Nestbox use by American Kestrels (Falco sparverius) and European Starlings (*Sturnus vulgaris*) in Eastern Pennsylvania

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Abstract. - In 1992-1997, American Kestrels (*Falco sparverius*) using nestboxes in farmlands in an approximately 500-km^2 study area in eastern Pennsylvania, had annual nestbox occupancy rates of 38 to 53% (x = 44%), annual nesting success rates of 58 to 83% (x = 72%), and a tendency to occupy boxes with nest openings directed to the south and west. In addition to American Kestrels, Eastern Screech-Owls (*Otus asio*), European Starlings (*Sturnus vulgaris*), white-footed mice (*Peromyscus leucopus*), and eastern grey squirrels (*Sciurus carolinensis*) also occupied nestboxes. Starlings, which were by far the most common nontarget species (71% of nontarget occupants), had occupancy rates of from 15% to 29%, annually (x = 20%). Kestrels were more likely to nest in nestboxes attached to barns, sheds, and poles (as opposed to trees) than were starlings. Kestrels, but not starlings, demonstrated a preference for nestboxes that opened to the south and west. The relatively stable annual occupancy rates of kestrels and starlings using our nestboxes in 1992 through 1997 suggests that an equilibrium in nestbox use existed between the two species at the time of our observations.

The American Kestrel (*Falco sparverius*) is the most widely distributed common diurnal bird of prey in the New World (Cade 1982, del Hoyo et al. 1994). The species, which regularly occurs in human-modified landscapes, including farmlands and suburban areas where it feeds on insects, mice, and occasionally birds, is a secondary cavity nester that breeds in old woodpecker holes, holes in earthen banks, and other natural cavities (Cade 1982, Bird and Palmer 1988, del Hoyo et al. 1994). American Kestrels readily adapt to nesting in nestboxes (Nagy 1963, Heintzelman and Nagy 1968, McArthur 1977, Bloom and Hawks 1983, Varland and Loughin 1993, Bortolotti 1994), making them one of the more widely studied raptors in the world (Brown 1976, Bird and Bowman 1987).

American Kestrels have been breeding in nestboxes in the farmlands of eastern Pennsylvania near Hawk Mountain Sanctuary since the early 1950s (Nagy 1963, Heintzelman and Nagy 1968, Wiehn et al. 1997). By the mid-1990s, more than 250 nestboxes had been erected in farmlands surrounding the Sanctuary (Bildstein 1996). Every year, some of the boxes erected for kestrels have been used by grey squirrels (*Sciurus carolinensis*), white-footed mice (*Peromyscus leucopus*), Eastern Screech-Owls (*Otus asio*), and European Starlings (*Sturnus vulgaris*). European Starlings, in particular, are known to use and compete with kestrels for nestboxes erected for the latter (Bechard and Bechard 1996, Van Balen et al. 1982, Weitzel 1988, Wilmers 1987).

Here, we report on kestrel nesting success, the use of kestrel nestboxes by kestrels and non-target species, and on characteristics of nestboxes used by kestrels and starlings (the principal non-target species using nestboxes) in the northern half of our approximately 1000-km^2 study area in eastern Pennsylvania in 1992-1997.

METHODS

Study area. - The portion of our study area used in this analysis consists of approximately 500 km^2 of farmlands north of US Interstate 78 in northern Berks, northwestern Lehigh, and southeastern Schuylkill counties, eastern Pennsylvania. The area, which lies within the Eastern Deciduous Forest Biogeographical Province (Udvardy 1984), is characterized by warm and humid summers (mean minimum-maximum temperatures of 16-30 C° in July) and cold winters (mean minimum-maximum temperatures of 2-7 C° in January). Annual precipitation averages 110 cm, including 75 cm of snow (Yarnal 1989).

