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Loggerhead shrike (*lanius ludovicianus L*) foraging patch and perch selection

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LOGGERHEAD SHRIKE (*LANIUS LUDOVICIANUS* L.) FORAGING PATCH AND PERCH
SELECTION

by

Miles Becker

Thesis

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Thesis Committee:

Peter Bednekoff, PhD, Chair

Catherine Bach, PhD

Jamin Eisenbach, PhD

Cara Shillington, PhD

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ABSTRACT

Loggerhead shrikes have disappeared across much of their former range, most likely due to habitat loss. I studied the habitat shrikes prefer for foraging. Shrikes forage from a perch on prey that they see in the surrounding vegetation. When I mowed the vegetation on one side of selected perches, shrikes strongly preferred to forage on the mowed side even though prey biomass was far lower on this side. These results suggest that access to prey is important to shrikes rather than simply the total amount of prey in a habitat. Within territories, shrikes chose to perch on dead or partially dead trees more often than expected.   I constructed artificial perches surrounded by leafy branches, dead branches, or no branches. Shrikes preferred artificial perches surrounded by dead branches. These results suggest that shrikes utilize perches with a good view of potential prey that also provide cover from potential attacks by predators.

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CHAPTER 1: INTRODUCTION

Loggerhead Shrikes (*Lanius ludovicianus* L.) are an open-habitat species endemic to North America and inhabit much of the continental United States. From the 1700s to the 1900s, the breeding range of loggerhead shrikes expanded into the northeastern states and southern Canada as forests were cleared by European settlers for low intensity agricultural production systems (Cade and Woods 1997). Starting in the 1930s, numbers of breeding shrikes in the northern part of their range declined, and the decline accelerated in the 1960s. Shrikes have now disappeared from much of their former range in the northeastern United States and Canada (Cade and Woods 1997).   Numbers have decreased sufficiently in certain regions for the U.S. Fish and Wildlife Service to list loggerhead shrikes as a species of concern. The San Clemente Island subspecies, *L.l.mearnsi*, is federally endangered in the U.S., and the migratory race *L.l.migrans* is federally endangered in Canada.

Habitat loss is a suggested explanation for the population decline in loggerhead shrikes. Shrikes nest and forage in a variety of agricultural habitats vulnerable to rapid shifts in farming practices and tend to prefer less intensively cultivated habitat. For example, grazed pasture is more commonly used than hayfields, row crops, and mowed grass (Smith and Kruse 1992, Telfer 1992, Chabot et al. 2001, Esely and Bollinger 2001). Several authors have suggested that the primary benefit of pasture or open habitat is provision of foraging opportunities for shrikes (Telfer 1992, Cuddy 1995, Temple 1995, Cade and Woods 1997). Decreased food availability associated with agricultural intensification is a contributing factor to declines in grassland bird populations throughout Europe and North America (Vickery et al. 2001, McIntyre and Thompson 2003, Wilson et al. 2005, Britschgi et al. 2006). Management practices that might decrease arthropod prey populations include chemical applications of herbicides or insecticides

(Brickle et al. 2000, Taylor et al. 2006), vegetation homogeneity (Fielding and Brusren 1993, McIntyre and Thompson 2003), and frequency of harvest and crop rotations (Haysom et al. 2004, Devereux et al. 2006).

Another management practice that affects prey availability for grassland birds is cutting tall vegetation down to stubble. Prey abundance differs with vegetation height or plant biomass (McIntyre and Thompson 2003, Perner et al. 2005), and a rapid reduction in plant biomass after cutting could decrease arthropod prey availability. Based on dietary analysis (Scott and Morrison 1995) and foraging behavior (Craig 1978), shrikes consume mostly arthropods and capture prey frequently on ground vegetation or bare ground. A decrease in arthropod availability would limit an important food source for shrikes (Yosef and Deyrup 1998). Additionally, shrikes depend primarily on visual detection of mobile prey (Craig 1978, Yosef and Grubb 1993), and the ability to detect prey changes with vegetation structure. Detection distances (Butler and Gillings 2004, Stillman and Simmons 2006) and capture rates (Devereux et al. 2004) decrease with vegetation height for birds in agroecosystems. While shrikes clearly prefer shorter grass habitat such as grazed pasture, the mechanisms driving habitat selection are unknown.

Another beneficial habitat feature associated with pastures and low intensity production systems is the availability of foraging perches and nest trees (Yosef and Grubb 1994, Chabot et al. 2001, Kim et al. 2003).   Shrikes have a sit-and-wait foraging mode of remaining stationary on a perch until prey are detected and then attacking prey directly from the perch. Shrubs and trees provide elevated perches from which to hunt, thorns on which to impale prey (Yosef and Pinshow 2005), possibly a place to display territory ownership or attract mates (Yosef and Pinshow 2005), and possibly cover from predators (Kim et al. 2003). Foraging flights from

perches to capture prey on the ground are usually less than 10m and the usable foraging area accessible to a perched shrike is effectively within a 10m radius circle of a perch-tree. The absence of perch substrate from large cultivated fields denies sit-and-wait avian predators access to otherwise suitable foraging habitat (Wolff et al. 1999, Sheffield et al. 2001).

There is currently a need for research on the foraging habitat requirements of loggerhead shrikes in order to improve the conservation value of managed land (most recently, Wiggins 2005). This project addresses the influence of two critical components of shrike foraging habitat, vegetation height and perch-tree quality, on foraging patch and foraging perch selection. Although many studies on shrikes are in agricultural or urban habitat, I observed shrikes in habitat managed for wildlife for three reasons: 1) observations in minimally modified habitat will provide a baseline of foraging behavior by shrikes in semi-natural habitat; 2) shrike populations in the region of the study site in Texas have remained stable or increased over the past 30 years (Sauer et al. 2003), presumably due in part to high quality habitat; and 3) the presence of both wintering and breeding populations at the study site offers a chance to compare foraging behaviors between seasons. I focused on microsite and territory scale habitat use because models for habitat use at the landscape level are well understood (Esely and Bollinger 2001). The determinants of microhabitat use within a generalized landscape of open areas and isolated perches are mostly unknown. Studying foraging habitat on a small scale also has a benefit in that any results may be applicable to enhancing shrike habitat relatively quickly, economically, and without disruption to other land uses.

CHAPTER 2: THE EFFECTS OF VEGETATION HEIGHT AND PREY BIOMASS ON

PATCH SELECTION

Introduction

Selection of foraging habitat in response to food resources is important for understanding the spatial distribution of birds. Foraging birds need to locate habitat with high prey availability to maintain the energy necessary for reproductive success (Granbom and Smith 2006) and avoid high stress levels associated with fitness costs (Kitaysky et al. 1999, Pravosudov and Kitaysky 2006). Prey availability is partly influenced by vegetation structure for ground foraging birds. Short vegetation may have decreased arthropod abundance compared to taller vegetation (McIntyre and Thompson 2003, Perner et al. 2005, Devereux et al. 2006). Food intake rates are positively related to food abundance (Brodman et al. 1997, Butler et al. 2005), and, as a result, a decrease in arthropod prey could consequentially decrease energy gain in short or open vegetation.

At the same time, foraging in short vegetation has benefits related to increased prey accessibility. For example, food items are easier to see in short or sparse vegetation (Butler and Gillings 2004, Bennetts et al. 2006, Stillman and Simmons 2006). Increased prey detection may lead to more successful foraging behavior, including increased foraging rates (Devereux et al. 2004, Jones et al. 2006), shorter prey detection distances (Stillman and Simmons 2006), or a change in diet from a primary prey species to an alternative prey species (Ontiveros et al. 2005). How do foraging birds with access to both short and tall vegetation choose between prey abundance and prey accessibility?

Several species of birds looking for different types of food items foraged more often in shorter and less dense vegetation even if tall vegetation had similar or slightly higher prey densities (Sheffield et al. 2001, Devereux et al. 2004, Wilson et al. 2005, Bennetts et al. 2006). Birds may prefer short vegetation to tall vegetation when prey abundance is similar, yet at low enough levels of prey abundance, the relative frequency of prey encounters and capture rates in short vegetation patches should approach or fall below that of tall vegetation. Once capture rates in a foraging patch are lower than surrounding patches, a forager is likely to switch to another potentially more profitable patch (Charnov 1976), in this case, taller vegetation with higher prey abundance. Captive Chaffinches (*Fringilla coelebs*) continued to spend more time foraging in short stubble even as relative prey abundance in adjacent tall stubble increased (Butler et al. 2005). Only after prey abundance in tall stubble reached 2.5-4 times the amount in short stubble did chaffinches show no preference for short stubble.

