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NESTING SUCCESS OF KENTUCKY AND HOODED WARBLERS IN BOTTOMLAND FORESTS OF SOUTH CAROLINA

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ABSTRACT.—We studied the nesting success of Kentucky Warblers (*Oporornis formosus*) and Hooded Warblers (*Wilsonia citrina*) in 15 bottomland hardwood forests on the Savannah River Site, South Carolina, during 1993–1994. The Mayfield success rate for Kentucky Warbler nests (N = 26) and Hooded Warblers nests (N = 33) was 34.7% and 28.7%, respectively. The daily survival rate for Kentucky Warbler nests (0.952, SE = 0.018) did not differ ($P = 0.157$) from that for Hooded Warbler nests (0.941, SE = 0.014). Successful Kentucky Warbler pairs fledged more ($P < 0.001$) young (3.7, SE = 0.2) than Hooded Warbler pairs (2.7, SE = 0.2). Hatch-year birds comprised a greater ($P < 0.01$) proportion of captured individuals for Kentucky Warblers (hatch-year:after-hatch-year = 2.2) than for Hooded Warblers (hatch-year:after-hatch-year = 0.4), possibly reflecting the greater number of young produced per successful nest for the former, and suggesting differences in post-fledging survival or in fledgling behavior between the species. *Received 17 May 1996, accepted 7 Dec. 1996.*

Bottomland hardwood forests support some of the highest bird densities in the southeastern United States (Dickson 1978). Many of the priority species of the Partners in Flight priorization scheme, including Kentucky Warblers (*Oporornis formosus*) and Hooded Warblers (*Wilsonia citrina*), rely on these forests as breeding and stopover habitat (Hunter et al. 1993a, 1993b). Both of these warblers inhabit the understories of moist deciduous forests in the region and are considered forest-interior specialists (Sprunt and Chamberlain 1949, Whitcomb et al. 1981). Hooded Warblers generally nest in low shrubs (Kilgo et al. 1996a) and forage within 5 m of the ground, whereas Kentucky Warblers nest (Kilgo et al. 1996b) and forage near ground level (Powell and Rappole 1986). Our objective was to quantify the nesting success rates of these two warblers in various-sized bottomland hardwoods on the Savannah River Site (SRS), South Carolina, and to identify the factors that limited nesting success.

STUDY AREA AND METHODS

Study sites were on the 77,891-ha SRS in the upper coastal plain of South Carolina. Bottomland hardwood forests (N = 15) ranged in width from <50 m to >1000 m and were bordered by extensive mature pine forest (*Pinus taeda* and *P. palustris*). Bottomland over-

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stories were dominated by sweetgum (*Liquidambar styraciflua*), water oak (*Quercus nigra*), and swamp tupelo (*Nyssa sylvatica* var. *biflora*). Dominant mid-story species included American holly (*Ilex opaca*), red bay (*Persea borbonia*), and ironwood (*Carpinus caroliniana*), and the understory species consisted of switchcane (*Arundinaria gigantea*), dog-hobble (*Leucothoe axillaris*), and Christmas fern (*Polystichum acrostichoides*).

We searched each site for nests every 1–2 weeks during May–July 1993 and 1994. Time expended searching each site was proportional to the average width of that site (i.e., twice as much time was expended searching for nests in a 300-m-wide bottomland as was spent searching in a 150-m-wide bottomland). We monitored the status of each nest following the procedures of Martin and Geupel (1993). We used the techniques of Best and Stauffer (1980) to assess the outcome of each nesting attempt. We calculated the daily survival rates (DSR) of nests and Mayfield success rates (Mayfield 1961, 1975). We assumed that the nest survival rates for the incubation and nestling intervals were similar within species because sample sizes were limited (Klett and Johnson 1982). Differences in nest DSRs between species were tested with a two-tailed *Z*-test. We compared Mayfield nest success rates between species using 2 × 2 Chi-square contingency tables. Student's two-sample *t*-test was used to compare the number of young fledged per successful nest between species.

