Article

First evidences of sexual divergences in flight behaviour and space use of lesser kestrel *Falco naumanni*

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Abstract

We present here the first description of recorded sexual differences in flight behaviour and space use of lesser kestrel *Falco naumanni*. Lesser kestrel is a migratory, colonial, small falcon breeding mainly in holes and crevices in large historic buildings within towns and villages, or in abandoned farm houses across the countryside. Using accurate GPS data-loggers, we gathered data on the activities of lesser kestrels in the two of main colonies of lesser kestrels in Italy, i.e. Gravina in Puglia and Altamura (Apulia, Southern Italy) and the surrounding rural areas in a 20-days monitoring during the reproductive period. We tested for sex differences in space use (home range's circularity ratio) and flight attributes (5-minute flight length, instantaneous speed, distance from nest, flight altitude above ground level) of 9 monitored individuals (4 males and 5 females). We found significant sexual differences for all the observed traits. Our results demonstrate that female lesser kestrels during the monitoring period employed a lower amount of energy in local movements as measured by four flight attributes that resulted significantly different (and lower) than for males. Compact home ranges for females could represent a maximization of the benefit-cost ratio between prospected surface and distance from nest, i.e. the optimal trade-off between foraging requirements (explored surface) and costs in terms of time and energy (distance from nest). On the contrary, males showed a significantly different space use with very elongated home ranges and mean distance from nest almost three times as elevated as females' one. We argue that the detected sexual divergence was the product of their respective ways to optimize the relationship between resource acquisition and reproductive activity.

Keywords data-loggers; flight attributes; local-scale movements; reproductive period.

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1 Introduction

Lesser kestrel *Falco naumanni* is a migratory, colonial, small falcon breeding mainly in holes and crevices in large historic buildings within towns and villages, or in abandoned farm houses in the countryside (Negro, 1997). Today the species is considered “least concern” in western Europe (BirdLife International, 2013).

In birds, the sexes usually differ in size if not also in proportions of body parts, being this usually considered as a consequence of variation among species in social mating system and the pattern of parental care (Andersson, 1994). However, there is only an occasional reference in the literature to sexual differences in relation to flight behaviour and space use (Selander, 1966; Weimerskirch et al., 2000), and to date none has been stated about *Falco naumanni*.

For this reason, the aim of our work has been to acquire knowledge about sexual differences in flight behaviour and space use of lesser kestrels during the reproductive period. In order to do this, we: 1) gathered data on the activities of male and female lesser kestrels; 2) compared the activity of male and female lesser kestrels with regard to space use and flight attributes. We investigated birds from the two main colonies of lesser kestrels in Italy, i.e. Gravina in Puglia and Altamura (Apulia, Southern Italy) and the surrounding rural areas (Bux et al., 2008).

2 Methods

The study area corresponds to the National Park Alta Murgia and the SPA (Special Protection Area) “Murgia Alta” IT9120007 (Apulia, Southern Italy) and is included within the IBA (Important Bird Area) “Murge” (Heath and Evans, 2000). It comprehends one of the main colonies of lesser kestrels in Italy (Bux et al., 2008), i.e. Gravina in Puglia, Altamura and the surrounding rural areas.

Surveys were conducted using TechnoSmart GiPSy-4 data-loggers (23×15×6 mm, 1.8 g plus 3.2 g battery), that provided information about date, time, latitude, longitude, altitude (meters a.s.l.) and instantaneous speed (km/h).

Nine individuals (4 males and 5 females) were surveyed for 20 consecutive days from June 21th to July 9th 2012, i.e. the period when youngs were in nests. Eight out of 9 individuals were from Gravina in Puglia, the other one from Altamura. Data acquisition occurred every 5 minutes during two time periods: day (08:00-19:00 H) and night (02:00-06:00 H).

GPS data were imported into the GIS GRASS (Neteler and Mitasova, 2008) and added to further layers: a) boundaries of the Alta Murgia National Park, b) digital terrain model of the study area, c) nest and roost locations. The digital terrain model at 1:10,000 scale of the study area was digitized by the authors from available topographic maps of Apulia Region (Fig. 1).

