BODY WEIGHT AND FAT DEPOSITION IN CAPTIVE WHITE-THROATED SPARROWS IN RELATION TO THE MECHANICS OF MIGRATION[1]

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In 1945 a study of body weight and fat deposition in transient birds was begun at Evanston, Illinois. The data for the White-throated Sparrow (*Zonotrichia albicollis*) for the years 1945-1947 have been analyzed and are in press (Wolfson, 1954). It was found that White-throats captured in the spring at Evanston varied greatly in body weight and that these variations were correlated with the amount of fat deposition. When the birds were classified according to fat deposition there were significant differences in the mean body weights of the four fat classes (none, little, medium, and heavy). The fact that birds arrived with different amounts of fat suggested that they had had different migratory behavior patterns during the 24 hours prior to capture. Those without fat (mean weight—22.9 gms.) possibly *had undertaken* a long flight the previous night which had brought them to Evanston on the date of capture. Those with "heavy" fat (mean weight—30.3 gms.) were thought to have been feeding in or near Evanston for the past several days and perhaps were "ready" *to undertake* a long flight at night. Irrespective of the interpretations, the marked difference in the body weight and fat deposition of these two groups of birds suggested that their behavior subsequent to arrival at Evanston would be different. On the basis of previous experimental studies (Wolfson, 1942, 1945), the birds without fat would be expected to remain "stationary" and restore their fat deposits. Those with heavy deposits would be expected to undertake a long flight as soon as other conditions were suitable.

The migratory behavior of transients can be studied by noting the length of stop-over time in a given locality and the number of birds which repeat during the migratory period. Two extensive studies of this kind have been made: Stack and Harned (1944) showed that the average stop-over time at Lansing, Michigan, was 4.5 ±1.6 days. Borror (1948) found the stop-over time at Columbus, Ohio, to be 5.3 ± .3 days. At Columbus, the average percentage of repeats was 48.5. At Lansing, it was 24.0. These data would be more meaningful if we knew the body weight and fat deposition of the birds which were trapped only once, and the entire weight history of those which repeated. Judging from our earlier studies, I would guess that repeaters are primarily birds that arrive with little or no fat. Non-repeaters are probably birds with moderate or large amounts of stored fat. To determine the facts

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entails only recording of the body weight and fat deposition in banded and free-living transients. So far this has not been done by others, and we did not do it in our study. A major weakness of this method is that one may fail to retrap the "repeats" at the proper times. This would prevent a correct evaluation of body weight and fat deposits in relation to subsequent migratory behavior. For example, one may have several weight records which show a gradual decrease in weight for a repeating individual before it disappears from an area. One has no way of knowing whether this individual is foraging a short distance away, or whether it has undertaken a long migratory flight. To overcome this weakness it was decided to retain the birds in captivity after their initial capture and weigh them regularly. In this way the *potential response* of each individual could be determined. I say potential response, because conditions in captivity are far from identical with those in nature. It will remain for studies of free-living birds to determine what actually occurs in nature, but studies of captive birds can yield important clues. I would expect the observations in nature and those in the laboratory to be in agreement conceptually. Differences in degree, if they are found, will probably be readily explicable in terms of the conditions of observation.

The purpose of our study, therefore, was to determine the "weight" and "fat" response of spring transients which arrive with different body weights and amounts of fat. It was thought that a knowledge of these responses would be useful in understanding the migratory behavior of transients. A secondary objective was to compare the data on body weight for the various fat classes in these captive birds with the same data for birds captured in nature. This would give some idea of any degree of difference which might be due to diet or continual availability of food in captivity. Data were obtained in 1946 and 1947.

Methods

The methods of trapping, weighing, and classifying the birds according to age and fat deposits have already been described (Wolfson, 1954). In captivity the birds were housed in flight cages (24 × 15 × 19 inches, or 18 × 18 × 16 inches) which were kept in a large, unheated room. Light was provided by natural daylight. Four to six birds were housed in each cage. Food consisted of unmixed canary seed, dried insects, and dog food, and was available at all times. Water, cuttlebone, and grit were also available at all times.

Results

The first determinations which were made were the changes in mean body weight from the time of capture until the termination of the period of captivity on June 26 and 27. This was done to permit comparisons with the data of

TABLE 1

COMPARISON OF MEAN BODY WEIGHTS OF CAPTIVE BIRDS FOR SUCCESSIVE DATES, 1946–1947. NO SEGREGATION ACCORDING TO SEX, AGE, OR FAT CLASS.

