The diet of Eurasian otters in the Jajrood River system, Iran

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Abstract. The diet and feeding habits of Eurasian otters (Lutra lutra) were studied by spraint analysis over a one year period on the four sections of the Jajrood River, eastern Tehran. Two methods were used to estimate the proportions of different prey consumed: frequency of occurrence and score-bulk estimate. The number of prey categories in a spraint varied between one and four. Fish, crabs, birds and insects were found in the spraints. Fish is the main prey. Otters mainly eat fish, preferring three species: the chub (Leuciscus cephalus), riffle minnow (Alburnoides bipunctatus) and various barbel (Capoeta spp.) species. The otters’ diet differed significantly across four sites positive for otter sign. Seasonal variation was also found: birds were taken more in the cold season and insects in the warm season. The proportion of crab in the diet was almost constant throughout the year. Leuciscus cephalus was the most taken fish species in the cold season and Capoeta spp. in the warm season. Only L. Cephalus appeared to be preferred. There was no significant correlation between the estimated proportion of fish in the diet and relative prey fish population at any of the four studies sites.

Key words: feeding habits, Iran, Jajrood River, Lutra lutra, spraint analysis.

Of the 13 otter species, two are found in Iran, namely the Eurasian (common) otter (Lutra lutra) and the smooth-coated or smooth otter (Lutrogale perspicillata) (Mirzaei et al. 2009a). Eurasian otters (Lutra lutra) are widespread throughout Iranian aquatic ecosystems, in the provinces of Guilan, Mazandaran, Azarbayejan, Tehran, Kordestan, Kermanshah, Markazi, Isfahan, Khorasan, Chaharmahal-o-Bakhtiar, Fars, Khuzestan and Lorestan. Although no comprehensive reports on their distribution are available (Karami et al. 2006; Mirzaei et al. 2009b), there are several local studies done in Iran (Hamzehpour 2005; Mirzaei 2006; Hadipour et al. 2011). Karami et al. (2006) indicated that the Eurasian otter is preset in wetlands, rivers and ponds in Iran. Hadipour et al. (2011) found that the otters occurred in the Amirkelayeh wildlife refuge, showing the presence of two hot spots. Also, they reported that the otters were present in international wetland in Guilan Province, and fishermen and local people suggested the presence of otters near Caspian Sea shore. The authors found two hot spots of otter presence during the nine month period in Amirkelayeh wildlife refuge (Hadipour et al. 2011). In most otter studies conducted in Iran, illegal shooting, habitat degradation and river pollution have been recognized as the major factors which adversely affect otter populations (Hamzehpour 2005; Rasooli et al. 2007; Mirzaei et al. 2010a; Hadipour et al. 2011).

Knowledge of feeding habits is a prerequisite for designing effective conservation management strategies. Otter diet has been the object of many studies throughout its wide range (Erlinge 1972; Fairley 1972; Hewson 1973; Webb 1975; Kruuk and Hewson 1978; Jenkins and Harper 1980; Wise et al. 1981; Kruuk and Moorhouse 1990; Kruuk 1995; Taastrom and Jacobsen 1999; Preston et al. 2006; Remonti et al. 2008; Smiroldo et al. 2009). Otters are highly specialized for preying on fish (Kruuk 2006) and have been described as ‘fish specialists’ (Mason and Macdonald 1986). However, several studies suggest that the otter can be better described as an opportunistic predator, the composition of its diet depending on prey availability (Breathnach and Fairley 1993; Carss 1995; Carss et al. 1998). Various methods such as direct observation, examination of feeding sites, and analysis of stomach contents or spraints have been used to determine the diet of wild otters (Webb 1975). Though fairly accurate, direct
observation is difficult in areas, when the animals are nocturnal (Kruuk and Moorhouse 1990), while feeding sites mainly only allow the identification of large prey which are eaten out of water. As large numbers of spraints can be easily collected in the field, most dietary studies have relied on faecal analysis. The feeding habits of otters living in Iran have not been studied as thoroughly as in other regions in the world, although Rasooli et al. (2007) estimated that in otter-containing natural habitats in Iran, chub (*Alburnoides bipunctatus*) (38.1%) and carp (*Cyprinus carpio*) (34.8%) form the bulk of otter diet. Therefore, the aim of this study was to investigate variation in otter diet, and by comparing the proportion of fish in the diet to fish availability, to assess otter preference for particular fish species.

