

NOCTURNAL ACTIVITY OF LESSER KESTRELS UNDER ARTIFICIAL LIGHTING CONDITIONS IN SEVILLE, SPAIN

JUAN JOSÉ NEGRO AND JAVIER BUSTAMANTE

Department of Applied Biology, Estación Biológica de Doñana, CSIC, Avda. María Luisa s/n, 41013 Sevilla, Spain

CIRO MELGUIZO AND JOSÉ LUIS RUIZ

Sociedad Protectora de Animales y Plantas de Sevilla, C/Santa Ana 10, Sevilla, Spain

JUAN MANUEL GRANDE

Department of Applied Biology, Estación Biológica de Doñana, CSIC, Avda. María Luisa s/n, 41013 Sevilla, Spain

KEY WORDS: *Lesser Kestrel*; *Falco naumanni*; *nocturnal activity*; *foraging behavior*; *prey deliveries*.

Lesser Kestrels (*Falco naumanni*) are migratory, colonial small falcons. Kestrels in western European populations breed mainly in holes and crevices in large historic buildings within towns and villages, or often in abandoned farm houses scattered across the countryside (Cramp and Simmons 1980, González and Merino 1990, Negro 1997). The species is considered Endangered in western Europe (Biber 1994).

In the city of Seville in southern Spain, three Lesser Kestrel colonies remain in the downtown area. To our knowledge, no other city in western Europe as large as Seville (population 750 000) currently has Lesser Kestrel colonies. In Seville, the main colony of about 70 pr is located in the Cathedral. This Gothic building is the largest cathedral in Spain and third largest in the Christian world. One smaller colony is located in El Salvador (25 pr), a Baroque church nicknamed Seville's second cathedral located about 500 m away from the Cathedral itself, and another is at Montesión (7–10 pr), a small chapel about 1.5 km from the Cathedral (C. Melguizo and J.L. Ruiz unpubl. data). The size of the city's population of Lesser Kestrels has not changed significantly in the last 10 yr (J.J. Negro, C. Melguizo, and J.L. Ruiz unpubl. data), although the kestrels were surely more abundant in the past, when numerous breeding colonies thrived in different city buildings (González and Merino 1990).

Reports from the early 1970s (Andrada and Franco 1974) indicate that Lesser Kestrels were active at night around the Cathedral, where they apparently took advantage of the powerful ornamental illumination that highlighted this historic building. However, no systematic study was ever conducted to determine whether Lesser Kestrels were active at night on a regular basis at the Cathedral or at other locations in the city. The fraction of birds involved in nocturnal behavior was also unknown, although Andrada and Franco (1974) suggested that up to 50% of individuals in the Cathedral could be active on any given night. The goals of our work were to: (1) determine if Lesser Kestrels were active every night

under ornamental lights, (2) determine which fraction of the colony was active at night, (3) determine the function of nocturnal activity, and (4) describe this unusual behavior in a typically diurnal species. In addition, prey deliveries by adults were recorded at selected nests during day- and night-time hours to determine the relative contribution of nocturnal activities in raising nestlings.

METHODS

We monitored seven nests in the Cathedral, which were clustered in two groups of three and four nests, respectively. In El Salvador, where there is also ornamental illumination at night, we observed a group of five nests and a group of four nests. Nests within each group were close enough to permit simultaneous observation from vantage points in the street, at an average distance from the nests of about 40 m. Surveys were conducted on days 3, 11, 17, 20, and 21 June 1998, coincidental with the period when young were in nests. Focal nests were monitored with 10× binoculars and 20–60× spotting scopes during three time periods: midday (1200–1400 H), late afternoon (1800–2000 H), and night (2200–2400 H). The first two periods occurred during full daylight. Sunset took place at about 2130 H during the study period, and ornamental illumination was on between 2200–2400 H, coincidental with our nighttime observations. Total observation time amounted to 30 hr/nest. Observations were not extended after 2400 H because, prior to this study, we had observed that kestrels roosted as soon as the lights were turned off.

During observations, we recorded instances of young being fed by adults and the sex of the feeder by plumage characteristics (Cramp and Simmons 1980). We tried to identify prey, but deliveries happened so quickly that it was impossible to identify them in most cases. Between 2300–2400 H, we also recorded the maximum number of kestrels that were flying together over the Cathedral and El Salvador, respectively.

Observations were carried out with the help of 40 students of the Faculty of Biological Sciences, University of Seville. They were trained on species recognition and different aspects of breeding biology prior to taking observations. They carried out observations in groups of two and were randomly assigned to the four observation spots. Each group observed for an average of 6 hr. At

Table 1. Maximum number of Lesser Kestrels seen flying together each night (2300–2400 H) of the study period in 1998 at the Cathedral and El Salvador in Seville, Spain.

	NO. OF BREEDING PAIRS	NUMBER IN FLIGHT				
		03 JUNE	11 JUNE	17 JUNE	20 JUNE	21 JUNE
Cathedral	70	26	23	22	55	33
El Salvador	25	5	10	19	15	21

least one of us was present with each student group to supervise fieldwork.

