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PLUMAGE BRIGHTNESS INDEX FOR WHITE-THROATED SPARROWS

BY DORIS J. WATT

Lowther (1961) first described plumage dimorphism, involving white- versus tan-striped forms in the White-throated Sparrow (*Zonotrichia albicollis*). Using a graded series of museum specimens, all in breeding plumage, he found in each sex that white-striped morphs had more black in the lateral crown stripe, less streaking on a wider and grayer chest band, less intense black on the malar markings, and brighter yellow on the superciliary stripe than did tan-striped morphs.

However, using live birds as well as a graded series of specimens, Vardy (1971) concluded that variation in crown color was not bimodal for any given age or sex class of the White-throated Sparrow. She employed two characters, median and lateral coronal stripes, establishing 8 categories for the lateral crown stripe and six for the median crown stripe. Her results suggested a greater diversity in plumage types than that described by Lowther (1961).

Thorneycroft (1966, 1975) found that in the alternate plumage a white median crown stripe indicated that an individual possessed a single 2m chromosome; individuals lacking this autosome had a tan median stripe. In the basic plumage, (1) all adult males with the 2m chromosome were white-striped, but (2) adult females with the 2m chromosome could be tan-striped or white-striped. Adults of either sex without the 2m chromosome were tan-striped, and among young of the year, the first basic plumage was not a certain indicator of either sex or karyotype.

Atkinson and Ralph (1980) used quantitative measures of plumage characteristics to examine 105 captive White-throated Sparrows in fall and spring plumage. Some of their characters were color measures involving use of the Munsell system of color notation (for description of the application of this system to bird plumage coloration see Wood and Wood 1972). This method removed much of the subjective interpretation of plumage variability that occurs when using a graded series of specimens (e.g., Lowther 1961, Vardy 1971). Atkinson and Ralph also computed a composite index by summing plumage variables. However, their index is complex, and requires fairly extensive character coding and computations.

The purpose of this paper is to introduce a simple index that provides sufficient detail to be useful in plumage studies by banders and others. Use of this quantitative index, in conjunction with measurements to indicate sex (wing length) and age (skull pneumatization), will facilitate accumulation of data on the distribution and abundance of White-throated Sparrow morphs, as well as provide important data for examining aspects of the species' biology. Several examples of applications are given

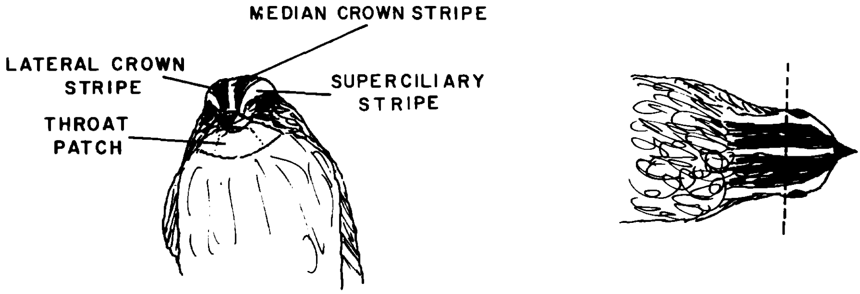

FIGURE 1. Left: head of a White-throated Sparrow showing the 4 characteristics measured. Right: the dotted line indicates the caudal limit of area of estimation for percent black in the lateral head stripes or the percent white in the median crown stripe.

that present new information and suggest further studies about the color morphs of the White-throated Sparrow.

METHODS

Ninety-nine White-throated Sparrows were netted in Fayetteville, Washington County, Arkansas from 26 November 1978 to 11 March 1979. Plumage scores (as described below) were obtained at capture. These birds were moved to the Animal Behavior Laboratory of the University of Oklahoma, Norman, Oklahoma. Fifty-four of the birds were maintained in captivity until after alternate molt, and on 23 April plumages were scored again. Nineteen of these birds were held through the following basic molt and measured again for plumage values in November 1979. Finally, 12 birds were kept until the following May when they were again scored for alternate plumage values.