We captured birds in mist nets in 11 of these sites during 7 July–29 July 1994. In each site, 10 nets (2.5 × 10 m, 30 mm mesh) were deployed along the center of the corridor, one every 30 m. We netted each site for two consecutive days, removed the nets for two weeks, then repeated the procedure. We banded each bird and aged them by their plumage, molt, skull pneumatization, or reproductive condition (Pyle et al. 1987). We calculated hatching-year (HY) to after-hatching-year (AHY) ratios for Kentucky and Hooded warblers as an additional index of reproductive success (Ralph et al. 1993). Recaptures were not included in the HY:AHY analysis. We compared the proportion of captured HY individuals between species using 2 × 2 Chi-square contingency tables.

RESULTS

Mean hatch and fledge dates for Kentucky Warbler nests were 4 June (N = 22; range = 17 May–10 July) and 14 June (N = 19; range = 26 May–19 July), respectively. The corresponding dates for Hooded Warbler nests were 13 June (N = 26; range = 11 May–20 July) and 24 June (N = 17; range = 19 May–29 July), respectively. Nests of both warblers generally were found in bottomlands averaging ≥300 m in width (Kentucky Warbler nests = 61.5%; Hooded Warbler nests = 66.7%). However, both species successfully fledged young in smaller sites, even bottomlands <50 m in width.

Successful Kentucky Warbler pairs fledged more ($t = 3.92$, $P < 0.001$, 34 df) young (3.7, SE = 0.2) than did successful Hooded Warbler pairs (2.7, SE = 0.2) (Table 1). Nest success rates did not differ ($\chi^2 = 0.052$, $P > 0.05$) between species. Daily survival rates for the nesting cycle were 0.952 for Kentucky Warblers and 0.941 for Hooded Warblers and were not significantly different ($Z = 0.482$, $P = 0.157$).

No Kentucky Warbler nests were parasitized by Brown-headed Cowbirds (*Molothrus ater*). Six (18.2%) Hooded Warbler nests were parasitized, containing an average of 1.2 cowbird eggs (Table 1). Host young

TABLE 1

PRODUCTIVITY ESTIMATES FOR KENTUCKY WARBLERS AND HOODED WARBLERS IN BOTTOMLAND HARDWOOD FORESTS ON THE SAVANNAH RIVER SITE, SOUTH CAROLINA, 1993–1994

Parameter	Kentucky Warbler	Hooded Warbler
Active nests	26	33
Mean clutch size	4.2 (6; 0.4)[a]	3.0 (14; 0.0)
Young fledged/successful nest	3.7 (19; 0.2)	2.7 (17; 0.2)
Mayfield success rate (%)	34.7 (145)[b]	28.7 (272)
Daily survival rate	0.952 (0.018)[c]	0.941 (0.014)
Nests parasitized by cowbirds	0	6
Cowbird eggs/parasitized nest		1.2 (0.2)[c]
Host eggs/parasitized nest		1.7 (0.2)

[a] Sample size and standard error.
[b] Number of nest exposure days.
[c] Standard error.

successfully fledged from just one of these parasitized nests. Predation accounted for 87% of nest failures, including all Kentucky Warbler nest failures, and 81.3% of Hooded Warbler nest failures (Table 2). Mayfield-corrected nest depredation rates were 65.3% and 57.9% for Kentucky Warblers and Hooded Warblers, respectively. Most depredated nests were found empty and undisturbed.

Excluding recaptures, we netted 47 Hooded Warblers and 29 Kentucky Warblers, representing the most- and third-most abundant species captured in these sites. Hatch-year birds comprised a greater proportion ($\chi^2 = 9.61$, $P < 0.01$) of captures for Kentucky Warblers (HY:AHY = 2.2) than for Hooded Warblers (HY:AHY = 0.4). No cowbirds were netted.