Differences in feeding rates were not significant between the two churches (one-way analysis of variance [ANOVA], $P > 0.05$), so data for the 12 focal nests were pooled for analysis. Differences in feeding rates (feedings/hr) during the time periods were also tested using a one-way ANOVA. For this analysis, we used all observed feedings, including those instances in which the sex of the feeder was unknown. To test for differences in feeding rates between males and females along the different time periods, a two-way ANOVA was used. Period and sex were used as factors, and the analysis was restricted to those observations where the sex of the feeding parent was known.

RESULTS

Lesser Kestrels were active every night we made observations. The number of kestrels that we observed simultaneously while flying at night ranged between 22–55 in the Cathedral, and 5–21 in El Salvador (Table 1). Therefore, a large fraction of birds from each colony was active every night. Kestrels typically soared together in circles over the illuminated buildings. The flock of soaring birds would suddenly disperse and individuals would chase and eat flying insects. Nocturnal flights took place at different heights over both the Cathedral and El Salvador. Often the birds circled and hunted above the Giralda, the Cathedral's bell tower, which is the tallest structure in the

downtown area with a height of about 98 m. Some kestrels descended to the nests from time to time, although prey deliveries were rarely observed.

A total of 411 prey deliveries were observed at the focal nests, 44 of them during night observation periods. Feeding of nestlings varied significantly between the three daily periods ($F = 25.56$, $df = 2$, $P < 0.001$). On average, we observed 1.3 prey deliveries/hr/nest during midday, 2.1 prey deliveries/hr/nest in the afternoon, and 0.4 prey deliveries/hr/nest during the nocturnal period. A two-way ANOVA showed significant differences between sexes ($F = 7.451$, $df = 1.66$, $P = 0.008$), periods ($F = 31.52$, $df = 2.66$, $P < 0.0001$), and the interaction effect between these two factors ($F = 3.30$, $df = 2.66$, $P = 0.042$). Males provided more food items to the young than females during the day (Fig. 1), as previously reported (Donázar et al. 1992). Nocturnal feedings to young by both males and females were very uncommon

DISCUSSION

We present the first description of nocturnal activity in Lesser Kestrels and examine its possible contribution to the successful raising of young. At the Cathedral and El Salvador, lights used to illuminate the buildings at night attracted large quantities of insects making them both visible and accessible to kestrels. The insects also attracted significant numbers of pipistrelle bats (*Pipistrellus pipistrellus*), which were sometimes found among prey remains of kestrels nesting at the Cathedral (Negro unpubl. data). Bat hunting by Lesser Kestrels is uncommon, and the few published records involved individuals that were hunting at dusk or in daylight (Carbajo and Ferrero 1981, Paterson 1991).

The unusual nighttime activity of Lesser Kestrels included a fairly large fraction of the adults in each colony. In fact, we believe that, at some time, all adult birds in the two colonies were active at night. Kestrels remained active until midnight, when the lights were turned down, approximately 2.5 hr after sunset. Unfortunately, lights did not stay on for the whole night, and we do not know whether the kestrels would be able to extend their activity period even further.

Compared to daytime hours, nest provisioning was minimal at night, so we inferred that the main purpose of the adult kestrels' activity at night was to feed them-

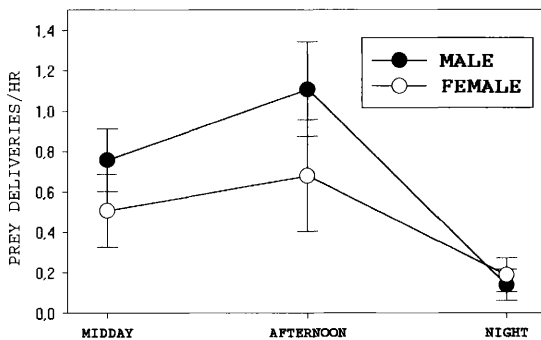


Figure 1. Prey delivery rates ($\bar{x} \pm 2$ SE) by male and female Lesser Kestrels during three periods of observation at the Cathedral and El Salvador in Seville, Spain.

selves. Daytime feeding rates at nests were similar to those found in other areas of southern Spain (2.0 prey deliveries/hr) and Portugal (2.2 prey deliveries/hr), but lower than in rural areas of northern Spain (3.9 feedings/hr) where distances to foraging areas were shorter (Negro 1997).

Lesser Kestrels in Seville breed in colonies in the old downtown area, far from foraging places in the city outskirts. While their nocturnal activity may not result in a significant increase in the prey delivery to the nestlings, it could facilitate feeding of adults during the breeding season perhaps making their urban existence easier (Tella et al. 1995). Urban sprawl around the city is already affecting the hunting areas of the kestrel and it could jeopardize the future of this population. Therefore, nocturnal feeding by the breeding population could make the difference that permits the large kestrel colonies to continue to thrive despite being encroached by many kilometers of apartment blocks in every direction.

