THE SPRING MIGRATION OF GAMBEL'S SPARROWS THROUGH SOUTHERN YUKON TERRITORY

BARBARA B. DEWOLFE

Department of Biological Sciences
University of California
Santa Barbara, California

GEORGE C. WEST

AND

LEONARD J. PEYTON

Institute of Arctic Biology
University of Alaska
College, Alaska

In their study of the spring migration in the Lapland Longspur (*Calcarius lapponicus alascensis*) through southern Yukon Territory, West et al. (1968a) hypothesized that longspur flocks are temporary associations, changing almost daily in composition. The authors also present evidence that longspurs enter Alaska by several routes: from prairies of southwestern Canada, through the Rocky Mountains, and along the Pacific Coast. To learn whether there is evidence for similar phenomena in other common passerine migrants, the authors began a study in 1965 of the migratory movements of the Tree Sparrow (*Spizella arborea ochracea*) and the Gambel's Sparrow (*Zonotrichia leucophrys gambelii*) through southern Yukon Territory. Data on the Tree Sparrow are presented elsewhere (West and Peyton 1972). In 1967 and 1968, DeWolfe joined West and Peyton at Watson Lake, Y. T., and collaborated on a study of the Gambel's Sparrow.

In this paper we document the movement of Gambel's Sparrows through the Watson Lake area (60° 07′ N, 128° 48′ W) and present data on their physiological state. Our observations for 1968 are supplemented with records from birdbanders at 10 localities in Canada and Alaska. Such records are pertinent to the question of whether Gambel's Sparrows, like longspurs, enter Alaska by several routes.

MATERIALS AND METHODS

Table 1 summarizes the locations and inclusive dates of the field work and the numbers of birds banded or collected. Four hundred and seventy-two birds were netted or trapped and, within a few minutes of capture, removed and kept in the dark until examined, usually within 15 min of removal from net or trap. Each bird was banded, examined for molt and amount of fat visible through the skin, and its winglength was recorded. We used lore color to distinguish *Z. l. gambelii* from *Z. l. leucophrys*. Birds banded in 1967 and 1968 were also weighed to the nearest 0.1 g on a triple beam balance.

Estimates of visible fat were made by blowing aside feathers in the furcular and abdominal regions. West and Peyton used a five-point scale modified from the system of West (1960) for tree sparrows:

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 intestinal folds
4 Moderate to heavy fat	Furcular depression bulging with fat, peritoneal fat filling in between intestinal folds
5 Heavy fat	Both furcular and abdominal areas bulging with fat, intestines not visible

DeWolfe confined her classification of live birds to a three-point scale of "Little fat," "Moderate fat," and "Heavy fat." She used the five-point scale for dissected specimens. The designation in the text of "Thin birds" includes Classes 1 and 2. "Fat birds" includes Classes 3, 4, and 5.

Recaptured birds were reweighed and reassigned to a fat category without reference to previous records.

Specimens were dissected and their gonads fixed in Bouin's solution. Testes were measured and their volume was calculated, and the diameters of the three largest ovarian follicles were recorded. Testes of nine males with representative volumes were prepared for microscopic examination, and assigned to one of the stages of spermatogenesis as defined by Blanchard (1941).

The numbers of Gambel's Sparrows migrating through the Watson Lake area were estimated in two ways. First, in 1966, 1967, and 1968, West and Peyton made daily censuses by car between Mile 633 and 680 on the Alaska Highway. They recorded the location of each roadside flock and the approximate proportions of each of the four commonest passerine species comprising it: Lapland Longspur, Tree Sparrow, Slate-colored Junco (*Junco hyemalis*), and Gambel's Sparrow. Second, from 2 through 10 May 1967, DeWolfe recorded numbers of Gambel's Sparrows at Watson Lake town (Mile 634 AH). From 25 April through 17 May 1968, she made a

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TABLE 1. Log of field work and numbers of Gambel's Sparrows banded and collected from 1965 to 1968.

Year	Reconnaissance trips and locations: Inclusive dates	Reconnaissance trips and locations: Geographic limits[a]	Birds banded: Dates	Birds banded: Location[a]	Birds banded: N	N specimens collected	Total N, banded and collected
1965	29 April–3 May	Between Liard, B.C. and Haines, Alaska	29 April	Liard, B.C.	31		
			30 April	Watson Lake area	9		
			1 May	(AH Mile 632–679)			40
1966	4–9 May	Watson Lake area (AH Mile 632–679)	5 May	AH Mile 668	10		
			6 May	AH Mile 632	4		
			6 May	AH Mile 679	107		
			7 May	AH Mile 679	60		
			8 May	AH Mile 679	8		
			8 May	AH Mile 661	3		192
1967	1–10 May	Watson Lake area (AH Mile 596–680 & side road to Cassiar)	5 May	AH Mile 634	6		
			7 May	AH Mile 679	1		7
1968	25 April–13 May	Watson Lake area (AH Mile 585–680)	2–8 May	AH Mile 661	92	26	
		(AH Mile 585–680)	9–13 May	AH Mile 679	106		
	25 April–17 May	Watson Lake town	2–15 May	AH Mile 634	35	3	262
			Totals, all years:		472	29	501

[a] AH = Alaska Highway.

daily patrol of a section of Alaska Highway which included Mile 634. She designated each landmark frequented by Gambel's Sparrows as a station and plotted its position on a detailed map, noted number of Gambel's Sparrows at each station, and tape-recorded their songs. On most days she traversed the same route in the evening. If numbers differed between morning and evening, the larger of the totals is given. DeWolfe also checked daily for the presence of migrants at the singing posts and forage sites in Watson Lake town where she had seen Gambel's Sparrows in 1967. Once birds arrived at any of these places, she incorporated the site into the patrol. The total area thus traversed in 1968 was 0.85 mile long and 0.25 mile wide at the widest point, and comprised 42 stations, including four trap sites which were kept continuously baited.

DeWolfe used the following criteria to document arrivals or departures of birds at stations on her patrol route: (1) a record of absence followed next day by presence of birds (or vice versa); (2) doubling (or halving) of numbers overnight; (3) first capture (or last capture) of a bird at a site where traps were open before and after the capture in question; and (4) appearance of a song pattern not previously recorded at a given station (criterion for arrival only).

In 1968, 141 Gambel's Sparrows were color-banded in coded form so that a view of only one leg was sufficient to determine within 1 or 2 days when that individual was first caught. On the daily patrols a search was made for color-banded birds.

Songs were recorded with a Uher 4000 L portable tape recorder. An Electrovoice Dynamic microphone, Model no. 655C, was set in a 24-inch parabolic reflector and connected to a preamplifier made by Moright Electronics. The recording equipment was capable of reproducing the complete frequency range of the bird's song. Sonagrams of the recorded songs were made with a Kay Electric Sonagraph. Distinc-

TABLE 2. Sources of data on migratory movements of Gambel's Sparrows during 1968.

Locality (south to north)	Latitude (°N)	Longitude (°W)	Observer
Kamloops, B.C.	50°39′	120°24′	A. Roberts
Green Lake, B.C.	51°26′	121°12′	R. W. Campbell
Kleena Kleene, B.C.	51°58′	124°59′	A. Paul
Williams Lake, B.C.	52°08′	122°09′	A. Roberts
Stettler, Alberta	52°21′	112°40′	L. Lohr
McBride, B.C.	53°21′	120°19′	R. F. Harrington
Juneau, Alaska	58°20′	134°20′	R. Williams
Watson Lake, Y. T.			
a. W. L. Town	60°07′	128°48′	Authors
b. AH Mile 679	60°01′	129°05′	Authors
Whitehorse, Y. T.	60°41′	135°08′	G. Bruce
Ferry, Alaska	64°00′	149°10′	H. Springer
College, Alaska	64°54′	147°55′	B. Kessel R. Weeden

tive song patterns were used as an adjunct to color-banding to identify individual singers.