This study used observations of a species associated with open-habitat, Loggerhead Shrike (*Lanius ludovicianus* L.), to determine the effects of vegetation height and prey availability on foraging patch selection. Shrikes employ a sit-and-wait foraging mode to watch and attack prey directly from elevated perches. Most prey captures are on the ground (Tyler 1991, Scott and Morrison 1995, Yosef and Grubb 1993), and the ability to detect prey movement should be affected by vegetation height and vegetation density. In territories containing tall grass that was then mowed, shrikes foraged more in flight at a greater energy cost before the mowing (Yosef and Grubb 1993), probably because prey in tall grass was more difficult to see from the perch. Given a choice between vegetation heights, shrikes are expected to select shorter or open grass with increased prey detectability.

Studies on a landscape scale support a preference by shrikes for short grass habitat. Habitat used by shrikes generally has less dense and shorter vegetation than unused available habitat (Brooks and Temple 1990, Smith and Kruse 1992, Gawlik and Bildstein 1993, Esely and Bollinger 2001) with the exception that shrikes in southeastern Alberta preferred areas with taller grass (Prescott and Collister 1993). The preference for tall grass could have resulted from relatively higher prey abundance although arthropod populations were not sampled in that study. Less is known about the factors involved in habitat selection on a patch level. One study found shrikes in wintering habitat foraged a similar amount in mowed areas and tall vegetation areas along a row of fence posts (Chavez-Ramirez et al. 1994). A lack of preference for a particular vegetation height might indicate foraging habitat is not selected for on a small scale, but further studies are needed.

I tested the hypothesis that shrikes forage in patches with accessible prey in preference to patches with abundant prey. I predicted that if vegetation height relates directly to prey accessibility, then shrikes will forage more often in short grass even if arthropods are more abundant in tall grass. I manipulated vegetation height by mowing plots next to foraging perches and sampled vegetation height, arthropod biomass, and shrike foraging patch selection.

Study Area

Loggerhead shrikes were observed at Matador Wildlife Management Area (MWMA; 34° 07' 30", 100° 22' 30'') in Cottle County, north central Texas. The MWMA is in the rolling plains region with mean daytime temperatures of 34° C in June and 20° C in December 2005. Average annual rainfall in the area is approximately 0.56m with most rain falling in May and June. The area ranges in altitude between 500-650m, and shrikes generally inhabited level to gently sloping areas. Shrikes occupied open habitats, mainly sand sage grassland, mesquite

grassland, and shin oak grassland, characterized by scattered or clumps of trees with short grass and forb ground cover. A mix of cool-season and warm-season graminoid species dominated ground vegetation that included little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), purple threeawn (*Aristida purpurea*), and sandbur (*Cenchrus insertus*). Sand sagebrush (*Artemisia filifolia*) was also prevalent in most study territories. A continuous moderate cattle stocking rate occurs at the site, but areas with shrike territories were not currently grazed during the observation period in 2005.

Methods

Behavioral observations

I located breeding pairs and delineated study territories in May and June 2005. Breeding pairs defend exclusive territories (Tyler 1992), and in some regions, permanent residents defend the same areas year round (Yosef 2001). Presumably, repeated observations in a single territory were restricted to the same two breeding adults. I defined independent study territories as the area outlined by foraging perch trees used by a resident shrike. A shrike was considered a territory resident if it delivered a food item to nestlings or fledglings, exhibited territorial displays or territory defense, or foraged from a tree previously marked as belonging to that study territory. Behavior of the breeding pair was not considered independent, so territories were used as the sampling unit.

Shrike territories at MWMA contained roughly 50-150 trees and shrubs available as perch substrate. Five trees per territory were selected as experimental perches in eight territories in early June. Experimental perches were trees previously used by foraging shrikes and in an open area surrounded by fewer than 4 trees within a 10m radius to facilitate mowing. If a

foraging perch-tree was in a dense area, the closest tree in an open area was designated an experimental perch. I mowed a 20m x 10m plot to cut vegetation less than 8cm high on one side of every experimental perch and left a control tall grass 20m x10m plot on the adjacent side. Shrike foraging flights to capture prey on the ground are generally less than 10m from the perch-tree and the two treatment plots covered the foraging area most likely to be used from that experimental perch. Mowed and control treatment plots were centered lengthwise on the experimental perch and the orientation of the plots was random except for experimental perches within 10m of a road or fence. For the 5 experimental perches within 10m of a road or fence, the treatment plots were aligned perpendicular to the road or fence so that an equal-sized area of each treatment plot was divided by the road or fence. Up to two trees or shrubs were left standing within a plot, provided both treatments had the same number of extra trees or shrubs.

I visited study territories once a day at 3-7 day intervals from June 21-July 5 and July 21-August 5, starting five days and thirty-four days after mowing. Shrikes actively forage from sunrise to early afternoon and again before sunset (Craig 1978). Daily observations occurred in one of three periods: early morning (0630-0830), mid-morning (0830-1030), and evening (1900-2100). The time for the initial observation in a territory was randomly assigned and consecutive observations rotated through the other time periods. The order of visits to different territories was randomly determined, but territories were placed in groups of three or four based on geographic proximity to reduce time traveled between territories visited on the same day.

During behavioral observations, I recorded four foraging behaviors to later relate to vegetation height: 1) the vegetation treatment where capture attempts were made (mowed or control); 2) the height the shrike perched on the tree before a capture attempt (height perched), estimated as a fraction of the total tree height; 3) the foraging flight distance from the base of the

foraging perch to the landing point on the ground (attack distance), estimated in tree height

lengths; and 4) the length of time the shrike stayed on the ground (ground time), estimated by

counting off seconds. Behavioral data were collected for an hour in continuous observation of a

resident shrike. I shortened an observation if at the start of the observation less than an hour

remained in the designated period or weather conditions prevented further observation (e.g. rain

or winds above 20 mph). If a shrike flew out of sight, the one hour observation continued but I

recorded the number of minutes the bird was out of sight. Observations with a shrike in sight for

less than 20 minutes were not included in the analyses. After an observation, vegetation height

and prey availability were sampled in treatment plots next to all experimental perches used by a

foraging shrike.

Habitat measurements

I measured the height of vegetation in the mowed and control treatments to quantify the

scale of difference. Vegetation height on both sides of the experimental perch-tree was

measured at 1m intervals on parallel 20m transects down the middle of each vegetation treatment

plot. Plant height was measured to the nearest centimeter for the tallest plant directly above the

interval mark. A measure of vegetation density was also recorded around trees used as foraging

perches and unused trees available in the habitat. Fifty observed foraging perch-trees in six

territories in May 2005 were paired with the tree closest to a point in a random direction and

100m away from the foraging perch. A 100m distance was still likely to remain in the same

study territory, but the same vegetation would not be accessible from both perches. Random

trees representing available perches were at least 1.5m in height and included any tree or shrub

species but not artificial substrates such as barbed wire or fence post. A randomly selected tree

was replaced with another if the first was located in atypical shrike foraging habitat such as dense mesquite brushland. I established a randomly oriented transect centered on the perch tree and extending 10m from the outermost branches on opposite sides of the tree. The presence or absence of ground cover was recorded at 1m intervals and percent bare ground calculated for the entire transect.

To measure prey availability, invertebrate populations were sampled in vegetation next to trees used as foraging perches on the same day as the associated observation. Invertebrate sampling transects were on the same transects as vegetation sampling for trees without vegetation manipulation that were used by foraging shrikes. I paced out the two 10m transects on both sides of the unmanipulated tree while sweeping the vegetation every step with a sweepnet. A single pitfall trap was placed on one of the 10m transects, the side determined randomly for every tree, at a distance of 5m from the tree. To sample invertebrates in the paired treatment plots next to experimental perch trees, I swept the vegetation with a net along the center of each plot in two 20m parallel transects. A single pitfall trap was placed in the center of each treatment plot, 5m from the experimental perch-tree. Each pitfall trap consisted of a 473ml plastic cup buried with the lip level to the soil surface and 2.5cm of 1:1 mix of water and propylene glycol in the bottom of the cup. A hard plastic 10cm by 10cm square with a nail in each corner suspended 2.5cm above pitfall traps prevented the traps from flooding by rain or liquid evaporating from direct sunlight. Pitfall traps remained in the field for 87-96 hours. Invertebrate samples were later stored in a freezer until measured for biomass calculations and identified.

Insects collected in pitfall traps and sweepnet were sorted by taxon, following Triplehorn and Johnson (2005). Insects were measured from the distal end of the head to the distal end of

the abdomen. I calculated an index of prey biomass for arthropods captured by sweepnet (sweepnet biomass) and pitfall traps (pitfall biomass), using an established linear regression relationship between length and weight (Rogers et al. 1976, Brady and Noske 2006) with length rounded up to the nearest 5mm. Insects less than 5mm were omitted from analysis because shrikes typically consume larger sized prey (Craig 1978, Scott and Morrison 1995).

