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Feeding ecology of the scops owl, *Otus scops* (Aves: Strigiformes), in the island of Pianosa (Tuscan Archipelago, Central Italy) outside the breeding period

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ABSTRACT

All of the published studies but one about the diet of the Eurasian scops owl *Otus scops*, a nocturnal raptor of conservation concern, were carried out during the breeding period, just before or immediately after the chicks fledged. The species is a trans-Saharian migrant with few resident populations in Europe. Orthoptera make up the staple of its diet in summer. In this study, we investigated the diet of scops owls on the island of Pianosa after the breeding period through the analysis of pellets. A total of 327 fragments belonging to at least 14 taxa were identified from 56 pellets collected after the breeding period, between late August and March. By frequency, invertebrates constituted 80.00% of the diet, with Coleoptera being the most represented order (62.35% of the total diet) and Orthoptera poorly represented (8.24%). Vertebrates included two bird species, three small mammals and the Moorish gecko. Although the meal-to-pellet interval for scops owls is unknown, we suggest that the bank vole, which is not recorded on any Italian island, and possibly the wild mice, may have been preyed upon in nearby areas, before a migratory movement towards a warm area (e.g. Pianosa) occurred.

Keywords: *Tuscan Archipelago, post-breeding period, Strigiformes, Coleoptera, Orthoptera*

Introduction

Feeding ecology of nocturnal raptors (Aves: Strigiformes) is often assessed through the analysis of pellet contents, i.e. bones, feathers, elytra and other food remains (Errington 1930; Glue 1970; Andrews 1990).

Among European owls, the Eurasian scops owl *Otus scops* Linnaeus, 1758 is the smallest species and, together with *Asio otus* (Linnaeus, 1758) and *Asio flammeus* (Pontoppidan, 1763), the only one exerting long migratory movements (Cramp & Simmons 1980). This nocturnal raptor is widely distributed as a breeding species throughout the Palearctic, mostly in its Southern part (Cramp & Simmons 1980). Then, most individuals migrate to overwinter in sub-Saharan Africa, whereas few resident populations remain in Eurasia throughout the coldest months (Cramp & Simmons 1980; Brichetti & Fracasso 2006). In Italy, the winter distribution range of the scops owl includes Southern regions and, in rare occurrences, Northern and Central Italy (Brichetti & Fracasso 2006).

Despite the wide distribution range, the European populations are markedly declining (Mañez 1994; Marchesi & Sergio 2005; Mori et al. 2014; but see Latkovà et al. 2012), although this species is reported as "Least Concern" by the Red List of Birds (Peronace et al. 2012; BirdLife International 2015). Scops owls select open habitats (e.g. meadows, steppes and farmlands) during the breeding period (March–July) as well as human settlements (Martínez et al. 2007; Treggiari et al. 2013; Panzeri et al. 2014), while preferring thermal, covered areas (i.e. within woodlands) during the coldest period in Central Italy (Panzeri et al. 2014). The diet of the scops owl is mainly

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insectivorous during the breeding period (Marchesi & Sergio 2005; Latkovà et al. 2012), although apparently shifting to small mammal prey in winter (Cramp & Simmons 1980; Mikkola 1983; Panzeri et al. 2014). Large Orthoptera species make up the staple of the diet of the scops owl throughout its breeding range (Herrera & Hiraldo 1976; Latkovà et al. 2012). The trophic spectrum of this species is wider in Italy, which is included, together with Northern Africa, in the southernmost part of its breeding range, with respect to Central Europe (Sergio et al. 2006, 2008; Latkovà et al. 2012). Collection of scops owl pellets is difficult because they are small and crumbly, and thus hard to detect. So far, most studies on its diet have been carried out during the breeding period (Massa 1981; Marchesi & Sergio 2005; Latkovà et al. 2012), when the species (and thus its perches/nests) is rapidly detectable through its unmistakable calling behaviour (Mori et al. 2014). As far as concerns the non-breeding period, collection of pellets is hard because density decreases and scops owls tend to live in covered habitats (i.e. woodlands), sometimes without emitting their typical loud calls (e.g. Southern Tuscany: Mori et al. 2014). On Pianosa, the species is present throughout the year (PS, pers. obs.), although no data concerning its diet on Tuscan Archipelago are available.

In this work, we analysed the diet of this small raptor in an insular environment of Central Italy outside its breeding period.

