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SPRING WEATHER AND BREEDING SUCCESS OF THE EURASIAN KESTREL (*FALCO TINNUNCULUS*) IN URBAN ROME, ITALY

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KEY WORDS: *Eurasian Kestrel;* Falco tinnunculus; *breeding success; weather conditions; urban habitats; Mediterranean areas.*

The breeding biology of the Eurasian Kestrel (*Falco tinnunculus*) has been well-studied in northern and central Europe mainly focusing on the influence of prey fluctuations on clutch size and productivity (e.g., Village 1990, Plesnik and Dusík 1994, Valkama et al. 1995) as well as on the influence of weather conditions on timing of breeding (Kostrzewa and Kostrzewa 1990, 1991). In Mediterranean Europe, few studies addressed these aspects (Gil-Delgado et al. 1995) and relevant accounts on kestrel breeding success are by Rizzo et al. (1993), Gil-Delgado et al. (1995), Fargallo et al. (1996), and Avilés et al. (2000). Here, I provide data on the breeding success of kestrels in two different habitats of Rome, central Italy, through 5 yr. I studied between-year differences in breeding success in relation to spring weather and I compare my results with data collected 15 yr earlier from the same population (Sommani 1986).

STUDY AREA AND METHODS

I conducted fieldwork from March 1996–July 2000 in Rome, Latium, central Italy (41°53′N, 12°28′E). The area is characterized by developed areas, urban parks, openlands (mainly dry pastures and cereal crops), and small oak woods (mainly *Quercus ilex*). The two census plots included one strictly urban area (inner city) and one suburban, built-up area (Appia Antica park). Breeding density was 1.9 pairs/km^2 (N = 86 pairs) in the urban area and 0.6 pairs/km^2 (N = 34 pairs) in the suburban area (Salvati et al. 1999). For census procedure to locate breeding pairs see Salvati et al. (1999, 2000).

Nests were monitored weekly from the pre-incubation period. Visits were increased to 2–3 d intervals during the nesting period. Laying date for each nest was determined by subtracting the mean incubation period of the species (28 d; Avilés et al. 2000) from the hatching date Hatching date was determined taking into account that all eggs hatch in 4 d (Avilés et al. 2000). Fledging date was defined as the first day when all fledglings leave the nest. Young generally stay for 5–10 d in the vicinity of the nest using perches previously frequented by the parents, but rarely come back to the nest during daylight (Komen and Myer 1989, Bustamante 1994). As the interval of nest visits was 2–3 d, an error of ± 1 d should be assigned to fledging date. Clutch size and laying date were recorded for a subsample of breeding pairs, because many nests were inaccessible for an exact count of eggs or chicks during the early stages of breeding (Salvati et al. 1999). I measured percent egg productivity as the number of fledglings in a nest divided by the total number of eggs laid in that nest. Breeding parameters for the years 1979–85 were obtained through the same technique from Sommani (1986).

As weather variables, I used mean monthly rainfall and

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Table 1. Breeding success and fledgling dates of Eurasian Kestrels in Rome (1979–85, 1996–2000).

Year	Fledglings per Breeding Pair	N	Mean Fledging Date (1 = 1 June)	N	Seasonal Decline in No. of Fledgings/Pair with Date[a,b]
1979–85[c]	2.98 ± 1.10	40	16.53 ± 6.41	38	—
1996	3.08 ± 0.57	25	13.28 ± 4.54	11	$r = -0.61$, df = 9*
1997	3.07 ± 0.83	27	15.43 ± 6.93	23	$r = -0.44$, df = 21*
1998	3.06 ± 1.01	36	23.97 ± 8.33	33	$r = -0.38$, df = 31*
1999	3.06 ± 1.00	46	27.11 ± 11.92	45	$r = -0.69$, df = 43**
2000	2.98 ± 0.84	54	28.28 ± 10.43	54	$r = -0.63$, df = 52**
1996–2000	3.04 ± 0.88	188	24.43 ± 10.84	166	$r = -0.56$, df = 154**

[a] Pearson correlation between fledging date and number of fledglings per pair (probability levels: * $P < 0.05$, ** $P < 0.001$).
[b] Fledging dates were log-transformed to obtain a normal distribution.
[c] Data recalculated from Sommani (1986).

mean minimum temperatures in March–June from 1979–85 and from 1996–2000. There were no correlations between monthly rainfall and minimum temperatures (Spearman's rank correlation test, $P > 0.1$). All meteorological data were obtained from the station of Collegio Romano, which is located within the study area.

All breeding parameters were compared by means of t-tests and analysis of variance (ANOVA) in order to investigate differences among years. Logarithmic transformation was performed on fledging date to correct for deviations from normality. Relationships between each weather variable and breeding parameters were examined using Spearman's rank correlation analysis. In all tests (two-tailed), a minimum probability level of $P < 0.05$ was accepted. Statistical analyses were performed using STATISTICA software. Results are presented as mean ±SD.

