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J. J. Negro [a], C. Ibáñez [a], J. L. Péérezjordáá [a] & M. J. Delariva [a]

[a] Estacióón Biolóógiea de Doññana, CSIC, Apdo. 1056, Sevilla, 51080, Spain

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Winter predation by Common Kestrel *Falco tinnunculus* on Pipistrelle Bats *Pipistrellus pipistrellus* in Southern Spain

J. J. NEGRO, C. IBÁÑEZ, J. L. PÉREZ JORDÁ *and* M. J. DE LA RIVA *Estación Biológica de Doñana, CSIC, Apdo. 1056, 41080 Sevilla, Spain*

Between January and March 1990 we radio-tracked a male Common Kestrel Falco tinnunculus *which hunted Pipistrelle Bats* Pipistrellus pipistrellus *at dusk on 11 of 15 days of observation. Bats left their roosts earlier, and in greater numbers, during fine weather (i.e. high air pressure, no rainfall and low wind speed). The Kestrel showed no interest in bats during poor weather and went to roost early, even though some bats were flying. From pellet analysis, we estimated that bats represented between 30% and 60% of the items eaten by this Kestrel.*

Predation upon bats has been recorded for several diurnal raptor species. Only the Bat Hawk *Machaerhamphus alcinus*, however, is truly specialized in bat hunting.[1] Additionally, the Bat Falcon *Falco rufigularis*, preys upon them regularly.[2] Bat hunting by kestrels has been recorded in Southern Europe, but all the records are casual observations.[3–6] We observed several kestrels hunting bats in Southern Spain and were able to mark and radio-track one of them. Our aims were to estimate the importance of the bats in the kestrel's diet and to relate the kestrel's daily activity patterns to the emergence of the bats.

STUDY AREA AND METHODS

The study was carried out in and around the city of Morón de la Frontera (37°10'N, 5°31'W), Southern Spain, from January to March 1990. The city is surrounded by arable farmland and the climate is typically Mediterranean.

Both members of a pair of Common Kestrels *Falco tinnunculus* were caught with Bal-chatri traps,[7] the female on 24 January and the male a week later. Both were colour banded, and the male was also fitted with a tail-mounted radio-transmitter. The bulk of our observations correspond to the radiotracking of the male, although the banded female was seen many times also.

The male was tracked by two observers during dawn-to-dusk surveys (4 days) or from midday to dusk (9 days). One of the observers followed the bird while driving a car and the other stayed at a fixed point near the roosting site. The observer at the roost recorded luminosity (measured with a luxometer BPW 21) and the number of bats seen in 5 min periods (starting 30 min before sunset). All bats seen were counted, and all were Pipistrelles *Pipistrellus pipistrellus*. The time and light intensity when seeing the first flying bat of the day, and the kestrel's arrival at the roosting site were also recorded.

Observations were terminated each day at 0 luxes, when visual observations become unreliable. Data on weather conditions were from the nearby military airport at Morón. To evaluate the importance of the bats in the kestrel's diet, we collected its pellets and determined the prey items using reference collections deposited in the Doñana Biological Station. We then counted presence or absence of every kind of item in each pellet.[8]

RESULTS AND DISCUSSION

Bat activity

The winter activity of bats is very low or non-existant in temperate zones.[9] Their activity level is related to air temperature and wind speed, which influence in turn the insect availability.[10] During our study we observed Pipistrelle Bats flying at dusk every day, probably because of the mild weather. Minimum temperature was never less than 0.4°C; while average minimum temperatures were 5.0, 6.2 and 8.4°C for January, February and March 1990, respectively.

We detected variations in the number of bats seen and the luminosity levels when they left their roost (Table 1). To examine the relationship between the bats' activity levels and weather variables we performed a principal component analysis on the data in Table 2. This analysis showed that bats began to leave their roost earlier on days with higher atmospheric pressure and low values of wind speed, rainfall and the 3 temperatures considered. The number of active bats was higher on those days when the temperature was high.

