SONG AND TREE SPARROW WEIGHT AND FAT
BEFORE AND AFTER A NIGHT OF MIGRATION[1]

BY CARL W. HELMS

THERE has been much recent interest in weight and fat increases before
and during migration, particularly in sparrows and buntings (Emberi-
zinae). These weight and fat increases, representing reservoirs of stored
energy which may be used during migratory flight, have been well documented
for the White-throated Sparrow (*Zonotrichia albicollis*) by Odum (1949).
However, Nice (1937) found no weight increase in Song Sparrows (*Melospiza
melodia*) during migratory periods. Wolfson (1945:117–118) suggested that
the presence of resident individuals obscured any weight increase which might
have been shown by migrant birds. Nice (1946) reanalyzed her data, but
found no weight increase in migrants. Farner (1955) cautions us that physio-
logical adjustments during migration may be different in different species.

Helms and Drury (1959), comparing weight and fat variation in winter and
migrant Tree Sparrows (*Spizella arborea*) and Slate-colored Juncos (*Junco
hyemalis*) find that such differences between species do exist. Although no
statistically reliable weight and fat increases were found to be associated with
migration in Tree Sparrows, weight and fat variation become temperature-
independent and are therefore subject to some other control, presumably
associated with migration. In order to determine whether migratory birds
such as Song and Tree Sparrows show any weight and fat increase with migra-
tion, and since this increase is not shown by mean data during migratory
periods, it is important to gather statistically reliable data before and after a
migratory flight is known to have occurred. Comparison of these data with
one another and with means from mixed "resident" and "migratory" popula-
tions of the species might permit clarification of this problem.

The purpose of this paper is to present weight and fat data collected before
and after a migratory flight, and from these data and that of Helms and Drury
(1959), tentatively propose two distinct patterns of weight-fat variation in
emberizines.

METHODS

Between April 4 and 6, 1958, while "mist-netting" in the "Pine Woods"
area on Plum Island, Parker River National Wildlife Refuge, Newburyport,
Massachusetts, I caught a number of migrant Song Sparrows. From April 5
to 6, there was a reduction from about 5000 to 2000 Song Sparrows on the
island as estimated by roadside counts (the resident population was about 300
birds). The evening of April 5 was partly cloudy with light southwesterly

winds. Mean temperatures were as follows: April 4, 42°F.; April 5, 48°F.; April 6, 44°F. Although no migratory departure of buntings was seen, about 200 Horned Larks (*Eremophila alpestris*) were observed leaving a marshy area just at dark and flying north. Isolated flight calls were heard during the early part of the night, indicating a general northward movement of several species of early migrants. Individual Song Sparrows were observed feeding and moving north during the day of April 5. On April 6, I caught only four birds which had been banded the previous day (two were residents and two had been weakened by our taking of blood samples). These facts indicate a general migratory movement during the day of April 5, and particularly that night along this part of the Atlantic coast.

SONG SPARROW

Morning weight and fat data for Song Sparrows captured before and after this migratory movement are summarized in Table 1. These data are shown graphically in Fig. 1.

TABLE 1
SONG SPARROW WEIGHT AND FAT BEFORE AND AFTER A NIGHT OF MIGRATION

	Sample Size	Mean Weight	Range	S. D.	S. E.	Fat
Pre-flight Data (April 5, 1958)	61	22.48	18.2–26.4	1.67	0.21	2.35
Post-flight Data (April 6, 1958)	44	21.07	17.4–26.2	1.61	0.24	1.40

Key: Sample Size = number of individual weights (n); Mean Weight = average weight in grams; Range = lowest and highest weights in grams recorded; S. D. = standard deviation, a statistical measure of spread of weight values on either side of the mean; S. E. = standard error, a measure of reliability of the sample. For an explanation of fat values, see text.

