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Revealing the prey items of the otter *Lutra lutra* in South West England using stomach contents analysis

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A b s t r a c t . Analysis of the stomach contents of otters recovered from South West England between 1999 and 2003 revealed that prey items taken were principally species of fish and amphibians, with mammals and birds occasionally taken. The fork length of fish recorded was 30 to 720 mm. Eel *Anguilla anguilla* was the dominant prey item, with up to five present per stomach. Estimated lengths ranged from 100 to 450 mm. Other common prey items were bullhead *Cottus gobio* and brown trout *Salmo trutta*. In addition to these freshwater species, there were recordings of sea bass *Dicentrarchus labrax* and thick lipped mullet *Chelon labosus*, indicating foraging in both freshwater and marine habitats. A seasonal peak was observed in the relative frequency of amphibians in diet, as otters took advantage of spawning aggregations. However, there were no seasonal trends in the relative frequency of other species in otter diet, with eel, bullhead and cyprinid species taken regularly in all months.

Key words: diet, eel, foraging, Eurasian otter

Introduction

The otter *Lutra lutra* is a piscivorous, territorial mammal which suffered a population decline throughout much Western Europe and the United Kingdom between the 1950s and 1980s (e.g. C h a n i n & J e f f e r i e s 1978, M a c D o n a l d & M a s o n 1983, M a s o n & M a c D o n a l d 1993, S t r a c h e n et al. 1990, C h a n i n 2003). A number of factors contributed to this decline, including bioaccumulation of pesticides and polychlorinated biphenyls (PCBs) (M a s o n & M a c D o n a l d 1993) and habitat destruction (M a c D o n a l d & M a s o n 1983). With improvements in habitat and fish stocks, controls in the use of pesticides and PCBs, legal protection of the species and programmes of otter re-introductions, populations have now recovered in many UK river catchments (C h a n i n 2003, C r a w f o r d 2003).

Work on the diet of otters has revealed that composition often reflects the species and length composition of the fish populations within their territory (C h a n i n 2003), with size selectivity occasionally a feature. For example, brown trout *Salmo trutta* and Atlantic salmon *Salmo salar* of between 70 and 90 mm have been recorded in disproportionate numbers in the diet of otters in north east Scotland (C a r s s et al. 1990). However, salmonids of up to 900 mm and 6.3 kg have also been recorded (C a r s s et al. 1990), demonstrating their ability to catch larger fish. The purpose of this paper was to record, analyse and summarise the major prey items ingested during the final foraging bouts of otters whose carcasses had been recovered from South West England between 1999 and 2003.

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Materials and Methods

The stomach contents of 171 otters were available as a result of their carcasses being submitted to a veterinary surgeon for post mortem analysis (Simpson & Coxon 2000). The stomachs were removed during the post mortem and frozen, enabling their contents to be examined at a later date. All of the carcasses were recovered from South West England between 1999 and 2003 (Fig.1).

The stomach contents analysis involved defrosting the sample prior to washing the prey items on a fine sieve with water. Large and partially digested prey items were separated out and identified from their gross morphology. For the prey remains consisting of only individual bones and scales, these were removed and soaked in diluted sodium hydroxide. Identification was then possible using the cleaned bones and scales; these were viewed under a binocular microscope (x10) and species identified using specialised keys and guides (e.g. Steinmetz & Müller 1991, Conroy et al. 1993, Hájková et al. 2003). Numbers of prey were ascertained from the presence of key bones, for example, the maxillary and dentary (Hájková et al. 2003). Identification of prey was taken to species level wherever possible. Measurements of the bones and scales enabled length (fork length, mm) estimates to be made from biometric relationships (Britton & Shepherd 2005).

To determine the dominant prey items taken, the relative frequency in diet was calculated (number of stomachs in which the item was found/ total number of stomachs x 100). Temporal trends in prey items presence were determined as the relative frequency by month (number of stomachs in which the item was found that month/ total number of stomachs from that month x 100).

