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REPRODUCTIVE SUCCESS AND NESTING HABITAT OF LOGGERHEAD SHRIKES IN NORTH-CENTRAL SOUTH CAROLINA

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ABSTRACT.—Breeding Loggerhead Shrikes (*Lanius ludovicianus*) were studied in the Piedmont physiographic region of north-central South Carolina during the breeding seasons of 1986 and 1987. Sixty-three percent of shrike nests were in red cedar (*Juniperus virginiana*). Shrikes nesting in red cedar fledged one more young per nest than did shrikes nesting in other trees. First nests were significantly lower and somewhat closer to the trunk of the nest tree than were second nests, suggesting that climatic effects during the nesting season affected nest placement. Within 100 m of shrike nests, short-grass habitats (e.g., pasture, hay fields, and residential lawns) predominated, comprising, on average, more than 80% of the area. Short vegetation around nests may result in increased prey availability. The relatively high reproductive success of Loggerhead Shrikes in this study is similar to that reported by researchers elsewhere, and it does not explain the recent decline in shrike populations in the region. *Received 29 Sept. 1988, accepted 15 Jan. 1989.*

Despite a broad distribution that extends coast to coast from southern Canada to Mexico, populations of Loggerhead Shrikes (*Lanius ludovicianus*) have recently declined over much of North America (Arbib 1972, Bystrak and Robbins 1977, Bystrak 1981, Geissler and Noon 1981, Morrison 1981, Robbins et al. 1986). Currently, the Loggerhead Shrike is listed as "endangered" in New York, Michigan, and Wisconsin; and as "threatened" or "watch" in several other states (Haas 1987). Audubon Society Christmas Bird Counts indicate that wintering populations of shrikes in southeastern Atlantic coastal states experienced a 22% decline between 1961 and 1978, the most severe decline reported for any region (Morrison 1981). Although habitat destruction has been suggested as a possible cause of population declines in both Illinois and Missouri (Graber et al. 1973, Kridelbaugh 1982), there are no studies of shrike reproductive success and habitat use in the southeastern Atlantic coastal region of the United States. Here, we (1) describe the results of a 2-year study of the nesting habitat and reproductive success in a population of Loggerhead Shrikes in north-central South Carolina, and (2) discuss our results in light of recent population declines.

STUDY AREA AND METHODS

We studied shrikes during the breeding seasons of 1986 and 1987 in the Piedmont physiographic region in central York County, South Carolina. The 33,518-ha study site consisted

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of pastures and small fields of row crops (mainly cotton, soybean, and corn) interspersed with hardwood forests and scattered residences.

From February to August each year, the study area was searched primarily from the road, and all areas where shrikes were sighted were observed intensively for signs of nesting with 7× binoculars and a 20× spotting scope. Nests were found by following the flight paths of adult shrikes carrying nest material or food. Areas where shrikes were sighted were rechecked frequently, and the first nest found in each territory was considered to represent a first nesting attempt; however, several first nests that failed early in the nesting cycle may have been missed. Nests were checked periodically to determine nesting success (% of nests that fledged at least one young), hatching success (% of eggs laid that hatched) and fledging success (% of young hatched that fledged). Nestlings that were at least 14 days old were considered to have fledged. After fledging, young were inconspicuous and difficult to find, and the number of fledglings may have been underestimated.

We observed house cats (*Felis catus*) near nests on several occasions in 1986. In 1987, each time a cat was seen in a shrike territory, we recorded its presence and distance from the nest.

In 1986, adult and juvenile shrikes were banded with a single aluminum U.S. Fish and Wildlife Service numbered leg band. In 1987, unique combinations of three plastic colored leg bands and one U.S. Fish and Wildlife Service aluminum band were placed on captured birds. The seams of colored bands were sealed with acetone to reduce the likelihood of their removal by shrikes.

Modified bal-chatri traps (Clark 1968) and bow nets baited with crickets, lab mice, or nestling shrikes were used to trap adults. The most effective method of trapping adults was to place their nestlings in bow nets within 5 m of a nest. This procedure did not appear to affect subsequent adult behavior.

