THE DIET OF THE MALHAM TARN OTTERS : UNDERSTANDING THE IMPACTS OF A NATIVE PREDATOR.

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Otter (*Lutra lutra*) populations have been recovering in the UK and expanding into new and often isolated habitats. Otters were first sighted at Malham Tarn in 2009, and have since been observed on a regular basis. This study looks at the diet of the Malham Tarn otters and considers their possible impact on prey populations, such as fish, wading birds and white-clawed crayfish.

INTRODUCTION

Since the late 1800s, the Eurasian otter (*Lutra lutra*), has suffered dramatic population declines right across Europe. Hunting, poisoning by polychlorinated biphenyls (PCBs), and organochlorine pesticides, have all contributed to the loss of this native predator (Jefferies, 1989; Mason & Macdonald, 1993).

Otter populations are now recovering across the UK, and much of Europe (Almeida *et al*., 2012; Prigioni *et al*., 2007). In some regions this recovery has been accelerated by re-introductions, but in most areas it is simply down to expansion of remnant otter populations. This population expansion is leading to otters arriving at new and increasingly isolated habitats, including the upland marl lake, Malham Tarn.

Otters were first sighted at Malham Tarn in the spring of 2009, and since then no more than two individuals have been observed on a regular basis. It is likely that these otters came from expanding populations on one of the three nearby river systems (Aire, Ribble or Skifare). The regularity of otter sightings at Malham Tarn suggests that they have established there permanently and are likely hunting solely at the Tarn.

The presence of otters at Malham Tarn is an unusual situation; there is very little published literature on the diet of otters in still waters, and none on the potential impacts of otters on species of conservation interest at such sites. Understanding the diet of the otters at Malham Tarn is essential for assessing both the food requirements of this recovering and protected predator, and the possible impacts their return might be having on prey populations. Of particular concern at Malham Tarn are potential impacts on wading birds, white-clawed crayfish (*Austropotamobius pallipes*), and species of angling interest, especially brown trout (*Salmo trutta*) and perch (*Perca fluviatilis*).

METHODS

In 2011 and 2012, otter diet at Malham Tarn was investigated through spraint (faeces) analysis (Alderton, 2012). Spraints were collected monthly from December 2011 to June 2012, from four known and regularly used latrine sites. Identifiable remains (including anuran bones, bird feathers, and fish scales and bones – Fig. 1), were extracted from the spraints, using a method based on that of Conroy *et al*. (2005). Spraint samples were defrosted and soaked in soapy water overnight, before being washed through a 0.5mm sieve using a jet of water (Roche *et al*., 1995, Smiroldo *et al*., 2009). Remains were air-dried in individual petri dishes at room temperature, to avoid shrinkage of bones (Conroy *et al*., 2005).

Identifications were undertaken by Emily Alderton and Charlotte Wicker (University College London), with the exception of bird feathers, which were examined by Mark Adams (Natural History Museum, London). The relative frequency of occurrence (RF) of different prey species, and estimates of different prey biomass (B), were calculated as:

Relative Frequency of Occurrence (RF) expresses the frequency with which a particular prey item occurs, as a percentage of the total number of prey items found in the spraints:

(number of occurrences of prey item / total number of prey items) x 100.

Proportional Biomass (B) expresses the estimated biomass of a particular prey type, as a percentage of the total estimated biomass of prey found in the spraints:

(estimated biomass of prey type / total estimated biomass of all prey) x 100.

It should be noted that both these methods are subject to errors and inaccuracies (Carss and Elston, 1996; Carss and Parkinson, 1996). However, they still provide a useful indication of otter diet, in terms of otter impact on

prey populations (frequency of occurrence of different prey species in the diet), and the relative contribution that different prey species make to the nutritional budget of the otter (estimated biomass of prey species).