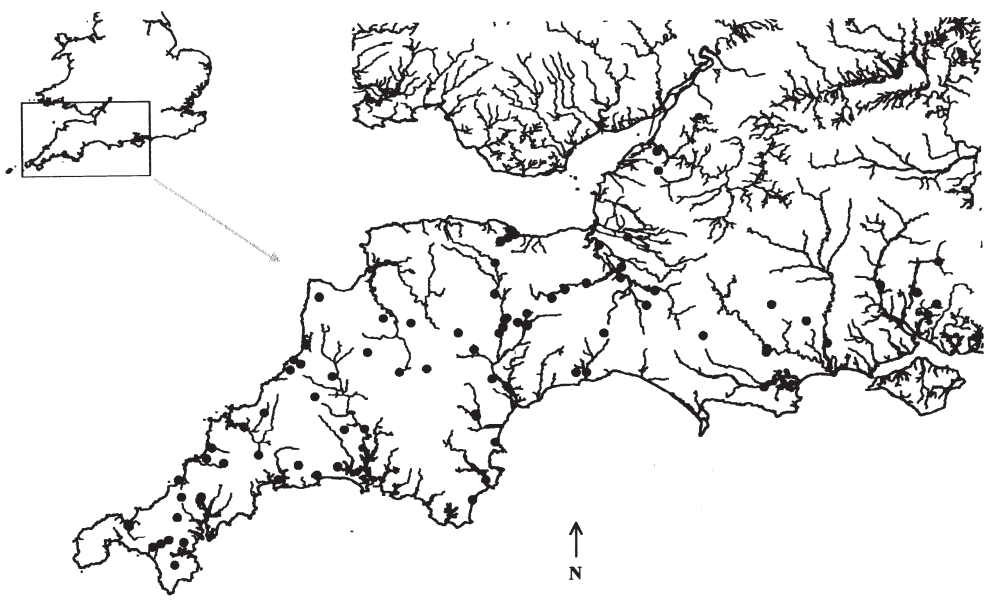

Fig. 1. Location (●) of 94 of the 171 otter carcasses recovered from South West England between 1998 and 2003, from which stomachs were removed for contents analysis. Precise location data for the remaining otters were unavailable.

Results

Of the 171 stomachs analysed, only 17 were empty; of the stomachs that contained food remains, eel *Anguilla anguilla* was the most frequent prey item, present in 36% of all stomachs (Fig. 2). Within the stomach contents, few bones were encountered that enabled further taxonomic differentiation between different salmonid species and between different cyprinid species. Therefore, in calculations for relative frequency of occurrence, the data for all salmonid species were combined, with the data for cyprinid species treated similarly (Fig. 2). The relative frequency of occurrence of all salmonid species was 20 % and for all cyprinid species was 24 % (Fig. 2). Where salmonid species could be identified to species level, fish of <120 mm were an approximate equal mix of brown trout *Salmo trutta* and Atlantic salmon *Salmo salar*, while fish of >120 mm were principally brown trout. Where cyprinid species could be identified to species level, these were principally roach *Rutilus rutilus* and minnow *Phoxinus phoxinus*. Bullhead *Cottus gobio* was present in 22 % of all stomachs (Fig. 2).

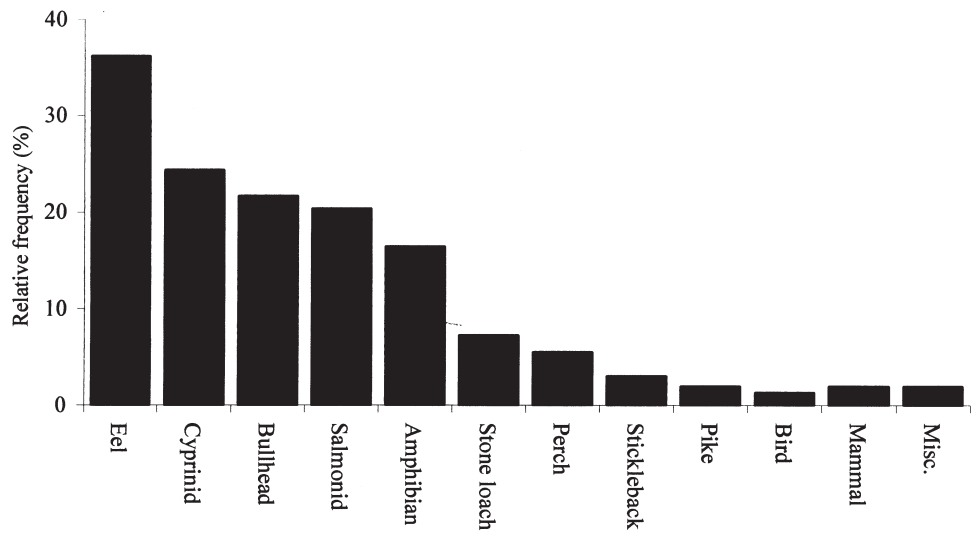

Fig. 2. Relative frequency of prey items recovered from 154 otter stomachs from South West England. Miscellaneous items (Misc.) include a juvenile otter, sea bass and thick lipped mullet. The remaining 17 stomachs were empty.