Although Lesser Kestrels are typically migratory, some birds remain all year round in southern Spain (Andrada and Franco 1975, González and Merino 1990) and, specifically in Seville (Negro et al. 1991). Andrada and Franco (1974) suggested that nocturnal activity could go on through the year at the Cathedral but it remains to be seen whether wintering kestrels are active at night in Seville.

Further studies are needed to assess the actual effect of nocturnal activity on adult kestrel foraging strategy, not only during the breeding season, but also during the remainder of the year. It is also important to clarify the role of nocturnal foraging in long-term survival in this population.

RESÚMEN.—Estudiamos la actividad nocturna del Cernícalo Primilla (*Falco naumanni*) en dos colonias de cría situadas en edificios históricos del centro de Sevilla (Sur de España). Nuestro objetivo fue describir este comportamiento inusual así como su importancia relativa para la alimentación de los pollos. Se observaron 12 nidos durante tres periodos diarios (1200–1400 H, 1800–2000 H y 2200–2400 H) en Junio de 1998. La mayoría de los cernícalos adultos de ambas colonias estuvieron activos cada noche a lo largo del periodo de estudio mientras funcionaba la iluminación ornamental. La actividad cesaba cuando era apagada la iluminación a medianoche. Los cernícalos capturaban y comían insectos en vuelo llevando pocas presas a los nidos. Los Cernícalos Primillas, por tanto, permanecen activos por la noche para incrementar su ingesta diaria de alimento y no para alimentar a sus pollos. El desarrollo urbanístico de Sevilla está reduciendo los territorios tradicionales de caza de los Cerní-

calos en el entorno de la ciudad. Es posible que la extensión de la caza a horas nocturnas permita que los Cernícalos perduren aún en el centro de Sevilla.

[Traducción de los autores]

ACKNOWLEDGMENTS

We are very thankful to the volunteers who helped us with the fieldwork: A. Ruiz, A. Crespo, M. Díaz, C. Chamorro, M.E. Fernández, P. Ibarra, M.C. Aroca, D. Ciudad, Leónidas, A. Iglesias, P. Aranda, J. Chaves, M.C. Torres, C. García, J. Renfel, Zurina, Sonia, R. Balbontin, L. Fernández, P. Alvarez, M. Narvaez, J. de la Rosa, G. Ortega, Susana, A. Alonso, J.R. Garceta, L. Morales, J. Hernández, Antonio, Reyes, Aura, E. Gómez, A. Gómez, M. Martín, I. Moreno, D. Doblás, Mónica, Rocío, and J. Esquivias. The manuscript benefitted from the comments of T.W. Carpenter and O. Hatzoffe.

LITERATURE CITED

- ANDRADA, J. AND A. FRANCO. 1974. Actividad nocturna en *Falco naumanni*. *Ardeola* 19:471.
- AND ———. 1975. Sobre el área de invernada de *Falco naumanni* en España. *Ardeola* 21:321–324.
- BIBER, J.P. 1994. Lesser Kestrel in G.M. Tucker and M.F. Heath [EDS.], *Birds in Europe: their conservation status*. BirdLife Conservation Series No. 3. BirdLife International, Cambridge, U.K.
- CARBAJO, F. AND J. FERRERO. 1981. Cernícalo Primilla (*Falco naumanni*). *Ardeola* 28:155.
- CRAMP, S. AND K.E.L. SIMMONS. 1980. *Handbook of the birds of Europe, the Middle East and North Africa*. Vol. 2. Oxford Univ. Press, Oxford, U.K.
- DONÁZAR, J.A., J.J. NEGRO, AND F. HIRALDO. 1992. Functional analysis of mate-feeding in the Lesser Kestrel *Falco naumanni*. *Ornis Scand.* 23:190–194.
- GONZÁLEZ, J.L. AND M. MERINO. 1990. El Cernícalo Primilla (*Falco naumanni*) en la Península Ibérica. Serie Técnica, ICONA, Madrid, Spain.
- NEGRO, J.J. 1997. The Lesser Kestrel. *Birds of Western Palearctic Update*, 1:49–56.
- , M. DE LA RIVA, AND J. BUSTAMANTE. 1991. Patterns of winter distribution and abundance of Lesser Kestrels (*Falco naumanni*) in Spain. *J. Raptor Res.* 25:30–35.
- PATERSON, A.M. 1991. Lesser Kestrel hunting bats. *Br. Birds* 84:151.
- TELLA, J.L., F. HIRALDO, J.A. DONÁZAR-SANCHO, AND J.J. NEGRO. 1995. Costs and benefits of urban nesting in the Lesser Kestrel. Pages 53–60 in D.M. Bird, D.E. Varland, and J.J. Negro [EDS.], *Raptors in human landscapes*. Academic Press, London, U.K.

Received 3 March 2000; accepted 3 August 2000