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SUSPECTED PREDATION BY ACCIPITERS ON RADIO-TRACKED AMERICAN KESTRELS (*FALCO SPARVERIUS*) IN EASTERN PENNSYLVANIA, U.S.A.

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KEY WORDS: *American Kestrel;* Falco sparverius; *Cooper's Hawk;* Accipiter cooperii; *predation; mortality; radiotelemetry.*

There is growing evidence that American Kestrel (*Falco sparverius*) populations in the northeastern United States are declining. Data from Christmas Bird Counts (National Audubon Society 2002), Breeding Bird Surveys (Sauer et al. 2004), and coastal hawkwatches, including Cape May Bird Observatory, all show decreasing trends, beginning in the mid-1990s (Sullivan and Wood 2005). Land-use change, West Nile Virus, increasing numbers of Cooper's Hawks, and declining populations of Northern Flickers (*Colaptes auratus;* primary cavity excavators) all have been proposed as possible explanations for the decreasing trends (Sullivan and Wood 2005). To date there is no empirical support for any of these hypotheses.

In fact, very little is known about kestrel survivorship and causes of death. The most commonly used estimates are more than 30 yr old (Roest 1957, Henny 1972), and are based on band returns and mark-recapture recoveries. Hu-

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man-related incidents are the most commonly reported cause of death (Roest 1957, Bird and Palmer 1988); however, human-caused deaths are more likely to be encountered and identified than other types of mortality (starvation, predation, etc.; Smallwood and Bird 2002). Here we report on our use of radiotelemetry to monitor American Kestrel behavior and survivorship in winter and to identify sources of kestrel mortality in eastern Pennsylvania.

METHODS

Study Area. The study area consisted of approximately 1500 km² of open, rolling farmland (including row crops) and pasture, interspersed with woodlots and orchards in eastern Pennsylvania. The center of the area is approximately 20 km north of Reading, and 30 km west of Allentown, Pennsylvania, and includes portions of northern Berks and northwestern Lehigh counties.

Radio-tracking. American Kestrels were captured with bal-chatri traps in autumn and winter (earliest 16 September, latest 23 January) of 1996, 1997, and 1998, when migrating individuals were not likely to be encountered, and after birds in the area had established wintering activity areas (Ardia and Bildstein 2001). Each kestrel was banded with an aluminum U.S. Geological Survey band and three plastic color bands, and fitted with a 3.8-g radiotransmitter (Holohil Systems, Ltd., Ontario, Canada, type PD-2 transmitter) attached with a fanny-pack harness. Transmitters weighed 2–2.5% of the birds' body mass.

Eleven female and eight male kestrels were radio-tagged. Five individuals were caught during 1996–1997, six during 1997–1998, and eight during 1998–1999. Radio-tagged birds were observed as early as 16 September and as late as 30 May. Each bird was monitored from 28 to 208 d (mean = 121 d, SD = 59 d).

Kestrels were located by triangulation or resighted every 1–2 d (2–6 locations per wk per bird). The behavior of the bird and the presence of other raptors in the area, as well as interactions with other raptors, were noted. Efforts were made to recover the transmitter and remains of any bird whose signal was received from the same location for several days.

RESULTS

Mortality. Of the 19 kestrels studied over three winters, eight were found dead. Annual winter mortality (se) was 0.40 (0.22) in 1996–97, 0.16 (0.13) in 1997–98, and 0.62 (0.17) in 1998–99. As mortality did not differ significantly among years (χ^2_2 with Yates correction = 4.37, $P = 0.11$), we pooled it across years to derive an average winter mortality of 0.39 (0.11).

Five of the deaths were attributed to avian predators based on our finding (1) plucked feathers with shafts that were smooth and clean of flesh (indicating that the feathers had been plucked from the body while it was still warm), (2) a partially plucked body, (3) avian fecal material, or (4) combinations of the above near or at the transmitter (Hamerstrom 1972). One extremely thin female found dead in a nestbox with no signs of injury was presumed to have starved. Two other carcasses left inconclusive evidence as to the cause of death.

