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Seasonal variations and changes in the diet of southern river otter in different freshwater habitats in Chile

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The diet of southern river otter *Lutra provocax* Thomas, 1908 was determined from 605 scats collected from four sites in Southern Chile between 1990–1991. Crustacean remains were the most common item found in scats. Crustacean species that were the most common in scats collected from lakes, became less important in the river outlets. Fish remains were all from fish less than 100 mm in length and were found more frequently in scats collected at the river sites than at the lake sites. Differences in the diet between otter's scats collected in lakes and their river outlets may be related to prey availability and vulnerability. Diet was more diverse in river habitats than in the lakes. The diet of southern river otter appears to be closer to that described for *Aonyx capensis* and *Lutra maculicollis* in South Africa. The southern river otter is heavily dependent on the abundance of three crustacean species. Differences in the diets observed between lake and their river outlets suggest important differences in habitat conditions. This may have future implications for prioritising habitat protection in the conservation of southern river otter.

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Introduction

Food studies on *Lutra lutra* in Europe and *Lutra canadensis* in North America indicate that in freshwater habitats these otters are primarily piscivorous (Melquist and Hornocker 1983, Mason and Macdonald 1986). In contrast, studies of the feeding habits of southern river otter in freshwater habitats in Chile and Argentina suggest that crustaceans and mussels are the most important dietary component (Chehébar 1985, Chehébar *et al.* 1986, Medina 1991, Medina 1997). However, there is a lack of information about the effects of different habitat conditions and seasons on the diet of the southern river otter. This research provides insights into the variations of the diet of southern river otter between lakes and rivers, seasons and size of prey.

Study area and methods

Two lakes and their main river outlets were chosen for this study (Fig. 1), representing two of the remaining regions holding southern river otter populations in freshwater habitat in Chile (Medina 1996). Lake Panguipulli (39°43' S, 72°13' W) is drained by the Enco River (140 m a.s.l.) (Fig. 1). The lake is oligotrophic with temperatures above 4°C and a maximum surface temperature of 21°C (Campos *et al.* 1981). Potential otter prey in Lake Panguipulli and Enco River include the introduced trout *Oncorhynchus mykiss* (20–210 mm length) and *Salmo trutta* (42–296 mm); the native fishes *Aplochiton zebra* (49–159 mm length, average 71 mm), *Trichomycterus areolatus* (27–100 mm length, average 52 mm), *Percilia gillissi* (26–64 mm length, average 42 mm), *Galaxias platei*, *Diplomystes chilensis*, and *Percichthys trucha* (18–520 mm length); the crabs *Aegla rostrata* (21–45 mm cephalotorax length), *Aegla abtao*, *Aegla denticulata* (8-37 mm cephalotorax length), the crayfish *Samastacus spinifrons;* and the mussels *Diplodon chilensis* and *Chilina spp.* (Jara 1977, 1989, Campos 1985, C. G. Jara, pers. comm.). The lake shoreline is mainly steep and rocky, 23% of its surface area is of shallow zones (< 30 m deep) (Campos *et al.* 1981). The Enco River is the only outlet for Lake Panguipulli (Fig. 1), with a rocky shoreline covered with abundant vegetation (eg, *Chusquea quila*, *Notofagus dombeyi*). Lake Todos los Santos (41°08' S, 72°12' W) is drained by the Petrohué River (Fig. 1) (189 m a.s.l.). The lake is oligotrophic with temperatures above 8°C and a maximum surface temperature of 19°C (Campos *et al.* 1990). Potential otter preys are the same as in Lake Panguipulli and the Enco River except that *Aegla denticulata* is absent (Campos 1985, Jara 1977, 1989, C. G. Jara, pers. comm.). The lake shoreline is steep and rocky and is covered with abundant vegetation (in particular *Amomyrtus luma*, *Myrceugenia exsucca*, *Luma apiculata*, *Drimys winteri* and *Nothofagus*

