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GREAT CRESTED FLYCATCHER (*Myiarchus crinitus*) NEST-SITE SELECTION AND NESTING SUCCESS IN TREE CAVITIES

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Abstract.—Nesting ecology of the Great Crested Flycatcher (*Myiarchus crinitus*) has rarely been studied, even though the species is widespread and relatively common. I provide here the first study of Great Crested Flycatcher nesting ecology and nest-site selection in tree cavities in the eastern United States. I monitored 44 Great Crested Flycatcher nests in a mosaic of slash pine plantations and longleaf pine sandhills in Clay County, Florida. Nest sites were located in slash pine (52%), turkey oak (39%), longleaf pine (7%), and unknown pine species (2%). Most (73%) Great Crested Flycatcher nests were located in abandoned tree cavities excavated by various species, especially the Red-bellied Woodpecker (*Melanerpes carolinus*). Cavity entrance diameters averaged 6.2 (± 2.5) cm, with most (55%) measured entrances smaller than the minimum previously reported for the species. These findings are contrary to earlier characterizations of the species as showing a strong affinity for large naturally occurring hollows in live trees. Only 19 of 44 Great Crested Flycatcher nests (43%) were successful in fledging ≥1 young. Mean cavity height was greater for successful nests than for unsuccessful nests, and the primary cause of nest failure was predation. Most flycatcher nests in oaks were located in the understory <3 m above ground where they were particularly vulnerable to predation. More research is needed on the relationships between nest-site selection and nesting success for cavity-nesting species in fire-suppressed habitats with a significant hardwood component.

Nesting ecology of the Great Crested Flycatcher (*Myiarchus crinitus*) has rarely been studied, even though the species is widely distributed and relatively common in the eastern United States. Data that do exist are almost entirely from nest boxes (Taylor and Kershner 1991, White and Seginak 2000). Nest boxes can differ from natural nest sites in several respects, including physical dimensions, condition, longevity, and susceptibility to nest predators (e.g., Moller 1989, Koenig et al. 1992, Lambrechts et al. 2010). Therefore, data from nest box studies potentially may yield an incomplete or misleading picture of nest predation rates, competition for nest sites, and other interspecific interactions.

Bent (1942) and Lanyon (1997) speculated that the Great Crested Flycatcher prefers to nest in naturally occurring tree hollows instead of in cavities excavated by woodpeckers, but they provided no quantitative data. I provide here the first study of nest-site selection for a Great Crested Flycatcher population using tree cavities in the eastern United States. The objectives of this study were to describe nest-site characteristics and nesting success of the species and elucidate the species' position within the cavity web context (*sensu* Martin et al. 2004, Blanc and Walters 2008) of the cavity-nesting bird community. These data can be used in developing a clearer understanding of the habitat requirements for this common yet rarely studied bird.

Study Area

I studied Great Crested Flycatchers as part of a larger study of the cavity-nesting bird community inhabiting a range of pinelands in north central Florida (Miller 2000). I conducted my research at Camp Blanding Training Site, a Florida Army National Guard facility encompassing approximately 30,000 ha in the sandhills of Clay County, Florida. My field assistants and I searched for nests of cavity-nesting birds in a pine mosaic dominated by slash pine (*Pinus elliottii*) plantations (even-aged, 35-42 years old) interspersed with longleaf pine (*P. palustris*) stands (uneven-aged, with a significant component of >60 year-old trees), several of which were occupied by Red-cockaded Woodpeckers (*Picoides borealis*). Understory woody species were generally absent in mesic sites and mostly limited to turkey oak (*Quercus laevis*) saplings and small trees in drier, sandier sites. Shrubs, which rarely exceeded heights of 1.5 m, included saw palmetto (*Serenoa repens*), gallberry (*Ilex glabra*), and other ericaceous species. Most nest searching focused on twelve 10-ha plantation study plots, one 16-ha plantation with a well-developed turkey oak understory, and on a few adjacent longleaf stands of varying sizes. For additional study area details see Myers (1990) and Miller (2000).