To limit the disturbance of breeding birds, we waited to measure nesting habitat until after the young had fledged. After fledging, we recorded nest location (in relation to roadsides, fields, residences, hedgerows, and isolated trees), nest-tree species, and the dominant vegetation within 2.5 m of the nest tree. We defined isolated trees as trees that were separated from other trees by at least 50 m. Nest height, tree height, tree canopy width, height of the lowest branch on the nest tree, and the relative position of the nest in the tree were measured with a clinometer, meter stick, and compass. We assessed exposure of the nest tree by measuring the percent of obstruction by adjacent foliage within 1 m of the nest tree.

To assess the importance of habitat parameters in shrike territories, we estimated the percent of each habitat type within 100 m (3.1 ha) of each nest. Distance from nests to nearest fence, hedgerow, road, building, and woodlot were measured directly with a distance measuring wheel (<200 m) or were estimated (>200 m).

Measurements of the vegetation height and density within 10 m of the nest tree were taken with a Robel pole (Robel et al. 1970). Four 10-m transects, the first determined randomly, were aligned at right angles from the nest tree. Three equidistant measurements were taken along each transect for a total of 12 measurements per nest. Dominant vegetation type at each measurement site was recorded.

The direction of the nest from the tree trunk for eight first nests and seven second nests was measured with a compass.

RESULTS

We found 22 shrike nests between 17 March and 16 July 1986, and 27 nests between 24 March and 12 July 1987. We believe that these nests

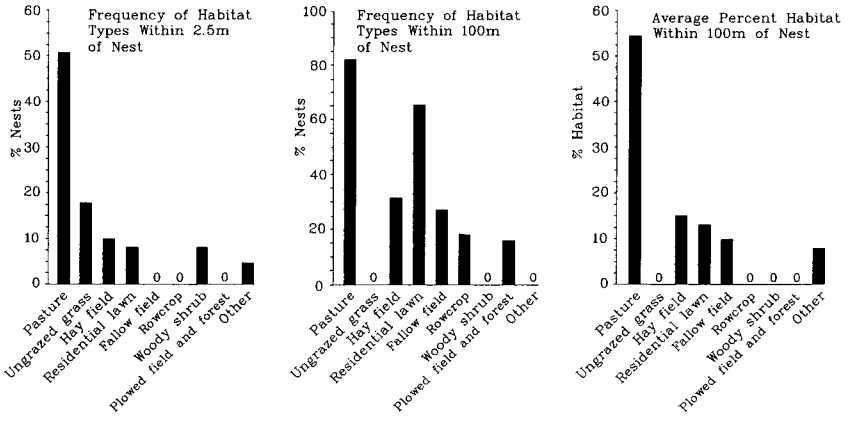

FIG. 1. Habitat types near Loggerhead Shrike nests in north-central South Carolina.

represented the majority of shrike nests in the study area each year. Thirty-seven (76%) nests were in fields of approximately 5–60 ha, and 8 (16%) were within 9 m of the center of a road. Four (8%) nests were in residential lawns. Shrikes nesting in fields and along roads usually nested in fencerows or hedgerows. All nests in residential lawns were in isolated trees. Fifty-seven percent (28) of the nests were in rows of trees or shrubs; the remaining nests were in isolated trees.

Pasture comprised an average of 54% of the habitat within 100 m of nests; hay fields, residential lawns, and fallow fields made up most of the remaining habitat. Pasture occurred within 100 m of 18 (82%) nests, and residential lawns occurred within 100 m of 16 (65%) nests. Hay fields, fallow fields, rowcrops, and plowed or forested land all were recorded less frequently. Pasture was the dominant habitat within 2.5 m of 25 nests (51%), while ungrazed grasses, hay fields, residential lawns and woody shrubs occurred less frequently (Fig. 1). Vegetation within 10 m of nests usually was low, with a mean Robel reading of 7.5 ± 6.4 cm (N = 49).