Behavioral Interactions. During 108 of 1091 (10%) observations, another species of raptor was seen within 100 m of a tracked kestrel. We also observed seven interspecies interactions involving a radio-tagged bird. Red-tailed Hawks (*Buteo jamaicensis*) were seen 68 times (63%) and were involved in one interspecies interaction during which a female kestrel stooped on a Red-tailed Hawk as it flew past. Cooper's Hawks (*Accipiter cooperii*) were seen 20 times (19%) and accounted for six interspecies interactions with tagged kestrels (86% of all interactions). In half of these interactions kestrels chased Cooper's Hawks; in the other half, Cooper's Hawks chased kestrels. Sharp-shinned Hawks (*Accipiter striatus*) were seen six times (<1%) but were never seen interacting with kestrels.

DISCUSSION

As North America's smallest diurnal raptor, the American Kestrel is potentially vulnerable to predation from larger raptors, particularly bird-eating accipiters (e.g., Petty et al. 2003). At least 26% of our kestrels were killed by avian predators, making the latter the primary cause of winter mortality (at least 62% of all deaths). Although avian predation has been identified as a significant source of post-fledging mortality in several species of raptors (Belthoff and Richison 1989, Petty and Thirgood 1989, Varland et al. 1993, McFadzen and Marzluff 1996), there are few reports of avian predation as a major mortality factor for adult raptors (Petty et al. 2003).

Several studies provide evidence that transmitters can increase mortality in birds due to increased metabolic requirements (particularly in large birds; Murray and Fuller 2000, Godfrey et al. 2003), as well as via harness problems and entanglement in vegetation (Guthery and Lusk 2004). However, we were unable to find any studies documenting effects on maneuverability in birds carrying properly-fitted transmitters. In our study, a pair of tagged kestrels successfully copulated, incubated, brooded, and fledged young and there were no indications that tagged individuals behaved differently than non-tagged birds, suggesting that the presence of transmitters did not significantly influence the maneuverability and, hence vulnerability, of birds we tracked.

That said, if the transmitters did increase the rate of avian predation in our study, we might have expected to find an unnaturally high mortality rate as well. Although we are not aware of any other studies of kestrel mortality in winter with which to compare our data, the average winter mortality rate in our study was well below previous estimates of annual mortality in both Common (Daan et al. 1996) and American (Smallwood and Bird 2002) Kestrels.

Moreover, there is evidence of significant adult kestrel predation by an accipiter in the absence of radiotelemetry equipment. The decline of the Common Kestrel in northern England is due in part to predation by the Northern Goshawk (*Accipiter gentilis*; Petty et al. 2003). Although Common Kestrels made up less than 5% of the goshawk's diet during the breeding season in that region, overall, goshawks removed more kestrels "than were recorded each spring in the study area" (Petty et al. 2003).

Although we do not have direct evidence indicating which accipiter or accipiters preyed upon our kestrels, observations during the study point to Cooper's Hawks. Cooper's Hawks were the raptor most frequently observed interacting with kestrels, and they were seen in the wintering areas of 68% of our telemetered birds. Diet studies of Cooper's Hawks indicate that the American Kestrel falls within the range of prey taken by this species (Rosenfield and Bielefeldt 1993, Dunn and Tessaglia 1994, Roth and Lima 2003), and there are several published reports of Cooper's Hawks preying on adult American Kestrels (Storer 1966, Stoddard 1978, Kirkpatrick 1980). More recently, during a five-year study of Cooper's Hawks in Georgia, researchers observed several of the telemetered Cooper's Hawks trap-lining bird nestboxes, including kestrel nestboxes (B. Millsap pers. comm.).

Northern Goshawks also can take American Kestrels. However, goshawks were not observed near any of the kestrel wintering areas during our study. Female Sharp-shinned Hawks, too, conceivably could kill kestrels; however, we saw Sharp-shinned Hawks only six times and never saw them interact with kestrels. Although our limited observations of these two species do not rule out goshawk and sharpshin predation, we believe such predation was far less likely than that by Cooper's Hawks.

Our study provides evidence that the presence of avian predators can significantly affect mortality in American Kestrels. Additional work is needed to evaluate both the extent of direct and indirect impacts of predation on the distribution and abundance of American Kestrels, particularly in areas that contain suitable breeding habitat for both kestrels and accipiters.