**Materials and methods**

**Study area**

The Jajrood River flows in the great basin area (about 710 km²) and lies between latitude 35°48’N to 36°03’N and longitude 51°25’E to 51°42’E. The Jajrood River watershed (area 460 km²), is comprised of 61.3% poor grassland, 34.6% good grassland, and 3.8% orchard (Mirzaei 2006). This important river system supplies 23% of the domestic water demand of the Tehran metropolitan area (population more than 10 million people).

The Jajrood River begins 140 km away in the Alborz mountain chain located in the north of Iran, flowing to Waramin plain, in the north eastern part of Tehran city. The Fasham and Shemshak rivers are the main tributaries of the Jajrood River, which join together in an area called Fasham to form the Jajrood River. The climate according to the de Martonne method is sub-humid, semi-arid and arid in north, central and south regions, respectively (Mirzaei 2006). Annual mean temperature is 26°C, with extreme values of 8°C and 32°C registered in January and July, respectively. Annual rainfall averages 280 mm and precipitation is at maximum in November (69.8 mm) and minimum in July (11.2 mm). The rainfall and flow water patterns in the Jajrood catchment exhibit seasonal differences. Based on the results obtained from the Bureau of Meteorology, and water resources research organisation records for rainfall and flow water patterns, it is clear that the dry season is summer-fall, and the wet season is winter-spring in the Jajrood catchment. Besides seasonal variation, discharge was influenced by the presence of dams. In the dry season, the range of discharge observed was between 0 and 16.2 m³/sec, while in the wet season, the range was 0.2–49.5 m³/sec. Agricultural activity with irrigated crops and recreational gardening has been extended in river side areas. There are several villages and towns along the way with a total population of nearly 200,000. The width of the river is between 2 and 100 m (Mirzaei 2006).

The study area included stretch of the river about 40 km long downstream of the Latian dam (Fig. 1), with altitude above sea level ranging from 1,200 m to 1,370 m.

The riparian vegetation is dominated by *Salix* spp. often associated with *Elaegnus angustifolia* and *Populus nigra*. Eleven fish species, 15 mammal species, 80 bird species, 2 snake species and 3 amphibian species have been identified in the Jajrood River habitat so far (Mirzaei 2006). A fish farm is located next to site No. 2 (Fig. 1). The river is a major recreational attraction. Visitors often camp along the river banks, thereby contributing to environmental pollution with litter, noise and disturbance. The visitor load increases during spring and summer. The tourist population comes to the region in the warm months, mainly on a daily basis. The daily variations in

![Fig. 1. Study area and survey sites (1, 2, 3 and 4) in Jajrood River, Iran in the present study.](image-url)
the tourist population are very high throughout the week, with a peak on Fridays (weekend) and holidays during the warm months of year. It is estimated that the tourist population on other week days is between 10% and 15%, of the Friday tourist population. The lower parts of the river are situated within the boundaries of the Khojir National Park (Mirzaei et al. 2010b).

Methods

Sixteen sites were selected along the river and each site was surveyed for otter presence. No otter signs were found in the upper part of Jajrood River. In the area below the Latian Dam, indications for the presence of otters were found at 6 sites, with there are four core areas where most records are concentrated. In order to detect subtle differences in the surrounding microhabitat characteristics, otter spraints were seasonally collected between August 2005 and July 2006 at four sites each about 10 km from the others (Fig. 1). Both banks and mid-channel features, such as rocks and tree roots, were carefully searched for spraints by ‘zigzagging’ along the banks and channels up to 30 m of river bank from the water’s edge. At all of the study sites surveys began at the river mouth and moved upstream, and at each site, 600 m of waterway were searched for signs of otters, in the course of which all located spraints were removed. Surveys were not carried out during or after a period of heavy rainfall, as this can reduce the number of spraints available. To avoid pseudoreplication of information, seasonally sampling involved recording only fresh faeces (i.e., current use); surveys were carried out for 2–3 weeks per season. The monitored stretches were between 4–25m wide and 0.5–2 m deep.