For each GPS point, flight height above ground level was achieved by subtracting terrain elevation from altitude a.s.l. provided by data-loggers. Five-minute flight length was calculated as length of flight between 2 successive GPS acquisitions. For each GPS point of each individual we also calculated the distance in meters from its nest.

We estimated home-range (HR) for each individual using the minimum convex polygon method (Graham, 1972). Besides the 100% contour, we also considered the 99% isopleth using probability polygons with the “proximity to mean of all fixes” criterion (Kenward, 1987).

Last, we used the circularity ratio index (CR; Jennrich and Turner, 1969) as indicator of lesser kestrels’ space use. For each one of the above mentioned HRs, we calculated CR as follows:

$$CR = \frac{S_{HR}}{S_{cc}} \qquad (1)$$

where S_{HR} is the HR size (in hectares), while S_{cc} is the size (in hectares) of the smallest circumscribing circle. CR is a unitless measure approximating 1 for compact HRs (similar to circles), and 0 for very elongated ones. For the purpose of our work, CR was more suitable than HR size. In fact higher values of CR suggest that individuals prospected larger surfaces whilst limiting their distance from nest, being the opposite for lower values.

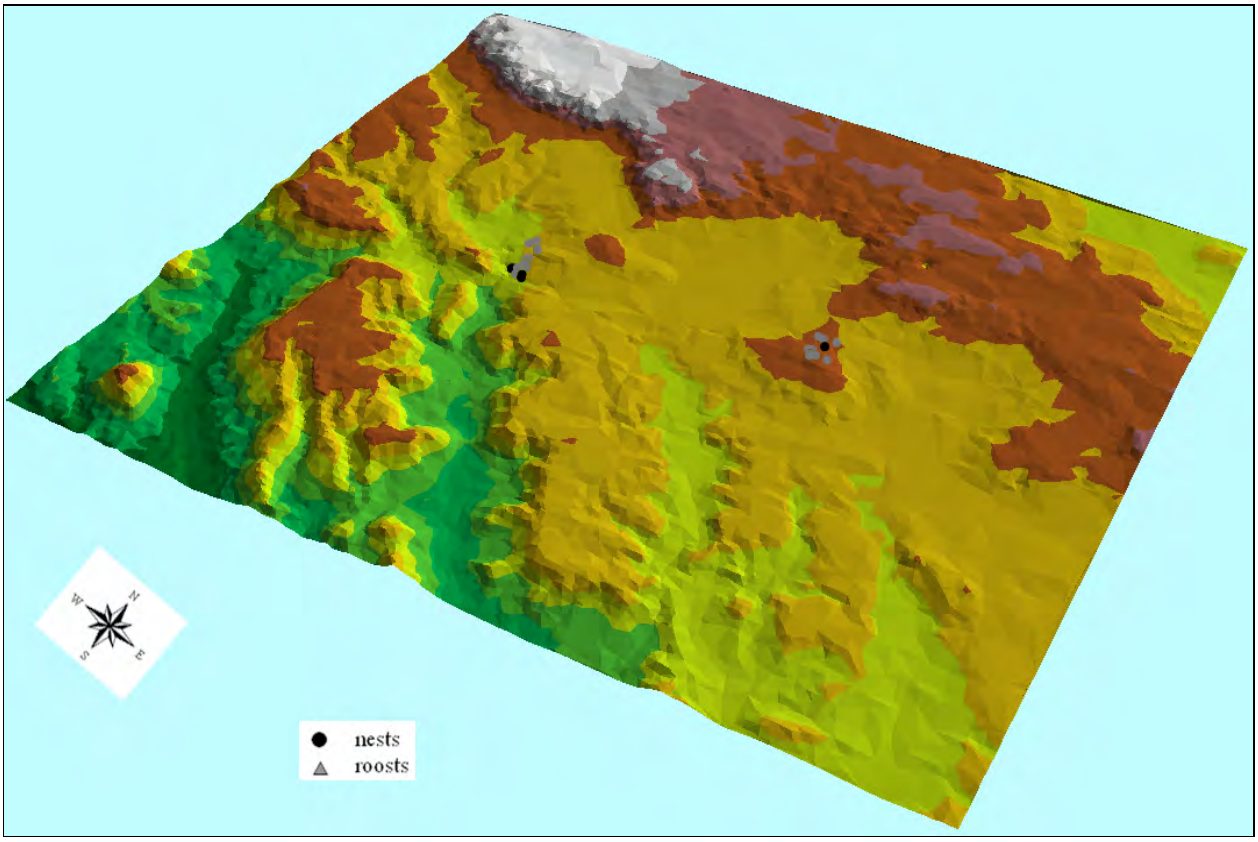

Fig. 1 The digital terrain model at 1:10,000 scale of the study area digitized by the authors from available topographic maps of Apulia Region. Black and grey points show the presence of nests and roosts in the two colonies of Gravina in Puglia (on the left) and Altamura (on the right).