Results

Mean clutch size was 4.43 ± 0.94 eggs (range = 3–6 eggs, $N = 14$), and mean laying date was 22.15 April ± 13.13 d ($N = 13$). Mean number of fledglings per successful pair was 3.08 ± 0.82 (range = 2–6 young, $N = 186$), and mean fledging date was 24.43 June ± 10.84 d ($N = 166$). Percent egg productivity was 80.6% ($N = 14$). As two pairs failed breeding (percentage of successful pairs = 98.9%, $N = 188$), mean number of fledglings per breeding pair was 3.04 ± 0.88 ($N = 188$). Seasonal decline in number of fledglings per pair was observed in all years of study (Table 1). I did not detect between-year differences in mean number of fledglings per breeding pair ($F_{4,183} = 0.09$, $P = 0.985$), whereas mean fledging date showed significant differences among years ($F_{4,161} = 6.78$, $P < 0.0001$). Pooling all data collected in urban Rome from 1979–85 and from 1996–2000, the difference in mean number of fledglings per breeding pair was not significant ($t_{226} = -0.37$, $P = 0.709$). Pairwise correlations between mean fledging date and all weather variables were not significant ($P > 0.1$), with only April rainfall bordering the significance level ($r_s = 0.56$, $P = 0.058$, $N = 12$).

Discussion

Breeding parameters of kestrels in Rome are similar to those observed in other Mediterranean areas (Rizzo et al. 1993, Gil-Delgado et al. 1995, Avilés et al. 2000). Since my study was restricted to pairs breeding in cavities other than nest-boxes, the overall reproductive success may be lower compared with that of populations breeding in nest-boxes, likely due to the potentially high predation rates (Avilés et al. 2000). However, the number of kestrel predators is generally low in cities, thus reducing the probability of nest predation.

Many authors have reported that large annual variations in kestrel productivity are linked to fluctuations in rodent density and to unfavorable weather conditions during breeding in northern and central Europe (Kostrzewa and Kostrzewa 1990, 1991, Village 1990, Valkama et al. 1995). In southern Europe, some studies have shown slight between-year differences in laying date (Avilés et al. 2000) and number of fledglings per pair (Gil-Delgado et al. 1995). Interestingly, voles generally show small fluctuations in density in the Mediterranean basin (Paradis and Guédon 1993, Rizzo et al. 1993). In these areas kestrels usually feed on alternative prey (Rizzo et al. 1993, Gil-Delgado et al. 1995, Piattella et al. 1999), thus reducing the influence of rodent fluctuations on productivity. Therefore, in southern Europe weather conditions may assume a role in determining annual variations in kestrel breeding success.

Mild climate (i.e., high temperatures and low rainfall) during spring triggers laying and favors chick rearing (Gil-Delgado et al. 1995). In Rome, the between-year stability of kestrel nesting success may confirm the importance of mild and stable weather conditions during breeding, as already observed for the Tawny Owl (*Strix aluco*) in the same area (Ranazzi et al. 2000), although it seems plausible that in the Mediterranean basin, high rainfall during spring may force kestrels to delay laying, as suggested by the weak relationship between mean fledging date and April rainfall. I suggest that the annual variation in mean fledging date is probably not affected by weather conditions. Factors linked to high population levels in Rome (Salvati et al. 1999) more likely could affect variations in laying date.

Following Avilés (2000) hypothesis, in dry and semiarid landscapes of southern Europe, high rainfall in the spring may result in higher prey availability (e.g., insects; Rizzo et al. 1993, Avilés et al. 2000), contributing to annual fluctuations in breeding success. Although data from this study area do not support Avilés and co-workers' hypothesis, I suggest that the improved reproductive output related to rainfall also depends on the feeding habits of kestrels in each area. In those Mediterranean areas, like Rome, where kestrels prey mainly on birds (Piattella et al. 1999), the effect of spring rainfall could be negligible. Whereas in most arid European areas, where kestrels feed mainly on insects (Gil-Delgado et al. 1995), the Avilés and co-workers' hypothesis seems to be plausible to explain the between-year differences in breeding performance of this raptor.

