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Preliminary data on Golden eagle *Aquila chrysaetos* diet in southern Sardinia

Gianni Sirigu[1], Lorenzo Serra[2], Massimiliano Di Vittorio[2,3]

[1] *Via Mozart 2, 09045 Quartu Sant'Elena (CA), Italy; gianni.sirigu@tiscali.it*
[2] *Area Avifauna Migratrice, ISPRA - Via Ca' Fornacetta 9, 40064 Ozzano Emilia (BO), Italy; lorenzo.serra@isprambiente.it*
[3] *Ecologia Applicata Italia srl - Via Jevolella 2, 90018 Termini Imerese (PA), Italy; divittoriomassimiliano@gmail.com*

Golden eagle *Aquila chrysaetos* is an opportunistic raptor whose diet includes a wide range of species (Watson 1997, Fasce & Fasce 1992, Hogstrom *et al.* 1992, Kochert *et al.* 2002, Whitfield *et al.* 2009). Diet is usually dominated by both mammals and birds, but the former accounts in a dominant way (Pedrini & Sergio 2001, Kochert *et al.* 2002). This species is also able to adapt its diet in response to anthropogenic changes to its habitat (Watson *et al*. 1993).

The Italian population of Golden eagle presently consists of at least 622 breeding pairs (Fasce & Fasce 2017), with a positive trend in the peninsular territories (Brichetti & Fracasso 2003, Fasce & Fasce 2017). In Sardinia the population has also enhanced considerably (Fasce & Fasce 2017), increasing from an estimated population of 25-38 pairs (Schenk 1976) to 40-50 pairs (Schenk 1995, Asuni *et al.* 2003, Fasce & Fasce 2003). Currently 57-70 breeding pairs are estimated (Ruiu 2017).

This short note provides the first preliminary data on the Golden eagle diet in Sardinia, for which quantitative information was not available so far.

The field study was carried out between 2014 and 2017 in southern Sardinia (Fig. 1).

The prey remains, representing the diet of the breeding period (from the beginning of March to mid of July) were collected from nest sites and/or below perches located in six breeding territories after the reproductive period (after eaglets fledging) in order to minimize disturbance (Watson 1997). Prey remains (bones, portions of leather and coat, feathers, fur) were identified to the species level whenever possible, paying attention that the collected parts of each individual did not result in the same individual being counted twice.

We used prey remains instead of pellets because the former allows a better taxonomic discrimination (Greene & Jaksic´ 1983). Prey diversity and dietary breadth were also calculated. Prey diversity was calculated with the Shannon-Weiner H index (Shannon & Weaver 1949, see below): $H = -\sum[n / N \log(n / N)]$, where n is the number of individuals of each species and N is the total number of individual prey items. Diet breadth was indexed using the Levins B index (1968): $B = 1/ \sum p^2i$, where pi = the proportion of the diet contributed by prey item i.

Between 2014-2017, we collected prey remains representing 149 individuals belonging to 20 prey species from 6 Golden eagle breeding territories. Among these 149 individuals, 102 (68.46%) were mammals, 42 (28.19%) were birds, and 5 (3.36%) were reptiles (Table 1, Figs. 2 and 3). To test for statistical differences in prey composition among the 6 territories visited between 2014 and 2017, we applied a Montecarlo χ^2 test (1,000 iterations), after Bonferroni correction, setting the novel alpha significance at $p = 0.0083$.

The results showed that there were no differences in prey composition among sampled territories (mean $p > 0.0083$). Except *Felis* sp, all the other prey were identified at specific level. However, considering the distance of nest sites from urban centres or rural dwellings, the probability of being feral cats could be rather low, as their density decreases rapidly when moving far from human settlements (Li *et al.* 2014). On the other side, the wild cat *Felis lybica sarda* is a common and widespread species on the island, so we could hypothesize that most *Felis* specimens refer to wild cats. In at least one case (see Fig. 2), the identification of the prey as a wild cat seems confirmed by morphological characters.

The most represented prey species is the wild rabbit *Oryctolagus cuniculus* (22.15%), while domestic species (goats and domestic free-ranging pigs) accounted only for the 3.36% of the diet.

The B index of diet breadth and the H diversity index were 10.00 and 2.59 respectively.

The Golden eagle in southern Sardinia shows a marked preference for mammals, in accordance with what reported by other authors (Cramp & Simmons 1980, Iborra *et al.* 1990, Gil Sanchez *et al.* 1994, Watson 1997, Pedrini & Sergio 2001, 2002).