Based on descriptive statistics of flight attributes (5-minute flight length, instantaneous speed, distance from nest, flight altitude above ground level) and space use (CR), we compared males and females using inferential tests. After testing for normality (Shapiro-Wilk test) and homoscedasticity (Levene's test), we applied the correct inferential test (T-test or Mann-Whitney test). All the statistical analyses were performed using SPSS (SPSS Inc., 2007) software and considered significant for $p<0.05$.

3 Results

The monitoring period amounted to 311 hours, of which 116 hours (1389 GPS points) for females and 195 (2337 GPS points) for males. Lesser kestrels flew 3674.2 km in total, of which 966.5 due to females and 2707.7 to males (Fig. 2).

Descriptive statistics (Tab. 1) suggested differences in flight attributes, hence we tested if:

a) 5-minute flight length for males was significantly higher than for females;

b) instantaneous speed for males was significantly higher than for females;

c) distance from nest for males was significantly higher than for females;
d) flight altitude above ground level for males was significantly higher than for females.

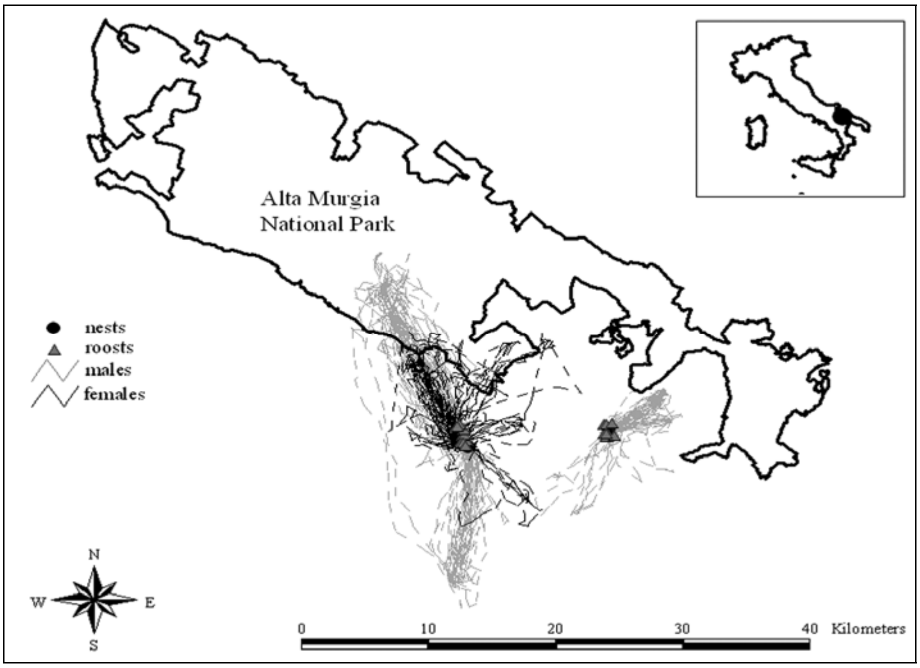

Fig. 2 Study area (Gravina in Puglia on the left, Altamura on the right and Alta Murgia National Park; Italy) with male and female flight trajectories followed by 9 individuals of lesser kestrels surveyed from June 21th to July 10th 2012.

