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EFFECTS OF TAIL-MOUNTED RADIO-TAGS ON ADULT LESSER KESTRELS

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Abstract.—The behavior, breeding success and survival of radio-tagged and non-radio-tagged (control) Lesser Kestrels (*Falco naumanni*) in southern Spain in 1989–1990 were compared. The copulation period, copulation rates and prey delivery rates to both mates and nestlings did not differ significantly between radio-tagged and control individuals. In addition, there were no differences in annual survival rates or breeding success between radio-tagged and control birds.

EFECTOS DE RADIO-EMISORES DE COLA EN CERNICALOS PRIMILLAS ADULTOS

Sinopsis.—Se compararon aspectos de comportamiento, éxito reproductor y supervivencia entre cernícalos primillas (*Falco naumanni*) portadores de radiotransmisores en la cola y otros marcados únicamente con anillas (controles) en el sur de España en 1989–1990. El periodo de cópulas, la frecuencia de las mismas, así como las tasas de cebas de pareja y a los pollos no se diferenció significativamente entre los individuos portadores de radiotransmisores y los controles. Tampoco se detectaron diferencias en las tasas de supervivencia anual y éxito reproductivo entre los dos grupos comparados.

Radio-telemetry is commonly used to monitor movements, habitat use and mortality of animals. The effects of radio-tags need to be examined, however, to determine if the data derived from their use are unbiased, and to ensure the well-being of the organisms under investigation. In some birds radio-tags appear to cause abnormal behavior, decreased productivity or reduced survival rates (e.g., Hines and Zwickel 1985, Johnson and Berner 1980, Marks and Marks 1987, Perry 1981, Sibly and McCleery 1980, Warner and Etter 1983). Few studies have evaluated the effects of radio-tags on birds of prey. Some have reported negative effects (Foster et al. 1992, Paton et al. 1991), whereas others reported no effects (Bray and Corner 1972, Kenward 1978, McCrary 1981, Sodhi et al. 1991). Beske (1978), Foster et al. (1992) and Paton et al. (1991) suggested that the negative effects could be related to how the transmitters were fixed to the animals (e.g., backpack-mounted vs. tail-mounted).

The Lesser Kestrel (*Falco naumanni*) is a small migratory falcon (120–200 g, Donázar et al. 1992) whose populations have decreased dramatically in the Western Palearctic since the 1960s (Cramp and Simmons 1980, González and Merino 1990). It is presently endangered in Europe (Biber 1990), and despite its relative former abundance, many aspects of its biology are still unknown. Only since the late 1980s have studies, including the use of radio-telemetry, been undertaken in Spain (Donázar et al. 1992; Negro et al. 1992, 1993a, b).

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Our objectives were to test the null hypotheses that birds wearing tail-mounted radio-tags did not differ from those marked only with PVC bands in: (1) behavior, (2) breeding success and (3) survival.

METHODS

Between February and July in 1989 and 1990, 14 adult Lesser Kestrels were fitted with radio-tags (three males and three females in 1989, and five males and three females in 1990) at Mairena del Alcor (37°22′N, 5°45′W), Seville province, southern Spain. The kestrels nested in an old castle where we counted 42 pairs in 1989 and 40 pairs in 1990. One-third of the adults in 1989 and two-thirds in 1990 wore PVC bands to permit individual recognition from a distance. The purpose of this study was to monitor their movements during foraging bouts and to quantify home range sizes (Donázar et al. 1993). Additional data on social behavior were recorded. Detailed information on the study area and trapping techniques were provided in Negro (1991) and Negro et al. (1993a, b).

The number of control individuals varied depending on the parameter being estimated, as behavioral observations were only recorded in a small portion of the colony and more data were available for productivity and survival estimates (see Negro et al. 1992).

The radio-tags (Urmeneta S.A., Arguedas, Spain) were attached dorsally to one or two central tail feathers and weighed on average 4.25 g (3.5% and 3.0% of the male and female minimum body mass, respectively, see Donázar et al. 1992). One transmitter failed a few hours after the bird was released. The rest lasted 2–12 wk.

