VARIATION IN WHITE-THROATED SPARROW SONGS

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ANYONE who has listened carefully to the songs of passerine birds knows that there is regional, local, and often individual variation in the songs of many species, but this variation has been critically studied (e.g., with a sound spectrograph) in relatively few species. Such studies as have been made (e.g., Borror, 1961) indicate that the nature and amount of variation in passerine songs differ greatly in different species.

The songs of the White-throated Sparrow (*Zonotrichia albicollis*) are relatively simple, and much of the variation in these songs is detectible by ear, yet little has been written about song variation in this species. Saunders (1935) and Arlton (1949) describe several variations of White-throat songs, but say little or nothing about the relative incidence of these variations.

This paper is based on a study of the recorded songs of 433 White-throated Sparrows from seven states of the United States and six provinces of Canada, recorded from 1951 to 1962. Field observations of 278 additional birds in four states and four provinces were used in an examination of the geographic distribution of the major song patterns. Most of the recordings were made by the writers, but we have been able to study the recordings of 29 birds from the collection of Cornell University (mostly recorded by P. P. Kellogg and the late A. A. Allen) and recordings of 61 birds made by J. Bruce Falls of the University of Toronto. We are grateful to Dr. Kellogg and Dr. Falls for the opportunity to examine their recordings. A summary of the birds studied is given in Table 1; the field observations (by Gunn) were made in 1960.

Data on the detailed character of the recorded songs (the pitch, length, and character of the notes) were obtained by means of a Vibralyzer sound spectrograph (Borror and Reese, 1953). At least one song of most birds was graphed, and in many cases two or more songs of a given bird were graphed to learn something of the variation in the songs of that bird. The recorded songs not graphed were studied by listening to the recordings played at a reduced speed.

We are concerned in this paper with what is usually called the territorial or advertising song; such songs consist of the vocalizations, usually given only by the male and usually more complex in character than the bird's various call notes, which appear to advertise the presence of the male, to attract a female, and/or to repel other males of the same species. We are not concerned with the biological significance of these songs or their variations; a discussion of this subject must await further study.

TABLE 1

SUMMARY OF THE BIRDS STUDIED

State or province	*Number of birds recorded by*				*Birds observed (Gunn)*	*Total birds*
	Borror	*Gunn*	*Falls*	*Cornell*		
North Carolina	6					6
Ohio	40					40
Quebec		20		7		27
New Brunswick		8				8
Maine	85					85
Vermont	1	5		2	11	19
Massachusetts				1		1
New York		7		13	18	38
Ontario		141	61		190	392
Michigan					9	9
Minnesota		1			2	3
Manitoba		20		6	48	74
Alberta		4				4
British Columbia		5				5
Total	132	211	61	29	278	711

THE GENERAL CHARACTER OF WHITE-THROATED SPARROW SONGS

The songs of a White-throated Sparrow consist of a series of clear, whistled notes, which are generally steady in pitch or nearly so; occasionally one note in the song may be abruptly slurred (usually upward, occasionally downward) at the beginning. The song generally ends in a series of three-parted notes, or triplets. There is nearly always at least one pitch change in the song, usually after the first or second note, and some songs contain two or three changes in pitch.

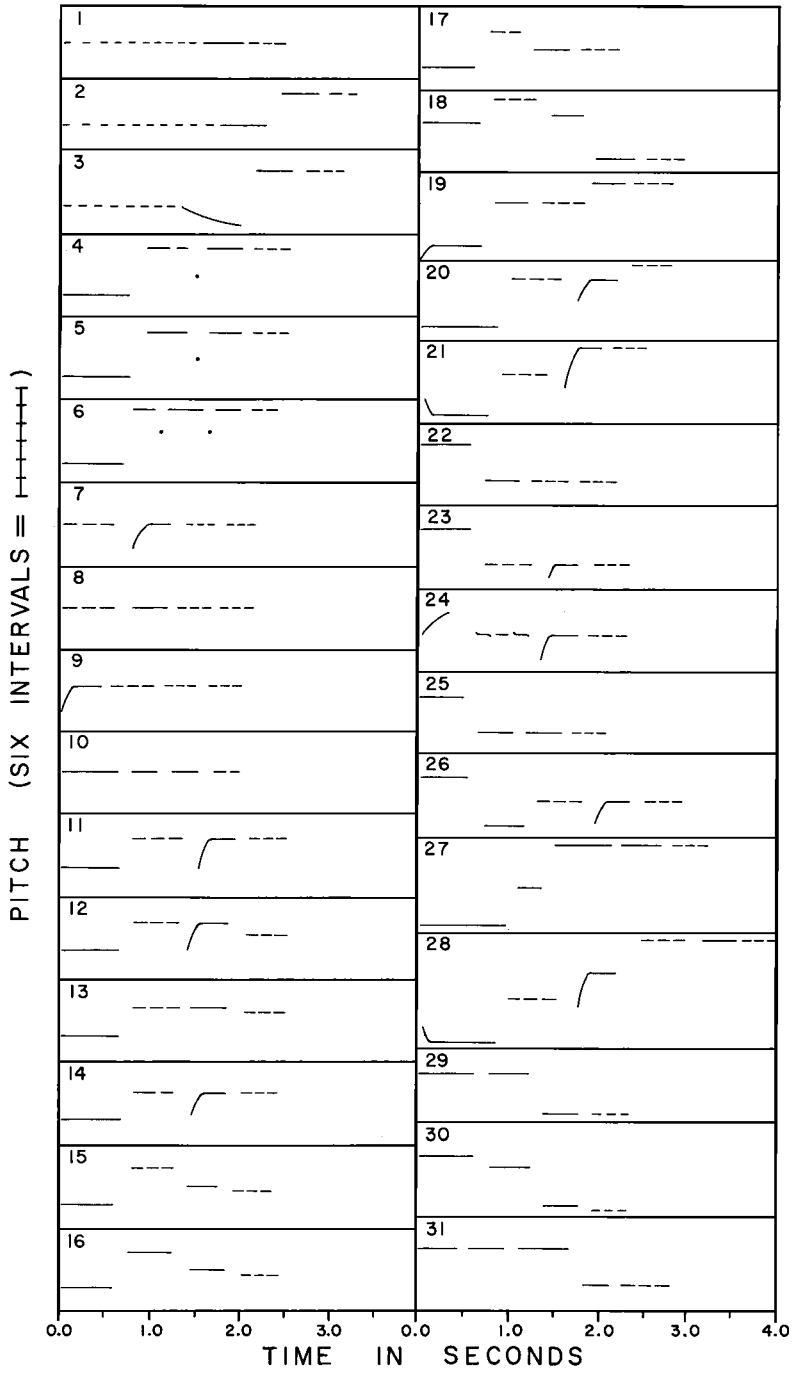
The recorded songs studied contained notes of several different types, which are listed below (the italicized letter in the description indicates the letter designation of the note). All but the last two of these are at least 0.20 second in length (usually longer), and may be described as *long* notes.

S—a long note that is *s*teady in pitch throughout, or nearly so; there is at least one *S* note in nearly every song.

U—a long note that is steady in pitch after an abrupt initial *u*pslur over two or more intervals; about half of the recorded songs contained a *U* note. (The term "interval," as used in this paper, refers to a musical interval, or a half-note on the musical scale; there are 12 intervals in an octave.)

L—a *l*ong note that is steady in pitch after an abrupt initial downslur; some songs began with an *L* note.