The mean weight, as indicated in Table 1, was 1.41 grams lower on the morning of April 6 than before migration on April 5. This difference is statistically significant ($P = <.001$, *i.e.*, there is less than one chance in 1000 that this difference could have occurred by chance). Afternoon weights on April 5 (mean weight in grams = 22.86; S.D. = 1.88; S.E. = 0.50) are excluded, since, due to rain, I have no comparable weights on April 6.

Fat reserves of all birds handled were determined visually as described by Helms and Drury (1959); they were assigned numbers from one to five (our "no fat" class, Class 0, is found only during post-nuptial molt). Birds in
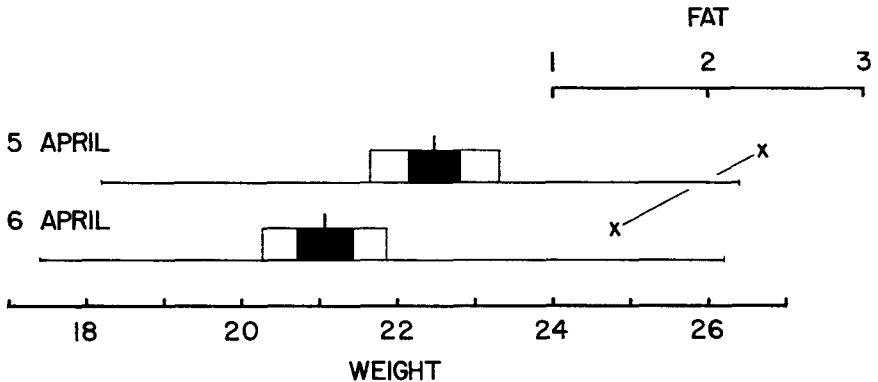
FIG. 1. Song Sparrow weight and fat before and after a night of migration. Weight data in grams (Table 1) are shown by a horizontal line representing range; an open rectangle, one standard deviation; a solid rectangle, three standard errors; and a vertical line, the mean [Mayr and Rosen (1956), based on a modification of Hubbs and Hubbs' modification of Dice and Leraas' method of graphic representation]. Non-overlap of the solid rectangles indicates a significant difference in the graphed means. For either date, mean fat is represented by an X (for explanation, see text).

Class 1 have only traces of fat on the abdomen and in the furculum, while birds in Class 2 have small visceral and abdominal deposits not forming a continuous pad. In Class 3, fat covers the abdomen but is not conspicuously mounded. In Class 4, the furculum is filled and fat on the abdomen is mounded. I have never seen Song Sparrows in our highest fat class, Class 5, in which fat in the furculum is bulging. Table 2 gives a rough comparison of our fat scheme with those of McCabe (1943) and Wolfson (1954a). Numbers assigned to fat conditions were averaged to arrive at figures presented in Tables 1–3 and Fig. 1.

The difference between fat on the two days is 0.95, or nearly one fat class, and may be regarded as significant.

It is clear that Song Sparrow weight and fat were higher in a migratory sample before than after a migration had occurred. Comparison of these samples with "resident," or what are actually mixed samples containing both residents and migrants (but with few data from actual pre-flight individuals; Helms and Drury, 1959), is complicated by the lack of proper seasonal data for this region.

Although Nice (1937) and Baldwin and Kendeigh (1938) list mean weights for April in a different geographical population of Song Sparrows, compari-

TABLE 2

COMPARISON OF PUBLISHED FAT CLASSIFICATIONS

Helms and Drury (1959)	McCabe (1943)	Wolfson (1954a)
0 +	No Fat	None
– 1 +	Little	
– 2 +	Moderate	Little
– 3 +	Fat	Medium
– 4 +	Very Fat	
– 5 +	Excessively Fat	Heavy

