

NEST-SITE SELECTION AND NEST-ENTRANCE ORIENTATION IN SPRAGUE'S PIPIT

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ABSTRACT.—Nest-site selection and nest-entrance orientation patterns in Sprague's Pipit (*Anthus spragueii*), an endemic grassland passerine that builds a domed nest on the ground were measured at nest sites and randomly selected non-nest sites, and nest-entrance orientations were compared to random, circular distributions and dawn azimuths. Pipits showed a preference for sites in dense, grassy, and relatively tall vegetation with low forb density and little bare ground, presumably because such sites offer protection against predation and heat stress. There was no significant directionality in terms of nest-entrance orientation, implying that potential thermal benefits of an east-facing nest play a limited role during nest-site selection. *Received 11 Oct. 1996, accepted 8 Feb. 1997.*

Breeding birds show a range of behaviors that can affect their survival and reproductive success, including nest-site selection (Espie et al. 1996, Woods and Cade 1996). The choice of a suitable nest site is especially important for songbirds and other short-lived species because each chick represents a potentially large contribution to life-time reproductive output. In grassland songbirds, nest-site selection is affected by factors ranging from heat stress (George et al. 1992, With and Webb 1993) to high predation risk (Martin 1993, Camp and Best 1994, With 1994), and many species have adapted by building or selecting nest sites that are sheltered and well hidden (Ehrlich et al. 1988).

Sprague's Pipit (*Anthus spragueii*) is an endemic grassland songbird that breeds throughout much of the Great Plains of North America (Owens and Myres 1973) and in grassland areas of British Columbia (McConnell et al. 1994). Singing males are uncommon in heavily grazed areas (Dale 1983) and show a preference for native grassland over fields dominated by introduced vegetation (Cody 1974, Wilson and Belcher 1989, Sutter 1996). Like other birds of the open prairie, pipits build a domed nest at the base of a dense tussock of grass, laying 4–5 eggs per clutch and requiring 22–26 d to complete incubation and nestling periods (Maher 1973, Sadler and Maher 1974, Sutter 1996). More information is required on the nesting ecology of this species, because little is known overall (Ehrlich et al. 1988) and population levels appear to be declining by 5–10% per year over much of its range (Sauer et al. 1996).

The aim of this study was to document the nest-site selection and nest-entrance orientation patterns of pipits breeding in native mixed-grass prai-

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rie. My objectives were to determine (1) whether pipit nests are located in relatively dense vegetation, presumably for maximum protection against predation and heat stress, and (2) whether their nest entrances are oriented towards sunrise to take advantage of the morning sun and to avoid mid-day heat. To address objective one, I compared the plant species composition and vegetation structure of pipit nest sites to that of randomly selected non-nest sites. For objective two, I tested nest-entrance orientations against a random circular distribution and compared the mean entrance direction to the dawn azimuth.

METHODS

This study was conducted from 13 May–9 August 1994 and from 9 May–8 July 1995, on approximately 256 ha of native mixed-grass prairie at the south end of the Matador Provincial Community Pasture (50°41'N 107°44'W) in Saskatchewan, Canada. The site has a flat to rolling topography and is grazed annually. Native vegetation on the site is dominated by northern and western wheat grass (*Agropyron dasystachyum* and *A. smithii*, respectively), June grass (*Koeleria gracilis*), and green needle grass (*Stipa viridula*). Other common plant species include snowberry (*Symphoricarpos occidentalis*), pasture sage (*Artemisia frigida*), prairie rose (*Rosa arkansana*), sedges (*Carex* spp.), and numerous forbs (Coupland et al. 1973). Plant nomenclature follows that of Vance et al. (1984) and Looman (1982).

Pipit nests were located by dragging a weighted 30-m rope over the study site and carefully searching wherever birds flushed. Nests were also found by chance and by tracking birds wearing radio-transmitters (see Sutter et al. 1996). Once a nest was located, nest-entrance orientation was measured with a compass and corrected for magnetic declination.