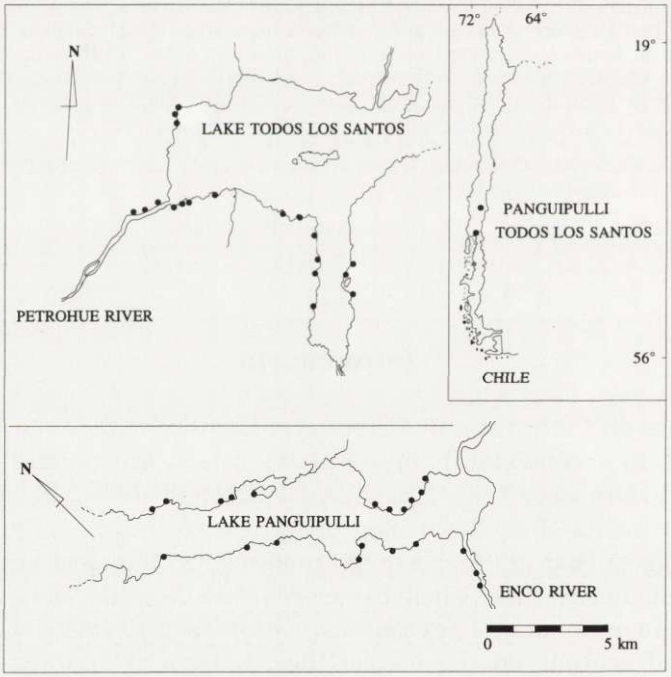

Fig. 1. Geographic location of the study areas and sites (•) where otter scats were collected.

dombeyi), 8% of the lake surface area is of shallow zones (< 30 m deep) (Campos *et al.* 1990). The Petrohué River (Fig. 1) is the only outlet for the lake, with a steep, rocky shoreline also covered with abundant vegetation (*Nothofagus spp.*).

From August 1990 to November 1991 monthly patrols were made on foot or by canoe along the shorelines of the study sites. During the initial survey only otter dens and rest-sites were located. Fresh otter scats (one month old or less) were collected monthly in or between dens and rest-sites that were earlier identified (Fig. 1). Scats were dried at 75°C for 24 to 48 hours (Bagenal 1978) and stored in paper bags for later analysis. Prey remains in the dried scats were identified and compared with reference material held at the Instituto de Ecología y Evolución, Universidad Austral de Chile. Fish remains in collected otter scats were identified using scales operculae and vertebrae, and their size estimated by comparing the size of abdominal and caudal vertebrae with previously measured reference material (adapted from Wise 1980). Fish were classified into eight length categories (< 39 mm, 40–49 mm, 50–59 mm, 60–69 mm, 70–79 mm, 80–89 mm, 90–99 mm, ≥ 100 mm). The results were tabulated as occurrence (number of scats in which a species occurred), frequency of occurrence (number of scats in which a species occurred divided by the total number of scats collected) and relative frequency (number of scats in which a species occurred divided by the total occurrence of all the species tested) (Erlinge 1968, Rowe-Rowe 1977, Medina 1997). These were tested as arcsine--transformed frequencies of occurrence.

Seasonal variation of prey categories and species in otter scats at the same lake and river were assessed by Friedman two-way ANOVA. Correlations of monthly frequency of occurrence between prey species and between prey categories at the same lake or river were determine by linear regression. Comparison of the mean frequencies of occurrence of prey species and categories between lakes and their river outlets were made using Wilcoxon signed rank (Berenson *et al.* 1988). Differences between fish size categories were evaluate by two-way ANOVA and pairwise compared using Fisher's Least-Significant-Difference Test (LSD). Prey diversity in the diet was assessed using the Shannon-Wiener diversity index (Krebs 1989) and the indexes were compared using Hutcheson's *t*-test method (Magurran 1988).

Results

Diet composition

Crustaceans were the most frequently found prey in the 605 otter scats collected followed by fish. Mussels and birds were rarely recorded (Table 1). At most sites there were no seasonal changes in the diet (Fig. 2) except at Enco River, where *P. trucha* recorded a significant seasonal change towards spring and summer ($F_{3,8} = 13.5$, $p < 0.05$).

There was no correlation between prey species and between prey categories.

Fish size

In otter scats a total of 127 fish remains for lakes and 98 for rivers were measured to estimate fish size. Fish eaten by otters were all less than 100 mm in length with no overall significant difference between the size categories. However, the frequency of fish size between 80 and 99 mm length was a significant less than the frequency of fish between 40 and 49 mm length (Table 2). Also, no significant difference was recorded between fish size estimated from remains found in scats collected at lakes and scats collected at river habitats (Table 2).

Table 1. Occurrence (O) and frequency of occurrence (FO) of prey species and category in otter scats collected in the study lakes (L) and rivers (R), n – indicate number of scats collected.

