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SHORT COMMUNICATIONS

Sex-Specific Predation on Two Lizard Species by Kestrels[1]

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Abstract—Sex-biased predation is thought to have important implications for sexual selection, sex allocation, and population dynamics (Magnhagen, 1991; Le-Galliard et al., 2005 for an example in lizards). Most studies found that males are subjected to higher predation pressure than females during the reproductive season (Korpimäki, 1985; Lodé et al., 2004; Christe et al., 2006; Costantini et al., 2007). In that period, males are very mobile, emit acoustic signals and exhibit brilliant colourations, which are needed to attract females but may make them more visible to predators.

With regard to lizards, a recent study provided the first evidence that males of a lizard species may be preyed on more than females (Costantini et al., 2007).

In the present study, we investigated whether there is sex-biased predation on two small lacertid species, the common wall lizard *Podarcis muralis* (Laurenti, 1768) and the Italian wall lizard *Podarcis sicula* (Rafinesque-Schmaltz, 1810), by Eurasian kestrels (*Falco tinnunculus*) during the reproductive season. We also examined whether (1) the rate of predation differed between species and (2) the rate of predation differed across years or among hunting habitats for each species.

Key words: birds of prey, Eurasian kestrel, Podarcis muralis, Podarcis sicula, sex-biased predation.

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MATERIALS AND METHODS

The study was carried out in the area around Rome in central Italy over five breeding seasons (May–June, from 2003 to 2007; Table 1). Freshly killed remains of *Podarcis muralis* and *Podarcis sicula* were collected from, respectively, 20 and 44 nest-boxes of kestrels (*F. tinnunculus*) and sexed by visual detection of hemepenes. All lizard remains were left in the nest after sexing but we are certain that these lizards were not considered a second time during the next visit to the same nest. On average, 3.5 ± 0.3 (mean ± s.e.m.) visits were made to each nest. Nest-boxes were located in three habitat types: cereal and cultivated fields ($n = 26$), set asides and pasturelands ($n = 20$), fields with bushes and woody patches ($n = 8$) (Costantini et al., 2005, 2007).

General Linear Models (GLM) with type III sums of squares (STATISTICA Version 7.0, StatSoft, Inc. 2004, Tulsa, OK, USA) were performed for *P. muralis* and *P. sicula*, respectively, with the factors sex, habitat, year and their two-way interactions. Since some nest-boxes appeared in our data-set in more than one year, the nest-box was included as a random factor to avoid pseudoreplication.

Interactions were removed from the models when non-significant and the analyses were repeated. Post-hoc comparisons were performed with the Tukey test when interactions were significant. Binomial tests were computed on the Internet with the Sisa Interactive Statistical Analysis (SISA), http://www.quantitativeskills.com/sisa/distributions/binomial.htm.

RESULTS

In total, we sexed 48 specimens of *Podarcis muralis* (26 males and 22 females; Binomial test, $P = 0.56$)

Table 1. Raw data about the number of males and females for every species collected over the study period

Year	*P. muralis*		*P. sicula*	
	males	females	males	females
2003	2	4	6	5
2004	1	4	7	8
2005	7	5	19	8
2006	11	5	29	21
2007	5	4	9	11

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Table 2. Full outcomes of General Linear Models (nest-box as random factor; sex, year and hunting habitat as fixed factors) performed for *Podarcis muralis* and *Podarcis sicula*. Significant results are shown in bold type

Podarcis muralis	*F*	d.f.	*P*
Habitat	0	0	0
Year	1.29	3.22	0.30
Sex	0.01	1.22	0.94
Habitat × Year	0.03	2.22	0.97
Habitat × Sex	0.17	2.22	0.85
Yea × Sex	0.60	4.22	0.67
Podarcis sicula	*F*	d.f.	*P*
Habitat	0	0	0
Year	0.89	4.62	0.47
Sex	2.38	1.62	0.13
Habitat × Year	0.25	3.62	0.86
Habitat × Sex	3.16	2.62	**0.05**
Yea × Sex	0.15	4.62	0.96

collected from 20 nest-boxes (mean ± s.e.m.: 2.4 ± 0.6 specimens per nest-box; range: 1–13) and 123 specimens of *Podarcis sicula* (70 males and 53 females; Binomial test, $P = 0.13$) collected from 44 nest-boxes (mean ± s.e.m.: 2.8 ± 0.4 specimens per nest-box; range: 1–12). *Podarcis sicula* was more common as prey than *P. muralis* (Binomial test, $P < 0.001$).

