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EFFECTS OF RESEARCHER-INDUCED DISTURBANCE ON AMERICAN KESTRELS BREEDING IN NEST BOXES IN NORTHWESTERN NEW JERSEY

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ABSTRACT.—Nest boxes for American Kestrels (*Falco sparverius*) may alleviate local nest site limitation, but there is concern that periodically opening nest boxes or handling adults may negatively affect nesting success. I monitored 536 kestrel breeding attempts (≥1 egg laid) in about 100 nest boxes in northwestern New Jersey, 1995–2012. To study return rates, I opportunistically captured adults in nest boxes and marked them with U.S.G.S. leg bands and patagial tags. To examine possible effects of this disturbance, I compared nesting success (≥1 nestling surviving to banding age) of marked and unmarked adults. Nesting success was 67% for 270 unmarked pairs, 76% for 25 pairs with only the male marked, 82% for 206 pairs with only the female marked, and 91% for 35 pairs with both adults marked. This significant difference likely reflects differences in the probability of capture: successful attempts last longer and successful parents may be more attentive. To control for these correlations, I examined attempts for which the first disturbance was encountering an adult in the nest box; that bird either flushed from the nest box or was captured and marked. Abandonment was not significantly related to this initial disturbance: breeding attempts continued for 94.3% of attempts in which the male flushed, 93.1% for males handled, 93.7% for females flushed, and 93.2% for females handled. Nesting success also did not differ significantly among these four treatment groups. The timing of the first disturbance did not significantly affect abandonment; breeding attempts continued for 90% of attempts in which males were first disturbed (flushed or handled) during the laying period, 94% for males during incubation, 97% for females during laying, and 93% for females during incubation. Nesting success also was not significantly related to timing of the initial disturbance. Thus, it appears that both the intensity (handling or not) and timing of disturbance had no substantial effect on abandonment or nesting success for this population.

KEY WORDS: *American Kestrel*; Falco sparverius; *disturbance*; *nest box*; *nesting success*; *reproduction*.

EFECTOS DEL DISTURBIO PRODUCIDO POR LOS INVESTIGADORES EN INDIVIDUOS DE *FALCO SPARVERIUS* REPRODUCIÉNDOSE EN CAJAS NIDO EN EL NOROESTE DE NUEVA JERSEY

RESUMEN.—La colocación de cajas nido puede aliviar la limitada presencia de sitios de nidificación para *Falco sparverius* a nivel local. Sin embargo, preocupa que la apertura periódica de las cajas nido o la manipulación de los adultos pueda tener efectos negativos en el éxito de cría. Se siguió 536 intentos de cría de *F. sparverius* (postura ≥1 huevo) en aproximadamente 100 cajas nido en el noroeste de Nueva Jersey, entre 1995 y 2012. Para estudiar las tasas de retorno, se capturó adultos en las cajas nidos y se los marcó con anillos provistos por el Servicio Geológico de los Estados Unidos (U.S.G.S. por sus siglas en inglés) y con etiquetas patagiales. Para examinar los posibles efectos de este tipo de disturbio, se comparó el éxito de cría (≥1 volantón sobreviviendo a la edad de anillado) de adultos marcados y no marcados. El éxito de cría fue de 67% para 270 parejas no marcadas, 76% para 25 parejas en las que sólo el macho fue marcado, 82% para 206 parejas en las que se marcó sólo a las hembras y 91% para las parejas con ambos adultos marcados. Probablemente, esta diferencia significativa refleja diferencias en la probabilidad de captura: los intentos exitosos duraron más y los padres exitosos pueden estar más atentos. Para controlar estas correlaciones, se examinaron los intentos en los que el primer evento de disturbio fue encontrar un adulto en la caja nido; el ave en cuestión voló escapando de la caja nido o fue capturada y marcada. El abandono del nido estuvo relacionado significativamente con este disturbio inicial: los intentos de cría continuaron para el 94.3% de los intentos en los que el macho escapó volando, para el 93.1% de los intentos en los que el macho fue manipulado, para el 93.7% de los intentos en los que la hembra escapó volando y para el 93.2% de los intentos en los que la hembra fue manipulada. El intento de cría tampoco difirió significativamente entre

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estos cuatro grupos de tratamientos. El periodo en el que ocurrió el primer disturbio no afectó el abandono de manera significativa; los intentos de cría continuaron en un 90% para los machos que fueron disturbados primero (escape volando o manipulación) durante el periodo de puesta de huevos, en un 94% para los machos durante el periodo de incubación, en un 97% para las hembras durante la puesta de huevos y en un 93% para las hembras durante la incubación. El éxito de cría no estuvo relacionado significativamente con el tiempo del disturbio inicial. Por lo tanto, parece que tanto la intensidad (manipulación o no) y el tiempo del disturbio no tuvieron efectos substanciales en el abandono o éxito del nido en esta población.

