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THE SPRING MIGRATION OF THE TREE SPARROW THROUGH SOUTHERN YUKON TERRITORY

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In the springs of the four years, 1965-1968, we estimated that the Tree Sparrow (*Spizella arborea*) was the commonest sparrow migrating through southern Yukon Territory. Only the Lapland Longspur (*Calcarius lapponicus*) was more numerous than the Tree Sparrow and because of the longspurs' larger size, flocking habit, and striking plumage of the males, were they more conspicuous along the roadsides. We reported earlier on the pattern of migration of the longspurs as they enter Alaska from the prairies of southwestern Canada, through the Rocky Mountains, and along the Pacific coast (Irving, 1961; West, Peyton, and Irving, 1968). In the course of our field work on that species, we became interested in documenting the pattern of migration of other abundant species through the same area. In 1967 and 1968, Barbara DeWolfe accompanied us in the field and we followed the spring migration of Gambel's Sparrows (*Zonotrichia leucophrys gambelii*) in the vicinity of Watson Lake, Y. T. (DeWolfe, West, and Peyton, 1973). From our work we hypothesized that flocks of longspurs and Gambel's Sparrows were temporary associations of individuals each pursuing its own schedule of migration. The same pattern of temporary associations in flocks of other migrants through interior Alaska (Common and Hoary redpolls, *Acanthis flammea* and *A. hornemanni;* West, Peyton, and Savage, 1968) and in arctic Alaska (Willow Ptarmigan, *Lagopus lagopus;* Irving, West, Peyton, and Paneak, 1967) has also been demonstrated.

This paper extends our hypothesis regarding the individual nature of migration to the Tree Sparrow based on analyses of fat content, fatty acid composition of lipids, and observations of numbers, body weight, and estimates of visible fat.

METHODS

We travelled from Fairbanks, Alaska, southeast along the Alaska Highway into southern Yukon Territory and along side roads into northern British Columbia in spring from 1965 through 1968. In 1965, we departed Fairbanks, mile 1520 of the Alaska Highway (AH) on 19 April and extended our observations to Dawson Creek,

B. C. (mile 0 AH) before returning to Fairbanks on 5 May. In 1966, we left on 1 May and concentrated our attention in the vicinity of Watson Lake, Y. T. (miles 632-635 AH) from 5 to 9 May and returned to Fairbanks on 12 May. In 1967, we departed on 29 April, remained near Watson Lake from 2 to 10 May and returned on 14 May. In 1968, we left on 25 April, worked in the Watson Lake area from 28 April to 10 May and returned to Fairbanks on 14 May.

We kept records of all Tree Sparrows observed as to location, date, and in most cases, to numbers of individuals. Observations in all years were made both from the Dodge Motor Home (Mobile Laboratory) driving slowly along the road and from stops at intervals to collect, net, and band, or observe flocks of birds. In 1968, we concentrated our attention on a specific stretch of road west of Watson Lake (miles 633 to 679 AH) and made daily censuses along this route. Where flocks of either longspurs or sparrows were large, we caught birds by mist nets in order to obtain body weights and estimates of visible fat and to band the individuals. By recapture of banded individuals we were able to determine minimum length of stay in the vicinity of Watson Lake and we hoped to determine the breeding location of birds we banded by subsequent recapture either by ourselves or others. However, as of July 1972, no recaptured individuals have been reported.

Body weight was recorded to the nearest 0.1 g on a triple beam balance. The method of estimation of visible fat from blowing aside feathers in the furcular and abdominal regions was modified slightly from the system of West (1960) for Tree Sparrows and used for Gambel's Sparrows (DeWolfe, West, and Peyton, 1973) and for Lapland Longspurs (West, Peyton, and DeWolfe, MS):

1	Little Fat	From no visible fat to traces lining the furcular region
2	Little to Moderate Fat	Fat visible in the furcular region but none in the abdomen
3	Moderate Fat	Fat filling furcular depression, some fat visible between the loops of the intestine
4	Moderate to Heavy Fat	Furcular depression bulging with fat, fat filling in between the loops of the intestine.
5	Heavy Fat	Both furcular and abdominal regions bulging with fat, intestines usually not visible.