We achieved the following results (Table 2): a) positive (p<0.001), b) positive (p<0.001), c) positive (p<0.001), d) positive (p<0.001). CRs of detected HRs (Fig. 3) resulted significantly higher for females (p<0.05) for all the considered isopleths (Table 3).

Table 1 Descriptive statistics of flight attributes of female (N_1: 1389 GPS points) and male (N_2: 2337 GPS points) lesser kestrels.

Flight attributes		Females	Males
5-minute flight length (km)	maximum	5.91	6.95
	mean	0.7	1.16
	median	0.19	0.84
	minimum	0	0
instantaneus speed (km/h)	maximum	88	96
	mean	7.91	10.62
	median	7.00	9.00
	minimum	0	0
distance from nest (km)	maximum	11.695	18.702
	mean	2.752	6.209
	median	1.014	4.820
	minimum	0	0
flight altitude a.g.l. (m)	maximum	4485	5614
	mean	135.55	170.29
	median	49.00	54.00
	minimum	0	0

a.g.l. stands for "above ground level"

Table 2 Inferential statistics for male and female flight attributes of surveyed lesser kestrels.

Flight attributes	Normality?	Equal variance?	H_0 and H_1 hypotheses	Test type	P (one tailed)	H_0 rejection?
5-minute flight lenght	no	no	H_0: $\eta_M=\eta_F$ H_1: $\eta_M>\eta_F$	Mann-Whitney	<0.001	yes
instantaneus speed	yes	yes	H_0: $\mu_M=\mu_F$ H_1: $\mu_M>\mu_F$	T-test	<0.001	yes
distance from nest	no	no	H_0: $\eta_M=\eta_F$ H_1: $\eta_M>\eta_F$	Mann-Whitney	<0.001	yes
flight altitude above ground level	no	no	H_0: $\eta_M=\eta_F$ H_1: $\eta_M>\eta_F$	Mann-Whitney	<0.001	yes

η_M stands for median of male values
η_F stands for median of female values
μ_M stands for mean of male values
μ_F stands for mean of female values

