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NOTE

NESTING HABITAT OF BELDING'S SAVANNAH SPARROWS IN COASTAL SALT MARSHES

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Abstract: Although the Belding's Savannah sparrow (*Passerculus sandwichensis beldingi*) is listed as endangered in California, little is known about the factors that affect its abundance and distribution. Numbers of breeding pairs, nesting territory sizes, and vegetation characteristics were measured at fourteen study plots in two southern California coastal wetlands, Tijuana Estuary and Los Peñasquitos Lagoon. Sparrows nested in middle salt marsh habitat in areas of dense pickleweed (*Salicornia virginica*) or saltgrass (*Distichlis spicata*). No nesting territories were found in transitional upland or low marsh habitat. Territory sizes were highly variable and significantly larger at Tijuana Estuary. Territory size may be related to nest site availability and water levels at time of establishment. More research is needed on the effects of habitat quality on reproductive success and territory size.

Key Words: Belding's Savannah sparrow, salt marsh, nesting habitat, endangered species.

INTRODUCTION

The Belding's Savannah sparrow (*Passerculus sandwichensis beldingi* (Ridgway)) was placed on the California state endangered species list in 1974 after it was estimated that fewer than 1500 individuals remained in the population (Bradley 1973). Belding's Savannah sparrow is a Category 2 candidate for federal listing (James and Stadtlander 1991). This nonmigratory subspecies of the Savannah sparrow (*Passerculus sandwichensis* (Gmelin)) occurs only in coastal salt marshes between Goleta, Santa Barbara County, California and Bahía de San Quintín, Baja California, Mexico (Bent 1968, Massey 1979, AOU 1983, Zembal et al. 1988). Belding's Savannah sparrows are dependent on coastal wetlands for all aspects of their life histories (Massey 1979). Factors implicated in population decline are reductions in both quantity and quality of suitable habitat and increased human disturbance.

Current coastal wetlands in California are few in number and diminishing in size. For example, it is estimated that the remaining salt marsh in San Diego Bay represents only 10–15 % of the pre-settlement wetland area (Zedler 1982). Many of the remaining salt marshes have been altered dramatically by development and no longer receive regular tidal circulation. Reduced tidal flow affects vascular plant community structure and influences bird use (Zedler et al. 1992). The effect of habitat modification through altered hydrology has been detrimental to other species of sparrows associated with coastal marshes and, in some cases, has resulted in extinction (Sykes 1980, Burger et al. 1982, Collins and Resh 1985, Greenburg and Droege 1990).

This study examines the vegetative characteristics of nesting territories of Belding's Savannah sparrows in two southern California coastal salt marshes. Comparisons are made between territory sizes and vegetative characteristics in salt marshes that differ in tidal flushing regimes. Conservation of rare endemic birds depends upon both preservation of quality habitat and knowledge of basic habitat requirements.

STUDY AREAS AND METHODS

Two coastal wetlands representing different hydrologic regimes were selected in San Diego County. Tijuana Estuary (32° 34′ N, 117° 7′ W) is a National Estuarine Research Reserve and is located just north of the Mexican border. Tijuana Estuary has good tidal circulation and includes 166 ha of intertidal marsh. In

Table 1. Habitat characteristics for study plots at Tijuana Estuary (N = 10) and Los Peñasquitos Lagoon (N = 4).

	Tijuana Estuary	Los Peñasquitos Lagoon
Mean plant height (cm)**	25.5 ± 6.1	36.5 ± 5.0
Plant species richness	6.2 ± 1.8	6.8 ± 3.3
Mean territory size (m^2)**	600.3 ± 189.0	273.8 ± 62.6
Number breeding pairs*	2.8 ± 1.4	5.3 ± 1.7

* $P < 0.05$, ** $P < 0.01$, by t-tests.

contrast, Los Peñasquitos Lagoon (32° 55′ N, 117° 15′ W) has a history of frequent and prolonged closure to the ocean due primarily to a small tidal prism and sedimentation problems. Los Peñasquitos Lagoon has 95 ha of salt marsh.

Given the endangered status of Belding's Savannah sparrows, methods to census individuals and map territories were used that would minimize disturbance to nesting individuals. Nesting densities were estimated by walking parallel line transects 100-m apart and recording the number of singing or territorial males (Massey 1979, Burnham et al. 1980). Censuses were conducted from 0600 to 0900 between 1 March and 1 June, 1985 and 1986. Tijuana Estuary was censused only north of the Tijuana River and Los Peñasquitos Lagoon west of the railroad tracks.