In addition to those birds handled for banding, we collected with shotgun 40 Tree Sparrows in 1967 and 41 in 1968 in the vicinity of Watson Lake, in order to obtain an estimate of the sex ratio of the population and in 1968, to preserve the birds for extraction of lipids and determination of fatty acid composition. The collected birds were weighed immediately and then frozen in plastic bags. Subsequently at the laboratory they were thawed, the gizzard contents (but not the gizzard itself) were removed for later dietary study. The whole bird was freeze-dried in order to determine water content, expressed here as the Water Index (WI = g water/ g dry weight). The whole dried bird was then crushed and placed in a soxhlet extractor and the lipids extracted with petroleum ether (30 - 60°C B.P.) for six to eight hours. The amount of fat is expressed as the Fat Index (FI = g fat in ether extract/ g fat-free dry weight).

The extracted lipids of nine individuals were saponified with ethanolic KOH and the fatty acids removed with petroleum ether after conversion with HCl. The fatty acids were methylated with borontrifluoride methanol. The fatty acid methyl esters were chromatographed on a one-eighth inch diameter column of 20% diethyleneglycolsuccinate (DEGS) on 60 - 80 mesh Chromosorb W using an F & M 810 hydrogen flame detector chromatograph operated isothermally at temperatures ranging from 178 to 185°C on different runs. Identifications of the fatty acids were made from known standards and by plotting the logarithm of the retention time of each peak relative to that of stearic acid (C_{18}) (Ackman, 1963). Relative amounts of acids were calculated by triangulation of the peaks. The double-bond index (DBI) was also calculated for each sample (the summation of the per cent of each acid in the sample multiplied by the number of double-bonds it contains divided by 100; Richardson, Tappel, and Gruger, 1961).

Student's *t-test* was used to determine significance of difference between sample means and a probability level of 0.05 or less was required for null hypothesis rejection. Linear correlations (regressions) are expressed in the standard format: $y = a + b\ (\pm$ standard deviation$)\ x$. Significant t values indicate rejection of the hypothesis that the regression coefficient (b) is equal to 0.

RESULTS AND DISCUSSION

Number of migrants

Initially Tree Sparrows occurred in the spring in small groups from two to 10 individuals and later in flocks of several hundred. As the flocks grew in size from day to day, they became multispecific as other species, mostly Slate-colored Juncos (*Junco hyemalis*), but also Gambel's, Fox (*Passerella iliaca*), Lincoln's (*Melospiza lincolnii*), and Savannah sparrows (*Passerculus sandwichensis*) and often a few Water Pipits (*Anthus spinoletta*) joined the flocks of Tree Sparrows. In 1965, we observed the first flock of Tree Sparrows early on 29 April at mile 495 AH. Apparently the birds had just arrived that morning as they were not noted there the previous evening. Tree Sparrows were seen daily and some flocks contained over 100 individuals at miles 660 and 671 AH on 1 May but on 5 May, only scattered individuals were seen as we had moved northwest to mile 1205 to 1350 AH. In 1966, we encountered the first Tree Sparrows at mile 733 AH on 4 May and saw them in large numbers daily until we returned to Fairbanks on 12 May. In 1967, Tree Sparrows had advanced farther northward much earlier because we saw a flock at mile 806 AH on 1 May and watched large flocks moving through the Watson Lake area from 2 to 10 May. The greatest populations were on 5 and 6 May but we did not count their numbers. In 1968, we saw the first Tree Sparrows at Watson Lake on 28 April. DeWolfe had not observed any there from 25 to 27 April. They increased in numbers until 5 May when we estimated 1810 individuals in the 46 miles of road west of Watson Lake (Fig. 1). The population fell rapidly thereafter. Many young were seen near Watson Lake on 10 August 1967 indicating that they breed in the area.

In contrast to the numbers of Tree Sparrows observed in 1968, the first Gambel's Sparrows did not arrive until 1 May and reached a peak of only 572 individuals along the same census route on 9 May (DeWolfe, West, and Peyton, 1973). Lapland Longspurs censused at the same time and location arrived before 25 April as DeWolfe saw 20 in Watson Lake on that date. The longspurs reached a peak of 1860 individuals on 1 May and a second peak of 1785 on 3 May (West, Peyton, and DeWolfe, MS). Their decline was much slower than that of the Tree Sparrow as there were still 1100-1200 birds on the census route from 5 to 7 May.

From the above, it appears that there was no overriding climatic or other factor governing the movement of the total populations of these three species through the same area at the same time since the peak numbers and the total range of migration time of the three populations were independent of each other. However, as discussed later, daily weather conditions probably have an effect on the movements of the individuals in the same area.

