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Changes in Five-striped Sparrow song in intra- and intersexual contexts.—Primary song in passerine birds transmits varied information which may have intrasexual and/or intersexual functions, and the types of songs employed have been influenced, in part, by intrasexual and/or intersexual selection. Catchpole (pp. 297–319 in *Acoustic Communication in Birds*, D. E. Kroodsma and E. H. Miller, eds., Academic Press, New York, New York, 1982) discussed the influence of sexual selection on bird song and developed a model which related inter- and intrasexual selection to two main types of song in passerines. In short, intersexual selection involves direct female choice of mate based on males' songs. Primary songs modified for female attraction are long, complex, and variable. Intrasexual selection involves indirect female choice based on the ability of males to repel rival males when obtaining and maintaining control of a territory. Primary songs modified for male repulsion are short, simple, and stereotyped.

Primary songs, however, may have dual functions—one directed at females and one directed at males. In order for this to occur, a bird must be able to change its songs or song patterning accordingly. Birds with single song repertoires can change the character of their delivery only by temporal means or by adding and deleting song components (note complexes). Ficken and Ficken (*Behaviour* 46:114–127, 1973) demonstrated that Golden-winged Warblers (*Vermivora chrysoptera*), which have simple, stereotyped songs, varied their responses to a playback tape depending on the number of terminal trills included in the playback song. Birds with large song repertoires have more options available to them. In addition to increasing or decreasing the rate of song delivery, the kinds of different song types used can be changed, or the pattern of delivery of the song types can be altered. Marsh Wrens (*Cistothorus palustris*) (Verner, *Living Bird* 14:263–300, 1975), Eastern Meadowlarks (*Sturnella magna*) (d'Agincourt and Falls, *Can. J. Zool.* 61:1086–1093, 1982), and Five-striped Sparrows (*Aimophila quinquestriata*; sensu Paynter, pp. 3–214 in *Checklist of Birds of the World*, R. A. Paynter, Jr. and R. W. Storer, eds., Harvard Univ. Press, Cambridge, Massachusetts, 1970) (Groschupf and Mills, *Condor* 84:226–236, 1982) vary their song bouts in this manner.

Yet another way of producing differences in songs and song bouts is to change the ordering of within-song components. This rarely occurs, as most birds have highly ordered note complexes within songs, but it does occur in at least two species, the Sedge Warbler (*Acrocephalus schoenobaenus*) (Catchpole, *Behaviour* 59:226–245, 1975) and the Five-striped Sparrow (Groschupf and Mills 1982). Five-striped Sparrow songs consist of an introductory note followed by one–six (usually two) note complexes. An individual has approximately 200 different song types which are comprised of about 45 different note complexes. New songs are made up of reordered note complexes rather than new note complexes. Song bouts may consist of one song type sung repeatedly or they may consist of several different song types sung in an unpredictable pattern. The purpose of this study was to determine whether Five-striped Sparrow note complex and song type use and delivery within songs and bouts were related to intra- or intersexual contexts. Using Catchpole's (1982) model, one would predict that songs and song bouts sung in an intrasexual context (those sung in response to playback of male's song) would be less variable and more simple than those sung in an intersexual context (those sung in the presence of a female).

Methods.—A "population" of Five-striped Sparrows southwest of Patagonia, Santa Cruz Co., Arizona, provided an ideal situation for the study. The "population" consisted of one pair of birds; the nearest known Five-striped Sparrows were located at Chino Canyon, 24 km NW of Patagonia (Mills, *Western Birds* 8:121–130, 1977). Thus, there were no male/male interactions possible during the study period. The male, SC8, was recorded 10 May–

28 July 1978. Most recordings were of spontaneous songs, but on a few occasions playback songs were used, and they now provide the basis for intrasexual interactions in this study.

Song bouts used for data analyses were selected based on the following requirements: (1) song bouts consisted of at least 10 songs; (2) both pre- and post-playback songs were recorded; (3) pre-playback songs were sung spontaneously and in the presence of SC8's mate; and (4) playback consisted of SC8's pre-playback song bout. Only five situations on four different dates were found which met all these requirements. Since members of a pair are rarely separated (Mills et al., *Living Bird* 18:95–110, 1980), in all situations SC8 was either singing while foraging with his mate, or he was singing perched near the foraging female. Playback was performed while SC8 was in view, and it was played inside his territory boundary. Five-striped Sparrows do share some note complexes. Of 81 different note complexes sung by three different males, 15 note complexes were shared by all three males (Groschupf and Mills 1982). Therefore, by using SC8's recently sung songs as playback, the possible effect that "unrecognizable" note complexes (those not included in SC8's repertoire) might have on his response would be eliminated. A maximum of 20 songs from each bout (those either immediately preceding or immediately following playback) was used. Song bouts sung during pre- and post-playback were sonographically analyzed to determine the types and numbers of songs and note complexes used. Songs were recorded with a 110 Sony cassette tape recorder at a tape speed of 18.7 cps with a Gibson EPM microphone and were analyzed with a Kay Elemetrics Company model 6061A Sona-Graph at the wide band-pass setting and by listening to playbacks at one quarter (4.5 cps) speed.