R—a long note that *r*ises gradually throughout in pitch over 1½ or more intervals (long notes that rose throughout in pitch over fewer than 1½ intervals were considered *S* notes); *R* notes occurred in the songs of only one of the birds studied.


PITCH (SIX INTERVALS =)
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3
4
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6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
0.0
1.0
2.0
3.0
0.0
1.0
2.0
3.0
4.0
TIME IN SECONDS

F—a long note that gradually *f*alls in pitch throughout over 1½ or more intervals (notes that fell in pitch throughout over fewer than 1½ intervals were considered *S* notes); *F* notes occurred in the songs of only one of the birds studied.

T—a *t*riplet: a long note divided into three parts by two very short (up to 0.02 second) silent periods, or by two points of greatly reduced amplitude; nearly all the songs studied contained one or more triplets.

D—a *d*oublet: a long note divided (as in *T* notes) into two parts; the second note in some songs was a doublet, and a few songs ended in doublets instead of triplets.

s—*s*hort notes, 0.07 second in length or less, steady in pitch or nearly so, uttered in rapid succession but not grouped into doublets or triplets; a few songs began with a series of *s* notes.

v—a *v*ery short note, 0.02–0.04 second in length; the songs of some birds contained one or two *v* notes.

Saunders (1935: 268–270) and Arlton (1949: 176) indicate that the first part of a triplet is the longest and the second part is the shortest; our graphs show that in most cases the three parts of a triplet are about equal in length, and if any one of them is longer or shorter than the others it may be any of the three. The first part of a doublet is usually a little longer than the second.

SONG PATTERNS OF THE WHITE-THROATED SPARROW

Different songs of this species differ in various ways: (1) in the types of notes they contain, (2) in the way the pitch changes through the song, (3) in the pitch of the first note, (4) in the amount of pitch change between notes, (5) in the length of the various notes, (6) in the length of

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Figure 1. Graphs of White-throated Sparrow songs. Graph 1. Pattern 1 $s_{10}ST$. Graph 2. Pattern 2 s_{10} *SSD*. Graph 3. Pattern 2 s_8FST. Graph 4. Pattern 3 *SDvST*. Graph 5. Pattern 3 *SSvST*. Graph 6. Pattern 4 *SSvSvSD*. Graph 7. Pattern 5 TUT_2. Graph 8. Pattern 5 TST_2. Graph 9. Pattern 5 UT_3. Graph 10. Pattern 5 *SSSD*. Graph 11. Pattern 6 *STUT*. Graph 12. Pattern 6 *STUT*. Graph 13. Pattern 6 *STST*. Graph 14. Pattern 6 *SDUT*. Graph 15. Pattern 7 *STST*. Graph 16. Pattern 7 *SSST*. Graph 17. Pattern 7 *SDST*. Graph 18. Pattern 8 *STSST*. Graph 19. Pattern 9 *USTST*. Graph 20. Pattern 9 *STUT*. Graph 21. Pattern 10 *LTUT*. Graph 22. Pattern 12 SST_2. Graph 23. Pattern 12 *STUT*. Graph 24. Pattern 12 *RTUT*. Graph 25. Pattern 12 *SSST*. Graph 26. Pattern 13 *SSTUT*. Graph 27. Pattern 10 *SSSST*. Graph 28. Pattern 11 *LTUTST* (because of space limitations, only two-thirds of the final triplet is shown). Graph 29. Pattern 14 *SSST*. Graph 30. Pattern 14 *SSST*. Graph 31. Pattern 15 *SSSST*.

The italicized letters following each pattern number represent the types of notes in the pattern illustrated; subscript numbers (graphs 1–3) represent the number of *s* notes. Subscript numbers (graphs 7–9) represent the number of triplets (T).

the song and the number of notes it contains, and (7) in the relative loudness of different notes in the song. The songs may be classified in a number of patterns on the basis of differences in the types of notes[1] they contain, and in the way the pitch changes through the song. The 15 patterns found in the songs studied may be outlined as follows (see Figure 1, graphs 1–31):

I. Songs beginning with a series of *s* notes.
   A. All the notes at or near the same pitch—Pattern 1 (graph 1).
   B. The final notes at a higher pitch—Pattern 2 (graphs 2 and 3).

II. Songs containing one or two *v* notes.
   A. Songs with a single *v* note—Pattern 3 (graphs 4 and 5).
   B. Songs with two *v* notes—Pattern 4 (graph 6).

III. Songs with long notes only.
   A. All the notes at or near the same pitch (except for the initial slur in a *U* note)—Pattern 5 (graphs 7–10).
   B. The second and third notes at about the same pitch and higher than the first, the remaining notes at the same pitch as the second and third or slightly lower—Pattern 6 (graphs 11–14).
   C. The second note higher in pitch than the first, the third note lower than the second, the remaining notes at the same pitch as the third or lower.
      a. The final notes higher in pitch than the first note—Pattern 7 (graphs 15–17).
      b. The final notes lower in pitch than the first note—Pattern 8 (graph 18).
   D. The second note higher in pitch than the first, the third and/or fourth higher than the second, the fifth and remaining notes at or near the same pitch as the fourth.
      a. The second and third notes at about the same pitch, the fourth note higher than the third—Pattern 9 (graphs 19–20).
      b. The third note higher in pitch than the second, the fourth and remaining notes at or near the same pitch as the third—Pattern 10 (graphs 21 and 27).
      c. The third note higher in pitch than the second, the fourth higher than the third—Pattern 11 (graph 28).
   E. The second note lower in pitch than the first, the third and remaining notes at about the same pitch as the second or higher.
      a. The third and remaining notes at or near the same pitch as the second—Pattern 12 (graphs 22–25).
      b. The third and remaining notes higher in pitch than the second but lower than the first—Pattern 13 (graph 26).

[1] The term "note" in the outline of song patterns, and hereafter in this paper, refers to any of the nine types described above, including doublets and triplets.

F. The first and second notes at or near the same pitch (the second not more than 1½ intervals lower than the first), the third at least 3 intervals lower than the second, the remaining notes at the same pitch as the third or slightly lower—Pattern 14 (graphs 29 and 30).

G. The first three notes at or near the same pitch, the fourth and remaining notes at least 3 intervals lower—Pattern 15 (graph 31).

Variations within each pattern were in (1) the types of notes in the song (Table 2), (2) the pitch of the first note (Table 5), (3) the amount of pitch change between notes (Table 6), (4) the length of various notes (Table 3), (5) the length of the song and the number of notes it contained (Table 4), and (6) the relative loudness of different notes in the song. Each of these variations was encountered in the songs of a given bird, but some (particularly nos. 1, 2, 3, and 6) were much more pronounced in the songs of different birds. The first note of the song was the one subject to the most variation in length. The length of the song is determined principally by the number of notes it contains, and this varied considerably, even in the songs of a given individual; the songs of a given pattern always started as shown in the figures, but would end anywhere, even in the middle of a triplet. Songs that ended after the first two or three notes could often be assigned to pattern only on the basis of longer songs of the same bird, since most birds sang songs of just one pattern. Many songs had one note (usually the first) noticeably weaker than the others, or they had one or more notes (usually the second, third, and/or the fourth) noticeably louder than the others. Some of the variations in each of the 15 song patterns are summarized in Tables 2 through 6.

The graphs of the song patterns (Figure 1) were drawn to scale from sound spectrographs; pitch changes are shown on a musical interval scale. The note lengths and pitch changes shown in most of the figures represent the average found in songs of the particular pattern and pattern variation shown. Only a single final triplet (or doublet) is shown in most of the figures; the maximum number found in the songs of each pattern is indicated in Table 2.