Length of stay at Watson Lake

In 1965, we banded only 21 and in 1966 only 53 Tree Sparrows in southern Yukon Territory, but we did not net consistently in the same location on successive days and therefore did not expect to obtain immediate recaptures. However in 1967, we netted consistently at the same location over several days and caught and banded 445 Tree Sparrows between 2 and 7 May and recaptured 12 within one and two days after initial capture. No individuals were caught more than two days after initial capture. In 1968, we banded 242 Tree Sparrows between 2 and 9 May and recovered 10 individuals within one to three days after initial capture.

Gambel's Sparrows in the same area also averaged about two days' length of stay (DeWolfe, West, and Peyton, 1973), and Lapland Longspurs were also judged to remain about two days in the same area in 1968 (West, Peyton, and DeWolfe, MS). However, in 1967, longspurs in the same location were estimated to stay four to five days (West, Peyton, and Irving, 1968). The difference in estimated length of stay of the same species (longspur) between 1967 and 1968 indicates that an outside factor influences the length of stay rather than an internal (endogenous) physiological factor (such as time required to deposit a certain fat load). As discussed later, we believe that these annual differences are due to local weather conditions that vary from year to year.

Sex ratio of the migrating population

In our opinion, it is not possible to determine accurately the sex of individual migrant Tree Sparrows after the prenuptial molt by the use of wing measurements because there is considerable overlap in length of wing between the sexes. Any correlations with body weight or fat would be biased by errors in sexing. Therefore, we determined sex only on collected individuals.

In 1967, 40 birds were collected between mile 628 and 775 AH from 1 to 5 May, and in 1968 41 birds were collected between mile 652 and 679 AH from 2 through 10 May. In both years, males predominated over females in our samples by a ratio of 12.3 : 1. Although we did not collect later than 10 May, we did not notice any increase in proportion of females over the 10-day collection period. By 10 May, the bulk of the migration that we observed was over (Fig. 1), and we can only assume that the females either moved north over another route, migrated later than 10 May, or moved faster than the males and did not stop in the Watson Lake area. Lapland Longspurs during the same periods showed a steady change in sex ratio from male to female as the migration progressed (West, Peyton, and Irving, 1968; West, Peyton, and DeWolfe, MS). Gambel's Sparrows also showed a similar pattern with males preceding females along the same route (DeWolfe, West, and Peyton, 1973). But with both of these species of sparrows, more field work is needed in order to determine the location and timing of migration of the female populations.

Changes in body weight and fat

In 1967 and 1968, we obtained 757 weights of Tree Sparrows from birds that we either collected or netted, banded, and released. Body weights are chiefly influenced by size of bird (usually correlated with sex), by the amount of material in the digestive tract, and by the amount of stored fat. Since our collections indicated no changes in sex ratio throughout the period of observation (see above), weights of all birds are treated together.

The amount of material in the digestive tract, and to some extent the amount of stored fat, depends on time of day, and thus we might expect a difference between morning and afternoon weights. In 1967, 10 Tree Sparrows were collected between 09:00 and 10:30, and 27 others were collected between 13:00 and 16:30. The average body weight of the morning birds was 17.8 $\pm$ 0.92 g and that of the afternoon birds was 18.8 $\pm$ 0.97 g; the difference is statistically significant ($t = 2.89$, $P < 0.01$). The difference of one g is however less than that found by Helms and Drury (1960) in a winter population of Tree Sparrows in Massachusetts. Their sample contained birds from both earlier and later in the day which would tend to increase the difference between morning and evening weights.

By far the greatest determinant of variations in body weight is stored fat. Therefore, these two parameters are treated together. In 1965, we noted the fat class of only 24 individuals at the beginning of migration in southern Yukon Territory, but we did not take any