Thirty-one nests (63%) were found in red cedar (*Juniperus virginiana*), four (8%) in hackberry (*Celtis laevigata*), three (6%) in live oak (*Quercus virginiana*), two (4%) in black cherry (*Prunus serotina*), and one nest each (2%) in the following: winged elm (*Ulmus alata*), grape vine (*Vitis* sp.), holly (*Ilex opaca*), honey locust (*Gleditsia triacanthos*), white oak (*Quercus alba*), water oak (*Q. nigra*), persimmon (*Diospyros virginiana*), loblolly pine (*Pinus taeda*), and an unidentified tree.

The average nest site is depicted in Figure 2. The distance at nest height

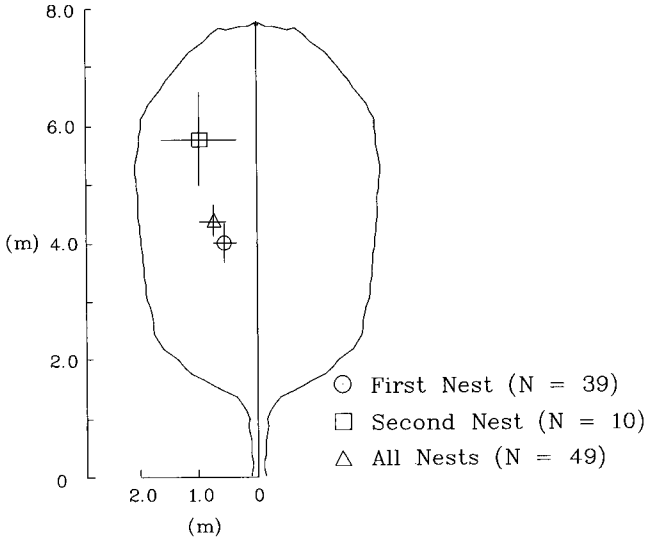

FIG. 2. Position of Loggerhead Shrike nests in trees in north-central South Carolina.

from the trunk to the canopy edge was significantly greater in 1987 than in 1986 (t-test, $t = 2.12$, df = 45, $P < 0.05$). Shrikes nested significantly higher in 1987 than in 1986 (t-test, $t = 2.09$, df = 47, $P < 0.05$), and, although nest-tree height did not differ between years (t-test, $t = 0.95$, df = 47, $P > 0.05$), relative nest height (nest height as a function of nest-tree height) also was greater in 1987 than in 1986 (t-test, $t = 2.23$, df = 47, $P < 0.05$) (Table 1).

First nests were significantly lower than were second nests ($\bar{x} = 4.00 \pm 1.99$ m, N = 39 vs $\bar{x} = 5.75 \pm 2.45$ m, N = 10, t-test, $t = 2.49$, df = 47, $P < 0.05$), and there was a nonsignificant tendency for first nests to be closer to the trunk than were second nests ($\bar{x} = 0.59 \pm 0.98$ m, N = 37 vs $\bar{x} = 1.41 \pm 1.47$ m, N = 10, t-test, $t = 1.67$, df = 46, $0.10 > P > 0.05$). The direction of the nest from the tree trunk tended to be more southerly in first nests than in second nests ($\bar{x} = 165° \pm 73$, N = 8 vs $\bar{x} = 265° \pm 72$, N = 7).

Nests were closer to utility lines (t-test, $t = 2.21$, df = 47, $P < 0.05$) in 1986 than in 1987, but there were no differences in the distances of nests to fencerows, hedgerows, roads, buildings, or woodlots between years (Table 1).