Four of the 15 song patterns were sung by 411 (94.9 per cent) of the 433 birds recorded (10 of these birds sang two of the four patterns) and by 275 (98.9 per cent) of the 278 birds observed but not recorded. These four patterns (Patterns 3, 6, 7, and 14) may be considered typical song patterns of the White-throated Sparrow, while the other 11 patterns (sung by 5.8 per cent of the recorded birds and 1.1 per cent of the birds not recorded) may be considered rare or unusual. Patterns 6 and 7 are widely distributed, Pattern 3 is principally an eastern pattern, and Pattern 14 is principally a midwestern and western pattern.

TABLE 2

SUMMARY OF PATTERN VARIATIONS IN THE SONGS OF THE WHITE-THROATED SPARROWS RECORDED

Song pattern		*Number of birds from*													
No.	*Note variation*[a]	*N.C.*	*Ohio*	*Que.*	*N.B.*	*Me.*	*Vt.*	*Mass.*	*N.Y.*	*Ont.*	*Minn.*	*Man.*	*Alta.*	*B.C.*	*Total birds*
1	$s_{10}ST_2$											1			1
2	$s_{10}SSD_3$											2			2
	s_8FST_3											1			1
	$s_{10}SSS$											1			1
	s_9SST_1											1			1
	Undet.											1			1
	Total[b]											5_1			5_1
3	$SDvST_4$			4	1	24		1	4	2					36
	$SSvST_4$			3	1	4			1	1					10
	$SDvSD_4$			1											1
	$STvST_1$					1									1
	Undet.			1											1
	Total[b]			9	2	25_1		1	5	2_1					44_5
4	$SSvSvSD_6$					1									1
5	TUT_4	1													1
	TST_3	1													1
	UT_4	1													1
	T_6	1													1
	$SSSD_4$									1					1
	Total[b]	1_1								1					2_1
6	$LTUT_1$									1					1
	$SDST_3$		2			3				1					6
	$SDUT_4$		1	1						3		1			6
	SSSS		1			1			1						3
	$SSST_1$		3							1					4
	$SSUT_7$					1				1					2
	ST_1		2			1				2					5
	$STSST_3$					1				1					2
	$STST_4$		6			2	2			12			2	2	26
	$STUD_1$									1					1
	$STUT_5$	1	12	9	4	38	3		7	107	1	12	2	1	197
	Undet.			4						9					13
	Total[b]	1	27	14	4	45_2	5		8	134_6	1	13	4	3	259_8
7	$LTUT_2$									1					1
	$SDST_4$					3	1		1	1		1			7
	$SDUT_3$					2									2
	SSSS											1			1
	$SSST_3$		2			1			2	5		2			12
	SST_1											1			1
	ST_3					1				1					2
	$STST_4$	1	1	1		8			4	8		1	1		25
	$STUT_4$					1				2					3
	$TTST_3$					1									1
	UT_2									1					1
	Total[b]	1	3	1		11_6	1		6_1	16_3		5	1		45_{10}

TABLE 2 *(Continued)*

Song pattern		*Number of birds from*													*Total birds*
No.	*Note variation*[a]	*N.C.*	*Ohio*	*Que.*	*N.B.*	*Me.*	*Vt.*	*Mass.*	*N.Y.*	*Ont.*	*Minn.*	*Man.*	*Alta.*	*B.C.*	
8	$SDSST_5$					1			1						2
	$SSSSD_1$					1									1
	$STSST_4$					1			1						2
	Total[b]					2_1			1_1						3_2
9	$STUT_3$			1											1
	$SSTST_2$										1				1
	$USTST_2$										1				1
	Total[b]			1							1_1				2_1
10	$LTUT_4$					1									1
	$STUT_2$					1									1
	SSSUT								1						1
	SSTS								1						1
	$SSSST_4$								1						1
	$STST_2$								1						1
	Total[b]					1_1			3_1						4_2
11	$LTUTST_5$					1									1
12	$STTST_2$	1													1
	$STUT_3$	1													1
	DT_3	1													1
	ST_3	1													1
	RTUT$_3$	1													1
	$SST_{3\frac{2}{3}}$	1							1						2
	$SSST_5$								1						1
	$SSSST_3$								1						1
	TUT_2	1													1
	Total[b]	2_1							2_1						4_2
13	$SSTUT_1$		1												1
14	$SSST_4$	3	10	2	2	2	2	3	47		1		1		73
15	$SSSST_3$								1						1
Total Birds[c]		6_2	40_1	27	8	85_3	8	1	20_2	202_5	1	26	4	5	433_{13}

[a] Subscript numbers in these note formulae represent the maximum number of notes (of the type indicated) found in the songs studied. In a few cases ("Undet.") the note types present could not be definitely determined.

[b] Subscript numbers represent the number of birds with two or more variations.

[c] Subscript numbers represent the number of birds with two song patterns.

Six of the 433 recorded birds (1.4 per cent) sang songs that ended in doublets instead of triplets: 1 from Quebec (Pattern 3), 2 from Maine (Patterns 4 and 8), 2 from Ontario (Patterns 5 and 6), and 1 from Manitoba (Pattern 2) (see Table 2). The occurrence of this feature in Whitethroat songs is thus not restricted to western birds, as Saunders (1935: 270) suggested.

TABLE 3

VARIATIONS IN NOTE LENGTHS (IN SECONDS) IN WHITE-THROATED SPARROW SONGS

Pattern	*First note*[a]		*Second note*[b]		*Third note*[b]		*Fourth note*[b]		*Final T or D*	
	Range	*Mean*	*Range*	*Mean*	*Range*	*Mean*	*Range*	*Mean*	*Range*	*Mean*
1	1.41–1.51	1.45	0.41–0.43	0.41	0.42–0.43	0.43	–	–	0.41–0.43	0.42
2	1.06–1.62	1.43	0.41–0.65	0.51	0.40–0.56	0.46	0.48	0.48	0.29–0.48	0.38
3	0.27–1.10	0.76	0.39–0.68	0.48	0.02–0.04	0.03	0.35–0.54	0.41	0.24–0.50	0.39
4	0.60–0.70	0.65	0.26–0.30	0.28	0.03	0.03	0.36–0.40	0.38	0.24–0.27	0.26
5	0.36–0.83	0.54	0.36–0.64	0.42	0.26–0.44	0.36	–	–	0.24–0.44	0.34
6	0.40–1.17	0.67	0.36–0.74	0.57	0.32–0.60	0.40	0.41–0.51	0.46	0.30–0.51	0.40
7	0.41–0.84	0.59	0.32–0.61	0.48	0.30–0.51	0.37	–	–	0.30–0.45	0.37
8	0.50–0.79	0.67	0.36–0.54	0.46	0.34–0.42	0.38	0.32–0.66	0.46	0.27–0.41	0.37
9	0.60–0.86	0.70	0.36–0.59	0.41	0.42–0.45	0.43	0.34–0.38	0.36	0.36–0.40	0.38
10	0.52–0.98	0.76	0.24–0.70	0.52	0.37–0.60	0.45	0.40–0.45	0.43	0.32–0.45	0.38
11	0.72–0.97	0.83	0.58–0.63	0.61	0.39–0.42	0.40	0.50–0.56	0.52	0.36–0.42	0.38
12	0.30–0.67	0.51	0.35–0.58	0.46	0.36–0.41	0.38	0.30–0.34	0.32	0.33–0.63	0.42
13	0.51	0.51	0.48	0.48	0.50	0.50	0.36	0.36	0.40	0.40
14	0.46–0.82	0.61	0.30–0.55	0.44	0.28–0.50	0.39	–	–	0.34–0.52	0.41
15	0.42	0.42	0.42	0.42	0.57	0.57	0.27	0.27	0.38–0.55	0.44
All birds[c]	0.27–1.17	0.68	0.24–0.74	0.52	0.02–0.60	0.31	0.27–0.66	0.41	0.24–0.63	0.39

[a] Includes the series of *s* notes in the cases of Patterns 1 and 2.
[b] Does not include instances where this note is in the final series of T or D notes.
[c] Excluding the data for the first note in the case of Patterns 1 and 2.