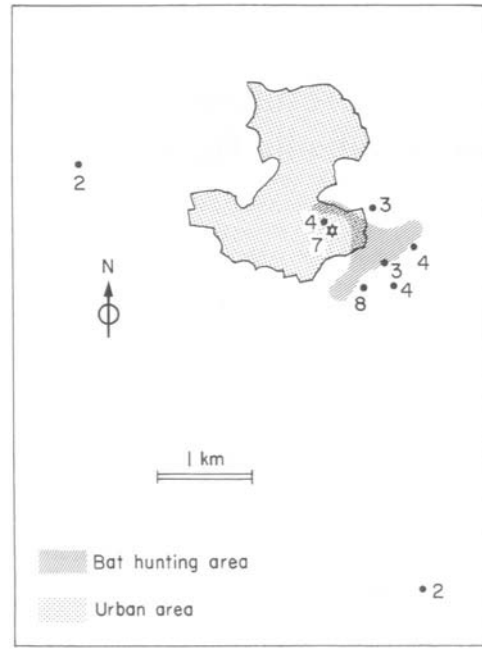

Figure 1. The kestrel's study area in Morón de la Frontera (37°10'N, 5°31'W). Perching-sites have been included (•) with a number indicating number of days that the kestrel used any of them during the study period. The roost has been denoted by an asterisk.

Kestrel activity patterns and bat hunting

We show in Fig. 1 the location of the different perching-sites of the male kestrel during the radiotracking surveys. Ninety-eight per cent of all kestrel locations were within a 2 km^2 area. These observations are consistent with the average winter home range of the species.[8]

The kestrel was usually located in the bat-hunting area just before sunset, even in those days (at least 5) when it had been away previously. On 4 out of 15 days of observation it went directly to the roosting site, without attempting to hunt bats (Table 1). On the other days, the kestrel left the perch to fly over the bat-hunting area when the first bat appeared. During the 4 days when the kestrel did not show any interest in the bats, they left their roosts significantly later in the day, and in smaller numbers than during the other days because of the poor weather.

We observed the kestrel catching bats on 4 days, and hunting them on 7 additional days when we were unable to verify bat captures. If our observation days were typical of the whole winter, the kestrel could have been trying to hunt bats on 70% of the days. We found bat remains in 32% of 19 pellets (Table 3). Assuming that half of the pellets were dropped by its mate (the banded female was observed in the same perching sites but never hunting bats), and a single pellet dropped per day, the consumption of bats by the male would be twice this value, and consistent with 70% of days of bat hunting.

Hunting technique

The kestrel stalked the bats from perches located on the edge of the hunting area, or patrolled over it. When the bats appeared, the kestrel flew straight to them and then struck. If a bat was captured, the kestrel took it to the perch to eat it. After a few minutes, the kestrel returned to the hunting area. A similar behaviour has been described in Merlins *Falco columbarius*,[11] but is remarkably different from the Bat Hawk's technique. The latter catches and

Table 1. Summary of parameters concerning activities of the kestrel and the bats as well

	First bat appearance		*No. bats counted in each survey*	*Kestrel's return to roosting site*		*No. bats taken by kestrel*	*Sunset*	*Active*
	Luxes	*Time*		*Luxes*	*Time*			
Date								
9/1	2783	—	—	—	—	1	17.25	yes
24/1	4800	—	—	—	—	5	17.40	yes
31/1	—	—	—	210	17.50	0	17.47	no
1/2	410	17.47	—	56	17.57	—	17.47	yes
3/2	2080	17.27	—	18	18.05	2	17.49	yes
5/2	1113	17.41	—	26	18.06	—	17.52	yes
9/2	1020	17.46	14	85	18.05	—	17.56	yes
15/2	750	17.56	9	57	18.15	—	18.02	yes
23/2	1201	17.58	28	16	18.39	—	18.10	yes
27/2	850	18.07	26	12	18.33	1	18.15	yes
1/3	130	18.20	5	98	18.24	0	18.17	no
6/3	136	18.27	13	400	18.20	0	18.21	no
7/3	440	18.15	34	30	18.34	—	18.22	yes
14/3	350	18.28	26	17	18.43	—	18.30	yes
23/3	490	18.40	6	180	18.45	0	18.38	no
T*	−2.81		−3.23	2.90				
DF	11.4		7.0	3.1				
P	0.016		0.014	0.060				

*T-tests have been calculated for selected parameters, to compare days with and without bat-hunting activities by the kestrel.

swallows entire bats in the air, maximizing the number of prey taken in the short period of time when they are available.[1,12,13] An intermediate behaviour would be that reported for the Hobby *Falco subbuteo*, which eats bats in the air but tearing them to pieces.[3]

We were unable to estimate the hunting success of the kestrel. Nevertheless, we observed several unsuccessful strikes due to evasive manoeuvres performed by the bats. Black[14] reported the same behaviour for the Big Brown Bat *Eptesicus fuscus* and the Mexican Free-tailed Bat *Tadarida brasiliensis*, escaping from American Kestrels *Falco sparverius*. On the other hand, we found a strong positive correlation between the number of luxes when the first bat went out and the number of bats taken by the kestrel ($r = 0.926$, $P = 0.002$, df = 6). This indicates that the kestrel hunting success would be more limited by the daily period of availability of bats than by its own hunting technique. If cannot be discounted either that kestrels are more successful in brighter conditions.

