SLACK, R. D. 1976. Nest guarding behavior by male Gray Catbirds. Auk 93:292–300.

SMITH, J. N. M., P. ARCESE, AND I. G. MCLEAN. 1984. Age, experience, and enemy recognition by wild Song Sparrows. Behav. Ecol. Sociobiol. 14:101–106.

UYEHARA, J. C. AND P. M. NARINS. 1995. Nest defense by Willow Flycatchers to brood-parasitic intruders. Condor 97:361–368.

WEATHERHEAD, P. J. 1989. Sex-ratios, host-specific reproductive success and impact of Brown-headed Cowbirds. Auk 106:358–366.

WILEY, J. W. 1988. Host selection by the Shiny Cowbird. Condor 90:289–303.

Wilson Bull., 110(1), 1998, pp. 136–139

Characteristics of Florida Grasshopper Sparrow Nests

Michael F. Delany[1,2] and Stephen B. Linda[1]

ABSTRACT.—We examined nests of the endangered Florida Grasshopper Sparrow (*Ammodramus savannarum floridanus*) on the U.S. Air Force Avon Park Range, Highlands County, Florida. Nests (n = 20) were located on the ground in shallow (≤3.2 cm) excavations in the sand substrate. All were domed (>50% of the cup covered) and made of grass and grass-like monocots. Most (75%) were shielded by a low (<29.5 cm) growth of dwarf live oak (*Quercus minima*). Nest opening directions were randomly oriented ($P > 0.05$). Vegetation density was significantly lower in the nest opening quadrant than in other quadrants ($P = 0.003$). An exposed area at the nest opening would facilitate access and make predator distraction displays more visible. *Received 24 May 1997, accepted 4 Oct. 1997.*

The Florida Grasshopper Sparrow (*Ammodramus savannarum floridanus*) is an endangered subspecies endemic to the south-central prairie region of the state (Fed. Reg. 1986). Basic information on nesting ecology is needed to develop and implement conservation strategies for the sparrow (USFWS 1988). Nest location, structure, and orientation may have important implications for reproductive success and population stability. Previous descriptions have been anecdotal (Howell 1932, Nicholson 1936). In this paper we present data on the placement, composition, dimensions, and orientation of Florida Grasshopper Sparrow nests.

STUDY AREA AND METHODS

Data were collected during 20 May 1993–31 July 1996 on the U.S. Air Force Avon Park Range, Highlands County, Florida. The study area was a 700 ha grass, shrub, and saw palmetto (*Serenoa repens*) plant community described by Delany et al. (1985). The prairie was burned with head fires (burned with the wind) between December and mid-March on a 2–3 year rotation.

The study area was systematically searched by walking transects at 50 m intervals. Observations of Grasshopper Sparrows delivering food to nestlings and females flushed from nests indicated possible nest sites. Nests were found by searching these locations. After termination of the nesting attempt, we measured nest outside diameter, nest inside diameter, nest height above substrate, and orifice width (diameter of the nest opening). Orientation of the nest opening was measured with a compass and grouped in 90° quadrants centered to orientations N, S, E, and W. Nests were measured in place within 5 days of termination.

Features of the vegetation composition and structure were measured at each nest in the 4 cardinal directions. Point subsample measurements (4/nest) were made within 1 cm of the nest and included: (1) vertical density—the total number of vegetation contacts with a 7 mm diameter metal rod placed vertically into the vegetation; (2) height—the height of the highest contact with the rod; and (3) percentage cover—the total cover by each of the vegetation components (grasses, forbs, shrubs, litter, and bare ground) as determined by counting the number of cm of each component along a 1 m transect adjacent to point samples (Whitmore 1981). Plant species providing shielding to the nest were recorded. Time post-burn was recorded for all sample locations.

Fifteen nests were collected and plant species used in construction were identified, and their relative abundance was visually estimated. Plant names follow Wunderlin (1982).

To test the null hypothesis that nest opening direction was uniformly distributed against any alternative

[1] Florida Game and Fresh Water Fish Commission, 4005 South Main St., Gainesville, FL 32601.