Of the 49 nests found, six (12.2%) represented second nestings following a failed first nesting, and four (8.2%) represented second nestings following a successful first nesting. Second nests were more difficult to find than

TABLE 1

NEST-SITE CHARACTERISTICS OF LOGGERHEAD SHRIKES IN NORTH-CENTRAL SOUTH CAROLINA, 1986 AND 1987

Nest-site characteristics	1986	1987	Both years	P[a]
Nest-tree exposure (%)	81.6 ± 29.8 (22)[b]	88.8 ± 16.9 (27)	85.6 ± 23.6 (49)	$P > 0.05$
Nest height[c] (m)	3.7 ± 1.2 (22)	4.9 ± 2.6 (27)	4.4 ± 2.2 (49)	$P < 0.05$
Nest-tree height	7.2 ± 2.3 (22)	8.2 ± 4.7 (27)	7.7 ± 3.8 (49)	$P > 0.05$
Relative nest height	0.5 ± 0.2 (22)	0.7 ± 0.4 (27)	0.6 ± 0.3 (49)	$P > 0.05$
Height of lowest nest-tree branch	1.4 ± 0.7 (22)	1.5 ± 1.0 (26)	1.5 ± 0.9 (48)	$P > 0.05$
Distance from trunk to:				
nest	0.5 ± 0.8 (21)	0.9 ± 1.6 (26)	0.8 ± 1.3 (47)	$P > 0.05$
canopy edge	1.4 ± 0.9 (21)	2.5 ± 2.4 (26)	2.0 ± 2.0 (47)	$P < 0.05$
Distance from nest to:				
fencerow	14.1 ± 19.3 (22)	21.7 ± 36.5 (27)	18.3 ± 30.0 (49)	$P > 0.05$
hedgerow	26.7 ± 36.8 (7)	25.9 ± 38.9 (6)	26.3 ± 36.2 (13)	$P > 0.05$
utility line	42.1 ± 40.2 (22)	75.2 ± 62.0 (27)	60.3 ± 55.4 (49)	$P < 0.05$
road	73.8 ± 68.4 (22)	95.7 ± 90.7 (27)	85.9 ± 81.4 (49)	$P > 0.05$
building	102.0 ± 68.7 (22)	133.1 ± 109.2 (27)	119.1 ± 93.6 (49)	$P > 0.05$
woodlot	226.0 ± 116.2 (22)	199.9 ± 105.2 (27)	211.6 ± 109.8 (49)	$P > 0.05$

[a] Significant difference between years using *t*-tests.
[b] $\bar{x}$ ± SD (N).
[c] All distances and heights are in meters.

TABLE 2
REPRODUCTIVE SUCCESS OF LOGGERHEAD SHRIKES IN NORTH-CENTRAL SOUTH CAROLINA, 1986 AND 1987

	1986	1987	Both years
Clutch size	5.3 ± 0.8 (6)[a]	5.2 ± 0.6 (14)	5.3 ± 0.6 (20)
Number young hatched per nest	4.8 ± 1.4 (15)	4.1 ± 1.9 (22)	4.4 ± 1.8 (37)
Number young fledged per nest	3.3 ± 2.4 (22)	2.8 ± 2.5 (27)	3.0 ± 2.5 (49)
Number young fledged per successful nest	4.6 ± 1.5 (16)	4.8 ± 1.0 (16)	4.7 ± 1.3 (32)
Hatching success	100.0% (5)[b]	92.6% (13)	94.7% (18)
Fledging success	94.4% (15)	83.5% (19)	88.3% (34)
Nesting success	72.7% (22)	59.3% (27)	65.3% (49)

[a] $\bar{x}$ ± SD (N).
[b] Mean percent (N).

were first nests, mainly because after the first brood fledged, male shrikes were often feeding up to five fledglings, as well as an incubating female, and we may have missed some of the latter feeding activity. Most renesting occurred within one week of failed nestings. First and second nests did not differ in clutch size, hatching success, nesting success, fledging success, number of young fledged per nest, or number of young fledged per successful nest; nor was there any difference among all nests from 1986 versus 1987 in these measures (all t-tests and χ^2 tests, $P > 0.05$, Table 2).