Methods

My field assistants and I located Great Crested Flycatcher nests by following adult behavioral cues and by systematically searching for and investigating tree cavities (Martin and Geupel 1993). Once located, each nest was monitored regularly at 3-4 d intervals to assess nesting status (Martin and Geupel 1993, Ralph et al. 1993). Nests located <4m above ground were reached with a stepladder and the contents checked with a light and dental mirror to determine clutch size and nest status. During 1995-1997, most cavities ≥4 m high in dead trees (snags) were monitored from the ground through observation of adult behaviors (e.g., carrying nest material or food into the cavity; Martin and Geupel 1993, Ralph et al. 1993, Martin et al. 1997). In 1998, most cavities ≥4 m high were monitored with a video probe mounted on a telescoping fiberglass pole (TreeTop II, Sandpiper Technologies, Inc., Manteca, California, USA).

I determined clutch size for nests that were accessible by ladder or by video probe. I developed site-specific values for the length of incubation (14 d) and nestling (15 d) periods through inspection of nests. I considered a nest to be successful if it produced ≥1 fledgling. Nestlings were considered to have fledged if they were alive when checked within 1d of expected fledging and subsequent checks showed no evidence of predation or disturbance to the nest (Martin et al. 1997). I visited nest territories within 1-2 d after the expected date of fledging to attempt visual confirmation of the fledglings.

Analyses of nest success included only data from nests in which at least one egg was laid. I calculated daily survival rates for the incubation and nestling stages with the Mayfield method (Mayfield 1961, 1975) as modified by Hensler and Nichols (1981). Because daily survival rates for the two stages did not differ (standard normal Z test, $P > 0.05$), I calculated a single daily survival rate for the entire nesting cycle and used that to estimate overall nesting success. For each nest site, I recorded tree species and condition and measured nest height and tree height with a clinometer. Cavity dimensions were measured to assist in identifying the source (i.e., excavator species) of cavities; measurements were taken from a ladder while the tree was standing or later after subsequent tree fall. When possible, I recorded the width of the cavity opening, the depth of the cavity (measured from the bottom of the cavity to the lower lip of the cavity entrance), and the maximum inside width of the cavity. Nest attributes of successful and unsuccessful nests were compared with Mann-Whitney U tests and Fisher's exact tests.

Results

Great Crested Flycatchers returned to the study area each year beginning the third week of March and began pairing up and building nests in April. Flycatchers often re-nested after nest failure, but no evidence of double brooding was observed. I found and monitored 44 Great Crested Flycatcher nests, with clutch initiation dates ranging from 22 April to 28 June. Fifty percent of all clutches found were initiated by 7 May. Clutch size was determined at 28 (64%) of these nests and averaged 4.9 (range 4-6).

Most nest sites were located in pine snags. Nest trees included slash pine (52%), turkey oak (39%), longleaf pine (7%), and unknown pine species (2%). Close monitoring of tree cavities used by cavity-nesting birds in consecutive years (Miller 2000) allowed identification of the source of most cavities used by Great Crested Flycatchers. Most (73%) Great Crested Flycatcher nests were located in abandoned tree cavities excavated by various species, while only 12 (27%) were located in naturally occurring tree hollows and crevices. The Great Crested Flycatcher thus exhibited a greater reliance on excavated cavities than did some of the other secondary cavity nester species occurring in the study area (Table 1; Miller 2000).

The source of the excavated cavities used by Great Crested Flycatchers included Red-bellied Woodpeckers (*Melanerpes carolinus*; n=20), Northern Flickers (*Colaptes auratus*; n = 2), Carolina Chickadees (*Poecile carolinensis*, n = 2), Pileated Woodpeckers (*Dryocopus pileatus*; n = 1), and Red-cockaded Woodpeckers (n = 1). Excavator species could not be determined for 6 flycatcher nest sites. A close relationship was apparent between the Red-bellied Woodpecker and the Great Crested Flycatcher (Table 1); any Red-bellied Woodpecker cavity that remained intact and was not reused by woodpeckers in its second year was usually occupied by Great Crested Flycatchers. I observed aggressive interactions between these two species at several Red-bellied Woodpecker nest sites, although flycatchers were never able to usurp a cavity occupied by woodpeckers. On at least one occasion, Great Crested Flycatchers nested in a Red-bellied Woodpecker cavity within the same breeding season following the woodpecker's initial nesting attempt.

Not all study plots had a turkey oak understory or midstory, but when oaks did occur, Great Crested Flycatchers used both pines and oaks. Most flycatcher nest sites in oaks were located <3 m above ground in the naturally occurring hollows created by branch scars and knotholes. In one instance, flycatchers nested in a small natural cavity formed between the trunks of a forked pine tree.

