J. Field Ornithol., 61(1):34–40

LABORATORY AND FIELD INVESTIGATION OF SKULL PNEUMATIZATION IN SONG AND SWAMP SPARROWS

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Abstract.—Cranial pneumatization in both Song Sparrows (*Melospiza melodia*) and Swamp Sparrows (*M. georgiana*) proceeds by the median line pattern (Yunick 1979). In both species pneumatization was faster among laboratory-held birds than among wild birds. Cranial pneumatization was faster among wild Swamp Sparrows than among wild Song Sparrows, but the difference was not apparent in the laboratory. Iris color changed from olive-brown to intense brown after skull pneumatization was completed. From these observations we conclude that timetables of age determination based on cranial pneumatization criteria derived from laboratory-held birds are conservative estimates of the age of wild birds and that iris color may be a character that can be used to identify young birds whose skulls have completely pneumatized.

INVESTIGACIÓN DE CAMPO Y LABORATORIO SOBRE LA PNEUMATIZACIÓN CRANEAL DE INDIVIDUOS DE *MELOSPIZA MELODIA* Y *M. GEORGIANA*

Sinopsis.—La pneumatización craneal en *Melospiza melodia* y en *M. georgiana* acaece a través del patrón de la línea media (Yunick 1979). Encontramos que en ambas especies, la pneumatización ocurre más rápido en individuos cautivos que en aves silvestres. En el estado silvestre la pneumatización ocurre más rápido en *M. georgiana* que en *M. melodia*, aunque no hubo diferencia aparente entre aves de estas especies mantenidas en el laboratorio. El color del iris cambió de pardo-olivaceo a un pardo intenso, una vez se completó el proceso de pneumatización. De nuestro trajabo concluímos que las tablas confeccionadas para determinar la edad en estas aves, basadas en la pneumatización craneal experimentada por animales cautivos, son estimados conservadores de la edad real que puedan tener aves silvestres. El color del iris muy bien podría ser utilizado para identificar aves jovenes cuyo craneo ya se hubiera pneumatizado.

Many studies of population ecology and behavior require a knowledge of the ages of individuals within the population being studied. Cranial pneumatization has frequently been used as a means of specifying the year of hatching of live passerine birds (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1978). As part of continuing studies of the behavioral ecology of wintering sparrows this work examines the process of skull pneumatization in Song Sparrows (*Melospiza melodia*) and Swamp Sparrows (*M. georgiana*).

The primary purpose of this research was to determine the pattern, rate, and timing of the skull pneumatization process in these two common wintering sparrows of the Clemson area. Accessory purposes were: (1) to determine a method for identifying birds in their first winter that have pneumatized skulls; (2) to ascertain whether pneumatization in labora-

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tory-held birds proceeds in similar fashion to that in wild birds, particularly with respect to rate; (3) to compare the pattern, rate, and timing of skull pneumatization in these two closely related species; and (4) to determine a schedule by which these species can be accurately aged on the basis of skull pneumatization.

METHODS

Birds were captured October 1982–March 1983 using mist nets in two creek-bottom old-fields near Clemson in northwestern South Carolina (Pickens and Anderson counties). Birds to be held in the laboratory were captured 27 Oct.–6 Nov. At the time of capture each bird was banded, weighed, its fat class determined following the method of Helms and Drury (1960), and its iris color noted.

Twenty hatching-year Song Sparrows and 13 hatching-year Swamp Sparrows were held in the laboratory. Twenty-three additional Swamp Sparrows and 79 more Song Sparrows with unpneumatized skulls were examined in the field. Two of the wild Swamp Sparrows and five of the wild Song Sparrows were recaptured during the study.

Captive birds were individually housed in visual isolation from each other under natural photoperiod, in a holding room with open windows. Temperatures in the room averaged 7.5 C above outside temperatures. Maximum laboratory temperature reached 25 C on one day only. Outdoor temperature exceeded 25 C on only two days during the study. Mean temperature outdoors and in the laboratory stayed below the 25 C level believed critical to the pneumatization process by Winkler (1979). Diet of laboratory-held birds consisted of Purina Layena® Checkerettes and water *ad libitum*. The laboratory diet was identical to that described by Hamel et al. (1983).

Skulls of laboratory-held birds were examined every 10 d. At the time of each examination, the birds were weighed, the fat class determined, and the iris color checked. All skull examinations were conducted by Hamel, using either a 7× jeweler's loupe in the field or a Luxo 1.5× illuminated magnifier in the laboratory. The unpneumatized window of each skull was drawn on a life-size outline drawing of the dorsal, lateral, and posterior views of a skull. If possible, the size of the unpneumatized patch was measured. Each drawing was assigned to a pneumatization stage (Hamel et al. 1983, Winkler 1979).