Prior to the start of the 1968 spring migration, DeWolfe asked birdbanders in Canada and Alaska to note when they first saw or trapped Gambel's Sparrows, the approximate numbers they saw migrating through their stations, and the last date they saw any individuals of this species. The names of persons contributing such information, and the locations of their banding stations, are given in Table 2.

RESULTS

MOVEMENT THROUGH SOUTHERN YUKON, 1968

Arrival. From 26 through 30 April, reconnaissance trips were made on sections of the Alaska Highway between Mile 584 and 680, soon to be occupied by migrants, but no Gambel's Sparrows were seen. On the morning of 1 May, a Gambel's Sparrow was seen 0.6 mile S of Watson Lake town. On 2 May, movement through the area was widespread. West and Peyton counted 40 Gambel's Sparrows between Mile 633 and 680 and banded 7 at Mile 661. DeWolfe saw 14 along her patrol route and banded 7 at Mile 634. Influxes of Gambel's Sparrows continued at least through 15 May, when 11 were recorded at points which had been vacant the day before. No influx was observed on 16 or 17 May, after which the field work was discontinued.

Numbers counted. Figure 1 shows total numbers of Gambel's Sparrows counted. Two marked fluctuations occurred in numbers of Gambel's Sparrows recorded between 1 and 13 May by West and Peyton on the Alaska Highway from Mile 633 to 680 (fig. 1a). The dip in the curve on 4 May is probably an artifact. That day the census was taken in the afternoon whereas on other days it was taken in the morning. In the roadside field at Mile 679, one minor and major fluctuation occurred during the same interval (fig. 1b). The 150 birds counted on 9 May comprise over one-fourth of all Gambel's Sparrows recorded that day between Mile 633 and 680. By 13 May, most of the birds had left Mile 679. We saw only four and failed to trap any unbanded birds.

In contrast to Mile 679, the number of Gambel's Sparrows passing through Watson Lake town was small (fig. 1c). Note that the ordinal scale is one-tenth that in figures 1a and 1b. The greatest number seen at one time was eight, at a trap site kept continuously baited. Each arrow in figure 1c represents an arrival or departure of one or more migrants at specific stations, documented as explained in the Method section. The close spacing of arrows indicates that, unlike the situation at

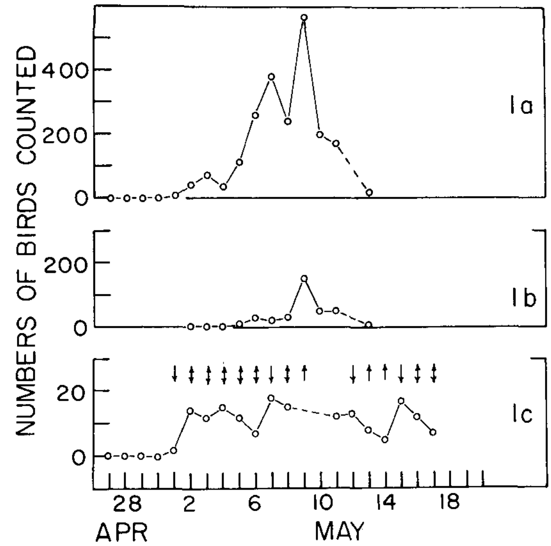

FIGURE 1. Total numbers of Gambel's Sparrows counted in censuses during 1968: (a) on Alaska Highway from Mile 633 to 680; (b) at a roadside field at Mile 679; and (c) in Watson Lake town (Mile 633.65–634.50). ↑ = arrival(s) documented for that date at one or more stations in Watson Lake town; ↓ = departure(s) documented between that date and preceding date; ↕ = both arrival(s) and departure(s) documented.

Mile 679, movement into and out of stations at Watson Lake town occurred almost daily from 1 through at least 17 May.

Figure 2 shows the average number of birds trapped in one trap-hour (defined as one hour when one trap was left continuously open). The highest figure for Watson Lake town (0.3 birds trapped in one trap-hour on 15 May) is less than one-seventh that of the highest figure for Mile 679 (2.2 birds per trap-hour on 11 May). We cannot compare numbers on identical dates since we could not trap at both sites simultaneously.

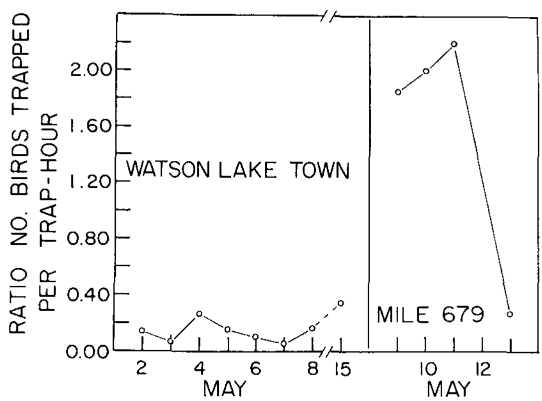

FIGURE 2. Average number of Gambel's Sparrows trapped per trap hour in Watson Lake town and at Mile 679 Alaska Highway during spring 1968.

TABLE 3. Summary of repeat and length of stay data: 1968.

Location	Minimum stay in days	N of birds which repeated: once	twice	thrice	four times	Total N repeating birds	Average minimum length of stay (in days)
Watson Lake Town	1	1	0	0	0	1	
	2	3	0	0	0	3	2.1
	3	2	0	0	0	2	
	Total	6	0	0	0	6	
Mile 661	1	0	0	0	0	0	
	2	1	0	0	0	1	
	3	1	0	0	0	1	
	4	3	0	0	0	3	3.8
	5	0	0	0	0	0	
	6	1	0	0	0	1	
	Total	6	0	0	0	6	
Mile 679	1	3	0	0	0	3	
	2	17	5	1	0	23	
	3	0	4	3	2	9	2.4
	4	1	3	0	0	4	
	Total	21	12	4	2	39	

Individuals which stayed more than one day may have been counted more than once. Before we can estimate the total numbers of Gambel's Sparrows moving through the Watson Lake area in 1968, we must examine the histories of color-banded birds to determine the average interval between dates of initial and final capture.

Minimal length of stay of repeating birds. The number of birds which had a chance to to repeat on at least one date subsequent to the day they were banded totaled 199 (26 for Watson Lake town, 67 for Mile 661, and 106 for Mile 679). Of these, 51 were recaptured. Table 3 summarizes the repeat data. Both at Watson Lake town and at Mile 661, only six birds repeated, each only once. At Mile 679, 21 out of 39 birds repeated only once. The rest repeated from two to four times.

Minimum length of stay was calculated according to methods used by Borror (1948) for White-throated Sparrows (*Zonotrichia albicollis*). A value of 1 day was assigned to individuals banded and recaptured for the last time on the same date, 2 days was assigned to birds captured for the last time one day after banding, and so on. The average minimum length of stay for each capture site is shown in the last column of Table 3. The overall average minimum length of stay for 51 birds at the three sites is 2.5 ± 0.14 days. In these calculations the assumption is made that all birds were trapped on the day they arrived.

If banded birds had stayed near Watson Lake town much longer than the repeat data indicate, we should have expected to see them during the daily patrols. Yet we obtained only six sight records of the 35 birds color-banded there. From the color code, we know that these represented five or six individuals. Intervals between banding and sighting ranged from a possible minimum of 7 hr to a possible maximum of 4 days. The sight records are not included in Table 3 since we do not know whether they represent individuals different from those retrapped.