Preliminary GLMs performed for each species revealed that the sampling effort did not affect the results, as shown by (1) the non-significant covariation (*P. sicula*: $F_{1.55} = 0.15$, $P = 0.70$: *P. muralis*: $F_{1.19} = 1.70$, $P = 0.21$) and (2) the non-significant interaction between the number of visits to each nest and the habitat, year and sex, respectively (all P-values ≥ 0.09; no output for the habitat × visits interaction in *P. muralis*). Therefore, the covariate was dropped from the full models and the analyses were repeated.

GLMs for *P. muralis* (Table 2) showed that (1) there was no sex-biased predation ($P = 0.94$), (2) the predation on both sexes did not differ among habitats (habitat × sex: $P = 0.85$) or across years (year × sex: $P = 0.67$). Similar results were obtained after dropping the non-significant interaction terms from the full model (results not shown). GLMs for *P. sicula* (Table 2) showed that (1) there was no sex-biased predation ($P = 0.13$), (2) the predation on the sexes differed among habitats (habitat × sex: $P = 0.05$) but not across years (year × sex: $P = 0.96$). Similar results were obtained after dropping the non-significant interaction terms from the full model (habitat × sex: $F_{2.69} = 4.32$, $P = 0.017$). Post-hoc comparisons showed that females were preyed on more in fields with bushes and woody patches than in the other two habitat types (both P-values $= 0.04$).

Since the GLMs did not give any output for habitat, it was tested separately with a one-way Analysis of Variance for each species. ANOVA showed that the rate of predation did not differ among habitats for either *Podarcis* species (*P. muralis*, $F_{2.51} = 0.38$, $P = 0.69$; *P. sicula*, $F_{2.117} = 1.62$, $P = 0.20$).

The predation rate did not differ between the sexes in both *Podarcis* species. The lack of sex-biased predation in *P. muralis* was observed each year over five breeding seasons and in all habitats. Similar results were obtained for *P. sicula*, although females of this species were preyed on more in fields with bushes and woody patches than in the other two habitat types.

Sex ratios of lacertid natural populations are usually around 1 : 1 or slightly skewed toward one sex; deviations from a 1 : 1 ratio may depend on several factors, such as the habitat, the methods of investigation, or the weather conditions (Turner, 1977). Assuming a 1 : 1 sex ratio, males and females of both *Podarcis* species were subjected to similar predation pressure by kestrels.

While some studies suggest that the predation risk of lizards differs between habitats (Bulova, 1994; Martín and López, 1995; Vanhooydonck and Van Damme, 2003), we did not find any differences in the number of prey between habitats for either lizard species. However, *Podarcis sicula* females were preyed on more in fields with bushes and woody patches than in the other two habitat types, although it is not clear why this occurred. It could have been due to specific local conditions rather than to a more general pattern, since *P. sicula* remains were found in only two nests located in more densely vegetated areas.

In both *P. muralis* and *P. sicula*, males are slightly larger than females; however, this did not seem to play a role given the absence of sex-biased predation.

Another result of our study was that *P. muralis* was less common as prey than *P. sicula*. Although the rate of predation did not differ between habitats for either lizard species, the higher occurrence of *P. sicula* could be explained by the fact that most nest-boxes were in habitats more suitable for this species than for *P. muralis*. Indeed, differences in habitat use could have made *P. muralis* less susceptible to predation than *P. sicula*. For example, when their ranges overlap, *P. muralis* is more abundant in humid places with thick vegetation while *P. sicula* prefers arid/open fields (Capula et al., 1993).

Differences in abundance between the two *Podarcis* species, regardless of habitat type, could be another explanation for the lower predation on *P. muralis*. However, we do not have any data to test this hypothesis. One study carried out in the centre of Rome showed that the population density of *P. muralis* was higher than that of *P. sicula* in humid and vegetated areas, while *P. sicula* was more abundant in sunny dry places (Capula et al., 1993). The study also showed that population densities of both lizard species were constant across seven years.

Differences in activity cycles between the two lizard species seem to be of minor importance. In fact, *P. muralis* and *P. sicula* have similar daily and annual activity cycles, with mating occurring from the end of March to mid-July in both species (Capula et al., 1993).

In conclusion, our study showed that (1) the rate of predation by kestrels did not differ between males and females in two lizard species, *Podarcis muralis* and *Podarcis sicula*, (2) differences in microhabitat use could explain the higher level of predation on *P. sicula*. Future studies should quantify the variation of sex ratio and population size of lizards across different habitats and populations in order to have a more clear picture on the lizard-kestrel system.

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