Laboratory birds were the main source of information on iris color. These birds were examined using the Luxo illuminated magnifier. Iris color of wild birds was determined in indirect sunlight only when the sun was not obscured by clouds. For all birds iris color was recorded as gray, brown, or intermediate between the two. These color differences were equally detectable using either lighting source. Iris colors of a small sample of birds were compared to the charts in Smithe (1975).

For minimum samples of 10 birds, Mann-Whitney *U*-tests were used for comparing distributions of skull stages of Song and Swamp sparrows

on a particular date or laboratory and wild populations on a particular date.

Birds were held under authority of federal collecting permit PRT 2-6029-AT and South Carolina collecting permit 0012-83. At the conclusion of the study the birds were acclimated to a flight aviary, banded with U.S. Fish and Wildlife Service bands, and released.

RESULTS

Identification of first winter birds with pneumatized skulls.—Our results concerning iris color were the same for both species. Iris color in fall adult Song and Swamp sparrows was a rich brown which corresponds to #32, Chestnut, 1.1 YR 3.31/5.0 or #33, Cinnamon-Brown, 7.5 YR 3.94/3.9 of Smithe (1974, 1975). Several recaptures of birds at least 18–42 mo old confirmed these observations. Iris color of birds with unpneumatized skulls in the fall corresponded to #28, Olive-Brown, 9.9 YR 3.91/2.1 or #29, Brownish-Olive, 2.8 Y 3.98/2.0 of Smithe (1974, 1975). The actual hue of the irides of the young birds was difficult for us to determine because the intensity of the color was so low.

During the study, the color of the irides of the young birds intensified. We noted qualitative changes of two types. In the first, more common type, the center of the iris remained gray and the rich brown color began as a ring around the periphery of the iris. In the second type, the increase in intensity was general throughout the iris. We noted no birds in the field with these intermediate irides until 18 Dec. Iris color was noted as gray at the time completed pneumatization was first observed in 30 of the 32 captive birds of both species. The 31st individual was noted as "gray-intermediate," and the 32nd as "intermediate-brown." This latter bird was the individual that did not complete pneumatization until 60 days after the other captives. One of the 135 birds with unpneumatized skulls captured during the study had the typical brown irides of an adult. We believed the Swamp Sparrow in question was an adult with an anomalous pneumatization because of the peculiar shape of the single unpneumatized patch on its skull.

The intermediate iris color appeared as early as 2 d after complete pneumatization was noted in three birds, within a week after pneumatization in three others, and not until at least 10 d later in three others. No determination was made of the point at which the intermediate color appeared in the remaining captive birds.

Pattern of pneumatization.—Skull pneumatization in both Song and Swamp sparrows proceeds through the median line pattern (Yunick 1979). None of the 36 Swamp Sparrows and four of the 99 Song Sparrows proceeded by the peripheral pattern described by Yunick (1979). The one Song Sparrow in the captive sample that proceeded by the peripheral pattern took 60 days longer to complete pneumatization than the remaining individuals.

Rate of pneumatization.—Sample sizes of field captures were too small to permit comparisons of the laboratory and wild birds on a weekly basis.