In the otter stomachs in which eel was recorded, up to five were present (direct counts). Complete specimens were recovered at lengths of between 100 mm and 165 mm; the remains of larger eels consisted of segments of up to 213 mm. There were a total of 84 eels recovered from all the stomachs and there was considerable variation in their estimated length range, with the majority between 150 and 270 mm (Fig. 3). This reveals that there are few eels in inland waters whose length is outside of the range that otters can kill (personal observation). Salmonids ranged from 45 to 310 mm, and cyprinids from 35 to 720 mm (Fig. 4). However, the most common lengths of these species were 40 to 130 mm (Fig. 4), with scales suggesting these fish were mainly at ages below 5+ years. Bullheads were present up to 70 mm. There were also two common carp *Cyprinus carpio* of approximately 685 and 720 mm recorded, with species identification possible from the presence of their scales in the stomach contents (B r i t t o n et al. 2005).

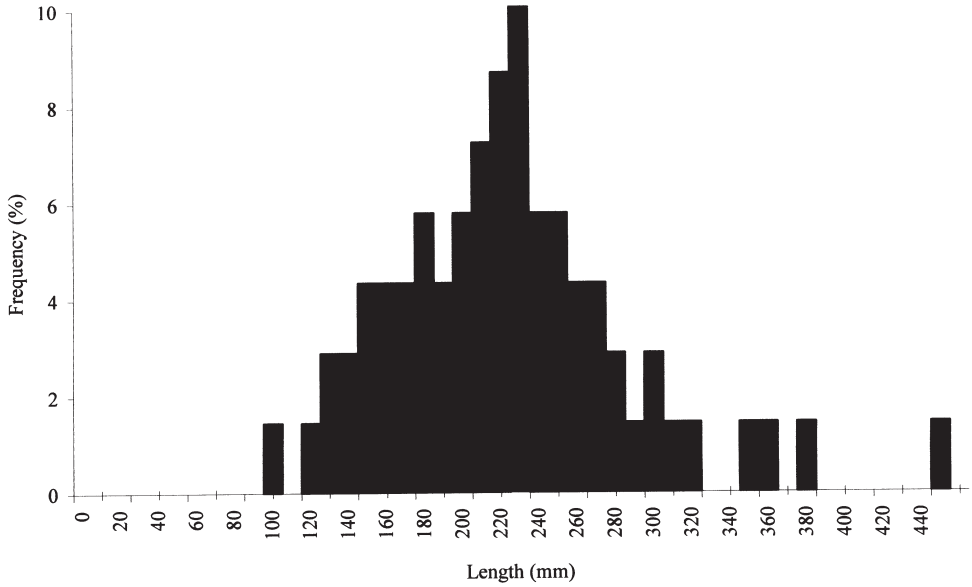

Fig. 3. Frequency of estimated lengths of eel recovered from otter stomachs (n = 84).

Although the remains of amphibians rarely enabled further taxonomic differentiation, they were present in 25% of stomachs (Fig. 2). Amphibians were the only food group whose contribution to otter diet revealed a distinct temporal pattern; they were most prevalent in the stomach contents in the spring of each year, peaking in April (Fig. 5). No other species

