

COMPARISON OF FAT LEVELS IN MIGRATING BIRDS KILLED AT A CENTRAL MICHIGAN AND A FLORIDA GULF COAST TELEVISION TOWER¹

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IN this paper fat levels in migrating birds killed at a Michigan television tower located near Cadillac are compared with levels found in the same species killed at a Florida Gulf coast tower located near Tallahassee. Extensive studies of birds killed at the latter tower, which is located astride what is believed to be a major trans-Gulf migratory route, are in progress at the University of Georgia (Odum, Connell, and Stoddard, 1961) and at the Tall Timbers Research Station, Tallahassee, Florida (Stoddard, 1962).

Birds killed during nocturnal flights were collected by Caldwell at the Michigan tower (Station WWTV) and by Mr. Herbert Stoddard, Sr., at the Florida tower (Station WCTV). All specimens were stored in plastic bags in deep freeze until processed. Total body fat was determined by a simple, rapid method now in routine use at the University of Georgia laboratory. The procedure involves vacuum dehydration of the specimen followed by extraction with petroleum ether. Three weights were taken: total wet weight, total dry weight (after dehydration), and total nonfat dry weight (after extraction); the difference between the latter two weights is the estimate of total fat content (see Odum, 1960).

In this paper fat is expressed as a percentage of the nonfat dry weight, that is, grams fat/100 grams of nonfat dry weight. This ratio is more satisfactory for direct comparisons than the ratio of fat to wet weight (the usual "fat index"), since it is not affected by variations in water content or by slight dehydration that may have occurred before specimens were recovered at the towers or while stored in the freezers. Also, in contrast to the wet weight index, the fat-nonfat ratio is linearly related to total fat content since the nonfat dry weight remains virtually constant. That is, a doubling of the index indicates a doubling of the fat deposits. Nonmigrating birds generally have a fat-nonfat ratio of 10-50 per cent, moderately fat migrants (or sometimes winter specimens) 50-100 per cent, while very fat migrants run between 100 and 300 per cent.

RESULTS

As shown in Table 1 and Fig. 1, fall migrant warblers, vireos, thrushes, and tanagers from the Florida Gulf coast had possessed much greater fat reserves than birds of the same species from Michigan. All these species winter in

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TABLE 1
MEAN FAT LEVELS OF MIGRATING BIRDS KILLED AT A CENTRAL MICHIGAN AND A FLORIDA
GULF COAST TV TOWER DURING AUTUMN MIGRATION

Species	Number of individuals	Grams fat/100 grams nonfat dry weight	
		Mean \pm SE ¹	SD ²
Gray-cheeked Thrush (<i>Hylocichla minima</i>)			
Michigan	10	64 \pm 7.5	23.6
Florida	26	168 \pm 13.6	69.5
Red-eyed Vireo (<i>Vireo olivaceus</i>)			
Michigan	14	74 \pm 10.3	38.7
Florida	59	121 \pm 6.1	47.1
Tennessee Warbler (<i>Vermivora peregrina</i>)			
Michigan	6	93 \pm 21.9	53.6
Florida	16	205 \pm 6.3	25.3
Magnolia Warbler (<i>Dendroica magnolia</i>)			
Michigan	15	55 \pm 3.8	14.5
Florida	25	155 \pm 11.1	55.5
Ovenbird (<i>Seiurus aurocapillus</i>)			
Michigan	12	86 \pm 10.6	37.1
Florida	16	151 \pm 6.9	27.1
American Redstart (<i>Setophaga ruticilla</i>)			
Michigan	5	73 \pm 10.9	24.4
Florida	17	129 \pm 12.4	50.9
Scarlet Tanager (<i>Piranga olivacea</i>)			
Michigan	2	117	
Florida	13	186 \pm 11.7	42.1
White-throated Sparrow (<i>Zonotrichia albicollis</i>)			
Michigan	9	59 \pm 5.4	16.2
Florida	17	20 \pm 2.2	9.2

¹ Mean and standard error of mean. All differences between Florida and Michigan are significant at the 99 per cent level where five or more individuals in each sample are available.

² Standard deviation.

Central or South America. In contrast, White-throated Sparrows, which winter in southeastern United States, were significantly fatter in Michigan than in Florida, even though the mean fat level in Michigan was generally lower than in the other species.

Only a few specimens were available for comparison in the spring. As shown in Table 2, mean fat levels in Florida and Michigan were about the same in three species of spring migrants, insofar as the meager data show.