Estimates of total numbers passing through Watson Lake area. The estimates that follow are based on the assumption that unbanded birds and banded birds not retrapped stayed the same length of time as did repeating individuals. At Watson Lake town, a total of 171 birds was counted on 15 observation days between 1 and 17 May. Dividing by the calculated average minimum sojourn period of 2.1 days, we obtain 81 birds as the estimated number passing through the town in 15 days. At Mile 679, from 5 through 11 May, a total of 340 Gambel's Sparrows was counted. Dividing by 2.4 days, the calculated average minimum stop-over period for this location, gives 142 birds as the approximate number passing by this roadside field in 7 days (from night of 4 May through night of 11 May).

Percentage of unbanded birds trapped. Table 4 shows that at Watson Lake town and Mile 661 the percentage of unbanded birds

TABLE 4. Records of capture of Gambel's Sparrows during May 1968.

	May 2	3	4	5	6	7	8	15
A. Watson Lake town								
N banded birds caught[a]	0	0	3	1	0	1	0	0
N unbanded birds caught	7	1	7	2	2	0	7	12
% unbanded birds in total catch	100	100	70	67	100	0	100	100

	May 2	3	4	5	6	7	8
B. Mile 661							
N banded birds caught[a]	0	0	0	1	0	2	3
N unbanded birds caught	7	3	1	15	13	28	25
% unbanded birds in total catch	100	100	100	94	100	93	89

	May 9	10	11	12	13
C. Mile 679					
N banded birds caught[a]	0	17	27	–	4
N unbanded birds caught	72	31	6	–	0
% unbanded birds in total catch	100	65	18	–	0

[a] Recaptures of birds on the same day as banded are not included.

captured each day remained high throughout the capture period. At Mile 679, in contrast, the percentage of unbanded birds caught decreased from 100 to 0 in 4 days.

RECORDS OF MIGRATION AT OTHER LOCALITIES, 1968

Passage through localities between wintering and breeding ranges. Figure 3 shows the localities mentioned in this section.

Table 5 summarizes data on migratory movements of Gambel's Sparrows for 1968 contributed by birdbanders at localities between Kamloops, B. C. and Juneau, Alaska. The banding stations are listed according to latitude, from lowest to highest, and our data for Watson Lake are included. There are discrepancies in earliest arrival dates between localities of similar latitude. For example, Gambel's Sparrows were first seen at Williams Lake 5 days before any were reported at Kleena Kleene, yet the former lies a few minutes' latitude N of the latter. Also, Gambel's Sparrows arrived at Watson Lake town 2 days before any were reported at McBride, which lies more than 6° S of Watson Lake. The duration of passage through a given locality varied from only 9 days at Kleena Kleene to 23 days at Williams Lake. Periods of peak numbers show discrepancies with latitude, and the maximum number reported for any one date varies widely from station to station. The possible significance of these discrepancies is discussed below.

Arrival at localities within the breeding range. Gambel's Sparrows were first seen at both Whitehorse, Y. T., and at Ferry, Alaska, over 3° latitude and 14° longitude apart, on 4 May (table 5). Although these localities

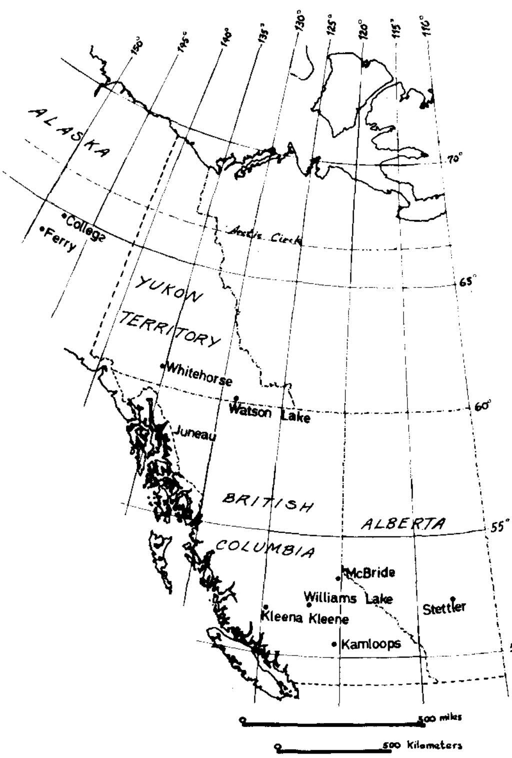

FIGURE 3. Localities for which records of earliest arrival dates in 1968 are available.

TABLE 5. Schedule of the migration and numbers of Gambel's Sparrows observed in 1968.

Localities, from south to north		Earliest record of arrival	Last date migrants seen	Duration of passage through locality	Peak numbers recorded: Date or period	Peak numbers recorded: Maximum no. on one date
I. Localities between wintering and breeding ranges	Kamloops, B.C.	20 April	9 May	20 days	—	—
	Green Lake, B.C.	26 April				
	Kleena Kleene, B.C.	28 April	6 May	9 days	2 May	10
	Williams Lake, B.C.	23 April	15 May	23 days	30 Apr.–1 May	200+
	Stettler, Alberta	5 May				
	McBride, B.C.	3 May	15 May	13 days	9–15 May	several hundred
	Juneau, Alaska	5 May			8–9 May	6
	Watson Lake, Y.T.					
	a. AH Mile 633–680	1 May	13 May[a]	At least 13 days	9 May	572
	b. Watson Lake town (Mile 634)	1 May	17 May[a]	At least 17 days	2–8 May	18
	c. AH Mile 679	5 May	13 May[a]	At least 9 days	9 May	150
II. Localities within breeding range	Whitehorse, Y.T.	4 May				
	Ferry, Alaska	4 May				
	College, Alaska	7 May				

[a] Last date of field work at that locality.

lie within the breeding range, we do not know whether the first individuals to arrive were destined to breed there. Except for one individual which presumably wintered nearby, Gambel's Sparrows were first seen at College, Alaska, on 7 May. Brina Kessel (pers. comm.) states that "the species was well established by 11–12 May and a full breeding population was present by 15–17 May." If we assume that the individuals seen on 7 May were local nesting birds, then the arrival period at College lasted at least 8 to 10 days.

MOVEMENT THROUGH SOUTHERN YUKON IN PREVIOUS YEARS

Arrival. Table 6 summarizes our data on earliest records of arrival and of increase in numbers of Gambel's Sparrows. The dates of first observed arrivals at Watson Lake town (2 May 1967 and 1 May 1968) may be considered identical, since 1968 was a leap year. Likewise, the earliest observed arrival dates for the Alaska Highway (3 May 1967 and 2 May 1968) may be considered identical. By the same reasoning, the dates for first observed increase in numbers on the Alaska Highway in 1966, 1967, and 1968 are within 3 days of each other.

Numbers counted. DeWolfe counted 92 Gambel's Sparrows along her patrol route between 2 and 9 May in 1967. In 1968, she recorded almost the same number on the same route during the comparable period (97 birds between 1 and 8 May). Figure 4 shows the

TABLE 6. Earliest observed arrivals of Gambel's Sparrows in the Watson Lake area.