Results.—Song playback induced an immediate change in SC8's behavior. Upon hearing playback, he flew or sneaked silently along the ground towards the speaker, and then began to vocalize as he approached to within 10 m. Initial vocalizations included *chucks*, *pips*, "alarm," and "pair bond" calls (Groschupf and Mills 1982) which were sometimes interspersed later between songs. It was shown previously for Five-striped Sparrows that there is a negative relationship between song pattern variability and intersong interval (Groschupf and Mills, *Auk* 95:758–760, 1978), but a comparison of intersong intervals or singing rates of songs sung before and after playback would not be valid in the present study because of the inclusion of non-song vocalizations (e.g., *chucks*, "alarm" calls). Delivery of songs within bouts which do not include other vocalizations may be faster, or even slower, than song bouts which do.

The data show that all songs and song bouts sung immediately after playback were less variable and more simple than those sung preceding playback, as predicted. The numbers of different song and note complex types used after playback were significantly less than the numbers used prior to playback (for each, $P < 0.05$, one-tailed Wilcoxon paired sample test [Zar, *Biostatistical Analysis*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1974]) (Table 1). Pre-playback songs consisted of one–five note complexes; post-playback songs consisted of only one–three note complexes. Of the total songs recorded, post-playback songs almost always (90%) were comprised of only one note complex type, whereas prior to playback, songs often (43%) consisted of more than one note complex type which were sung in various positions within songs in a given bout (Table 2). Because almost all post-playback bouts consisted of songs comprised of only one or two note complexes (95%), as compared to the pre-playback bouts which consisted of several three, four, and five note complex songs (37%), post-playback songs tended to be shorter than pre-playback songs. In addition, SC8 often sang different note complexes, and hence, songs, during playback than during pre-playback even though the songs he had heard during playback were the same as those he had just sung (Table 2).

Discussion.—Five-striped Sparrow songs and song bouts are variable in the type, number, and sequence of note complexes used. Complexity and versatility of song bouts, as measured

TABLE 1
 QUANTITATIVE SUMMARY OF SONG AND SONG BOUT CHARACTERISTICS BEFORE (PR) AND
 AFTER (PO) PLAYBACK

	10 May		10 May		21 May		19 July		28 July		Total	
	Pr	Po	Pr	Po	Pr	Po	Pr	Po	Pr	Po	Pr	Po
No. of songs in bout	13	20	20	20	12	10	16	18	20	12	81	80
No. of diff. songs	5	2	6	2	4	4	8	3	11	6	30	10
No. of diff. note complexes	3	2	4	1	5	4	4	3	3	2	16	7
% of total songs with 1 note complex	23	100	55	10	17	10	6	6	0	17	21	33
% of total songs with 2 note complexes	77	0	45	90	83	90	13	94	15	50	42	63
% of total songs with 3 note complexes	0	0	0	0	0	0	69	0	55	33	27	5
% of total songs with 4 note complexes	0	0	0	0	0	0	13	0	25	0	9	0
% of total songs with 5 note complexes	0	0	0	0	0	0	0	0	5	0	1	0
% of total songs with 1 note complex type only*	100	100	100	100	58	50	75	100	45	100	90	57

* This category consists of single or multiple note complex songs, e.g., L, LL, LLL, J, JJ, JJJ, etc.

by total versatility, were previously shown to be related to nesting stages (Groschupf and Mills 1982). Total versatility values, which are the product of song type versatility and transition versatility (Kroodsma and Verner, *Auk* 95:703-716, 1978), were significantly higher when eggs or young were in the nest than when no nest or just a nest was present. It was proposed that the complexity of the song bouts stimulated females to begin incubation, to further egg-lay, or to maintain the pair bond. Thus, the increased complexity and versatility of singing performances had an intersexual function.

Intersexual function of large song repertoires has been shown in at least two bird species. It was experimentally demonstrated that Sedge Warblers (Catchpole, *Behaviour* 74:149-166, 1980) and Northern Mockingbirds (*Mimus polyglottos*) (Howard, *Evolution* 28:428-438, 1974) with large song repertoires obtained mates sooner than males with small repertoires.