Cavity dimensions were taken at 20 flycatcher nests. Mean (± SD) cavity entrance diameter was 6.2 (± 2.5) cm. Although entrance diameters ranged from 4.0 to 13.3 cm, most (55%) measured entrances

Table 1. Source of cavities used by secondary cavity nester species, Clay County, Florida. Species codes: RBWO = Red-bellied Woodpecker, CACH = Carolina Chickadee, BHNU = Brown-headed Nuthatch, GCFL = Great Crested Flycatcher, TUTI = Tufted Titmouse, EASO = Eastern Screech-Owl, EABL = Eastern Bluebird. See text for scientific names.

	Cavity origin					
Secondary cavity nester	RBWO	Other woodpecker	CACH and BHNU	Unknown excavator	Natural cavities	Total
GCFL	20	4	2[1]	6	12	44
TUTI	1	1	1	3	8	14
EASO	0	2	0	1	5	8
EABL	1	0	3	0	0	4

[1]Chickadee excavations were enlarged by unknown avian or mammalian species prior to their use by flycatchers.

were ≤5.0 cm. Cavity depth and inside cavity width averaged 29.2 (± 12.3) cm and 11.3 (± 3.4) cm, respectively. Mean nest cavity depth was larger in oaks than in pines (33.1 cm versus 19.2 cm; Mann-Whitney, 1-tailed, $P = 0.04$). However, cavity depth was not correlated with clutch size ($r_s = 0.14$, $P = 0.65$).

Nineteen of 44 Great Crested Flycatcher nests (43%) were successful in fledging at least one young. However, many nests failed during the incubation period, which resulted in relatively low estimates of daily survival rate. Years pooled, daily survival rate (± SD) was 0.965 (± 0.007), yielding an overall Mayfield estimate of nest success of 0.353. At least 18 nests failed because of nest predation, one nest was abandoned during the incubation period, and one nest in a pine snag failed because the tree fell. Without cameras at nests, I was unable to document the relative importance of nest predators, but evidence gathered from a companion study on nest boxes in the study area (Miller 2002, Miller and Leonard 2010) suggested that southern flying squirrels (*Glaucomys volans*) and rat snakes (*Elaphe* spp.) were the primary species of nest predators. In addition, one nest failure in this study was attributed to usurpation by nesting Wood Ducks (*Aix sponsa*).

Mean height of successful nests was significantly greater than mean height of unsuccessful nests (7.5 m versus 2.9 m; Mann-Whitney, 1-tailed, $P = 0.032$). The proportion of nests that were successful did not differ between pines and oaks (Fisher's exact, 2-tailed, $P = 0.54$). However, it should be noted that all four nests in cavities >10 m above ground were successful (Fig. 1) and all of those were located in pines. Nearly all (88%) nests in oaks were located <3m above ground.

DISCUSSION

Great Crested Flycatchers breeding in a mosaic of slash pine plantations and longleaf pine sandhills primarily used tree cavities excavated by Red-bellied Woodpeckers. The Red-bellied Woodpecker and Great Crested Flycatcher were the most abundant primary (i.e., excavator) and secondary cavity nester species, respectively, in this system (Miller 2000), and overlap in nest-site selection likely reflected their abundance and similar body size. Similarly, Great Crested Flycatcher nest-site selection closely overlapped that of Red-headed and Red-bellied Woodpeckers in riparian forests in Iowa (Stauffer and Best 1982). Although the Red-headed Woodpecker was formerly the most common woodpecker in peninsular Florida (Dennis 1951), widespread habitat changes and perturbations have resulted in the Red-bellied Woodpecker becoming the primary cavity engineer in the contemporary Florida landscape (Miller 2000; personal observation).

