Survival and Reproductive Biology of the Bachman's Sparrow

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Abstract: We estimated breeding season survival rates and nest success for Bachman's Sparrows at the Savannah River Site, South Carolina, using radio telemetry. The 1995 breeding season (2 May–9 Aug) survival rate was 0.905 (95% C. I. 0.779–1.03) with 2 mortalities out of 20 individuals. The 1996 breeding season (10 May–25 Jul) survival rate was 0.882 (95% C. I. 0.729–1.04) with 2 mortalities out of 18 individuals. No significant differences in survival rates were detected between years, sexes, or habitat types. The overall breeding season survival rate was 0.893 (95% C. I. 0.794–0.992). Daily nest survival rate in 1995 was 0.952 (0.013 SE N=26) and 0.889 (0.027 SE N =15) in 1996. Daily nest survival was significantly greater during 1995, with only 1 of 15 nests fledging a single individual in 1996. Nests attempts initiated before 15 June (0.975 [0.012], N=15) had higher survival rates than later nest attempts (0.914 [0.029] N=11, χ^2=3.77, 1 df, P=0.05).

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Bachman's sparrow *(Aimophila aestivalis)* is a ground-nesting, ground-foraging resident of fire-managed mature pine forests and early successional habitats throughout the southeastern United States. The conversion of forest to farmland in the nineteenth and early twentieth centuries allowed Bachman's sparrow to expand its range northward to Pennsylvania, Ohio, Indiana, and Illinois (Brooks 1938, Dunning 1993). Following 1930, the species gradually retracted its range and the population declined. But recent surveys indicate a dramatic reduction in range and population size (Dunning 1993, Sauer et al. 1999), with an annual population decline of 5.2% between 1980 and 1998 based on the Breeding Bird Survey (BBS) (Sauer et al.

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1999). In the southeastern United States the sparrow is most abundant along the Gulf Coast, having further retracted its range from the Piedmont and the upper coastal plain (Sauer et al. 1999). Bachman's sparrow is considered a Species at Risk by the U.S. Fish and Wildlife Service (Hunter et al. 1993), and is on the National Audubon Society's Watch List for species of concern (Muehter 1998).

Bachman's sparrow declines are probably due to fire suppression, shorter timber rotations and intensified agricultural operations that have led to the continued loss of suitable habitat (Dunning 1993). Bachman's sparrows were endemic to the longleaf pine *(Pinus palustris)*-wiregrass (*Aristida* spp.) community that occurred across the coastal plain from East Texas to Southern Virginia (Landers et al. 1995). The grassland understory of this community consisted of bunch grasses such as bluestem (*Andropogon* spp.) and wiregrass. Before European colonization, this habitat burned every 1–10 years, most commonly during the breeding season. Presently, the sparrow is found in fire-managed mature pinelands and early successional habitat such as clearcuts with minimal site preparation (Dunning and Watts 1990, Gobris 1992, Plentovich et al. 1998, Tucker et al. 1998). Basic demographic information on Bachman's sparrows remains scant.

Survival rates are unknown for many passerines including Bachman's sparrow. Brawn et al. (1995) hypothesized that ground-gleaners, such as Bachman's sparrows, have shorter life spans than species that forage above the ground because ground-gleaners are more susceptible to reptilian and mammalian predators. Because only female Bachman's sparrows incubate eggs (Dunning 1993), they should have lower survival rates than males.

Reproductive behavior of the Bachman's sparrow has been difficult to study due to their secretive nature and well concealed nests (Haggerty 1986, Dunning 1993). Bachman's sparrows are primarily monogomous and double-brooded, although Weston (1968) speculated that Bachman's may be triple-brooded in South Carolina. The breeding season extends from mid-April until the last fledglings becoming independent in early October (Haggerty 1986). During 3 years of study, Haggerty (1986) found a higher probability of nest failure during the nestling period, and nest success was independent of year, timing of successive nesting attempts, clutch size, and habitat.

As Bachman's sparrows occupy mature pinelands and early successional habitats, whether survival rates and reproductive rates are habitat specific is of interest to managers. Finally, no demographic information exists for Bachmann's sparrow in the eastern portion of its range (Dunning 1993).

Our objectives were to 1) estimate Bachman's sparrow survival rates for the breeding season and compare survival rates between years, sexes, and habitats (early successional and mature pine stands), and 2) estimate nest success rates and compare nest success rates between years, habitats, and nesting attempt.

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Methods

Bachman's sparrows were studied at the Savannah River Site (SRS), a 770-km^2 U.S. Department of Energy facility in western South Carolina along the Savannah River in Aiken, Barnwell, and Allendale counties. The SRS is managed as a research park by the Savannah River National Resource Management and Research Institute, and lies in the Upper Coastal Plain physiographic province. At the SRS, Bachman's sparrows inhabit understory grass and shrublands found in mature loblolly pine *(P. taeda)* and longleaf pine stands managed for red-cockaded woodpeckers *(Picoides borealis)* and regenerating pine stands for the first 6 years after replanting (Dunning and Watts 1990, Gaines et al. 1995). Mature pine stands were managed with periodic thinning and burning on a 3- to 5-year rotation. Both dormant season and growing season prescribed fires were used (Sparks et al. 1999). All mature stands monitored had been burned 1–2 years previously and were on a 3-year burn rotation. Both mature and regenerating stands had oldfield understory with mostly *Andropogon* spp. and *Pancium* spp. grasses rather than the native wiregrass ground cover (Stober 1996). Regeneration stands consisted of areas recently clear cut and planted in longleaf pine. Site preparation generally included a prescribed burn and planting of longleaf pines. Patches of shrubs within an open grass and forb understory occurred in both regeneration and mature pine stands.