[2] Corresponding author.

TABLE 1. Plant species (≥ 20% occurrence) comprising Florida Grasshopper Sparrow nests (n = 15), Avon Park Air Force Range, Highlands County, Florida, 20 May 1993–31 July 1996.

Plant species	% occurrence
Elliot's yellow-eyed grass (*Xyris elliottii*)*	87
Roadgrass (*Eleocharis baldwinii*)*	87
Wiregrass (*Aristida beyrichiana*)	80
Bluestem (*Andropogon* sp.)	80
Short-leaf yellow-eyed grass (*Xyris brevifolia*)	73
Yellow hatpins (*Syngonanthus flavidulus*)	60
Dwarf live oak (*Quercus minima*)	47
Panic grass (*Dicantheleium ensifolium*)	47
Moss (*Polytrichum* sp.)	33
Golden aster (*Pityopsis graminifolia*)	27
Torrey's nutrush (*Scleria reticularis*)	27
Bottlebrush threeawn (*Aristida spiciformis*)	20

* Species that comprised a distinct inner lining of the nest cup.

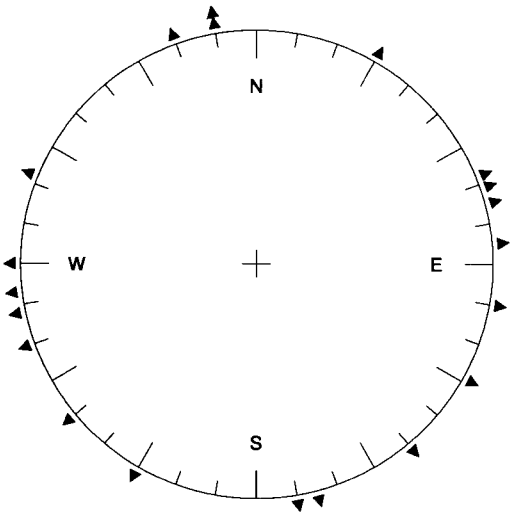

FIG. 1. Orientation of nest entrances of 20 Florida Grasshopper Sparrow nests at Avon Park Air Force Range, Florida. Triangles show direction of opening. Opening directions were randomly oriented ($P > 0.05$).

hypothesis, the omnibus test (Fisher 1993) was performed, in which the modified Kuiper statistic (V) was computed. A Rayleigh test (Fisher 1993) was performed to test the null hypothesis of uniformity against unimodal and bipolar alternatives.

An analysis of variance (ANOVA) was performed to test for differences in percent bare ground coverage and density (number of vegetation contacts) between the compass quadrant towards which a nest opened and other quadrants. In order to induce homogeneity of variance, the Box-Cox variance stabilizing transformation for vegetation contacts was used. The logit transformation was used for percent bare ground to maintain consistency with Aitchison's (1986) approach for the analysis of compositional data. The 0% bare ground value in the dataset was changed to 1% bare ground for this analysis because the logit of 0% is $-\infty$. A split-plot model was used in the ANOVA, in which the main-plot factor was MONTHS POST-BURN, the main-plot error term was NEST NUMBER WITHIN MONTHS POST-BURN, the sub-plot factor was QUADRANT (levels were: nest opening quadrant and not nest opening quadrant), and the sub-plot error term was QUADRANT × NESTNUMBER WITHIN MONTHS POST-BURN. If the MONTHS POST-BURN × QUADRANT interaction was not significant, then that term was deleted from the model, the reduced model was fitted, and the reported P-value for QUADRANT was based on the reduced model. Least-squares means for QUADRANT levels were back transformed to the original scale, and the SE of the back transformed least-squares means was obtained by application of the delta method.

RESULTS

Twenty active nests (containing eggs or young) were located on the ground in shallow (≤3.2 cm) excavations in the sand substrate. Nest cup rims were level with or slightly (≤1.3 cm) above the ground. Primary shielding vegetation was dwarf live oak (*Quercus minima*, n = 15), but also included wire grass (*Aristida* sp., N = 1), gopher apple (*Licania michauxii*, n = 1), yellow-eyed grass (*Xyris* sp., n = 1), saw palmetto (n = 1), and St. Johns-wort (*Hypericum brachyphyllum*, n = 1).

