SHORT COMMUNICATIONS

Song Sparrows Grow and Shrink with Age

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Studies of avian morphology and its correlates frequently involve comparisons of body weight, winglength, tarsus length, and beak dimensions (e.g. Helms et al. 1967, Willson 1969, Boag 1983). In most such studies, groups of birds of unknown age are compared. It is therefore of interest to know if these commonly measured morphological traits vary with age beyond the period of initial growth as a nestling or fledgling. Arcese (1984) and Alatalo et al. (1984) have reviewed studies of over 20 bird species whose winglength increases with age. Ewald and Rohwer (1980) showed that winglength decreases with age in a hummingbird. Increases in winglength with age are particularly large in passerines that do not change their primary feathers in the postjuvenile molt (Alatalo et al. 1984). Beak dimensions of Darwin's Medium Ground-Finches (*Geospiza fortis*) increase with age, and body weight of these finches may increase or decrease with age (Price and Grant 1984). When morphological traits vary with age, comparisons must be made with caution, or appropriate corrections for the effects of age must be made.

Between 1975 and 1979 we measured age-dependent morphological variation for six traits in the Song Sparrow (*Melospiza melodia*) population inhabiting Mandarte Island, British Columbia, Canada. As a test of the robustness of patterns of variation with age, we present additional measurements for three of these traits made in 1982–1984. Measurements from 1975-1979 were made by J. N. M. Smith, André A. Dhondt, and Reto Zach. Care was taken to ensure high repeatability of measurement procedures among these observers. All measurements in 1982–1984 were made by P. Arcese. The measurements were collected as described by Smith and Zach (1979). Ages were known because birds had been banded as nestlings. Birds were retrapped as independent juveniles or adults using mist nets, mainly in July–October of each year. Most individuals were measured several times as juveniles but only once or twice as adults. The six traits measured from 1975 to 1979 were body weight (in g), winglength, tarsus length, beak length, beak depth, and beak width (all in mm). Growth of these traits asymptotes at 95% or more of adult size by 8 weeks of age (Smith and Zach 1979).

Table 1 presents mean values for all individuals measured between 1975 and 1979 in the following age classes: 9–35 weeks (class 1), 36–90 weeks (class 2), and greater than 90 weeks (class 3). These classes correspond to immature birds in their year of hatching (class 1), yearling birds (class 2), and adults after their second year (class 3). We compared data for the sexes separately and for the sexes combined, for birds trapped in both class 1 and class 2, and for birds trapped in both class 2 and class 3 (Table 1). Winglength, beak length, and beak width increased highly significantly from class 1 to class 2, while body weight, tarsus length, and beak depth did not. Only for beak width were differences not strongly concordant between the sexes (males increased markedly, but females only slightly). From class 2 to class 3, sample sizes were small and were composed mostly of males. Nevertheless, both tarsus length and beak depth decreased significantly from class 2 to class 3.

Six statistical tests were conducted on each of the above characters for each class in Table 1. The Bonferroni inequality (Miller 1981) indicates that only probabilities less than or equal to α/c should be considered significant, where c is the total number of comparisons made. This revised significance level ($P < 0.008$) had little effect on the changes between age classes 1 and 2, but only the decrease in tarsus length from age class 2 to 3 remained statistically significant. We therefore tested the robustness of these findings on further data collected in 1982–1984. Only body weight, winglength, and tarsus length were measured during this period. The same marked increases in winglength as in 1975–1979 were evident from age class 1 to 2 (Table 2). Winglength also increased significantly from age class 2 to age class 3 when the sexes were combined. Body weight did not change significantly with age as found in 1975–1979. As we also found in 1975–1979, tarsus length decreased significantly in the full sample from age class 2 to age class 3 ($P < 0.025$), but it also decreased significantly from age class 1 to age class 2, especially for males (Table 2). When the sexes were considered separately, male tarsi shortened significantly ($P < 0.01$) between age classes 1 and 2, but not between age classes 2 and 3. Female tarsi shortened significantly between age classes 2 and 3 ($P < 0.05$), but not between age classes 1 and 2. Thus, only the data for tarsus length from 1982–1984 showed a very different pattern from the data collected in 1975–1979.

These data showed that of the six traits measured, only body weight was stable with age. As in studies reviewed by Arcese (1984) and Alatalo et al. (1984), winglength showed a strong tendency to vary with

TABLE 1. Mean values for six morphological traits of Song Sparrows measured at different ages from 1975 to 1979. Age class 1 = 9-35 weeks, 2 = 36-90 weeks, 3 = over 90 weeks. *n* is the sample size of individuals measured in both adjacent age classes. Sample size varies slightly among measurements because of missing values. SE is the standard error of the mean difference between adjacent age and sex classes for the measurement in question. *P* is the two-tailed probability that the mean difference between adjacent classes is zero (paired *t*-test).