[Traducción del equipo editorial]

A wide range of methodologies are available to facilitate investigations of the breeding behavior and ecology of birds. These procedures often involve the capture, handling, and marking of breeding adults. The response to these disturbances can range from no apparent effect on the birds or their reproduction to abandonment of the breeding attempt and/or increased mortality of either the adults or young. In addition to the undesirable effects on the birds, disturbance also can introduce inadvertent bias into the data collected on reproductive behavior and nesting success. Rosenfield et al. (2007) reviewed the various disturbances associated with studying raptors and provided recommendations on how to minimize them.

North American populations of the American Kestrel (*Falco sparverius*) have been declining in recent decades (Farmer et al. 2008, Smallwood et al. 2009). As part of an ongoing investigation of the population dynamics of this species, I have been monitoring kestrels that breed in nest boxes in northwestern New Jersey. The disturbance to breeding kestrels included multiple visits to the nest boxes prior to egg-laying and up to the banding of young, and many of the adults were captured and marked with patagial tags. The objective of this study was to examine the effects that these disturbances, and the timing of these disturbances, might have on nesting success.

Methods

Study Area. In 1995, my field assistants and I established a nest box program for kestrels in rural northwestern New Jersey. The study area was bordered to the north and west by the Kittatinny Ridge and the Delaware River, and to the east and south by residential and commercial development. Land use was primarily agriculture, including row crops (corn and soybeans), hay, dairy, and beef production, and fragmented forest plots in the Ridge and Valley Physiographic Region (Sauer et al. 2011). Between 1995 and 1997, we erected 141 wooden nest boxes (internal dimensions: 20 × 23 cm floor, approximately 34 cm height) in Sussex County (centered approximately 41°11′N, 74°38′W) and Warren County (approximately 40°47′N, 75°04′W). We attached nest boxes to roadside utility poles, trees, and barns or other buildings in apparently suitable habitat, open patches covered by short herbaceous vegetation (Smallwood and Wargo 1997). In subsequent years, some nest boxes were lost or removed and others were erected so that about 100 nest boxes were available each year.

Monitoring of Nest Boxes. Kestrels typically produce 4- or 5-egg clutches, laying one egg every 2 d, and incubation is about 30 d, beginning with the penultimate egg (Smallwood and Bird 2002). Thus, a 5-egg clutch requires about 9 d to produce, and hatching occurs about 30 d after the onset of incubation (Bird and Palmer 1988). We considered the presence of at least one egg in the nest box to represent a breeding attempt. In this study area, clutches were initiated from March through June, but mostly in late April and early May (J. Smallwood unpubl. data). We checked each nest box by opening it and inspecting the contents at 21- to 28-d intervals from March through early July, ensuring that all breeding attempts by kestrels would be discovered during the laying or incubation stage. A clutch can be initiated and then lost to predation between two consecutive monitoring checks, and because kestrels do not bring nesting material into the nest box there may be no evidence that a breeding attempt had taken place. Thus, in our monitoring scheme, a failed attempt may go undetected, while a successful attempt cannot. However, standardizing the monitoring interval and scheduling additional visits (see below) makes estimates of nesting success comparable among years.

When a nest box was observed to contain one or more kestrel eggs, we scheduled additional visits as necessary to determine the completed clutch size, to observe the nestlings within a few days of hatching, and to band and mark them with patagial tags before they fledged. The mean number of visits to each nest when eggs or nestlings were present was 5.3, and varied from 1, a clutch present on only one visit, to 18, during a study of nestling vocal development (Smallwood et al. 2003); nests typically were visited 4–6 times. We attempted to capture adults in nest boxes by covering the entrance hole with a long-handled butterfly net, opening the side door, and carefully hand-grabbing the incubating or brooding bird. All the adults handled in this study were captured in this manner; none were trapped outside of their nest box. Once captured, each bird was banded with a U.S.G.S. aluminum leg band, individually marked with a unique vinyl-coated nylon patagial tag (Smallwood and Natale 1998, Varland et al. 2007), examined, and measured; we also plucked a single feather from the breast or side for future DNA analysis. Each bird was handled in this manner for 15–20 min, then released at the site. We never saw a bird pull on the attached tag or otherwise react to it behaviorally, and we never observed signs of injury upon subsequent examinations. We scheduled a final visit to band and tag nestlings at age 18–22 d (generally 20–22). A breeding attempt that resulted in at least one banded nestling was considered successful.

Analysis. Kestrels in this study only rarely made two breeding attempts during the same year; these 11 renests were excluded from all analyses. I categorized four levels of disturbance: neither adult was marked, only the male was marked, only the female was marked, and both adults were marked. I then compared nesting success among these four treatments using a chi-square test of independence.

