AMPHIBIAN AND REPTILE CONSUMPTION BY OTTERS (LUTRA LUTRA) IN A COASTAL AREA IN SOUTHERN IBERIAN PENINSULA

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Through the analysis of 1518 otter spraints we determined the importance of amphibians and reptiles in otter diet and the seasonal patterns of consumption of the different species in a heterogeneous coastal environment in southern Spain. Otters fed on a minimum of six amphibian and three reptile species. Amphibians were present in 13.2% and reptiles in 3.9% of the spraints analysed. Remains of amphibians and reptiles were significantly associated in otter spraints, but negatively associated with crayfish occurrences. Maximum reptile consumption occurred during the summer. Though terrapins have been rarely cited as otter prey, they were consumed more than twice as frequently as water snakes in the study area. The highest frequency of amphibians in the otter diet was recorded in late winter-spring surveys, coinciding with the spawning periods of most species. However, the frequency of amphibians remained high during summer months due to predation on the Iberian green frog (Rana perezi), a very aquatic frog that was almost the only amphibian species consumed in this season.

Key words: Bufo bufo, coastal otters, predation, Mediterranean streams, Mauremys leprosa, Rana perezi

INTRODUCTION

The otter (Lutra lutra, Carnivora, Mustelidae) is a top predator in freshwater ecosystems. Featuring both anatomical and physiological adaptations for semi-aquatic living, the otter is specialized in obtaining virtually all its food in the water (Carss, 1995). Fish are the main prey of otters, and are preferentially consumed whenever readily available (Erlinge, 1968; Mason & Macdonald, 1986). However, otter diet is very variable (both temporally and geographically) and may incorporate most kinds of aquatic animals, including amphibians and reptiles, as well as crayfish and other crustaceans, aquatic insects, birds and mammals (Jędrzejewska et al., 2001; Clavero et al., 2003).

Amphibians are predated by the otter throughout the species’ European range (Clavero et al., 2003), constituting an important part of otter diet in many locations (Erlinge, 1972; Adrián & Delibes, 1987; Brzeziński et al., 1993; Beja, 1996a; Sulkava, 1996). Reptiles are rarer in the otter’s diet, since their consumption is usually restricted to lower latitudes (Ruiz-Olmo, 1995). However reptiles, specially water snakes (Natrix spp.), have been shown to be frequent otter prey in some Italian (Arcá & Prigioni, 1987) and Iberian studies (Simões-Graça & Ferrand de Almeida, 1983; López-Nieves & Hernando, 1984).

In this work we analyse the consumption of amphibians and reptiles by otters in the species’ southernmost European location. Here, the diet of the otter has been described previously by Clavero et al. (2004). In particular we will try to answer the following questions: (1) what species of amphibians and reptiles are consumed and in what proportions? (2) Are there seasonal patterns in the consumption of the different species?

STUDY AREA

The study was conducted in the surroundings of Tarifa (Cádiz, Spain), the southernmost European town. The area occupied by otters is very heterogeneous, including sandy and rocky coastal stretches, estuarine areas and four main streams (Fig. 1). Mean annual precipitation ranges from 1300 to 620 mm, while mean annual temperature is around 17.5°C (Ibarra, 1993). Due to the oceanic influence, it is extremely rare that temperature falls below 0°C, and the mean minimum temperature in January is 11°C. More information on the study area’s characteristics can be found in Clavero et al. (2004).

The area holds a very rich herpetofauna, with 20 reptile species – including four with semi-aquatic habits – and 10 amphibian species (Pleguezuelos et al., 2002).

METHODS

Otter diet was studied through the analysis of faeces (spraints). Otter spraints were collected in nine 600 m transects placed in lower and upper stretches of the four streams included in the study area and in the common estuary of two of them (Fig. 1). The different transects were classified as lower (coastal, numbers 2, 4, 5, 6 and 9 in Fig. 1) or upper (inland, numbers 1, 3, 7 and 8). Spraint collection was performed bimonthly from December 1999 to December 2001, with the exception of October 2001, due to heavy rains.