Nest material was a mixture of several narrow leaved grasses and grass-like monocots (Table 1). Nests (n = 15) were comprised mainly of wire grass, bluestems (*Andropogon* sp.), and yellow-eyed grass (*Xyris* spp.). Mean nest outside diameter was 10.3 cm (SD = 0.9, range = 8.8–12.3), inside diameter was 6.9 cm (SD = 0.6, range = 5.8–7.9), and height was 7.7 cm (SD = 0.5, range = 6.5–8.5). All nests were domed (nest material covered ≥50% of the cup) with an average orifice width of 5.1 cm (SD = 0.8, range = 3.7–7.2). Opening directions were randomly oriented (V = 0.88, $P > 0.05$; Fig. 1) and not significantly grouped using unimodal and bipolar alternatives ($P > 0.05$ for each test).

Nests were located in grasslands that were 4 (n = 16), 16 (n = 1), and 24 months (n = 3) post-burn. Differences in bare ground coverage and vegetation density at the nest site were evident after fire (Table 2); however, the

TABLE 2. ANOVA results of a comparison of bare ground coverage and vegetation density (number of contacts) in the compass quadrant towards which a nest opened with the same features in other quadrants (n = 20 nests). Results are for reduced model (P-values for MONTHS POST-BURN × QUADRANT were 0.68 and 0.28 for % bare ground and CONTACTS, respectively). Avon Park Air Force Range, Highlands County, Florida, April 1993–July 1996.

Response variable	Source	df	Type III mean square	F	P-value
$\log\left(\frac{\text{percent bare ground}}{\text{100-percent bare ground}}\right)$	Months POST-BURN	2	9.4899	14.47	0.0002
	Quadrant	1	0.1090	0.25	0.6211
log (CONTACTS + 1)	Months POST-BURN	2	2.8967	3.37	0.0586
	QUADRANT	1	5.6966	11.71	0.0029

quadrant effect did not depend on months post-burn for either response variable ($P > 0.05$ for each). The back transformed least squares mean bare ground coverage in the nest opening quadrant ($\hat{\bar{x}} = 21.2$, $\widehat{SE} = 4.3$) was higher than in other quadrants ($\hat{\bar{x}} = 16.9$, $\widehat{SE} = 2.1$) but the effect was not significant ($P = 0.05$; Table 2). However, the mean number of vegetation contacts in the nest opening quadrant ($\hat{\bar{x}} = 4.1$, $\widehat{SE} = 1.1$) was significantly lower ($P = 0.003$) than in other quadrants ($\hat{\bar{x}} = 12.8$, $\widehat{SE} = 2.0$).

DISCUSSION

The placement, dimensions, and composition of Florida Grasshopper Sparrow nests were similar to those reported for other subspecies (McNair 1984, Vickery 1996). However, most (75%) *A. s. floridanus* nests were shielded by dwarfed shrubs rather than grass clumps (sources cited above). Unpublished information from Florida Grasshopper Sparrow oological collections (McNair 1986) indicated that 28 of 44 nests were shielded by saw palmetto (D. B. McNair, pers. comm.). Compared to the eastern race (*A. s. pratensis*), habitat occupied by *A. s. floridanus* had a much higher value for shrub cover (including saw palmetto; Delany et al. 1985) which appears to be the preferred nesting site.

Wiens (1969) reported a nonrandom east and northeast orientation of most (10 of 15) Grasshopper Sparrow (*A. s. pratensis*) nest openings in Wisconsin. Nonrandom nest orientation of some grassland birds has been related to thermal constraints (With and Webb 1993). In our study, orientation may have been random because openings were positioned towards areas of low vegetation density and bare ground near nests. Results were consistent despite significant differences in vegetation structure related to time post-burn. Adults visiting a nest usually approached the entrance on the ground (pers. obs.). Also, adult females flushed from nests engaged in predator distraction displays (see Vickery 1996). An exposed area near the nest entrance would facilitate access and make distraction displays more visible.

