The Condor 91:736–738

NEST CHARACTERISTICS AND NESTLING DEVELOPMENT OF CASSIN'S AND BOTTERI'S SPARROWS IN SOUTHEASTERN ARIZONA[1]

BRIAN A. MAURER[2]
Arizona Cooperative Wildlife Research Unit and Department of Ecology and Evolutionary Biology, University of Arizona, Tucson, AZ 85721

ELIZABETH A. WEBB
Museum of Natural History, City Park, Denver, CO 80205

RICHARD K. BOWERS[3]
Department of Ecology and Evolutionary Biology, University of Arizona, Tucson, AZ 85721

Key words: Aimophila; *Arizona; Botteri's Sparrow; Cassin's Sparrow; nesting biology; nestling growth.*

In southeastern Arizona, two closely related species of *Aimophila,* the Cassin's Sparrow (*A. cassinii*) and the Botteri's Sparrow (*A. botterii*) breed together in similar habitats (Maurer 1984, 1985, 1986; Webb 1985). Although these species have been known to occur together in Arizona for quite some time (Phillips et al. 1964), only recently has breeding been documented (Ohmart 1966, 1968). Subsequently, Webb (1985) collected extensive life history data on the Botteri's Sparrow and documented the breeding biology of this species in Arizona.

Nest placement, nest size, clutch size, and nestling development were studied to provide some insight into the ecological adaptations of each species. This paper compares aspects of the nesting biology of these two species in an area where they occur sympatrically and examines the possible significance that the patterns of interspecific variation have for the ecological and evolutionary relationships between the species.

STUDY AREAS AND METHODS

Research was conducted at the National Audubon Society Appleton-Whittell Research Sanctuary, Santa Cruz County, Arizona, in the foothills of the Huachuca Mountains. Mesas in the northeastern corner of the sanctuary were dominated by mesquite (*Prosopis juliflora*). Upland areas farther south in the sanctuary were composed primarily of oak (*Quercus* spp.) woodland. Large drainages between mesas were dominated by sacaton (*Sporobolus wrightii*) grassland.

Data on nests and nestlings of Botteri's Sparrows were collected during May–August in 1981–1983 (Webb 1985). Data on Cassin's Sparrow nests and nestlings were collected during June–August of 1983. Nests of both species were located by searching systematically through the grass and flushing adults on the nest. Nests were visited daily, and the weight and tarsus length of nestlings were measured. For most nests, it was not possible to identify individual nestlings. In the following calculations, all measurements for nestlings of the same species and age were analyzed together. Because data from individual nestlings on subsequent days were used, the observations upon which regression analyses were based were not independent. This introduces autocorrelation in the data, causing estimates of the variance to be too small (Neter and Wassermann 1974, p. 352). However, since the data were used primarily to estimate growth curves and not for inferential purposes (see below), this poses no problem as least squares produces unbiased estimates of the parameters even in the presence of autocorrelation. For the few analyses that required inferential statistics, a conservative significance value was used (see below). After the young fledged we measured each nest and took data on the characteristics of the nest plant, habitat surrounding the nest, and nest height. We tested for differences between species for clutch sizes and nest parameters using Student's t-tests with degrees of freedom adjusted if variances were found to be different at $P < 0.05$ (Sokal and Rohlf 1981). The significance level for these tests was $P < 0.05$.

Growth curves for weight and tarsus length were calculated from the nestling data using a nonlinear least squares regression program. Logistic growth curves were used because they generally seem to produce the best estimates of nestling growth in birds. In addition, we estimated allometric growth curves for tarsus length ($\log_{10}$ tarsus length regressed against $\log_{10}$ body weight). We tested for differences between slopes and intercepts for these allometric relationships between species. Because of the autocorrelation problem mentioned above, we expected the tests to be too liberal, so we used a significance level of $P < 0.001$ for these tests. A significant difference between intercepts would indicate that tarsus length was proportionately longer in one species, while a significant difference between slopes would indicate that the tarsi grew at different rates in the two species.

---

[1] Received 16 December 1988. Final acceptance 6 March 1989.

[2] Present address: Department of Zoology, Brigham Young University, Provo, UT 84602.

[3] Present address: 2925 N. Cascade Circle, Tucson, AZ 85715.

TABLE 1. Characteristics of the nests of Botteri's and Cassin's sparrows on the Audubon Society Appleton-Whittell Research Sanctuary in southeastern Arizona, 1982–1983.

Variable	Botteri's Sparrow			Cassin's Sparrow			t
	n	$\bar{x}$	SD	n	$\bar{x}$	SD	
Clutch size	23	3.26	0.69	10	3.00	0.94	0.34
Nest plant height (m)	23	0.89	0.34	18	0.71	0.16	2.23*
Density of grass(/20 m^2)	24	3.00	1.59	18	3.06	1.11	−0.13
Density of shrub(/20 m^2)	24	0.17	0.48	18	1.56	0.62	−8.21*
Nest-cup diameter (cm)	22	6.85	0.65	18	6.47	0.39	2.33*
Nest-cup depth (cm)	22	6.00	0.89	17	5.36	0.39	3.03*
Nest-rim width (cm)	21	2.55	0.92	18	1.51	0.53	4.40*
Nest height (cm)	24	0.06	0.84	18	10.77	5.90	−7.65*

* $P < 0.05$, two-tailed test.