Mean percent bare ground around trees within a territory was compared between used trees and unused trees with a 1-tailed paired t-test. Differences between mowed and control vegetation treatment plots in mean number of capture attempts, pitfall biomass, sweepnet biomass, and vegetation height were analyzed independently with multiple 1-tailed paired t-tests. All habitat measurements at individual experimental perch-trees were combined into a single mean within a territory in order to use territory as the sampling unit. The number of capture attempts in each vegetation treatment was summed within a territory. Too few capture attempts were made in control tall grass plots to directly compare other foraging behaviors between vegetation treatment heights. Instead, I compared height perched, strike distance, and ground time between mowed plots and tall vegetation surrounding non-experimental perch-trees. Differences in foraging behavior between experimental perch-trees next to mowed plots and foraging behavior from unmanipulated perch-trees was tested with 2-tailed paired t-tests. The two types of perch-trees were not generally adjacent in a territory but considered paired within the territory. The interactive effect of perch-tree type (experimental, unmanipulated) and time since mowing (June, July) on number of capture attempts was tested in a 3 factor ANOVA with repeated measures using territory as the third random factor.

Results

Vegetation and prey availability

Vegetation height and arthropod biomass differed between treatment plots at 24 experimental perch-trees used by shrikes in 39 observations. As expected, vegetation height was shorter in the mowed plots than in control plots (t = -7.549, df = 7, P < 0.001) with an average difference of 26.4 cm. Vegetation density, measured as percent bare ground, did not differ significantly between used trees and unused trees available in the habitat (t = 0.107, df = 5, P = 0.460). Arthropod biomass was lower in mowed plots for both sweepnet (t = -4.526, df = 7, P < 0.003; Fig. 1.1A) and pitfall trap (t = -5.021, df = 7, P < 0.001; Fig. 1.1B) samples. Arthropod composition was similar in mowed and control treatment plots but certain taxa contributed more depending on the sampling method. Sweepnet sampling targeted vegetation dwelling arthropods, and pitfall sampling targeted ground dwelling arthropods. Orthoptera, mainly Acrididae, contributed most of the mass in sweepnet samples, and most arthropods collected in pitfall traps were in the order Coleoptera, mainly the families Scarabidae, Carabadiae, and Silphidae (Table 1.1).

Foraging behavior

The majority of capture attempts from experimental perch-trees were in the mowed treatment plots. Shrikes in eight territories made 62 (88.6%) capture attempts in mowed plots and only 8 (11.4%) capture attempts on the ground in tall grass control plots (t = 5.224, df = 7, P < 0.001; Fig. 1.2). Shrikes making capture attempts in mowed grass tended to perch lower and spend less time on the ground than when foraging in tall grass from unmanipulated perch-trees, but the differences were not significant (Table 1.2). Foraging flight distances from both types of

perch trees were similar. Experimental perch-trees were on average 0.36cm taller than non-experimental perch-trees although the difference was not significant.

Time since mowing and perch type had an interactive effect on the number of times shrikes used each type of perch (date x perch type: $F = 5.879$, df = 1, 7, $P = 0.046$; Fig. 1.3). Between 5-19 days after mowing, shrikes in eight territories made an average 6.9 (SE ± 2.1) foraging flights from experimental perch-trees compared to only 1.9 (SE ± 1.0) foraging flights in a later observation period 34-49 days after mowing. Conversely, the mean number of foraging flights from perch-trees without manipulated vegetation increased from 4.3 (SE ± 0.5) in the earlier observation period to 7.4 (SE ± 1.2) in the later observation period. Foraging flights to mowed treatment plots were consistently more numerous from experimental perch-trees for both observation periods. Shrikes in only three territories foraged from experimental perches in both observation periods, and mean invertebrate biomass in mowed plots increased from the earlier to the later observations for both pitfall sampling (earlier: 423.7 mg, SE ± 234.0; later: 651.0 mg, SE ± 309.4) and sweepnet sampling (earlier: 52.6mg, SE ± 25.3; later: 120.2mg, SE ± 76.2). Mean invertebrate biomass in the paired tall grass treatment decreased over that time in those three territories from 1079.0 mg (SE ± 195.9) to 822.6 mg (SE ± 190.6) for pitfall sampling and from 831.3 mg (SE ± 454.1) to 742.5 mg (SE ± 218.1) for sweepnet sampling.

Table 1.1. Relative biomass composition (%) for arthropod taxa contributing >1% of total biomass in two vegetation height treatment plots used by foraging Loggerhead Shrikes (*Lanius ludovicianus*).

| Taxon | Sweepnet | | | Pitfall trap | |
	Mowed	Control		Mowed	Control
Coleoptera					
Carabidae	0.0	0.0		8.8	7.2
Scarabidae	0.0	0.0		51.4	47.6
Silphidae	0.0	0.0		11.0	13.8
Mantidae	0.7	2.2		0.0	0.0
Orthoptera					
Acrididae	95.9	83.9		17.2	21.4
Tettigonidae	0.1	4.8		0.1	0.9
Phasmatodia	0.0	3.5		0.0	0.0
Scorpiones	0.0	0.0		1.0	2.8
Unknown					
larvae	2.4	0.1		0.0	0.0
adult	0.0	5.3		0.0	0.0

Table 1.2. Foraging related variables (mean ± SE) of Loggerhead Shrikes (*Lanius ludovicianus*) using experimental perch-trees with mowed plots and perch-trees without manipulated vegetation.