After we combined data for both years, both the number of young hatched per nest (t-test, $t = 3.22$, df = 34, $P < 0.05$) and the number of young fledged per successful nest (t-test, $t = 2.18$, df = 30, $P < 0.05$) were significantly greater for nests in red cedar than for nests in other species of trees (Table 3). And, although none of the differences were significant, shrikes nesting in red cedars had higher hatching, fledging, and nesting success than those nesting in other species of trees (Table 3).

Nesting success of shrikes nesting in isolated trees was 76.2% (N = 21), compared with 57.1% (N = 28) for nests in fence and hedgerows; however, the difference was not significant ($\chi^2 = 1.19$, df = 1, $P > 0.05$).

The nesting success of shrikes breeding within 100 m of pasture averaged 70.0%, compared with 44.4% for those that nested further from pasture ($\chi^2 = 1.18$, df = 1, $P > 0.05$), and shrikes nesting near pasture fledged 1.4 more young per nest than those nesting further from pasture (3.3 ± 2.4, N = 40 vs 1.9 ± 2.4, N = 9, $t = 1.58$, df = 47, $P > 0.05$); however, neither of these differences was significant.

In 1987 cats were observed in 10 shrike territories that had 13 nesting

TABLE 3

REPRODUCTIVE SUCCESS OF LOGGERHEAD SHRIKES NESTING IN RED CEDAR AND OTHER SPECIES OF TREES IN NORTH-CENTRAL SOUTH CAROLINA, 1986 AND 1987

	Nests in red cedar	Nests in other species of trees
Clutch size	5.4 ± 0.7 (11)[a]	5.1 ± 0.6 (9)
Number young hatched per nest	5.2 ± 0.9 (21)	3.5 ± 1.9 (15)
Number young fledged per nest	3.4 ± 2.5 (31)	2.4 ± 2.3 (18)
Number young fledged per successful nest	5.0 ± 1.1 (21)	4.0 ± 1.3 (11)
Hatching success	98.3% (10)[b]	90.2% (8)
Fledging success	90.9% (21)	83.0% (13)
Nesting success	67.7% (31)	61.1% (18)

[a] $\bar{x}$ ± SD (N).
[b] Mean percent (N).

attempts. Nesting success was 53.8% in these territories, compared with 71.4% for nests where no cats were observed ($\chi^2 = 0.29$, df = 1, $P > 0.05$).

Two shrikes were found dead on the road. One was an adult that had been dead for several days when it was found about 150 km from the study area. The other was a color-banded juvenile that had fledged the previous week from a nest 23 m from where the carcass was found. There were no utility lines or other obstructions in the area with which the fledgling could have collided. Shrike feathers were scattered along the road within 2 m of the carcass. Juveniles and adults from the nest were seen foraging along the same road.

DISCUSSION

Loggerhead Shrikes nested more frequently in red cedar, which is common in disturbed fields, than in any other species of tree. In central South Carolina, 120 km S of our study site, where red cedar is less common, shrikes also used it as a nest tree more often than any other species (Cely and Corontzes, unpubl. data). In Virginia, shrikes used red cedar and hawthorn (*Crataegus* spp.) more than expected based on availability (Luukkonen 1987). In general, red cedar appears to be a preferred nest tree for shrikes wherever shrikes and cedars co-occur (Graber et al. 1973; Siegel 1980; Kridelbaugh 1982, 1983; Luukkonen 1987). Luukkonen (1987) suggested that nests in cedar and hawthorn were more concealed than nests in other locations. In South Carolina, the amount of cover provided

by red cedar may be especially important early in the nesting season when deciduous trees have not yet leafed out. In Colorado, outside the range of red cedar, where shrikes selected thorny trees, Porter et al. (1975) hypothesized that the degree of cover a plant provided was more important than the particular species of tree. Hawthorns have thorns and red cedars have prickly needles that may discourage predators. Reduced predation due to the presence of thorns has been documented previously in a study of Long-tailed Tits (*Aegithalos caudatus*) in England (Lack and Lack 1958). In north-central South Carolina, shrikes that nested in red cedar, on average, fledged one more young per nest than did shrikes that nested in other trees (Table 3). Similarly, in Alabama, shrikes that nested in red cedar and osage orange (*Maclura pomifera*) had higher nesting success than did shrikes that nested in other tree species (Siegel 1980). Kridelbaugh (1983), however, working in Missouri, found that shrikes that nested in deciduous trees had higher nesting success than did those that nested in red cedar. In Virginia, nest success did not change with species of tree (Luukkonen 1987).