RESULTS

We found a total of 24 Botteri's Sparrow nests and 18 Cassin's Sparrow nests. Breeding activity of Botteri's Sparrows occurred earlier in the season (May–August) than that of Cassin's Sparrows (July–August) (Maurer 1984, 1985; Webb 1985). There was no significant difference in clutch sizes (Table 1), although the Botteri's Sparrow had a slightly larger average clutch size than the Cassin's Sparrow. Botteri's Sparrow nests were larger and more robust than Cassin's Sparrow nests, and were located closer to the ground (Table 1).

Density of grasses was equal around the nests of the two species, but density of shrubs around Cassin's Sparrow nests was greater (Table 1). This reflects the differences in habitats associated with each species (Maurer 1984, 1986; Webb 1985).

Growth curves for weight suggested that initially the two species were similar in size, but when they neared fledging, Botteri's Sparrow was heavier (Fig. 1). An analysis of adults of both species that were mist-netted during the breeding season (May to September) indicated that Botteri's Sparrows were larger as adults than Cassin's Sparrows (Table 2). These findings were similar to Wolf's (1977) results. Tarsus length was initially greater in the Botteri's Sparrow than in the Cassin's Sparrow (Fig. 2). The difference in lengths between the species increased as they neared fledging. These data suggest that the absolute rate of growth in the tarsus length of the Botteri's Sparrow was greater than that of the Cassin's Sparrow.

Comparison of allometric growth curves indicated that the exponents of the relationship between tarsus length and body weight (i.e., the slope of a log-log regression) were not significantly different ($F = 0.3$, $df_1 = 1$, $df_2 = 163$, $P > 0.5$). However, the intercepts of the allometric curves were different ($F = 16.4$, $df_1 = 1$, $df_2 = 163$, $P < 0.01$). Thus, we conclude that the higher growth rate for the tarsus of the Botteri's Sparrow is an allometric consequence of the larger size of this species. An important implication of these results is that for a given body size, the Botteri's Sparrow will have on the average a longer tarsus than the Cassin's Sparrow (Fig. 3). This will be true despite the fact that at a given weight, a Botteri's Sparrow will be younger on the average than a Cassin's Sparrow (Fig. 1).

DISCUSSION

At hatching, Cassin's and Botteri's sparrows appear to be similar in weight (Fig. 1), but differ in the size of their tarsi (Fig. 2). The implication is that prior to hatching, the tarsi of the Botteri's Sparrow grows at a faster rate than that of the Cassin's Sparrow. This difference in relative tarsus length is exaggerated in subsequent development after hatching (Fig. 3). Thus, the developmental difference indicated between the species leads to a difference in adult shape between the species, with adult Botteri's Sparrows being both larger, and having relatively longer tarsi.

Although Cassin's and Botteri's sparrows are similar ecologically, there are important differences in the details of their autecologies. The Cassin's Sparrow nests in shrubs, is smaller, and has relatively short tarsi. The Botteri's Sparrow, on the other hand, nests on the ground, is larger, and has relatively long tarsi. The ecological consequences of those differences are differences in habitat use and distribution of the species (Maurer 1984, 1986; Webb 1985). At least some of the evolutionary history of these species occurred when they were geographically separated (Hubbard 1974). Thus, the coexistence of these species together in the

TABLE 2. Weights of adult Cassin's and Botteri's sparrows captured in mist nets during the breeding season in southeastern Arizona.

Species	Male			Female			Both sexes
	n	$\bar{x}$	SD	n	$\bar{x}$	SD	$\bar{x}$
Cassin's Sparrow	28	17.8	1.2	15	18.1	1.3	17.9*
Botteri's Sparrow	47	19.7	1.5	9	21.0	3.0	19.9*

* A two-way ANOVA indicated that the only significant effect was differences between species, $P < 0.05$. No sex or interaction effects were significant, $P > 0.05$.

