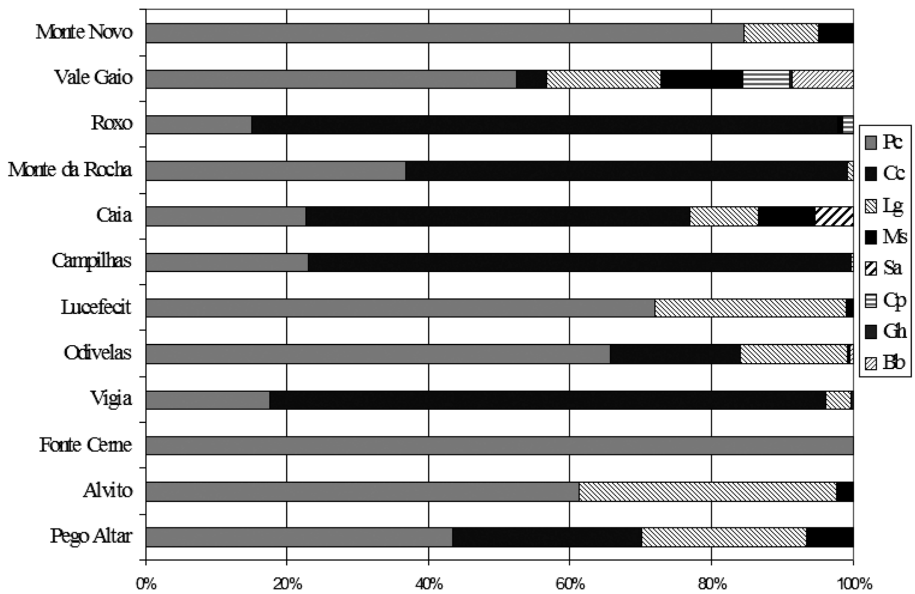

Figure 3 – Percentages of fish and crayfish consumed biomass in Alentejo large reservoirs (Pc: *Procambarus clarkii*; Lg: *Lepomis gibbosus*; Ms: *Micropteros salmoides*; Sa: *Squalius alburnoides*; Cp: *Chondrostoma polylepis*; Cc: *Cyprinus carpio*; Gh: *Gambusia holbrooki*; Bb: *Barbus bocagei*).

consumed prey; in addition, *P. clarkii* was observed in all water systems, being, on average, more abundant in rivers/streams (it was classified as "highly abundant" or "abundant" in 8 of the 12 lotic systems, including the ones where the species was more consumed than the overall of fish species).

DISCUSSION

The favourable status of otter populations in Portugal may lead otters to occupy, especially during dry seasons, suboptimal habitats in terms of refuge but offering profitable prey (Pedroso *et al.*, 2004).

Although our data are restricted to one season, reservoirs, offering plenty of water and suitable prey, seem to constitute an "attraction point" for otters, during the recurrent periods of dryness suffered by Mediterranean water systems (Prenda *et al.*, 2001).

Our results confirm the otter as a specialist feeder (e.g. Jenkins and Harper, 1980), relying on two main food sources, fish and crayfish. Nevertheless, data on prey availability suggest that otters, although not consuming a broad range of prey, mostly use the most abundant species, revealing an opportunistic character: *C. carpio* and *L. gibbosus* dominated the fish assemblage in the dams and represented more than 75% of the otter diet in terms of PO. The same pattern concerned *P. clarkii*, which, in accordance with their higher

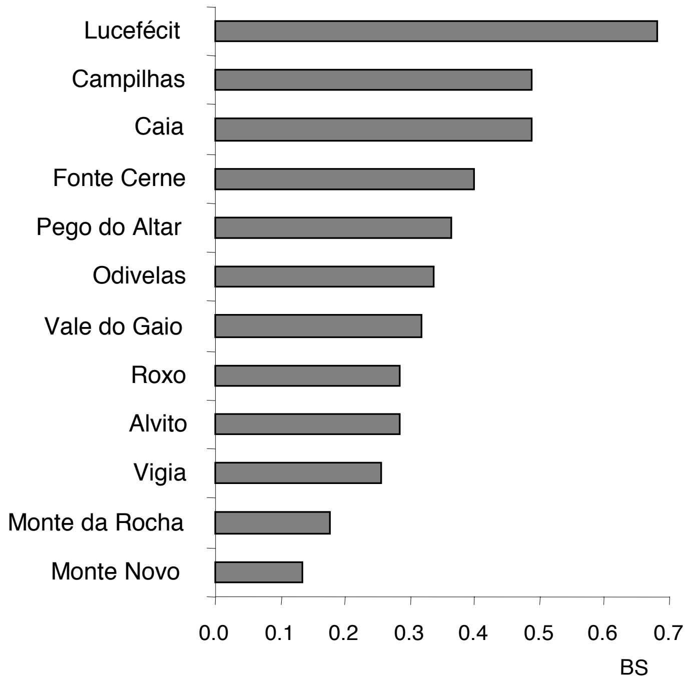

Figure 4 - Trophic niche of the otter (Simpson Índex - BS) in Alentejo large reservoirs.

abundance, were more consumed along rivers/streams. The importance of reservoirs in summer may be particularly significant, many surrounding streams being dry or turned to small pools. Some of these are able to sustain *P. clarkii* populations but not fish. As suggested by the higher consumption of *P. clarkii* in lotic than in lentic systems, the abundance of *P. clarkii* may be one of the most important features associated with the otter presence in rivers and streams of the Mediterranean area (see also Beja, 1996; Magalhães *et al.*, 2002; Clavero *et al.*, 2003 and 2004; Ottino and Giller, 2004; Cruz *et al.*, 2004). Otters can be considered as "food-limited" in Mediterranean ecosystems, apparently tolerating the lack of water during dry periods if there is sufficient prey availability (Ruiz-Olmo *et al.*, 2001). Even if *P. clarkii* is actually considered a main prey for otters in the Iberian Peninsula (e.g. Beja, 1996; Clavero *et al.*, 2004), in terms of consumed biomass fish species are more important overall, and otters may still be limited by fish availability (Beja, 1996).

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