Most published descriptions of White-throated Sparrow songs paraphrase the songs as *Old Sam Peabody Peabody Peabody* (or something similar), indicating a song consisting of two long steady notes (*S*, *L*, or *U*) followed by triplets. It is interesting to note that in the birds studied there were only three with such songs (SST_{1+}; see Table 2). One of these was a bird from Manitoba, represented in the recordings by 11 Pattern 7 songs, only one of which was *SST*; another was a bird from Ontario represented by 2 Pattern 12 *SST* songs; the third was a bird from North Carolina represented by 18 Pattern 12 songs, only one of which was *SST*.

Many writers (e.g., Saunders, 1935) have commented on the musical qualities of White-throat songs, and Arlton (1949) has used musical symbols to describe them. The implication in these accounts is that the notes are steady in pitch and the pitch changes follow our musical scale; neither implication is supported by our studies. Many notes rise or fall slightly (sometimes as much as an interval or more), and there is usually a drop in pitch of about half an interval through the final triplets. The changes in pitch through the song are very rarely an integral number of intervals (see Table 6). Songs of the White-throated Sparrow are *relatively* musical, but the birds do not stay on key very well, and the changes in pitch in their songs do *not* follow our musical scale.

TABLE 4

VARIATION IN THE LENGTH OF WHITE-THROATED SPARROW SONGS

Pattern	*Number of final triplets*[a]			*Song length (in seconds)*		
	Number of songs studied	*Range*	*Mean*	*Number of songs studied*[b]	*Range*	*Mean*
1	3	0–2	1.0	3	1.92–2.96	2.46
2	25	0–3	1.4	12	1.52–4.20	3.23
3	272	0–4	1.7	94	1.52–4.86	2.83
4	5	2–6	4.0	3	2.67–4.07	3.43
5	25	0–5	3.1	15	1.42–3.44	2.64
6	704	0–7	1.5	205	1.24–5.94	2.77
7	206	0–5	2.3	63	2.00–4.16	2.92
8	14	0–5	2.8	3	2.25–4.41	3.12
9	13	0–3	1.0	6	1.72–3.70	2.76
10	62	0–4	2.1	17	1.52–4.50	3.24
11	44	0–5	2.1	10	2.00–6.06	4.09
12	25	0–5	1.9	11	1.44–4.46	3.01
13	1	1	1.0	1	2.84	2.84
14	113	0–4	2.1	39	1.70–3.85	2.85
15	1	3	3.0	1	3.56	3.56
All songs	1,513	0–7	1.8	483	1.24–6.06	2.87

[a] Includes the number of final doublets in the case of songs ending in doublets.

[b] The number of songs graphed, excluding two in which a part of the song was distorted and the length could not be accurately determined.

SONG VARIATION IN INDIVIDUAL BIRDS

Most (390) of the 433 birds whose songs were studied from recordings were represented by a single recording; the single recordings contained from 1 to 28 songs each. Only 34 birds were represented by more than one recording: 14 birds by two recordings, 5 by three recordings, 6 by four recordings, 7 by five recordings, and 2 by seven recordings. These 34 birds nested on a 30-acre peninsula at the north end of Hog Island, Lincoln County, Maine, where Borror made recordings in eight consecutive summers. Recordings made in the same general area in a given nesting season and containing songs of the same pattern and pitch characteristics were assumed to be from the same bird (none of these birds was color-banded or otherwise marked for individual recognition). There were three instances of what was assumed to be the same bird in approximately the same portion of this area for three successive seasons; one of these birds had two song patterns and the songs of each pattern each year had similar pitch characteristics; another had Pattern 3 songs and the third Pattern 10 songs with similar pitch characteristics each year.

Variation in song pattern.—Thirteen (3.0 per cent) of the 433 recorded birds sang songs of two patterns; the rest sang songs of a single pattern. These 13 birds were as follows: *North Carolina*, 2 of 6 migrant birds (Pat-

TABLE 5

PITCH VARIATIONS IN WHITE-THROATED SPARROW SONGS

Pattern	*Number of songs graphed*	*Pitch range of first note*		*Range of lowest pitch in song*		*Range of highest pitch in song*		*Pitch range of song (in intervals)*	
		cps	*Intervals*	*cps*	*Intervals*	*cps*	*Interva's*	*Range*	*Mean*
1	3	3650–3700	0.2	3450–3550	0.3	3650–3700	0.2	0.7–1.0	0.9
2	12	2800–3500	3.9	2800–3500	3.9	3750–3950	0.9	1.9–6.0	3.6
3	94	2450–3950	8.3	2450–3950	8.3	3550–5200	6.6	3.6–7.0	5.8
4	3	2300–2350	0.4	2300–2350	0.4	2700–3750	5.7	7.9–8.5	8.2
5	15	3400–4600	5.2	2900–4350	7.0	3500–4600	4.7	0.2–4.6	2.0
6	205	2150–4250	11.8	2150–4250	11.8	3050–5400	9.9	0.9–7.9	4.0
7	63	2500–5100	12.4	2500–5100	12.4	3600–6500	10.2	3.3–6.6	4.2
8	3	4600–4900	1.1	3800–4850	4.2	5500–5950	1.4	3.4–6.9	5.6
9	6	2700–2900	1.2	2300–2900	4.0	4200–4350	0.6	6.4–10.4	7.9
10	18	2150–2750	4.3	2150–2750	4.3	3150–4350	5.6	5.5–9.8	8.2
11	10	2250–2500	1.8	2250–2500	1.8	4750–5000	0.9	11.3–12.7	12.3
12	11	4500–5900	4.7	3300–4900	6.8	4500–5900	4.7	3.2–6.7	5.2
13	1	4450	–	3300	–	4450	–	5.2	5.2
14	40	4050–5650	5.8	2700–4250	7.9	4050–4650	2.4	3.7–7.1	5.7
15	1	5500	–	4400	–	5500	–	3.9	3.9
Total	485	2150–5900	17.5	2150–5100	15.0	3050–6500	13.1	0.2–12.7	4.8

terns 5 and 12, 7 and 14); *Ohio*, 1 of 40 migrant birds (Patterns 6 and 13); *New York*, 1 of 13 migrant birds (Patterns 6 and 7), and 1 of 7 birds on their nesting territory (Patterns 6 and 14); *Maine*, 3 of 85 birds on their nesting territories (2 with Patterns 3 and 6, 1 with Patterns 6 and 7); *Ontario*, 5 of 201 birds on their nesting territories (2 with Patterns 6 and 14, 2 with Patterns 7 and 14, and 1 with Patterns 6 and 10).