Capture and Tagging Methods

We captured Backman's sparrows by placing 25 12-m (30mm) mist nets in a 5 × 5 grid with nets 50 m apart. Sparrows were captured in mature stands 40–98 years old and in pine regeneration stands <6 years post-planting. Stands were randomly selected from groups with similar management. Captured birds were weighed, sexed, aged, and banded with a National Biological Service leg band. Sparrows were categorized as either hatch-year or after-hatch-year and sexed by presence of brood patch, weight, and wing length (Pyle et al. 1987). We attached radio transmitters to the sparrows using the Rappole and Tipton (1991) thigh harness method. The radio with harness weighed 1.1–1.2 grams (Advanced Telemetry Systems, Isanti, Minn.), about 6% of body mass (18.6g±0.24SE female; 18.2±0.31 male).

Determining Survival

We located each bird daily and recorded the status of the bird (alive, dead, unknown). We used the staggered entry Kaplan-Meier method (1958) to estimate period survival rates (White and Garrott 1990). At the end of the monitoring period, each individual was categorized as survived, mortality, or censored. Survival was assigned to individuals when a bird's radio signal began to deteriorate with reduced range and frequency drift. Mortality was assigned to individuals when the recovered radio or radio-harness was disfigured or the bird's remains were found. Censored was applied to all other individuals. We excluded 1 female killed by a mammal in 1996 because her death occurred only 7 days after marking and before 50% of the sample had been marked. This mortality would have had a disproportionately large influence on the estimated survival rate because so few individuals had been marked when she died (White and Garrott 1990, Pollack et al. 1989). We identified potential predators (mammal, bird, reptile, or unknown) by examining physical evidence at the recovery site. We used program CONTRAST (Hines and Sauer 1989) to determine if there was a significant difference in survival between years, between sexes, or between habitat types.

Determining Reproduction

Nests were found by closely monitoring radioed females that had a swollen brood patch. Two methods of radio attachment were used: thigh harness or gluing to the interscapular region with cattle tag cement (Nasco, Ft. Atkinson, Wisc.). Glued-on radios usually remained attached for 2–3 days. Some nests were located by flushing unmarked females from nests. Once located, nests were monitored every 2–4 days until the nest failed or nestlings fledged.

Nests that fledged at least 1 young were considered successful. Nest survival rates were calculated with the program SURVIV, incorporating the exact days between nest checks for increased survival rate precision (White and Garrott 1990). Program CONTRAST (Hines and Sauer 1989) was used to compare nest survival rates between years, management practices (regeneration vs. mature), and segments within a breeding season (early 1 Apr–14 Jun vs. late, 15 Jun–31 Aug). All means presented are ± 1 SE.

Results

We radio-tagged 38 sparrows (24 males: 14 females). In 1995, sparrows were marked in 1 2-year-old (4m:2f), and 1 4-year-old (4m:2f) regenerating stand, and 3 mature stands (6m:2f) 58, 69, and 74 years old. In 1996, sparrows were marked in 2 3-year-old (2m:1f), and 3 5-year-old (5m:4f) regenerating stands, and 3 mature stands (3m:3f) 59, 75, and 98 years old. Individuals were tracked for an average of 45 ± 17.7 (range 7–73) days for a total of 1,884 exposure days (Table 1). Three individuals were marked and after radio or harness failure were marked again. Two of 20 marked sparrows died during 1995; a male was killed by a raptor and a female by a mammal. Two females of 18 marked sparrows died during 1996; both were killed by corn snakes *(Elaphe guttata)*. The 1995 period survival rate (0.905, 95% C.I. =0.779–1.03) was not significantly different (χ^2=0.022, 1 df, P=0.88) from the 1996 period survival rate (0.882, 95% C.I. =0.729–1.04). Survival rates of males (0.957, 95% C.I. =0.873–1.04) were not significantly different (χ^2=0.282, 1 df, P= 0.59) from the survival rate of females (0.794, 95% C.I. =0.586–1.00). Survival rates of sparrows in the regeneration stands (0.915, 95% C.I. =0.802–1.027) were not significantly different (χ^2=0.321, 1 df, P=0.57) from the survival rates of sparrows in

Table 1. Fate of radio-marked Bachman's sparrows during 1995–1996 breeding season at the Savannah River Site, South Carolina.