Year	Location	Records of absence Date	Earliest record of presence: Date	Earliest record of presence: Number observed	Earliest record of increase in numbers: Date	Earliest record of increase in numbers: Number estimated
1967	Watson Lake town	1 May	2 May	1	4 May	16
1968	Watson Lake town	Daily, 25–30 April	1 May	1	2 May	14
	Alaska Highway					
1965	Mile 632	—	30 April[a]	4		
1966	Mile 668–679	—	5 May[a]	10	6 May	107 banded; many more seen.
1967	Mile 627–648	1 May	3 May	3	4 May	32
1968	Mile 634–661	Daily, 27 April Thru 1 May	2 May	40	5 May	110
1967	Mile 679	1, 4, 5, 6 May	7 May	1 or 2	8 May	"several"
1968	Mile 679	27, 30 April	5 May	10	6 May	30

[a] Birds already present when authors arrived.

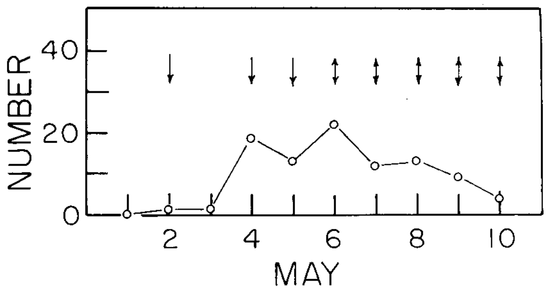

FIGURE 4. Total numbers of Gambel's Sparrows counted in Watson Lake town and immediate vicinity during early May 1967. Arrows as in figure 1.

influxes and departures of Gambel's Sparrows recorded on the patrol route in 1967. As in 1968, movement in and out of stations occurred almost daily.

In contrast, the number of Gambel's Sparrows at Mile 679 varied greatly between identical dates in 3 consecutive years. In 1966, West and Peyton banded 107 Gambel's Sparrows on 6 May, 68 more on 7 and 8 May, and counted more than 100 on 9 May. Since very few banded birds repeated, a conservative estimate of the number of birds moving past Mile 679 from 6 through 9 May would be between 200 and 300. In 1967, West and Peyton counted fewer than 20 Gambel's Sparrows on the same four dates at the same place. In 1968, 90 birds were recorded during the comparable 4-day period. The largest influx came a day later when 150 were counted. Thus during the same span of dates, many more Gambel's Sparrows were seen at Mile 679 in 1968 than in 1967, but not so many as in 1966.

ANNUAL VARIATIONS IN EARLIEST OBSERVED ARRIVAL DATES

Table 7 shows the span of dates for earliest observed arrivals of Gambel's Sparrows at five localities, for all years for which data are available. At three places we have records for both 1967 and 1968. Stettler, Alberta, shows the greatest difference. It lay in the path of unseasonable 1967 spring storms (Robert Lister, pers. comm.).

PHYSIOLOGICAL CONCOMITANTS OF THE 1968 SPRING MIGRATION

In this section, data on recaptured birds are included for each date they were inspected. Unless otherwise stated, when an individual was trapped more than once on the same day, only the data recorded at the first capture for that date are included.

Means and extremes of body weight. Figure 5 shows daily means and extremes of 318 body weights of 233 banded individuals and 29 specimens from the Watson Lake area. We do not know the proportion of females in our sample, but three of the collected specimens were females, the first of which was collected on 8 May. At least from that date on, some females must be represented in some or all of the body-weight averages. The means of body weights fluctuated between 24.85 g and 30.75 g. The extremes were 20.0 g and 33.1 g and the widest range in extremes occurred on 9 May.

The large variability in body weights on a given date is due partly to the presence of birds in both "light" and "heavy" fat classes in most of the samples. Other factors which

TABLE 7. Annual variations in earliest observed arrival dates of Gambel's Sparrows at various locations.

Locality	N years' records	Difference between earliest & latest year	Earliest record	Latest record	Median date, all records of earliest arrival
A. All years for which data are available					
Williams Lake, B.C.	5	6 days	19 April 62	25 April 64	22 April
Stettler, Alberta	9	16 days	1 May 64	17 May 67	4–5 May
Juneau, Alaska	10	17 days	23 April 56	10 May 54	2 May
Whitehorse, Y.T.	7	15 days	22 April 63	7 May 67	4 May
College, Alaska	3	5 days	4 May 57	9 May 67	7 May

	Earliest Observed Arrival 1967	Earliest Observed Arrival 1968	Difference[a]
B. 1967 and 1968			
Stettler, Alberta	17 May	5 May	11 days
Whitehorse, Y.T.	7 May	4 May	2 days
College, Alaska	9 May	7 May	1 day

[a] Taking into account that 1968 was a leap year.

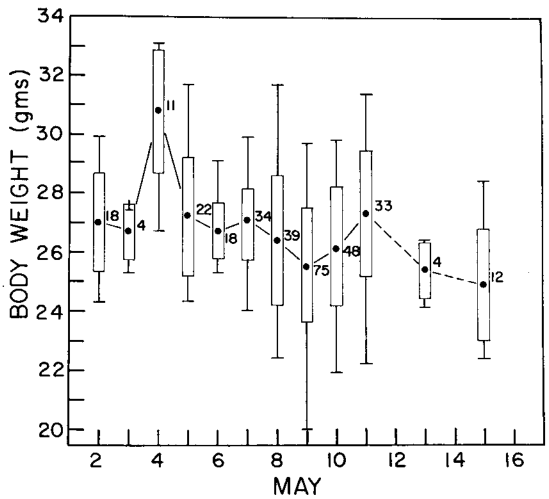

FIGURE 5. Body weights of Gambel's Sparrows from Mile 633–680 Alaska Highway during spring 1968. Mean plus and minus one standard deviation and the extremes are shown for each date. Numbers indicate sample size.

may be involved are sex, intrasexual variation in body size, and time of day the birds were weighed.

We tested for the combined effects of sex and body size by examining means and extremes of body weights of only those birds with winglengths of 77 mm or over. By excluding birds with shorter wings, we assumed that females and the smaller males were eliminated. Banks (1964) gives 63.4–75.8 mm as extremes of winglengths for the breeding female specimens he examined from Alaska and northwestern Canada, and 71.3–80.5 mm as extremes of winglengths for males from the same geographic area. The elimination of females and small males left 152 weights of 129 banded birds plus weights of the 26 male specimens. This exclusion did not alter the shape of the curve of body-weight means, nor did it change the dates of the weight maxima and minima.

The effects of the time of weighing on mean body weight were tested on dates for which we had large enough samples. The exact time of body-weight determination (immediately after capture) was recorded for 149 birds caught on 9, 10, 11, 13, and 15 May. The times ranged from 07:20 to 16:15 hr, but the majority of the weights were obtained before 13:00 hr (only 18 birds were trapped and weighed between 13:00 and 16:15 hr). Nevertheless, there was a significant increase in body weight with time in our sample (body weight $= 22.62 + 0.313 \pm 0.080 \times$ hour of day; $r = 0.307$, $t = 3.910$, $P < 0.001$). The slope is not steep and the correlation is not strong. This is probably the result of several factors: (1) birds were not caught and weighed either very early or very late in the day; (2) there may have been a continual change in the sex ratio of the population being sampled; and (3) birds caught on different days undoubtedly had different amounts of stored fat (see below).

Despite the above correlation, the data do not suggest that sex, body size, or time of weighing were important in determining fluctuations in the means, or the wide ranges in extremes, of body weights in the daily samples. The most likely factor is variation in subcutaneous fat, which is discussed in the section on Fat.

Changes in body weights of recaptured birds. Direction and magnitude of weight changes varied markedly. Of 46 individuals weighed on two or more dates, 38 gained weight, 7 lost weight, and 1 stayed the same between first and last capture. Of 13 individuals weighed within one hour of the same time on two consecutive dates, 10 gained and 3 lost weight. Of 16 birds weighed twice the same day, 12 gained and 4 lost weight.

