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TERRITORY SIZE IN THE WHITE-CROWNED SPARROW (*ZONOTRICHIA LEUCOPHRYS*): MEASUREMENT AND STABILITY

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The problems involved in reliably measuring bird territories and estimating their stability have often been ignored by ornithologists. Observers frequently use the same technique to measure territories as that used by Noble (1939) and other pioneers. Typically, the observer carries a map into the field and notes where a subject bird flies, sings, or has aggressive encounters during a given period of time (e.g., Ralph and Pearson 1971). This method provides intuitively satisfying results because the birds are interacting without human interference. However, it is often time-consuming, and owing to the rarity of interactions on some territorial boundaries it may not be feasible to wait for these interactions to occur.

To avoid some of these problems, Wiens (1969, 1974) proposed a method of mapping territories that he termed the "territory flush" procedure. With this method, an observer approaches a singing male until it flushes from its initial position, and then maps both the flight path and the landing location.

In another method, Dhondt (1966) presented Great Tits (*Parus major*) with a stuffed conspecific model and a recording of their territorial song at different locations in the territory. By noting where the subject responded to the stimulus, he soon defined all of the territorial boundaries in a given area. Some investigators (e.g. Krebs 1971, Howard 1974) have used both approaches interchangeably and have combined the data from them. The methods should be evaluated by using both the standard mapping procedure and the stimulus procedure, and comparing the results as to territorial boundaries. In this study, we used both methods to delimit territories and to estimate their stability throughout a breeding season.

TERRITORY SIZE: PLAYBACK VERSUS OBSERVATIONAL METHODS

Between 21 March and 14 July 1975, we studied eight pairs of breeding White-crowned Sparrows (*Zonotrichia leucophrys*) on the east side of Twin Peaks in San Francisco, California. The study area, approximately 120 × 100 m, was open grassland with sparsely distributed bushes, mostly baccharis, and some berry brambles, thistles, and poison oak. Almost the entire area could be seen from several places on the hill. We took aerial photographs and made detailed scale maps showing every bush. These maps enabled us to establish accurately the territorial boundaries during the breeding season.

All the sparrows were color-banded and all of their nests were found. We mapped the territories six times during the breeding season (Table 1). Three of those times, using the observational method, we waited for aggressive encounters at the bushes along all territorial boundaries, plotted them on a map, and drew a line around these points. About 14–16 h were required to map the eight territories.

On the other three occasions, we mapped the territories by noting where birds responded to a recording of territorial White-crowned Sparrow song in the local dialect, accompanied by a freeze-dried specimen displayed beside the loudspeaker. With this playback mapping method, we first presented the stimuli at a nest, assumed to be the center of a territory. After a sparrow approached the stimuli, we moved them 5 m away and played the song again. If the bird again approached and responded, we moved the stimuli another 5 m away from the nest. We repeated this procedure either until the subject failed to respond to twenty playback songs or another bird approached and responded to the stimuli.

TABLE 1. Correlations between two techniques to characterize territories (in m^2). N = 8.

	$\bar{x}$	s	range	$\bar{x}$	s	range	Correlations
	Playback 4/14			Observation 4/27			
Total area	1227	963	491–3207	1234	875	647–3175	.93**
Bush area	275	80	181–405	274	84	131–381	.72
Grass area	866	995	192–2832	962	864	340–2794	.99**
Bush/Grass	.56	.48	.10–1.55	.47	.32	.08–.96	.98**
	Playback 5/17			Observation 5/22			
Total area	1197	781	473–2783	1112	864	432–3018	.99**
Bush area	262	68	135–337	284	42	227–337	.75*
Grass area	524	398	177–1770	828	871	169–2755	.98**
Bush/Grass	.57	.53	.08–1.68	.63	.48	.10–1.56	.97**
	Playback 6/18			Observation 6/25			
Total area	1059	911	542–2855	1175	783	536–2855	.99**
Bush area	300	85	227–474	294	73	227–446	.96**
Grass area	876	818	258–2628	880	809	255–2628	.99**
Bush/Grass	.57	.37	.09–1.09	.56	.38	.08–1.10	.99**

* $P < .05$.
** $P < .01$.

TABLE 2. Correlations between changes of territories across successive nestings. (The correlations in brackets are with the pair that adjusted to the ingression of a new pair removed.)

	1st vs 2nd (N = 8)	2nd vs 3rd (N = 8)	3rd vs 4th (N = 5)
Total area	.87**(.89)**	.93**	.99**
Bush area	.78**(.82)**	.95**	.96**
Grass area	.91**(.94)**	.98**	.99**
Bush/Grass	.57* (.96)**	.96**	.99**

* $P < .05$.
** $P < .01$.

The loudspeaker and the specimen were then moved 5 m to one side or to the nearest bush; by adjusting their location, we mapped the periphery of the territory. About 8 h were required to map all the territories with this technique.

The first map by the observational method and the first map by the playback method were found to be correlated .93 for the total area of territories. Measurements from the second and third pairs of maps showed even closer agreement between the two methods (Table 1). All the territories were contiguous and non-overlapping. Measurements of bush area, grass area, and the bush/grass ratio, as determined by the two methods, also agreed closely.

The average size of the territories in this area and of eight other pairs in two adjacent areas was 1127 m^2.

TERRITORY STABILITY

Several studies of passerines have found that territory size may change when the female is incubating eggs or feeding nestlings (Young 1951, Odum and Kunzler 1955, Stenger and Falls 1959, Stefanski 1967, Root 1969, and Yarrow 1970). We sought to find out if such changes occurred in our population of White-crowned Sparrows. Examination of the data on territory size during different breeding conditions revealed no fluctuations, indicating that with one exception, it was quite stable throughout the breeding season. In the exceptional case, a new pair of birds arrived and established a territory after the first nesting, forcing an existing pair to reduce their territory, which had been extremely large during the first nesting. Eliminating the data for these birds increases considerably the correlation coefficients for territory size between the first and second nestings.

Rank-difference correlations of total area, bush area, grass area, and bush/grass ratio between nestings (Table 2) are also high and stable (Hardyck and Petrinovich 1976:227–229). The relatively low correlation between the size of the territories during the first and second nestings is due to the arrival of a new pair of birds; by establishing their territory, they forced changes in the extremely large territory of another pair. Removing the data for these two pairs increases the correlation coefficients. Except in this instance, territory size fluctuated only slightly during the breeding season.

DISCUSSION

Playback of recorded song accompanied by a conspecific model to elicit "territorial encounters" speeds the initial mapping of territories. This method can also be used to check the stability of boundaries after they have been determined. Using both observational and playback techniques seems to be a valid and a useful way to map territories.

The stability of territories in the White-crowned Sparrows we studied may be due to a low population density. Given a low density with a small floater population, such stability would be expected. A long-term study of territory stability in areas with high and low population density, may find less stable territories in high density years and areas. On the other hand, if this stability is characteristic of the species, we may find that territories do not fluctuate as density changes. In fact, Ralph and Pearson (1971) reported an average territory size of 2360 m^2 while we found an average of only 1127. This difference suggests that our population is quite dense and that stability will not vary with an increase in population density. Pairs establishing a new territory within a territorial mosaic may introduce instability, as we found in one instance. However, such events would be expected to take place early in the breeding season, as we found here.

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