Permanent plots were established at Tijuana Estuary (N = 10) and at Los Peñasquitos Lagoon (N = 4) to determine vegetative characteristics of nesting territories. Study plots were 50 m × 50 m and marked with yellow flagging. All plots were visited at least twice per breeding season during April 1985 and March 1986. Spot mapping techniques were used to delineate nesting territories. Mapping was conducted between 0600 and 0900 h by recording movements of male sparrows and active defense of territories. No mapping was conducted in rain or foggy conditions. Final measurements of territory size were determined by drawing polygons from the outermost points of each territory. The areas were measured with a planimeter and probably underestimate true size because straight-edged polygons may not represent actual territory boundaries. No attempts were made to locate nests, thus reducing the chances of abandonment (Massey 1979).

Vegetation at each plot was sampled between June and July, 1985. Four 50-m transects, randomly chosen to begin along one side of each plot, were sampled at 5-m intervals with a circular 0.25-m^2 quadrat. Percent cover of each plant species was estimated using six cover classes (< 1%, 1–5 %, 6–25 %, 26–50 %, 51–75 %, 76–100 %) (Zedler and Nordby 1986). Mean percent cover by species was determined for each plot by summing the midpoints of each cover class recorded and dividing by 20. The distance of each plot to the nearest dependable water source was measured. Kolmogorov-Smirnov two-sample tests were used to compare the frequency distributions of territory sizes. Stepwise multiple regressions explored the relationships of habitat characteristics to sparrow territory size and nesting density (Sokal and Rohlf 1981).

Table 2. Vegetative characteristics for study plots at Tijuana Estuary (N = 10) and Los Peñasquitos Lagoon (N = 4).

	Vegetative Cover (% ± S.D.)	
Plant species	Tijuana Estuary	Los Peñasquitos
Salicornia virginica L.**	56.4 ± 18.1	27.3 ± 18.5
Distichlis spicata L.**	3.7 ± 4.9	35.8 ± 21.1
Frankenia grandifolia (Cham. & Schlecht)**	8.9 ± 14.2	18.0 ± 14.6
Salicornia subterminalis (Parish)**	1.4 ± 1.9	6.8 ± 13.5
Batis maritima L.**	9.1 ± 9.1	0
Monanthochloe littoralis (Engelm)*	4.0 ± 8.4	0.5 ± 1.0
Jaumea carnosa (Less.)	0.9 ± 1.5	0.3 ± 0.5
Cressa truxillensis (HBK)	0	8.8 ± 12.0
Triglochin concinnum (Davy)	<1	0
Atriplex watsonii (A. Nels.)	0	<1
Limonium californicum (Boiss.) Heller	<1	0
Cakile maritima (Scop.)	<1	0
Cuscuta salina (Engelm)	0	<1
Rumex crispis L.	0	<1
Bare ground*	8.0 ± 16.4	1.3 ± 1.9
Dead vegetation	<1	0
Debris	<1	0

* P < 0.05, ** P < 0.01, by t-tests.

RESULTS

Nesting pair density ranged from 4 to 24 per ha at Tijuana Estuary and 12 to 28 per ha at Los Peñasquitos Lagoon. Total pair counts were 81 and 106 at Tijuana Estuary and 66 and 59 at Los Peñasquitos Lagoon in 1985 and 1986, respectively. Census results showed a 31 % increase in the sparrow population at Tijuana Estuary and a 9 % decrease at Los Peñasquitos Lagoon.

Although there seemed to be changes in local populations from year to year, there were no corresponding changes in territory sizes. However, territory size was highly variable at both study sites, and territories were significantly larger at Tijuana Estuary (D = 0.741; P