Two non-nest sites were examined for each nest site, to reduce variability introduced by sampling an atypical non-nest site. Each non-nest site was located by walking a random distance away from the nest (between 1 and 100 m) in a randomly chosen cardinal direction. Non-nest sites were limited to the area within 100 m of a nest to increase the chance of non-nest sites being within the nesting territory of the bird in question (see Sutter 1996).

At both nest sites and non-nest sites, vegetation structure was measured in a 0.5 × 0.5 m quadrat that was centred over the nest (in the case of the nest site) or over a suitable tussock of grass (in the case of non-nest sites). All measurements were taken after chicks had fledged or the nest had been abandoned.

The methods I used to measure vegetation structure are described in detail elsewhere (Sutter et al. 1995). Briefly, percent cover was estimated for grasses and sedges, forbs and shrubs, bare mineral soil, and litter using the Daubenmire scale (Barbour et al. 1980). Forb density was measured by dividing the quadrat into four equal subquadrats and measuring the distance between the center point and the nearest forb in each subquadrat. These measurements were then converted to a density (D) estimate using the equation: $D = (2(d)^2)^{-1}$, where d = the mean distance in meters and 2 is a constant correction factor (Barbour et al. 1980). Vegetation density in the vertical plane was measured in each subquadrat by counting the number of plant contacts above and below 10 cm along a thin (2 mm diameter) metal rod placed randomly within each subquadrat. Litter depth and maximum plant height were estimated, respectively, by measuring the depth of loose (unattached) dead vegetation and the height of the tallest plant in each subquadrat, excluding influorescences. I also estimated the distance to the nearest potential perch, generally a shrub or rock.

In 1995, I examined plant species composition at nest sites and non-nest sites by identifying vascular plant species (sedges were identified to genus) and estimating their percent

TABLE 1
MEANS AND STANDARD ERRORS (SE) FOR HABITAT STRUCTURE VARIABLES AT SPRAGUE'S
PIPIT NEST SITES AND NON-NEST SITES BASED ON 0.5×0.5 M QUADRATS

Variable	Nest sites		Non-nest sites		Wilcoxon results
Grass and sedge cover (%)	52.7	(3.5)	42.2	(2.2)	***
Forb and shrub cover (%)	10.5	(1.5)	13.3	(0.8)	*
Litter cover (%)	15.2	(1.2)	14.4	(1.0)	ns
Bare ground cover (%)	16.8	(3.1)	25.1	(2.2)	***
Forb density (plant contacts $\cdot$ m ⁻²)	55.6	(15.6)	93.1	(14.3)	**
Maximum height (cm)	27.7	(0.9)	25.6	(0.6)	**
Litter depth (cm)	2.4	(0.4)	1.9	(0.1)	ns
Contacts above 10 cm	1.1	(0.1)	0.9	(0.1)	ns
Contacts below 10 cm	3.0	(0.3)	2.9	(0.3)	ns
Nearest perch (m)	20.7	(2.2)	16.8	(1.9)	ns

* $P < 0.05$, ** $P < 0.005$, *** $P < 0.001$, Wilcoxon matched pairs test, $N = 47$.

cover in the 0.5×0.5 m quadrat. Unknown species were collected and compared to herbarium specimens for identification or revisited later in the growing season when they were easier to identify. Plant species richness was determined for all vascular species and separate totals were generated by life form (grasses and sedges versus forbs and shrubs) by counting the number of species in each quadrat. Plant species diversity and evenness were estimated based on the indices developed by Hill (1973).

For each structural and floristic variable, I calculated means for the pair of non-nest sites associated with each nest site, and tested for differences between nest sites and non-nest sites with a Wilcoxon matched pairs test. I used a paired, nonparametric test because non-nest sites were selected relative to nest locations and most data sets violated the assumptions required for parametric analysis. I pooled measurements from 1994 and 1995 because there was no obvious difference in grazing pressure between years.

I examined nest-entrance orientation by applying Rayleigh's test for circular uniformity (Zar 1984) and comparing the mean entrance direction to 60° , which is the mean dawn azimuth during the breeding season at the study site (Herzberg Institute of Astrophysics, National Research Council of Canada).