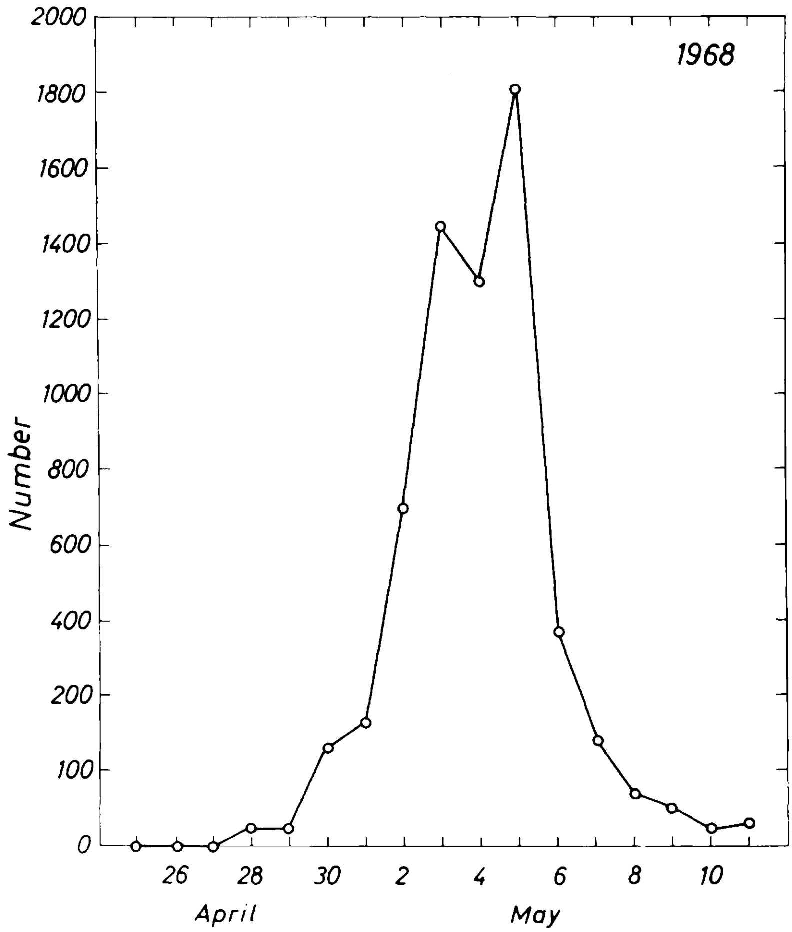

FIGURE 1. Numbers of Tree Sparrows observed between miles 633 and 679 of the Alaska Highway daily from 25 April to 11 May 1968.

body weights. However, from the correlation between visible fat class and body weights made from data obtained in 1967 and 1968 (see below), we assumed that high fat class values indicated high weights. We estimated that the five Tree Sparrows netted on 29 and 30 April 1965 all were in fat class 5 or "heavy fat". On 1 May, we netted 19 birds and the fat class value was significantly lower, 2.8 $\pm$ 1.49 (t = 3.099, $P < 0.01$), indicating an influx of birds with less fat stores.

In 1966, we examined 53 Tree Sparrows from 5 to 8 May, or later in the migration than in 1965. On 5 May, the 11 birds averaged fat class 3.1 $\pm$ 1.81 and 22 examined on 6 May were significantly lower, 2.1 $\pm$ 1.01 (t = 2.048, $P < 0.05$). On 7 May, 19 birds averaged fat class 2.5 and only one bird caught on 8 May was in class 1. Therefore, as in 1965, we examined heavier (fatter) birds at the beginning of the migration.

In 1967, we weighed 469 Tree Sparrows and estimated the fat of 428 of those (Fig. 2). The first arrivals were encountered some distance northwest of Watson Lake, and the expected heavier birds might have already moved on or else had used their heavy deposits before we found them on 1 May. There was a significant decrease in body weight from 2 to 3 May and then the weights rose again to a maximum on 5 May (Fig. 2). There was a slight decline on 6 May which was accompanied by a significant lowering of the estimated fat class value (Fig. 2). We did not capture any Tree Sparrows after 7 May in 1967.

In 1968, we weighed 288 Tree Sparrows and estimated the fat class of 231 of these from 28 April when we saw the first arrivals in Watson Lake until 10 May when the migration had passed. As in 1965 and 1966, early arrivals were heavy, averaging almost 21 g (Fig. 2). Body weights fell significantly until 2 May, rose slightly to 4 May and fell to a low on 5 May. From 6 to 8 May, there was a continual increase in both weight and fat, and by 8 May most of the birds had left the area. On 9 and 10 May, the small samples included only individuals with little fat and low body weights (Fig. 2).

Dolnik and Blyumental (1967) also noted that Chaffinches (*Fringilla coelebs*) in the initial wave of fall migration in the Baltic Sea area had heavy fat deposits.

Significant differences occur between the average body weight of birds in the five fat classes (Table 1), and there is a significant linear correlation between the two parameters (fat class = $-26.55 + 1.56 \pm 0.08 \times$ body weight; r = 0.99, t = 19.32, $P < 0.001$). From this relationship, calculated here from the means only, the missing fat class estimates have been plotted in Figure 2. The range of average weights in the five fat classes of Tree Sparrows spans 2.6 g. However, Helms and Drury (1960) found a range of 3 g in only four fat classes, and with a few individuals that they assigned to fat class 5 that averaged over 24.5 g, the range is increased to almost 6.5 g. Two possibilities may account for the difference between the two sets of data. One is the fact that Helms and Drury (1960) were working with the eastern race of the Tree Sparrow, *Spizella arborea arborea*, whereas we were working with the western race, *S. a. ochracea.* The second is that birds in winter and early spring in preparation for migration may deposit greater amounts of fat than those during the course of migration. Gambel's Sparrows also showed small changes in body weight with different fat classes, but this could be a species-specific characteristic (DeWolfe, West, and Peyton, 1973; King, Farner, and Morton, 1965).