Large song repertoires also have been shown to have intrasexual functions. It was shown experimentally that areas occupied by loudspeakers emitting Great Tit (*Parus major*) recordings consisting of many song types were settled last by newly arriving male Great Tits, whereas those areas broadcasting single song type repertoires were settled first (Krebs, pp. 47-62 in *Evolutionary Ecology*, B. Stonehouse and C. Perrins, eds., Macmillan, New York, New York, 1977). The effect of large song repertoires repelling rival males also has been shown experimentally in Red-winged Blackbirds (*Agelaius phoeniceus*) (Yasukawa, *Anim. Behav.* 29:114-125, 1981).

TABLE 2
SONG TYPES USED IN EACH SONG BOUT BEFORE (Pr) AND AFTER (Po) PLAYBACK

10 May			10 May			21 May			19 July			28 July		
Pr	Po		Pr	Po		Pr	Po		Pr	Po		Pr	Po	
A* (1) ^b			C (2)			GG (4)	GG (1)		NNN (2)			LL (2)	LL (3)	
AA (5)			D (4)			HI (5)	HI (5)		ONNN (2)			LLJ (3)	LLJ (2)	
BB (5)			DD (6)			JJ (1)	JJ (3)		O (1)			LLJJ (2)	LLMM (1)	
C (1)	C (19)		E (2)			K (2)			OO (1)			LJJ (1)	LJJ (1)	
B (1)			EE (3)				J (1)		OJJ (1)			JJJ (5)	JJJ (3)	
			F (3)						JJ (1)	JJ (8)		JJL (1)		
									JJJ (7)			JLL (1)		
									JJP (1)			JJL (2)		
										BB (9)		JJLL (1)		
										C (1)		JJLL (1)		
												JJLL (1)	L (1)	
													LLL (1)	
													J (1)	
													JJ (3)	

^a Different letters represent different note complex types. A song consists of 1-5 note complexes.

^b Number in parentheses is the number of times the song was used in the song bout.

In each of the preceding examples, the primary song of each species was demonstrated to have either an intrasexual or an intersexual function; none showed that primary songs serve a dual function. Dual function of primary song has been experimentally demonstrated in the Cuban Grassquit (*Tiaris canora*). Songs used to court females are longer and contain more syllable types than those which are used in male/male interactions (Baptista, J. Ornithol. 119:91–101, 1978). In the present study, it was shown that a Five-striped Sparrow changed the complexity of his songs and song bouts according to the context in which they were sung. The songs of males singing in the presence of a female, consisted of numerous note complex types occurring together within a song, and song bouts consisted of many nonrepetitive song types. During a male/male interaction (i.e., after playback), the songs and song bouts became less complex and more stereotyped. Songs often consisted of only one note complex type and, within a song bout, song types were sung repetitively. Thus, it appears that songs of Five-striped Sparrows play a dual role and are influenced by both intra- and intersexual selection; their songs are short, simple, and stereotyped when used for male repulsion, and are longer, more complex, and variable when used for female attraction or stimulation. This may be the first evidence of a species exhibiting repertoire elasticity within songs, as well as between bouts, and how it is related to the sexual context in which it occurs.

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Sandhill Crane use of nest markers as cues for predation.—Many authors have raised concerns about increased nest predation on study species as a result of investigator activities. Examples include research on waterfowl (e.g., Hammond and Forward, *J. Wildl. Manage.* 20:243–247, 1956; Strang, *J. Wildl. Manage.* 44:220–222, 1980), larids (e.g., Robert and Ralph, *Condor* 77:495–499, 1975; Fetterolf, *Wilson Bull.* 95:23–41, 1983), and passerines (e.g., Lenington, *Auk* 96:190–192, 1979), but see Nichols et al. (*Auk* 101:398–402, 1984). Although increased nest predation has often been observed, there is little information about how the predators are attracted to nests. I describe here direct observations of a Sandhill Crane (*Grus canadensis*) locating shorebird nests by cueing in on nest markers.

The observations were made in 1983, during a study of breeding Red-necked Phalaropes (*Phalaropus lobatus*) at the Queen's University Tundra Biology Station at La Pérouse Bay, 40 km east of Churchill, Manitoba (58°24'N, 94°24'W). The 2-km² study area is in the delta of the Mast River, characterized by numerous small islands dominated by 0.2–1.0 m high willow (*Salix brachycarpa*) and dwarf birch (*Betula glandulosa*), and sedges (e.g., *Carex aquatilis*). A more detailed description of the study area is provided by Jefferies et al. (*Can. J. Bot.* 57:1439–1450, 1979).

From mid-June to late July, the locations of 50 phalarope nests and 130 Semipalmated Sandpiper (*Calidris pusilla*) nests were marked with 50-cm high unpainted wooden stakes that were placed 2–3 m south to southeast of each nest. In addition, 3061 Snow Goose (*Chen caerulescens*) nests were staked similarly on the shorebird site and in the surrounding