RESUMEN.—Estudie las diferencias entre años en el éxito reproductivo del cernícalo euroasiático (*Falco tinnunculus*) en relación con el clima primaveral en un periodo de cinco años, y comparé mis resultados con datos colectados 15 años atrás en la mi misma población. El tamaño medio de la postura fue 4.43 ± 0.94 huevos, y la fecha media de la postura fue 22.15 Abril ± 13.13 d. El promedio de volantones por pareja exitosa fue 3.08 ± 0.82 y la fecha promedio del primer vuelo fue 24.43 Junio ± 10.84 d. La productividad de huevos fue 80.6%. La diferencia entre años en el promedio de volantones por pareja reproductora no fue significante, en tanto que la fecha promedio del primer vuelo mostró variaciones significativas entre años. No hubo correlación entre la fecha promedio del primer vuelo y las variables climáticas. El éxito reproductivo de los cernícalos en Roma es comparable a los observados en otras áreas del mediterráneo. El clima moderado durante la primavera puede ser el detonador de las posturas y favorecer la cría de los pichones. Por otro lado, en paisajes semi áridos, donde los cernícalos se alimentan principalmente de insectos, la alta precipitación en primavera puede dar como resultado la alta disponibilidad de presas, contribuyendo a las fluctuaciones anuales en el éxito reproductivo. Los datos de esta área de estudio, donde los cernícalos comen primordialmente aves, no dan soporte a esta hipótesis. Sin embargo esta hipótesis puede explicar las variaciones anuales en el éxito reproductivo de las rapaces insectívoras en algunas áreas del mediterráneo.

[Traducción de César Márquez]

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FATAL *CARYOSPORA* INFECTION IN A FREE-LIVING JUVENILE EURASIAN KESTREL (*FALCO TINNUNCULUS*)

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KEY WORDS: *coccidiosis;* Caryospora kutzeri; *Protozoa; Eurasian Kestrel;* Falco tinnunculus.

Infections in birds of prey by *Caryospora* spp. are a common and often serious problem in captive breeding stations (Heidenreich 1996). In British breeding centers, nestlings of Merlins (*Falco columbarius*) fall ill due to infections with *C. neofalconis* (Forbes and Simpson 1997). Typically, symptoms are displayed at an age of 28 to 55 d and may include regurgitation, hemorrhagic feces, depression, and reduced appetite. Peracute or acute death with or without clinical signs may occur also. The possible explanation for this disease in young birds at this particular age is waned maternal immunity and incomplete development of their own active immunity. In experimentally-infected adult Eurasian Kestrels (*F. tinnunculus*) the prepatency of *C. neofalconis* was 8–10 d and the patency 10–93 d, and for *C. kutzeri* 8–13 d and 4–34 d, respectively (Böer 1982). The developmental cycle can be either direct or indirect. In captivity caryosporans apparently utilize the direct life cycle, possibly also using paratenic hosts, such as earthworms (Heidenreich 1996); free-living birds of prey acquire infection by feeding on infected prey (Cawthorn and Stockdale 1982).

Previously, 16 species of *Caryospora* have been described in raptors, 10 from birds in Europe and six from North America, including one which also occurs in Venezuela (Upton et al. 1990, Klüh 1994). Because most publications on *Caryospora* (Yamikoff and Matschoulsky 1936, Wetzel and Enigk 1937, Schellner and Rodler 1971, Böer 1982) consider only captive birds of prey, the distribution and significance of *Caryospora* in free-living birds of prey remains unclear. No *Caryospora* oocyst could be found in 72 free-living Merlins examined in Great Britain (Forbes and Fox 2000), nor in 247 birds of prey (including 35 Eurasian Kestrels, four Hobbys [*F. subbuteo*] and 22 Peregrine Falcons [*F. peregrinus*] from Germany [Krone 1998]). However, *C. boeri* was found in seven of 15 free-living Eurasian Kestrels from Germany in another study (Klüh 1994). Furthermore, in free-living Eurasian Kestrels from Austria, oocysts of *C. falconis* and oocysts of *Caryospora* spp. were diagnosed (Kutzer et al. 1980).

CASE REPORT

A juvenile Eurasian Kestrel observed in Berlin on 29 August 2000 showed distinct signs of a general weakness. The bird was conspicuous, it demonstrated a reduced-flight distance, and when chased away, the bird flew only short distances. On 30 August 2000 the kestrel was captured and a hemorrhagic diarrhea was reported. On the morning of 31 August 2000 the kestrel died. Post-mortem findings indicated a heavy protozoan infection which lead to death from associated severe dehydration and cachexia.

As the bird was banded its history was known. The bird and its clutch mates had been banded on 11 July 2000 at an age of 18–19 d in a nesting box. The bird was found less than 500 m away from the nesting box. The necropsy of the 69-d-old male Eurasian Kestrel revealed a poor condition and a mass of 101 g. A heavy *Caryospora* spp infection (Fig. 1) resulting in a severe hemorrhagic enteritis was documented during the examination of the digestive tract. The highest level of oocysts (ca. 100/visual field at magnification of 200×) were detected in the first third of the jejuno-ileum.

Oocysts were mixed with potassium dichromate solu-

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