RESULTS

Vegetation structure was measured at 47 nest sites and 94 non-nest sites. Nest sites had significantly higher grass and sedge cover and maximum height, and significantly lower forb and shrub cover, bare ground cover and forb density (Table 1), suggesting that pipits seek out dense, grassy vegetation during nest-site selection.

Northern wheat grass (*Agropyron dasystachyum*) was the most common grass and pasture sage (*Artemisa frigida*) was the most common forb at both nest sites and non-nest sites (Table 2), and northern wheat grass often formed all or most of the nest canopy (pers. obs.). There were no significant differences between nest sites and non-nest sites in terms of

TABLE 2
MEANS AND STANDARD ERRORS (SE) FOR PLANT COMMUNITY PARAMETERS AT SPRAGUE'S
PIPIT NEST SITES AND NON-NEST SITES BASED ON 0.5 × 0.5 M QUADRATS

Variable	Nest sites	Non-nest sites	Wilcoxon results
Community parameter			
Grass and sedge species richness	3.9 (0.2)	3.9 (0.1)	ns
Forb and shrub species richness	4.3 (0.4)	4.8 (0.3)	ns
Total plant species richness	8.2 (0.4)	8.7 (0.3)	ns
Plant species diversity	4.4 (0.2)	4.8 (0.2)	ns
Plant species evenness	0.77 (0.02)	0.78 (0.01)	ns
Grasses and sedges (%)			
<i>Agropyron dasystachyum</i>	18.8 (2.4)	13.4 (1.6)	ns
<i>Agropyron smithii</i>	4.5 (0.8)	4.0 (0.6)	ns
<i>Carex</i> spp.	6.8 (1.5)	8.9 (1.5)	ns
<i>Koeleria gracilis</i>	8.0 (1.6)	11.1 (1.4)	ns
Forbs and shrubs (%)			
<i>Achillea millefolium</i>	2.9 (1.0)	1.8 (0.4)	ns
<i>Artemesia frigida</i>	6.8 (1.3)	6.7 (0.9)	ns
<i>Phlox hoodii</i>	1.1 (0.3)	3.1 (0.8)	*

* $P < 0.05$, Wilcoxon matched pairs test, $N = 21$.

plant species richness, diversity or evenness (Table 2), suggesting that plant community parameters are not directly involved in nest-site selection. There were also no differences between nest sites and non-nest sites in terms of dominant plant cover, except that nest sites had slightly less cover due to moss phlox (*Phlox hoodii*). This difference is probably not biologically significant, however, since it involved only a very small amount (2%) of the vegetation cover (Table 2).

The mean ($\pm$ SE) entrance-orientation of pipit nests was $82 \pm 36^\circ$ ($N = 49$, Fig. 1), which is not significantly different from the average dawn azimuth at Matador during the breeding season (95% confidence interval = $13\text{--}152^\circ$). This result should be viewed with caution, however. The distribution of the nest-entrance data was statistically uniform (Rayleigh test of circular uniformity, $P > 0.05$), indicating no strong directionality in the entrance orientation of pipit nests and little, if any, effect due to the dawn azimuth.

All of the nests examined here were also used in a larger study of pipit incubation behavior which addressed the effects of disturbance and nest-site manipulation (see Sutter 1996). As a result, I was unable to determine whether nest-site vegetation parameters and (or) nest-entrance orientation had any direct impact on nesting success.

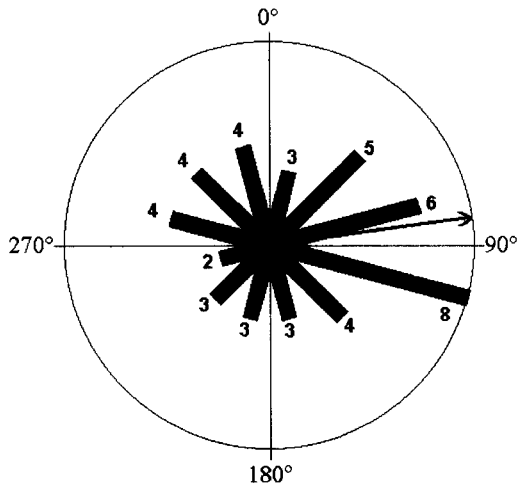


FIG. 1. Circular histogram of entrance directions for Sprague's Pipit nests. Numbers associated with each bar indicate the number of entrances that were pointing toward each direction. The overall mean direction (82°) is indicated by the arrow.