Rijnsdorp *et al.*[15] reported that the kestrels they studied showed a daily routine adapted to the activity patterns of voles. The methodical predation upon bats by the kestrel that we followed could be explained in the same way: it had learned the bats' habits and waited for them when they were most likely to appear. This behaviour is similar to that displayed by Peregrine Falcons[16] *Falco peregrinus* and Merlins[11] stalking bats at the entrance of caves containing hundreds of thousands of bats. Moreover, the fact that our kestrel retired sooner to the roosting site those days when the bats were less active suggests a certain capacity to evaluate prey availability by the kestrel. This skill could be acquired through previous experience.

The reason the male kestrel but not its mate specialized on bat-eating, although they shared the same territory, could be related to reversed size dimorphism. Males being the lighter sex[17] would have more chances to take evasive prey.[18] The only other report of bat

Table 2. Values of the weather variables for every survey

	t_{18h}(°C)	t_{max}	t_{min}	*Rainfall (mm)*	*Wind speed (km/24 h)*	*Air pressure (mbar)*	*Active*
Date							
9/1	11.8	15.0	5.6	0.0	297	1019.4	yes
24/1	14.6	15.5	4.0	0.0	111	1021.1	yes
31/1	9.8	15.7	7.0	4.8	495	1006.8	no
1/2	12.8	14.3	3.0	0.0	174	1013.5	yes
3/2	14.6	16.4	4.4	0.0	220	1014.8	yes
5/2	17.4	19.2	6.0	0.0	161	1010.2	yes
9/2	19.0	20.6	7.0	0.0	175	1016.0	yes
15/2	19.6	20.7	5.6	0.0	197	1009.8	yes
23/2	21.8	24.3	5.6	0.0	184	1020.4	yes
27/2	21.2	23.3	5.4	0.0	232	1017.4	yes
1/3	16.2	19.1	6.5	0.0	370	1009.4	no
6/3	17.8	21.1	7.0	0.0	317	1010.9	no
7/3	18.8	22.5	10.0	0.0	259	1010.0	yes
14/3	22.8	23.5	7.7	0.0	223	1016.2	yes
23/3	17.0	20.8	10.4	0.8	360	1009.8	no
*T**	1.76	−0.22	1.76	1.22	4.43	−4.04	
df	5.5	8.2	5.6	3.0	4.0	12.3	
P	0.29	0.82	0.13	0.31	0.01	0.002	
FL1†	−0.32	0.00	0.64	0.76	0.91	−0.80	
FL2	0.91	0.97	0.62	−0.38	0.00	0.00	

**T*-test comparisons have been done between days when the kestrel actively tried to hunt bats and days when it did not. LF1 and LF2 = load factors corresponding to the first and second axes of a principal component analysis. These two axes explained 82% of the variance. There are significant negative correlations between the starting of bats' activity and the first ($r = -0.62$, $P = 0.01$, df = 12) and the second axes ($r = -0.582$, $P = 0.02$, df = 12). The number of bats counted is significantly positively correlated with the second axis ($r = 0.80$, $P = 0.006$, df = 7).

Table 3. Winter diet of the Kestrel in Morón de la Frontera (Southern Spain) from pellet analysis; 19 pellets were collected between January and March 1990

Items	*Number of pellets*	*(%)*
Insects	17	89
Coleoptera	15	79
Orthoptera	12	63
Hymenoptera	3	16
Dicthyoptera	1	5
Reptiles	4	21
Lacertidae	4	21
Birds	4	21
Passeriformes	4	21
Mammals	14	74
Chiroptera (*Pipistrellus pipistrellus*)	6	32
Lagomorpha (*Oryctolagus cuniculus*)	4	21
Small mammals	3	16

hunting by a Common Kestrel where the sex was determined, also involved an adult male.[3] Bat hunting by kestrels could be widespread in those parts of Southern Spain were bats are active and abundant in winter.

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