Florida Field Naturalist

PUBLISHED BY THE FLORIDA ORNITHOLOGICAL SOCIETY

VOL. 20, NO. 3 AUGUST 1992 PAGES 57-88

Fla. Field Nat. 20(3):57-64, 1992.

USE OF NEST BOXES BY THE FLORIDA KESTREL[1]

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Abstract.—From 1978 to 1984, the Duval Audubon Society monitored nest boxes for kestrels in Clay and Putnam counties, Florida. In 164 opportunities, kestrels produced 41 nests. Fifty-three kestrels are known to have fledged from 16 nests. If kestrels were already present in an area they would use the nest boxes. However, kestrels were not attracted to new areas by placement of the nest boxes. Nest boxes placed in longleaf pine/turkey oak habitat were used more frequently and had more young fledge from them than nest boxes placed in or near pastures. European Starlings were the most important competitor for the use of nest boxes. Results of this study suggest that placing nest boxes in pastures or areas where kestrels are not already present may not be effective in increasing kestrel populations in Florida.

The Southeastern American Kestrel (*Falco sparverius paulus*) is classified as "threatened" by the Florida Council on Rare and Endangered Plants and Animals (Wiley 1978). Hoffman (1983) documented an 85% decline in breeding kestrels in Alachua and Levy counties since 1940. In most other parts of their range, both inside and outside Florida, the decline has also been serious (Imhof 1976). Kestrels formerly ranged throughout Florida, except on the Lower Keys (Howell 1932), but the subspecies has now been extirpated over most of its former range (Woolfenden and Robertson, in press). Pesticides have impacted many raptors, and are known to cause reproductive failure in captive kestrels deliberately dosed with high levels of organochlorides (Porter and Wiemeyer 1969), but wild kestrels nesting in Florida do not seem to have high levels of pesticide residues in their eggs (Hoffman 1983). Lack of habitat is the most probable cause of the decline, but foraging habitat such as pastures and roadsides is abundant in Florida. Therefore, the lack of suitable

[1]This paper is dedicated to the memory of Mrs. Jack ("Virg") Markgraf, who first encouraged the Duval Audubon Society to undertake this project.

nesting cavities has been suspected to be the limiting factor for kestrels in Florida (Hoffman 1983).

Several authors have suggested that nest boxes might be an effective way to augment shrinking populations of this falcon (Wiley 1978, Hoffman 1983, Bohall-Wood and Collopy 1986). Kestrels readily accepted boxes in other parts of their range (Hamerstrom et al. 1973, Bloom and Hawks 1983, Spicer and Field 1975). To examine this in Florida, the Duval Audubon Society maintained boxes for kestrels for eight years, from 1977 to 1984. The goals of the project were: (1) to increase the kestrel population by providing nest sites, (2) to learn about kestrel management in Florida, and (3) to gather information about kestrel breeding behavior and basic biology.

Methods

Clay County was selected as the nearest area to Jacksonville where kestrels were breeding (Sam Grimes and Joyce Williams, pers. comm.) In January of 1977 I assisted the Duval Audubon Society in erecting 25 boxes along a continuous route across the county from just south of Orange Park through Penney Farms and ending at Grandin, just across the line into Putnam County. We secured the permission of the landowners and placed the boxes 3.5 to 4 m high in lone trees in pastures and on the edges of pastures. Starting in 1978, we placed boxes in longleaf pine (*Pinus palustris*)/turkey oak (*Quercus laevis*) sandhill habitat in Gold Head Branch State Park.

Boxes were constructed from standard pine lumber in two sizes to ascertain which size was best for kestrels. One box was based on 10-inch (25-cm) lumber and the other on 8-inch (20-cm) lumber. Both boxes were about 38 cm deep with a 7.6 cm diameter hole. Boxes were placed in three types of habitat (pastures, edges of pastures, and sandhills) to test which was best for kestrels. Pasture boxes were placed in lone trees in the middle of a pasture. Edge boxes were placed on the edge of a pasture (entrance facing the pasture) with woods behind. Sandhill boxes were placed in open longleaf pine/turkey oak associations. At the beginning of the project most boxes were pasture boxes because we assumed that by providing nest sites where they were not available, we would be benefiting the kestrels more than by placing boxes in habitats where at least some natural cavities were available. Kestrels sometimes abandon nests after human disturbance (Hamerstrom et al. 1973) so boxes were checked from the ground only for the first three years, then with a ladder to avoid leaving a scent trail for predators.