All birds were housed in indoor aviaries (approximately 2 m on a side) and fed ground dog food, mixed seeds, and, occasionally, lettuce. Colored leg bands were used to identify individuals. Artificial, timed lighting was used to control daylength approximating natural lights (e.g., 8 h light: 16 h dark in winter, 12 h light: 12 h dark in summer). Birds were sexed by wing length (Atkinson and Ralph 1980) where: <69 mm = female; >71 mm = male; and 69–71 were classified as unknown sex.

PLUMAGE MEASUREMENT

Four plumage characteristics on the heads of the birds were assessed (Fig. 1, left) including the median crown stripe, lateral crown stripe, throat pattern, and yellow in the superciliary stripe. Values for each character, used to compute a "brightness index," were determined as follows.

Median crown stripe (*MCS*) values were determined by estimating the percentage of the stripe that contained white feathers. The bird was held so that I looked directly down on the top of its head. A ruler was placed across the top of the head at the posterior edge of the eyes and perpendicular to the crown stripes (Fig. 1, right). Then the percentage

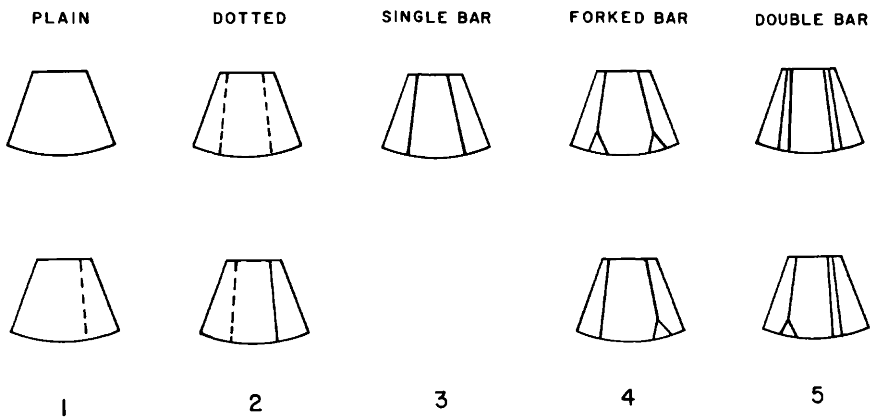

FIGURE 2. Throat patterns recorded in White-throated Sparrows; patterns and names (above) from Lowther (1961), and intermediate conditions I recorded (below). Rank values (1–5) assigned to both types of patterns are given at the bottom of the Figure.

of the median crown stripe containing white was estimated from the area between the edge of the ruler and the base of the bill. Similarly, lateral crown stripe (*LCS*) values were estimates of the percentage of black in the area between the ruler and the base of the bill in the lateral stripe regions (Fig. 1).

Classification of throat patterns (*TP*) followed Lowther's (1961: fig. 1) method in which five possible throat patterns were represented: plain, dotted, single bar, forked bar, and double bar. Most birds matched one of Lowther's categories (Fig. 2, top row); however, when a specimen had a different pattern combination (Fig. 2, bottom row; e.g., one single bar and one forked bar), the bird was given the throat pattern classification most different from the median (#3) value. In the above example, a bird with a throat pattern of one single bar and one forked bar, intermediate between a #2 and #3 classification (see Fig. 2), would arbitrarily be given the value of #2 as the most different from the median value. Intermediate conditions were uncommon (12 of 99 in fall; 5 of 54 in spring), and all conditions that I recorded are given in Figure 2 with their assigned value.

The condition of the yellow in the superciliary stripe (*SSY*) was scored as very bright, bright, medium, dull, or very dull. I first determined these categories on a set of specimens (OU numbers 4792, 1501, 4531, 6294, and 2892) selected from the large collection of several hundred White-throated Sparrows in the Stovall Museum, University of Oklahoma. Additionally, quantitative values were determined by using the Munsell system and can be compared to the qualitative categories used in this paper (Table 1). These *SSY* measures are the extremes found in the museum collection and were assumed to represent the maximum variation found in wild individuals. Single pages (5Y page) of the Munsell

TABLE 1. Values of Munsell system color variables that correspond to the categories of yellow brightness in the superciliary stripe (*SSY*; see text for explanation).

