DIFFERENTIAL HABITAT USE BY SYMPATRIC LOGGERHEAD SHRIKES AND AMERICAN KESTRELS IN SOUTH CAROLINA

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ABSTRACT.—Loggerhead Shrikes (*Lanius ludovicianus*) and American Kestrels (*Falco sparverius*) appear to occupy similar habitats; however, many North American shrike populations are declining while those of most kestrels are increasing. Our habitat models, based on discriminant function analysis, indicate that in South Carolina, USA, shrikes and kestrels exhibit substantial habitat separation; shrikes and male kestrels are more similar in their use of habitats than are shrikes and female kestrels. In general, shrikes inhabit areas dominated by short, grassy vegetation while kestrels are found in large, open areas of cropland. Also, shrikes perch lower and over taller vegetation than do kestrels. Female kestrels inhabit more open areas than do male kestrels, which are more closely associated with grassy habitats and woodland. Declines in shrike populations may be tied to the decline in short, grassy vegetation throughout much of their range.

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Loggerhead Shrikes (*Lanius ludovicianus*) and American Kestrels (*Falco sparverius*) hunt primarily from perches, feed mostly on insects, and appear to inhabit similar habitats (Miller 1931, Roest 1957, Bildstein and Grubb 1980). Contrastingly, populations of Loggerhead Shrikes have declined during the last 20 years (Geissler and Noon 1981, Morrison 1981, Robbins et al. 1986), possibly due to habitat loss (Brooks and Temple 1990b; Gawlik and Bildstein 1990, 1993; Tyler 1992), whereas kestrel populations have increased over most of North America (Fuller et al. 1987).

This apparent inconsistency led us to investigate the possibility that sympatric shrikes and kestrels exhibit habitat separation. The objectives of our study were to (1) determine the extent to which shrikes and kestrels in South Carolina use the same habitats and (2) identify which habitat variables, if any, best separate shrikes and kestrels.

STUDY AREA AND METHODS

We conducted road surveys from a vehicle with a single observer approximately every two weeks from October 1985 to July 1987. Our 277-km route extended from York County in north-central South Carolina to Georgetown County in coastal north-eastern South Carolina (Gawlik 1988). To reduce directional and time biases, we initiated and concluded each survey 56 km (one-fifth of the route) from the starting and ending point of the preceding survey. After five surveys the starting and ending point occurred at an end of the route, at which time we reversed the direction of the next survey, and repeated the cycle. We recorded only those birds sighted within 100 m of the survey road.

Kestrels are sexually dimorphic in plumage, and we determined their sex whenever possible. Shrikes, however, are sexually monomorphic, and we did not determine their sex. Each time a bird was sighted, we estimated the percentage of each habitat type (i.e. mowed grasses, grazed grasses, uncut grasses, plowed fields, rowcrops, wooded, or other) within 100 m of each bird, and recorded the bird's location in relation to habitat features (i.e. fields, forests, residences, or roads), its perching substrate, and the dominant habitat directly below the perch. If a bird was perched along a roadside and adjacent to a field, we recorded its location as roadside. Residential lawns and hay fields were classified as mowed grasses. Distance from the bird to the center of the survey road was determined using a measuring wheel. Perch height was measured with a clinometer. A visual obstruction measurement of the vegetation below perched birds was taken with a Range Pole (Robel et al. 1970) 1 m in length.

In South Carolina, shrikes are year-round residents and kestrels occur primarily from August to April (Gawlik 1988). We include in this analysis only those observations that occurred while both species were present on the survey route (August–April). To examine multivariate differences in habitat and perch use among bird groups we used stepwise discriminant function analyses (DFA) (SPSS^x 1988). We performed separate 2-group DFAs, to model differences

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TABLE 1. Correlations between model variables and the discriminant function of Loggerhead Shrikes (centroid = 0.74) and American Kestrels (centroid = −0.58) along a 277-km survey route in South Carolina, 1985–1987 (n = 367).

Variable	Structure coefficient
Percent mowed grass	0.59
Perch height	−0.48
Frequency perched above plowed field	−0.44
Frequency residential location	0.32
Vegetation height	0.29
Frequency perched above grazed grass	0.27
Percent uncut grass	0.27

between shrikes and kestrels, as well as differences between male and female kestrels. We conducted an additional 3-group DFA to differentiate among shrikes, male kestrels, and female kestrels. Observations with missing variables were excluded. Nominal variables were changed to dummy binary variables (i.e. if present coded as 1 and if absent coded as 0) (Raphael 1981). The relative contribution of each variable in differentiating among groups was determined using structure coefficients. Structure coefficients with relatively high absolute values indicate large contributions in distinguishing between groups, and signs indicate which end of the axis each variable describes. Group centroids range from −1 to 1 and indicate where bird groups occur along a discriminant function axis. Prior probabilities of group membership for each bird group were assumed to be equal. None of the group covariance matrices were equal (all Box's M-tests, $P < 0.01$); however, since DFA is robust to departures from assumptions of equal covariance matrices (Nie et al. 1975, Johnson 1981b), results are discussed based on the ecological interpretability regardless of Box's M-test outcome (Green 1974). We validated our models using a jackknife classification procedure (Dixon and Brown 1979), which classified birds into groups independent of each individual's contribution to the model.