| Variable | Vegetation height | | t | df | p |
	Mowed	Tall			
Relative height perched	0.88 ± 0.06	0.98 ± 0.02	-1.458	7	0.188
Flight distance	1.30 ± 0.23	1.23 ± 0.31	0.113	7	0.913
Time on ground	2.45 ± 0.40	3.52 ± 0.93	-0.962	7	0.368
Tree height (m)	3.42 ± 0.50	3.06 ± 0.48	0.501	6	0.634
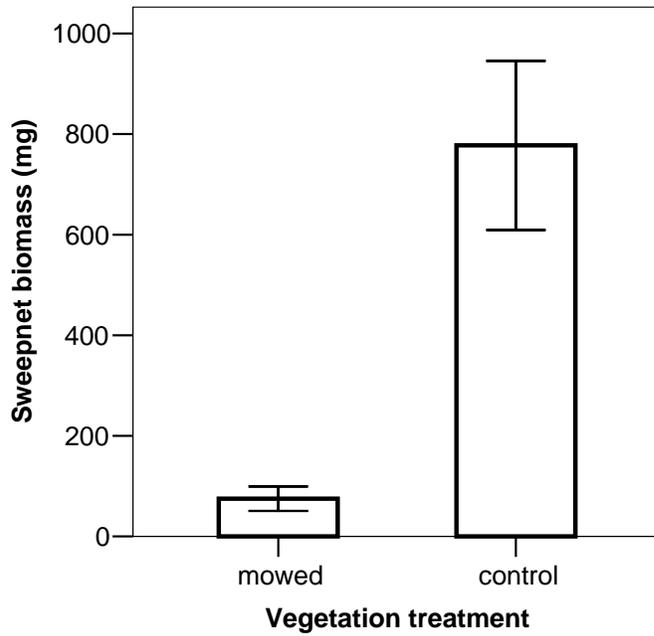
Figure 1.1A. Mean (± SE) biomass of arthropods collected by sweepnet in two vegetation heights in eight Loggerhead Shrike (*Lanius ludovicianus*) territories during the 2005 breeding season.
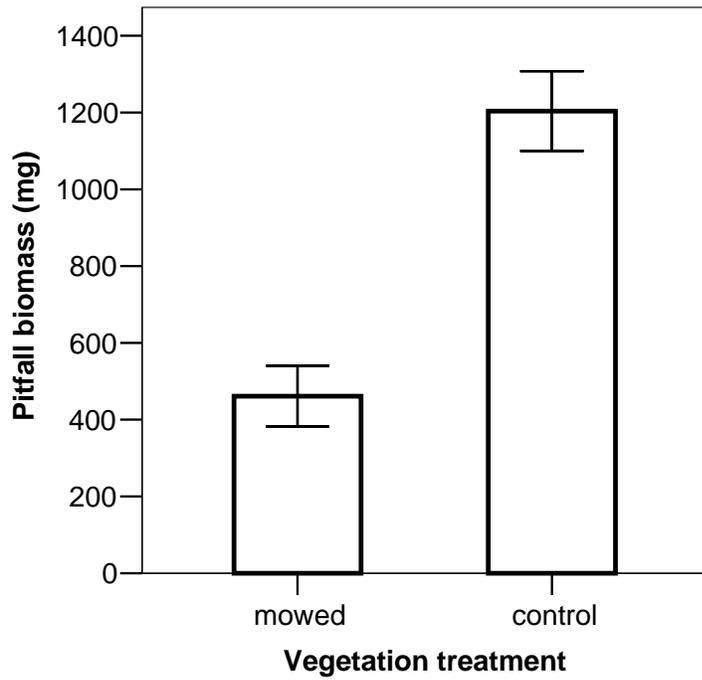
Figure 1.1B. Mean (± SE) biomass of arthropods collected in pitfall traps in two vegetation heights in eight Loggerhead Shrike(*Lanius ludovicianus*) territories during the 2005 breeding season.
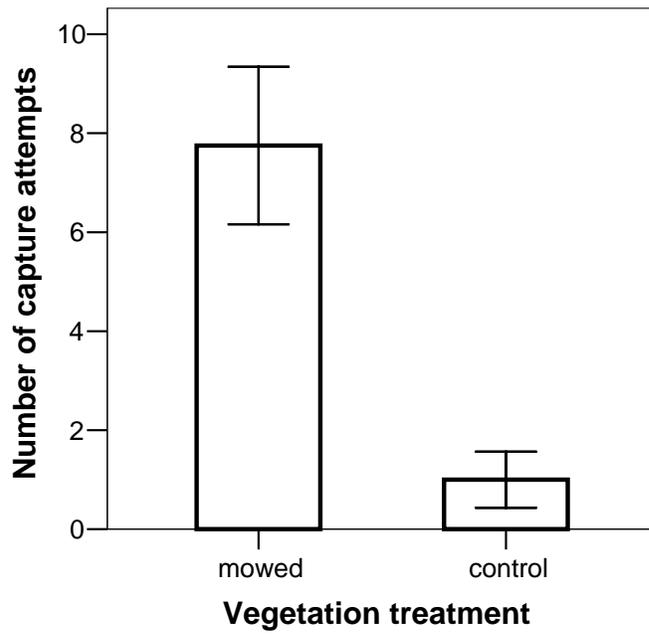
Figure 1.2. Mean (± SE) number of capture attempts by Loggerhead Shrikes (*Lanius ludovicianus*) in two vegetation heights in eight territories during the 2005 breeding season.
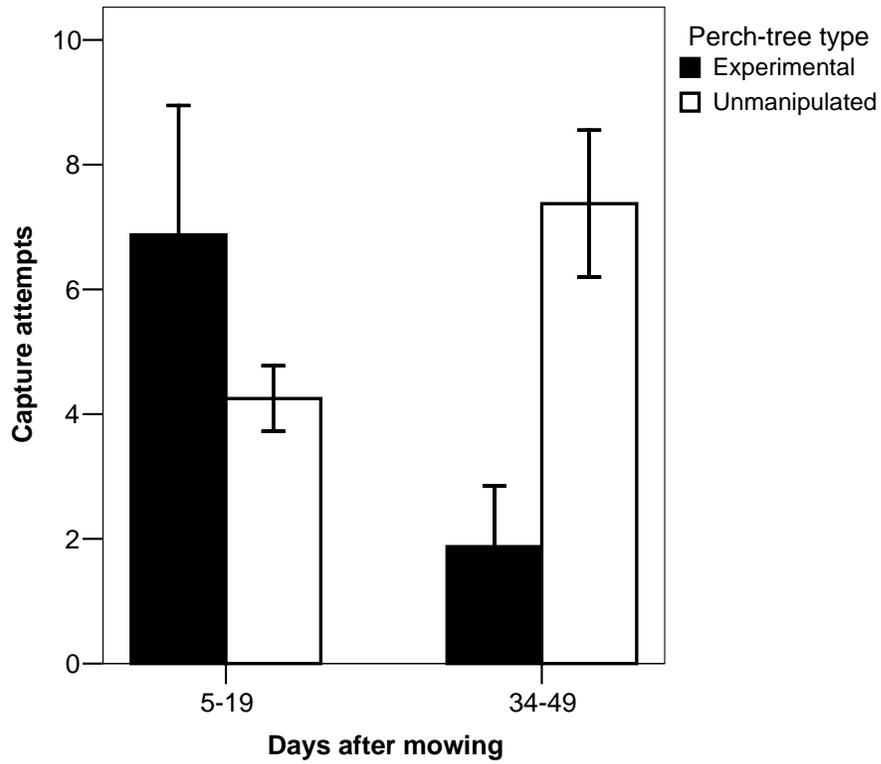
Figure 1.3. Loggerhead Shrike (*Lanius ludovicianus*) use of perch-trees (mean ± SE) next to mowed treatment plots (black bars) or unmanipulated vegetation (white bars), at two periods after mowing.

Discussion

Tall vegetation may sustain increased prey densities (Perner et al. 2005, Devereux et al. 2006), but prey may be more accessible in short vegetation (Bennetts et al. 2006, Stillman and Simmons 2006). I predicted shrikes would selectively forage in cut grass with less abundant but more accessible arthropod prey. Vegetation cut to less than 8 cm had $1/8^{th}$ to $3/8^{th}$ as much arthropod prey biomass as tall grass, and shrikes still foraged more in mowed plots. These results are consistent with a preference for short or open vegetation by raptors (Sheffield et al. 2001, Bennetts et al. 2006) and passerines (Wilson et al. 2005, Buckingham et al. 2006) in agricultural landscapes. However, captive chaffinches reached a limit on the profitability of short vegetation at levels of relative prey abundance 2/5-1/4 times as much as in tall vegetation (Butler et al. 2005).

Shrikes visually detect mobile prey and probably see prey easier in less structurally complex vegetation as do other grassland birds (Butler and Gillings 2004). I did not measure prey visibility directly, but changes in the shrikes' foraging behavior would suggest tall grass increases prey concealment. Prey in tall vegetation should be easier to see from an acute angle and more difficult to see at longer distances (Stillman and Simmons 2006), resulting in shrikes perching higher and flying shorter distances in tall grass. Shrikes in this study had similar perching heights and foraging flight distances; neither measure conclusively showed an effect of increased prey detectability.

Decreased prey handling time in short vegetation could also contribute to the profitability of foraging in mowed plots. Handling prey on the ground in areas with low structural complexity requires less time and energy (Brodmann 1997). Observations of shrike/prey interactions on the ground, often through tall grass and at a distance of 60-120m, were not

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reliably accurate enough to determine handling time directly. Instead, the length of time a shrike remained on the ground could be an indirect measure of prey handling time. Shrikes showed a slight trend towards remaining on the ground longer in tall grass than in mowed plots, but the difference was not great enough to indicate that short grass facilitated prey capture and decreased handling time.

Foraging in mowed plots decreased over time, and it is not clear what led to this change. The shrikes in this study used perch-trees with accessible mowed plots less often in later summer observations and not at all in winter (pers.obs.). Mowed plots were clearly outlined at the time of the later summer observations although vegetation had grown several centimeters. Prey are less conspicuous in more complex vegetation structure (Jones et al. 2006) and prey may have been more difficult to detect as vegetation regenerated in mowed plots. Shrikes could also have switched to tall vegetation if arthropod abundance in mowed plots decreased over time, either by depletion from foraging birds or avoidance by source populations in tall grass. Arthropod biomass in mowed plots actually increased from within 2 weeks of mowing to 5 weeks after mowing in three shrike territories. Decreased prey abundance in mowed plots does not appear to be the reason for the observed change in use of mowed plots although long term prey abundance in mowed grass may be dependent on a source population in tall grass. Seasonal declines in overall arthropod abundance from summer to winter may limit a source population for short vegetation and would explain why wintering shrikes showed no preference for mowed areas (Chavez-Ramirez et al. 1994).

The size of the patches I mowed may also have influenced the foraging response to short vegetation. Arthropod abundance in mowed patches may vary along a gradient of distance from the edge. Shrikes in this study appeared to forage throughout the entire 10m x 20m mowed area

without a preference for edges. Larger mowed plots including more perch-trees might have lower arthropod abundance in vegetation around trees farther from the edge and eventually limit potential capture rates. In habitat consisting mostly or entirely of tall vegetation, mowed areas would probably increase foraging opportunities without depleting prey abundance. In habitat already consisting of very short vegetation, prey abundance could be a limiting factor and preserved patches of tall vegetation would offer refugia for invertebrate populations. Experimentation with the effects of mowed patch size on invertebrate abundance and shrike foraging preferences would be useful.