Category (*SSY*)	Color variables		
	Chroma	Value	Hue
Very bright	8	8	5
Bright	6	7	5
Medium	8	7	5
Dull	8	6	5
Very dull	6	5	5

Soil Color books can be ordered form the Macbeth Co., Munsell Color, 2441 North Calvert St., Baltimore, Maryland 21218. However, the quality of yellow can be estimated without use of the chart. Persons unfamiliar with the species might wish to survey the variation in yellow coloration from a collection of specimens.

After these four measures were recorded for each bird, I assigned a "rank value," from 1 to 5, for each measure as described in Table 2. For example, a bird with 90% white in the median stripe, 90% black in the lateral stripe, a dotted throat, and a bright yellow superciliary stripe would receive rank values of: $MCS = 1$, $LCS = 1$, $TP = 2$, and $SSY = 2$. I next calculated a plumage brightness index (*BI*) as the mean rank for the 4 characters:

$$BI = (MCS \text{ value} + LCS \text{ value} + TP \text{ value} + SSY \text{ value})/4$$

The index value for the example bird above would be 1.5 (computed from [1 + 1 + 2 + 2]/4). The dullest possible bird would have an index value of 5.0 ([5 + 5 + 5 + 5]/4); the brightest, 1.0 ([1 + 1 + 1 + 1]/4).

This index can be easily calculated and measured without any specialized equipment. Two colleagues (D. Scott Wood and Joe A. Grzybowski) and I independently obtained nearly identical *BI* values for the same set of birds, suggesting a high degree of reproducibility. It is also a sensitive measure of plumage variability in the White-throated Sparrow as the examples in the next section demonstrate.

TABLE 2. Rank values (1–5) assigned to 4 head plumage variables of White-throated Sparrows reflecting 5 categories of each.

Median crown stripe	Lateral crown stripe	Throat pattern	Superciliary stripe	Rank value
81–100%	91–100%	Plain	Very bright	1
61–80%	81–90%	Dotted	Bright	2
41–60%	71–80%	Single bar	Medium	3
21–40%	61–70%	Forked bar	Dull	4
0–20%	0–60%	Double bar	Very dull	5

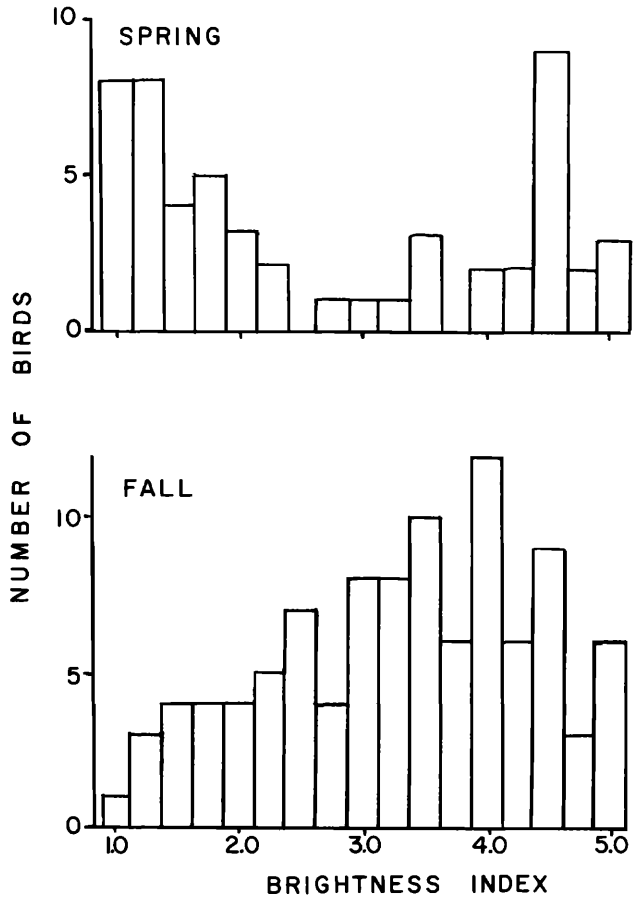

FIGURE 3. Number of birds occurring in the 17 categories of the brightness index in spring (above) and fall (below).