RESULTS

Stepwise discriminant function analysis of habitat and perch use revealed significant differences between shrikes and kestrels (Wilk's lambda = 0.70, $X^2 = 129.68$, df = 7, $P < 0.01$). Seven variables were retained in the habitat function which is best explained by magnitude and signs of the structure coefficients (Table 1). The variable that best discriminated between shrike and kestrel habitat was the percentage of mowed grass. Shrikes were closely associated with grassy habitats and rural residences (Fig. 1). Shrikes perched closer to the ground and over taller vegetation than did kestrels (Table 2). Kestrels perched more frequently over plowed fields than did shrikes. This model correctly classified 76% of the birds into their respective groups. Jackknife validation resulted in only a minor drop in correct classification (75%), indicating a stable model.

Discriminant function analysis also revealed that male and female kestrels differed in habitat use (Wilk's lambda = 0.79, $X^2 = 35.57$, df = 5, $P < 0.01$). Percentage of plowed fields was the variable that best discriminated between habitats of the two sexes (Table 3). Habitats surrounding female kestrels had larger percentages of rowcrops, plowed fields, and fallow grass than did habitats surrounding male kestrels (Fig. 1). Female kestrels also perched over wooded areas more often than did males. This model correctly classified 70% of our male and female kestrel sightings. Jackknife valida-

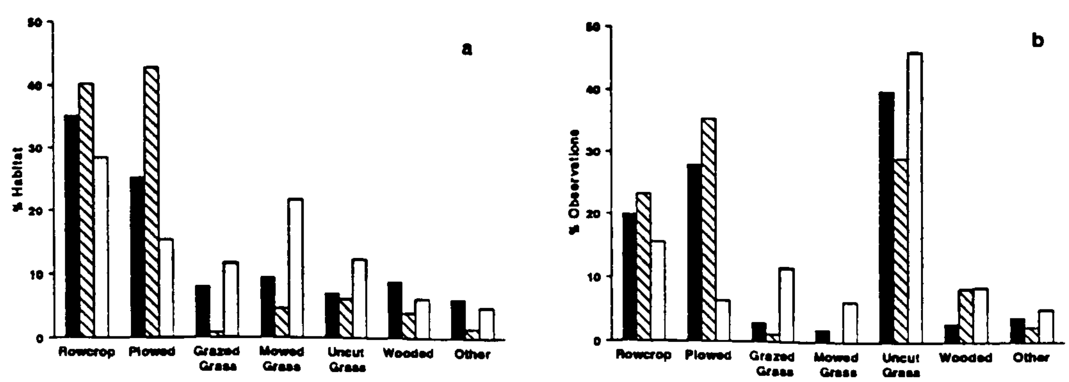

Fig. 1. Percent habitat types within 100 m (a) and frequency of habitat types below (b) Loggerhead Shrikes and American Kestrels along a 277-km survey route in South Carolina, 1985–1987. Solid bars = male Kestrels, hatched bars = female Kestrels, open bars = shrikes.

TABLE 2. Perch-site characteristics for Loggerhead Shrikes and American Kestrels along a 277-km route in South Carolina, 1985–1987.

	Vegetation height (cm)			Perching height (m)			Distance to road (m)			Frequency of perch location				
	$\bar{x}$	SD	*n*	$\bar{x}$	SD	*n*	$\bar{x}$	SD	*n*	Roadside	Field	Residence	Other	*n*
Loggerhead Shrikes	11.4	17.6	164	6.2	2.0	166	35.1	24.6	165	75	82	17	2	176
American Kestrels														
Males	6.2	11.5	85	7.6	2.4	85	23.5	23.2	85	73	24	2	2	101
Females	6.0	10.9	74	7.2	1.6	74	27.1	24.2	74	53	29	0	0	82
Both sexes[a]	6.2	10.9	208	7.5	2.2	206	29.6	26.9	206	150	93	4	2	249

[a] Includes kestrels whose sex was not determined.

tion indicated a drop to 65% correct classification, indicating a slightly less stable model relative to the others.

Discriminant function analysis also showed habitat and perch use differences among all three bird groups (Wilk's lambda = 0.61, X^2 = 153.15, df = 14, $P < 0.01$, first function; Wilk's lambda = 0.92, X^2 = 25.75, df = 6, $P < 0.01$, second function) and produced two functions which cumulatively explained 100% of the variance. Variables best describing these functions varied slightly from the previous two models (Fig. 2); however, mowed grass was still more closely associated with shrikes than kestrels, and plowed fields were more closely associated with female kestrels than males. The expected correct classification of a three-group model by chance alone would be 33%, however, this model correctly classified 62% of the birds sighted. Jackknife validation procedure showed the overall correct classification to be 61%, indicating a stable model. Seventeen percent of shrikes were misclassified as male kestrels, and 14% of shrikes were misclassified as female kestrels. Thirty-two percent of male kestrels were misclassified as female kestrels and 19% were misclassified as shrikes. Twenty-five percent of female kestrels were misclassified as male kestrels, and 15% of females were misclassified as shrikes.