Year	Sex	Harness failed	Mortality	Censored	Survived	*N* Exposure days
1995	Male	1	1	3	11	704
1995	Female	2	1	1	6	248
1996	Male	0	0	2	8	515
1996	Female	0	2	0	6	417
Total		3	4	6	31	1,884

mature stands (0.857, 95% C.I. =0.674–1.04). Because we detected no survival rate differences by year, sex, or habitat, we combined all data to estimate an overall period survival rate of 0.893, 95% C.I. =0.794–0.992.

We found 26 nests in 1995 and 15 nests on 1996. The mean clutch size was 3.6 ± 0.12 eggs, with a modal clutch size of 4. Clutch size ranged from 3–5 eggs per nest with 3 of 151 eggs (1.9%) being infertile. Clutch size declined over the breeding season ($F_{1,39}$=5.83, P=0.02). We found no sparrow nests with brown-headed cowbirds *(Molothrus ater)* eggs. The earliest nest that we found was initiated on 10 April 1995. The last nest we found was on 5 August 1995, at the beginning of incubation. One female made 5 nest attempts laying a total of 15 eggs. She fledged young from her first 2 nests, but 3 subsequent nests were all depredated. This is the first known evidence that Bachman's sparrow attempt to triple-brood.

The overall daily nest survival rate was 0.952 (0.013, N=26) in 1995 and 0.899 (0.027, N=15) in 1996. Daily nest survival was significantly different between years (χ^2=4.12, 1 df, P=0.04). In 1995, we found no difference in daily nest survival between habitats (regeneration 0.958 [0.015, N=17] mature stands 0.941, [0.026, N =9] χ^2=0.34, 1 df, P=0.55). However, nest attempts before 15 June (0.975 [0.012], N=15) had higher survival rates than later nest attempts (0.914 [0.029], N=11, χ^2=3.77, 1 df, P=0.05). Nest survival tended to be lower during the incubation period (0.922 [0.027], N=17) compared to the nestling period (0.973 [0.013], N=18, χ^2=2.89, 1 df, P=0.08). Nests destroyed during the incubation period were often found seemingly undisturbed. Nests destroyed during the nestling period were often torn or dug out of the ground, suggesting mammalian predators.

Both parents fed nestlings but were not observed visiting the nest at the same time. When females were flushed off the nest, they always performed the "injury feigning" display, while males only occasionally performed this behavior when leaving the vicinity of the nest.

Discussion

Variation in survival rates across time occurs in both nonpasserines (Nichols and Hines 1987, Krementz et al. 1988, 1989) and passerines (Clobert et al. 1988, Lebreton et al. 1992, Powell et al. 2000). These differences are commonly attributed to large-scale changes in landscape (Sauer and Bortner 1991), climate (Nichols and Hines 1987, Sauer and Droege 1990), and relative abundances (Clobert et al. 1988). Our survival rate estimates did not differ significantly between years. Concurrent with this telemetry study and at the same study site, Krementz and Christie (1999) estimated monthly Bachman's sparrow survival rate (0.94, SE 0.2674) using mark recapture methods in 8 regeneration and 8 mature stands. Krementz and Christie (1999) reported no difference in survival rates between years or habitats (mature and regeneration) for Bachman's sparrows. In 1997, Seaman (1998) examined the effect of growing season prescribed for burns in mature stands on Bachman's sparrows at the SRS and Carolina Sandhill National Wildlife Refuge, South Carolina. Seaman (1998) reported only 3 deaths of the 38 marked individuals and a breeding-season period survival of 0.800 (SE 0.111). The overall breeding season period survival rate (89.3%) that we observed was higher than we expected for an obligate ground nester and forager. This estimate suggests that the breeding season may not be a period of high mortality. Survival rates for juveniles and for adults during other periods remain unknown. The high breeding season survival rate supports the assumption that most adult Bachman's sparrow mortality takes place during the non-breeding season (Pulliam et al. 1992).

We predicated that female survival rates would be lower than male survival rates because females exclusively incubate the eggs, defend the nests using risky behaviors, e.g., "injury feigning," and because 80% of Bachman's sparrow nests under observation by Haggerty (1988) were destroyed by predators. All 3 mortalities of the 38 marked Bachman's sparrows were females in Seaman's (1998) study. We remain cautious of our lack of a sex-specific difference in survival rates because of our small sample sizes and large differences in point estimates.

Observations of Bachman's sparrow reproductive biology at the SRS corroborate Haggerty's (1986) estimates of clutch size and duration during breeding. There appear to be few differences in reproductive biology as a result of geography. Predators were responsible for most Bachman's sparrow nest failure at SRS and in Arkansas (Haggerty 1986). Haggerty (1986) found that predation on nests in regenerating pine stands occurred more often during the nestling period with snakes as the primary nest predators. In our study, there was a trend toward nests being destroyed more often during the incubation period than during the nestling period. We found nest success declined significantly over the breeding season, which is contrary to Haggerty's (1995) findings. Our nest success rates between regeneration and mature stands were not significantly different suggesting that managers can use either early successional or mature pine-grassland savannahs to manage for Bachman's sparrows. Note though that Bachman's sparrow densities are significantly lower on mature stands than on regeneration stands (Stober 1996).

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