When eggs were first observed in a nest box, that nest may have already failed, so that visit was not a disturbance potentially contributing to failure. To control for this possibility, I conducted a second analysis focused on how breeding attempts proceeded after known disturbance by examining only those breeding attempts in which an adult was in the nest box when a new clutch was discovered; i.e., attempts that were known to still be ongoing. The adult was either captured or not at that first disturbance; adults often flush from the nest box at the sound of the vehicle or the extension of the aluminum ladder. If we observed the bird in attendance on subsequent visits, or if the breeding attempt obviously continued, we considered that the initial disturbance had not caused abandonment. I then used Fisher's Exact Tests to compare the rates of continuation and nesting success among these four treatment groups: male flushed from nest box during first disturbance, male was handled during first disturbance, female flushed during first disturbance, and female was handled during first disturbance.

Table 1. American Kestrel pairs that experienced the greatest levels of researcher-induced disturbance also had the highest nesting success ($\chi^2 = 20.25$, df = 3, $P = 0.0002$), probably because successful breeders were more likely to be captured and marked. Data are from nest boxes in northwestern New Jersey, 1995–2012.

Disturbance Level	Number of Breeding Attempts	% Successful
Neither adult marked	270	66.7
Only male marked	25	76.0
Only female marked	206	82.0
Both adults marked	35	91.4

Results

We observed a total of 536 breeding attempts by kestrels in the nest boxes from 1995 through 2012. Overall, 74.6% of these attempts were successful. We captured and marked 301 adults (60 males and 241 females) in the nest boxes throughout the breeding seasons. For 474 breeding attempts, an adult was in the nest box when the clutch was discovered. Of those breeding attempts, 444 (93.7%) continued after the disturbance, and 373 (78.7%) were successful.

Nesting success was significantly associated with whether the adults were captured and marked (Table 1). Attempts in which neither adult was marked had the lowest success and those attempts in which both adults were marked had the highest success. For breeding attempts in which an adult was present in the nest box upon first disturbance, there was no significant association between handling and either abandonment or nesting success (Table 2). Similarly, the nesting stage during which an adult was initially flushed from or captured in a nest box also was not significantly associated with abandonment or nesting success (Table 3).

Discussion

The result that pairs of kestrels experiencing the greatest amount of researcher-induced disturbance also had the highest nesting success was unexpected. However, because this was an observational experiment rather than a controlled manipulative one, the four treatment groups (neither adult handled, only the male handled, only the female handled,

Table 2. Capturing and marking breeding American Kestrels did not increase nest abandonment (i.e., the breeding attempt continued) and did not reduce nesting success. Data are breeding attempts in which an adult was present in the nest box during the first disturbance (opening the nest box), northwestern New Jersey, 1995–2012.

Initial Disturbance	Number of Breeding Attempts	% Continued[a]	% Successful[b]
Male was flushed	87	94.3	78.2
Male was handled	29	93.1	82.8
Female was flushed	285	93.7	78.6
Female was handled	73	93.2	78.1

[a] $P = 0.97$, 2-tailed Fisher's Exact Test.
[b] $P = 0.98$, 2-tailed Fisher's Exact Test.

and both adults handled) were not randomly assigned; we captured adults when the opportunity was present; i.e., when they were encountered in a nest box. Successful pairs provided us more opportunities to capture them.

Breeding kestrels spend considerable time in the nest box both during incubation and after the eggs hatch. Both adults incubate, but most incubation is performed by the female (Smallwood and Bird 2002). The female alone broods the young throughout much of the day, from immediately after hatching until they are able to thermoregulate at about 8–10 d old (Bird and Palmer 1988). In addition, nestlings younger than about 2 wk are unable to tear apart prey, so they are fed by their parents, mostly the female (Smith et al. 1972). In this study, males were rarely observed in the nest box after the eggs hatched. The greater number of females captured in this study reflects the greater amount of time that the females spent in the nest boxes.

Table 3. The nesting stage during which breeding American Kestrels were first disturbed was not significantly related to abandonment (whether the breeding attempt continued) or to nesting success. Data are breeding attempts in which an adult was present in the nest box during the first disturbance (opening the nest box and either flushing or capturing the bird), northwestern New Jersey, 1995–2012.

Initial Disturbance	Number of Breeding Attempts	% Continued[a]	% Successful[b]
Male, during laying	10	90.0	70.0
Male, during incubation	106	94.3	80.2
Female, during laying	78	97.4	71.8
Female, during incubation	280	92.5	80.4

[a] $P = 0.35$, 2-tailed Fisher's Exact Test.
[b] $P = 0.32$, 2-tailed Fisher's Exact Test.

A successful breeding attempt, as defined above, proceeds at least until late in the nestling stage when the young are ready for banding (about 20 d). By that time, the young are well feathered and don't normally require brooding, and they are able to tear apart prey items themselves, so the adult female spends much less time inside the nest box with them. Thus, most of the time that adults spent in the nest box, and were therefore available for us to catch, had occurred by the time of our last visit.

