

Evidence of carrion consumption behaviour in the long-eared owl *Asio otus* (Linnaeus, 1758) (Aves: Strigiformes: Strigidae)

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Abstract

Evidence of necrophagous behaviour has been reported for 8.43% of nocturnal raptors. To determine whether preys were captured alive or consumed as carrion is challenging, as the diet of Strigiformes is mainly studied through pellet analysis, rather than direct observation. The diet of the long-eared owl *Asio otus* has been widely studied all over the distribution range of this species, but proven evidence of this feeding habit is still lacking. We collected 106 pellets under a suburban dormitory in Southern Tuscany (Central Italy) between December 2012 and April 2013. Prey remains (skulls, mandibles) were compared with a specific atlas. Four fragments of crested porcupine (*Hystrix cristata*) quills and a jawbone of *Martes* sp. were found in pellets collected after a snowfall (20–40 cm in depth). Although voles and mice constituted the staple of the diet of this species, accordingly with previous studies, these findings represent the first proof of carrion consumption by the long-eared owl. Body sizes of crested porcupine and *Martes* sp., as well as the defence behaviour of the rodent, rule out a direct predation by the owl. Our study enlarges the trophic spectrum of the long-eared owl, thus adding a further dimension to the behavioural plasticity of this species.

Keywords: Long-eared owl, necrophagy behaviour, crested porcupine, *Martes* sp., trophic spectrum

Introduction

Although improved by large eyes with respect to the skull, sight does not represent the principal sense in owls (Aves: Strigiformes) because of their nocturnal habits. The specialized auditory systems of nocturnal raptors represent the main aid for food searching (Konishi 1973; Knudsen & Konishi 1978). Evolution has acted on owls by adapting hearing functions and by making them highly sensitive (Van Dijk 1972; Bye et al. 1992). Moreover, the fringed outer parts of the flight feathers allow owls to emit very little noise during flight (Lilley 1998; Bachmann et al. 2007). Such considerations may mitigate in favour of hunting behaviour, which includes the capture of live preys. Owls, flying silently, hear potential preys moving on the ground (e.g. small mammals), or flying (e.g. birds, bats). The diet of Strigiformes is often assessed by analysing content of pellets (i.e. bones, feathers and other food remains: e.g. Errington 1930; Alivizatos et al. 2005). Thus, to determine whether preys were captured alive

or consumed as carrion is challenging, and not always verifiable.

Consumption of carcasses has been documented for 8.43% (21/249) of Strigiformes species (e.g. Kapfer et al. 2011; Allen & Taylor 2013). Among European nocturnal raptors, necrophagy have been described only for eagle owls *Bubo bubo* (Linnaeus, 1758) (Hiraldo et al. 1975; Serrano 2000; Diaz-Ruiz et al. 2010) and barn owls *Tyto alba* Scopoli, 1769 (Welch 2012).

The long-eared owl *Asio otus* (Linnaeus, 1758) is a medium-sized nocturnal raptor widely distributed all over the Holarctic (BirdLife International 2012). The main preys of this species are small mammals, with seasonal variations recorded (e.g. Cramp 1985; Tome 2009): voles and mice represent the staple of the diet (see Birrer 2009, for a review). When access to these ground-dwelling rodents is denied (e.g. by snow cover), long-eared owls may supplement their diet with birds (Canova 1989; Birrer 2009).

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The winter diet of this species has been analysed throughout its distribution range (see Birrer 2009 for a review). A group of individuals may share the same roost outside the breeding season (Cramp 1985); thus, collecting a high number of pellets in the surroundings of communal roosting areas may be easy, especially in urban environments, and it requires little time (Korpimäki 1992; Maccarone & Janzen 2005). Scavenging behaviour has been suggested also for this species: a small bone fragment, maybe belonging to a roe deer (*Capreolus capreolus*), was detected within a pellet (Erfurt & Stubbe 1987), but other irrefutable, well-ascribed evidence is still lacking.

On the other hand, pellet analysis is a valid method used to obtain new data on small mammal (Rodentia and Soricomorpha) communities and dynamics of a certain area, which is essential for research and conservation (e.g. Cecere & Vicini 2000). Since the long-eared owl is commonly considered a feeding specialist (Cramp 1985; Tome 2009), pellets of generalist species (e.g. barn owl: Michel et al. 2006; Obuch & Benda 2009) are preferred for this purpose; this may partly feed a limit in the knowledge of the diet of *Asio otus*. We performed an analysis of long-eared owl pellets in the framework of a checklist project about mammal communities of a Natura 2000 site in southern Tuscany. In this paper, we report the first evidence of carrion consumption in the winter diet of this nocturnal raptor.