Aside from possible effects of prey densities, the continual decrease in use of mowed plots could be a result of experience learning by shrikes. Shrikes might be innately attracted to short vegetation and initially unable to accurately assess potential capture rates. White-fronted geese seemed unable to select fields with higher food abundance but compensated by leaving food-poor patches sooner (Amano et al. 2006). If the mowed patches actually provided fewer foraging opportunities, shrikes could have eventually associated low capture success with mowed plots and switched to foraging in tall grass. This study did not include any direct measure of benefits to foraging in mowed grass, including increased capture success, increased capture rates, and decreased giving-up densities. Recording a measure of profitability would be necessary to determine if the shrikes' preference for short grass is a response to perceived benefits or actual increased foraging success. Comparing foraging behaviors shortly after mowing and at later periods would be necessary to determine if a change in use of mowed areas over time relates to foraging success.

Introduction

Perch availability is an important habitat component for avian predators with a sit-and-wait foraging mode. The abundance of perch-trees is an accurate predictor of habitat use for several raptors, including Madagascar fish-eagle, American Kestrel, and Bald Eagle (Berkelman 1999, Meunier et al. 2000, Thompson and McGarigal 2002). The introduction of artificial perches to cultivated areas even attracted raptors to previously unused foraging habitat (Hall et al. 1981, Wolff et al. 1999, Sheffield and Crait 2001). Birds often prefer foraging perch-trees with particular characteristics. Bald Eagles preferred a specific canopy structure at the scale of a forest patch or even a small clump of trees (Thompson and McGarigal 2002). Acadian flycatchers (*Empidonax virescens*) selected bare dead branches instead of branches with more foliage (Guilfoyle et al. 2002), apparently to mitigate visual obstruction. The same effect was achieved by Brown Shrikes (*Lanius cristatus*) perching on branches protruding from the side of the canopy rather than above the canopy (Yosef 2004) to watch for prey on the ground. Red-tailed Hawks (*Buteo jamaicensis*) perched on trees with fewer surrounding small trees and less shrub cover than available (Leyhe and Ritchison 2004), leaving more ground vegetation uncovered and more prey in sight from an elevated view point. Birds appear to often select foraging perches with few visual obstructions to detecting prey movement.

I studied perch-tree selection in the Loggerhead Shrike, *Lanius ludovicianus* L. (hereafter, shrikes), an obligate perch hunting species. Shrikes have a sit-and-wait foraging mode in open habitats and consume a remarkable range of prey taxa (Tyler 1991, Yosef 1993), considering their relatively small size. Most prey capture attempts are made on the ground

directly from a perch, and perch abundance is correlated with territory size and reproductive success in agroecosystems (Yosef and Grubb 1994). There is some evidence to suggest that shrikes are selective about particular characteristics of foraging perch substrate. Shrikes in north-central Florida perched frequently on high utility wire and perched on bare trees more often than live trees (Bohall-Wood 1987). Gawlik and Bildstein (1993) also found shrikes perched mainly on utility wire although use of trees and shrubs increased significantly in winter.

My specific objectives were to identify characteristics of shrike foraging perch-trees and to determine the seasonal effects on perch-tree selection. I hypothesized that if shrikes perch on trees to detect prey movement below, then foraging perch-tree characteristics would facilitate improved views of the ground. Measurable tree variables likely to influence ground visibility include tree height, woody plant density, and the amount of foliage on branches. I predicted shrikes would perch on taller trees, on trees with fewer surrounding woody plants, and on bare or dead trees. At the study site, deciduous trees with leafy branches in summer lose their leaves in winter and appear superficially similar to dead trees. If shrikes avoid trees with leafy branches in the summer, then those trees should be used more in winter.

Study Area

Loggerhead shrikes were observed at Matador Wildlife Management Area (MWMA; 34° 07' 30", 100° 22' 30'') in Cottle County, north central Texas. The MWMA is in the rolling plains region, with mean daytime temperatures of 34° C in June and 20° C in December 2005. Average annual rainfall in the area is approximately 0.56m, with most rain falling in May and June. Altitude ranged between 500-650m, and shrikes generally inhabited level to gently sloping areas. Shrikes occupied open habitats, mainly sand sage grassland, mesquite grassland, and shin oak grassland, characterized by scattered solitary or clumps of trees with short grass and forb

ground cover. Common woody species available as foraging perches consisted of honey mesquite (*Prosopis glandulosa*), redberry juniper (*Juniperus pinchotii*), netleaf hackberry (*Celtis reticulate*), and shin oak (*Quercus havardii*). The management strategies employed at the MWMA, most notably prescribed burns, grazing, mechanical tree removal, and herbicide sprays, provide a mix of potential foraging trees with different ages, heights, and conditions.

Methods

Behavioral observations

Shrikes in the region defend exclusive breeding territories while nesting from late February to late June (Tyler 1992). The distributions of two subspecies, *L.l. excubitorides* and *L.l. migrans*, overlap in a zone adjacent to the study site (Vallianatos et al. 2001), and there may be some shifting between breeding and non-breeding territories. Within a single season, I assumed repeated observations in a single territory were restricted to data on the same two breeding adults. I defined independent study territories as the area outlined by foraging perch trees used by a resident shrike. A shrike was considered a territory resident if it delivered a food item to nestlings or fledglings, exhibited territorial displays or territory defense, or foraged from a tree previously marked as belonging to that study territory. Shrikes are sexually monomorphic when viewed from a distance, and behavior of the breeding male and female was pooled within study territories.

I visited study territories in the 2005 breeding season during three observation periods starting on May 21, June 21, and July 21. An observation period was 15 days and territories visited once a day at 3-7 day intervals. Territories were visited twice in the non-breeding season, 5 days apart, between December 24 and December 31 2005. In the 2006 breeding season, I

visited each territory every 4-6 days between May 17 and June 16. Daily observations occurred

during one of three periods: early morning (0630-0830), mid-morning (0830-1030), and evening

(1900-2100). Daily observation times in winter observations were adjusted to compensate for a

later sunrise and earlier sunset. The time for the initial observation in a territory was randomly

assigned, and consecutive observations rotated through the other time periods.   The order of

visits to different territories was randomly determined, but territories were placed in groups of

three or four based on geographic proximity to reduce travel time between territories visited on

the same day.

During territory visits, behavioral data were collected for an hour in continuous

observation of a resident shrike. I shortened an observation if, at the start of the observation, less

than an hour remained in the designated period or weather conditions prevented further

observation (e.g. rain or winds above 20 mph). If a shrike flew out of sight, the one-hour

observation continued, but I recorded the number of minutes the bird was out of sight.

Observations with a shrike in sight for less than 20 minutes were not included in the analyses.

After an observation, foraging perch trees were marked with flagging for later habitat

measurements.

Tree characteristics

Tree measurements included tree height, tree category, and a density index of woody

plants. Tree height was measured to the nearest centimeter for trees below 3m and estimated to

the nearest 10cm for trees above 3m. The four categories of woody perch substrates in the

habitat were 1) completely foliated mesquite with no dead branches exposed beyond the canopy

(mesquite), 2) partial canopy mesquite with at least one dead branch projecting 0.5m past the

canopy (dead/mesquite), 3) bare or dead mesquite with less than 20% of the tree covered by foliage (dead), and 4) all other types of non-mesquite substrates were grouped into a single category (other) that made up less than 8% of the total perches used. A density index of woody plants around the perch tree included all shrubs and trees over 1.5m and within a 50m radius of the perch tree. Distance estimation of woody plants from the foraging perch was initially calibrated with a Bushnell Yardage Pro range finder (Bushnell Co., Overland Park, Kansas, USA). Universal Transverse Mercator (UTM) coordinates of foraging perch trees were recorded with a Garmin GPS 12XL (Garmin, Olathe, Kansas, USA) and used to estimate territory size with ArcGIS software (ArcMap Version 9.1, ESRI).

Foraging perch selection was initially tested in the May 2005 observation period by comparing characteristics of trees used by foraging shrikes to unused trees available in the habitat. Fifty observed foraging perch-trees in six territories were paired with the tree closest to a point 100m away from the foraging perch in a random direction. A 100m distance was still likely to remain in the same study territory (average territory size in 2006 was 11.1 hectares) and within reasonable interperch flying distance. Random trees representing available perches were at least 1.5m in height and included any tree or shrub species but not artificial substrates such as barbed wire or fence post. A randomly selected tree was replaced with another if the first was located in atypical shrike foraging habitat such as dense mesquite brushland. The use and availability experiment was repeated in December 2005 on 57 foraging perch trees in eight territories.