SOSPECHAS DE DEPREDACIÓN POR *ACCIPITER* SOBRE INDIVIDUOS SEGUIDOS CON TELEMETRÍA DE *FALCO SPARVERIUS* EN EL ESTE DE PENSILVANIA, EUA

RESUMEN.—Estudiamos 19 individuos marcados con radio collares de *Falco sparverius* en un mosaico de fincas y pequeños fragmentos de bosque en el este de Pensilvania, EUA, durante los inviernos de 1996–1997, 1997–1998 y 1998–1999. Seguimos a once hembras y a ocho machos por un promedio de 121 días (DE = 59; rango 28–208). Ocho (42%) de las aves fueron halladas muertas o se presumió que estaban muertas basándonos en sus restos y en la recuperación de los radio transmisores. Debido a que las tasas de mortalidad invernal no fueron estadísticamente diferentes entre los años, combinamos los datos y calculamos una tasa promedio de mortalidad invernal que fue de 0.39. Cinco muertes fueron directamente atribuibles a aves depredadoras de aves, presumiblemente del género *Accipiter*. Se observó la presencia de *Accipiter cooperii* en las áreas de invernada del 68% de las aves con radio collares y esta especie representó el 19% de todas las aves rapaces observadas en estas áreas (excluyendo a *Falco*). De todas las interacciones interespecíficas que observamos de *F. sparverius*, el 86% involucró a *Accipiter cooperii*. Nuestro estudio brinda evidencia de que la presencia de aves depredadoras puede ser un factor significativo de mortalidad de *F. sparverius*. Se necesitan estudios adicionales para evaluar la magnitud de los impactos directos e indirectos sobre la distribución y la abundancia de *F. sparverius*, particularmente en áreas que contienen sitios de cría adecuados para *Falco* y *Accipiter*.

[Traducción del equipo editorial]

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THE FOOD HABITS OF EURASIAN EAGLE-OWLS IN SOUTHERN PORTUGAL

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KEY WORDS: *Eurasian Eagle-Owl*; Bubo bubo; *diet*; *Mediterranean habitats*; *Portugal*; *principal component analysis.*

Knowledge of the food habits of a predator is essential for its conservation because diet may influence survival (Hakkarainen et al. 2002) and breeding performance (Viñuela and Veiga 1992, Arroyo 1998, Penteriani et al. 2002), or reveal possible conflicts with human activities (Thirgood and Redpath 2000). Moreover, the analysis of the diet of top predators may be particularly useful for species conservation when intraguild predation is occurring (Sergio et al. 2003).

The Eurasian Eagle-Owl (*Bubo bubo*) is a large predator with a Palearctic distribution and the diet of European populations has been widely studied in several countries (Penteriani 1996). However, the information on the diet of this species in the Iberian Peninsula is only available for Spanish regions (e.g., Hiraldo et al. 1975, Donázar 1989, Serrano 1998, Martínez and Zuberogoitia 2001), and no information is available for Portugal.

Lagomorphs, and more specifically European rabbits (*Oryctolagus cuniculus*), play an important ecological role in the food webs of western Mediterranean ecosystems (Delibes and Hiraldo 1981, Iborra et al. 1990). Iberian eagle-owls are rabbit specialists (Hiraldo et al. 1976, Donázar et al. 1989) and, due to the abundance of this prey, attain locally high population densities (Delgado et al. 2004, Ortego and Díaz 2004). In recent decades, myxomatosis and rabbit hemorrhagic disease were responsible for the large decline of rabbit populations in the Iberian Peninsula (Villafuerte et al. 1995). Consequently, rabbit-dependent species such as the Spanish Imperial Eagle (*Aquila adalberti*) and the Iberian lynx *Lynx pardinus* are presently in need of conservation action (Ferrer and Negro 2004). Although the large scale effects of rabbit diseases on Iberian eagle-owl populations have never been evaluated, rabbit declines have been shown to influence negatively both this owl (Martínez and Zuberogoitia 2001, Penteriani et al. 2002) and other raptors through direct and indirect effects (Tella and Mañosa 1993). The objective of this study was to describe the diet of eagle- owls in southern Portugal, and to analyze possible intrapopulation differences in diet.

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