As would be expected, individuals of tropical-wintering species that strike the Florida Gulf coast tower have much greater fat reserves in fall than in

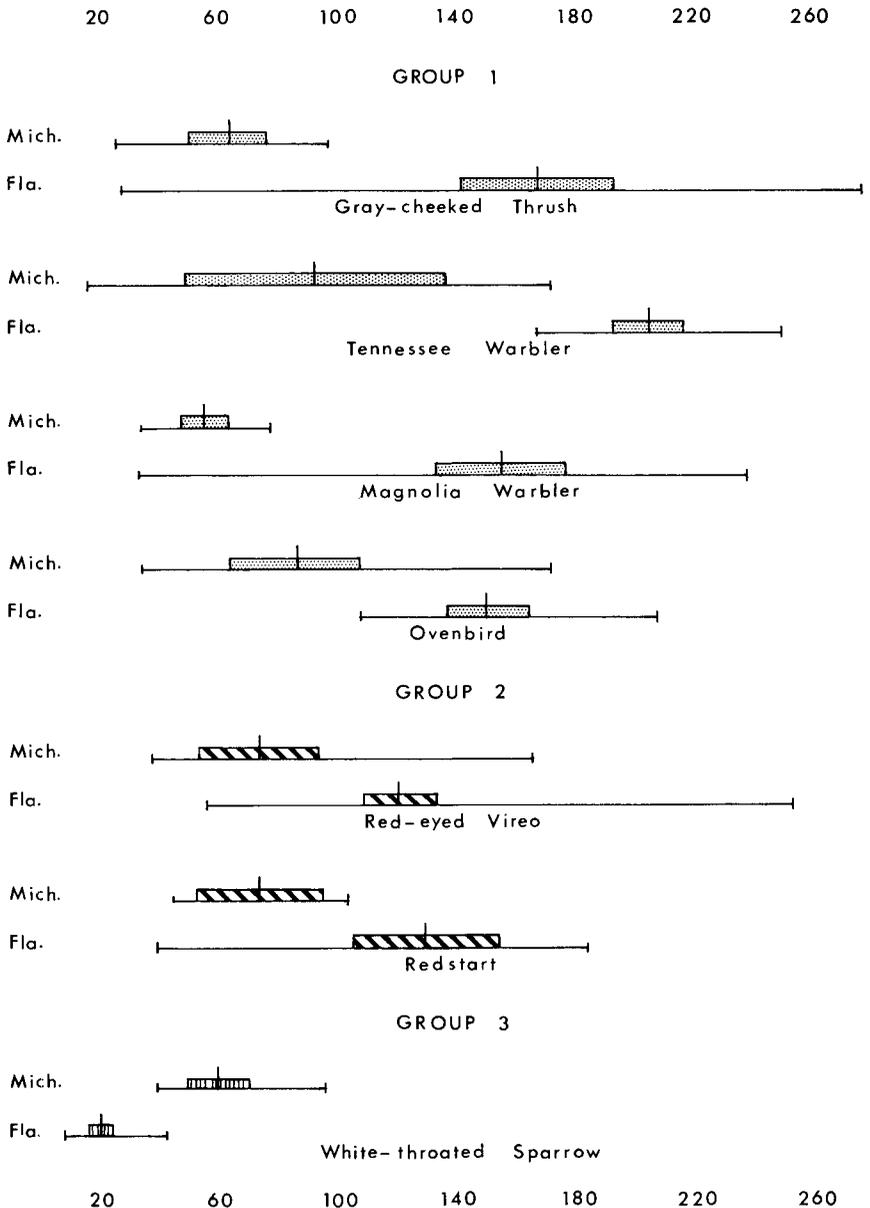


FIG. 1. Comparison of fat levels in migrating birds killed at a central Michigan and a Florida Gulf coast TV tower during the autumn migration. Fat is expressed as grams per 100 grams of nonfat dry weight. Vertical lines indicate means, horizontal lines extremes, and shaded boxes two standard errors on each side of the mean. The four species

TABLE 2
MEAN FAT LEVELS OF MIGRATING BIRDS KILLED AT A CENTRAL MICHIGAN AND A FLORIDA
GULF COAST TV TOWER DURING SPRING MIGRATION

Species	Number of individuals	Grams fat/100 grams nonfat dry weight	
		Avg \pm SE ¹	SD ²
Red-eyed Vireo (<i>Vireo olivaceus</i>)			
Michigan	13	54 \pm 6.5	23.4
Florida	26	67 \pm 4.8	24.7
American Redstart (<i>Setophaga ruticilla</i>)			
Michigan	3	43 \pm 11.8	20.1
Florida	3	34 \pm 3.5	6.0
Bobolink (<i>Dolichonyx oryzivorus</i>)			
Michigan	2	87 —	—
Florida	9	97 \pm 8.9	26.7

¹ Mean and standard error of the mean. Difference between Michigan and Florida not statistically significant for any of the species.

² Standard deviation.

spring (Odum, Connell, and Stoddard, 1961). As shown in Table 3, fall migrants in central Michigan were also fatter than spring migrants, but the difference is not nearly so great as is the usual case in Florida. The Michigan spring birds were surprisingly uniform in fat content, and not much above the level to be expected in nonmigratory birds at that season. For example, a series of nonmigratory Carolina Wrens (*Thryothorus ludovicianus*) which we have extracted during the spring and fall seasons averaged 35 grams/100 grams dry weight with a range of 20 to 55. Thus, the mean level of 51 for warblers (Table 3) and the mean of 54 for vireos (Table 2) in Michigan in spring are within the upper range of nonmigrating individuals.

DISCUSSION

Although birds from the two localities were not collected in the same year, the fall specimens from Michigan were picked up about two weeks earlier in the season than the Florida specimens with which the comparisons were made. Consequently, the samples may indicate trends in fat deposition which occur as migrants move from the northern border to the southern border of the United States. All the tropical-wintering species were fatter in Florida, indicating increasing fat reserves as these species move southward.