Nestboxes are made of untreated pine (*Pinus spp.*) or cedar (*Cupressus spp.*), and are 26 cm deep, 24 cm wide, and 33 cm high, with 7.6 cm diameter entrance holes centered 26 cm above the floor of the box. Most boxes have been erected in relatively open farmland adjacent to or over mowed grasslands and meadows. Nestboxes are mounted 3-6 m above the ground and, with few exceptions, each box is at least 0.5 km from its nearest neighbor. All boxes are within 50 m of the nearest road, usually with their opening away from the road. Eighty-nine percent of the boxes are mounted on trees; the remaining boxes are on barns, sheds, and utility poles.

Nestboxes are cleaned and new nesting material (wood chips) is added in March. Boxes are checked for activity beginning in mid-April. All mice and squirrels found in boxes, and any associated nesting materials, are removed upon discovery. Starling nesting material and eggs also are removed upon discovery, but starling nests with nestlings are not disturbed. Eastern Screech-Owls nesting in boxes are not disturbed. Kestrel and Eastern Screech-Owl nestlings are banded 16-20 days after hatching.

For purposes of data analysis, we classified nestboxes as being mounted on trees or on barns, sheds, and poles, and with openings to the north, south, east, and west. We also characterized nestboxes mounted on trees according to the genus of the tree.

RESULTS

Occupancy rates and nesting success. - Between 1992 and 1997, 96 to 112 nestboxes (x =107.86; SD = 5.9) were available to kestrels each year for a total of 647 nestbox years. In addition to American Kestrels, one or more European Starlings, Eastern Screech Owls, grey squirrels, and white-footed mice, used nestboxes each year (Table 1). American Kestrels occupancy rates ranged from 38% in 1994 to 53% in 1995 (x = 44%). European Starlings occupancy rates ranged from 15% in 1996 to 29% in

1992 (x = 20%) (Fig. 1). Occupancy rates for both species did not change significantly during the six years of our study (r^2 = 0.136, df = 4, p > 0.05). American Kestrel nesting success (measured as the percentage of occupied boxes in which nestlings were banded) and reproductive activity are given in Table 2.

Table 1. Numbers of kestrel nestboxes occupied in eastern Pennsylvania, 1992-1997.

	1992	1993	1994	1995	1996	1997	Total
Numbers of boxes	96	111	110	109	109	112	647
American Kestrel	38	48	42	58	49	48	283
European Starling	28	24	18	19	16	20	125
Eastern Screech Owl	1	0	0	4	1	2	8
White-footed mouse	1	1	0	1	1	4	8
Grey squirrel	2	4	8	1	9	10	34
All species	70	77	68	83	76	84	458

Nestbox orientation. - *Twenty-six* percent of all nestboxes had openings facing north, 41% facing south, 17% facing east, and 16% facing west. Kestrels used 46% of nestboxes facing south and 61% of those ones facing west, but only 33% and 37% of boxes facing north and east respectively (X^2 = 12.41, df = 3, p > 0.05). Starlings used 22% of nestboxes facing north, 24% of those ones facing east, 17% of those facing west and 15% of those facing south (X^2 = 3.53, df = 3, p > 0.05). Kestrel and starling occupancy rates differed depending on nestbox orientation (X^2 = 11.32, df = 3, p > 0.05) (Fig. 2).

Nestbox support. - During our study, 89% of all nestboxes were attached to trees and 11% were attached to barns, sheds, and poles. Kestrels used 42% of the nestboxes on trees and 55% of those mounted on barns, sheds, and poles. Starlings used 20% of boxes placed on trees, and 11% of those on barns, sheds, and poles. Although neither kestrels (X^2 = 0.62, df = 1, p > 0.05) nor starlings (X^2 = 2.24, df = 1, p > 0.05) demonstrated a significant difference in their use of boxes mounted on trees versus those mounted on barns, sheds, and poles, the two species differed significantly in their relative use of boxes based on this habitat characteristic (X^2 = 5.89, df = 1, p > 0.05).