Unsuccessful breeding attempts are of shorter duration. Most of the failures in this study occurred during incubation (J. Smallwood unpubl. data), thus cutting short the time in which we had the opportunity to capture those adults. Also, it is likely that successful adults spend more time in the nest box with eggs and/or young either because they are naturally more attentive, or perhaps because their territories contain relatively high prey densities, requiring less time foraging and freeing up more time for nest duties. It is also possible that successful adults defend their eggs and nestlings more aggressively, being more likely to remain in a nest box than to flush upon hearing an unfamiliar noise such as the researcher approaching.

Because there were more opportunities to capture successful adults, I employed a second analysis to examine the effect of our disturbance. When one or more kestrel eggs were first observed in a nest box, it is possible that that attempt had already failed. To account for that possibility, I analyzed only those breeding attempts in which an adult was in the nest box when one or more eggs were first observed, indicating that the attempt was still ongoing. That bird either flushed or was captured. The adult thus disturbed, that breeding attempt either continued or not. This analysis directly addressed whether the intensity of the initial disturbance (flushed from the nest box or captured, handled, and marked) increased abandonment. I found no evidence that it did, despite a large sample of 474 breeding attempts.

Bird species vary widely in their sensitivity to being disturbed at the nest. Atlantic Puffins (*Fratercula arctica*) are prone to abandon nests when their eggs are handled, and the young that do hatch tend to fledge later, suggesting that their growth rates were reduced (Rodway et al. 1996). Colonies of Black Skimmers (*Rynchops niger*) that were subjected to daily nest checks during incubation suffered lower hatching success than that of undisturbed colonies (Safina and Burger 1983). For Mourning Dove (*Zenaida macroura*) nests visited at 3-d intervals, nests in which the attending adult was flushed had lower daily nest survival probability (*sensu* Mayfield 1975) than nests checked at a greater distance so that the adults did not flush (Westmoreland and Best 1985). In contrast, nests of American Robins (*Turdus migratorius*) in which the eggs were handled once and the young were handled every 1–3 d had the same nesting success as controls (Ortega et al. 1997). In a 14-yr study of Cooper's Hawks (*Accipiter cooperii*) in Wisconsin, 330 nests were visited a cumulative total of >3000 times, and only four breeding attempts were known to have failed due to researcher disturbance; in each case, the female deserted after visits >1 hr during the incubation period (Rosenfield et al. 2007).

Even if the initial disturbance did not cause abandonment, it is possible that the experience, and especially wearing a patagial tag, could negatively affect the bird's ability to successfully raise young. In a preliminary study of the same kestrel population (Smallwood and Natale 1998), 40 adults from 39 pairs were marked with patagial tags while 23 pairs served as controls. No significant difference in nesting success was detected, but the small sample size yielded low statistical confidence. In the present study with a much larger sample (301 tagged adults, 536 breeding attempts), I found no evidence that wearing a patagial tag reduced nesting success.

However, negative effects on breeding performance have been found in other avian species. For example, Trefry et al. (2013) found that Magnificent Frigatebirds (*Fregata magnificens*) that underwent wing-tagging in combinations with other procedures including banding, measuring, and bleeding, had lower nesting success, and they suggested that although no immediate negative effect of handling was evident, the tags may have impaired the aerodynamic functioning of the wing. In their study, frigatebirds wore wrap-around tags in which the fabric contacted the leading edge of the wing. The importance of tag design and its effect on the wing was discussed by Varland et al. (2007).

Finally, I expected that kestrels would be sensitive to disturbance early in the breeding attempt, but would be less prone to abandonment later on; i.e., kestrels would be more likely to abandon small investments than large investments. Increased sensitivity to disturbance early in nesting has been observed in Northern Pintails (*Anas acuta*), Gadwall (*A. strepera*), and Northern Shovelers (*A. clypeata*; Garrettson et al. 2011), Black-crowned Night-Herons (*Nycticorax nycticorax*; Tremblay and Ellison 1979), Franklin's and Laughing gulls (*Leucophaeus pipixcan* and *L. atricilla*; Burger 1981), and Tree Swallows (*Tachycineta bicolor*; Burtt and Tuttle 1983, Cohen 1985). In the present study, kestrels first disturbed during laying were no more likely to abandon than those first disturbed during incubation, and their nesting success also did not differ significantly.

In summary, breeding American Kestrels are highly tolerant of disturbance, including capturing them in the nest box, handling them, and marking them. Patagial tags greatly facilitate individual identification in the field, and appear to be safe for the bird and not detrimental to breeding success. This finding has important implications in selecting protocols for future research. In many ways, kestrels are an ideal species for studying the behavior and ecology of wild raptors.

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