In our study first nests were significantly lower and somewhat closer to the trunks of nest trees than were second nests, a trend that has been noted by previous researchers (Kridelbaugh 1983, Luukkonen 1987, Cely and Corontzes, unpubl. data). First nests were on the southerly sides of trees more often than were second nests. Placement of nests in trees appears to be determined by the opposing factors of predation and wind (cf. Horvath 1964, Collias and Collias 1984). Shrikes are typically one of the earliest nesting passerines (Kridelbaugh 1983), and their eggs and young may be subject to periods of harsh weather (Porter et al. 1975, Kridelbaugh 1983). In Missouri, predation was the major cause of nest failure in the first breeding season studied, and high winds and rains were responsible for the greatest number of nest failures in the second breeding season (Kridelbaugh 1983). Similarly, in Colorado, although predation was the major cause of nest failure overall, hail and heavy thunderstorms accounted for 9 of the 12 failed nests in 1970 (Porter et al. 1975). In our study, early in the year, shrikes placed their nests on the south side of trees, lower and closer to the trunks. Presumably, they did so to take advantage of the less windy microclimate and greater protection from inclement weather, despite the probable increased risk of predation. Later in the year as temperatures increased, shrikes oriented their nests on the west side of trees, higher and further from the trunks, presumably to make the nest more difficult for ground predators to reach, or, possibly, to impede the development of a search image by predators (cf. Collias and Collias 1984).

Pasture was the most conspicuous habitat component, both within 2.5

m and 100 m of shrike nests (Fig. 1). Similarly, in Missouri 67% of shrike nests were surrounded by pastures (Kridelbaugh 1983). In Colorado, shrikes nested in grasslands more frequently than in cultivated areas (Porter et al. 1975); and, in Alabama, 65% of shrike nests were in hedgerows associated with pastures or cultivated fields (Siegel 1980).

Shrikes that nested within 100 m of pasture fledged 1.4 more young per nest than did shrikes that nested farther from pasture. Similarly, in Virginia shrikes were more productive in, and were more likely to reoccupy areas dominated by pastures (Luukkonen 1987). In West Germany, the number of young Red-backed Shrikes (*L. collurio*) fledged per nest was greater in pastures than in other habitats, and shrikes occupied this habitat longer than they did other habitats (Brandl et al. 1986).

Lawns and hay fields also appeared to be heavily used by shrikes in north-central South Carolina, where, when combined with pastures, these habitats occupied over 80% of the 100-m area sampled around all nests. In Missouri, Kridelbaugh (1982) reported that shrikes preferred grassy habitats (i.e., lawn, pasture, and hay fields) and avoided rowcrops when establishing breeding territories. All of these habitats provide (1) permanent grassland (i.e., land not tilled regularly), (2) routine disturbances by mowing or grazing, and (3) lower vegetation than similar undisturbed grassy habitats.

The presence of short vegetation near nests in this study was apparent from the low Robel readings obtained within 10 m of nests. In West Germany, Red-backed Shrikes that nested in pastures had increased prey available to them (Brandl et al. 1986). The American Kestrel (*Falco sparverius*), which is sometimes considered an ecological counterpart of the Loggerhead Shrike in portions of its range, exhibits reduced hunting success with increasing height of vegetation (Toland 1987).