Results

Kestrels bred 41 times in 164 opportunities. Sixteen attempts were successful while 18 failed. The outcome is unknown in seven cases. Fifty-three young kestrels are known to have fledged (Table 1). Boxes were used 32 times by European Starlings (*Sturnus vulgaris*), eight times by Great Crested Flycatchers (*Myiarchus crinitus*), eleven times by flying squirrels (*Glaucomys volans*), four times by gray squirrels (*Sciurus carolinensis*), once by a Northern Flicker (*Colaptes auratus*), once by an Eastern Screech-Owl (*Otus asio*), and once by an Eastern Bluebird (*Sialia sialis*).

Table 1. Nest box history of use. Of a total of 41 kestrel nests, 16 were successful in producing one or more fledglings, 18 nests failed, and the success of 7 nests was not determined. A total of 53 kestrels are known to have fledged from the 16 nests.

Box[a]		Year[b]								No. of kestrel nests	No. of kestrels fledged
No.	Habitat	1977	1978	1979	1980	1981	1982	1983	1984		
1	P	ES	GS	NA						0	0
2	P	ES	ES	ES						0	0
3	P	NA								0	0
5	P	ES	NA	NA						0	0
8	P	ES	ES	NA		ES				0	0
10	P	ES	ES	NA						0	0
11	P	ES	NA	NA						0	0
13	P	ES	NA	ES	NA	ES				0	0
14	P	GC	NA	GC	GC	NA	FS	FS		0	0
16	P		NA	KU	GC	EB	ES	ES	ES	1	0
17	P	ES	NA	ES	–	ES	NA	ES	NA	1	0
18	P	NA	NA	NA	ES	NA	ES	ES	ES	0	0
23	P	NA	NA	NA	FS	FS	+(2)			1	2
24	P	NA	GC	NA	–	NA	NA	NA	–	2	0
26	P		NA	NA	FS	GC	ES	FS	FS	0	0
27	P		NA	NA	+(1)	NA	ES	ES	ES	1	1
4	E	ES	GS							0	0
6	E		NA	NA						0	0
7	E	ES	GS			NA				0	0
9	E	NA	FS	NA						0	0
19	E	ES	NA	ES						0	0
20	E	NA	GS	NA	NF					0	0
21	E	KU	KU	–	+(3)	+(4)	–	–	NA	7	7
22	E	NA	FS		NA	NA	NA	NA	NA	0	0
25	E	NA	KU	NA	+(4)	+(5)	+(3)	–	–	6	12
12	L		NA	NA						0	0
15	L	NA	NA	NA	GC	FS	GC	SO		0	0
28	L		NA	NA	+(4)	+(4)	+(2)	+(2)	KU	5	12
29	L		NA	NA	–	+(3)	+(4)	+(5)	NA	4	12
30	L						NA	–	KU	2	0
31	L			NA			–	–	NA	2	0
32	L						–	FS	–	2	0
33	L						+(4)	–	–	3	4
35	L						NA	–	KU	2	0
36	L						+(3)	–		2	3
Total										41	53

[a]P = pasture; E = edge; L = longleaf pine/turkey oak

[b]NF = Northern Flicker; ES = European Starling; GS = gray squirrel; EB = Eastern Bluebird; GC = Great Crested Flycatcher; FS = flying squirrel; SO = Eastern Screech-Owl; KU = kestrel nest but success unknown; NA = no activity; no symbol = box not available; + = successful kestrel nest; – = failed kestrel nest; number of kestrels fledged in parentheses

Mean clutch size was 4.06 eggs per nest and ranged from one to five eggs. The average number of young fledged per successful nest was 3.25 and nest success averaged 47%. Of 44 fledglings whose sex is known, 22 were males and 22 were females. Some nests had as many as four of one sex and one of the other. No nest with more than two fledglings contained all of either sex.

The earliest clutch found was an incomplete set of 2 cold eggs on 29 March. According to Newton (1977), kestrels lay every other day, so this would give an early egg date of 27 March 1981. Another clutch of five eggs was found in the same box in late April that hatched by 24 May, but it may or may not have been laid by the same pair. Some pairs were still laying eggs as late as 10 May. The latest that chicks were still in the box was 1 August 1983. One of these hatched on 22 June and the other after that; therefore, chicks can stay in the boxes up to 40 days.

In this study, virtually all egg laying occurred during a six-week period from 1 April to 15 May. Most chicks were in the nest during a six-week period from 1 May to 15 June in this study, but this may not reflect the nesting schedule of all kestrels nesting in boxes in northcentral Florida (J. Smallwood, pers. comm.)

Renesting after nest failure occurred twice; one attempt failed while the other succeeded. Double brooding has been reported for kestrels in Florida (Howell 1932), in other parts of their range (Stahlecker and Griese 1977), and in captivity (Porter and Wiemeyer 1972), but we saw no evidence of it.