The maximum increase in body weight regardless of interval between weighings was 4.3 g in 51 hr (initial weight = 22.1 g, final weight = 26.4 g, or 19.4% increase over initial weight). Maximum loss in weight was 3.6 g in about 44 hr (initial weight = 29.6 g, final weight = 26.0 g, or 12% decrease from initial weight).

FAT

Distribution of birds in visible fat classes. Table 8 shows the number of birds assigned either by visual inspection or dissection to each of the fat classes defined in the Methods section. Birds in classes 1 and 2 are designated as "thin," those in classes 3, 4, and 5 as "fat." During the first week, thin birds comprised less than half those inspected (46.6%). In the second week, more than two-thirds of the birds inspected (72.1%) were thin. On 15 May, the last trapping day, all birds were assigned to fat class 1. As will be shown below, most of the recaptured birds increased in visible fat between initial and final capture. Hence the temporal trend toward thin birds indicates that newly arrived birds had less fat. Migrants with greater amounts of fat examined in the first week may have been farther from breeding, both physiologically and geographically, than those which passed through the Watson Lake area the second week. Male

TABLE 8. Number of Gambel's Sparrows in visible fat classes.

Fat classes	Thin birds 1	Thin birds 2	Fat birds 3	Fat birds 4	Fat birds 5	
Date	(Light)	(Light-medium)	(Medium)	(Medium-heavy)	(Heavy)	Total
2 May	10	2	0	2	4	18
3	3	1	0	0	0	4
4	1	0	2	0	8	11
5	10	4	4	1	3	22
6	5	2	9	1	1	18
7	3	5	14	5	7	34
8	14	8	6	3	8	39
9	52	12	7	1	3	75
10	29	3	10	4	2	48
11	11	1	6	1	14	33
12	–	–	–	–	–	–
13	2	2	0	0	0	4
14	–	–	–	–	–	–
15	12	0	0	0	0	12
Grand Total	192			126		318

Weekly periods		Thin birds	Fat birds	Total
I. 2–8 May	N	68	78	146
	%	46.6	53.4	100
II. 9–15 May	N	124	48	172
	%	72.1	27.9	100

specimens collected during the first week had smaller testes, on the average, than those taken the second week (see below).

Fluctuations in percentages of thin and fat birds. The percentages of thin and fat birds trapped or collected on each date except 3 and 13 May, when the numbers are very small, are shown in figure 6. There was an alternation in predominance of thin and fat birds so that the percentage of thin birds was high on 2, 5, 9, and 15 May and the percentage of fat birds was high on 4, 7, and 11 May. We assumed that a large percentage of thin birds correlated with an influx of migrants on the preceding night, and that a large percentage of fat birds indicated imminent departure. If these assumptions are correct, influxes occurred on nights prior to 2, 5, 9, and 15 May, and departures on the evenings of 4, 7, and 11 May. Thus three "in-out" cycles are indicated (2–4 May, 5–7 May, and 9–11 May). A fourth, for 15–17 May, is indicated by the fact that only thin birds were caught on 15 May, and by the decline in numbers observed on 16 and 17 May. These "in-out" cycles were each 2 days in length, comparable to the average minimum length of stay for all recaptured birds calculated from banding records (2.5 days, see above).

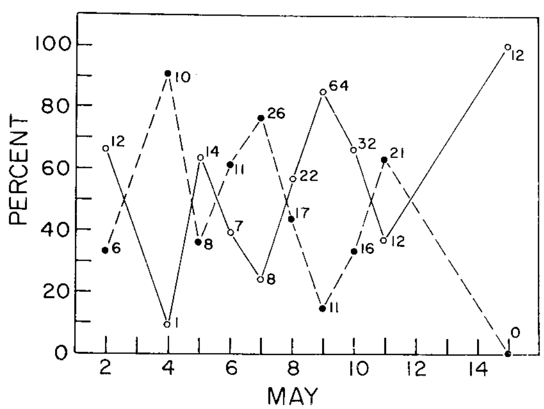

FIGURE 6. Percentage of Gambel's Sparrows classified as "thin" (fat classes 1 and 2) and "fat" (fat classes 3, 4, and 5) examined from Mile 633–680 Alaska Highway during spring 1968. Numbers indicate sample size. ○ = thin birds, ● = fat birds.

RELATION BETWEEN BODY WEIGHT AND VISIBLE FAT

The difference between means of body weight for pairs of adjacent fat classes are, with one exception, statistically significant (see *P* values in table 9A). Mean body weight for "thin" birds is 2.43 g lower than that for "fat" birds. The extremes for thin and fat birds overlap. Nevertheless, the difference is statistically significant ($P < 0.001$, table 9B).

Dates when the percentage of thin birds in a sample is high coincide, either exactly or within one day, with dates for lowest values of mean body weight. Dates when the per-

TABLE 9. Mean values of Gambel's Sparrows body weights in each visible fat class.

Fat Class	Designation	N	Extremes (g)	Mean body weight (g)	S.D. σ	Significance of differences between means[a]
A. Individual fat classes						
1	Light	152	20.0–31.9	25.40	1.8295	
						$P < 0.025$
2	Light medium	40	22.4–28.6	26.07	1.2732	
						$P < 0.001$
3	Medium	58	22.9–29.9	27.07	1.4551	
						$P > 0.125$
4	Medium-heavy	18	25.3–29.6	27.43	1.3046	
						$P < 0.001$
5	Heavy	50	24.2–33.1	29.18	1.9255	

Fat Class	Designation	N	Extremes (g)	Mean body weight (g)	S.D. σ	Significance of differences between means[a]
B. "Thin" and "fat" birds						
1, 2	Thin	192	20.0–31.9	25.53	1.7325	
						$P < 0.001$
3, 4, 5	Fat	126	22.9–33.1	27.96	1.9177	

[a] Results of Student's t-test.

centage of fat birds is high coincide with dates for highest means of body weight (cf. figs. 5 and 6).

MOLT

All the birds we trapped had completed the prenuptial molt before arrival in the Watson Lake area. None showed any molt, and none had brown feathers on the head.

TESTIS VOLUME AND HISTOLOGIC STAGE

Average volumes of the two testes for 25 males varied from 16.9 mm³ to 137.1 mm³. Only the two most advanced histologic stages were represented: Stage 6, in which spermatids but no mature sperm are present; and stage 7, breeding condition, in which mature sperm are present in the lumens of the seminiferous tubules. All but two specimens had testes either in Stage 6 or intermediate between Stages 6 and 7 (i.e., had metamorphosing sperm but none in the tubule lumens). One exception was a male collected on 11 May. Although its average testis volume was 137.1 mm³, well within the range of volumes for breeding birds, according to histologic criteria it had not achieved full breeding condition since there were only a few mature sperm in the lumens of a few tubules. The second exception was a bird collected on 15 May which had many mature sperm in most of the tubule lumens and hence should have been capable of breeding. This male weighed only 22.4 g, and dissection revealed almost no subcutaneous fat. It was probably near the end of its journey. Its average testis volume (119.5 mm³) was almost identical with the mean for 11 males collected between 6 and 8 May 1957, at College, Alaska (DeWolfe 1967). These males were known to be newly arrived on breeding territories and averaged 118.4 mm³ as to testis volume.

Fifteen males collected between 2 and 8 May averaged 60.19 mm³ in testis volume. All were fat, and six were designated as "heavy." Ten males collected between 9 and 15 May averaged 86.11 mm³ in testis volume. Eight of these were thin, and neither of the two "fat" birds was "heavy."