Four (6.8 per cent) of 59 migrant birds had two song patterns, while only 9 of 374 (0.2 per cent) birds on their nesting territories had two song patterns. The difference is not highly significant (Chi-square = 3.35), but suggests that the occurrence of two song patterns is more common in migrants than in birds on their nesting territories.

Variation in note types.—The variations in note types present in the recorded songs are shown in Table 2; the subscript numbers in the totals for each pattern give an indication of the number of birds with two or more variations of the notes in their songs. Of the 433 recorded birds, 30 showed variations in the notes of their songs: 1 from *North Carolina* with ten variations (in two patterns, 5 and 12); 12 from *Maine* with two variations and 1 with three; 13 from *Ontario* with two variations; and 1 from *New York* (on its nesting territory) with two variations. One of 59 migrants (1.7 per cent) and 29 of 374 birds on their nesting territories (7.8 per cent) showed variations in the notes of their songs; this difference is not highly significant (Chi square = 2.90). The North Carolina migrant

TABLE 6

VARIATIONS IN PITCH CHANGES (IN INTERVALS) IN WHITE-THROATED SPARROW SONGS[a]

Pattern	*Notes 1 to 2*		*Notes 2 to 3*		*Notes 3 to 4*		*Up-slur of* U		*Notes 4+*	
	Range	*Mean*	*Range*	*Mean*	*Range*	*Mean*	*Range*	*Mean*	*Range*	*Mean*
1	0.0	0.0	0.3^{F}	0.3^{F}	0.2^{F}	0.2^{F}	–	–	–	–
2	0.0–0.3^{F}	0.0	1.9^{R}–6.0^{R}	3.6^{R}	0.0–0.2^{F}	0.0	–	–	0.0–0.2^{F}	0.1^{F}
3	3.6^{R}–6.6^{R}	5.6^{R}	2.0^{F}–4.4^{F}	3.3^{F}	1.8^{R}–4.4^{R}	3.2^{R}	–	–	0.2^{R}–1.3^{F}	0.2^{F}
4	7.9^{R}–8.5^{R}	8.2^{R}	2.0^{F}–3.4^{F}	2.7^{F}	2.0^{R}–3.4^{R}	2.7^{R}	–	–	0.0–0.2^{F}	0.1^{F}
5	1.0^{R}–0.6^{F}	0.0	0.3^{R}–0.5^{F}	0.2^{F}	0.3^{R}–0.5^{F}	0.1^{F}	1.9–3.0	2.3	0.3^{R}–0.5^{F}	0.1^{F}
6	0.4^{R}–6.6^{R}	3.1^{R}	0.3^{R}–0.8^{F}	0.1^{F}	0.7^{R}–0.6^{F}	0.1^{F}	1.2–6.2	3.5	0.2^{R}–0.8^{F}	0.1^{F}
7	3.0^{R}–6.6^{R}	4.1^{R}	0.4^{F}–3.2^{F}	1.9^{F}	0.0–1.0^{F}	0.4^{F}	1.4–2.0	1.8	0.0–0.7^{F}	0.0
8	3.1^{R}–3.4^{R}	3.3^{R}	1.7^{F}–2.5^{F}	1.9^{F}	4.7^{F}–5.2^{F}	4.9^{F}	–	–	0.0	0.0
9	4.4^{R}–5.5^{R}	4.9^{R}	0.0	0.0	0.9^{R}–2.7^{R}	2.2^{R}	0.6–3.4	1.7	0.0	0.0
10	3.5^{R}–6.0^{R}	5.0^{R}	2.0^{R}–5.3^{R}	3.3^{R}	0.2^{R}–0.2^{F}	0.0	0.8–5.5	4.1	0.0–0.3^{F}	0.1^{F}
11	4.3^{R}–6.0^{R}	5.2^{R}	1.8^{R}–3.2^{R}	2.9^{R}	3.4^{R}–3.9^{R}	3.6^{R}	3.9–5.1	4.4	0.6^{F}–0.8^{F}	0.6^{F}
12	2.5^{F}–5.8^{F}	4.3^{F}	0.0–0.5^{F}	0.2^{F}	0.0–0.5^{F}	0.1^{F}	0.7–2.2	1.6	0.0–1.5^{F}	0.3^{F}
13	5.2^{F}	5.2^{F}	2.9^{R}	2.9^{R}	0.0	0.0	2.9	2.9	0.2^{F}	0.2^{F}
14	0.0–1.5^{F}	0.6^{F}	3.4^{F}–5.8^{F}	4.4^{F}	0.0–1.8^{F}	0.5^{F}	–	–	0.0–0.7^{F}	0.2^{F}
15	0.0	0.0	0.0	0.0	3.9^{F}	3.9^{F}	–	–	0.0	0.0

[a] In the case of notes that rise or fall in pitch gradually throughout, the pitch change given is that from the end of one note to the beginning of the next; in the case of *U* notes, the pitch change given is that to or from the upper pitch of the *U* note.

[F] A fall in pitch.

[R] A rise in pitch.

showed much more variation in the notes of its songs than any birds on their nesting territories. The notes subject to variation differed somewhat in different patterns, but generally (in 19 of the 30 birds) it was the second note that varied; 8 birds showed variation in the third note, 7 showed variation in the first note, and 1 showed variation in the fourth note.

Variation in length.—The songs of a given pattern always began as shown in the figures, but ended at various points, even in the middle of a triplet. Most songs went at least to the first of the final triplets (only one of which is shown in most of the figures), and the number of final triplets usually varied in the songs of a given bird (see Table 7). The greatest variation found in a single bird was in the bird that sang Pattern 11 songs, where the number of notes in the song varied from 3 to 10, and the song length from 2.00 to 6.06 seconds. No correlation was found between song length and time of day, season, or the age of the bird.

Variation in pitch and pitch changes.—The variations in pitch and pitch changes in the songs of several individual birds are shown in Table 7. In most birds of which two or more songs were graphed there was some difference in the pitch of the first note and in the pitch changes through the song, but these differences were usually less than an interval. In some cases, however (e.g., eight of the birds shown in Table 7), the differences