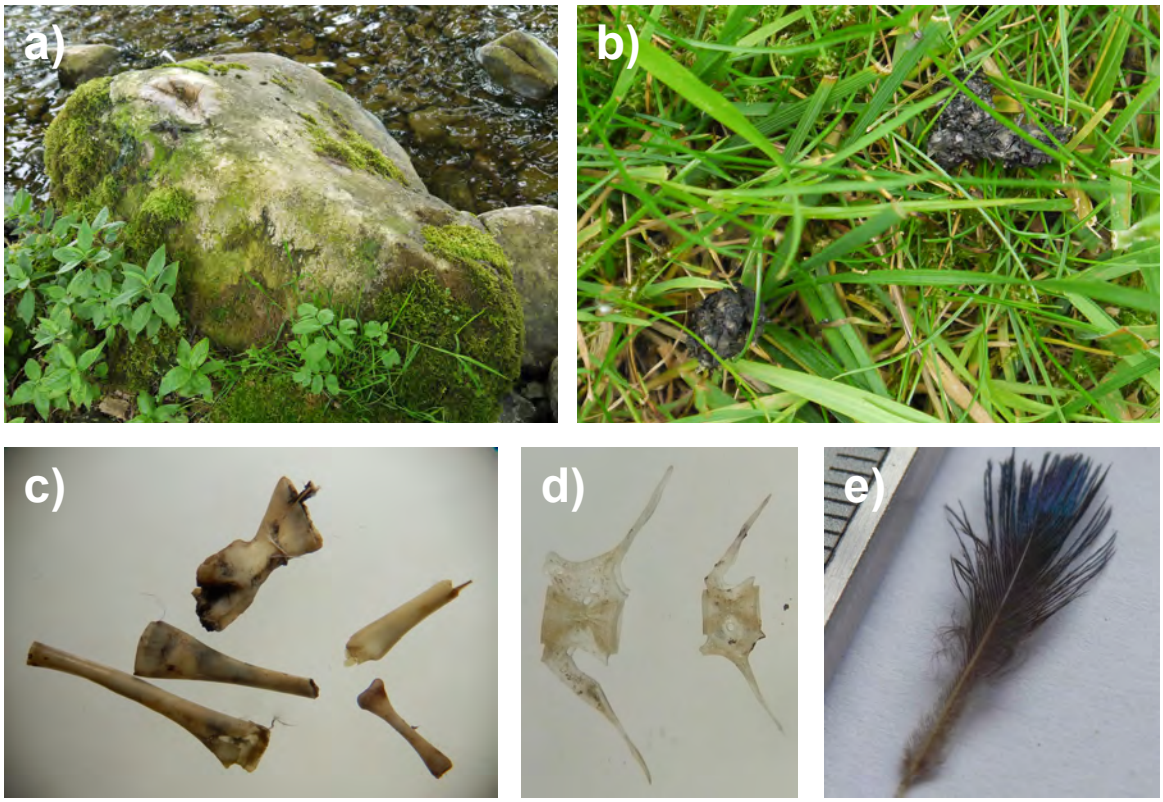

FIGURE 1. Typical sprainting sites used by the otters at Malham Tarn (a & b), and examples of commonly found prey remains (c - anuran bones, d - bullhead *Cottus gobio* vertebrae, e - tufted duck *Aythya fuligula* feather).

RESULTS AND DISCUSSION

General observations on otter diet

Otters are generally considered to be opportunistic predators (Carss, 1995; Wise *et al*., 1981), with a diet reflecting prey abundance and / or ease of capture. This seems to hold true in the case of the otters of Malham Tarn.

In the time period December 2011 to June 2012, spraint analysis showed bullhead (*Cottus gobio*) to be the most frequently consumed prey, followed by small brown trout (*Salmo trutta*), anurans (common frog *Rana temporaria* and toad *Bufo bufo*), and birds. Other fish species (stone loach, perch and three-spine stickleback) and crustaceans (white clawed crayfish and *Gammarus* sp.) occurred in the diet infrequently. Depending on season, bullhead made up between 30-50% of total prey items, while small trout were the second most frequently encountered prey type, at 15-20% total prey items.

Despite their lower frequency of occurrence, birds (<10% of total prey items) and anurans (5-15% of total prey items) contributed the highest proportional biomass to the diet, as they provide more meat per individual than the small fish. Anurans were more common in the diet of otters during the winter and early spring, likely reflecting their vulnerability during hibernation and breeding. Such 'prey switching' from fish to frogs and toads has been documented in other studies of otter diet, and can either coincide with a decline in fish availability (Román 2011), or peaks in amphibian activity (Garcia-Diaz and Ayres, 2010).

Bird feathers were found infrequently (in 20 of 159 spraints) and included both waterfowl (tufted duck, mallard and gull) and other birds (pheasant and rook). The presence of rook in the otters' diet suggests scavenging, as it seems unlikely that otter would predate this species directly. Peregrine falcons (*Falco peregrinus*) often hunt over Malham Tarn and observations suggest a high number of peregrine kills around the lake margins likely affording a readily available food source for otters.

Subsequent work on otter diet at Malham Tarn, conducted in 2013-2014 (Wicker, 2014) has revealed some changes. While bullhead remained the most frequently consumed prey type, followed by brown trout; there were shifts in the relative importance of other prey types. Fewer anurans (frogs and toads) occurred in the diet between 2013-2014 than in 2011-2012, and fewer birds (all of which were waterfowl, in contrast to the findings from 2011-2012)

were recorded. Another noticeable change was the occurrence of perch in the otters' diet in 2013-2014, a prey type which was absent during 2011-2012. While perch are abundant in the Tarn, and as far as known, equally so during the two study periods, there was a marked increase in the number of perch carcasses found around the lake edge in 2014. Many of these carcases showed no obvious signs of predation suggesting a disease-driven fish kill. Nonetheless some of the carcasses had been partially eaten suggesting that otters took advantage of this.