Our preliminary results were consistent with Watson's (2010) generalization that Golden eagles prefer medium-sized prey (0.5–4.0 kg), especially mammals, but also birds and, occasionally, reptiles (Kochert *et al.* 2002). Moreover this raptor can expand its diet when "usually preferred" prey species decrease or are scarce (Watson 2010), and therefore when preferred prey abundance declines, diet diversity should increase (Steenhof & Kochert 1988, Bedrosian *et al.* 2017).

Lagomorpha, prey of high energy yield and ideal weight (Fernandez 1991, Gil Sanchez *et al.* 1994, Bautista *et al.* 2016) accounted to 27% of the diet, according with other studies (Watson 1997, Whitfield *et al.* 2009). Moreover, some studies showed that the density of this prey is strongly related to breeding parameters of Golden eagle, as productivity, fledging rate and brood size at fledging (e.g. Steenhof & McDonald 1997).

Golden eagles are both generalist (Whitfield *et al.* 2009) and opportunistic predators. The diet of this raptor, in fact, includes a wide range of prey species, but it is usually based on the most abundant species present (Bedrosian *et al.* 2017).

Our results on dietary breadth and prey diversity during the breeding period showed larger values than those observed in other studies (see e.g. Pedrini & Sergio 2002, Whitfield *et al.* 2009, Bedrosian *et al*. 2017). This could be linked to the reduction of the distribution (Ruiu 2017) and the low densities of Lagomorpha in the island, especially of the Hare *Lepus capensis* (Murgia *et al.* 2003, Meriggi *et al.* 2005, 2010, Rondinini *et al.* 2013, Ruiu 2017).

In several studies dietary breadth showed in fact a significant negative association with the proportion of Lagomorpha and, on the contrary, a positive association with other mammals species and birds (Watson 1997, Pedrini & Sergio 2002, Whitfield *et al.* 2009, Bedrosian *et al.* 2017). Our results, albeit preliminary and limited to a low sample size, show that the Golden eagle diet in the southern part of Sardinia is characterized by a high number of prey species, showing a possible generalist behaviour.

Although these results can be considered a relatively good proxy for the diet of the species in southern Sardinia, which hosts around 28% of the Sardinian population (Ruiu 2017), they cannot be generalized to the entire population, since the different areas of the island are characterized by

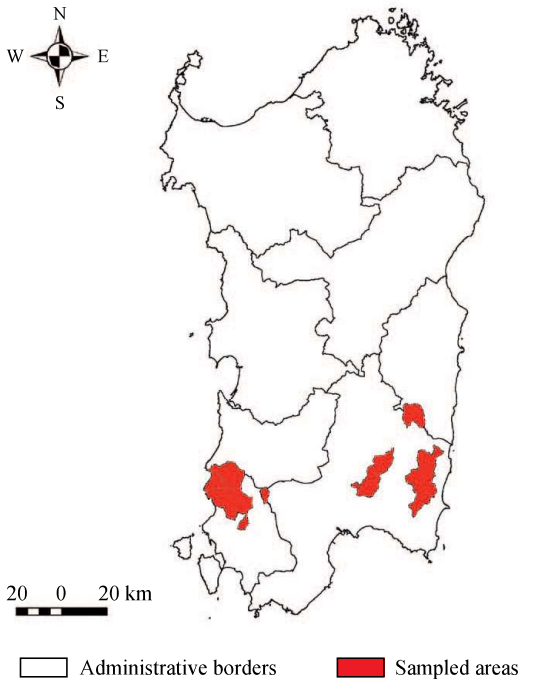

Figure 1. Distribution of sampled Golden eagle breeding territories.

Table 1. Prey species (n = sample size and %) found in Golden Eagle nests and perches in south Sardinia.

Species	**n**	**%**
Erinaceus europaeus	4	2.68
Goat	2	1.34
Felis sp.	11	7.38
Lepus capensis	7	4.70
Domestic pig	3	2.01
Martes martes	16	10.74
Oryctolagus cuniculus	33	22.15
Sus scrofa meridionalis	12	8.05
Vulpes vulpes	14	9.40
Mammals	**102**	**68.46**
Accipiter nisus	2	1.34
Alectoris barbara	9	6.04
Buteo buteo arrigonii	2	1.34
Columba livia	1	0.67
Columba palumbus	7	4.70
Corvus corax	12	8.05
Corvus cornix	4	2.68
Falco tinnunculus	3	2.01
Garrulus glandarius	1	0.67
Tyto alba	1	0.67
Birds	**42**	**28.19**
Emys orbicularis	5	3.36

Figure 2. Golden eagle with *Felis lybica sarda.*

Figure 3. Golden eagle with Wild boar *Sus scrofa.*

different habitats and environmental conditions. Hence, different densities and presence of possible prey species for the Golden eagle are expected. In this regard, it could be important to organize a coordinated study on the whole island to obtain a more complete information on the diet of this important insular population.

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