TABLE 7

SUMMARY OF SOME VARIATIONS IN THE SONGS OF INDIVIDUAL WHITE-THROATED SPARROWS

Pattern	*Bird*[a]	*Number of songs*[b]		*Length of first note (seconds)*	*Variation in pitch of first note*		*First pitch change (intervals)*	*Second pitch change (intervals)*	*Third pitch change (intervals)*	*Number of final T*	*Song length (seconds)*
		Gr.	*Ex.*		*cps*	*Intervals*					
2	202	4	10	1.23–1.57†	3000–3050	0.3	3.6[r]–3.9[r]	–	–	0–2[d]	2.76–3.66
	206	4	4	1.46–1.62†	3450–3550	0.5	1.9	–	–	0–1	1.52–3.44
3	119	32	32	0.67–1.10	2950–3250	1.7	5.3[r]–6.2[r]	3.0[f]–4.1[f]	–	0–1	1.53–2.84
	126	6	37	0.53–0.64	3000–3650	3.4	5.5[r]–6.2[r]	2.5[f]–4.1[f]	0.0–1.3[I]	0–3	2.90–3.48
	137	8	16	0.44–0.64	3300–3500	1.0	3.6[r]–4.3[r]	2.9[f]–3.9[f]	0.6–1.1[I]	0–3	1.80–3.41
5	2	10	10	0.36–0.83	3400–3500	0.5	0.9[r]–0.5[f]	–	–	⅔–5	1.51–3.44
	240	5	15	0.44–0.58	4400–4600	0.8	–	–	–	0–4	1.42–3.08
6	90	8	25	0.62–0.68	3850–3950	0.4	0.4[r]–1.1[r]	–	–	0	1.48–2.06
	118	7	41	0.56–0.64	3550–3750	1.0	2.4[r]–2.6[r]	–	0.8–1.3[I]	0–4	1.94–4.06
	136	18	18	0.55–0.64	2900–3250	2.0	3.2[r]–3.9[r]	–	0.0–0.2[I]	1–4	2.32–3.94
	137	7	15	0.53–0.62	3400–3500	0.5	3.2[r]–4.1[r]	–	–	0–3	1.80–3.46
7	134	28	28	0.46–0.73	4300–4800	1.9	3.6[r]–4.6[r]	1.9[f]–2.9[f]	0.0–0.6[f]	2–3	2.55–3.40
9	198	5	12	0.60–0.71	2750–2900	0.9	4.4[r]–5.1[r]	2.3[r]–2.7[r]	–	0–2	1.72–3.16
10	122	13	52	0.64–0.83	2450–2750	2.0	4.5[r]–6.0[r]	2.6[r]–3.5[r]	–	0–4	1.52–4.15
11	148	10	44	0.72–0.97	2250–2500	1.8	4.3[r]–6.0[r]	1.8[r]–3.2[r]	3.4[r]–3.9[r]	0–5	2.00–6.06
12	2	6	17	0.30–0.67	4500–5200	2.5	2.9[f]–5.8[f]	–	–	0–3	1.44–3.74

[a] The birds are indicated by number, as follows: 202, Riding Mountain National Park, Manitoba, 30 June 1956; 206, same, 27 June 1958; 119, Hog Island, Lincoln County, Maine, 11 June to 12 July 1960; 126, same, 28 June 1960; 28 June to 6 July 1961; 17 June to 19 July 1962; 137, same, 27 June to 2 August 1961; 2, Greensboro, North Carolina, 15 April 1960; 240, Temagami District, Ontario, 4 June 1960; 90, Hog Island, Lincoln County, Maine, 8 July 1956, 12 June 1957, 18 June 1958; 118, same, 11 June to 20 July 1960; 136, same, 18 June to 6 August 1961; 137, same, 27 June to 2 August 1961; 134, same, 13 June to 3 August 1961; 198, The Pas, Manitoba, 6 July 1954; 122, Hog Island, Lincoln County, Maine, 19 June to 13 July 1960; 28 June to 19 July 1961; 15 June 1962; 148, same, 15 June to 13 July 1962.

[b] The number of final triplets is based on the number of songs examined (Ex.); other data are based on the number of songs graphed (Gr.).

[d] The final notes were *D* notes.

[f] A fall in pitch.

[r] A rise in pitch.

† The length of the first note refers to the series of *s* notes.

[I] Fall in pitch from the fourth note to the end of the song.

in the pitch of the first note ranged over more than an interval. The greatest variation in the pitch of the first note, found in bird no. 126 (a bird that was recorded over three successive seasons), was 3.4 intervals. It is possible that it was not the same bird that occurred in this area each season, but the variation in 1961 was 1.2 intervals, and the variation in some birds recorded during only a single season was between 1.5 and 2.5 intervals (1.7 for no. 119, 2.0 for no. 136, 1.9 for no. 134, 2.0 for no. 122, and 2.5 for no. 2). The differences in changes of pitch through the song were generally over less than an interval, but were over more than an interval in a few cases (nos. 122, 137, and 148 in Table 7). In bird no. 122 the rise in pitch between the first and second notes was a little less the third year than the first two years (5.1–6.0 intervals in 1960, 5.1–5.8 in 1961, and 4.5–5.0 in 1962).

One of the birds studied, a bird from British Columbia (Gunn, Cut 43), sang, more or less alternately, two slightly different Pattern 6 songs, the two differing in the amount of pitch rise between the first two notes. This pitch rise varied from 1.8 to 2.3 intervals in one song, and from 4.9 to 5.0 intervals in the other. In the first song there was a pitch drop through the second note of about half an interval; in the second song this note was steady in pitch. The songs of the first type were *STST*, but the majority of them contained only the first two notes; all the songs of the second type were two-noted (*ST*), and were *assumed* to be Pattern 6 songs.

GEOGRAPHIC VARIATION IN WHITE-THROATED SPARROW SONGS

Studies of geographic variation in passerine songs (e.g., Borror, 1956, 1959, 1961) indicate that variation may occur in the character of the notes and phrases in the song, in phrase rate, in the number of notes per phrase, and in pattern preference. There are considerable portions of the White-throated Sparrow's breeding range from which we still have no data (e.g., Saskatchewan, Alberta, Yukon Territory, and much of Quebec), but it seems safe to say that the geographic variation in the songs of this species is principally in pattern preference. Relatively few song patterns are sung by this sparrow, and their incidence among the population differs in different geographic areas.

Of the 15 song patterns here described, 11 were sung by only 27 (3.8 per cent) of the 711 birds studied (24 of the recorded birds and 3 of the birds not recorded) (Table 8). The number of birds that sang these patterns is too small to permit any generalizations regarding their geographic distribution. The apparently random distribution of these 11 less common patterns might be explained by considering them as variations of similar patterns whose incidence was greater (e.g., Pattern 4 from Pattern 3, Pat-

TABLE 8

CHARACTERS OF PATTERN 6 SONGS IN BIRDS FROM DIFFERENT AREAS (MEANS ARE GIVEN PLUS OR MINUS THE STANDARD ERROR)

Character		*Quebec*	*Maine*	*New York*	*Ontario*	*Ohio*	*Manitoba*
Lowest pitch in the song (cps)	Range	2400–3600	2600–3900	2800–3400	2150–4250	3000–3800	2700–3400
	Mean	3000±135	3206±20	3105±67	3208±67	3433±95	3150±128
Pitch rise, notes 1 to 2 (intervals)	Range	3.2–6.0	0.4–6.6	1.7–6.1	1.9–6.3	2.2–4.1	2.2–3.7
	Mean	4.4±0.4	2.6±0.1	3.0±0.5	3.6±0.1	2.3±0.2	2.6±0.3
Pitch fall, note 3 to end (intervals)	Range	0.0–0.3	0.0–1.7	0.0–0.5	0.0–1.5	0.0–1.1	0.0–0.2
	Mean	0.1±0.0	0.2±0.1	0.2±0.1	0.2±0.0	0.5±0.4	0.2±0.1
Length of first note (seconds)	Range	0.52–0.80	0.48–0.80	0.61–0.82	0.44–1.17	0.40–0.69	0.48–1.06
	Mean	0.67±0.04	0.64±0.01	0.67±0.02	0.75±0.02	0.57±0.04	0.62±0.11
Song length (seconds)	Range	1.38–3.90	1.34–4.28	1.36–3.41	1.61–5.94	1.71–3.04	2.30–5.01
	Mean	2.76±0.19	2.88±0.07	2.54±0.18	2.84±0.08	2.14±0.14	3.16±0.47
Number of final T	Range	0–4	0–4	0–3	0–7	0–2	1–4
	Mean	1.75±0.16	1.40±0.09	1.03±0.15	1.54±0.08	0.71±0.24	1.94±0.19

tern 8 from Pattern 7, and Patterns 12, 13, and 15 from Pattern 14). Table 9 shows the relative incidence of the four more common song patterns in different states and provinces.