	1946			1947		
	Mean Body Wt.	% change from preceding Wt.	% change from initial Wt.	Mean Body Wt.	% change from preceding Wt.	% change from initial Wt.
Initial Weight	27.8 (20)	—	—	26.6 (29)	—	—
May 7–10	——	—	—	26.7 (4)*	+ .4	+ .4
May 13–19	27.5 (20)	-1.1	-1.1	27.9 (10)*	+4.5	+4.9
May 23	27.3 (20)	- .9	-1.9	——	—	—
May 30	26.0 (20)	-4.7	-6.5	——	—	—
June 4	25.8 (20)	- .8	-7.3	——	—	—
June 11–13	24.8 (20)	-3.9 -9.8**	-10.9	24.7 (22)	-11.5	-7.1
June 26–27	22.3 (20)	-10.1	-17.7	22.6 (20)	-8.5	-15.1

*Data from None and Heavy fat classes only.

**Percentage from May 13–19 for comparison with similar period in 1947.

other investigators, and to test again the value of mean body weight determinations. In our first report (1954) it was shown that mean body weight determinations were of little value in themselves and tended to mask or distort important information. The data are presented in Table 1. The initial weight is the mean body weight at the time of capture for all of the individuals which were subsequently held in captivity. This is followed by the mean body weight for the periods of time or the dates given. From the time of capture, there were relatively small changes in weight until June 11–13. In June the mean body weights decreased markedly. The final mean weights and the percentage lost from the initial weight are almost identical for the two years. This pattern of weight change is what Baldwin and Kendeigh (1938) have shown to be true for many species. The weaknesses of mean body weight determination have been pointed out before and it will become evident that these same weaknesses are applicable here.

In view of the marked variations in body weight and fat deposition on arrival the changes in body weight were analyzed for each of the fat classes. The data for 1946 were more complete and suitable for this purpose, and they are summarized in Figure 1. Using the initial mean body weight as 100%, the percentage change is shown for each date of weighing for each fat class. The marked difference in response between the birds that were initially in the "heavy" and "none" fat classes is evident. By May 16 the birds in the "heavy" fat class had lost about 8% of their weight while the bird in the "none" class had gained about 15%. Unfortunately, only one bird was in the "none" class and four in the "heavy" class so that the quantitative aspects of these responses are open to question. They are also open to question because sex and age differences are not taken into account in this analysis. Nevertheless the pattern of response is consistent. Birds with "little" fat also gained weight. The birds in the "medium" class remained about the same. It is interesting to note that after the bird in the "none" class reached a maximum weight it began to lose weight just as the "heavy" birds did previously. It is also noteworthy, despite the weakness of the quantitative aspects of this analysis, that the "heavy" birds lost about 25% of their initial weight and the "none" bird lost about 22% of its *maximum* weight.

In view of the fact that "mean" figures tend to obscure the extent of response in individuals, especially in a group where the variations in time of response can occur, Table 2 was prepared. It shows the change in body weight and fat deposition for each individual of each fat class. The marked changes in certain individuals on a given date and the absence of any change in others is clearly evident. The variations in each group are also evident and emphasize the need for more data to determine the quantitative aspects with accuracy. In 1947, the dates of capture were too late and too irregular to permit comparison with the data for 1946.

To satisfy the secondary objective of the study—to compare wild and captive birds with respect to body weight and fat deposition—the mean body weights were calculated for each of the fat classes and are presented for both years in Table 3. The means and percentage change from the "none" class for each year are similar. The data for the captive birds are compared with the wild birds in Table 4. Birds in the wild are slightly heavier than those in captivity in all fat classes, but the differences are too small to be significant.