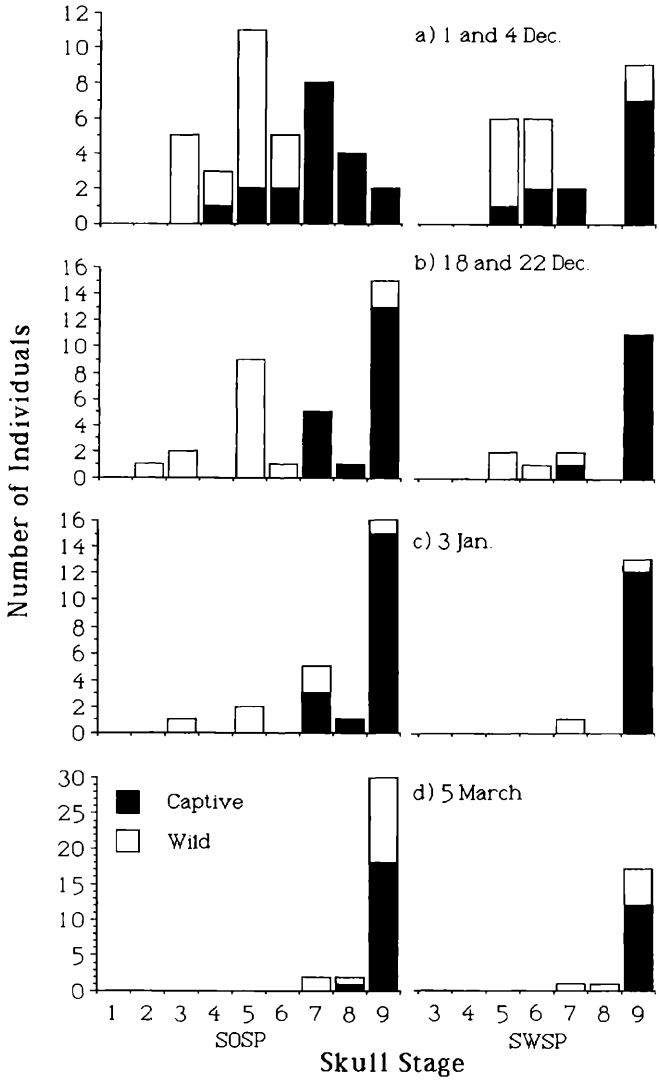

FIGURE 1. Distribution of skull stages of wild and captive Song Sparrows (SOSP) and Swamp Sparrows (SWSP) among skull pneumatization stages of Hamel et al. (1983). Where more than one date is indicated for a particular plot, the earlier date is the one on which the captive birds were examined.

On those dates where samples were adequate, the skulls of laboratory birds were significantly closer to completion of pneumatization than were those of wild birds (Fig. 1).

Among Swamp Sparrows, laboratory-held birds were significantly ahead of wild birds on 4 Dec. ($U = 72$, $P < 0.001$, Fig. 1a). However, by 5

TABLE 1. Suggested timetable for aging Song and Swamp sparrows based upon cranial pneumatization and iris color. The data for this table were derived from captive birds.

1. Before 26 November:
   a. cranium completely pneumatized (unpneumatized area, if present, 0.5 mm or less): age = AHY (after hatching year)
   b. cranium not completely pneumatized (unpneumatized area greater than 0.5 mm): age = HY (hatching year)
2. 26 November–1 January:
   a. cranium completely pneumatized:
      1. irides brown[a]: age = U
      2. irides gray[b] or intermediate: age = HY
   b. cranium not completely pneumatized (as in 1b): age = HY
3. After 1 January:
   a. cranium completely pneumatized:
      1. irides brown[a]: age = AHY
      2. irides gray[b] or intermediate: age = SY (second year)
   b. cranium not completely pneumatized (as in 1b): age = SY

[a] #32, Chestnut, 1.1 YR 3.31/5.0 or #33, Cinnamon-Brown, 7.5 YR 3.94/3.9 of Smithe (1974, 1975).
[b] #28, Olive-Brown, 9.9 YR 3.91/2.1 or #29, Brownish-Olive, 2.8 Y 3.98/2.0 of Smithe (1974, 1975).

Mar. there was no significant difference between laboratory and wild Swamp Sparrows ($U = 37.06$, NS, Fig. 1d). Skulls of laboratory birds on 22 Dec. (Fig. 1b) were not distributed differently from those of wild birds on 5 Mar. ($U = 88$, NS, Fig. 1d).

Laboratory-held Song Sparrows were significantly ahead of wild birds on 4 Dec. ($U = 31$, $P < 0.001$, Fig. 1a). The skulls of laboratory birds on 11 Dec. were significantly ahead of those of wild birds examined on 18 Dec. ($U = 27.5$, $P < 0.001$). No significant difference existed between laboratory and wild Song Sparrows on 5 Mar. ($U = 120.5$, NS, Fig. 1d). The distribution among skull stages of laboratory birds' skulls on 3 Jan. (Fig. 1c) was not different from that of wild birds on 5 Mar. ($U = 144.5$, NS, Fig. 1d).

Comparison of the rates of pneumatization for the two species showed that at the time of initial capture (1 Nov.) Swamp Sparrows were slightly advanced over Song Sparrows ($U = 62$, $P < 0.02$). On 4 Dec. wild Swamp Sparrows were still ahead of the wild Song Sparrows ($U = 51$, $P < 0.01$, Fig. 1a). On 1 Dec. the skulls of laboratory Song and Swamp sparrows were not distributed differently among skull stages ($U = 74$, NS, Fig. 1a). This relationship persisted on all subsequent dates in the laboratory birds.