sons with these data might be instructive. Recalculating Nice's (1937) data to arrive at a mean April weight for both sexes of 21.99 grams, with an estimated standard deviation of 1.97 grams (Snedecor, 1956:37–38; considering the largest sample size of 50 given in his Table 2.2.2, p. 38, compared with this sample of 150, and the S.D. values in this paper, this point estimate is probably generous), it is possible to perform t-tests. These indicate that morning mean weights of the April 5 sample are significantly higher than April means ($P = .025 - .010$), and weights of the April 6 sample are significantly lower ($P = <.001$). Baldwin and Kendeigh (1938) list a mean weight of 21.4 grams for 464 adult Song Sparrows in April. Assuming that S.D. = 1.9 grams, mean weight on April 5 is significantly above the mean monthly weight ($P = <.001$), while the April 6 mean is not significantly different ($P = .20 - .10$).

In connection with these comparisons, both diurnal and seasonal variation must be borne in mind. The monthly means used are based on weights throughout the day whereas means for April 5 and 6 are only morning weights. Normal diurnal weight increases would tend to increase differences between April 5 weights and the means used for comparison, while decreasing the difference between the April 6 weights and those means. Seasonal varia-

tion would, however, reverse this tendency since weights are dropping during April (Nice, 1937), and these samples were obtained near the beginning of the month. Thus, these comparisons are only indicative.

I suspect, however, that if local morning averages for the first half of April were available for comparison, April 5 weights would be significantly higher. I believe that weight and fat on this date do indeed represent a true preparation for migratory flight.

TREE SPARROW

This view is supported moreover, by data on migrant Tree Sparrows from the same migration at Plum Island, although these data are based on a much smaller sample. These are summarized in Table 3 and include only morning weights.

TABLE 3

TREE SPARROW WEIGHT AND FAT BEFORE AND AFTER A NIGHT OF MIGRATION

	Sample Size	Mean Weight	Range	S. D.	S. E.	Fat
Pre-flight Data (April 5, 1958)	7	20.13	19.0–22.5	1.20	0.45	2.86
Post-flight Data (April 6, 1958)	4	18.98	17.9–20.0	—	—	1.75

Key: See Table 1.

The difference between these mean weights, 1.15 grams, is not significant (P = .20 – .10), probably due to the small samples. This difference between pre-flight and post-flight individuals is, however, on the same order of magnitude as in the Song Sparrow and is certainly suggestive.

Helms and Drury (1959) do have mean weights from the same period which may be compared with these data. The mean daily weight for the first two weeks of April, 19.73 grams, is significantly below the April 5 weights (a total of 13 weights for April 5 averaged 20.61; S.D. = 1.18; S.E. = 0.33 gram; P = .025). Morning weights on April 6 differ insignificantly from morning means for the half-month period (19.66 grams; P = .40 – .20).

These statistical comparisons are free of the objections raised by the Song Sparrow comparisons, and indicate that Tree Sparrows may show a weight and fat preparation for migratory flight.

The similarity of Song and Tree Sparrow weight and fat is striking and indicates the following: (1) Energy reserves measured by body weight and visible fat are greater in these sparrows prior to a migratory flight than after. (2) These sparrows may show a true migratory preparation involving increased lipid reserves and body weight when compared with predominantly resident samples.

DISCUSSION

Baumgartner's (1938) weight data on Tree Sparrows have been cited frequently as evidence for premigratory or migratory increases. Study of her graphed data (p. 608) compared with similar graphs in Helms and Drury (1959), and her own separation of resident and migratory periods, indicates that migratory weights are lower than the winter maximum. The heaviest samples during migration (March 15, 20–25) are significantly less than the weights of February 26 and March 4–10 during the winter peak (P = < .001). However, the lateness of this peak in the winter is puzzling, and it precedes migration directly. Due to the lack of temperature data and the relatively small samples, however, interpretation of this peak as premigratory seems inadvisable.