DISCUSSION

All three bird-groups were strongly associated with cultivated cropland; but especially female kestrels. Male and female kestrels show habitat separation consistent with other studies (Koplin 1973, Stinson et al. 1981, Smallwood 1987). Female kestrels occupied more open and less wooded area that had more plowed fields and less pasture than did males. However, in

TABLE 3. Correlations between model variables and the discriminant function of male (centroid = −0.47) and female (centroid = 0.55) American Kestrels along a 277-km survey route in South Carolina, 1985–1987 (n = 158)

Variable	Structure coefficient
Percent plowed field	0.54
Frequency perched above wooded	0.26
Frequency field location	0.20
Percent rowcrop	0.06
Percent uncut grass	0.05

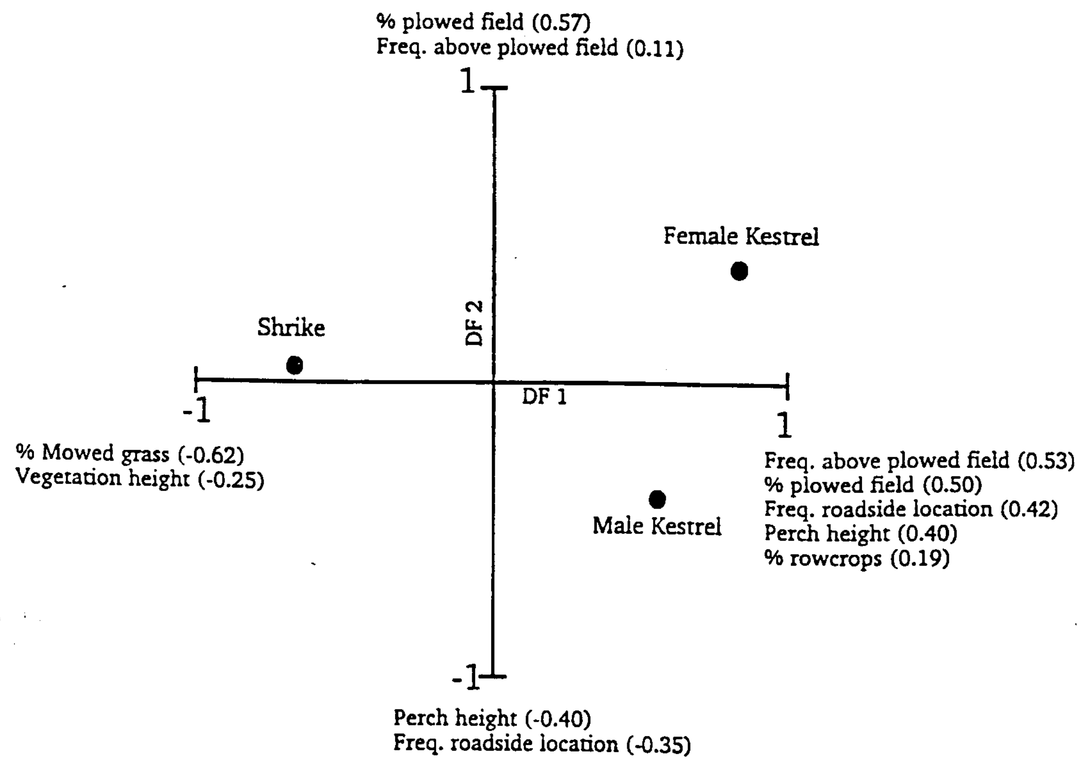

Fig. 2. Discriminant function scores for Loggerhead Shrikes (centroid = −0.69, 0.05), female American Kestrels (centroid = 0.89, 0.39), and male American Kestrels (centroid = 0.54, −0.43) along a 277-km survey route in South Carolina, 1985—1987. Structure coefficients for each variable (in parentheses) reflect the strength of their correlation with that function.

this study both sexes used habitat more similar to each other than to that used by shrikes. Shrikes also perched lower and over taller vegetation than did kestrels suggesting that these birds may differ in the way in which they use habitat.

Percent of mowed grass was the best discriminator between shrike and kestrel habitat, and grassy areas in general were closely associated with shrikes. Residential areas and pastureland often served as nesting sites for shrikes because they provided short grasses with potential nest trees and foraging perches scattered throughout. Loss of pastureland was significantly correlated with declining shrike populations nation-wide and particularly in the southeastern United States (Gawlik and Bildstein 1993). However, during the nonbreeding season shrikes were more closely associated with cultivated cropland, habitat more similar to that of wintering kestrels (Gawlik and Bildstein 1993). Thus resident shrikes in our study site were influenced by seasonal factors, and they occupy habitats that exhibit relatively fine-grain patchiness on the scale of individual territories which typically range from 0.2 to 14.6 ha (Yosef and Grubb 1992).

We believe that widespread conversion of relatively small pastures to larger cropland fields changes the habitat mosaic from a fine to a coarse-grain system. Therefore, we recommend that conservation efforts for resident shrike populations focus on providing fine-grain diversity of grassy habitats.

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