		Age class 1 to age class 2					Age class 2 to age class 3				
Trait	Sex	*n*	Age 1	Age 2	SE	*P*	*n*	Age 2	Age 3	SE	*P*
Body weight	♂♂	37	25.49	25.68	0.30	NS	11	25.15	25.51	0.48	NS
(g)	♀♀	17	23.40	24.10	0.51	NS	2	26.25	24.75	2.10	NS
	Both	54	24.83	25.18	0.27	NS	13	25.32	25.39	0.51	NS
Winglength	♂♂	35	67.75	68.94	0.23	0.000	10	68.65	69.20	0.62	NS
(mm)	♀♀	15	64.89	65.92	0.40	0.022	2	67.00	66.00	2.00	NS
	Both	50	66.90	68.03	0.20	0.000	12	68.38	68.65	0.60	NS
Tarsus length	♂♂	36	20.10	20.21	0.12	NS	10	20.30	19.64	0.24	0.023
(mm)	♀♀	16	19.71	19.87	0.13	NS	2	20.00	18.98	0.08	0.047
	Both	52	19.98	20.11	0.09	NS	12	20.24	19.52	0.20	0.005
Beak length	♂♂	38	8.71	9.04	0.05	0.000	11	8.87	8.95	0.08	NS
(mm)	♀♀	17	8.51	8.96	0.08	0.000	2	8.65	8.80	0.25	NS
	Both	55	8.65	9.01	0.04	0.000	13	8.83	8.93	0.07	NS
Beak depth	♂♂	38	5.96	5.99	0.04	NS	11	5.97	5.88	0.04	0.029
(mm)	♀♀	16	5.86	5.86	0.04	NS	2	6.00	6.00	0.05	NS
	Both	54	5.93	5.95	0.03	NS	13	5.98	5.90	0.03	0.033
Beak width	♂♂	38	6.72	6.82	0.03	0.001	11	6.80	6.80	0.07	NS
(mm)	♀♀	17	6.75	6.77	0.05	NS	2	6.60	6.88	0.28	NS
	Both	55	6.73	6.81	0.03	0.004	13	6.77	6.81	0.07	NS

age, and increased markedly from age class 1 to age class 2, and slightly thereafter in 1982–1984 only. The increase from class 1 to class 2 could have occurred either in the postjuvenile molt or in the first adult molt. Data on juvenile molt were available in 1978 only. The mean winglength of 25 juveniles measured before and after molt in 1978 did not increase [mean difference = -0.06 ± 0.18 (SE)]. We therefore suggest that the major source of increase in winglength with age is the first adult molt. It remains to be tested whether the longer wings of adults are related to a greater ability to obtain food during the molt, or whether juveniles have short wings because of a greater need for maneuverability than adults (Alatalo et al. 1984). Because weight changes little with age, older birds probably have lower wing loadings.

Our most surprising result was that tarsus length decreased with age, especially in adult birds after their second year. The shrinkage in tarsus length could represent loss of bone material, shrinkage of the scutes on the anterior of the tarsus, or both. These results are surprising because the tarsus is generally regarded as the best indicator of size in birds (e.g. Slagsvold 1982, Boag 1983). Beak length increased strikingly (by about 4%) from age class 1 to age class 2, and this increase was maintained thereafter. The increase in beak length presumably represents growth that more than compensates for the wear experienced by the beak-tip of a ground-feeding granivore like the Song Sparrow. Beak depth remained stable from age class 1 to age class 2, but declined slightly from class 2 to class 3.

One feature of our study is that four different individuals made the measurements. Some of the age differences therefore might result from procedural differences among observers. We do not feel that this can explain the differences reported, because the major patterns were consistent for two independent sets of data gathered by different observers on three of the characters. The only major discrepancy between 1975–1979 and 1982–1984 was that tarsus length declined significantly among males only from age class 1 to 2 in 1982–1984, but remained stable in 1975–1979. A second source of uncertainty in our results is that samples for older birds are small. Larger samples of measurements are clearly desirable among older birds, and are likely to reveal further patterns of interest. The generality of patterns other than that for winglength will remain unknown until more species and populations have been studied. Our data suggest that a complete knowledge of age structure is a significant advantage in studies of morphological variation, and that this knowledge can appreciably reduce error variation. Other known sources of temporal variation in size include year effects (Smith and Zach 1979, Price and Grant 1984) and effects of the time of hatching (Smith and Zach 1979, Garnett 1981). Studies of the morphology of populations of unknown age therefore should be interpreted cautiously, unless the differences between group means are

TABLE 2. Mean values for three morphological traits of Song Sparrows measured at different ages from 1982 to 1984. Headings and age classes as in Table 1.

		Age class 1 to age class 2					Age class 2 to age class 3				
Trait	Sex	*n*	Age 1	Age 2	SE	*P*	*n*	Age 2	Age 3	SE	*P*
Body weight (g)	♂♂	27	25.21	25.51	0.24	NS	8	25.75	25.87	0.64	NS
	♀♀	25	23.37	23.90	0.37	NS	5	23.94	23.59	1.21	NS
	Both	52	24.33	24.74	0.22	NS	13	25.06	24.97	0.58	NS
Winglength (mm)	♂♂	24	68.30	69.91	0.25	0.000	5	69.96	70.80	0.42	NS
	♀♀	21	64.60	65.99	0.31	0.000	4	65.70	66.10	0.40	NS
	Both	45	66.57	68.08	0.20	0.000	9	68.07	68.71	0.26	0.036
Tarsus length (mm)	♂♂	27	20.05	19.87	0.06	0.006	8	20.11	19.87	0.14	NS
	♀♀	25	19.45	19.39	0.07	NS	5	19.60	19.41	0.07	NS
	Both	52	19.76	19.65	0.04	0.023	13	19.91	19.69	0.09	0.025

much larger than those found among age groups in our study. Our results are of particular relevance to studies of natural selection during the first year of life.

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