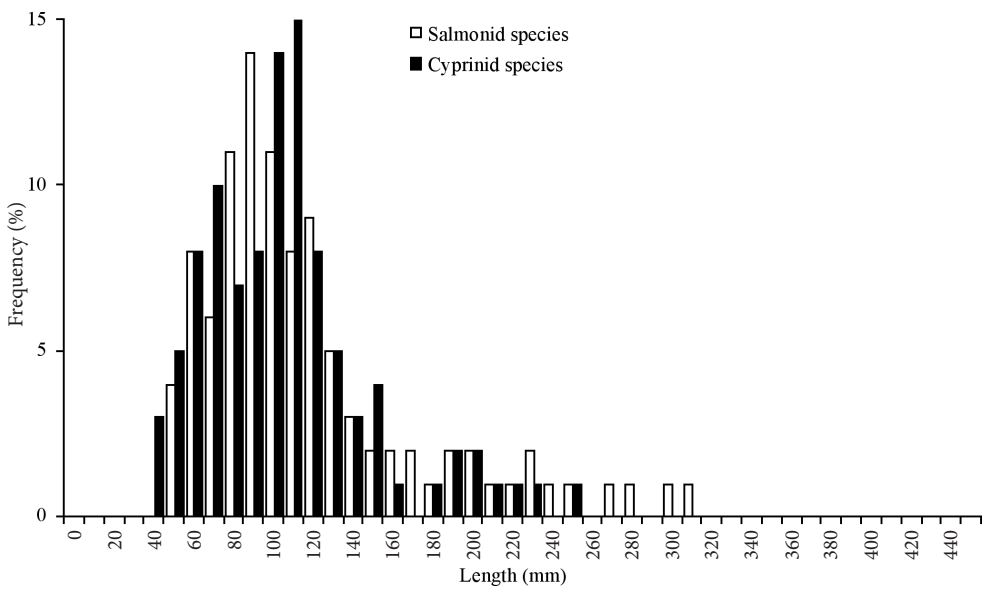

Fig. 4. Frequency of estimated lengths of cyprinid species (n = 124) and salmonid species (n = 120) recovered from otter stomachs. There were also two common carp of 685 and 720 mm recorded.

showed a significant seasonal trend in their occurrence in otter diet, for example bullhead, cyprinids and eel were taken in similar amounts in all months (Fig. 5).

Other notable findings in the stomach contents were the remains of small mammals in four stomachs (species identification was not possible from the items found), remains of a male great crested newt *Triturus cristatus* in one stomach (identified principally from the distinctive orange colouration on the belly) and bird remains (unidentified species) in two stomachs. There were also the remains of a juvenile otter recovered from the stomach of an adult male, the result of otter infanticide (Simpson & Coxon 2000). In addition, there was a singular recording of both sea bass *Dicentrarchus labrax* and thick lipped mullet *Chelon labosus* discovered in the stomach contents of otters recovered from coastal areas, revealing foraging in either estuarine or marine habitats. In some stomachs, remains of aquatic invertebrates were identified, including *Gammarus pulex*, *Asellus aquaticus* and unidentified species of the Hydropsychidae family. However, these were believed to have been secondary prey items, having been present in the gut of fish that had been eaten, rather than the otter specifically taking these invertebrate prey items.

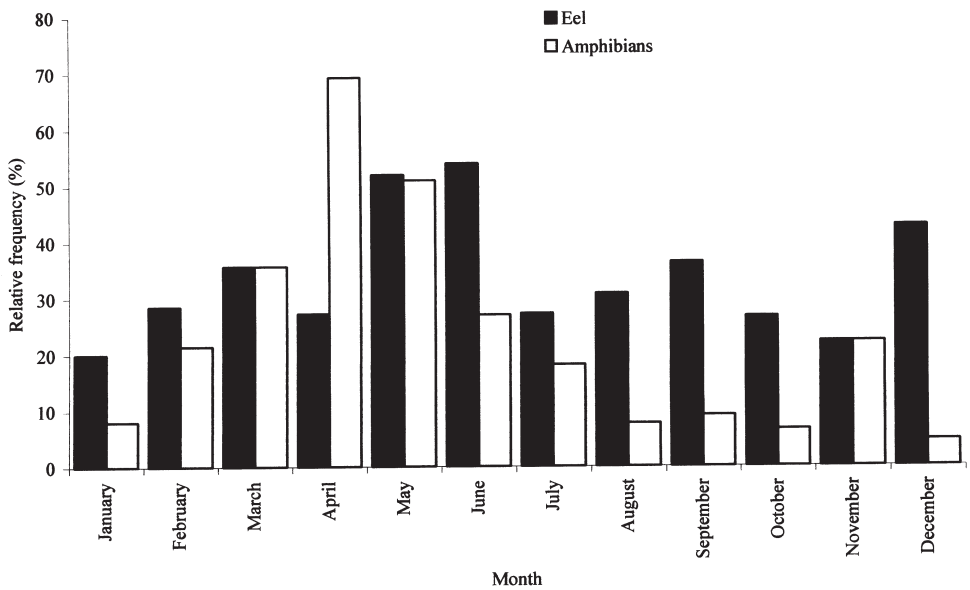

Fig. 5. Relative frequency by month (all years combined) of recordings of amphibians and eel in the otter stomachs.