Tree height and woody plant density were compared for used perch-trees and available trees in 1-tailed paired t-tests. Height and density for trees included in the paired analysis were averaged within a territory by treatment (used, available). Differences in tree categories between

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trees used as foraging perches and trees available in the habitat were tested with a two-way

ANOVA with repeated measures. Tree category (mesquite, dead/mesquite, dead, other) and

treatment (use, available) were the within-subjects factors tested for an interactive effect. The

number of trees assigned to every tree category was summed within a territory. Data were

square root transformed to correct for group variance increasing with group mean, and

transformed data met the assumptions of equal variances and normal distribution. F statistics

were Greenhouse-Geisser corrected for a conservative α probability value. A selection index

was calculated with Ivlev's electivity index equation where the difference in trees used and trees

available is divided by the sum of trees used and trees available. Values greater than zero

indicate a preference and values less than zero indicate avoidance. The effect of season and tree

category on the tree selection index was tested in a two-way ANOVA with repeated measures to

determine if shrikes used different types of trees in the breeding season and in winter. Only the 5

territories observed in both sampling periods were included in the analysis.

Results

Shrikes in 16 study territories foraged from 482 perches in 154 observations. The

number of natural foraging perch trees used in a territory over a 31-day period in 2006 ranged

from 10 to 32 (mean = 20.8, SD = 6.2). A minimum convex polygon connecting the outermost

foraging perch-trees in ten territories covered an area of 11.08 ha on average (SD = 5.90) in

2006.

The height of foraging perch-trees ranged from 0.92m to 7.50m (mean = 3.47, SD = 1.2,

N = 437) and the number of woody plants within 50m ranged from 1 to 61 (mean = 21.23, SD =

12.4, N = 410). Shrikes did not perch on all of the four tree categories a similar amount.

Mesquite with a partial canopy was the most common category of perch tree (40%) followed by

bare or dead mesquite (31.8%), all other types of trees (19.6%), and full canopy mesquite (8.6%, N = 469). Fence posts constituted 4.3% of foraging perches and were the most common type of non-mesquite perch. Shrikes also foraged from the dead branches of juniper, hackberry, shin oak, and occasionally a yucca inflorescence or the dead stem of a sand sage.

All mesquite trees were bare in winter but still identifiable as one of the three canopy cover categories based on the presence or absence of buds and living stems. Trees in the dead or bare mesquite category also appeared to have fewer and stiffer branches than living trees. I field-checked 25 random foraging perch-trees from winter 2005 the following spring, and only two out of 25 trees were incorrectly categorized. Those two individual trees survived a low intensity fire in September 2005 that caused bud mortality. Shrikes foraged from a greater percentage of leafy mesquite in winter than the previous summer and following spring (Table 2.1). The number of trees used in the dead or completely bare category was lowest in winter and 7-8% higher in spring and summer (Table 2.1).

Shrikes foraged from taller than expected trees in the breeding season ($t = 2.142$, $df = 5$, $P = 0.043$) and also during winter ($t = 2.042$, $df = 7$, $P = 0.040$), but there was no difference in density of woody plants around foraging perches for either season (breeding: $t = 1.809$, $df = 5$, $P = 0.065$; winter: $t = -1.622$, $df = 7$, $P = 0.075$)(Table 2.2). Woody plant density was very similar for used foraging perches in both seasons although the number of woody plants around unused trees increased 41% in winter (Table 2.2). Shrikes in the breeding season foraged more from mesquite trees with at least some bare branches even though mesquite with a full canopy was the most common available tree category (used/available x tree category: $F = 9.03$, $df = 2.1, 10.5$, $P = 0.005$; Table 2.2). Tree categories used by foraging shrikes in winter were also not in proportion to their availability (used/available x tree category: $F = 5.77$, $df = 1.7, 12.2$, $P = 0.020$; Table 2.2)

and mesquite with at least some exposed dead branches was still used more.   Shrikes preferred

dead or partially dead mesquite trees and avoided completely leafy mesquite (Fig. 2.1). Tree

preferences did not differ between the breeding season and winter (month x tree preference: F =

0.846, df = 6, P = 0.517; Fig. 2.1).

Table 2.1. Conditions of foraging perch trees used (mean ± SE) in six Loggerhead Shrike (*Lanius ludovicianus*) territories in three seasons.

Tree category	Season Summer	Winter	Spring	Total
Mesquite (%)	3.2 ± 2.0	22.5 ± 8.0	3.8 ± 2.0	9.8 ± 3.4
Dead/mesquite (%)	46.2 ± 9.8	36.5 ± 11.5	36.2 ± 8.2	39.6 ± 5.5
Dead (%)	30.2 ± 12.0	22.1 ± 11.8	39.2 ± 13.9	30.5 ± 7.0
Other (%)	20.5 ± 8.1	18.9 ± 4.1	20.8 ± 9.0	20.1 ± 4.0

Table 2.2. Characteristics (mean ± SE) of trees used as foraging perches and unused trees available to Loggerhead Shrikes (*Lanius ludovicianus*).

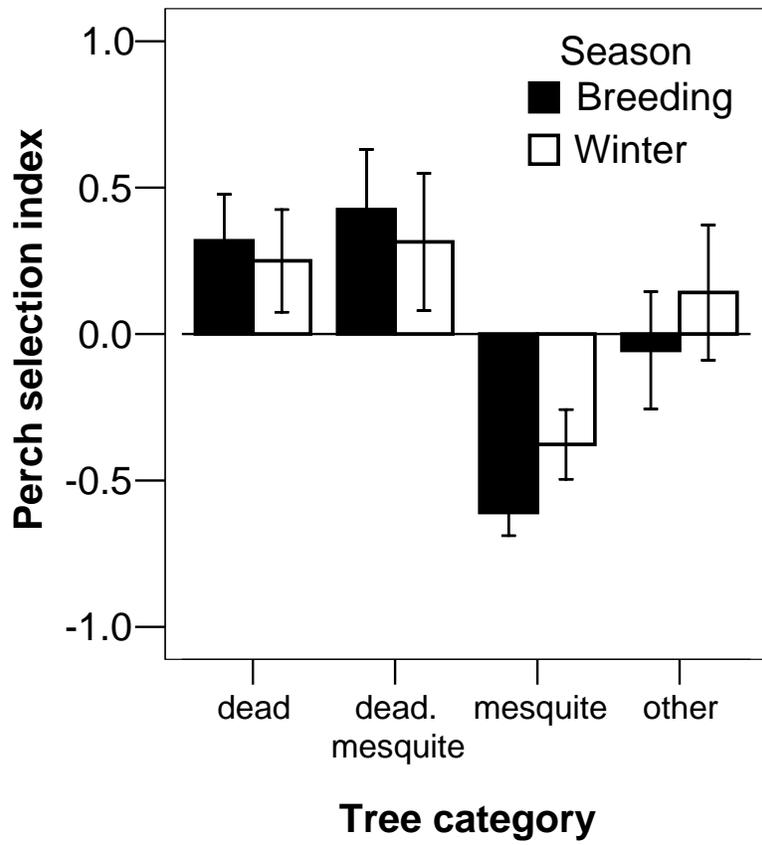| Tree measurement	Breeding (*n* = 6)		Wintering (*n* = 8)	
	Used	Available	Used	Available
Category (number per territory)				
dead	3.8 ± 1.4	2.8 ± 1.5	2.0 ±0.9	1.8 ± 1.0
dead/mesquite	2.8 ± 0.9	1.3 ± 0.6	2.8 ±0.7	1.0 ± 0.4
mesquite	1.0 ± 0.3	3.5 ± 0.8	1.5 ±0.4	3.8 ± 0.9
other	0.7 ± 0.4	0.7 ± 0.3	0.9 ±0.4	0.6 ± 0.4
Tree height (m)	3.4 ± 0.2	3.1 ± 0.2	3.3 ± 0.2	2.9 ± 0.2
Perch density index	20 ± 3	17 ± 2	21 ± 2	24 ± 2

Figure 2.1. Types of trees preferred or avoided by foraging Loggerhead Shrikes (*Lanius ludovicianus*) in 5 territories during the breeding season and winter 2005.

Discussion

Foraging habitat for sit-and-wait avian predators requires perch-tree availability and trees with specific characteristics. Several species selected exposed and prominent foraging perches with little visual obstruction that were well suited to detecting mobile prey from a stationary position (Guilfoyle et al. 2002, Thompson and McGarigal 2002, Yosef 2004). I predicted that shrikes would forage from taller trees with less foliage in areas of low woody density to facilitate prey detection below and immediately surrounding the perch.