TABLE 2

PROBABLE CAUSES (%)[a] OF NESTING FAILURE FOR KENTUCKY WARBLERS AND HOODED WARBLERS IN BOTTOMLAND HARDWOOD FORESTS ON THE SAVANNAH RIVER SITE, SOUTH CAROLINA, 1993–1994

Nest outcome	Kentucky Warbler	Hooded Warbler
Success	73	52
Predation: nest undisturbed	23	27
Predation: nest disturbed	4	12
Cowbird parasitism[b]	0	3
Abandoned	0	3
Weather	0	3

[a] Apparent nest percentages.
[b] Only nests for which failure could be attributed solely to parasitism.

DISCUSSION

Robinson (1992) reported a Mayfield success rate of 22% (N = 3 nests) for Kentucky Warbler nests in small Illinois woodlots. Martin (1992), in a review of nest studies conducted in a variety of habitats, reported a mean Mayfield success rate of 42% and a mean apparent success rate of 44%. Mayfield nest success rates from our study were low by comparison, particularly for Hooded Warblers, while apparent success rates were relatively high. Although our data were below average productivity estimates for these species elsewhere, the paucity of nest success data from the southeastern United States for Kentucky Warblers and Hooded Warblers renders our conclusions tenuous.

The HY:AHY ratios were higher than those of Neotropical migrants captured in small (i.e., <65 ha) Illinois woodlots (but see Bollinger and Linder 1994) and were within the range of ratios (0.4-1.0; total HY:AHY = 0.1) reported for much larger forests in southern Illinois (Robinson 1992). Hatch-year Kentucky Warblers proportionally were more common in our bottomland sites than were HY Hooded Warblers, suggesting that Kentucky Warblers had greater reproductive success. Because the Mayfield analysis indicated similar reproductive success for these species, differences in the proportion of HY birds may be explained, in part, by the greater mean clutch sizes of Kentucky Warbler nests. Differences in the proportion of HY birds also may be due to dissimilar post-fledging survival or dissimilar fledgling behavior (i.e., Kentucky Warbler fledglings may have been more susceptible to capture), or may reflect differences in the frequency of double brooding between the species.

Predation appears to have been the principal cause of nesting failure in our study, as frequently reported elsewhere (Martin 1992). Stutchbury and Howlett (1995) reported annual nest depredation rates of 38.3% to 50% for Hooded Warblers in northwestern Pennsylvania. The mean depredation rate for Hooded Warbler nests (57.9%) in this study was similar to these results. The depredation rate for Kentucky Warbler nests (65.3%) also was comparable to most studies (Martin 1992, Robinson 1992) but was high relative to nest depredation rates for ground-nesting warblers in upland hardwoods of Arkansas (Martin 1993).

Nests of these warblers commonly are parasitized by Brown-headed Cowbirds in the midwestern and northeastern United States (Friedmann 1963, Evans Ogden and Stutchbury 1994). Brood parasitism rates were moderate for Hooded Warbler nests in this study, and no parasitism was observed for Kentucky Warbler nests. The Brown-headed Cowbird is considered an uncommon species in the SRS region in summer (Norris 1963, Post and Gauthreaux 1989). The lack of cowbirds captured during netting,

and the dearth of observations of this species during a concurrent census study (J. C. Kilgo, unpubl. data), suggest that cowbirds are uncommon in these bottomland sites.

Robbins (1979) estimated that 30 ha was the minimum area required to sustain viable populations of Hooded and Kentucky Warblers in Maryland woodlots. Although both species successfully reproduced in small bottomlands in this study, including sites <50 m in width, all of our sites were enclosed by mature pine forest. This mature timber habitat minimized edge contrast and may have increased the functional size of the bottomland forests, thereby improving the suitability of these sites as nesting habitat for these warblers (Harris 1984). Further research is needed regarding the value of the forest matrix for songbirds nesting in riparian forests. Maintenance of riparian forests in landscapes dominated by a pine forest matrix appears to be essential to the conservation of Kentucky and Hooded Warblers in the southeastern U.S.

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