DIAMETER OF OVARIAN FOLLICLES

The three largest follicles in the ovary of each of the three females collected ranged from 0.5 to 1.8 mm in diameter and averaged 1.1 mm. The largest follicles of three females newly arrived on nesting grounds at College, Alaska, in 1957 ranged from 1.8 to 2.8 mm, and averaged 2.1 mm in diameter (DeWolfe, unpubl. data).

DISCUSSION

STOP-OVER TIME OF REPEATING BIRDS

Our calculated minimum lengths of stay for Gambel's Sparrows in the Watson Lake area (table 3) are shorter than those reported for White-throated Sparrows (*Zonotrichia albicollis*). Data cited by Wolfson (1954), however, indicate that the overall average minimum stop-over time of 2.5 ± 0.14 days which we calculated is theoretically long enough to permit migrants arriving thin to acquire a substantial amount of fat. Wolfson selected captive White-crowned Sparrows with heavy fat deposits and starved them until their minimum weights were reached, then gave them food again. In 3 days some of the birds had returned to the "heavy" fat class. They restored their weights at the rate of about 2 g per day. Stack and Harned (1944) calculated the average stop-over period for 2712 migrant White-throated Sparrows, banded in the springs of 1924 through 1940 at East Lansing, Michigan, to be 4.5 ± 1.56 days. Borror (1948) analyzed repeat records of White-throated Sparrows at Columbus, Ohio, and found that the average minimum length of stay of repeating birds in the springs of 8 years was 5.3 ± 0.3 days.

West and Peyton (1972) found the average lengths of stay of Tree Sparrows in southern Yukon to be even shorter than our estimates for Gambel's Sparrows. In 1967, the average length of stay of Tree Sparrows was 1.3 days, and in 1968, 1.8 days.

MODE OF MIGRATION: IN ORGANIZED FLOCKS OR AS INDIVIDUALS?

Although migrating Gambel's Sparrows are sometimes seen in large flocks, as at Williams Lake and McBride in 1968, most of the data presented in this paper support the hypothesis of West et al. (1968a) that migrating flocks are temporary aggregates, each member of which follows its own schedule. Evidence for the individuality of flight schedules may be summarized as follows.

Absence of large flocks at certain banding stations. Although Gambel's Sparrows are seen each spring at Kleena Kleene, B. C., Stettler, Alberta, and Juneau, Alaska, no large flocks have been reported even by operators of banding stations who have kept records for many years.

Absence of flocks at Watson Lake town. In both 1967 and 1968, the arrivals of Gambel's Sparrows at Watson Lake town and their departures therefrom were so unspectacular as to require careful daily counts to reveal them. The number of Gambel's Sparrows counted at one spot was rarely more than five and never more than eight for any given date. Except when feeding, the birds did not stay close together. Males took up temporary singing posts and often alternated in singing as do breeding birds, although the songs lacked force. The only interactions between individuals observed, other than alternate singing, were brief disputes over food.

Absence of synchronized departure from Mile 679. Intervals between first and last capture of 31 birds banded on 10 May 1968 at Mile 679 vary from less than 22 hr to more than 72 hr. This suggests that birds banded on that day did not depart as a group. By 13 May, all but four Gambel's Sparrows had disappeared from Mile 679. The four that remained had all been banded on 10 May. This is direct evidence for lack of synchrony of departure. We do not know whether or not the 31 birds arrived together, but we can say that they did not depart together.

Absence of synchronized beginning and end of spring migration. Data from the Watson Lake area fit with previous observations on wintering and breeding grounds. We know that individuals wintering together do not all begin spring migration together. At Davis, California, color-banded members of a group which had shared the same headquarters in winter took nearly as long to disappear in spring as did the entire wintering population (Blanchard and Erickson 1949). Specimens taken from one group varied as to stage of prenuptial molt, amount of fat, and stage of testis development. Just as not all individuals of a given wintering group begin migration together, so not all birds destined to breed at one place arrive together. In 1950 at Mountain Village, Alaska, Gambel's Sparrows color-banded shortly after arrival, and which nested there, came into the area over a 19-day period (Oakeson 1954). In 1957 at College, Alaska, the breeding population arrived over a period of at least 14 days (DeWolfe 1967).

Thus most of our observations indicate that individuals wintering together do not begin migration together, that individuals feeding together during migration do not follow identical flight schedules, and that birds nesting in the same place do not all arrive on the breeding grounds on the same date.

Variability in behavior, numbers, and physiological state. Indirect evidence for the individuality of migration schedules is furnished by the marked variability we found in behavior and numbers of migrants recorded at nearby localities. Even if we restrict the analysis of data to our observations for 1968 alone, we do not eliminate wide variability in dates of earliest arrival at localities of similar latitude, in duration of passage through nearby banding stations, or in numbers recorded at neighboring localities (table 5). The data from Watson Lake town and Mile 679, which are an insignificant distance apart compared with the vast area over which migration takes place, indicate differences in patterns of movement. At Watson Lake town we never saw large flocks, but we documented almost daily influxes and departures of small numbers of birds at one or more stations on the patrol route. The percentage of unbanded birds caught each day remained high throughout the banding period. At Mile 679, in contrast, the number of birds increased quickly from none to about 150, then decreased even more rapidly. The percentage of birds trapped which had already been banded rose from 35% on the day after the initial trapping date to 100% 4 days later. We cannot believe that the birds passing through two localities so close together represented different populations. None of our data on song pattern, physiological condition, lore color, or winglength indicates such a dichotomy. Thus the variation in pattern of movement through these localities must indicate individual differences in behavior.

Variation in body weight was also great. On any one day, body weights of captured birds varied by as much as 30%. A part of this variability was due to time of day the birds were caught and weighed (see above). Several investigators have found increases in body weight from a low in the early morning to a maximum in late afternoon in wild birds, including *Zonotrichia atricapilla* and *Z. albicollis* (references are summarized in Kontogiannis 1967). However, the most likely factor responsible for body weight variation on any one day in Gambel's Sparrows migrating through the Watson Lake area appears to be differences in subcutaneous fat. A foraging group included individuals in each of the five classes of visible fat.

Evidence for individual variability in physiological state of the migrants is also provided by analysis of changes in relative amounts of visible fat in recaptured birds. We postulated that the longer an individual remained in an area, the fatter he should become. To test this, 46 birds recaptured on a date other than initial capture were sorted into four categories according to the time interval elapsing between first and last capture. Of the total, 26 were recaptured after one day, and averaged an increase of 1.3 fat-class units. Twelve were recaptured after 2 days, and these averaged an increase of 1.6 fat-class units. Seven were recaptured 3 days later and had increased on the average by 0.3 fat-class units. Only one individual was recaptured after an interval of 5 days and it gained 3 fat-class units. This analysis indicates that length of stay and increase in visible fat are not well correlated. Dolnik and Blyumental (1967) noted that, in autumn, feeding flocks of migrant chaffinches (*Fringilla coelebs*) consist of individuals in all fat classes. These authors hypothesized that the fattest birds begin a migratory flight, and that they draw birds with less fat into flight with them. Similarly, the leanest individuals are the first to stop a particular migratory flight, and they draw birds with more fat down with them. This results in heterogeneous flocks of both feeding and flying birds, with individuals in all fat classes. The wide variation in fat class of the Gambel's Sparrows we trapped on any one day is in accord with this hypothesis.

When we examined the change in fat class of the 46 birds regardless of length of stay, we found that, on the average, birds gained in fat-class units regardless of their arrival condition. Fourteen birds that arrived in fat class 1 gained an average of 1.6 fat-class units by their last recapture. Similarly, 8 caught at class 2 gained an average of 1.4 units, 13 at class 3 gained 1.2 units, and 5 at class 4 gained 0.4 units. Of the six birds that arrived at fat class 5, five did not change class while one was judged to decrease 1 fat-class interval.