Pattern 6 (Figure 1, graphs 11–14), by far the most common, was also the most widely distributed, occurring in birds of each state and province for which we have data (except Massachusetts, represented in our data by only one bird). Its incidence was greatest in the central part of the range (Ohio, Ontario, Michigan, Minnesota, and Manitoba), where it was sung by about two birds out of every three. In the east it was sung by only about half the birds, this decrease being coincident with the increase in Pattern 3.

Pattern 14 (graphs 29–30), the second most common pattern, was sung by 132 (18.6 per cent) of the birds studied. This pattern is quite different from Pattern 6, having the first two notes at about the same pitch and the remaining notes considerably lower. This pattern was most common in the central part of the range and least common in the extreme eastern part.

Pattern 3 (graphs 4–5), which differs from Pattern 6 in having a very short but distinctive third note, is primarily an eastern pattern (Tables 2 and 9). From one-fourth to one-third of the birds in Quebec, New Brunswick, and Maine sang this pattern, and it was well represented in Vermont and New York. On the other hand, only 2 of the 391 birds in Ontario sang

TABLE 9

INCIDENCE OF WHITE-THROATED SPARROW SONG PATTERNS IN DIFFERENT AREAS[a]

State or province	*Birds with songs of pattern*					*Total birds*[b]
	3	*6*	*7*	*14*	*Other*	
North Carolina		1 16.7	1 16.7	3 50.0	3 50.0	6_2
Ohio		27 67.5	3 7.5	10 25.0	1 2.5	40_1
Quebec	9 33.3	14 51.9	1 3.7	2 7.4	1 3.7	27
New Brunswick	2 25.0	4 50.0		2 25.0		8
Maine	25 29.4	45 52.9	11 12.9	2 2.4	5 5.9	85_3
Vermont	3 15.8	10 52.6	3 15.8	3 15.8		19
Massachusetts	1 100.0					1
New York	8 21.1	17 44.7	11 29.0	5 13.2		38_3
Ontario	2 0.5	264 67.4	28 7.1	95 24.2	9 2.3	392_6
Michigan		6 66.7		3 33.3		9
Minnesota		2 66.7		1 33.3		3
Manitoba		47 63.5	12 16.2	7 9.5	8 10.8	74
Alberta		4 80.0	1 20.0			5
British Columbia		3 75.0		1 25.0		4
Total	50 7.0	444 62.5	71 10.0	134 18.9	27 3.8	711_{15}

[a] Based on both recordings and field observations; the upper figure in each entry is the number of birds, and the lower figure is the percentage of birds from that state or province.

[b] Subscript numbers are numbers of birds with two song patterns.

this pattern and it was not found in any birds in Ohio, Michigan, Minnesota, or the western provinces of Canada.

Pattern 7 (graphs 15–17) resembles Pattern 6 but is generally higher in pitch and has the third and following notes lower in pitch than the second. As did Pattern 6 it had a broad distribution, but it was much less common. It was least common in the extreme east (Quebec and New Brunswick, of the areas represented by a substantial number of birds).

The six birds singing the highly distinctive Pattern 2 (5 recorded, 1 in the field observations), with its curious preamble of several short notes (graphs 2–3), occurred only in Riding Mountain National Park, Manitoba.

This park also provided the only bird singing Pattern 1, which might be considered a variation of Pattern 2. These birds did not form an exclusive colony, but were intermingled with other birds singing other patterns. Pattern 2 may at one time have had a much wider distribution (see following section).

There was little significant geographic variation in the two common song patterns with a wide distribution (Patterns 6 and 7). Some characteristics of Pattern 6 songs from different states and provinces are summarized in Table 8. The Quebec songs averaged lowest in pitch and those from Ohio the highest; the rise in pitch from the first note to the second was greatest in the Quebec songs and least in the songs from Manitoba, but there was no definite trend from east to west in this character. The Manitoba songs averaged the longest, and those from Ohio the shortest. There was no significant variation in the character of the notes in the songs of birds from different areas (Table 2).

The recordings studied did not show any significant geographic variation in the songs of Pattern 14, but the field observations of Gunn indicate that the incidence of songs with a noticeable pitch drop between the first two notes increases as one goes westward in Ontario, and in Manitoba, Alberta, and British Columbia such songs are practically the only Pattern 14 songs one hears. Unfortunately, we do not have enough recorded songs from western areas to show this variation statistically. The Pattern 14 songs of the eastern birds studied (North Carolina, New England, and Quebec) showed a drop in pitch between the first two notes of 0.2 to 1.2 (average, 0.7 ± 0.1) intervals; the songs of the midwestern birds studied (New York, Ohio, and Ontario) showed a drop between these two notes of 0.0 to 1.5 (average, 0.5 ± 0.1) intervals; in one Manitoba bird this drop was 1.1, and in one British Columbia bird it was 1.3.

TEMPORAL VARIATION IN SONG PATTERNS

The White-throated Sparrow songs studied by the writers were recorded over a period of 12 years, 1951–62. Even over this relatively short span of time there is some evidence that pattern distribution and incidence should be treated as dynamic rather than static phenomena.

Table 10 shows the song patterns of White-throated Sparrows in a 30-acre area in Maine during eight successive seasons. No special effort was made from 1955 through 1959 to obtain recordings of every White-throat in the area, so the data for these years may be incomplete, but such data as we have suggest that the relative incidence of birds with Pattern 3 songs has decreased in this area in the last several years (from 3 out of 3 or 4 birds in 1956–57 to 2 out of 12 birds in 1962). Pattern 7 songs were re-

TABLE 10

SONG PATTERNS OF WHITE-THROATED SPARROWS NESTING ON HOG ISLAND, LINCOLN COUNTY, MAINE, 1955–1962

Year	*Number of birds with pattern*				*Total birds*[a]
	3	*6*	*7*	*Other*	
1955		3			3
1956[b]	3	2			4
1957[b]	3	1			3
1958[b]	2	5			6
1959	2	1	2		5
1960	2	4	2	1[c]	9
1961[b]	3	5	2	1[c]	10
1962[b]	2	7	2	2[d]	12

[a] Probably does not include all the birds present, 1955–1959.
[b] One bird with two patterns.
[c] Pattern 10.
[d] Patterns 10 and 11.

corded only in the last four seasons, and Pattern 10 songs only in the last three.

Pattern 2 songs have apparently not always been distributed as they are at present. Snyder (1928), reporting on an ornithological investigation of the Lake Nipigon region of Ontario in the summers of 1923 and 1924, states that about 50 per cent of the White-throat songs he heard in that area were prefaced by a number of short notes all on the same pitch. He made a similar investigation in the western Rainy River district of Ontario in 1929, and recalls hearing the same pattern at Emo, near Fort Frances, Ontario (pers. comm.). While on recording trips in 1956 and 1960, Gunn traversed the region between the north shore of Lake Superior and the Manitoba border a number of times and, though he did not visit the exact location of Snyder's observations, he heard no Pattern 2 songs in this region. An investigation of White-throat songs in June, 1960, in the Falcon Lake area of Manitoba (just west of the Ontario border) failed to reveal any Pattern 2 songs. Riding Mountain National Park, Manitoba, now the only known site of Pattern 2 songs, is more than 500 miles west of Lake Nipigon and about 350 miles west-northwest of Emo. The present distribution of this pattern is apparently quite different from what it was some 35 years ago.