Materials and methods

Study area

The island of Pianosa is entirely included within the Tuscany Archipelago National Park (Tyrrhenian Sea, Tuscany, Central Italy: Figure 1).

The island has an extension of about 1025 hectares and it is almost flat, with an elevation of 0–29 m above sea level (asl; average 18 m asl: Colom et al. 2004; Tomassone et al. 2013). A small human settlement covers 4% of the island, in the proximity of the harbour; tourism is allowed only within the village and in neighbouring coastal portion (about 5% of the total island), although closely regulated. Until 1997, a prison was present and much of the island surface was cultivated or grazed, while currently only few areas (< 1%) are covered with crops. Most of the inner part of the island is covered with abandoned pastures and arable areas, partially recolonised by Mediterranean scrub species, *Pinus halepensis* Miller and *Quercus ilex* L. Coastal areas are mainly occupied by garrigues with *Helichrysum litoreum* Gussone, Mediterranean "macchia" (e.g. *Pistacia lentiscus* L., *Rosmarinus officinalis* L.), and *Juniperus phoenicea* subsp. *turbinata* (Gussone) Nyman arborescent matorral (Colom et al. 2004). The morphology of Pianosa prevents the condensation of moist air, resulting in a low annual rainfall (176–716 mm: Vaccari et al. 2012). Mean environmental temperature is 15.8°C (Vaccari et al. 2012). Four species of small mammals are known to be present, as a result of ancient introductions from the mainland (Amori et al. 2015): the Etruscan shrew *Suncus etruscus* Savi, 1822, the black rat *Rattus rattus* Linnaeus, 1758, the Norway rat *Rattus norvegicus* Berkenhout, 1769 (never reported in the last few decades, possibly misidentified) and the house mouse *Mus musculus* Linnaeus, 1758 (Amori et al. 2015). Records of wild mice *Apodemus sylvaticus* Linnaeus, 1758, in Pianosa are due to misidentification, and re-analyses ascribed all of the individuals to *Mus musculus* on the basis of body and cranial morphology (PS, unpub. data).

Despite lists of some insect groups (i.e. Coleoptera, Orthopteroidea, Lepidoptera: Baccetti 1976; Dapporto et al. 1999; Lo Cascio et al. 1999, 2000; Abbazzi et al. 2004; Dapporto & Cini 2007) having been published, a complete checklist of

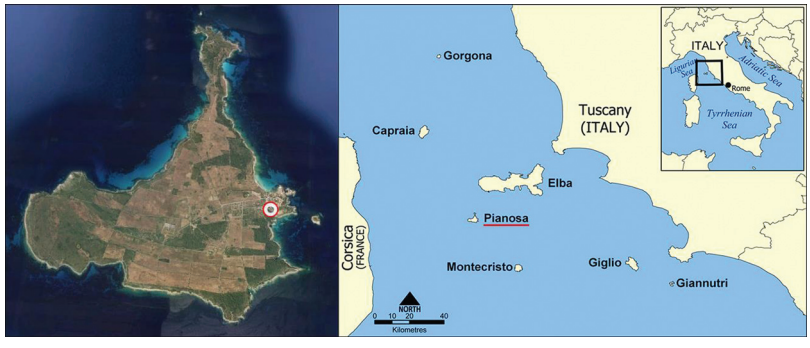

Figure 1. Location of the study area. The circle shows the site where scops owl pellets were collected. Sources: Data SIO, NOAA, US Navy, NGA, GEBCO © 2016 TerraMetrics © 2016 Google; Wikimedia Commons, user Norman Einstein, CC-BY-SA-3.0.

insects of the Tuscan Archipelago and of the island of Pianosa is lacking. A total of seven species of reptiles are recorded in Pianosa, with the Moorish gecko *Tarentola mauritanica* Linnaeus, 1758 possibly introduced at the end of the 1990s (Vanni & Nistri 1998).

Arcamone and Sposimo (2002) listed the breeding bird species of Pianosa. Among nocturnal raptors, the barn owl *Tyto alba* Scopoli, 1759, the little owl *Athene noctua* Scopoli, 1759 and the scops owl are present; the short-eared owl *Asio flammeus* is an irregular migrating presence. The scops owl is known to breed and regularly overwinter within the Tuscan Archipelago (e.g. Elba and Montecristo Island: Tellini Florenzano et al. 1997; Mori et al. 2014; PS pers. obs.). No data are available on its current density on Pianosa, although at least 30 singing males were present in 2015 (C. Gotti, pers. comm., 2015).