That some individuals lost fat correlates with the fact that a substantial fraction of recaptured birds lost weight between initial and subsequent capture. The fact that most recaptured birds gained fat between initial and final capture does not imply that all individuals arrived thin. At least six birds judged newly arrived according to one or more criteria set forth in the Methods section were fat enough to be placed in fat classes 4 and 5. Nor did all "fat" individuals disappear immediately. Of 18 birds designated as "fat" on initial inspection, 11 stayed at least until the next day and 3 stayed at least 2 days.

Conversely, we have indirect evidence that thin birds did not necessarily stay until they became fat. At Mile 679, of 64 birds trapped only once, 79% were thin; of 36 birds recaptured, a similar percentage, 78%, were thin. If we group together all "thin" birds that were trapped soon enough to allow at least one retrapping at a later date, we find that 93 out of 128, or 73%, were not retrapped. The proportion of initially "fat" birds not retrapped is roughly the same—81%. The fact that many birds entered the Watson Lake area with appreciable amounts of fat, and others left the area before becoming fat, also argues for the individual nature of physiological states and of migration schedules. Why such individual variation exists can be partly explained by the hypothesis of Dolnik and Blyumental cited above.

MIGRATION ROUTES

Records of earliest arrival at different localities provide clues to migration routes. In 1968, we found some discrepancies between date of earliest observed arrival and latitude (table 5 and fig. 3). (1) Latitudes of Kleena Kleene and Williams Lake are only 10′ apart, yet the dates of earliest observed arrivals of Gambel's Sparrows at these places differ by 5 days. (2) Although Watson Lake lies over 6° N of McBride, Gambel's Sparrows were observed 2 days earlier at Watson Lake than at McBride. (3) Whitehorse lies more than 2° N of Juneau (actually about 165 miles NW of Juneau), yet the first arrivals were recorded a day sooner at Whitehorse than at Juneau. (4) Ferry lies over 3° N and 14° W of Whitehorse, yet Gambel's Sparrows were first seen on the same date at both places. Even in the Watson Lake area, first arrivals of Gambel's Sparrows in two localities 45 miles apart differed by 4 days. It seems unlikely that these discrepancies can be accounted for solely by errors in observation.

In cases where the earliest record of arrival for one locality is ahead of that for another place farther south, the birds seen at the two localities must represent different groups of migrants rather than the same seen twice. The data suggest that Gambel's Sparrows migrate not as a wave moving northward along a broad front, but rather by independent movements along several routes. Where weather and ground conditions permit, a group of individuals surges ahead while in adjacent areas, other individuals lag behind. When weather is bad over a large area as it was near Edmonton in early May 1967, migration from the prairies can be delayed. Because of the concentration of individuals waiting for a break in the weather, the birds moving north after the break appear to do so as a cohesive group. However, as with Lapland Longspurs (West et al. 1968a), even these groups can be shown to be composed of birds each with its own individual program of migratory movement. Other examples of independent activity of individuals in flocks during migration are pointed out by Irving et al. (1967) for Willow Ptarmigan (*Lagopus lagopus*) in northern Alaska, by West et al. (1968b) for Common and Hoary Redpolls (*Acanthis flammea, A. hornemannii*) migrating through interior Alaska, and by West and Peyton (1972) for Tree Sparrows (*Spizella arborea ochracea*) in southern Yukon.

At least three routes are indicated for the observed migration of Gambel's Sparrows toward Alaska—the same as those described for the Lapland Longspur (see fig. 1 in West et al. 1968a): a coastal, an intermountain, and a prairie route. Birds moving through the Watson Lake area can come via either the intermountain or prairie route. This may account for birds arriving at the field at Mile 679 4 days after other individuals had been seen at nearby locations. As with longspurs, the larger groups observed at roadside fields probably came from the prairies while earlier migrants probably came via either coastal or intermountain routes. This same reasoning can explain the other discrepancies in arrival at specific locations as shown in table 5. For example, the fact that the earliest Gambel's Sparrows were recorded at Juneau a day later than at Whitehorse some 165 miles to the northwest, and 4 days later than at Watson Lake, suggests that the earliest Gambel's Sparrows to reach Whitehorse may have flown via Watson Lake and could have come over the prairies or intermountain route. The Gambel's Sparrows that reached Juneau on 5 May would then represent a movement separate from that recorded at Whitehorse on 4 May. This is evidence for a coastal route of migration.

The birds arriving at Ferry in 1968, a day ahead of those arriving at Juneau some 640 miles to the southeast, suggest either a migration across the Gulf of Alaska with entry via the Copper River or Susitna River valleys or a rapid flight cross country via an inland route. Observations by West and Peyton in late April and early May at Valdez and Cordova at the mouth of the Copper River in 1969 and 1970 indicate that very few Gambel's Sparrows move through these areas. Birds we observed along the Copper River drainage in the first week of May probably came south into this area from flocks moving westward from the Whitehorse area.

Other examples can be added by examining the data for 1968 in table 5 and for other years in table 7.

RATES OF TRAVEL

The dates for earliest observed arrivals provide clues to approximate rates of travel by individuals (probably all males) in the vanguard of the spring migration. If we draw lines between localities for which the earliest records of arrival of Gambel's Sparrows in 1968 show an orderly sequence, we can plot a theoretical flight route which passes through Kamloops, Williams Lake, and Watson Lake and ends either at Whitehorse or at College. If we then assume that this is a route actually

TABLE 10. Calculations of rates of travel of Gambel's Sparrows migrating in 1968.

Basis of calculations	Pairs of localities	Differences between dates	Distance between localities	Average rate of travel/24 hr
A. Dates of earliest recorded arrivals	Kamloops, B.C. and Williams Lake, B.C.	3 days	air miles: 132 road miles: 185	43.0 air miles 61.7 road miles
	Williams Lake, B.C. and Watson Lake, Y.T.	8 days	air miles: 604	75.5 air miles
	Watson Lake, Y.T. and Whitehorse, Y.T.	3 days	air miles: 219 road miles: 282	73.0 air miles 94.0 road miles
	Watson Lake, Y.T. and College, Alaska	6 days	air miles: 683	113.8 air miles
B. Dates of peak numbers observed	Williams Lake, B.C. and Watson Lake, Y.T.	9 days	air miles: 604	67.1 air miles
	Watson Lake, Y.T. and College, Alaska	6–8 days	air miles: 683	85.6–113.8 air miles

followed, we can calculate the rates of travel required for arrival at each locality on the date Gambel's Sparrows were first seen there. Table 10 shows the data and the calculated rates of travel, first using distances in air miles and second, in the two cases where localities are connected by highways, using road miles. The rates based on air miles are almost certainly too low. The distances actually covered may be closer to road miles. In either case, the rates of travel as calculated are of the same order of magnitude.

Dates for peak numbers of Gambel's Sparrows are available for the 1968 migration from Williams Lake, Watson Lake, and College. Since they bear the same relation to one another at these places as do dates of earliest recorded arrivals, calculations based on dates of peak numbers yield rates of travel comparable to those based on earliest arrival dates.

The sources of error in such calculations are obvious, but until we capture marked birds at two or more points on the spring migration pathway, it is the best we can do. It may be more than coincidence that the calculated average rates of travel between Williams Lake and Watson Lake (67–75 air miles per day) and between Watson Lake and Whitehorse (73 air miles per day) are close to the calculated average rate of travel of Gambel's Sparrows from Santa Barbara, California, to Mountain Village, Alaska, based on data from earlier years. Since the air distance between these two points is about 2700 miles, and the estimated interval for the flight is not more than 35 days, the average rate comes to about 77 air miles per day (Oakeson 1954).