Materials and methods

Pellets ($N = 106$) were gathered from one site inside the village of Prata, in the municipality of Massa Marittima (Province of Grosseto, Southern Tuscany: 43°05'N 10°59'E), from 20 December 2012 to 30 April 2013. The study area is located in a rural hilly landscape (475–903 m above sea level); a Natura 2000 network site ("Poggi di Prata": Tuscan Regional Law 56/2000) and an International Waterbird Census area (IWC "Gabellino") are part of it. Habitat types were determined through an ortophoto, provided by a local hunting district (ATC Gr6), and by on-the-spot investigations. Habitat composition resulted as follows: mixed deciduous woods (52.14%), fallows (19.49%), chestnut woods (14.89%), cultivated areas (7.78%), pine-woods (2.02%), built-up areas (1.97%) and scrubwoods (1.71%) (Cantini et al. 2013). Four other species of Strigiformes are recorded within the study area (Vannini et al. 2013): the barn owl, the tawny owl *Strix aluco* Linnaeus, 1758, the little owl *Athene noctua* Scopoli, 1769 and the scops owl *Otus scops* Linnaeus, 1758. According to a 2-year survey, the long-eared owl is the least common owl

species within the study area, and the tawny owl the most detected (Vannini et al. 2013). Data on local small mammal densities and composition are scanty and incomplete (Sforzi & Ragni 1997). Pellets were collected under a winter roost, the only one identified during the survey, used by six individuals of *Asio otus* located on a stone pine (*Pinus pinea* L., 1753) at the side of the main street of the village. All the pellets detected on the ground were collected once every 3 days, then dried, softened in hot water and in pure ethanol, to better separate parts corresponding to different prey species (skulls, mandibles: Cecere & Vicini 2000). We considered a single individual for each species detected per pellet, as no more than one hemimandible per side was observed within the same pellet.

Identification of preys, from both broken and whole pellets, was carried out to the genus or species level, by comparison with Nappi (2001), and with the aid of a binocular microscope (20 × and 40 ×). Skulls and mandibles belonging to the genus *Apodemus* presented similar morphology and measurements (Nappi 2001; Chassovnikarova & Markov 2007), so it has been not possible to assess whether remains belonged to *A. sylvaticus* (Linnaeus, 1758) or to *A. flavicollis* (Melchior, 1834). Both species are present within the study area (Mori, unpublished). Diet composition was calculated as the relative percentage of prey items belonging to each identified species.

Results

We determined 112 prey items belonging to 9–10 species ($N = 5$ –6 Rodentia, 3 Soricomorpha, 1 Carnivora) from a total of 106 pellets. Remains from the other 34 pellets were not identified. The relative percentage of prey items belonging to each identified species, and the number of pellets, are reported in Table I.

Wood mice and bank voles represent the bulk of the diet (53.62% and 30.14% respectively, Table I). Other species are less represented. No insects, bats or birds were found in our sample.

We reported the presence of crested porcupine (fragments of quills) and *Martes* sp. (fragment of a jawbone) in the diet of the long-eared owl (Figure 1). The type of teeth (permanent teeth) and the level of dental wear found in the fragment indicate that the *Martes* sp. is an adult individual (Marshall 1951).

Discussion

In our study, the diet of the long-eared owl was strongly dominated by *Apodemus* spp. and bank

Table I. Winter diet composition (number of pellets containing each prey and percent by number of prey items) of long-eared owl in the study area. *Apodemus* spp. includes both *A. sylvaticus* and *A. flavicollis*.

Species	N_{pellets}	% by number
<i>Apodemus</i> spp.	41	43.62
Bank vole <i>Myodes glareolus</i> (Schreber, 1780)	22	23.40
Black rat <i>Rattus rattus</i> Linnaeus, 1758	14	14.89
Savi's pine vole <i>Microtus savii</i> (de Selys-Longchamps, 1838)	8	8.51
Crested porcupine <i>Hystrix cristata</i> Linnaeus, 1758	4	4.26
Bicoloured white-toothed shrew <i>Crocidura leucodon</i> (Hermann, 1780)	2	2.13
Lesser white-toothed shrew <i>Crocidura suaveolens</i> (Pallas, 1811)	1	1.06
Etruscan shrew <i>Suncus etruscus</i> (Savi, 1822)	1	1.06
Marten <i>Martes</i> sp.	1	1.06