Of 40 opportunities, edge boxes were accepted 13 times, but this represents only two boxes used repeatedly. One edge box was used seven times in successive years, while another was used six times in seven years. The first box succeeded twice and failed three times with two unknown outcomes. The other box succeeded three times and failed twice, with one unknown outcome. The chances of an accepted edge box succeeding was about 50% with the mean number of young fledged about 3.8 from successful nests (Range 3-5, SD = 0.837, $N = 5$).

Sandhill boxes were readily accepted by kestrels. Out of 41 opportunities, 21 boxes were accepted. This represents eight boxes: one used five years in succession; one for four years; one for three years; four for two years; and one used two times in three years. Every box that was placed and maintained in sandhill habitat where kestrels were known to be present and breeding (Gold Head Branch State Park) was accepted by kestrels at least twice. Sandhill boxes were successful at about the same rate as edge boxes. We had nine successful nests in sandhills while 10 failed with three unknown. When sandhill boxes were successful, they fledged relatively large numbers of young (range 2-5, $\bar{x} = 3.4$, SD = 1.014, $N = 9$).

Out of 83 opportunities in sixteen boxes, five pasture boxes were used by kestrels six times (7.2%). Two attempts were successful while three failed with one unknown. We found about a 4% chance that a pasture box would be successful if it was located near a population of kestrels. However, even when a pasture box was successful, few young fledged. In one case, only one young fledged, in the other case only two.

DISCUSSION

We were unable to document a single case of nest abandonment due to our visits. In 1982 a pair abandoned three chicks after a visit from us, but we did not handle the female or flush her off the nest. For the first three years we monitored the nests by watching from a distance, but when we began to put a ladder up to the nest to inspect the contents directly, we did not find that the success rate declined. For example, in 1981 we were inspecting nests regularly and not a single nest failed. In 1982, when 18 young fledged from nine nests we also were inspecting nests directly. We conclude that kestrels are fairly tolerant of human activity at the nest and most can be flushed from the nest and even caught on the nest without abandonment.

Some pairs were much more willing than other pairs to approach the nest while humans were present. The first pair to nest in one of our boxes showed no reluctance to feed the young while humans were present, so we mistakenly assumed that all pairs would behave similarly. We discovered our mistake in the fourth year of the project when I climbed to a box which had shown no activity of any kind and found four young kestrels! This made it evident that we had probably overlooked other nests of "shy" pairs.

A kestrel nest box project could be managed with only three visits to each box annually: the first visit, about March 1, to clean out and repair boxes, a second visit about 15 May to count and band young, and a final check on about 15 July to ascertain fledging. Because young kestrels defecate on the sides of the box and even on the roof, one can often determine that a box has fledged a brood by examination of the condition of the inside of the box at the end of the season. If the interior of the box is liberally plastered with excrement, a large brood probably fledged from that box.

Most pairs made no attempt to defend the nest. Typically, adults left the area as we approached, or flew to a nearby perch and watched silently while we inspected the nest. When the nest contained eggs, the adults seldom vocalized, but if chicks were present, the adults were more likely to scold, especially if one of the chicks vocalized. Those pairs that did defend the nest limited their defense to flying directly at the observer

and flaring off, usually silently, without coming close to contact. There is an instance in the literature (Anonymous 1982) of a female kestrel twice hitting a human's arm and drawing blood, but this apparently is quite rare.

Since lumber comes in standard sizes, it is most practical to build nest boxes based on either 10-inch or 8-inch boards. Many sources recommend a box based on 10-inch lumber (e.g., Hamerstrom et al. 1973, Bohall-Wood and Collopy 1986) while others suggest an 8-inch square floor (Terres 1968). In a detailed study of cavity size Hoffman (1983) found that Florida kestrels readily accepted old holes of the Pileated Woodpecker (*Dryocopus pileatus*) or the Northern Flicker (*Colaptes auratus*), but that holes of the Red-headed Woodpecker (*Melanerpes erythrocepalus*) are often too small. We experimented with boxes based on 10-inch lumber in the early part of the program, but found that a smaller box, based on 8-inch lumber, was as readily accepted as the larger box and had ample room to fledge up to five young kestrels. The box should be at least 45 cm deep to discourage predators, with a 7.6-cm hole 10 cm down from the top. Smaller boxes are lighter, easier to transport, cheaper, and stay in place longer because there is less strain on the nail holding the box to the tree. A toe block to support the weight of the box from beneath is highly recommended.