Shrikes used trees that were approximately 10% taller than trees available in the territory. A vantage point from a taller tree may cover more surface area on the ground or provide a more penetrating angle into ground vegetation and, as a result, improve prey detection rates (Stillman and Simmons 2006). A preference for taller trees in this study may also be a function of tree condition. Taller trees are usually older and exposed to a greater number of traumatic events such as prescribed burns that leave some or all of the branches dead and defoliated. Because shrikes foraged more often from dead or partially dead mesquite trees, tree height may not have been as an important factor as extent of canopy cover in foraging perch selection.

Shrikes did not forage from perches with fewer surrounding trees or potential perches. Foraging perch-trees had a similar number of woody plants within 50m in the breeding season and winter. The absence of selection for more open habitat at the territory scale or smaller is consistent with other studies. Small scale areas used by shrikes in natural grassland and savannah of Kansas had similar tree and shrub densities to unused areas (Michaels and Cully 1998). At a microhabitat scale of less than 12m from a nest tree, shrikes in southeastern Canada did not use trees with a different density of surrounding trees or shrubs (Chabot et al. 2001). However, at the territory level ($\leq$ 200m from the nest), shrikes in agricultural habitat nested in

areas with more trees and fenceline (Esely and Bollinger 2001).   Tree or shrub density might be important for territory scale habitat selection, but within territory habitat use appears to be independent of woody plant density.

Few studies have identified characteristics of shrike natural perching substrate in relation to condition of the perch-tree. Shrikes in Florida foraged from dead trees more than living trees (Bohall-Wood 1987), and shrikes in South Carolina perched on trees instead of utility wire more often in winter (Gawlik and Bildstein 1993). Shrikes at this study site used the most common tree species available, honey mesquite, but use of individual mesquite trees related positively to the presence of bare branches. Shrikes made capture attempts on the ground from completely bare trees or trees with a partial canopy a disproportionate amount to their availability. The absence of foliage on lower branches probably provides a wider view of the ground below and increases the visible area in which to detect prey.

If the amount of foliage on a tree limits its potential as a foraging perch, I would predict removing foliage attracts shrikes to trees with a previously full canopy. As expected, an increase in the use of mesquite trees that had a complete canopy in summer coincided with the loss of leaves in winter. However, all mesquite trees were bereft of foliage in winter and rather than use each category in proportion to its availability, shrikes still foraged more often from trees with at least some dead branches. Shrikes repeatedly use the same foraging perches within a territory and may simply have continued to use favorite summer perch trees in winter. Tree structure could also play a role in perch selection. Dead mesquite branches are much more rigid than living branches, and in the windy conditions at my field site, a stationary shrike on a relatively immobile branch may be able to more effectively focus on small prey items than if moving around on a flexible branch.

Foraging perch selection based strictly on characteristics related to visual obstruction fails to explain why shrikes foraged from trees with a partial canopy a similar amount to entirely bare trees. One explanation is that from a shrike's view, visual obstruction does not differ while perched on an upper branch of either type of tree. Another possibility is that trees with a partial canopy are safer. Loggerhead shrikes are a 50g songbird overlapping in range with larger raptors and at risk of predation themselves. Exposed perches may offer better views to watch for prey, but potentially increase predation risk to the forager. Studies of other passerines show a preference for foraging closer to dense cover (Walther and Gosler 2001, Lee et al. 2005), and exposure is positively related to the risk of predation by aerial predators (Gotmark and Post 1996). Published reports of predation on loggerhead shrikes by larger raptors are scarce, but shrikes spent more time in plots with woody cover (i.e. escape cover) in areas of overlap with a larger raptor, Northern Harrier, *Circus cyaneus* (Kim et al. 2003). In the same study, wintering shrikes preferred plots with natural brushy perches compared to artificial brushy perch plots and simple artificial perch plots, possibly for the advantages of additional protective cover. A trade-off may exist in shrike foraging perch selection between trees with an unobstructed view and trees with a protective canopy.

Artificial perch experiment

To determine how canopy cover affects perch selection, I introduced artificial perches to study territories in May 2006. Shrikes were given a choice of artificial perch treatments with different types of cover below an exposed, rigid perch. The cover treatments offered relatively unobstructed views of the ground or relatively dense cover from predators. If shrikes select perches based only on criteria related to visual obstruction, we predicted the artificial perches with bulky cover would be avoided. Alternatively, if shrikes select perches with increased predator protection, the artificial perches with the most cover should be used more often.

Methods and materials

Behavioral observations started four days after artificial perches were introduced to territories in May 2006. I visited each territory every 4-6 days between May 17 and June 16 and followed the same protocol as 2005 observations. If a shrike foraged from an artificial perch, I recorded the perch treatment and the length of time the shrike perched before a capture attempt (perched time), measured with a stopwatch to the nearest second.

Artificial perches were constructed of 3.05m long by 1.2cm diameter metal tubes, painted black and mounted vertically on metal stakes. A forked "Y" stick with 15-25cm long split branches was broken off a dead mesquite and placed in the top of each tube for a natural perching material. Artificial perch treatments differed in the type of vegetative cover at the base of a tube. Tubes were erected above either 1) a living mesquite tree for a cover with foliage treatment (foliage cover), 2) a bundle of upright bare mesquite branches cut from trees defoliated by a prescribed burn for a cover without foliage treatment (bare cover), or 3) without any branches at the base for a treatment without cover (no cover).

To standardize the height and branching density of the two cover treatments, branches cut from burned mesquite were 2.2-2.8m long and 10-15cm in circumference at the base. Five cut branches were tied at the base to make a single bundle for each bare cover artificial perch. Living mesquite trees used for the foliage cover artificial perches had branches of the same number, length, and diameter range as branches cut for the bare cover treatment branches.

The mesquite tree closest to a random point in the territory and within protocol height and branch diameter was designated a foliage cover perch. Random points were between 40m and 100m and at a random bearing from the current nest. A minimum distance of 40m from an active nest was less likely to disturb nesting activity, and 100m approximated the average distance between consecutive natural foraging perches in 2005. Living mesquite trees that met the experimental protocol were limited in two territories, and the only two mesquite trees available within 100m were designated as the foliage cover treatment. If a nest in a study territory failed and the pair re-nested elsewhere in the territory, I moved the artificial perches to within 100m of the new nest. If a random point landed outside the known boundaries of the territory, on inaccessible land (e.g. private land), or in atypical shrike foraging vegetation (e.g. plum thicket), then a new point was selected with a different bearing and distance.

A bare cover perch and a perch without cover were erected 10m from the foliage cover perch in an equilateral triangle. Orientation of the bare cover perch and no cover perch from the living mesquite tree was random for every triangle. The 10m distance between experimental perches was chosen to avoid potential biases in perch selection resulting from differences in ground vegetation. Shrike foraging flights are typically less than 10m, and the same vegetation within a triangle was accessible to a shrike perched on any artificial perch in the group of three. I removed any existing trees or shrubs that would be potential foraging perches within 10m of an

artificial perch. Two groups of three artificial perches were erected in 10 territories for a total of 60 artificial perches.

I used Friedman's non-parametric test of ranked data to look for relative differences in the number of times shrikes used each artificial perch treatment. All ten study territories with artificial perches were included in the analysis even if resident shrikes did not perch on all artificial perch treatments. A corrected x_r^2 value was calculated to account for the presence of tied ranks (Zar 1999). The length of time shrikes perched on each artificial perch treatment was summed within territories, and differences between treatments tested with a 2 factorial ANOVA.

Results

Shrikes in eight out of ten study territories perched on the introduced artificial perches a total of 28 times in 64 observations. Shrikes perched on the bare cover treatment (50%) and the no cover treatment (35.7%) more than the cover with foliage treatment (14.3%, Table 2.3). Shrikes showed a lack of preference for foraging from the artificial perch treatment with a foliage cover ($x_r^2 = 7.22$, df $= 2$, P $= 0.027$; Fig. 2.2). Shrikes perched on the bare cover treatment longer than the other two cover treatments (F $= 5.130$, df $= 2, 14$, P $= 0.021$; Fig. 2.3). Foraging flight distances from the artificial perch to the ground were very similar for all three treatments. Shrikes stayed on the ground longest next to the foliage cover treatment and shortest next to the artificial perches without any cover (Table 2.3). Shrikes did not use all the artificial perch treatments often enough to statistically compare flight distances and ground time between treatments.

Table 2.3. Behavioral responses (mean ± SE) by Loggerhead Shrikes (*Lanius ludovicianus*) to artificial perches.