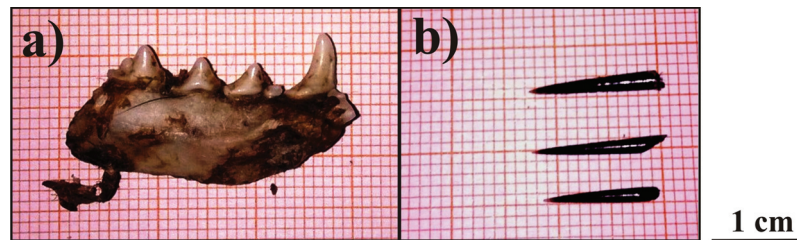


Figure 1. **a**, quills of crested porcupine and **b**, fragment of jawbone of a marten, found in the pellets of long-eared owl.

voles (53.62% and 30.14% of prey items, respectively), consistent with other studies (see Birrer 2009, for a review). Accordingly, both black rats and Soricomorpha are poorly represented.

Fragments of crested porcupine quills were detected in four pellets, the day after a snowfall (20–40 cm in depth); their sturdiness suggests that they do not belong to a newborn individual (Mohr 1965). All four pellets were collected in the same location and on the same date, suggesting that they may belong to the same porcupine. The weight of crested porcupines (median weight of adult porcupines: 11.2 kg, Q_1 – Q_3 = 9.9–13.3; Mori & Lovari 2014) is higher than the heaviest verified species preyed by long-eared owls (*Bonasa umbellus*, 400–500 g; Cramp 1985; Birrer 2009). Given also the anti-predatory behaviour displayed by porcupines (Mori et al. 2014), the hypothesis of a direct predation by the long-eared owl can be ruled out, thus suggesting a necrophagous behaviour. This feeding habit have never been described with certainty for *A. otus*, but only suggested (Erfurt & Stubbe 1987). The crested porcupine is inhomogeneously distributed throughout Italy, and higher population densities seem to occur in Central Italy, on the Tyrrhenian side (<http://www.naturaesocialmapping.it/istrice>, accessed 6 December 2013). At least 13 den setts inhabited by porcupines have been identified through camera trapping within the study area (Mori, unpublished). The peak of road-killed porcupines seems to occur during

the winter (in February: Mori et al. 2013). Local hunters report that a similar rate is observed when the ground is covered by snow in vegetation-covered areas (i.e. scrubwoods, woodlands), thus possibly increasing the availability of this trophic source for the long-eared owl.

Three days later, when the ground was still covered by snow, a pellet containing a fragment of a jawbone of *Martes* sp. was collected. As for Mustelid remains, Cramp (1985) reports only stoats *Mustela erminea* and weasels *Mustela nivalis* in the diet of *A. otus*, while *Martes* spp. are never mentioned (see Birrer 2009, for a review). The presence of *Martes* spp. has been sporadically observed in pellets of other European strigiforms: *Bubo bubo* (one *M. foina* in 2533 vertebrate preys: Wassink & Hingmann 2010; one *M. martes* in 164 vertebrate preys: Obuch & Karaska 2010), *Strix aluco* (one *M. foina* and one *M. martes* in 2651 vertebrate preys: Obuch 2011) and *Tyto alba* (one *M. foina* in 135 vertebrate preys: Obuch & Benda 2009). We assume that a medium-sized owl, which *Asio otus* is, cannot kill an adult *Martes* spp., because of its body size (Reig 1992, for marten size; Cramp 1985; Birrer 2009 for long-eared owl prey sizes) and aggressiveness (cf. Fryxell et al. 1999). Moreover, the level of tissue wear suggests that the fragment here described may belong to an individual that had been dead for a few days, and not to a directly preyed animal (D. Scaravelli, personal communication, 2013; cf. Behrensmeier 1978).

Bertolino et al. (2001) showed that diet of *A. otus* is more variable in Italy than in other countries. According to the optimal foraging theory (Pyke et al. 1977), variations in the abundance of small rodents in the field may trigger changes in the diet of this species, as a functional response to food scarcity (Holling 1959).

Surprisingly, the possible limited availability of small rodents has not been bypassed through predation on birds, whose activity is not obstructed by the snow cover (cf. Canova 1989; Sergio et al. 2008). High mortality peaks of mammals after snowfalls in the study area (Mori et al. 2013) may also provide an easily accessible trophic source to species adapted to hunt live prey, when these last are not available. Our findings provide new evidence that the long-eared owl is a specialized predator, which preys mainly on voles and wood mice. However, it may adapt its trophic spectrum when environmental conditions (e.g. snowfall, winter temperatures) reduce access to its preferred preys (e.g. ground-dwelling rodents: Canova 1989; Bertolino et al. 2001; Birrer 2009), including also carrion in its diet.

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