Spraint analysis followed standard procedures (Beja, 1997). Amphibian species were identified using the key for ilia bones by Felix & Montori (1986) and drawings of other bone structures provided by Boulenger (1897).
Each prey type identified in a spraint was considered an occurrence, diet composition was then expressed either as Frequency of Occurrence (FO; number of occurrences of a certain prey type/number of spraints analysed) (Mason & Macdonald, 1986). Before being subject to statistical analysis, frequency data were arcsine transformed (Zar, 1984). The minimum number of individuals of a certain prey type present in a spraint was estimated from the number and position of ilia, tibia-fibulas and paraphenoid bones. Whenever these key structures did not appear in spraints, remains of a certain prey type were considered to belong to a single individual.

The association between amphibians and reptiles and other prey types was analysed using the χ² test. The prey types analysed were fish, crayfish (Procambarus clarkii) and insects. Eels (Anguilla anguilla) and freshwater fish (the pool of chub, Squalius pyreneicus, and loach, Cobitis paludica) were also analysed separately, since these are the only three fish species which can be found far from the coast in the area (Clavero et al., 2002). In coastal stretches other fishes, such as grey mullet (Mugilidae), flatfish (Soleidae) or wrasses (Labridae), are present and are important components of otter diet (Clavero et al., 2004). Since coastal otters often feed in estuaries or in the open sea, where they are not supposed to find amphibians or reptiles, two different analyses of the association of prey types in spraints were performed. One was done considering all the spraints analysed, while in the second one we only considered spraints collected in upper stretches. The few samples that contained two or more pooled spraints were excluded from the association analyses.

RESULTS

AMPHIBIAN AND REPTILE OCCURRENCE IN OTTER DIET

A total of 1518 otter spraints were analysed (Table 1). Amphibian remains were identified in 13.2% of the spraints while reptiles were present in 3.9%. The FOs of amphibians in the different transects ranged from 4.8% to 54.3% and that of reptiles from 0.5% to 30.0%. The FO of amphibian was significantly higher in upper stretches than in lower ones (t=2.9, df=7, P<0.05). Though reptiles were also more frequently found in otter spraints in upper stretches, differences were not significant.

Overall, a minimum of 319 amphibian and 60 reptile individuals were identified (Fig. 2). Over 95% of the identified amphibians were anurans, while the urodeles were poorly represented in otter diet. More than a third of the amphibians predated by the otter were Iberian green frogs (Rana perezi). Iberian parsley frogs (Pelodytes ibericus), common toads (Bufo bufo) and stripeless tree frogs (Hyla meridionalis) constituted between 10% and 15% of the consumed individuals. Around 20% of the anuran individuals remained unidentified, as did the few urodeles that were found in spraints. Among reptiles, leprous terrapins (Mauremys leprosa) were the dominant prey. Around one third of the consumed reptiles were viperine snakes (Natrix maura), while only one lacertid – which remained unidentified – was found.

When the total number of spraints analysed was considered, amphibians and reptiles were shown to occur together in spraints more often than would be expected by chance (Table 2). Both amphibians and reptiles followed a similar pattern of association in spraints with another prey types, being positively associated with freshwater fish and insects and negatively associated with all fish included in otter diet. The occurrence of eels and crayfish in spraints was found to be independent of amphibians and reptiles. However, when only samples from upper stretches were considered, the patterns of association of the different prey types in spraints displayed clear changes. In freshwater habitats crayfish was the only prey type negatively associated both with amphibians and reptiles, while fish became independent of them. The positive association in spraints among amphibians, reptiles and insects remained significant in upper stretches.

SEASONAL VARIATION IN AMPHIBIAN AND REPTILE CONSUMPTION

The overall analysis of the occurrence of amphibians and reptiles in the otter diet must be treated carefully, since there were clear seasonal variations in their consumption by otters (Fig. 3). An increase in reptile consumption was observed from winter to summer reaching its peak in June in upper transects, and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones. However, predation upon the two reptiles consumed by the otter in different stretches and in August in lower ones.
Viperine snakes were consumed exclusively in spring-summer months with a marked peak in June. Consumption of terrapins showed a summer peak both in upper and lower transects, though we found their remains in otter spraints also during winter and spring. However, there was a sharp decrease in terrapin occurrence in October.