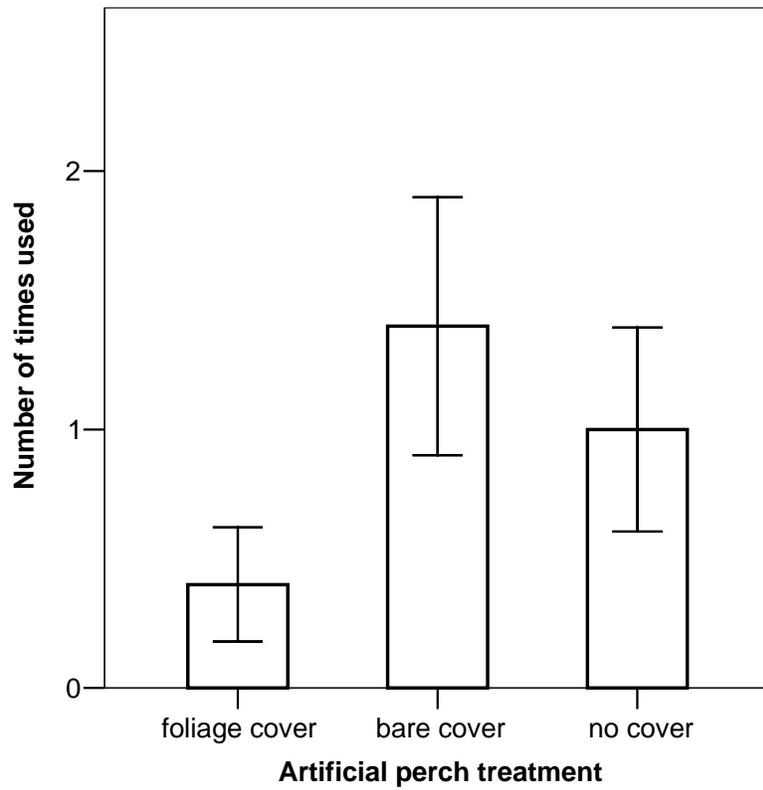| Behavior	Cover treatment		
	foliage (*n* = 4)	bare (*n* = 14)	none (*n* = 10)
Foraging flight distance (proportion of perch height)	1.5 ± 0.3	1.6 ± 0.2	1.6 ± 0.4
Ground time (s)	4.3 ± 1.9	3.3 ± 1.9	2.5 ± 0.7

Figure 2.2 Use of artificial perches (mean ± SE) by Loggerhead Shrikes (*Lanius ludovicianus*) in ten territories during the 2006 breeding season.
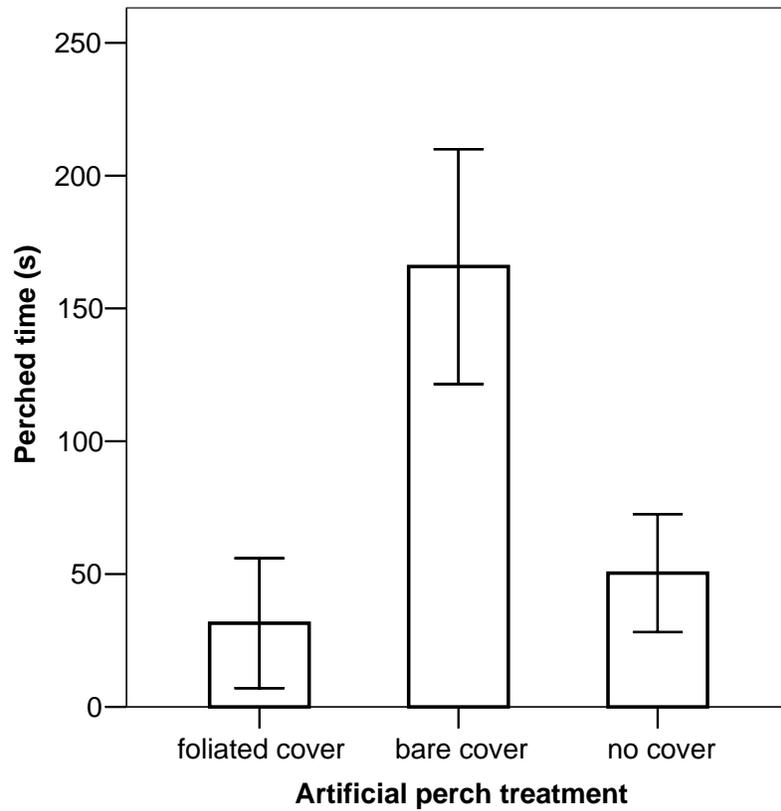
Figure 2.3. Length of time (mean ± SE) Loggerhead Shrikes (*Lanius ludovicianus*) in ten territories perched on artificial perches with different types of cover.

Discussion

The shrikes' preference for artificial perches without leafy cover supports the hypothesis that foraging perches are selected for fewer visual obstructions. These results are consistent with flycatchers that perched on branches with fewer leaves (Guilfoyle et al. 2002) and Brown shrikes that foraged from lateral branches in a position to see more of the ground (Yosef 2004). Interesting to note, the number of times shrikes perched on the bare cover treatment and the treatment without cover did not differ significantly. If shrikes select perches with fewer visual obstructions, it's not clear why the more structurally complex cover treatment was used to such an extent. The simplest explanation is that the view from the top of the metal tubes was effectively the same from either treatment, and a shrike looking down was not limited by the dead branches in the cover treatment. Another possibility is that the bare cover treatment had lower predation risk than the treatment without cover. Dense canopies offer songbirds protection and a place to escape from aerial attacks by raptors (Walther and Gosler 2001, Gotmark and Post 1996, Walther and Gosler 2001, Lee et al. 2005). I did not observe any direct attacks on adult shrikes by raptors in the study area, but shrikes wintering in southern Texas were more likely to forage from complex or bushy perches when larger raptors were present (Kim et al. 2003).

The shrikes in this study exhibited two behavioral trends that might indicate the cover treatments are perceived as lower predation risk. The length of time shrikes stayed on the ground was longer while foraging from the two cover treatments than while foraging from the artificial perches without cover. Foraging birds approached by a human observer remained on the ground longer next to taller trees, possibly because taller trees are safer (Fernandez-Juricic et al. 2002). It is possible shrikes remained on the ground longest next to cover because of the increased likelihood of a successful escape.

Differences in the length of time shrikes perched on each artificial perch treatment might also indicate that perches with cover are safer. Prior to a foraging flight to the ground, shrikes perched significantly longer on the bare cover treatment than on the artificial perch without cover. Birds attending feeders perched on feeders in woods or on forest edges with cover longer than at feeders farther from cover in open fields (Lee et al. 2005). The amount of time perched on an artificial perch could represent relative predation risk, with the cover treatments having lower risk.

Overall, the results from the observational and artificial perch experiments indicate that shrikes prefer trees that have fewer visual obstructions. Bare and exposed branches or artificial substrate should be considered in assessments of foraging perch-tree availability and the conservation value of potential shrike habitat. Artificial perches are relatively easy and economically efficient to construct, and the addition of artificial perches to habitat without perch substrate could make foraging habitat more accessible and likely to be used by shrikes. The results related to the effects of predation risk on perch-tree selection were inconclusive. There may be a trade-off between visual obstructions and cover from predators, but further research needs to address 1) if shrikes retreat into the canopy in the presence of raptors as do chaffinches in the presence of a simulated aerial attack (Krams 2001); 2) if time perched on a trees changes with tree characteristics; and 3) if time spent on the ground changes with distance from tree, tree height, or amount of canopy cover.

CHAPTER 4: SUMMARY AND CONCLUSIONS

In conclusion, this study showed that Loggerhead Shrikes (*Lanius ludovicianus*) will forage in vegetation with accessible prey in preference to vegetation with abundant prey. Mowed grass contained less invertebrate prey, but prey accessibility was probably lower in taller grass because of increased prey concealment or increased prey handling. I did not record any measurements related to foraging success in different vegetation heights, but in habitat with only taller grass available, mowing small patches might increase foraging opportunities for shrikes. Use of mowed patches decreased within 5 weeks of mowing, and the benefits of short grass may be time limited. More research is needed on the response of shrikes and invertebrate prey to mowed patches of different sizes and length of time between consecutive mowing dates.

Most trees at the study site were relatively short (<5 m) and shrikes in this study used taller trees than expected. The observational experiment on foraging perch selection showed that shrikes are more likely to use trees with at least some exposed dead branches. Shrikes also perched more often and perched for more time on artificial perches without leafy cover, supporting the hypothesis that perch selection positively relates to fewer visual obstructions. Shrikes avoided leafy trees in summer and continued to avoid the same type of trees without dead branches even in winter when all trees lost their leaves. Other variables, possibly the rigidity of dead branches or the location of a foraging perch within the territory, might help to explain shrike perch-tree selection and warrant additional research. The data provide some evidence to support the importance of predation risk in perch selection. More conclusive evidence would require additional research on responses to threats from predation.

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