There is some indication that Pattern 2 is rapidly disappearing in Riding Mountain National Park. Gunn is of the opinion that 15 to 20 per cent of the White-throats he heard in the park in 1956 sang this pattern, but in mid-June of 1960 he heard only 1 of 23 birds singing it. An independent check by Mr. W. John Smith at the end of June, 1960, showed virtually the same situation, 1 bird in 28 singing Pattern 2 songs (pers. comm.).

Another case of the same sort concerns the song paraphrasings given by Forbush (1929), Taverner (1934), Peterson (1947), Arlton (1949), and others: *old Sam Peabody Peabody Peabody, sow wheat peverly peverly peverly, hard times Canada Canada Canada,* and the like. The origin of these paraphrasings goes back a long way and they are obviously based on songs that consist of two long steady notes (probably *S* notes) followed by three (more or less) triplets. Saunders (1935) indicates that such a pattern is a common one in the species. It was sung by about 25 per cent of the White-throats he studied in the Adirondacks in the summers of 1925 and 1926 (pers. comm.). It is remarkable that songs of this type were *almost absent* from the songs we studied (see Table 2); only 3 of the 711 birds studied sang songs of this type (see p. 34). No songs of this type (SST_{1+}) were heard by Gunn in the Adirondacks in 1960. The most common pattern variation we found, 6 $STUT_{1+}$, might be paraphrased *tooooo tititi tweee tititi tititi tititi.* This does not imply that the early naturalists were not listening carefully when they did their paraphrasing; it is more likely that their translations represent one or more patterns that were relatively common at one time, particularly in New England, but have since died out.

APPLICATIONS OF KNOWLEDGE OF SONG VARIATION

Variation in song pattern is much less extensive in the White-throated Sparrow than in many other passerines (Borror, 1961) and the different patterns can generally be identified in the field. The ability to recognize different song patterns, and hence different individuals, greatly facilitates the problem of censusing breeding birds and mapping their territories. An hour or two in the field in an area of, say 30 to 40 acres, at a time when the birds are in full song, is usually sufficient to establish the number of males present and their approximate territories. For example, in the summer of 1960 Borror found nine males singing in a 30-acre area in Maine (Table 10); two of these birds with adjacent territories sang Pattern 6 $STUT_{1+}$, and in the field it was necessary to hear these two birds singing at the same time to be sure they were different birds, but when their recorded songs were later graphed it was found that the songs of one of these birds was a little higher in pitch and had less rise in pitch between the first and second notes.

In species such as the White-throated Sparrow, which show some geographic variation in song pattern preference on the nesting grounds and which sing in migration, it should be possible to get some idea of a spring migrant's destination by the song pattern it sings. The absence of Pattern 3 songs (primarily an eastern pattern) in 40 migrants in Ohio (Tables 2 and 8) suggests that birds nesting in New England and the eastern prov-

inces of Canada do not migrate north through Ohio. Similarly, the absence in the migrants studied of Patterns 1 and 2 (which occurred only in Manitoba birds) suggests that the Manitoba birds do not come as far east as Ohio in their spring migration. The similarities in the relative incidence, in Ohio and Ontario birds, of songs of Patterns 6, 7, and 14 suggest that White-throats move more or less directly north in their spring migration. More data on the songs of migrating birds should be of considerable interest in this connection.

Certain general features are common to all the White-throat song patterns we found (clear, whistled notes steady in pitch or nearly so, usually one or two pitch changes through the song, and the song ending in triplets), so it may be assumed that these features are hereditary. Since different birds often sing songs of different patterns, it is likely that the patterns are learned by listening to other birds; the 11 uncommon patterns, each of which occurred in only a few (1 to 5) of the birds studied, might be explained as inaccurate copies of the four more common patterns.

The bird with a Pattern 11 song occurred in an area in Maine where Borror has been recording White-throats for several years, yet this particular pattern had never been heard there before (and to our knowledge has never been heard anywhere else). This Pattern 11 bird nested on Hog Island during the summer of 1962, and a bird with a somewhat similar pattern (Pattern 10) nested about 200 yards away in 1960, 1961, and 1962; perhaps the Pattern 11 bird heard the Pattern 10 song when it was young (assuming it was hatched on Hog Island), and developed its own song as a somewhat inaccurate copy of the Pattern 10 song.

The bird with the Pattern 4 song occurred on Harbor Island, Knox County, Maine, in 1961. Harbor Island is located in Muscongus Bay, several miles from the nearest mainland. We have recordings of seven White-throats from this island; three sang Pattern 3 songs, two sang Pattern 6 songs, one sang Pattern 8 songs, and one sang Pattern 4 songs. The Pattern 4 song probably represents an inaccurate copy of a Pattern 3 song. Two of the Harbor Island White-throats sang uncommon patterns (4 and 8), and the songs of these birds ended in doublets instead of triplets. Perhaps birds in more or less isolated areas may be the ones more likely to develop unusual songs.

SUMMARY

This paper is based on a study, by means of a sound spectrograph, of the recorded songs of 433 birds and field observations of 278 additional birds; these 711 birds were in eight states of the United States and six provinces of Canada.

White-throated Sparrow songs consist of a series of clear, whistled notes, and usually end in triplets. The songs studied contained 9 types of notes, and were classified in 15 patterns on the basis of note character and pitch changes through the song. The songs of each pattern varied in several ways; each type of variation was found in the songs of a given bird, but some types were more pronounced in songs of different birds.

Four of the 15 song patterns were sung by 96.5 per cent of the birds studied. The most common pattern, sung by 62.5 per cent, had the first note low, the second higher, the third about the same pitch as the second, and the remaining notes at the same pitch as the third or slightly lower; the most common variation of this pattern, sung by 197 birds, might be paraphrased *tooooo tititi tweee tititi tititi tititi.* Only 3 of the 711 birds sang songs consisting of two long, steady notes followed by triplets, the pattern suggested by the common descriptions of this species' song in the literature.

The range of pitch in the songs studied was 2,150 to 6,500 cps; the range of pitch in individual songs varied from 0.2 to 12.7 musical intervals. The amount of change in pitch through the song varied in a given pattern, principally in songs of different birds, sometimes as much as 5 intervals. The first note of the song varied in length from 0.27 to 1.17 seconds, and the entire song from 1.24 to 6.06 seconds. The songs of each pattern followed a definite sequence of notes, but ended at various points; most songs ended in triplets (up to a maximum of 7), but 6 birds had songs ending in two-parted notes.

Of the 711 birds, 15 sang songs of two patterns; the others sang songs of a single pattern. Of the 433 recorded birds, 30 showed variations in the types of notes in the song; the second note varied most often. Most birds showed variations, usually less than an interval, in the pitch of the first note of the song and in the amount of pitch change through the song. The songs of migrants were more variable than those of nesting birds.

Two of the four most common song patterns were widely distributed; one was primarily eastern, the other was most common in the midwest. The differences in songs of a given pattern from different areas were rarely significant.

The relative incidence of different patterns in a given area may vary from year to year, and some patterns once common in certain areas are now rare or absent there. The pattern on which the widely quoted paraphrasing (*old Sam Peabody Peabody Peabody*) is based is now apparently quite rare.

There are relatively few patterns in the song of the White-throated Sparrow, and these are generally recognizable in the field. Since each bird usually sings songs of a single pattern, it is often possible to recognize

individual birds; this is of value in censusing breeding birds and mapping territories. Since this species sings in spring migration, songs of migrants suggest their destination. A White-throat's song pattern is probably learned from other birds; occasionally a bird develops an inaccurate copy of another song, resulting in an unusual pattern; 11 such patterns were found, in 27 of the 711 birds.

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