Behavior at the colony.—Observations were made 2–3 d per week and lasted from dawn to dusk. The entire breeding season was monitored, from the arrival of the first migrants in February to the end of the fledgling period in July. We spent 475 h in 1989 and 567 h in 1990 observing kestrels. Radio-tagged individuals and control birds nested in the same walls of the castle. Detailed information on the routine of recording behavior was provided in Donázar et al. (1992) and Negro et al. (1992).

We considered pairs in which at least one member of the pair was tagged as "marked" for mate-switching and copulation rate analyses. To estimate rates of mate-switching, as well as colony and nest-switching for banded individuals, we pooled the data from the study colony and two adjacent colonies, as there were no significant differences between colonies for those variables (Negro 1991). We pooled data from 1989 and 1990 for copulation analyses, as there were no significant differences between years (Donázar et al. 1992, Negro et al. 1992). The copulation period was estimated as the time between the first and last observed copulation for each pair. The total number of copulations per season was estimated by multiplying the mean number of copulations per day by the duration of the copulation period (the number of days of observation for each pair is given in Table 1).

We considered males and females separately for prey delivery analyses because males usually fed the young more than females (unpubl. data).

TABLE 1. Breeding success and survival rates of radio-tagged and control Lesser Kestrels in Spain, 1989–1990.

	Radio-tagged			Controls		
	n^1	$\bar{x}$	SD	n^1	$\bar{x}$	SD
Copulation period (d)	4	83.7 (32, 31, 29, 45)	9.5	6	79.3 (33, 30, 19, 31, 32, 32)	5.2
Copulations/season	4	235.2	32.7	6	361.5	47.4
Mate-feeds/h						
1989	1	0.48 (7)		4	0.42 (3, 11, 12, 7)	0.06
1990	2	0.44 (17, 16)	0.16	3	0.49 (12, 10, 12)	0.04
Chick-feeds/h						
Males 1989	2	1.69 (8, 5)		3	1.33 (8, 6, 5)	0.38
Females 1989	3	0.89 (8, 5, 6)	0.22	2	0.95 (5, 4)	0.13
Males 1990	1	0.83 (12)		3	1.02 (11, 13, 12)	0.46
Females 1990	2	0.62 (11, 13)		2	0.53 (11, 11)	
% mate-switching	5	100.0		61	70.5	
% nest-switching	7	100.0		40	75.0	
% colony-switching	10	10.0		130	7.7	
Clutch size	7	4.6	0.5	29	4.2	0.90
Fledged young	10	1.5	1.3	71	1.7	1.00
Survival						
1989	6	66.7%		122	78.7%	
1990	8	75.0%		141	66.7%	

[1] Number of pairs (copulation period, copulations/season, clutch size and fledged young) or number of individuals (all other variables). Number of days that each pair or individual was observed are indicated in parentheses.

We also considered each year separately for prey-delivery analyses because of variation among radio-tagged males (Kruskal-Wallis test, $H = 12.57$, 1 df, $P < 0.01$), radio-tagged females ($H = 7.90$, 1 df, $P < 0.01$) and control females ($H = 7.90$, 1 df, $P < 0.01$). To test for statistical differences within years and between groups, we used pairwise comparisons (Mann-Whitney U tests) for the daily prey delivery rates of one radio-marked individual and one control individual, both observed in the same year. Sample sizes are given in Table 1.

Clutch-size and breeding success.—Clutch size and number of fledged young were compared between radio-tagged and control pairs in the colony. We pooled data from different years, as clutch size did not differ among years in control ($H = 0.007$, 1 df, $P = 0.39$) or radio-tagged pairs ($H = 0.08$, 1 df, $P = 0.77$). Similarly, there was no yearly variation in the

number of young fledged per pair between either radio-tagged ($H = 1.17$, 1 df, $P = 0.27$) or control pairs ($H = 2.09$, 1 df, $P = 0.14$).

Annual survival rates.—As breeding dispersal in the Lesser Kestrel is low and of short range (Negro 1991), those banded individuals that were not observed the year after their last sighting were considered dead. We therefore estimated minimum annual survival rates empirically as the percentage of banded birds that returned from those present the previous year. The causes of mortality were unknown in most cases. One radio-tagged bird disappeared while wearing a transmitter, but was not relocated.