RESULTS AND DISCUSSION

As suggested by Thorneycroft (1975) and documented by Atkinson and Ralph (1980), fall distribution of plumage is described by a normal curve, while spring distribution is bimodal. These distributions found by Atkinson and Ralph in Pennsylvania also applied to my birds captured in northwestern Arkansas (Fig. 3). Spring birds are more easily separated into bright and dull types, whereas fall birds are more variable and overlapping in plumage characteristics. My index was sensitive enough to reveal these patterns (Fig. 3).

Thorneycroft (1966, 1975) and Lowther (1961) reported that examination of the median crown stripe color was sufficient to determine the color morph of White-throated Sparrows in alternate plumage. Figure

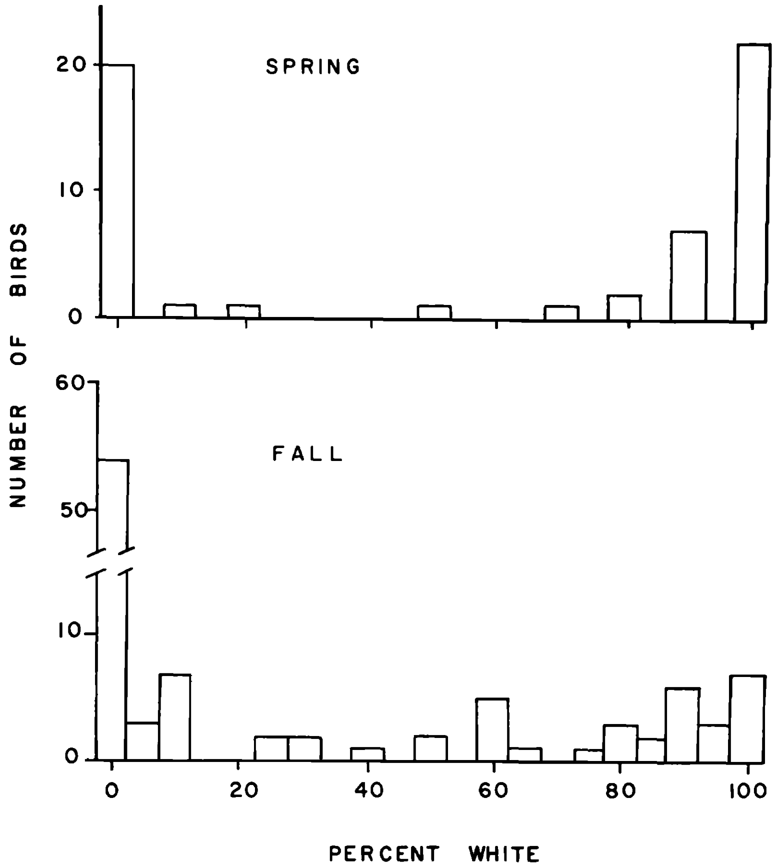

FIGURE 4. Number of birds with differing frequencies of white feathers in the median crown stripe in spring (above) and fall (below).

4 shows the *MCS* measurements I obtained for birds in spring and fall. In alternate plumage, 44% (24/54) of the birds had no white in the median crown stripe, and only 2 of the remaining birds had less than 50% white in the stripe. Thus, there is clearly a bimodal distribution of plumage types based on this one character in the spring, in agreement with Lowther (1961), Thorneycroft (1975), and Atkinson and Ralph (1980) but contrary to Vardy (1971). In the fall, birds were more evenly distributed with respect to *MCS* (Fig. 4). Thorneycroft (1975) pointed out that the large number of immature birds (often tan morphs) in fall samples skewed distributions to the tan side, as seen in my fall example (Fig. 4). However, the extreme bimodality of this character (*MCS*) is not apparent in the distribution of composite *BI* scores (Fig. 3) due to the effects of other plumage characteristics.

Information available for 19 birds followed through 2–3 molts and

TABLE 3. Wing length, sex, and brightness index (*BI*) values recorded for 19 birds in 4 seasons. *BI* for each bird was measured twice in alternate plumage (spring 1979 and 1980) and twice in basic plumage (winter 1979 and 1980), except for 7 birds that died before spring 1980.