Unless kestrels are present in an area, there is a very small chance that they will be attracted to a pasture where a nest box is available. After the first three years we abandoned the 12 boxes on the route which were farthest from kestrel breeding areas, because no kestrels were seen in the vicinity and the boxes regularly were occupied by starlings. The seven pasture boxes that were nearest to natural populations of kestrels were the boxes most used in this habitat.

Pasture boxes were much more likely to be taken by starlings than by kestrels. In 1980, Peggy Powell (pers. comm.) watched an agonistic encounter between a pair of European Starlings and a male kestrel at a pasture box. After a serious fight, the starlings retained possession of the box. Other studies have assumed that lack of nesting cavities, lack of foraging habitat, or pesticides have been the cause of the decline of the kestrel in Florida, but none have mentioned competition with the European Starling. Competition for nest sites also appears to be an important factor.

Considering all boxes that were in the field for more than just one year, starlings occupied 12 of 15 pasture boxes, three of nine edge boxes, and none of the 10 sandhill boxes. Three pair-wise comparisons using Fisher's exact tests controlling experiment-wise error rate by multiplying each P-value by the total number of comparisons (Snedecor and Cochran 1980) indicates: (1) the difference between pasture boxes and edge boxes in the occurrence of starlings was not significant

($P=3\times0.032=0.096$), (2) edge boxes did not differ significantly from sandhill boxes ($P=3\times0.087=0.261$), and (3) the difference between pasture boxes and sandhill boxes was significant ($P=3\times0.0001=0.0003$). Overall, pasture and edge boxes were more likely to be occupied by starlings (15 of 24 boxes) than sandhill boxes ($P=0.0007$). Because of competition for nest sites with starlings, placing nest boxes in pastures in Florida may not be an effective way to manage kestrels, despite the fact that it has been successful in other parts of the country (Hamerstrom et al. 1973). To discourage the use of kestrel nest boxes by starlings, the inside of the box should be painted white. This is very important if the box is to be located in open habitat because light interiors reportedly discourage starlings but are accepted by kestrels (P. Bohall-Wood, pers. comm.; Curley et al. 1987).

In addition to the European Starling, the gray squirrel and possibly the flying squirrel may be serious nest competitors. Gray squirrels filled the nest boxes to the top with leaves making them unsuitable for kestrels. Unless the box is cleaned in early spring, kestrels will not use it.

Great Crested Flycatchers often used boxes, but they return from their wintering grounds only after kestrels start breeding activity; thus they are not serious competitors.

The influence of habitat on success is difficult to quantify because of small sample sizes. The sample of known outcomes in pastures (two successes and three failures) is too small to be treated separately, but they may be pooled with the known edge outcomes which gives seven successes and eight failures in pasture/edge habitats versus nine successes and 10 failures in sandhills. For this comparison, $\chi^2=0.002$, $df=1$, and $P=0.97$. A Fisher's exact test, which is better for small samples, generates a P-value of 0.62. Thus the difference in success rate between habitats is no more than what may be expected by chance.

This small sample size makes it difficult to detect a difference between success rates in different habitats even if there is one. Nesting attempts occurring in the same box in different years probably do not constitute independent samples because multiple attempts probably involve one or both of the same birds nesting more than once and individual birds almost certainly differ in their reproductive abilities. Thus, the appropriate sample is the number of boxes that were active in at least one year and have known outcomes ($N=14$), rather than the total number of nesting attempts. A Fisher's exact test yields a P-value of 0.41; therefore, a significant difference in success rates between habitats was not detected.

It is evident that once a box is accepted in Florida, it is very likely to be accepted again. This is not necessarily true of migratory populations of kestrels. In Wisconsin Hamerstrom et al. (1973) found no tendency for boxes to be used in successive years. Southeastern Kestrels stay on their territories year-round and use the same nest site in successive years.

The best management strategy probably is to erect large numbers of inexpensive boxes in likely places. Those boxes that are accepted should then be carefully maintained and the others abandoned. Sandhills apparently provide the most suitable habitat for Southeastern American Kestrels, not only in terms of starling competition, but also the availability of natural cavities in longleaf pine and perhaps available prey base. This is not surprising, since *F. s. paulus* presumably evolved in this habitat and is particularly adapted to it. However, the sandhills are themselves an endangered habitat, and a management plan for kestrels probably should not rely too heavily on sandhills as the primary habitat for kestrels. If current land practices continue, kestrels may soon be forced to depend on other habitats such as pastures and highway rights-of-way.

ACKNOWLEDGMENTS

I express sincere appreciation to all the Duval Audubon members who worked on this project, especially Peggy Powell and Marion Hines. I also thank Peter Merritt, Peter Bloom, and, especially, John Smallwood for helpful comments on the manuscript.

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