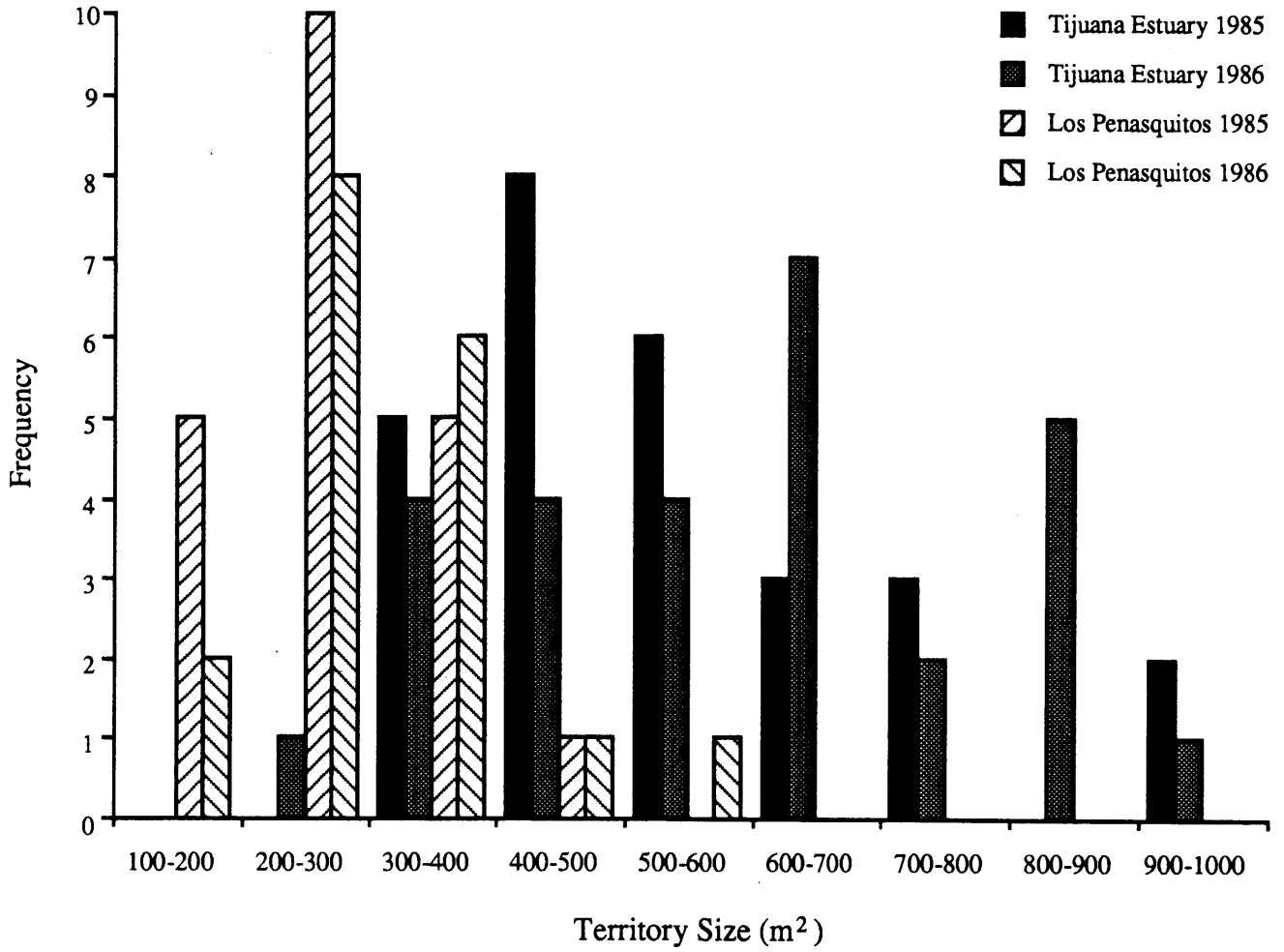

Figure 1. Breeding territory sizes for Belding's Savannah sparrows at Tijuana Estuary (n = 55) and Los Peñasquitos Lagoon (n = 39).

< 0.01) (Figure 1). Territory size ranged from 80 to 420 m^2 at Los Peñasquitos Lagoon and from 308 to 936 m^2 at Tijuana Estuary. Nesting density was significantly higher at Los Peñasquitos Lagoon (t = 7.8 in 1985, 7.2 in 1986, $P < 0.001$) (Table 1). Territory size and nesting density were inversely related ($r^2 = -0.54$, $P < 0.01$).

The two estuaries differed significantly in plant species composition. Tijuana Estuary was dominated by pickleweed (*Salicornia virginica* L.), had significant cover of saltwort (*Batis maritima* L.) and shoregrass (*Monanthochloe littoralis* (Engelm)), and included patches of bare ground (Table 2). In contrast, Los Peñasquitos Lagoon was dominated by pickleweed and saltgrass (*Distichlis spicata* L.) (Table 2). In general, plant height ranged between 19 and 42 cm, and vegetation at Los Peñasquitos Lagoon was taller and denser (Table 1). All of the plots at both locations were within 100 m of a permanent water source, including tidal creeks and lagoons.

Stepwise multiple regressions using territory size and nesting density as dependent variables indicated that habitat characteristics were highly correlated. At Tijuana Estuary, the number of plant species, percent bare ground, and mean plant height accounted for 44 % of the variation in territory size. At Los Peñasquitos Lagoon, percent cover by saltgrass and bare ground accounted for 22 % of the variation in territory size. When data from the two areas were combined, percent cover by pickleweed, alkali heath (*Frankenia grandifolia* (Cham. & Schlecht)), saltgrass, bare ground, mean plant height, and number of plant species correlated with territory size ($r^2 = 0.41$). Overall, vegetation characteristics accounted for less than 50 % of the variation in territory size.

Simple regressions were used to examine correlation coefficients of variables selected by stepwise regressions. Because of the small sample size and interrelationships between variables, few of the correlations were significant (Table 3). Relationships between ter-

Table 3. Correlation coefficients (r) of independent habitat variables. Size is the estimated territory size; density is the number of nesting pairs per study plot.