FIGURE 2. Feathers found in otter spraints at Malham Tarn.
Left: tufted duck *Aythya fuligula*, Right: male pheasant *Phasianus colchicus*.

Impacts on species of conservation and angling concern

Diet analysis of the otters at Malham Tarn strongly suggests opportunistic predation, with the otters choosing prey which are in high abundance and easy to catch. Hunting appears to be targeted towards the inflow and north shore of the Tarn — possibly due to the high availability of bullhead in these locations, combined with a reduced effort required to catch fish in shallow rather than deep water. Both Alderton (2012) and Wicker (2014) observed the greatest levels of otter activity in these areas.

Large trout were rare in the diet which may reflect the difficulty and high energy requirements associated with catching fish in the open waters of the Tarn (where the larger trout typically reside). The high frequency of occurrence of small brown trout in the otters' diet could be due to a targeting of young fish in their spawning and nursery areas (inflow stream). Despite their relatively high abundance in the diet, the impact of two otters on the trout population of Malham Tarn is likely to be negligible, however. Indeed, in this respect, loss of spawning habitat in the inflow stream may be a more important factor to consider with regards to trout population dynamics (Bradley, 2007).

Wading birds occur in the diet of Malham otters relatively infrequently, and a major direct impact upon wader populations seems unlikely. The presence of mink and ferret at the Tarn prior to the arrival of the otters would likely have had similar impacts on bird breeding success and predation, while issues with declining habitat quality, food availability and changing weather patterns, are likely to be more important contributors to bird declines (Bradley, 2007). The occurrence of white-clawed crayfish (*Austropotamobius pallipes*) in the diet of the Malham otters was also very occasional, reflecting their extremely low abundance in the Tarn (Bradley, 2007).

The diet of otters at Malham Tarn varies seasonally and inter-annually, reflecting changes in prey availability. Prey switching seems to occur as new sources of food become available, and there is a strong indication that scavenging, either on bird of fish carcasses, may be important.

Observations of otter hunting activities

Observations of otter hunting behaviour were made over 20 days in June 2012. Most observations were made from the bird hide on the north bank of the Tarn (marked H in Fig. 3). Otters seemed to have a preference for fishing in the shallow waters around the inflow to the Tarn, and along the rocky north shore. Otters exhibited a specialised fishing technique for catching bullhead; they would thrash and roll around on the rocks in shallow water, flipping them over to expose the fish. This technique (referred to as "rolling" in Table 1) was observed on several occasions.

As well as "rolling", otters were observed to engage in other feeding-like activities. In deeper water, otters were seen "diving" for up to 30 seconds at a time, with short surfacing breaks between dives. On one occasion, an otter

was seen eating a fish as it surfaced from a dive. Other observed behaviours were "travelling" (when an otter was swimming at the surface for an extended time) and "snorkelling" (when an otter was swimming just below the water surface, its progress evident from a trail of bubbles or by occasional glimpse of its tail or back). This focus of activity around the inflow stream and north shore of the Tarn was also observed in June 2014, when camera traps were deployed at 12 locations around the Tarn. One camera trap, located at the inflow stream, captured 38 separate visits from otters over a 23 day period (4th - 27th June 2014). In contrast, camera traps located along the south and east shores, and by the boat houses, recorded no visits from otters during an 8 - 15 day period.

The locations of otter activity observed by Alderton (2012), and location of the inflow stream camera trap, which recorded most otter activity in the Wicker (2014) study, are marked on Fig. 3.