There are similarities in the day-to-day changes in body weight and fat of the Tree Sparrows reported here (Figure 2) and those of

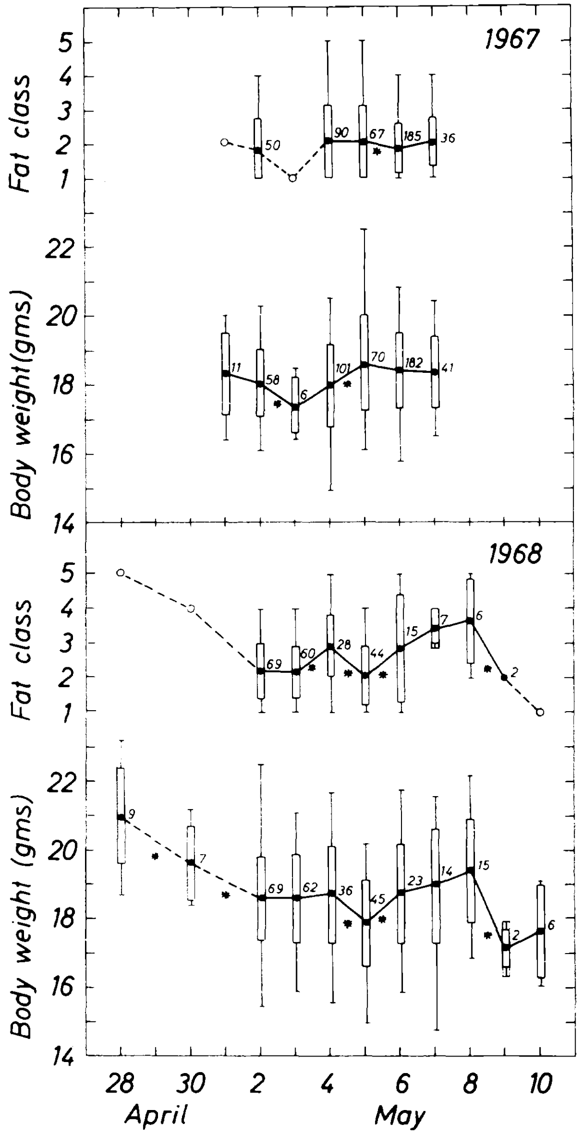

FIGURE 2. Variations in fat class estimated visually and body weights of Tree Sparrows netted or collected along the Alaska Highway between miles 633 and 679 in 1967 and 1968. The mean, one standard deviation, and the extremes are shown for each sample. Open circles represent fat class estimates derived from the linear regression of fat class on body weight (see text). Numbers beside means indicate sample size. The asterisks indicate that the difference between adjacent means are statistically significant at the 0.05 level or less.

TABLE 1. Average body weights of Tree Sparrows assigned to five visually estimated fat classes.

Fat class	n	Mean body weight (g) ± 1 SD	P
1 Little	196	17.55 ± 0.99	
			<0.001
2 Little to Moderate	239	18.33 ± 1.04	
			<0.001
3 Moderate	167	19.02 ± 1.08	
			<0.02
4 Moderate to Heavy	31	19.46 ± 1.06	
			<0.05
5 Heavy	9	20.16 ± 0.79	

of the Gambel's Sparrow in 1968 (DeWolfe, West, and Peyton, 1973). Both species showed peaks of body weight and fat on 4 May, a significant decline to 5 May, an increase to 7 May (Gambel's) or 8 May (Tree), and an abrupt decline to 9 May. The number of Tree Sparrows diminished on 9 and 10 May, but the Gambel's Sparrows went on to another weight peak on 11 May. In both species, low weights were correlated with low visual fat estimates and high weights with high fat class estimates (see above and DeWolfe, West, and Peyton, 1973). As with similarities in length of stay noted earlier to which these cycles of high and low weights appear to be related, we see that the day-to-day scheduling of migration of these two species is related and probably influenced by a common factor which we assumed to be daily changes in local weather.