	Tijuana Estuary		Los Peñasquitos Lagoon		Areas Combined	
Species	Size	Density	Size	Density	Size	Density
Salicornia virginica (%)	0.28	0.18	0.37	−0.72	0.58*	−0.43
Relative cover (% *S. v.*)	0.66*	−0.01	0.58	−0.79	0.79**	−0.60*
Disticlis spicata (%)	−0.29	−0.24	−0.65	0.94	−0.66**	0.67**
Relative cover (% *D. s.*)	−0.24	−0.27	−0.76	0.93	−0.66**	0.68**
Frankenia grandifolia (%)	−0.42	−0.15	0.32	−0.76	−0.16	−0.02
Bare ground (%)	0.31	−0.29	0.90	−0.94	0.38	−0.34
Mean plant height	0.13	0.09	−0.35	−0.18	−0.41	0.38
Number of plant species	−0.57	0.26	0.10	0.37	−0.34	0.31
Total plant cover (%)	−0.37	0.25	−0.94	0.94	−0.51	0.44

* $P < 0.05$, ** $P < 0.01$.

ritory size at Tijuana Estuary and percent cover of bare ground and *S. virginica* were positive, and relationships with number of plant species, percent cover of *F. grandifolia*, and total percent cover were negative. At Los Peñasquitos Lagoon, territory sizes were smaller and bird density higher, with low percent bare ground and high percent cover by *D. spicata*. When data from the two areas were combined, territory size was positively correlated with percent cover by *S. virginica* and negatively correlated with percent cover by *D. spicata* (Table 3).

DISCUSSION

Differences between territory size and nesting pair density at Tijuana Estuary and Los Peñasquitos Lagoon were due in part to the different hydrologic regimes at the two estuaries. The low- to middle-marsh areas at Los Peñasquitos Lagoon were flooded in 1985 due to the closure of the river mouth and subsequent water impoundment. Although the river mouth was artificially opened in April 1986, sparrows had already established territories during the period of impoundment.

Belding's Savannah sparrows nest close to the ground and are therefore susceptible to high water levels caused by impounded water or high storm tides. Reduction in available nesting habitat at Los Peñasquitos Lagoon may have resulted in artificially higher densities and corresponding small territory sizes. Although nesting pair density was high in Los Peñasquitos Lagoon during periods of inundation, the productivity of these nests was unknown. Short-term changes such as inundation of nest sites may not affect overall distribution because of high site tenacity by male sparrows (Dixon 1978, Massey 1979, Bedard and LaPointe 1983).

Chronic closure to tidal flow combined with reduced freshwater flow and long periods of drought have affected the composition of vegetation at Los Peñasquitos Lagoon. The large, dense stands of saltgrass found at Los Peñasquitos Lagoon are atypical of southern California salt marshes and are most likely a result of this altered hydrologic regime (Zedler 1982). *Distichlis spicata* may provide good nesting material, cover from predators, and support high insect abundance (Zedler 1982, Bedard and LaPointe 1983). The small territory sizes found in this tall, dense vegetation may be related to food availability (Cody 1981, Vince and Valiela 1981, Collins and Resh 1985). Both pickleweed and saltgrass are tolerant of drought, high salinity, and extreme conditions associated with poor tidal circulation. However, long periods of inundation during summer months can eliminate pickleweed stands altogether (Zedler and Nordby 1986). Although *F. grandifolia* is salt tolerant, it is susceptible to drought and has disappeared from higher elevations at Los Peñasquitos Lagoon (Zedler 1982).

In contrast, Tijuana Estuary was characterized by good tidal circulation and had an abundance of available middle-marsh habitat. The vegetation composition at Tijuana Estuary is more typical of southern California salt marshes than Los Peñasquitos Lagoon (Zedler 1982, Zedler et al. 1992). Tijuana Estuary has patchier vegetation, which includes areas of bare ground interspersed with large, dense pickleweed stands. This patchiness may have accounted for larger and more variable territory sizes at Tijuana Estuary.

Belding's Savannah sparrows nested in salt marsh vegetation characteristic of middle intertidal marsh—primarily pickleweed, saltwort, saltgrass, and alkali heath. Overall, salt marshes with regular tidal circulation may provide the best habitat for Belding's Savannah sparrows (White 1986). Tidal circulation re-

duces inundation during periods of high rainfall in winter and spring and results in healthy stands of middle-marsh species. Maintaining the quality of the remnant salt marshes in California and Mexico is particularly important because Belding's Savannah sparrows show little movement between marshes and tend to be site tenacious (Bradley 1974). More research is necessary to determine the influences of habitat quality, such as food availability, on the reproductive success of this endangered species.

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