Data collection and analysis

A total of 56 pellets (N = 41, 27 September 2015; N = 6, 14 December 2015; N = 9, 8 March 2016) were collected in the village of Pianosa (coordinates: 42.5852°N, 10.0967°E), egested between August 2015 and March 2016 (Figure 1). Pellets were egested by at least four individuals, which were observed by PS while flying over the collection site; only two of them were observed in December and March. Pellets by other species are 80–300% larger and more compact than those collected.

All the pellets detected on the ground were collected, dried and softened in hot water and 95% ethanol, to better separate parts corresponding to prey species, e.g. skulls, mandibles (Andrews 1990). Emimandibles found in different pellets collected in the same data were checked and compared each other to avoid misinterpretations, i.e. to exclude that single prey individuals were split into separate pellets. For small mammals, birds and reptiles, we considered a single individual for each species detected per pellet, as no more than one emimandible per side was detected within the same pellet. Given the great number of insect fragments found, we followed the procedure proposed by Cassola and Lovari (1979) to obtain an estimate of the number of individuals eaten per pellet. Fragments of single organs (e.g. head, ovipositor, pronotum) were separated and counted to assess the minimum number of insect prey belonging to each taxonomical group. When any fragment of single organs was found, we determined the minimum number of prey by the number of right (or left) organs in our sample, or we divided per six (and rounded up) the number of legs detected in each pellet (Ganey 1992). Identification of prey from both broken and entire pellets was carried out to species level for vertebrates, to family or genus level for arthropods, by comparison with Lapini et al. (1996) and Nappi (2001) for vertebrates, and with the help of a binocular microscope (AmScope SE420Z-*E*: 20× and 40× magnification). Diet composition was calculated as the relative percentage of each identified taxonomic class.

Results

Altogether, a total of 327 fragments belonging to at least 14 taxa of five taxonomic classes were identified from 56 pellets of scops owl (Table I).

The staple of the diet was built up by insects (72.94%), especially Coleoptera, with Vesperidae as predominant (32.94%), followed by the superfamily of Scarabaeoidea, i.e. Geotrupidae + Tenebrionidae + Melolonthidae (23.95%). The order Orthoptera contributed less than 10% to scops owl diet (8.24%), and all of the fragments found were identified as belonging to the genus *Calliptamus*. To finish, Hemiptera (Heteroptera) was the least represented order of insects (2.35%) in the scops owl diet on Pianosa. Isopoda (Oniscidae) constituted 7.06% of the diet, while the remaining 20.00% was built up by vertebrates.

Discussion

The scops owl is the smallest European nocturnal raptor and it requires important conservation measurements (Mañez 1994; Treggiari et al. 2013), although it is considered of "Least Concern" by the International Union for Conservation of Nature (IUCN; Peronace et al. 2012; BirdLife International 2015). Preservation of farmlands and meadows is claimed to be mandatory for its conservation (Treggiari et al. 2013), as its diet is mostly composed by insects typical of open habitats, e.g. Orthoptera (crickets and grasshoppers: Krištìn et al. 2011), at least during the breeding period (March–July). Although different from country to country, i.e. according to local availability and habitat structure/complexity (Latkovà et al. 2012), the proportion of Orthoptera remains always high (from 46.8% in north-western France to over 90% in Slovakia, mainly *Tettigonia viridissima* Linnaeus, 1758: Bavoux et al. 1993; Šotnàr et al. 2008; for a review, Latkovà et al. 2012), just before or immediately after the chick fledged out. Abundance and number of species of Orthoptera in the diet of scops owl decrease with declining temperatures from

Table I. Abundance of prey taxa in the diet of scops owl on the island of Pianosa. ND, not determined.