During our study, nestboxes were mounted on six types of trees, ashes (*Fraxinus spp.*) (13%), cherries (*Prunus spp.*) (10%), oaks (*Quercus spp.*) (6%), hickories (*Carya spp.*) (21 %), and walnuts (*Juglans spp.*) (37%), and other species (*Robiniapseudoacacia, Catalpa sp., Liriodendron tulipifera,* and *Acer spp.*) (13%). Neither kestrels nor starlings used trees disproportionate to their availability (X^2 = 6.33, and X^2 = 3.32, df = 5, p > 0.01, for kestrels and starlings respectively).

DISCUSSION

Research suggests that kestrels select nestboxes based on a variety of general nest site characteristics, including vegetation around the box, box orientation, the structure to which the box is attached, and temperature and light levels in the box (Bloom and Hawks 1983, Bortolotti 1984, Curley et al. 1987, Rohrbaugh 1994, Toland and Elder 1987). Our results support studies which report that kestrels prefer south-facing boxes, a preference believed to be associated with higher levels of interior light and protection from inclement weather (Balgooyen 1976, Curley et al. 1987, Rohrbaugh 1994). This choice also could be associated with the fact that in natural conditions, kestrels frequently use woodpecker cavities, most of which face south (Conner 1975, Inouye 1976).

Although we failed to detect significant differences in the relative use of nestboxes placed on trees versus those on barns or poles, American Kestrels use of nestboxes on barns, sheds and poles was slightly higher than their use of nestboxes on trees, a result that also is consistent with previous reports (Stahlecker and Griese 1979, Toland and Elder 1987).

Conservation Implications. American Kestrel populations appear to be decreasing in southern New England and several mid-Atlantic states (Illif 1999, Perkins 1999). The implementation of nestbox programs provides opportunities to increase kestrel reproductive output and thus, potentially, breeding populations (Toland and Elder 1987, Rohrbaugh 1994, Anonymous 1997). The results of our study suggest that placing nestboxes on barns, sheds or poles rather than on trees increases their use by kestrels, as does facing the boxes towards the southwest. As neither of these site characteristics appears to be favored by starlings, the kestrels chief competitors for nestboxes in our area, we recommend both characteristics be employed in new kestrel nestbox programs.

Finally, we also suggest that although the removal of starling nestlings may enhance kestrel reproductive output regionally, it is not necessary to do so in instances where volunteers associated with nestbox programs are reluctant to kill nestling starlings.

Table 2. American Kestrel reproductive activity in eastern Pennsylvania, 1992-1997.

Year	Number of Boxes used	Mean clutch size	Mean hatching date	Mean brood size[b]	% of success[c]
1992	38	4.4+0.76a	5 Jun + 18a	2.3+2. 1 a	58
1993	48	4.8+0.81	30 May + 12	3.5 + 1.9	81
1994	42	4.5+0.94	29 May + 16	3.5+ 1.8	83
1995	58	4.7+0.85	23 May + 15	3.1 +1.9	79
1996	49	4.3+0.96	7 Jun + 12	2.5+2.1	67
1997	48	4.7+0.61	29 May + 10	3.7+ 1.3	63
All years	283	4.6+0.85	30 May + 15	3.1 + 1.9	72

a Mean ± standard deviation.
b At nestling banding age (16 to 20 days old).
c Percentage of boxes where nestlings banded at > 16 days were believed to have fledged.

ACKNOWLEDGMENTS:

We thank Hawk Mountain Sanctuary personnel, volunteers, and interns, particularly Jorge Aguilar and Adrien Tanguay for their assistance in the field. Ursula Valdez was supported by a Hawk Mountain Sanctuary

internship during her fieldwork in the project. This is Hawk Mountain Sanctuary contribution number 44.