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in Group 1 are thought to be habitual trans-Gulf migrants, the two species in Group 2 are thought not to be so strongly trans-Gulf in their southward flights, while the one species in Group 3 does not migrate south of the Gulf Coast.

TABLE 3
MEAN FAT LEVELS OF MIGRATING BIRDS KILLED AT A CENTRAL MICHIGAN TV TOWER
IN FALL AND SPRING

Species	Number of individuals	Grams fat/100 grams nonfat dry weight	
		Avg \pm SE ¹	SD ²
Black-and-white Warbler (<i>Mniotilta varia</i>)			
Fall	10	70 \pm 7.5	23.4
Spring	12	48 \pm 3.5	12.7
Nashville Warbler (<i>Vermivora ruficapilla</i>)			
Fall	10	66 \pm 4.8	15.1
Spring	14	69 \pm 6.9	25.5
Ovenbird (<i>Seiurus aurocapillus</i>)			
Fall	12	86 \pm 10.6	37.1
Spring	8	45 \pm 7.1	20.0
American Redstart (<i>Setophaga ruticilla</i>)			
Fall	5	73 \pm 10.9	24.4
Spring	3	43 \pm 11.6	20.1

¹ Mean and standard error of mean.

² Standard deviation.

This would mean that these birds could make much longer flights by the time they reach the Gulf Coast than would be possible in Michigan. Notably, the Gray-cheeked Thrush and Tennessee and Magnolia Warblers, species believed to be habitual trans-Gulf migrants, were more than twice as fat in Florida. In contrast, the north-south difference in fall was not quite so great in the Red-eyed Vireo, and Redstart (see Fig. 1), species believed not to be strongly trans-Gulf in their migration (since many individuals are observed using the circum-Gulf routes: see Stevenson, 1957). The situation in the White-throated Sparrow is what would be expected since Michigan is near the beginning and Florida at the end of its migration route. White-throats apparently never become as fat as the long-range migrants (see also Odum, 1958). These preliminary data indicate that fat levels of birds killed at towers located at different geographical points along the migratory route do reflect the pattern of migration characteristic of the species.

Using the tentative model proposed in a previous paper (Odum et al., 1961), maximum flight ranges estimated from the mean fat levels of birds at the two localities are as follows (estimates in round numbers):

Table 1. Tropical-wintering species, fall migration: Florida—1,100 miles
Michigan— 500 miles

Table 1. White-throated Sparrow, fall migration: Florida—150 miles
Michigan—350 miles

Table 2. Tropical-wintering species, spring migration: Florida—350 miles
Michigan—350 miles

Table 3. Tropical-wintering species, Michigan:
spring migration—250 miles
fall migration—500 miles

Since the data in Table 2 are inadequate and involve three species of rather different migratory patterns, a better comparison in the spring is between the average flight range of about 350 miles in species of the northern warblers arriving in Florida, and the average of 250 miles for Michigan as shown in Table 3. Thus, it would seem that tropical-wintering species may be expected to be fatter on the average in Florida than in Michigan for both fall and spring, but much more so, of course, in the fall migration.

It should be emphasized that these estimates of flight range are the maximum range possible if all of the fat reserves are used (and assuming favorable weather). Actually, telescope and radar observations indicate that many migrants terminate nocturnal flights when flying over continental areas after a few hours, and before the fat reserves are exhausted. Hassler, Graber, and Bellrose (1963), for example, report that mass flights in September over Illinois occur mostly in the early hours of the night, the density of flying birds dropping off sharply after midnight. Trans-Gulf flights, of course, require a much longer time in the air. While we do find spring individuals in Florida that have largely depleted their fat reserves, the mean fat levels of spring arrivals are still substantial, indicating reserve fuel over that normally needed. The lowest fat levels, in fact, are found in birds that are near the end of their migratory routes, such as the White-throated Sparrow in Florida in fall, or the northern warblers in Michigan in spring. As discussed in more detail in a previous paper (Odum, 1960), it is now clear that many species begin migration with low or moderate fat reserves and with consequent short flights. In long-range migrants the fat reserves are apparently increased with each stop until the maximum level is reached at or near points where long nonstop flights are required, as, for example, on or near the Gulf Coast.

SUMMARY

Mean fat levels of six species of tropical-wintering thrushes, warblers, and vireos killed in the fall migration at a Florida Gulf coast television tower were significantly greater than in the same species killed at a central Michigan tower; levels in species believed to be habitual trans-Gulf migrants were more than twice as great in Florida.

In contrast, fat levels in White-throated Sparrows, a species wintering in the Gulf states, were significantly greater in Michigan in the fall.

In spring, fat levels of four species breeding in Michigan were low to moderate and not significantly different at the two tower locations.

The results provide indirect evidence for the hypothesis that long-range northern

migrants begin southward migration with low to moderate fat reserves and with consequent short flights, then increase their reserves with each stop until the maximum level is reached at or near points, as on or near the Gulf Coast, where long nonstop flights are undertaken.

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