Bird no.	Wing length (mm)	Sex[a]	Brightness index (*BI*) Winter 79	Spring 79	Winter 80	Spring 80
1	66	F	2.75	2.00	3.75	—
2	67	F	3.00	1.25	2.75	1.25
3	67	F	4.25	4.50	5.00	4.50
4	67	F	3.50	1.75	3.50	1.25
5	68	F	5.00	5.00	4.75	—
6	68	F	4.25	2.25	3.50	1.25
7	69	U	3.50	1.25	3.75	—
8	70	U	bright[b]	2.25	3.00	1.50
9	70	F	dull[b]	1.25	1.00	1.00
10	70	U	2.00	1.25	2.75	—
11	70	U	2.00	1.75	1.50	1.50
12	72	M	dull[b]	2.00	3.25	—
13	72	M	3.50	1.25	2.25	—
14	72	M	3.25	2.00	4.00	3.75
15	72	M	1.50	1.00	1.00	1.00
16	73	M	2.25	1.00	1.00	1.00
17	74	M	1.75	1.50	1.75	—
18	74	M	3.75	4.00	3.75	3.50
19	75	M	4.00	4.50	4.50	5.00

[a] Sex was determined from wing lengths where <69 mm = F (female), >71 mm = M (male), 69–71 mm = U (unknown) except for bird no. 9, where gonads were examined.

[b] Qualitative assessments of plumage for 3 birds were recorded where quantitative measurements were not made and are designated as "bright" and "dull."

having 3–4 measurements of plumage index values (Table 3) provided information on color morph stability of individuals across seasons. Of 8 male birds, 2 (nos. 12 and 14) showed a large increase in index value (darkened) from spring to winter (contra Thorneycroft 1975). Five of the males (nos. 15–19) stayed bright or dull across seasons and 1 (no. 13) was dark the first winter and bright thereafter. Females, on the other hand, often exhibited reversals of bright plumage in spring to dull plumage in the fall (nos. 1, 2, 4, and 6). Two females (nos. 3 and 5) remained dull in all seasons and 1 (no. 9) stayed bright after being dull the first winter. Thorneycroft (1975) documented that immatures in their first winter could be dull and then become brighter in later plumages, which may explain the 2 individuals in my sample (nos. 9 and 13) that became brighter with time.

Ficken et al. (1978) found that white-morph birds on spring migration were more often aggressors than tan-morph birds. Watt et al. (1984) have shown that birds in fall flocks demonstrated the opposite relationship with respect to females: tans dominated whites. Clearly, there are demonstrable differences in aggressive levels for the two morphs, especially when sex and age are known. Further investigations into these behavioral differences are needed, and the brightness index introduced here could be used to quantify plumage differences.

Ketterson and Nolan (1976) have shown that adult sex ratios of Dark-eyed Juncos (*Junco hyemalis*) differ from north to south in their wintering range. This question, as yet unstudied in White-throated Sparrows, would benefit from banding information where wing length, age, and brightness index were recorded. For example, do White-throated Sparrows of different sex or morph or age tend to winter at different latitudes? If sexual differences in wintering latitude exist in the White-throated Sparrow, they should be reflected by geographic differences in brightness index frequencies. Such data should be evaluated in light of Thorneycroft's (1975) finding that the frequencies of morphs within each sex are different (more tan females and more white males).

SUMMARY

A plumage index is described for White-throated Sparrows. It can be measured easily, perhaps during banding operations, and is useful in describing distributions of plumage variation in the species. The quantitative index is a combination of measurements of relative amounts of white feathering in the median crown stripe, relative amounts of black in the lateral crown stripe, pattern of barring on the throat, and brightness of yellow feathering in the superciliary stripe. The index is easily calculated, measured without any specialized equipment, reproducible from one researcher to another, and sensitive when used to describe plumage variability in the species as shown by several examples. Seasonal measurements of a group of birds showed fall plumage variability was normally distributed whereas spring distribution was bimodal. Study of captive individuals showed males were relatively more stable in coloration over time than females. Applications of the new index to winter studies of White-throated Sparrow age, sex, and morph distributions, long-term studies of captive birds, and investigations of aggressive behavior are suggested.

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