The birds collected in 1968 were analyzed for water and fat content. There were no statistically significant differences in dry weight, fat-free dry weight, water index, or lipid index on successive collection days from 4 to 10 May 1968 (Table 2). The coefficient of variability (V) of fat-free dry weight of samples collected on any one day ranged from 5.1 to 12.6 per cent. This variability could be the result of measurement of birds of different body sizes or real differences in non-fat body components. As Evans (1969) found with Common Redpolls (*Carduelis* = *Acanthis flammea*), there was no significant correlation between wing length and fat-free dry weight, and this also holds true for the Tree Sparrow measured here (wing length = 7.78 $-0.026 \pm 0.039 \times$ fat-free dry weight, n = 41, $r = -0.104$, $t = 0.651$, $P > 0.5$). Thus, variations in fat-free dry weight must be a result of changes in non-fat body components due to the migrational state of the individual (cf. Berthold, 1971; King, Farner, and Morton, 1965). Evans (1969) suggested the possible use of protein in migratory flight, but we have no data to test his suggestion. It is only a fact that in our samples, individuals collected from the same flocks at the same time vary greatly in fat-free mass and body fat.

TABLE 2. Fresh body weight, dry weight, fat-free dry weight, water index, and fat index of Tree Sparrows collected in the vicinity of Watson Lake, Y. T. in 1968.

Date	Sex	n	Mean fresh body wt. (g) ± 1SD	Mean dry[1] wt. (g) ± 1SD	Fat-free[2] dry wt. (g) ± 1SD	Water[3] index WI ± 1SD	Fat[4] index FI ± 1SD
2 May	♂	1	19.4	8.1	6.0	1.40	0.35
4 May	♂	8	19.67 ± 1.50	8.80 ± 0.97	5.56 ± 0.38	1.25 ± 0.12	0.60 ± 0.26
6 May	♂	8	19.24 ± 0.85	8.36 ± 0.75	5.53 ± 0.28	1.31 ± 0.15	0.52 ± 0.14
	♀	1	17.0	7.0	4.9	1.43	0.43
7 May	♂	8	19.83 ± 1.14	8.00 ± 0.86	5.91 ± 0.60	1.50 ± 0.23	0.36 ± 0.17
8 May	♂	8	20.11 ± 1.53	8.94 ± 0.74	6.28 ± 0.79	1.25 ± 0.06	0.44 ± 0.18
	♀	1	18.5	7.7	5.4	1.40	0.43
10 May	♂	5	18.00 ± 1.21	7.64 ± 0.89	5.96 ± 0.70	1.37 ± 0.13	0.29 ± 0.11
	♀	1	16.1	6.6	5.7	1.44	0.16
Total	♂	38	19.48 ± 1.37	8.41 ± 0.92	5.84 ± 0.61	1.33 ± 0.17	0.45 ± 0.20
	♀	3	17.20	7.10	5.33	1.42	0.34

[1]dry weight of whole bird less gizzard contents
[2]dry weight less ether extractable compounds
[3]g water/ g dry weight
[4]g fat in ether extract/ g fat-free dry weight

The coefficient of variability in fat index values of Tree Sparrows collected on any one day ranged from 26.9 to 47.2 per cent. This indicates to us that the Tree Sparrows we sampled ranged from those that had just entered the collection area to those that had fattened in preparation for departure. If we had been sampling on one day only from groups that had just arrived from a long migratory flight, we would expect the lipid index to be lower than that of groups sampled after several days feeding in the Watson Lake area. We also would expect that the lipid index from such homogeneous groups would show less variability than we have found. Although we estimated from records of individual birds that they remained about two days to feed, we believe that there was a continuous turnover in the population. Individual fat index values ranged from 0.13 to 0.88 on the same day (4 May 1968) and were equally scattered on all other days of collection except on 10 May, the last day of collection and at the end of the observed migration. On this date, when the lowest average fat index value (Table 2) occurred, the highest fat index was 0.44, whereas on all previous dates the highest values ranged from 0.67 to 0.88. This is further indication that the males sampled on 10 May were either residents or were among the last birds to arrive in the area, whereas heavier individuals had left previously.

The extracted fat of the 38 male Tree Sparrows varied from 4.7 to 21.9 per cent of the total body weight and averaged 13.5 per cent. This value places the Tree Sparrow in the group of short and middle distance migrants (Odum, Connell, and Stoddard, 1961) that deposit low amounts of fat (13-17% of total body weight) in contrast to many long distance migrants (35-45%) (Berthold, 1971).

