THE FAT DEPOSITION PICTURE IN THE WHITE-THROATED SPARROW IN COMPARISON WITH THAT IN LONG-RANGE MIGRANTS*

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The purpose of this brief report is to summarize all of the data which we have obtained on fat deposition in the White-throated Sparrow *(Zonotrichia albicollis)*. Recent material obtained from a Gulf coast TV tower fills a gap and enables us to present a fairly complete picture of the lipid levels in relation to season and migration. This picture is of special interest because fringillids of the genus *Zonotrichia* are being widely used in experimental studies of migration (see review by Farner, 1955). In addition to persons co-authoring papers cited below I am indebted to Mr. Herbert L. Stoddard for collecting the TV tower material, to Mr. Clyde E. Connell, Mr. J. Smith Kimbell, and Miss Guthrie Tolbert for extracting lipids from these specimens, and Dr. Robert A. Norris for suggestions concerning the manuscript.

Our investigations of White-throats began in 1947 with a study of the weights of banded birds wintering on the campus of the Unversity of Georgia; two distinct peaks in weight were found, one in mid-winter and the other just before northward migration in April (Odum, 1949). The actual amount of fat present at different seasons was determined in a subsequent study; it was found that the premigratory deposition or "migratory fat" was different in amount and body distribution from the "winter fat" (Odum and Perkinson, 1951). Averages and extremes for four seasonal periods are given in Table 1. Next, we discovered that fat deposition induced experimentally by long photoperiods was the same as "migratory fat" (Odum and Major, 1956). As shown in Table 1 the maximum amount of fat which could be induced experimentally, or which was observed in nature, was about 25% of body weight. In contrast, we are finding that maximum fat deposition in

TABLE 1

Lipid Levels in White-throated Sparrows Under Various Conditions in Comparison with Maximum Levels in Long-range Migrants

	Number	Total Lipids as Percentage of Total (Wet) Weight	
White-throated Sparrows	Birds	Average	Extremes
1. Post-migration period; Oct.-Nov.	23	6.8	4.3-12.8
2. Mid-winter period; Jan.-Feb.	15	12.0	8.1-17.4
3. Spring molt period; March	27	6.2	4.4-10.0
4. Pre-migration period; April	19	16.7	9.7-24.8
5. Maximum deposition induced experimentally by long photoperiods	22	15.7	11.8-24.5
6. Birds killed while in actual migratory flight at Gulf Coast TV tower; Sept.-Dec.	45	6.2	1.9-14.2
Long-range "overseas" migrants			
7. Warblers killed at same tower as item 6 above	29	30.1	6.1-42.1

*Studies on lipid deposition in birds have been aided by funds from the University of Georgia Graduate School and the University Center in Georgia.

many species of warblers, vireos, thrushes, and tanagers, which winter south of the United States, is much greater, ranging up to 42% (Odum and Connell, 1956).

During the fall of 1956 Mr. Herbert Stoddard of Thomasville, Georgia, made a special effort to preserve all birds which were killed during migration by striking a newly erected TV tower. The tower is located between Thomasville and Tallahassee, Florida, only a few miles from the Gulf coast. Mr. Stoddard had several acres of ground under the tower planted in low growing grass to facilitate the finding of fallen birds, and he also chlordaned the area to keep down ants which will "chew up" specimens in a few hours. He visited the tower early every morning from August through December and put all birds immediately into deep-freeze; thus, all specimens were in excellent condition.

In common with all serious bird students Mr. Stoddard deplores the kill of birds at towers, but feels that every possible scientific use should be made of the specimens, especially since systematic studies must be made before means of reducing the kill can be devised. Accordingly, Mr. Stoddard kindly turned over to us for fat studies a large number of birds which were not needed in his own studies.

Included in this material was a series of 45 White-throated Sparrows, all of this species which struck the tower during the fall migration of 1956. The first specimens appeared on Oct. 26 when six individuals were picked up. Thereafter, they hit the tower at intervals as follows (number of individuals in parentheses): Oct. 29 (10); 30 (6); 31 (2); Nov. 3 (2); 4 (2); 5 (1); 8 (6); 9 (1); 12 (2); 20 (1); Dec. 3, 7, 12 (1 each); 21 (2); 23 (1).

The average and extremes of fat content of the 45 "TV tower birds" are shown in item 6 of Table 1 (for methods used in extracting total lipids see Odum and Connell, 1956). These birds were relatively lean and similar to the post-migratory birds previously studied at Athens, Ga. (compare with item 1, Table 1). In fact, several individuals had less than 2% fat, which is less than we ever found in a bird collected during the daytime in non-migratory seasons at Athens. Thus, the White-throats striking the tower at Tallahassee had used up all or most all of their fat, which is not unexpected since the Gulf coast is near the "end of the line" for fall migration (the species winters somewhat further south in peninsular Florida).