However, all surveys were undertaken by the same experienced surveyor, thereby standardising and minimising observer error over the entire duration of field sampling. We do not believe that our selection of four sites imposes a serious bias in our results. In other words the spraint searching method employed was considered quite accurate because the river surveyed were very well known, and at most of the sites surveyed; we knew the otter sprainting sites fairly precisely. This river was also quite small, which allowed thorough surveying even by just one person, not only of sites in or near the water but of the banks distant from the main channel (30 m).

All spraints were stored separately until the analysis. In the laboratory, spraints were allowed to dissolve in a detergent solution for one week, and then washed under tap water in a steel sieve of 1 mm mesh size. The remains were analyzed in a petri dish containing water. Prey remains were identified from characteristic skeletal remains, e.g., vertebrae, scales and pharyngeal teeth for fish and feathers for birds. Insects were only considered as deliberately eaten by the otter when remains of large insects were found. After analysis the remains were dried and weighed.

Following Jacobsen and Hansen (1996), otter diet was expressed by both the percent frequency of occurrence and score-bulk estimate methods. By the first method, all prey categories in each spraint were noted. The number of occurrences of each prey category was then expressed as percentage (%) of the total number of occurrences of all prey categories in the whole sample (Erlinge 1968; Umapathy 2000).

By the second method, the proportion of each prey category in the sample was estimated visually. Each prey category was given a score from 1 to 10, so that the total was 10. The score for each prey category was then multiplied by the dry weight of the spraint and the resulting figures expressed as percentage (Taastrom and Jacobsen 1999).

Electro-fishing was used to assess fish availability for otters in the study area. The Khojir National Park Authorities allowed us to electrofish only once, in winter, as the method is deemed to be destructive to wildlife. At each site, electrofishing was carried out along 100 m long stretches; all fish were identified and their total lengths measured. The results were converted into relative biomass proportions using known length/weight ratios for each species.

Seasonal variation in the frequency of occurrence of food items was tested by the chi-squared test ($\chi^2$) for contingency tables. Whenever necessary, prey categories were grouped to ensure that all frequencies were > 5 (Siegel and Castellan 1988). The bulk percentages of fish prey species were compared to fish biomass by Spearman’s rank-order correlation coefficient (Siegel and Castellan 1988). Jacobs’s index of preference was used to assess the degree of otter preference for each prey category. Finally, a principal component analysis (Jongman et al. 1987) was applied to the data to illustrate diet variations between sites (habitats) and seasons with all prey categories represented in the spraints as variables.

Results

A total of 305 spraints were collected at the four sites (site 1: 89; site 2: 75; site 3: 57; site 4: 84). The average
The number of prey categories per spraint was 2.6 and the average number of prey categories per season was 1.73; these values for spring, summer, autumn and winter were 1.80, 1.66, 1.69 and 1.77 respectively. On the whole, fish was the most common prey item recovered in spraints and four fish species formed the bulk of the diet (86–95%); while crabs (*Potamon persicum*), birds and insects were secondary resources. In other words, insects were the second prey category in order of importance, amounting to 4.76% of the overall volume, crab and birds were food sources of minor importance, with an overall volume in the diet of approximately 3.15 and 3.08% respectively (Table 1). The proportion of *Capoeta* spp. in otter diet increased from site 1 (15.53%) to site 4 (36.52%); conversely the proportion of *A. bipunctatus* in the diet decreased from site 1 (32.76%) to 4 (7.12%). The proportion of *L. cephalus* was lowest in site 1 and was approximately constant in other three sites. The maximum and minimum proportion of birds belonged to site 1 and 4 respectively. The maximum proportion of insects and crab belonged to site 2 and minimum proportion of insects and crab belonged to sites 1 and 3 respectively (Table 1). The overall prey composition varied significantly throughout the year at site 3 ($\chi^2 = 26.6, P < 0.01, df = 8$) and site 4 ($\chi^2 = 22.0, P < 0.01, df = 8$), whilst there was no significant difference in the otter diet at site 2 ($\chi^2 = 11.2$, n.s., $df = 8$).