Fatty acid composition of migrants

The fatty acid composition of the extracted lipids from nine birds collected in May 1968 was analyzed in order to assess any differences among individuals or any trends with time. Fatty acid composition of depot lipids, which make up the bulk of the total lipids in migrant birds, are influenced at least in part by diet (Moss and Lough, 1968; West and Meng, 1968b), but also by the physiological state of the individual (West and Meng, 1968a). Although all of these relationships are not yet clear, we can assume that all birds were in a similar migratory physiological state, and any differences in fatty acid composition of the birds are reflections of differences in fatty acid composition of the dietary lipids used to fatten the birds. Therefore, differences among individuals would indicate that birds had either fed on different food sources in the same location, which we consider unlikely (West, 1967, 1973; Willson, 1971), or else they had fed on different species of seeds (with different fatty acid compositions) since they had been feeding in different locations.

Thirty different fatty acids were identified from the total lipids of nine migrating Tree Sparrows. The predominant acids were palmitic (C_{16}), oleic ($C_{18:1}$), and lineoleic ($C_{18:2}$) acids which together accounted for from 76 to 86 per cent of the total acids (Table 3).

TABLE 3. Percentages of the principal fatty acids and double-bond index (DBI) of the total ether extractable lipids of Tree Sparrows collected in the vicinity of Watson Lake, Y. T. in 1968

Fatty Acid	Date and Specimen Number								
	2 May 3	4 May 23	6 May 7	6 May 18	7 May 39	7 May 40	8 May 15	8 May 17	10 May 29
C_{16} (Palmitic)	24.09	24.01	18.52	23.07	11.08	19.63	18.73	9.91	24.71
$C_{16:1}$ (Palmitoleic)	5.69	3.53	5.01	3.39	2.11	3.31	3.10	2.39	3.68
C_{18} (Stearic)	6.37	11.78	5.43	6.71	3.86	5.26	5.09	3.51	7.21
$C_{18:1}$ (Oleic)	33.96	27.60	24.26	35.01	19.76	31.03	30.58	17.15	35.92
$C_{18:2}$ (Linoleic)	17.61	25.17	37.16	26.63	55.36	34.15	34.51	54.85	22.28
$C_{18:3}$ (Linolenic)	0.35	1.00	2.93	0.22	2.98	0.77	2.76	8.90	0.20
Total[1]	88.07	93.09	93.31	95.03	95.15	94.15	94.77	96.71	94.00
DBI	0.878	0.903	1.177	0.959	1.494	1.134	1.208	1.598	0.854

[1]Balance of 100 per cent made up of 24 minor acids; details available from the authors.

Other acids that usually occurred in one per cent or more of the total were myristic (C_{14}), palmitoleic ($C_{16:1}$), and stearic (C_{18}) acids. The remaining 24 acids which ranged in chain length from 10 to 23 carbons and up to 5 double-bonds made up less than five per cent of the total.

There was great variation in fatty acid composition between two individuals collected on the same date (6, 7, and 8 May) and among all individuals (Table 3). Due to these variations which amounted to differences of 2 to 3 times the amount of a single acid from one bird to another, we did not average the composition of birds collected on the same day. From unpublished observations in our laboratory, we know that the principal fatty acid composition of caged animals fed the same diet have weighted average coefficients of variability of less than 20 per cent. The weighted average coefficient of variability of the principal fatty acids reported here is 35 per cent. Therefore, we believe that the individual Tree Sparrows that we examined were feeding on different diets prior to their collection.

If the individuals are ranked according to the percentage of each fatty acid and the double-bond index taken from Table 3, the following pattern emerges. Specimen numbers 39 and 17 have the lowest amounts of palmitic, palmitoleic, stearic, and oleic acids, and the highest amounts of linoleic and linolenic acids and thus the highest double-bond index. Conversely, specimens 29 and 3 have the highest palmitic, the first and third ranked palmitoleic and oleic, the lowest linoleic, the seventh and last linolenic acid, and the lowest DBI. Specimens 40, 15, and 7 can also be grouped together as can 23 and 18 by proximity in rank.

Those individuals that can be grouped by similarity of their fatty acid compositions probably fattened on the same diet prior to their flight to Watson Lake and flew to Watson Lake over the same route. Since there are great differences between individuals collected on any one day, we assume that these individuals travelled from separate localities and/or over different routes. Furthermore, the similarity in fatty acid composition of individuals collected up to 7 days apart indicates that the same route is utilized for several days where individuals feed and fatten on the same diet prior to their flight that brings them to Watson Lake. A similar finding has been obtained with Lapland Longspurs which showed marked differences in fatty acid composition between populations that had entered southern Yukon Territory over different routes (West, Peyton, and DeWolfe, MS).