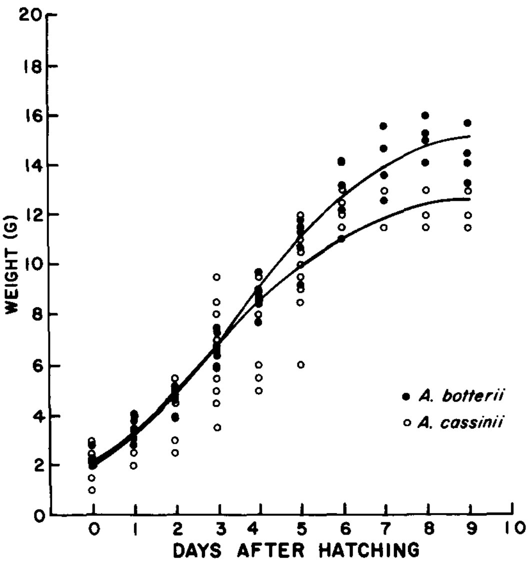

FIGURE 1. Nestling growth curves describing weight changes prior to fledging for the Botteri's Sparrow (*A. botterii*) and the Cassin's Sparrow (*A. cassinii*) in southeastern Arizona.

grasslands of southeastern Arizona may be facilitated by the ecological differences that resulted from the different evolutionary histories of the species rather than coevolutionary adjustments of the species to one another.

We thank the National Audubon Society Appleton-Whittell Audubon Research Ranch Sanctuary for support of the research described herein through fellowships to EAW and BAM from the Research Ranch Foundation. C. and J. Bock helped make the facilities of the Research Ranch available to us. L. Wolf and one anonymous reviewer made helpful suggestions on the manuscript.

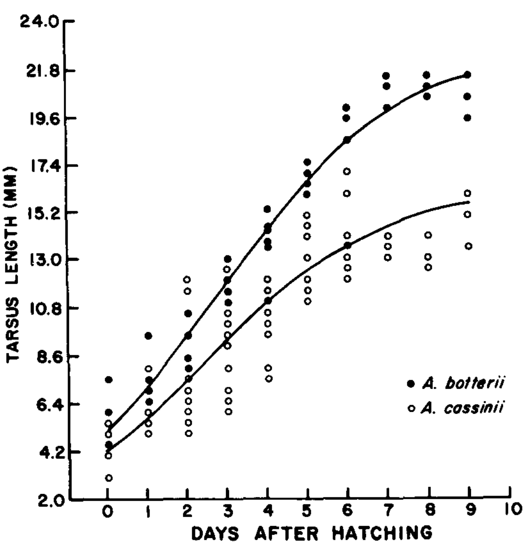

FIGURE 2. Nestling growth curves describing changes in tarsus length prior to fledging for the Botteri's Sparrow (*A. botterii*) and the Cassin's Sparrow (*A. cassinii*) in southeastern Arizona.

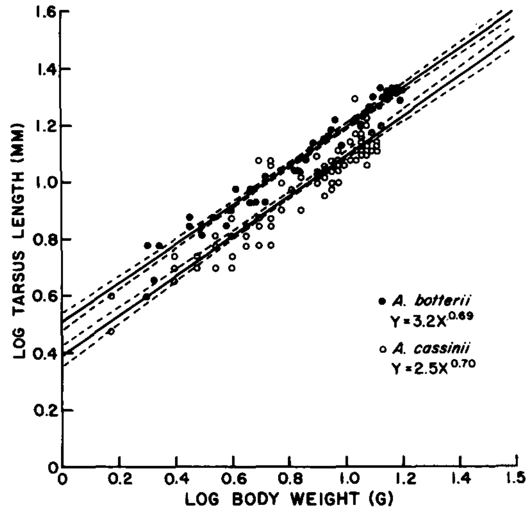

FIGURE 3. Allometric curves for tarsus length in the Botteri's Sparrow (*A. botterii*) and the Cassin's Sparrow (*A. cassinii*) in southeastern Arizona.

LITERATURE CITED

HUBBARD, J. P. 1974. Avian evolution in the aridlands of North America. Living Bird 12:155–196.

MAURER, B. A. 1984. Environmental heterogeneity and avian community structure in southeastern Arizona semidesert shrub-grasslands. Ph.D.diss. Univ. of Arizona, Tucson.

MAURER, B. A. 1985. Avian community dynamics in desert grasslands: observational scale and hierarchical structure. Ecol. Monogr. 55:295–312.

MAURER, B. A. 1986. Predicting habitat quality for grassland birds using density-habitat correlations. J. Wildl. Manage. 50:556–566.

NETER, J., AND W. WASSERMANN. 1974. Applied linear statistical models. Richard D. Irwin, Homewood, IL.

OHMART, R. D. 1966. Breeding record of the Cassin Sparrow (*Aimophila cassinii*) in Arizona. Condor 68:400.

OHMART, R. D. 1968. Breeding of Botteri's Sparrow (*Aimophila botterii*) in Arizona. Condor 70:277.

PHILLIPS, A. R., J. MARSHALL, AND G. MONSON. 1964. The birds of Arizona. Univ. of Arizona Press, Tucson.

SOKAL, R. R., AND F. J. ROHLF. 1981. Biometry. W. H. Freeman, San Francisco.

WEBB, E. A. 1985. Distribution, habitat and breeding biology of the Botteri's Sparrow (*Aimophila botterii arizonae*). M.Sc.thesis. Univ. of Colorado, Boulder.

WOLF, L. L. 1977. Species relationships in the avian genus *Aimophila*. Ornithol. Monogr. 23:1–220.