In fact, the entire picture of weight and fat variation in Tree Sparrows differs sufficiently from that of Slate-colored Juncos to warrant a brief discussion. In the former species, only two birds (in over 3000 records) have been seen with Class 5 fat. Migrant juncos, on the other hand, commonly had Class 5 fat. Differences in mean weights between successive fat classes decrease with increasing fat classes in Tree Sparrows (1.36, 0.96, 0.72 grams, respectively), and inversely in juncos (0.65, 1.42, 1.27, 1.59 grams, respectively; Fig. 3, Helms and Drury, 1959). Tree Sparrows showed no peaks in mean weights clearly associated with migration, whereas Slate-colored Juncos did.

On this basis, I propose two different patterns of weight–fat variation in emberizines. Type I variation (Slate-colored Junco) may be characterized by: (1) significant weight and fat increases evident in spring migratory periods in wild populations, if these populations are migratory; (2) heavy fat deposition (Class 5) regularly found in migrant individuals; and (3) mean weight differences between fat classes increasing with increasing fat class. The sex of birds showing this type of variation may be determined at all times of the year by the cloacal protuberance (Drost, 1938; brief discussion below). This may be contrasted with Type II variation (Tree Sparrow), characterized by: (1) insignificant weight and fat increases in grouped mean data during migratory periods in wild populations; (2) heavy fat deposition (Class 5) rarely or never found; and (3) differences in mean weights between fat classes decreasing with increasing fat class. In my experience the sex of birds in this type may be reliably determined by the cloacal protuberance only during the breeding season.

Since these patterns are based on findings in two species, it would be well to see if other emberizines fit either pattern. My own observations of captive and wild White-throated Sparrows indicate that they are typical Type I

variants. Wolfson's (1954a:419) data on this species verifies condition
(3) of Type I if differences in our fat classifications are borne in mind, and
Odum (1949) and Odum and Perkinson (1951) verify conditions (1) and
(2) for this species. White-throats can be sexed at any season by the
cloacal protuberance.

My observations on captive White-crowned Sparrows (*Zonotrichia leu-
cophrys*) and Oregon Juncos (*Junco oreganus*) indicate that they also are
Type I variants.

Nice's (1937, 1946) weight data suggest that Song Sparrows fit condition
(1) of Type II variation. It should be noted that this condition applies to
grouped mean data in wild populations and does not preclude significant
weight increments in migratory individuals prior to flight as reported in
this paper. My own field observations indicate that condition (2) is satisfied
for this species. Although limited data on fat in Song Sparrows are available,
it seems that condition (3) is also met. In the Tree Sparrow, a Type II
variant, the mean weight difference between Classes 1 and 2 fat is 1.36 grams.
In the Song Sparrow samples considered here, in which the fat differences
are essentially those between Classes 1 and 2, the mean weight difference is
1.41 grams, in close agreement with the Tree Sparrow increment. Limited
data on higher fat classes indicate mean differences do decrease, and condi-
tion (3) is fulfilled. I am unable to sex Song Sparrows in spring by the
cloacal protuberance.

My field data suggest that Type II variation is also shown by Fox Sparrows
(*Passerella iliaca*), Swamp Sparrows (*Melospiza georgiana*), and possibly by
Savannah Sparrows (*Passerculus sandwichensis*). Data on one captive female
Lark Sparrow (*Chondestes grammacus*) suggest either Type II or a third
type of variation.

Whether these particular types and conditions of variation are upheld or
not, it seems evident that there are at least two distinct physiological patterns
of weight and fat variation in different species of emberizines.

The Cloacal Protuberance.—Since the usefulness of the cloacal protuberance in deter-
minations of sex of non-breeding birds is frequently overlooked, and because this useful-
ness is different in the two variant types, a brief discussion is in order. Salt (1954)
and Wolfson (1952, 1954b) have described the anatomy and function of the breeding
protuberance. Drost (1938), after long study of the protuberance, concluded that it
could be used satisfactorily to sex many non-breeding species of European birds. In
general, the male protuberance, which contains paired seminal vesicles, forms a distinctly
angular junction with the abdomen and has a more or less flattened tip. The female
protuberance, lacking the sac-like seminal vesicles, forms a curved junction with the
abdomen and has a more or less pointed tip. The male protuberance is generally larger
but not consistently so (Helms, 1959 MS). When determination is questionable, the
bird is usually a female. Errors are most likely in juvenile birds, and in adults following
the gonadal regression into early post-nuptial molt, and in very fat birds in which the

mass of subcutaneous abdominal lipid often makes the female protuberance look angular. Plumage characters and measurements should be used to check protuberance determinations.