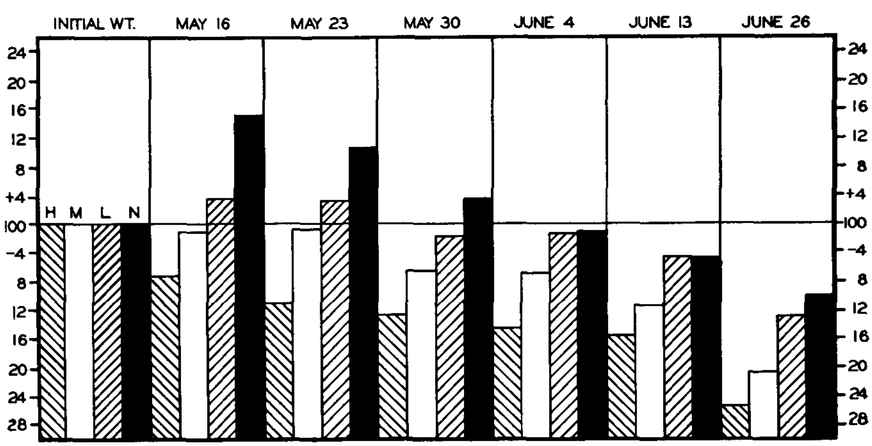

FIG. 1. Percentage change in mean body weight from initial weight for each of the fat classes in 1946. Abbreviations H, M, L, N, refer to fat classes. See text for further explanation.

TABLE 2
BODY WEIGHT AND FAT CLASS OF CAPTIVE BIRDS, SEGREGATED ACCORDING TO FAT DETERMINATION ON DATE OF CAPTURE, 1946*

No.	Age	Cage No.	Date of Capture	May 16	May 23	May 30	June 4	June 13	June 26
			HEAVY						
83	Ad.	2	(14) 31.0–H	29.1–M	25.0–M	24.7–L	23.7–L	24.7–M	22.2–N
91	Ad.	9	(14) 31.6–H	28.4–M	27.0–M	26.6–L	27.0–L	26.3–L	24.3–N
64	Int.	10	(9) 32.2–H	30.5–H	31.0–H	29.1–H	28.5–H	27.5–M	24.0–L
80	Imm.	5	(11) 30.0–H	27.5–M	27.4–M	28.6–M	27.7–M	26.7–M	22.4–N
			MEDIUM						
73	Ad.	9	(11) 31.1–M	29.5–M	31.5–H	29.8–H	31.4–H	29.5–H	27.6–M
77	Ad.	9	(11) 26.2–M	24.7–M	24.3–M	22.9–L	23.7–L	22.4–N	21.2–N
78	Ad.	9	(11) 29.6–M	29.7–M	29.7–M	26.0–L	27.9–L	27.0–L	22.6–N
85	Ad.	6	(14) 28.2–M	27.0–L	26.5–L	25.2–N	25.4–N	26.6–L	22.5–N
88	Ad.	2	(14) 28.1–M	27.6–M	26.3–M	26.0–M	24.2–M	23.2–M	20.1–N
69	Int.	8	(9) 29.7–M	30.5–M	32.0–H	27.1–M	28.1–M	27.7–M	23.3–N
70	Int.	8	(9) 23.3–M	23.0–M	22.8–M	21.4–L	21.5–N	20.0–N	18.9–N
71	Int.	10	(9) 28.5–M	30.0–H	29.2–H	25.7–M	25.8–M	25.4–M	23.8–N
90	Int.	5	(11) 27.3–M	26.2–M	27.5–M	28.8–M	27.4–M	25.0–M	22.7–N
75	Imm.	6	(11) 26.1–M	27.0–M	28.0–H	27.8–H	25.6–M	22.3–L	20.8–N
79	Imm.	6	(11) 26.1–M	24.9–M	24.1–M	23.8–M	22.2–L	20.0–N	18.0–N
			LITTLE						
65	Ad.	10	(9) 23.5–L	24.5–M	26.0–M	25.3–M	25.1–M	24.6–M	23.2–L
74	Ad.	9	(11) 26.9–L	25.5–L	24.7–M	23.8–L	25.4–M	23.2–L	21.6–N
67	Int.	8	(9) 26.6–L	28.1–M	28.1–M	26.9–M	26.0–M	27.3–M	23.3–N
72	Imm.	8	(9) 24.6–L	27.0–M	26.0–M	23.8–L	23.7–L	21.9–L	20.1–N
			NONE						
62	Int.	10	(9) 25.8–N	29.7–M	28.5–M	26.7–L	25.5–L	24.6–L	23.2–N

(Weights on Various Dates)

*The number in the first column represents the last two digits of the band number, the complete number for the series of bands being *40–134100*. The number in parenthesis preceding the weight in the date of capture column is the exact day of capture in May. The letter following each weight indicates the fat class.

To put it another way, the mean weight of captive birds can be expected to be 95 to 97 per cent of the mean weight of wild birds for the same fat class.