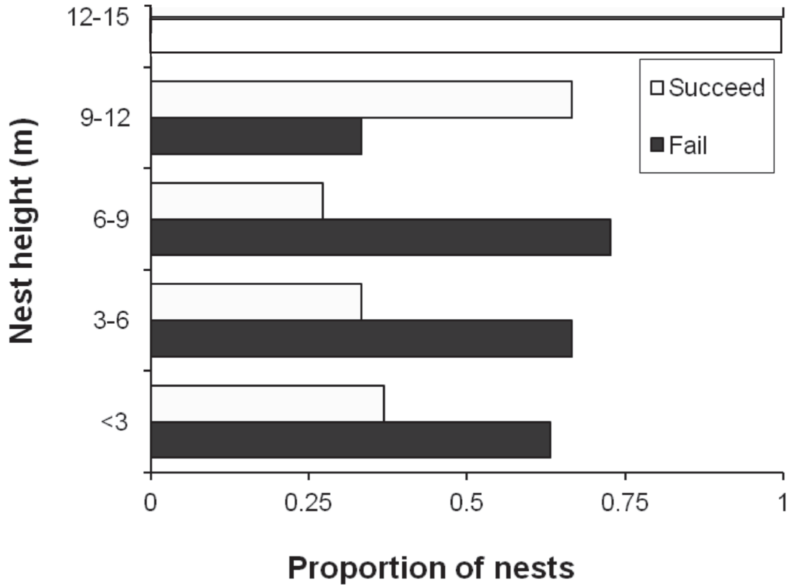

Figure 1. Height of successful Great Crested Flycatcher (*Myiarchus crinitus*) nests was significantly greater than height of unsuccessful nests (Mann-Whitney, 1-tailed, *P* = 0.032), Clay County, Florida.

In an old-growth longleaf pine forest, the Northern Flicker was the primary cavity provider for the American Kestrel and Eastern Screech-Owl while the Red-bellied Woodpecker was the primary cavity provider for the Great Crested Flycatcher and Tufted Titmouse (Blanc and Walters 2008).

Characterizations of the Great Crested Flycatcher as closely associated with natural tree hollows in live trees (Bent 1942, Peck and James 1987, Lanyon 1997) were not supported by the present study, where the Great Crested Flycatcher demonstrated greater affinity for abandoned cavities excavated by woodpeckers and other species. Although the present study did not inventory all cavities to compare used versus available cavities, it compared usage patterns among species and confirmed that flycatchers used natural cavities less frequently than other secondary cavity-nesters. These results underscore the importance of local variation in resource availability on nest-site selection. Secondary cavity nesters are more likely to be nest-site limited in younger forests and in forests dominated by conifers because they are structurally less complex than mature deciduous forests (Brawn and Balda 1988, Waters et al. 1990, Walter and

Maguire 2005, Wesolowski 2007, Miller 2010). Therefore, within the pine-dominated southeastern coastal plain, it is likely that the Great Crested Flycatcher will be widely reliant on cavities excavated in pine trees by medium- and large-bodied woodpeckers.

In addition, the present study refines our understanding of the size appropriateness of nesting substrates. Cavity entrance diameters in this study (4.0 to 13.3 cm, n = 20) were somewhat smaller than those reported in Ontario (5 to 18 cm, n = 7; Peck and James 1987). Most striking was the fact that most (55%) measured entrances in this study were smaller than the minimum previously reported (Peck and James 1987, Lanyon 1997). These data can be useful when designing nest-box management programs to attract, or deter, particular species.

Great Crested Flycatcher nest success appeared to be lower in this system than previously reported for nest boxes in central Florida (Taylor and Kershner 1991) or nest boxes in South Carolina (White and Seginak 2000), but comparisons are difficult given differing field methods, differing analytical methods, and a lack of information about predator communities in the respective studies.

Finally, higher nests were more likely to be successful than nests located close to the ground (Fig. 1). Great Crested Flycatcher nest sites in oaks tended to be closer to the ground, where they were more vulnerable to nest predators. Nest predation is an important selective pressure for cavity-nesting birds (Nilsson 1984, Li and Martin 1991), and the study system had a rich assemblage of nest predators (see Miller 2000, 2002) including rat snakes which are excellent climbers (e.g., Jackson 1970, Neal et al. 1993, Withgott and Amlaner 1996, Leonard 2009). Although point-count studies have demonstrated associations between various bird species and hardwood vegetation in fire-suppressed sandhills (e.g., Provencher et al. 2002, Allen et al. 2006, Steen et al. 2013), few data are available about higher-order habitat selection (*sensu* Johnson 1980) and its associated demographic effects. Presence of a hardwood understory or midstory may provide alternative nest sites for the Great Crested Flycatcher and other cavity-nesting species (Miller 2000; Leonard 2005; this study) but consequently also reduce nesting success. More research is needed on the relationships between nest-site selection and nesting success for cavity-nesting species in fire-suppressed habitats with a significant hardwood component.

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