Discussion

The use of stomach contents analyses for the investigation of prey items taken by otters in Europe is unusual; the majority of dietary literature being based upon spraint (otter faeces) analyses (Chanin 2003). While spraint analysis enables temporal relationships in the diet of otters and territories to be monitored, stomach contents analyses can only report on the final foraging bouts of each otter. However, stomach contents analyses have the advantage of being able to provide information on prey items with few indigestible parts and can provide a better insight into the number of prey items taken. For example, five eels were found in the stomach of one otter, of which three were recovered in their entirety (lengths 97, 125 and

146 mm). It is unlikely that such precise information on these eels would have been able to be obtained from spraint analysis. The majority of these otters were recovered from road traffic accidents. An initial concern was that these individuals were killed whilst travelling to a feeding site and so a high proportion would have few items in the gut. However, only 17 of the 171 stomachs analysed were empty, with the majority of the stomachs containing numerous prey items, with total weight of contents of up to 390 g.

With 154 of the stomachs containing prey items, the study was able to provide a broad overview of the prey items taken by otters across South West England between 1999 and 2003. It revealed that the range of prey items taken was wide and comprised species of fish (freshwater and marine), mammals, birds and amphibians. This is similar to studies that have been done using spraints and supports the argument that otters are highly opportunistic during foraging (e.g. Chanin 2003, Copp & Roche 2003, Britton et al. 2005). The peak in recordings of amphibians in April demonstrated this opportunistic foraging behaviour (Fig. 5), presumably as otters took advantage of spawning aggregations. Similar temporal trends in amphibian presence in otter diet has been reported in Scotland (Weber 1990) and Hungary (Lanszki & Molnár 2003), with consumption of amphibians usually dependent on the stocks available (Erlinge 1969, Weber 1990). There were no other significant temporal trends in the relative frequency of species in diet.

Eel has been reported as a favoured food source of otters due to their ease of capture, comparatively large size and high fat to weight ratio making them an energetically valuable prey (Beja 1996, Carss et al. 1998). These factors may explain why they were the most common prey item taken by otters in this study. However, this finding is in contrast with dietary studies undertaken elsewhere in England. For example, Copp & Roche (2003) found that eel was a comparatively minor component of otter diet in the River Lee catchment, South East England, with cyprinid species being the most prevalent prey items taken. This spatial divergence was likely to relate to differences in local prey availability (Kruuk et al. 1993). The River Lee is a lowland river dominated by cyprinid species, such as roach and chub *Leuciscus cephalus*, whereas rivers in South West England are usually dominated by salmonid species, with eel more prevalent in lower and estuarine reaches. This suggests that otters in South West England were taking eel due to their prevalence in the region.

The lengths of eel most commonly taken were from 180 to 270 mm (Fig. 3). Where larger eels were taken, sections of to 213 mm were present in the stomach. These findings are in contrast to Thom (1997), who found that the lengths of eel taken by otters were generally between 150 and 200 mm, but was in agreement with Taastrøm & Jacobsen (1999) who found otters took few eels below 180 mm and above 420 mm. In fish other than eels, the most common length range was 40 to 130 mm (Fig. 4), lengths that are in contrast to the prey size often preferred by otters of 90 to 210 mm (Hansen & Jacobsen 1992, Chanin 2003, Copp & Roche 2003). However, this may relate to the species of fish being taken here, with many being minnow, bullhead, and juvenile salmonid species, i.e. fish which are predominantly below 100 mm in length.

Regarding the eel, whilst a common prey item for otters in South West England, their European population has declined markedly in recent years and stringent conservation measures are being considered to prevent population collapse (Starkie 2003). The decline is shown by the 90% reduction in the recruitment rate of glass eels since the 1980s (Moriarty & Dekker 1997, Dekker 2003). Therefore, should this European

decline be subsequently reflected in decreased eel abundance in South West England then alternative, less profitable, prey items may become more prevalent in the prey of otters in future years.

In summary, stomach contents analyses of otters in South West England were able to reveal the common prey items taken, their length ranges and seasonal trends in relative frequency. Analysis confirmed that otters are opportunistic foragers and, although they may predate upon numerous prey items, the most common items are fish and amphibians. Despite the decline in eel populations across Europe, they were the most prevalent species in the diet, with individuals taken between 100 and 450 mm.

A c k n o w l e d g e m e n t s

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