DISCUSSION

Sprague's Pipit nest sites tended to be in dense, grassy and relatively tall vegetation with relatively low forb density and low bare ground cover (Table 1). All nests were completely or partially domed, and the canopy was often comprised of northern wheat grass (*Agropyron dasystachyum*). This plant may have been an integral part of pipit nest canopies by chance, given that it was the dominant grass on the study site (Coupland et al. 1973, Sutter 1996). Alternatively, pipits may seek out this plant species because it provides abundant litter and tends to form rather loose tussocks (pers. obs.). A preference for certain plants has been shown in Tree Pipits (*Anthus trivialis*) which place their nests at the base of the grasses *Calamagrostis epigeos* and *Brachypodium silvaticum* (Loske 1987).

The thermal importance of nest cover has been recognized for some time (Wiens 1974, Walsberg 1981). Domed, well-hidden nests are used by other ground-nesting birds (Norment 1993, With and Webb 1993, Haggerty 1995) and several congeners (Verbeek 1981, Högstedt 1978, Loske 1987), presumably because ground-level microclimates can get very hot (Salzman 1982, Vispo and Bakken 1993, Sutter 1996). Nest canopies can also be beneficial at night because the vegetation limits heat loss and emits 20–30% more long-wave radiation than the night sky (Walsberg 1985).

A well-hidden nest site may also reduce (Wray and Whitmore 1979, Norment 1993), increase (With 1994), or have no effect on predation (Howlett and Stutchbury 1996), depending on the types of predators in a system and the hunting techniques they use (Martin 1993). Common songbird predators at Matador include coyotes (*Canis latrans*) and predatory birds, which hunt at least partly by sight (Maher 1974, pers. obs.), so domed nests may be an effective way for pipits to reduce the risk of predation in this area. Also, pipits may tend to avoid placing their nests in areas with high bare ground cover (Table 2) to reduce the chances of being detected by a predator as they travel to and from the nest.

Other studies have shown a connection between predation risk and the orientation of ground-level nests. Högstedt (1978) redirected the entrances of Tawny Pipit (*A. campestris*) nests from northeast-northwest to southwest and found a concomitant increase in predation. The proposed explanation was that the contents of nests facing southwest were more illuminated by sunlight and, therefore, more obvious to flying predators. Haggerty (1995) used the same argument to explain nest directionality in Bachman's Sparrows (*Aimophila aestivalis*), which nest in forest openings and tend to aim the entrance north or northeast. Significant directionality has also been reported for Water Pipits (*A. spinoletta*; Verbeek 1981) and Tree Pipits (Loske 1987).

The absence of strong nest-entrance directionality in Sprague's Pipit (Fig. 1) may be due to the fact that nests of this species are often at the end of a partially or completely covered runway which can be up to 15 cm long and sharply curved (pers. obs.). The extra shelter afforded by the runway cover may ensure that the nest contents are rarely illuminated or overheated by the mid-day sun. In contrast, nests of Tawny and Water pipits have been described as "partly covered" (Högstedt 1978) and "overhung by sod or rock" (Verbeek 1981) or even "open" (Rendell and Robertson 1994). Presumably, sunlight is able to penetrate such nests for at least part of the day, putting selective pressure on birds to optimize the orientation of the nest entrance.

In conclusion, Sprague's Pipits appear to be selective in choosing their nest site, showing a preference for more protected locations and little regard for plant species composition. I found no strong directionality in the orientation of their nest-entrance, presumably because the nest is often placed at the end of a covered runway.

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