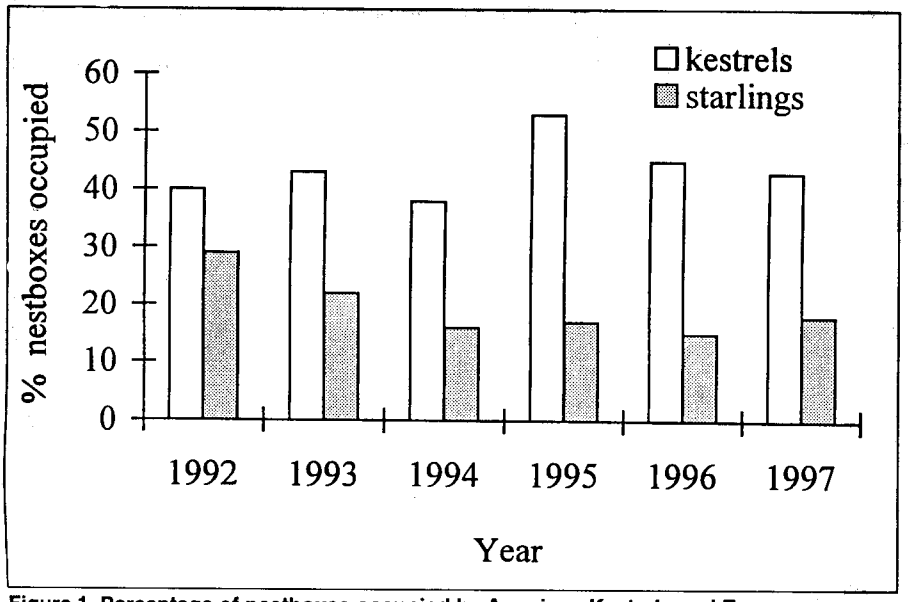

Figure 1. Percentage of nestboxes occupied by American Kestrels and European Starlings in eastern Pennsylvania, 1992-1997

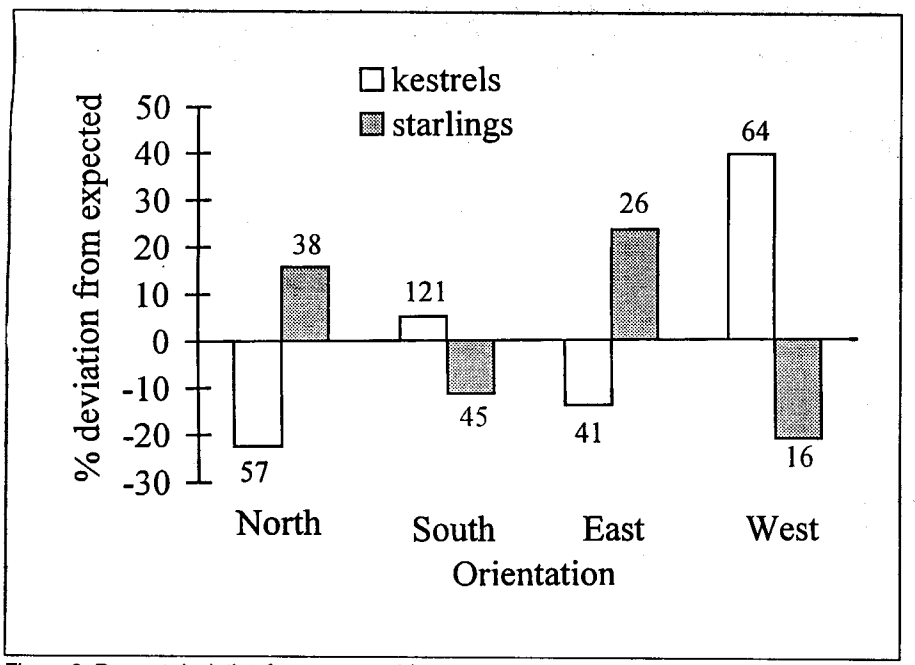

Figure 2. Percent deviation from expected for nestboxes opening to the N, E, S, and W that were occupied by American Kestrels and European Starlings in eastern Pennsylvania, 1992-1997. Numbers above or below bars represent the total numbers of occupied boxes.

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