Sexing error in Type I variants is less than 10 per cent on first handling and can be reduced to less than one per cent with subsequent determinations. I have found also that angularity of the protuberance may be used to determine gonadal regeneration in incomplete castrates.

Although Type II variants show protuberance differences, they are not consistently reliable. Sexing error by the protuberance alone is about 40 per cent and shows no reduction with subsequent determinations. The seminal vesicles of non-reproductive Tree Sparrows are less than half as large as those of White-throated Sparrows (1.4–2.0 mgm., compared with 5.5–7.4 mgm.), are slimmer, and are more tangentially oriented to the cloaca.

It should be noted that all species mentioned have bulbous type protuberances (Wolfson, 1954b), with the possible exception of the Lark Sparrow, whose type is unrecorded.

I have mentioned the protuberance in this paper because of the possibility of functional indications with weight and fat variation. Condition (3) of the respective types probably has an anatomical basis in the relative amounts of fat deposited in various body areas. A study such as Odum and Perkinson's (1951) would be desirable on a Type II variant. Conditions 1 and 2 would reflect these differences if such exist. However, the development of the seminal vesicles, which are responsible for the appearance of the male protuberance, is under the control of androgens (Marshall, 1955) and may be used as a crude indicator of androgen secretion (Salt, 1954). Fat deposition is essentially different in relative distribution and amount during migratory periods (Odum and Perkinson, 1951) and under a different physiological control (Helms and Drury, 1959). It can be influenced by the sex steroids (Wagner, 1956). These facts suggest that the lower level of androgen secretion indicated by the smaller seminal vesicles of non-breeding Type II variants might influence the pattern of weight and fat variation during non-breeding periods. Therefore, different hormonal levels, timing, balances, and/or sequences during migration, coupled with different morphology of the lipid reserves, might account for the differences in variation patterns.

SUMMARY

1. Song Sparrow and Tree Sparrow samples taken before and after a night of coastal migration show that pre-flight individuals have significantly higher body weight and fat than post-flight individuals. Weight differences before and after the flight were 1.41 grams in Song Sparrows and 1.15 grams in Tree Sparrows. Fat was one class lower after the flight.

2. Comparison of these samples with monthly or half-monthly means obtained from "mixed" populations suggest that pre-flight individuals show a true migratory preparation which is not reflected in the mean values over longer periods in these two species.

3. Two patterns of weight and fat variation in emberizines are proposed with criteria for each: Type I variation is shown by Tree Sparrows, and Type II variation by Slate-colored Juncos.

4. Determination of sex using the cloacal protuberance is possible at all

seasons in Type I variants, but only during the breeding season in Type II variants.

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NEW LIFE MEMBER

Karl H. Maslowski, an active member of the Wilson Ornithological Society since 1934, became a Life Member this year. He lives in Cincinnati, Ohio, with his wife, three sons, and one daughter. Mr. Maslowski is a motion picture producer and lectures for the National Audubon Society. His principal interest in ornithology is motion picture studies of life histories. He has been a nature columnist for the *Cincinnati Enquirer* for 23 years, and has written popular articles (many illustrated by his fine photographs) for many magazines and special publications. He has published notes in *The Wilson Bulletin*, *The Auk*, and *Journal of Mammalogy*.

Karl is also a member of the A. O. U. and the American Society of Mammalogists, and has been a board member of the Cincinnati Society of Natural History Museum and a Trustee of the Cincinnati Zoological Society for about 10 years.