Return rates for subsequent breeding seasons were compared between radio-tagged and control individuals. We pooled the data for control birds from Mairena del Alcor and adjacent colonies within a radius of 30 km^2, because there were no significant differences for return rates of adults between colonies (Negro 1991). We considered each year separately, however, because return rates were statistically different for control birds ($\chi^2 = 4.13$, 1 df, $P = 0.04$), even though the differences were not significant for radio-tagged birds (Fisher's exact $P = 0.59$).

RESULTS

Of 14 radio-tagged individuals, 13 exhibited normal behavior within 1 h after release. One female left the colony for 24 h, however, during which its mate copulated with another female. When the radio-tagged female returned to the colony, it acted normally, expelled the intruder female and paired with its former mate (Negro et al. 1992).

There were no significant differences between radio-tagged and control pairs, either in the duration of the copulation period (Mann-Whitney U test, $Z = 0.75$, $P = 0.45$) or in the estimated total number of copulations per season ($Z = 1.17$, $P = 0.23$) (Table 1). Both radio-tagged and control individuals exhibited similar prey delivery rates (Table 1). There were no significant differences ($P > 0.05$) in prey delivery rates for any of the pairwise comparisons between one radio-tagged and one control individual.

Considering two consecutive breeding seasons, there were no significant differences between the frequency of mate-switching for radio-tagged and control birds (Fisher's exact $P = 0.19$), the frequency of nest-switching (Fisher's exact $P = 0.16$), or the frequency of colony switching (Fisher's exact $P = 0.57$). All these rates were slightly higher for radio-tagged individuals, however (Table 1).

Clutch size ($H = 0.54$, 1 df, $P = 0.46$) and number of fledged young ($H = 0.45$, 1 df, $P = 0.45$) were not significantly different between radio-tagged and control birds (Table 1). Survival rates were also similar for radio-tagged and control birds in both 1989 (Fisher's exact $P = 0.39$) and 1990 ($P = 0.47$) (Table 1).

DISCUSSION

In some avian studies, the use of radio packages attached with backpack harnesses decreased productivity and/or lowered the percentage of

breeding pairs (Foster et al. 1992, Paton et al. 1991, Sibly and McCleery 1980, Warner and Etter 1983). As far as we know, however, there are no reports indicating negative impacts of tail-mounted radio-tags on avian reproduction. Sodhi et al. (1991) found no significant differences in reproductive output or hatching success of Merlins (*Falco columbarius*) wearing tail-mounted tags and untagged individuals. In our study, the reproductive variables (clutch size and number of fledged young) of Lesser Kestrel pairs with at least one radio-tagged individual were unaffected. We also found no differences in the duration of the copulation period, the number of copulations, or prey delivery rates to mates and chicks. These behavioral components have rarely been quantified in previous studies investigating the effects of radio-tags. Although the relatively small sample size of radio-tagged birds in our study may have limited the usefulness of statistical comparisons, there was no indication of any serious problems associated with tail-mounted radio-tags.

Current literature suggests that backpack-mounted radio-tags can significantly affect survival rates (Johnson and Berner 1980, Paton et al. 1991, Perry 1981, Warner and Etter 1983; but see Foster et al. 1992, Hines and Zwickel 1985). On the other hand, our study and work by Sodhi et al. (1991) indicate that tail-mounted radio-tags are less likely to affect survival rates. We conclude, therefore, that tail-mounted radio-tags, representing 3.0–3.5% of the body mass of the birds, did not significantly affect the social behavior, breeding success or survival of breeding Lesser Kestrels. Thus, we recommend the use of tail-mounted transmitters whenever possible. Birds can lose them naturally when molting and are not at risk of becoming entangled or strangled, as with transmitters attached with harnesses. Tail-mounted radio-tags cannot be used on young birds, however, which leave the nest before the tail feathers are fully developed. Unless recapture of the birds under investigation is easy, tail-mounted radio-tags are also not particularly useful for studies involving long-term continuous collection of data, since they are lost when birds undergo their annual molt.

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