Food preference index was calculated for sites 2, 3 and 4. Food preference Jacobs index for sites 2, 3 and 4 showed that *L. cephalus* were preferred at these sites (with values of 0.69, 0.67 and 0.62 respectively). Also at site 2, otters seemed to prefer *O. mykiss* ($D = 0.87$), but there is an uncertainty due to the presence of a fish farm. Only 9 species of fish were recorded from the River Jajrood including *Alburnoides bipunctatus*, *Leuciscus cephalus*, *Nemachilus* sp., *Capoeta damasinus*, *Capoeta capoeta*, *Capoeta aculeuta*, *Capoeta baroisi*, *Oncorhyncus mykiss* and *Pseadorasbora parva*. There was no significant correlation between the estimated proportion of fish in the diet and relative prey fish population at any of the four study sites (Fig. 2) (only winter): site 1 ($r = 0.77, n = 4, P > 0.05$); site 2 ($r = 0.8, n = 4, P > 0.05$); site 3 ($r = 0.2, n = 4, P > 0.05$); site 4 ($r = 0.63, n = 4, P > 0.05$).

Figure 3 shows the seasonal variation of prey items in spraint at the four sites. No regularities in otter diet in different seasons were apparent at first glance but more careful attention disclosed some relationships. For example, insects were mostly eaten during warm season and the highest proportion of insects in the diet was at site 2 in spring (13.40%). Conversely, birds mostly occurred in the diet during the winter-autumn in all of the study sites and highest proportion of birds in the diet was found at site 4 in winter (12.28%). In the study area, crabs were taken in all seasons except spring, and the highest proportion in the diet was found at site 4 in winter (12.28%). In the study area, crabs were taken in all seasons except spring, and the highest proportion in the diet was found at site 4 in summer (11.90%). In other words, the consumption of crabs did not show a clear seasonality. A common feature for most study areas was that the proportion of fish in the diet was lower in summer-autumn than in winter-spring. The proportion of *L. cephalus* was low in summer and highest in autumn. The lowest proportion of *A. bipunctatus* in the diet was found in summer. At sites 3 and 4, *Capoeta* spp. predominated in the diet in spring. Frogs were not taken at any of the study sites, although in spring, the number of frogs encountered on the river was quite high.

The results of principal component analysis confirmed

### Table 1. Annual prey composition in otter diet for all study areas in Jajrood River, Iran. FOE and SBE indicate frequency of occurrence and score-bulk estimate, respectively