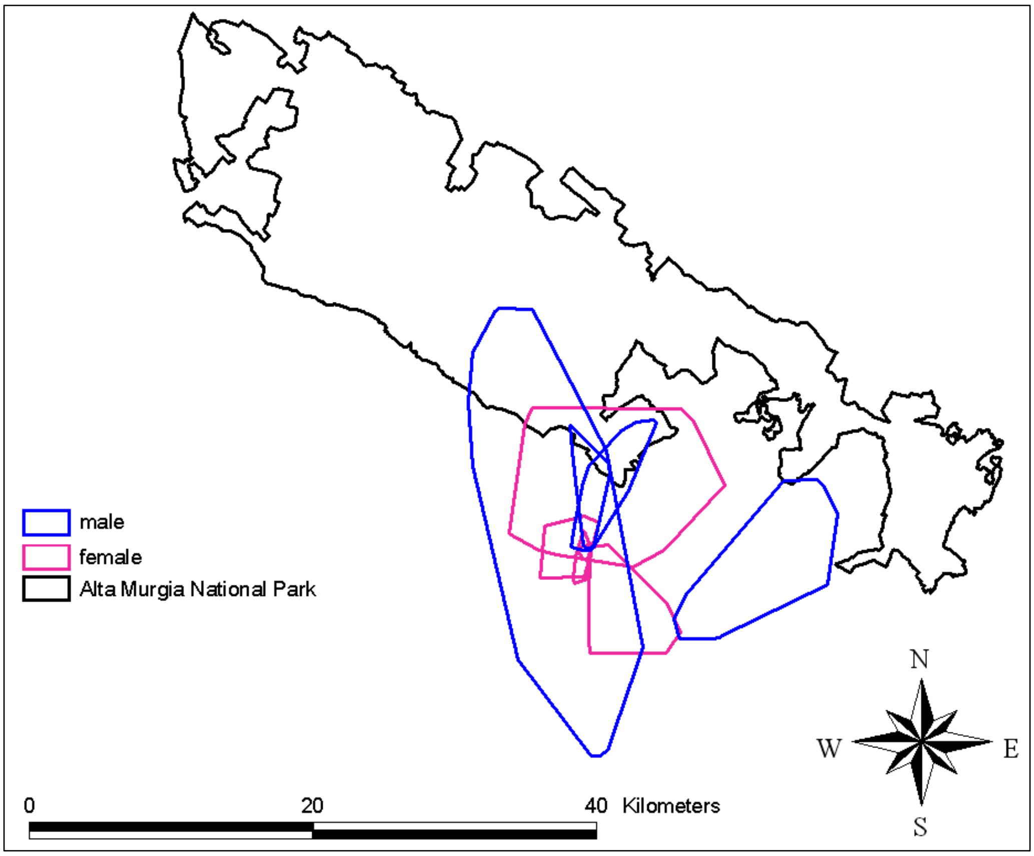

Fig. 3 Home-ranges (100% isopleths) of 4 male and 5 female lesser kestrels surveyed from June 21th to July 10th 2012.

Table 3 Inferential statistics for circularity ratios of female and male lesser kestrels' home-ranges (100% and 99% isopleths).

Home-ranges (100% isopleths)	Females	Males
	0.565	0.289
	0.302	0.271
	0.529	0.418
	0.554	0.220
	0.699	
N	5	4
Mean	0.5298	0.2995
95% conf. for means	0.3516 - 0.7079	0.1654 - 0.4335
Variance	0.0206	0.0071
Inferential tests		
Levene's test	0.28	p(same variance): 0.614
one tailed T-test	2.82	p(same mean): 0.012

Home-ranges (99% isopleths)	Females	Males
	0.569	0.321
	0.299	0.274
	0.549	0.374
	0.524	0.220
	0.700	
N	5	4
Mean	0.5282	0.2972
95% conf. for means	0.3481 - 0.7083	0.1926 - 0.4018
Variance	0.0210	0.0043
Inferential tests		
Levene's test	0.48	p(same variance): 0.512
one tailed T-test	2.92	p(same mean): 0.011

4 Discussion and Conclusions

Our work is the first description of recorded sexual divergences of lesser kestrels with regard to local-scale movements and space use.

We might expect that any sex divergence in lesser kestrel's behaviour was the product of their respective ways to optimize the relationship between resource acquisition and reproductive activity. In most animal species, while egg production is energetically expensive, the gametic contribution of the male usually requires less energy (e.g., Emlen and Oring, 1977), hence strong sexual divergences in reproductive role were expected to translate into strong divergences in movements patterns and space use between males and females, at least during the reproductive season (during 2012, surveyed nests of 77 lesser kestrels in the study area had a clutch of 3.79 ± 0.82 eggs; Gustin et al., 2012).

Our results demonstrate that female lesser kestrels during the monitoring period employed a lower amount of energy in local movements as measured by four flight attributes that resulted significantly different (and lower) than for males. Furthermore, female lesser kestrels exhibited significantly higher CRs. We argue it was as a consequence of two necessities: a) spending as much time as possible in parental care, b) limiting energy requirements for resource acquisition. Owing to budgetary requirements of time and energy for reproduction and parental care, an upper limit to female flight activities was expected.

Compact HRs for females represented a maximization of the benefit-cost ratio between prospected surface and distance from nest, i.e. the optimal trade-off between foraging requirements (explored surface) and costs in terms of time and energy (distance from nest). On the contrary, males showed a significantly different space use with very elongated HRs and mean distance from nest almost three times as elevated as females' one. Possible reasons for these long-distance flights include their roles as an exploratory surveillance of the HR, the search for food-rich patches and exploring neighbouring territories (Perez-Garcia et al., 2012).

In order to detect if sexual differences in flight behaviour and space use of lesser kestrels is a prerogative of the reproductive period, we are planning to extend our surveys to the pre-reproductive period.

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