Prey species	L. Panguipulli (n = 242)		Enco R. (n = 86)		L. T. Los Santos (n = 217)		Petrohué R. (n = 60)	
	O	FO	O	FO	O	FO	O	FO
Total crustaceans	269		96		289		74	
Aegla rostrata	220	0.91	32	0.37	0	0.00	0	0.00
Aegla abtao abtao	48	0.20	64	0.74	83	0.38	46	0.77
Samastacus spinifrons	1	0.00	0	0.00	206	0.95	28	0.47
Total fish	117		74		40		41	
Percilia gillissi	48	0.20	37	0.43	7	0.03	11	0.18
Percichthys trucha	20	0.08	15	0.17	8	0.04	2	0.03
Oncorhynchus mykiss	16	0.07	8	0.09	8	0.04	14	0.23
Salmo trutta	3	0.01	5	0.06	6	0.03	9	0.15
Galaxias spp.	0	0.00	1	0.01	0	0.00	0	0.00
Undetermined	30	0.12	8	0.08	11	0.05	5	0.08
Total mussels	2		0		1		0	
Chilina spp.	2	0.01	0	0.00	1	0.00	0	0.00
Total birds	1		0		0		0	
Podilymbus podiceps	1	0.00	0	0.00	0	0.00	0	0.00
Total	389		170		330		115	

Table 2. Fish size relative frequency (%) in otter scats collected at the studied lakes (L) and rivers (R). Fish length categories with the same letter differ significantly (Fisher's LSD: $p < 0.03$).

Fish length (mm) categories	Species									
	Percilia gillissi		*Perachthys trucha*		*Oncorhynchus mykiss*		*Salmo trutta*		Total	
	L	R	L	R	L	R	L	R	L	R
0 < 39 a	39.4	33.3	9.1	0.0	10.5	4.0	0.0	7.1	24.4	19.4
40–49 b	31.8	39.2	33.3	12.5	5.3	8.0	0.0	14.3	26.0	25.5
50–59 c	13.6	15.7	18.2	0.0	5.3	12.0	33.3	0.0	15.0	11.2
60–69 d	1.5	9.8	12.1	12.5	31.6	48.0	33.3	21.4	11.0	21.4
70–79 e	13.6	2.0	12.1	37.5	21.1	20.0	22.2	35.7	15.0	14.3
80–89 f, b	0.0	0.0	12.1	12.5	15.8	4.0	11.1	7.1	6.3	3.1
90–99 g, b	0.0	0.0	3.0	25.0	10.5	4.0	0.0	14.3	2.4	5.1
Sample size	66	51	33	8	19	25	9	14	127	98

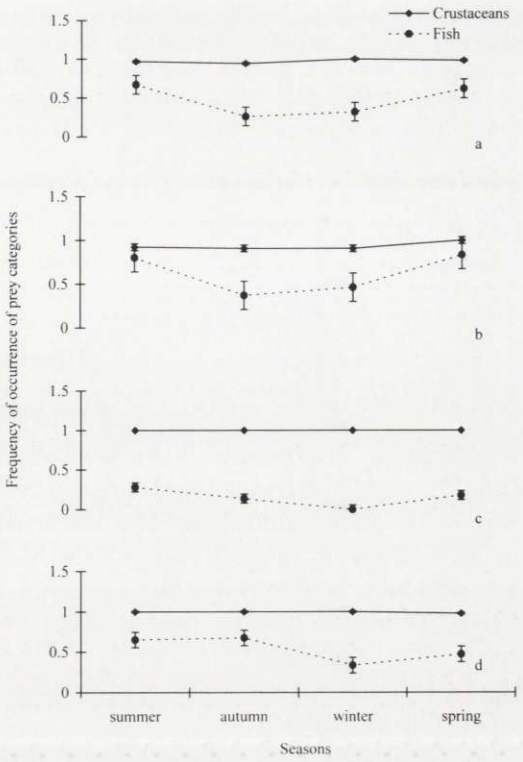

Fig. 2. Seasonal frequency of occurrence of fish and crustaceans in otter scats collected at (a) – Lake Panguipulli (n = 242), (b) – Enco river (n = 86), (c) – Lake Todos los Santos (n = 217), and (d) – Petrohué river (n = 60).