In sharp contrast were Red-eyed Vireos *(Vireo olivaceus)* and warblers striking the tower during the same fall migration period; most individuals of these groups were fat and many were at the maximum level of 40% or more. For comparison, averages and extremes for 29 warblers of three species, Tennessee *(Vermivora peregrina)*, Bay-breasted *(Dendroica castanea)*, and Magnolia *(Dendroica magnolia)* are listed in Table 1 as item 7. The three species can be considered together because they did not differ in fat content and all three species breed far to the north and winter to the south of the point where they were killed in migratory flight.

The White-throats and warblers are compared in a different way in Figure 1, which shows the frequency distribution of individuals in different fat classes. Shown also is the frequency distribution of 101 Red-

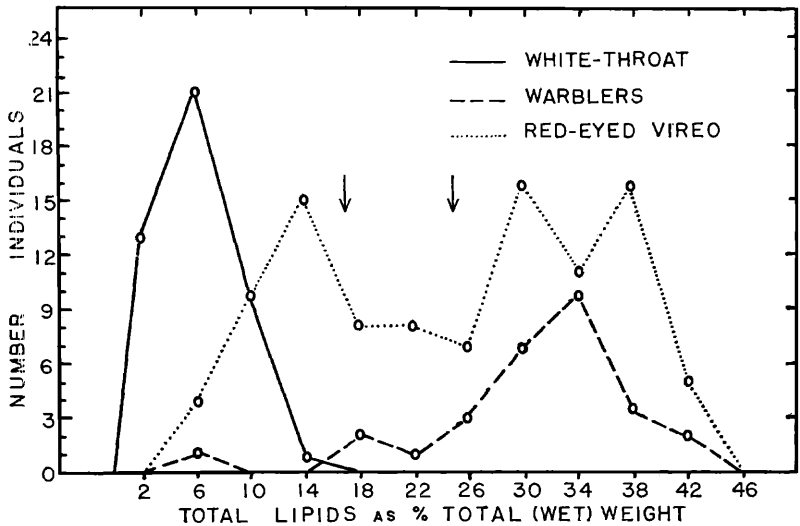

Fig. 1. Frequency distribution of fat deposition in 45 White-throated Sparrows, 29 Warblers (Tennessee, Bay-breasted, and Magnolia), and 101 Red-eyed Vireos killed by flying into the Tallahassee, Florida, TV tower during the 1956 fall migration. Class interval is 4% (0-4; 4-8; 8-12; etc.). The two arrows indicate the average and maximum levels found in pre-migratory White-throated Sparrows in spring.

eyed Vireos, this species being one of the most common to fall victim of the tower. The White-throats and the warblers show essentially "bell-shaped" distributions indicating that the samples are from a homogeneous population in so far as the degree of fatness is concerned. The warbler curve is skewed to the left or tends to be slightly bimodal because one individual (a Tennessee Warbler) was lean and several were only moderately fat. The curve for the Red-eyed Vireos is definitely bimodal with the largest group at the same high level as the warblers and another group of individuals showing only a moderate amount of fat suggesting that two or more populations are involved (a possibility we hope to analyze when more specimens have been processed).

The arrows on Figure 1 indicates the average (15%) and the maximum (25%) levels of White-throats in pre-migratory conditions. Note that White-throats apparently never attain the high levels of the long-range migrant warblers and vireos which migrate nonstop over the Gulf or at least make long flights along the coasts.

It is quite clear from Figure 1 that the White-throats which had reached the Gulf coast were in a post-migratory condition; that is, they were in no condition for much more flying. The warblers and most of the vireos, on the other hand, migrating at the same time and place were definitely in "pre-migratory" condition; that is, they carried stored energy which would enable them to continue flying for a long time.

There was no evident seasonal trend in the White-throat series. The average and range was about the same both early and late in the

migratory period. October birds, for example, ranged from about 2 to about 14%, while the smaller number of December birds ranged between 3 and 11%. The fattest bird (14.2%) was picked up on Oct. 30 along with individuals having only 4%.

There was one other very interesting feature about the "TV White-throats" which seems to bear out a prediction which we made in an earlier paper. In the 1951 paper we reported that after all of the banded birds wintering on the University campus had "fattened up" and disappeared in late April a few White-throats could be found in the bottomlands for two or three more weeks; these birds nearly always turned out to be females, mostly immatures, and many were not fat. We suggested that these birds were probably migrants from further south which had used up one load of fat and had stopped to accumulate another deposit. Accordingly, we suggested that immature or first-year females probably tend to winter further south than adults in general and males in particular.

According to this theory, then, most of the White-throats migrating as far south as Florida (the southern edge of the winter range) should be immature females. As a matter of fact there was not one single adult in the tower series (as determined by skull ossification pattern), and 35 out of 45 individuals were females! While hundreds of individuals are required before one is justified in testing for differences in age and sex ratios, the high per cent of immature females in the Tallahassee tower sample is at least suggestive.

The sex ratio among the warblers and vireos was approximately 1:1 and the age ratio 5:1 in favor of immatures, which is what one might expect in a general population of small birds at the end of the breeding season. Thus, there was no evidence that the tower was "selective" in regard to age or sex. Since immature birds get just as fat as adults when in true migratory condition it is also clear that the low fat level of the Tallahassee tower White-throats is not the result of the age and sex distribution in the sample but an indication of their essentially "post-migration" status.

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