Shrikes characteristically hunt from unobstructed perches including utility lines and exposed branches (Craig 1978). This hunting technique allows shrikes to scan the territory for predators, and, simultaneously to perform intraspecific displays and hunt for food, at a low energetic cost (Craig 1978). Increased hunting efficiency as a result of shorter vegetation would be especially important during the breeding season when adults are providing approximately 165 food items per day to their nests (Gawlik unpubl. data).

Shrikes are generalists that prey on the most abundant and obtainable food source within their dietary range (Miller 1931). Shrikes are known to capture prey flushed by farm machinery (Caldwell 1986), and in north-central South Carolina shrikes capitalize on recently plowed or mowed fields by frequently foraging in these areas soon after the disturbance. The extent to which shrikes use a recently discovered food source was made

TABLE 4
REPRODUCTIVE SUCCESS OF LOGGERHEAD SHRIKES IN NORTH AMERICA

Location	Number of nests	Mean clutch size	Nesting success (%)	Hatching success (%)	Number fledged per successful nest	Reference
Southern Illinois[a]	20	5.7	80	—	4.6	Graber et al. (1973)
Central Illinois[a]	25	5.6	71	—	4.8	Graber et al. (1973)
Colorado	77	6.4	66.2	79.5	5.4	Porter et al. (1975)
Illinois[a]	13	5.2	72.0	—	3.9	Anderson and Duzan (1978)
Alabama	37	5.0	43.2	84.7	—	Siegel (1980)
Missouri	55	5.7	69.1	85.3	—	Kridelbaugh (1982)
Virginia[a]	57	5.1	62.1	90.6	4.0	Luukkonen (1987)
South Carolina	49	5.3	65.3	94.7	4.7	This study

[a] The Mayfield method was used to calculate reproductive success.

apparent on several occasions when a clear plastic tray containing approximately 40 crickets was placed within 20 m of a nest. The adult that discovered the food source repeatedly took crickets from the tray to the nestlings until all of the crickets were gone or until the bird was captured.

Shrikes often forage and nest along roads (Robertson 1930; Miller 1931; Graber et al. 1973; Craig 1978; Luukkonen 1987; Cely and Corontzes, unpubl. data, this study), leading some researchers to suggest that collisions with vehicles are a major cause of shrike mortality (Robertson 1930, Miller 1931). Sixteen percent of shrike nests we found were in roadside hedges or fencerows less than 9 m from the center of a road, and we saw shrikes foraging in the mowed strip along roads on numerous occasions. Robertson (1930), reported that in his study area in California, shrikes were the fourth most common roadkilled species observed. Based on these observations, Miller (1931) estimated that 2–7% of that population died as a result of collisions with vehicles. In Virginia, Luukkonen (1987) reported that 17.6% of his known mortality cases were juveniles that were probably killed by vehicles. He cautioned, however, that his sample was biased towards conspicuous carcasses found on roads, and might not be representative of the population. In our study, the two known cases of shrike mortality appeared to be due to collisions with vehicles.

Predation supposedly accounts for many of the reported cases of shrike mortality (Porter et al. 1975, Kridelbaugh 1983); however, actual predation rarely has been observed. Although no incidents of predation were observed in our study, domestic cats and black rat snakes (*Elaphe obsoleta*) commonly were seen near shrike nests, and there was a non-

significant tendency for nesting success to be lower at nests where cats had been observed. Adult shrikes vigorously swooped at and hovered over cats and snakes until the intruders were out of the territory or out of sight, suggesting that both cats and snakes pose a recognized threat to shrikes.

Reproductive success of shrikes in South Carolina is similar to that reported by researchers in other areas (Table 4). Kridelbaugh (1983) suggested that, despite considerable annual variability, shrike reproductive success was still high for an open-nesting passerine in the North Temperate Zone and concluded that factors other than reproductive success were responsible for the decline of shrike populations in Missouri. Similarly, in Illinois, although shrikes had high reproductive rates, fall populations remained low (Graber et al. 1973). Productivity data from our study support the notion that shrikes are fledging high numbers of young in areas where populations are declining and they suggest that population declines in the southeastern U.S. do not result from low reproductive success.

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