Grasshopper Sparrows are ground-dwelling birds that usually require at least 20% bare ground for unrestricted movement but enough vegetation to provide nest cover (Whitmore 1981, Vickery 1996). Frequent burning maintains prairie grasslands in a sparse, early successional stage (Delany et al. 1985) and appears to provide vegetation compositions suitable for nesting at this location. Features of occupied and abandoned territories indicate the Florida subspecies probably cannot adapt to habitat perturbations that remove potential nest sites (Delany and Linda 1994). Information presented here provides a better understanding of the sparrow's habitat requirements. Measures of Florida Grasshopper Sparrow reproductive success are needed to determine habitat quality and evaluate variables influencing nesting outcome. If *A. s. floridanus* continues to decline in numbers and nears extinction, the Recovery Plan (USFWS 1988) recommends that a captive population be established. Information on nests and nest sites of a wild population would be important should that recovery effort become necessary.

ACKNOWLEDGMENTS

This study was funded by the Florida Nongame Wildlife Trust Fund. C. S. Collins, T. F. Dean, D. K.

Ford, L. N. Herrlinger, B. W. Mansell, B. C. Pranty, D. R. Progulske, Jr., M. D. Scheurell, and P. B. Walsh helped search for nests. E. L. Bridges and S. L. Orzell identified nest material. T. L. Steele provided word processing assistance. J. R. Brady, D. B. McNair, S. A. Nesbitt, J. A. Rodgers, Jr., P. D. Vickery, R. C. Whitmore, and D. A. Wood reviewed previous drafts.

LITERATURE CITED

AITCHISON, J. 1986. The statistical analysis of compositional data. Chapman and Hall, London.

DELANY, M. F., H. M. STEVENSON, AND R. MCCRACKEN. 1985. Distribution, abundance, and habitat of the Florida Grasshopper Sparrow. J. Wildl. Manage. 49:626–631.

DELANY, M. F. AND S. B. LINDA. 1994. Characteristics of occupied and abandoned Florida Grasshopper Sparrow territories. Fla. Field Nat. 22:106–109.

FED. REG. 1986. Endangered and threatened wildlife and plants; determination of endangered status of the Florida Grasshopper Sparrow. Federal Register 51(147):27,492–27,495.

FISHER, N. I. 1993. Statistical analysis of circular data. Cambridge Univ. Press, Cambridge, UK.

HOWELL, A. H. 1932. Florida bird life. Coward-McCann, New York.

MCNAIR, D. B. 1984. Breeding status of the Grasshopper Sparrow in the coastal plain of the Carolinas with notes on behavior. Chat 48:1–4.

MCNAIR, D. B. 1986. Clutch information for the Florida Grasshopper Sparrow from oological collections. Fla. Field Nat. 14:48–49.

NICHOLSON, W. H. 1936. Notes on the habits of the Florida Grasshopper Sparrow. Auk 53:318–319.

USFWS. 1988. Recovery plan for Florida Grasshopper Sparrow. U.S. Fish and Wildlife Service, Atlanta, Georgia.

VICKERY, P. D. 1996. Grasshopper Sparrow (*Ammodramus savannarum*). *In* The Birds of North America, No. 239 (A. Poole and F. Gill, Eds.). The Academy of Natural Sciences, Philadelphia; The American Ornithologists' Union, Washington, D.C.

WHITMORE, R. C. 1981. Structural characteristics of Grasshopper Sparrow habitat. J. Wildl. Manage. 45:811–814.

WIENS, J. A. 1969. An approach to the study of ecological relationships among grassland birds. Ornithol. Monogr. 8:1–93.

WITH, K. A. AND D. R. WEBB. 1993. Microclimate of ground nests: the relative importance of radiative cover and wind breaks for three grassland species. Condor 95:401–413.

WUNDERLIN, R. P. 1982. Guide to the vascular plants of central Florida. Univ. Florida Presses, Gainesville.