Comparisons between the study sites

The monthly frequencies of occurrence of *A. abtao* and *A. rostrata* were of significant difference between the scats collected in lakes and their river outlets (Lake Panguipulli vs Enco River; Wilcoxon: $Z = 2.9$, $p < 0.05$; $Z = 3.0$, $p < 0.05$ respectively) and *A. abtao* and *S. spinifroms* (Lake Todos los Santos vs Petrohué river; Wilcoxon: $Z = 2.8$, $p < 0.05$; $Z = 3.0$, $p < 0.05$ respectively). Furthermore, there was a switch from the most important crustacean prey species between lakes and their river outlets (Table 1). The crustacean prey species that were the most important at lakes became less important at the river outlets. Significant differences in the monthly frequency of occurrence to the introduced trouts between Lake Panguipulli and Enco river (Wilcoxon: $Z = 2.1$, $p < 0.05$), and Lake Todos los Santos and Petrohué river (Wilcoxon: $Z = 3.0$, $p < 0.05$) were also recorded.

Fish remains were significantly (Wilcoxon: $Z = 4.6$, $p < 0.05$) more frequent in scats collected at the rivers than at the lake sites.

All prey species recorded were equally represented by their occurrences in the scats collected from the river outlets (larger Even and H' indices) more than those collected from the lakes (Table 3).

Table 3. Diet diversity indices assessed from river otter scats obtained in two Chilean lakes and two rivers. H' – Diversity index (Shannon and Weaver 1963), N – number of groups of scats tested, H'Max – Maximum diversity, VarH' – Variance, Even – Evenness. All H' are significantly different ($p < 0.05$).

Study areas	N	H'	H'Max	VarH'	Even
Lake Panguipulli	10	0.80	2.20	0.01	0.36
Enco river	8	1.05	2.08	0.01	0.51
Lake T. Los Santos	8	0.45	2.08	0.01	0.21
Petrohué river	7	0.86	1.95	0.02	0.44

Discussion

Food preference

Although, crustaceans have been described as a lower quality food for otter than that of fish (Kruuk 1995), this study shows that southern river otter is heavily dependent on the abundance of three crustacean species. This differs from *L. lutra* in Europe and *L. canadensis* in North America where diets in aquatic habitats are primarily piscivorous (Melquist and Hornocker 1983, Mason and Macdonald 1986). Therefore, the feeding strategy of the southern river otter appears to be closer to that of the African species *A. capensis* and *L. maculicollis*, which predate highly on crabs where freshwater habitats have poor fish faunas (Rowe-Rowe 1977, 1991, Lejeune 1990).

L. lutra and *L. canadensis* rarely prey on fish less than 100 mm in length (Toweill 1974, Jenkins and Harper 1980, Wise *et al.* 1981, Adrian and Delibes 1987). Conversely, all the fish eaten by *L. provocax* in this study were less than 100 mm in length. Similarly, Lejeune (1990) found that 81% of the fish eaten by *L. maculicollis* in Rwanda were less than 100 mm long. However, scats from southern river otters living permanently in a marine habitat contained 75% fish and 62% crustaceans (relative frequency) (Sielfeld 1984). Therefore, the low frequency of fish in the diet recorded in this study may be the result of habitats with poor fish availability. Otter hunting success is influenced by prey availability, water depth and prey vulnerability (prey size) (Mason & Macdonald 1986, Kruuk 1995). This may explain the small size of fish eaten by southern river otter, and the greater frequency of trout remains found in scats collected at rivers compared with those collected at lake habitats. Most fish length recorded in these habitats were 42 mm for *P. gillissi*, 72 mm for *P. trucha* and 21 mm for young trout (Campos 1985). These fish are slower than trout over 100 mm in length (Bainbridge 1958). Furthermore the studied rivers have more shallow areas and ponds than the studied lakes (Campos *et al.* 1981, 1990, H. Campos, pers. comm.).

Prey seasonality

Crustaceans and fish are assumed to be more active in the warmer months, so seasonal variations in occurrence in the otter's diet may be expected (Rowe-Rowe

1977). However, in this study crustaceans and most species of fish were eaten by otters throughout the year without any apparent seasonal variation.

Comparison between the study sites

The present study does not contain any details of prey availability. However, the significant differences between lakes and rivers recorded, along with the heavy dependence of the southern river otter on crustaceans, would suggest there are different habitat conditions. These include water depth, water surface (ha), current, differences in prey availability and vulnerability that may have been affecting the diet of southern river otter. This is also supported by the significant differences in diversity indices between the determined diet of otters from lakes and from their river outlets. All prey species recorded were equally represented by their occurrence in the scats collected from the river outlets (large Even and H' indexes) more than those collected from the lakes sites. Therefore, the seven regions holding southern river otter populations described by Medina (1996) may not be the best habitats for river otter, but otters are found there because there may be no more habitats available due to their destruction and disturbances by human activities (Medina 1996).

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