<table>
<thead>
<tr>
<th>Prey</th>
<th>Site 1</th>
<th></th>
<th>Site 2</th>
<th></th>
<th>Site 3</th>
<th></th>
<th>Site 4</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FOE</td>
<td>SBE</td>
<td>FOE</td>
<td>SBE</td>
<td>FOE</td>
<td>SBE</td>
<td>FOE</td>
<td>SBE</td>
</tr>
<tr>
<td>Fish</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>O. mykiss</em></td>
<td>1.8</td>
<td>3.41</td>
<td>3.08</td>
<td>4.32</td>
<td>0</td>
<td>0</td>
<td>0.89</td>
<td>0.54</td>
</tr>
<tr>
<td><em>Capoeta</em> sp.</td>
<td>11.61</td>
<td>15.53</td>
<td>22.12</td>
<td>25.35</td>
<td>25.63</td>
<td>29.88</td>
<td>35.91</td>
<td>36.52</td>
</tr>
<tr>
<td><em>L. cephalus</em></td>
<td>25.8</td>
<td>22.17</td>
<td>33.17</td>
<td>37.44</td>
<td>30.12</td>
<td>34.77</td>
<td>37.39</td>
<td>36.14</td>
</tr>
<tr>
<td>Unidentified</td>
<td>10.95</td>
<td>17.82</td>
<td>3.12</td>
<td>4.17</td>
<td>11.02</td>
<td>13.75</td>
<td>7.67</td>
<td>15.05</td>
</tr>
<tr>
<td>Total</td>
<td>90.6</td>
<td>91.68</td>
<td>88.21</td>
<td>86.24</td>
<td>92.53</td>
<td>92.97</td>
<td>91.72</td>
<td>95.36</td>
</tr>
<tr>
<td>Birds</td>
<td>5.81</td>
<td>5.29</td>
<td>1.86</td>
<td>2.19</td>
<td>3.60</td>
<td>3.81</td>
<td>3.07</td>
<td>1.03</td>
</tr>
<tr>
<td>Insects</td>
<td>0</td>
<td>0</td>
<td>5.99</td>
<td>7</td>
<td>0.8</td>
<td>1.02</td>
<td>1.19</td>
<td>0.76</td>
</tr>
<tr>
<td>Crab</td>
<td>3.6</td>
<td>3.02</td>
<td>3.92</td>
<td>4.56</td>
<td>3.1</td>
<td>2.20</td>
<td>4.02</td>
<td>2.84</td>
</tr>
</tbody>
</table>

**FOE and SBE indicate frequency of occurrence and score-bulk estimate, respectively.**
these results. Figure 4 is a bi-plot based on spraint contents and illustrates study areas in all seasons as well as prey categories. Variation along the x-axis expresses differences between river habitats and variation along the y-axis expresses individual differences between the river habitats. The y-axis also expresses the seasonal variation; for most study areas, summer diets have higher values on the y-axis than winter diets. The loadings of the prey categories illustrate this seasonality, with insects being an important component during summer whereas birds and fish were relatively more important in winter. Crabs had the same importance in all seasons at all four sites. In addition, the loadings of the fish categories illustrate which type of prey characterized each area. Species such as trout and A. bipunctatus were associated with river habitats. Trout in particular but also A. bipunctatus was associated with site 2, whereas L. cephalus was common at three sites and Capoeta spp. important at site 4. Of the non-fish prey categories, insects were important at sites 3 and 4 whereas birds were mostly associated with the sites 2 and 3 (Fig. 4).

Discussion

In the River Jajrood, fish are the dominant prey item of otters, as reported previously (Breathnach and Fairley 1993; Sulkava 1996; Taastrom and Jacobsen 1999; Remonti et al. 2008; Smiroldo et al. 2009), but otters occurring in this river show several interesting features. No predation of mammals and reptiles was noted in the present study, in accordance with some studies such as Lanszki et al. (2010) who found no reptiles, birds and mammals in the spraint samples in his study area. Most previous studies reported some small mammals such as woodmice (Apodemus sylvaticus) and bank vole (Myodes glareolus) and reptiles in the diet (Breathnach and Fairley 1993; O’Sullivan 1994; Preston et al. 2006; Remonti et al. 2008; Smiroldo et al. 2009). Although frogs may represent a major food item for otters, especially in river habitats (Weber 1990; Breathnach and Fairley 1993; Sulkava 1996; Taastrom and Jacobsen 1999) and were abundant in spring along the riverside (personal observations), they were not preyed upon at any of the study sites.
Although some authors have shown that the common frog (*Rana temporaria*) is taken most often during late winter and early spring (Fairley 1984; Ottino and Giller 2004) reflecting seasonal aggregations and high local abundance during the spawning period from January to April, others suggested that otters do not prey on breeding Natterjack toads (*Bufo calamita*) presumably due to the distasteful exudates from their dermal glands (Fairley and McCarthy 1985). Otter diets in different countries appear to differ markedly on frogs, although the extent to which this is in response to ecological variables remains unclear. Miscellaneous and unidentified items typically included groomed hair (Kyne et al. 1989; Breathnach and Fairley 1993) and vegetation (O’Sullivan 1994). The latter is sometimes reported in the diet as ingested incidentally; for example, grasses on a river bank consumed whilst eating prey items such as larger fish. However, some studies have recorded blackberries (*Rubus* spp.) and have suggested that these may have been actively foraged (O’Sullivan 1994). Certainly, North America otters (*Lutra canadensis*) are known to take blueberries (*Vaccinium* spp.) and rose hips (*Rosa* spp.) (Whitaker and Hamilton 1998). Birds were mostly taken in winter, perhaps because the fish farm in the study area attracted waterfowl during winter (personal observations); these results are in accordance with some other surveys (Taastrøm and Jacobsen 1993) and vegetation (O’Sullivan 1994).
The occurrence and frequency of fish components tends to peak during winter, whilst other prey, such as insects, appear less important at this time of year (Breathnach and Fairley 1993), probably reflecting their lower levels of activity in colder water (Erlinge 1968). Although insects may be indirect prey (as insects may be eaten by chub and riffle minnow), the numerous remains of large insects in otter spraints suggest that they were directly taken by otters. Prenda and Gallardo (1996) correlated the harsh environmental conditions during the summer with lower consumption of fish. These conditions may be a key factor explaining the composition and dynamics of Jajrood communities since the reduction of the river to isolated pools during the summer reduces the availability of fish. In addition, the high intra and interannual variability in the precipitation and temperature regime characteristic of these river areas severely affects freshwater ecosystems, necessarily resulting in unpredictable fish availability (Mooney 1981; Prenda et al. 2001).