Timing of pneumatization.—First laboratory-held birds of both species with pneumatized skulls were noted on 26 Nov. All laboratory-held Swamp Sparrows had completed pneumatization by 3 Jan. and all but one Song Sparrow finished by 23 Mar. First wild Swamp Sparrows with pneumatized skulls and gray irides were captured on 4 Dec. and the first

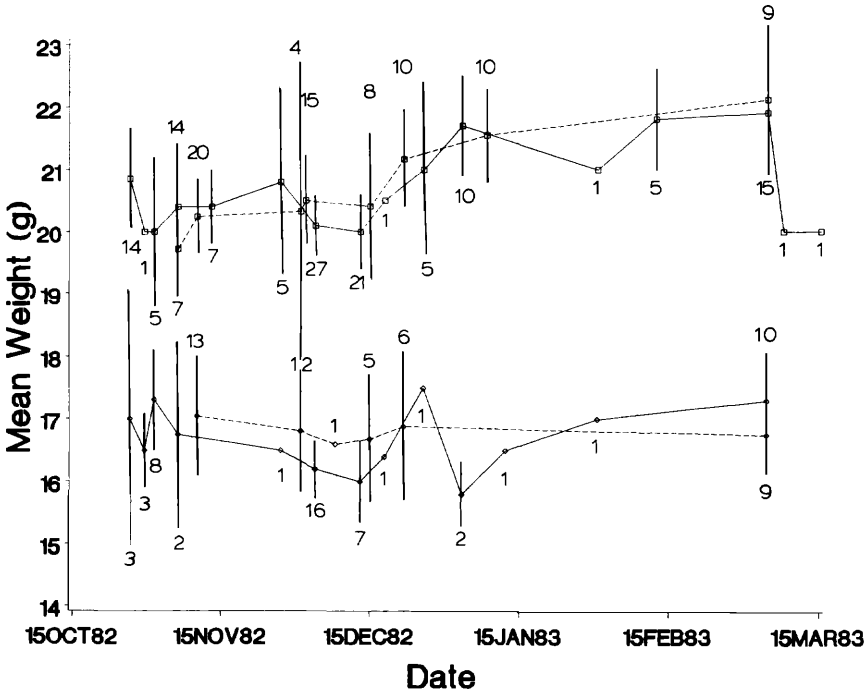

FIGURE 2. Weights of wild and captive Song Sparrows (upper curves) and Swamp Sparrows (lower curves) in northwestern South Carolina, October 1982–March 1983. Solid lines depict wild birds, dotted lines show the captive birds. Vertical bars indicate ±2 SE. Numbers above and below the bars indicate sample sizes for captive and wild birds, respectively.

wild Song Sparrows with pneumatized skulls and gray irides were caught on 18 Dec.

DISCUSSION

An important unanswered question in earlier laboratory studies of skull pneumatization (Hamel et al. 1983) was what is the relationship between the process as observed in the laboratory with that in the wild? Our results bear on that question. Both Song and Swamp sparrows held in the laboratory with unlimited diets of calcium-enriched food pneumatized faster than their conspecifics in the field. This result indicates that pneumatization timetables (such as Table 1) based upon laboratory-held birds will provide conservative estimates of the ages of birds in the field.

The consistent lag between completion of pneumatization and completion of eye color change in these species is an important finding. It provides an additional means by which free-ranging Song and Swamp sparrows can be aged accurately after skull pneumatization is complete. Should this finding extend to other species as well, improved accuracy in

aging wild-caught individuals will be possible in winter field studies of passerine birds. However, the color changes observed are subtle. This method should therefore only be used after some practice and only with adequate lighting (i.e., indirect sunlight or artificial lighting).

The difference in rate of pneumatization was not accompanied by differences in the weights of wild and laboratory birds. Wild individuals of both species maintained weights equivalent to those of laboratory birds (Fig. 2). A possible interesting implication of this result is that we may have shown that Song and Swamp sparrows in the field in the study area were calcium-limited during the winter of 1982–1983.

ACKNOWLEDGMENTS

This study was made possible by the cooperation and support of the Clemson University Department of Biological Sciences. We thank Anna Ross for advice, help in the field, and assistance in caring for caged birds. E. H. Burtt, Jr. and an anonymous reviewer provided useful comments on an earlier version of the manuscript.

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Received 19 Oct 1988; accepted 23 May 1989.