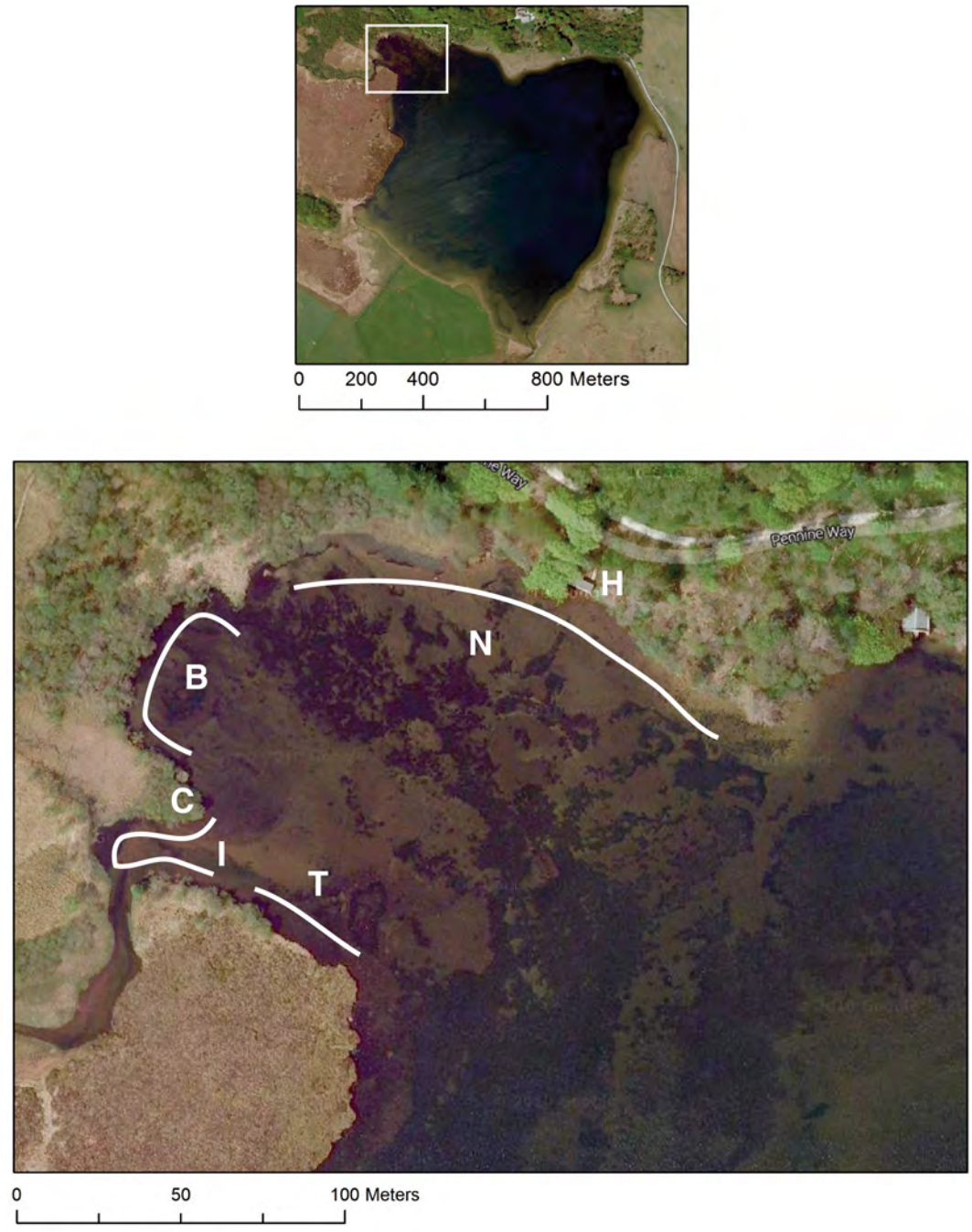

FIGURE 3. Aerial view of Malham Tarn, highlighting locations of most frequent otter activity (June 2012).
H - bird hide, **N** - NW bank, **B** - inflow bay, **I** - inflow stream, **T** - in front of Tarn Moss,
O - open water, **C** - inflow stream camera trap (2014).

FIGURE 4. Otter caught on camera by the inflow stream to Malham Tarn. Photo captured at 20:30 on 6th August 2014.

TABLE 1. Observations of otter behaviour separated by location, number of sightings in that location, and the type of activity occurring in that location (listed in order from most commonly observed to least commonly observed behaviour). The final column gives a count of the number of successful fish catches observed in each location.
Otter behaviours: *Travelling* - swimming at the surface for an extended time. *Diving* - diving motion, followed by otter remaining submerged for up to 30 seconds at a time. *Snorkelling* - otter swimming just below water surface. *Rolling* - otter rolling around in shallow water, disturbing fish hiding under stones.

Location	No. of sightings	Activity	Successful catch?
Inflow stream (I)	5	Travelling, Diving	0
Inflow bay (B)	5	Diving, Snorkelling, Rolling	1
NW bank (N)	4	Rolling, Snorkelling, Travelling	3
In front of Tarn Moss (T)	4	Diving, Snorkelling, Travelling	1

CONCLUSIONS

The return of otters to Malham Tarn is an exciting indication of the high habitat quality provided by this site. As a popular location for wildlife watching and tourism, the presence of one of our most charismatic protected animals at the Tarn is a real cause for celebration. Spraint-based diet analysis suggests that the otters at Malham Tarn are opportunistic predators, favouring prey types which are both abundant and easy to catch. It is unlikely that the presence of otters at Malham Tarn will have a negative impact on other conservation interest species, or upon angling activities.

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