*Alburnoides bipunctatus*, *L. cephalus* and *Capoeta* spp. were the major prey fish in the present study. *Capoeta* spp. were taken less often in winter than the summer, whereas, *L. cephalus* was taken more in winter. During spring, *Capoeta* spp. have poisonous eggs, and it is taken less in spring (Taastrøm and Jacobsen 1999; Abdoli 2000), but no evidence was found to support this in the Jajrood River. *Leuciscus cephalus* lives near the surface of the water and the mid-section of the river, but is less active in winter, and so easier to catch (Taastrøm and Jacobsen 1999; Abdoli 2000), and this may be the main reason for its preference in otter diet in winter. There were more *A. bipunctatus* and fewer *Capoeta* spp. upstream at site 2 than downstream at site 4, reflecting their lifestyles. Rainbow trout (*Oncorhyncus mykiss*) remains were only found in spraints from site 2, probably because of otters feeding in the fish farm, or eating escaped fish.

Opportunistic feeding behavior has been recorded in Eurasian otters, with seasonal and spatial patterns in their diet related to prey availability (Gordon and Roche 2003). Early studies suggested the otter was a fish specialist (Mason and Macdonald 1986) but it is now widely accepted that the species is an opportunist whose diet varies depending on prey availability (Kruuk and Moorhouse 1990; Chanin 1991; Breathnach and Fairley 1993; Kruuk 1995; Carss and Parkinson 1996; Carss and Nelson 1998; Ottino and Giller 2004).

Estimation of prey proportions in the diet based on bulk has shown to give a reliable picture of the actual diet of the otter, reducing the overestimation of minor prey categories which are frequently present but in small
amounts and the underestimation of major prey categories which are present in large amounts in each spraint. However, general inaccuracies in spraint analysis still exist. Different fish species that have similar size can be under/overestimated, because of differences in the amount of hard remains and recognizable parts as discussed in Mason and Macdonald (1986) and Jacobsen and Hansen (1996). Therefore, non-fish prey categories such as birds may be over-represented in the spraints, as a result of proportionally large amounts of recognizable feathers compared to fish remains. Moreover, the use of a 1 mm sieve, a common routine in spraint preparation, can cause a loss of parts of the smallest fish, particularly small parts such as otoliths. We believe this to be of minor importance, since in the present study almost all the fish were identified by pharyngeal teeth.

We have tried to present some aspects of otter diets in Jajrood River, but further works are needed to more thoroughly characterize the otter diet in Iran. Also a comprehensive ecological study on otters is needed to establish baseline data for otter ecology in Iran.

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