Predation on amphibians reached its maximum between February and April, but was maintained at relatively high levels during the summer. This pattern was the result of the seasonal variation in consumption of the different anuran species (Fig. 5). Toads, stripeless tree frogs, and Iberian parsley frogs were consumed almost exclusively during the breeding periods in late winter and the beginning of the spring. However, predation upon the Iberian green frog – the most frequent amphibian in the otter diet – reached its maximum in August, when it was almost the only amphibian consumed.

### DISCUSSION

In the study area, otters fed on a minimum of nine different amphibian and semi-aquatic reptile species. Though higher frequencies in otter diet have been previously reported for both amphibians and reptiles (i.e. Arcá & Prigioni, 1987; Brzeziński et al., 1993), no other otter diet studies have yet recorded such diverse predation on these groups. The overall secondary role of amphibians and reptiles is undoubtedly influenced by the high proportion of marine and estuarine prey in otter diet in the area (Clavero et al., 2004), since coastal otters rarely feed on non-fish prey (Jędzejewska et al., 2001).

The positive association of amphibians and reptiles in otter spraints suggests that they are frequently captured during the same foraging bouts. On the other hand, when only upper stretches were considered, crayfish were negatively associated both with amphibians and reptiles. Crayfish are by far the most important freshwater...
ter prey for the otter in the study area (Clavero et al., 2004) and amphibians and reptiles are apparently captured in different locations or using different techniques to those used for crayfish consumption. The strong association of these two prey types with insects could be explained by secondary ingestion. In fact Cars & Parkinson (1996) showed that the remains of small fish placed in the gut of larger ones could be identified in otter spraints. However, the same authors also proved that otters predate actively on aquatic insects such as Dytiscus beetles. In the study area small animals such as dragonfly nymphs or shrimps were frequent otter prey and were often the only prey types found in spraints (Clavero et al., 2004).

**Reptile Consumption**

Little attention has been paid to otter predation on reptiles, mainly due to its almost complete absence in otter diet in central and northern European studies. Ruiz-Olmo (1995) showed that reptiles were not included in the diet in Europe north of 43ºN, while Clavero et al. (2003) reported a clear increase in reptile consumption in Mediterranean European locations in relation to temperate ones. This inverse relation between latitude and reptile consumption is a common feature of many carnivore species which occupy a wide latitudinal range (Delibes et al., 1997; Zielinski et al., 1999).

Terrapins have been rarely cited as otter prey (Barrio & Bosch, 1997). In a review of 12 studies of reptile species consumed by the otter Ruiz-Olmo (1995) found a ratio of snakes to terrapins of 177.5:1, suggesting that the hard shell of terrapins would account for their low frequency of occurrence. However, Beja (1996a) reported a ratio snakes to terrapins of 2:1 in southern Portugal, while in this study terrapins were more frequent than snakes in the diet, with a ratio of 1:2.5. The analysis of otter spraints revealed that small terrapins were eaten entirely, since numerous fragments of the bony shell could be found in spraints. That was not the case for larger individuals, which were apparently mutilated by the otter (see Barrio & Bosch, 1997). Remains of large terrapins in spraints included legs, tails, jaws and marginal horny scutes, but not pieces of the bony shell.

![FIG 4. Yearly consumption of viperine snakes (*Natrix maura*) and leprous terrapins (*Mauremys leprosa*) by otters in upper and lower transects of the study area.](image)
Reptile consumption showed a continuous increase from winter to summer, following the increased activity of leprous terrapins and viperine snakes at higher temperatures (Salvador & Pleguezuelos, 2002). Nevertheless, the different activity periods and habitat use of both species is reflected in their consumption by otters. Due to the mild winter temperatures, terrapins maintain their activity throughout the whole year in southern Iberia, though it shows a clear increase in spring and summer (Andreu & López-Jurado, 1998). This yearly activity pattern would allow otters to predate upon terrapins even in the colder months, as is shown in Fig. 4. On the other hand, viperine snakes hibernate at least from November to March even in southern areas of the Iberian Peninsula. Moreover, snakes are mostly diurnal and spend an important proportion of the time on land in spring and autumn, being nocturnal and largely aquatic in the summer (Braña, 1998). Since south Iberian otters are almost exclusively nocturnal (Beja, 1996b), it is possible that the marked peak of viperine snake consumption in June coincides with the moment when encounters between otters and active snakes are more likely to occur.