DISCUSSION AND CONCLUSIONS

There is good agreement between captive birds and wild birds with respect to maximum and minimum weights. White-throats arriving in Evanston without fat have a mean weight of 22.9 grams. The lowest mean weight reached in captivity was 21.8. The maximum mean weight (on day of capture) for wild birds was 30.3 grams; for birds in captivity it was 29.5 grams. This agreement in wild and captive birds gives us a fairly good idea of the maximum range of variation which we can expect in the White-throated Sparrow. The data from the captive birds seem to strengthen the interpretation made earlier

(Wolfson: 1954) that a White-throat has a maximum of about 8 grams of "metabolizable tissue" which could be used to provide energy for sustained flights. If all of this were fat, an energy source of about 72 Calories would be available. Considering that the daily needs of a White-throat are about 18 Calories a day at 22°C and for a 15-hour photoperiod (Siebert, 1949), one gains some idea of the relative amount of energy available for a single flight at night.

The agreement in captive and wild birds of the mean weights of the fat classes substantiates our classification of birds according to their fat deposits, and confirms the existence of these "classes" in the White-throated Sparrow. It also suggests that the data obtained from captive birds are representative of what occurs in nature. The use of captive birds in ornithological studies is not only permissible, but could well be encouraged in view of the difficulty in making certain studies in the field. I do not suggest that laboratory studies replace field studies, but that they substitute for them when necessary, and

TABLE 3*

MEAN BODY WEIGHTS OF FAT CLASSES IN CAPTIVE BIRDS, 1946–1947

			Fat Class			
			Heavy	Medium	Little	None
Mean body weight	1947	M	29.23 (24)	25.81 (18)	24.85 (10)	21.26 (20)
		E	25.2 - 32.7	22.2 - 30.0	20.2 - 29.0	18.8 - 26.3
	1946	M	29.82 (25)	26.61 (85)	24.77 (53)	22.11 (42)
		E	26.4 - 32.7	22.8 - 30.5	21.4 - 27.9	18.0 - 26.9
	Both yrs.	M	29.5 (49)	26.5 (103)	24.8 (63)	21.8 (62)
Percentage increase from None class	1947		37.5	21.4	16.9	——
	1946		34.9	20.4	12.0	——
	Both yrs.		35.3	21.5	13.8	——
Percentage increase from lower preceding fat class	1947		13.3	3.9	16.9	——
	1946		12.1	7.4	12.0	——
	Both yrs.		11.3	6.8	13.8	——

TABLE 4*

COMPARISON OF MEAN BODY WEIGHTS OF FAT CLASSES IN WILD AND CAPTIVE BIRDS

		Fat Class			
		Heavy	Medium	Little	None
Mean body weight	Wild	30.3 (38)	27.2 (26)	25.7 (27)	22.9 (15)
	Capt.	29.5 (49)	26.5 (103)	24.8 (63)	21.8 (62)
Percentage increase from None class	Wild	32.5	18.8	12.1	——
	Capt.	35.3	21.5	13.8	——
Percentage increase from lower preceding class	Wild	11.5	6.0	12.1	——
	Capt.	11.3	6.8	13.8	——
Body weight of captive birds in relation to wild birds — in percentage		97.0	97.4	96.5	95.2

*In tables 3 and 4, M=mean, E=extremes, numbers in parentheses following weights indicate numbers of birds.

supplement them whenever possible.

The difference in response of the birds in the various fat classes during the first week in captivity suggests that a difference in migratory behavior might be expected in free-living birds. Birds without fat or with "little" fat may stop-over in an area for 4-5 days to replenish their "fuel" before their next major flight. Those with "heavy" and "medium" deposits of fat may be ready to undertake a major flight and will leave an area perhaps after being trapped once. The length of the average stop-over time (4–5 days) and the time it takes to deposit a "medium" or "heavy" amount of fat (4–6 days) are in close agreement. Judging from the condition on arrival, however, it is evident that a bird may not stay in a restricted area and "repeat" there until it achieves a "heavy" deposition of fat. It may move away after restoring its base weight (about 26.0 grams) or putting on some fat, and, hence, arrive at another trapping station with a "medium" or "heavy" amount of fat and without having "migrated" the night before. It would not be difficult for banders to study stop-over time, as has been done, and *add* observations on body weight and fat deposition.

Many more data are needed to determine the migratory behavior of transients, but the combination of studies of body weight and fat deposition in wild and captive birds shows promise of bringing us closer to an understanding of the mechanics of migration. In the last analysis, the problem of the mechanics of migration is a problem in ecology, behavior, and physiology, and many data from each of these fields will be needed to solve it.

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