RELATION BETWEEN BODY WEIGHT AND VISIBLE FAT

Correlations exist between body weight and fat as shown by the values for mean body weight of the five fat classes (table 9A), by the coincidence in dates of high and low values for estimated fat and mean body weight (figs. 5 and 6), and by the increase in both fat and body weight of the majority of recaptured birds (see Discussion).

If we assume that the increase in body weight of birds already in migration was all fat (and not changes in lean body weight or water), then the difference between the average weight of birds in fat classes 1 and 5 (table 9A) represents the average minimum fat content of migrants classed as "heavy." The per cent difference (14.9) is similar to that reported elsewhere for other short- and middle-range migrants (Odum et al. 1961; Berthold 1971).

There is much overlap between extremes of body weights of adjacent fat classes (table 9A). We have no evidence that the total amount of fat that a bird can carry is correlated with its lean body weight. Therefore, at any one time, one can expect to find birds of different sizes with the same weight because of variable fat loads, and conversely birds of the same size with greatly different weights for the same reason. The lack of consistent correlation between body weight and visual fat class which we found in spring migrant Gambel's Sparrows was also found in autumn by King et al. (1965), who showed a decrease in fat-free body weight concurrent with premigratory fat deposition in wild Gambel's Sparrows at College, Alaska. They state that "variation in total body weight is not a reliable index of variation in lipid reserves in the White-crowned Sparrows in summer and autumn."

ANNUAL VARIATIONS IN NUMBERS OF MIGRANTS COUNTED

A discrepancy in the data on numbers recorded at Watson Lake town and at Mile 679 is mentioned above in the Results Section. At Watson Lake town, we recorded almost the same number of Gambel's Sparrows between identical dates in 1967 and 1968, whereas at Mile 679 the numbers recorded between identical dates in 1966, 1967, and 1968 were 200–300, fewer than 20, and 90, respectively. These wide swings in numbers from one year to the next could be explained by one of three possibilities: (1) that marked fluctuations in actual numbers of this race occur from one year to the next; (2) that annual variations in date of arrival of peak numbers occur, and that the peak arrived in 1967 after we had left the area; or (3) that in 1967 most of the migrants bypassed Mile 679 altogether. We have no evidence for the first and second possibilities. There is indirect evidence that Gambel's Sparrows may bypass an area to avoid unseasonable storms. In 1967, late spring storms occurred in the area of Edmonton, Alberta. Dr. Lister (pers. comm.) reported that no Gambel's Sparrows were seen by him or other ornithologists in the vicinity of Edmonton during the period when, in normal years, this race passes through that area. Yet the arrival of Gambel's Sparrows farther north, at Whitehorse, Y. T., and College, Alaska, was only 1 or 2 days later in 1967 than in 1968 (table 7). If some Gambel's Sparrows changed their migration route in 1967 to avoid the unseasonable storms on the prairies, this indicates potential flexibility of behavior, of obvious adaptive value to a race which must often meet unfavorable or locally variable weather conditions during the long flight north.

SUMMARY

During the spring migration of Gambel's Sparrows (*Zonotrichia leucophrys gambelii*) in 1965–68, through northern British Columbia and southern Yukon, the authors banded and weighed 472 birds, examined them for molt, and assigned them to one of five classes of visible fat.

Most of the data were collected in 1968. That year the authors made daily counts of numbers of Gambel's Sparrows between Mile 633 and 680 of the Alaska Highway, banded and examined 233 birds, collected 29 specimens to determine state of the gonads, and followed individuals by color-banding. Additional data on spring migration of Gambel's Sparrows in Canada and Alaska were contributed by 11 other ornithologists.

Contrasts between Gambel's Sparrow movements through Watson Lake town (Mile 634, Alaska Highway) and past a roadside field at Mile 679 were found as follows. In 1968, the total number of Gambel's Sparrows migrating through Watson Lake town during 15 days was estimated at 81; the highest average number captured per trap-hour in any one day was only 0.3; and the percentage of unbanded birds remained high throughout the observation period. In contrast, the total number of Gambel's Sparrows migrating past Mile 679 in 7 days was estimated to be 142; the highest average number captured per trap-hour in a day was 2.2; and the percentage of unbanded birds decreased from 100 to 0 in only 4 days. During identical periods in 1967 and 1968, the number of Gambel's Sparrows counted at Watson Lake town was 92 and 97, respectively. During comparable periods in 1966, 1967, and 1968, the number of Gambel's Sparrows counted at Mile 679 was over 200, less than 20, and 90, respectively. These differences in pattern of movement suggest that individuals follow their own flight schedules rather than migrating as members of cohesive flocks.

Earliest observed arrivals of Gambel's Sparrows at northern banding stations in 1968 showed discrepancies between date and latitude which provide clues to the migration routes used. The data suggest that Gambel's Sparrows, like the Lapland Longspur, follow three general routes: a coastal, an intermountain, and a prairie route.

Earliest arrival dates at Watson Lake town were identical in 1967 and 1968, and within one day of the same date at Mile 679.

Histories of recaptured banded birds indicate short sojourns in the Watson Lake area in 1968. Intervals between initial and final capture averaged 2.1 days for 6 birds banded at Watson Lake town, 3.8 days for 6 birds banded at Mile 661, and 2.4 days for 39 birds at Mile 679. The average interval calculated for 51 recaptured birds was 2.5 ± 0.14 days. This agrees with the 2-day duration of four influx-efflux cycles indicated by dates when high proportions of thin birds were trapped (indicating influxes) and the dates when high proportions of fat birds were trapped (indicating imminent departures).

Rates of travel of birds in the vanguard of the migration, calculated from earliest arrival dates at four pairs of localities in Canada and Alaska, ranged from 43 to 114 miles per day.

Body weights of birds captured on the same date varied widely. Eliminating birds with winglength 76 mm or less (most if not all females) does not significantly reduce the range of variability: the extremes are still wide in most samples and the standard deviations of the means are large. Mean body weight shows a significant increase with the hour of weighing, although the correlation is not strong. The most important factor in determining daily fluctuations in body weights is thought to be variations in subcutaneous fat.

The majority of recaptured birds weighed more and were judged fatter at final than at initial capture. Maximum recorded gain in weight was 4.3 g in 51 hr. Maximum weight loss was 3.6 g in 44 hr.

The difference between means of body weight for pairs of adjacent fat classes are, with one exception, statistically significant. A qualitative relation between body weight and amount of visible fat is indicated by the coincidence of dates for high and low values of both mean body weight and visible fat, and by the increase in both weight and visible fat of most recaptured birds. No consistent relation exists, however, between direction or magnitude of changes in body weight and changes in estimated amount of visible fat in individual birds.

Some birds known to be newly arrived already had enough visible fat to be classified as "heavy," and some of these stayed in the area at least 1 or 2 days before disappearing. Conversely, there is indirect evidence that not all thin birds stayed until they became fat.

Twenty-five males collected and dissected had average testis volumes ranging from 16.9 mm^3 to 137.1 mm^3. All were either in the histologic stage prior to appearance of mature sperm or in breeding condition. Only one male had fully mature gonads, with large numbers of sperm in the lumens of the seminiferous tubules. It weighed only 22.7 g (the least of any known male weighed) and had no fat. This bird was probably near the end of its migration.

The relation of the data on Gambel's Sparrow migration to those for other migrant species is briefly discussed.

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