**AMPHIBIAN CONSUMPTION**

Amphibians are important prey for the otter in many European locations, occurring independently of latitude (Jędrzejewska *et al.*, 2001 and Clavero *et al.*, 2003). However, in most of the diet studies from central and northern Europe, common frogs (*Rana temporaria*) and occasionally common toads are the only amphibian species consumed by the otter (i.e. Weber, 1990; Brzeziński *et al.*, 1993; Sulkava, 1996). In our study area a minimum of six different amphibian species were preyed upon. The Iberian green frog was the most frequent amphibian in the diet, but the proportion of ranids in relation with other amphibians was much lower than in most published studies. The frequency of occurrence of stripeless tree frogs and Iberian parsley frogs was unusually high. Up to seven Iberian parsley frogs were found in a single spraint.

Though some authors proposed that otters do not eat toads due to their venomous skin (Jenkins *et al.*, 1979; Fairley, 1984; De Jongh, 1988), since the first description on otter preda­tion on toads by Lizana & Pérez Mellado (1990) many studies have shown that toads can be common otter prey. Otters avoid the ingestion of the

![Graphs showing yearly consumption of amphibians](image-url)
toads’ poisonous substances by skinning them, a behaviour that has been described in Portugal (Beja, 1996a), Spain (Lizana & Pérez Mellado, 1990), Belarus (Sidorovich & Pikulik, 1997) or Finland (Sulkava, 1996). Several common toad skins were observed in the study area during the spraint collection. The ratio of frogs to toads is nevertheless very high in most of the studies, with a clear preponderance of the former (Weber, 1990; Brzeziński et al., 1993; Sidorovich & Pikulik, 1997). However, in our study this ratio was 2.6:1, while Beja (1996a) reported less frequent predation on frogs than on toads, with a ratio of 1:1.2. The occurrence of toads in the diet could have been underestimated in some studies in which amphibians were identified mainly by jaw bones (see discussion in Sulkava, 1996), since skinned toads’ skulls are rarely eaten by otters (Lizana & Pérez Mellado, 1990). This problem should be avoided using the ilia bone for specific identifications.

Most of the studies reporting annual patterns on amphibian consumption by otters (Weber, 1990; Brzeziński et al., 1993; Sulkava, 1996) show that the highest occurrence of amphibians occur in late winter and early spring, when common frogs are either hibernating or spawning. This seasonal pattern is related to the habitat use of common frogs, a species which is absent in southern Iberian Peninsula, and that after spawning moves to adjacent woodlands (Weber, 1990). In the study area most amphibian species do not hibernate, but remain active throughout the whole year (Salvador & García París, 2001). However, for most of the species the more intense predation events by otters do occur during spawning periods, in winter and early spring. This is the period when the diversity of amphibians preyed upon by the otter reaches its highest values. The exception to this pattern is the Iberian green frog, which does not overlap with spawning events. In fact, the Iberian green frog is strictly aquatic, remaining in streams throughout the year, in contrast with the terrestrial habits of other anurans in the study area and the common frog in other European locations (Salvador & García París, 2001).

In October, with temperatures being still high, there was a sharp decrease in the consumption of all amphibian and reptile species (Fig. 4 and 5). In this period leprous terrapins and Iberian green frogs are still active and thus available for the otter. But at this time the frequency of occurrence of grey mullet, eels and flatfish experienced a pronounced increase. These fishes constitute the bulk of otter diet in the area (Clavero et al., 2004) and are scarcely predated during the summer (Clavero, 2004). It is possible that the autumnal minimum in amphibian and reptile consumption is the result of a switch in otter predation, that during this period, would be centred on estuarine fishes.

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