Day-to-day changes in movement of Tree Sparrows

By referring to Figures 1 and 2, and recalling the similarities in body weight and fat changes with Gambel's Sparrows, we can make certain assumptions about the movement of Tree Sparrows through the Watson Lake area in 1968. Initial migrants in the first wave of the migration are few in number but heaviest in body weight because of large amounts of stored fat. Perhaps these individuals travel farthest north or northwest to their breeding grounds. It is doubtful that we examined only those birds at Watson Lake in late April that had made a short flight from their last feeding point since we encountered the same pattern in three years.

On 27 April 1968, a front moved north with high winds and by morning of 28 April, it was clear. The initial wave of Tree Sparrows and a twenty-fold increase in Slate-colored Juncos moved in at the same time. It rained on the night of 28-29 April, and no influx was detected. It was partly cloudy on the evening of 29 April and clear on the morning of 30 April, and some migration occurred since the Tree Sparrow population increased five times and large numbers of longspurs arrived. It was cloudy until midnight of 30 April, but cleared in the early morning of 1 May. The night of 1 May was clear after afternoon showers, but it clouded up by early morning of 2 May. The early evening clear skies following the rain showers allowed large numbers of Tree Sparrows to move in. On 2 May, the birds we handled had low body weights and fat, and these features remained low as new migrants arrived on the night of 2-3 May. It was partly cloudy with occasional snow flurries and windy on 3 May; on 4 May few new birds arrived, and those birds present from 2 and 3 May had fattened slightly. Weather was clear on the night of 4-5 May, and migration occurred with a large wave of light-weight birds arriving and, probably at the same time, numbers of fattened birds departing. Therefore both weight and fat class values dropped on 5 May. The weather was also clear during the night of 5-6 May, and by the time of census in the morning of 6 May we noticed that many of the birds had left the area and few new ones had arrived. This decline in numbers continued on 7 and 8 May when the remaining migrants had fattened prior to their departure on the night of 8-9 May. On 9 and 10 May, only those birds that might have been local breeders remained in the area.

The weather patterns mentioned here obviously affected the migration of Gambel's Sparrows at the same time so it is not surprising that large influxes of migrants with their concommitant low weights and fat values occurred simultaneously with that of the Tree Sparrows (DeWolfe, West, and Peyton, 1973).

Dolnik and Blyumental (1967) do not believe that day-to-day variations in numbers of migrant Chaffinches in the Baltic region are due to changes in local weather but rather to depot fat cycles of the migrants. Although one can argue this for a single species, we have seen in one spring, that Lapland Longspurs, Gambel's Sparrows, and Tree Sparrows exhibit the same day-to-day pattern in movement in the same place but the peak numbers and total range of migration time through the same location were greatly different. The only factor we can see responsible for the similarity in day-to-day changes in numbers of arriving and departing individuals of the three species is local weather.

SUMMARY AND CONCLUSIONS

From the evidence of changes in numbers, body weights, body fat, and fatty acid composition, the flocks of Tree Sparrows that we observed in the vicinity of Watson Lake, Y. T. in four successive springs appear to have been temporary associations of migrating individuals drawn together by social behavior and availability of suitable food and cover along the migration route. Individuals pursue their own schedule of migration to their goal and arrive and leave locations en route independently. Those individuals that are in the same physiological state probably depart together, but we believe that the association is only a transient one, some individuals stopping to feed before others, some moving on depending on stored fat reserves and proximity to their destination. Since Tree Sparrows nest in the Watson Lake area, we sampled birds that had completed some part of their total migration as well as those that had already reached their destination.

The large variations in body weight and extracted lipid content on any one day are evidence for the mixing of individuals in varying stages of migration, from those that have just arrived to those that are ready to depart the area.

Except for the indications derived from the fatty acid analysis of lipids, we have no direct evidence that Tree Sparrows use more than one general entry route into southern Yukon Territory contrary to findings with longspurs (West, Irving, and Peyton, 1968) and as is indicated for Gambel's Sparrows (DeWolfe, West, and Peyton, 1973). We never saw Tree Sparrows along the Haines Highway crossing Chilkat Pass to the coast, nor did we notice large flocks farther northwest of Watson Lake until after we had seen them at Watson Lake first. Therefore, it is probable that Tree Sparrows move northwest into Alaska almost exclusively from the prairies of Canada and migrate along the lowland river valleys and road ways rather than along the coast or through the mountains.

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