Class	Order (family or suborder)	Species	Pellets (N)	Fragments (N)	Individuals (N)	Frequency (%)
Insecta	Coleoptera (Vesperidae)	*Vesperus* cf. *luridus*	13	28	28	32.94
	Coleoptera (ND)	ND	24	104	8	9.41
	Orthoptera (Acrididae)	*Calliptamus* sp.	4	29	7	8.24
	Coleoptera (Geotrupidae)	ND	21	82	4	4.71
	Coleoptera (Tenebrionidae)	ND	9	26	3	3.53
		Pimelia bipunctata	9	12	8	9.41
	Coleoptera (Melolonthidae)	ND	12	21	2	2.35
	Hemiptera (Heteroptera)	ND	4	8	2	2.35
Crustacea	Isopoda (Oniscidae)	ND	4	6	6	7.06
Mammalia	Rodentia (Muridae)	*Apodemus sylvaticus*	8	8	8	9.41
	Rodentia (Muridae)	*Mus musculus*	4	4	4	4.71
	Rodentia (Cricetidae)	*Myodes glareolus*	1	1	1	1.18
Aves	Passeriformes (Muscicapidae)	*Muscicapa striata*	1	1	1	1.18
	Passeriformes (Muscicapidae)	*Ficedula hypoleuca*	1	1	1	1.18
Reptilia	Squamata (Phyllodactylidae)	*Tarentola mauritanica*	2	2	2	2.35
Total			56	327	85	100.00

Mediterranean countries to Central Europe, following the distribution gradient of this insect order (Ingrisch & Köhler 1998). Accordingly, within the same place, number of species and abundance of Orthoptera peak at the beginning of summer, while declining in late summer (Detzel 1998; Latkovà et al. 2012; Panzeri et al. 2014), when the availability of this prey category decreases (Wolda 1988). Lower temperatures occurring after August may play a role in the modification of scops owls diet (N = 8 pellets; Panzeri et al. 2014). Thus, the current study provides new evidence on the diet of scops owl after the nesting season. Only one grasshopper species belonging to the genus *Calliptamus* was detected in this study; this genus includes species active until late summer/beginning of autumn (e.g. *C. italicus* Linnaeus, 1758: Sergeev & Van'kova 2008). Coleoptera represented the bulk of the diet of this species in Pianosa (62.35%), with special regard to Cerambycoidea Vesperidae, which are mainly abundant (as adults) during the late summer and autumn (Nappini & Bracalini 2008; Sechi 2011). Particularly, *Vesperus* cf. *luridus* (Rossi, 1794) seems to be an abundant species in coastal Tuscany (Nappini & Bracalini 2008), which is characterised by a similar habitat composition with respect to Pianosa. Also, vertebrates played an important role, although their detectability in pellets is higher with respect to invertebrate taxa (Errington 1930; Andrews 1990): Moorish geckos, migratory Passeriformes (i.e. flycatchers, Muscicapidae) and rodents were present in the diet. Particular attention should be paid to small mammals detected within the pellets. The house mouse *Mus musculus* is known to occur on Pianosa (Amori et al. 2015), whereas the bank vole *Myodes glareolus* Schreber, 1780 has never been recorded on any Italian island (Amori 2008; Angelici et al. 2009; Amori et al. 2015; D. Capizzi, pers. comm. 2015; Figure 2).

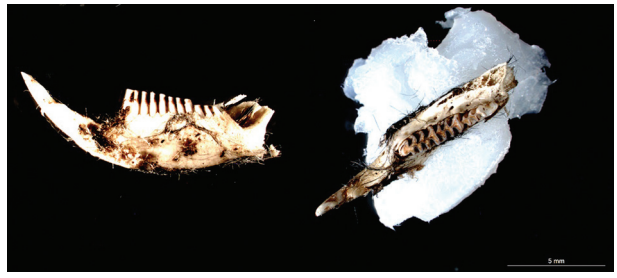

Figure 2. Mandible of the bank vole detected within a scops owl pellet in Pianosa.

As well, the presence of wild mice *Apodemus sylvaticus* in Pianosa is still to be confirmed. Mandibles of *Mus musculus* and *Apodemus* sp. can be distinguished according to the number of tubercle rows in the first molar tooth (Lapini et al. 1996). The meal-to-pellet interval (MPI) becomes longer as meal size increases (Duke et al. 1976; Duke & Rhoades 1977). Accordingly, while all the insects may have been eaten on the island, we cannot exclude that small mammals, rich in indigestible parts and in proteins, may have been preyed upon elsewhere. Thus, the bank vole and wild mice detected in Pianosa may have been eaten in the surrounding areas by the scops owl a few hours before (10–13 hours on average for owls: Duke et al. 1976) and then the pellet egested in Pianosa. Our results provide important insights into the diet of this species outside the breeding period, as well as a potential new support to the hypothesis of ineffectiveness of distribution studies assessed through raptor pellet dissection.

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