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NESTING HABITAT OF THE LIGHT-FOOTED CLAPPER RAIL IN SOUTHERN CALIFORNIA

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The Light-footed Clapper Rail (*Rallus longirostris levipes*), a reclusive resident of the coastal marshes of southern California and northern Baja California, Mexico, has suffered a severe decline in population during this century, and is listed as an endangered species by both the federal and state governments (U.S. Dept. of the Interior 1973, California Dept. of Fish and Game 1972). Loss of habitat is a major cause of the birds' diminished status (Wilbur 1974); it is estimated that 75% of California's coastal wetlands have been destroyed or severely altered since the turn of the century (California Coastal Zone Commission 1975). There are currently only about 200 breeding pairs of Light-footed Clapper Rails in the state (Zembal and Massey 1981).

None of the marshes where the rails still reside is in pristine condition, and the large stands of dense tall cordgrass (*Spartina* spp.) with which Clapper Rail nests have been historically associated (Applegarth 1938, Kozicky and Schmidt 1949, Johnson 1973, Jorgensen 1975) are found in only a few. Conditions in the marshes range from healthy to severely degraded, from ample in size (e.g., 250 ha of saltmarsh) to miniscule (1–2 ha), and from diversely vegetated (salt- and freshwater marsh, all littoral zones, full tidal action) to restricted (no freshwater input, limited zonation and tidal prism) (Zembal and Massey 1981). Severe winter storms periodically damage marsh vegetation and deposit heavy silt loads that kill large numbers of invertebrates on which the rails feed (Seapy 1981). In order to survive, the rails have had to adapt to nesting under altered, and often extremely adverse conditions.

In 1979 we began a study of the Light-footed Clapper Rail focused on the three largest remaining populations in California, Anaheim Bay and Upper Newport Bay in Orange County, and Tijuana Marsh in San Diego County. This paper covers one phase of the study, nest site selection in the three marshes over a period of three seasons.

STUDY AREAS

Anaheim Bay.—The saltmarsh in Anaheim Bay is entirely within the Seal Beach National Wildlife Refuge in Seal Beach Naval Weapons Station, Orange County. The total area of the refuge is 440 ha (1100 acres) of which 226 ha (565 acres) are saltmarsh vegetation. The surrounding lands are flat or gently sloping and provide little drainage into the bay. Consequently there is very little freshwater input other than winter rains. Our study area encompassed all of the saltmarsh. Most of the vegetation is characteristic of the low and middle littoral zones (Purer 1942) and is completely inundated by a 1.8 m tide (Mean Lower Low Water). A mixture of low growing plants pervades the marsh; the major species are cordgrass (*Spartina foliosa*), pickleweed (*Salicornia virginica*, *S. bigelovii*), saltwort (*Batis maritima*), seablite (*Suaeda californica*), saltgrass (*Distichlis spicata*), sea lavender (*Limonium californicum*), arrow grass (*Triglochin maritimum*), *Jaumea carnosa*, and *Frankenia grandiflora*. Tall dense stands of *Spartina* (>70 cm) occur at only a few sites and cover fewer than 2 ha (4.9 acres). Higher marsh, dominated by dense *Salicornia virginica* and interspersed with *Suaeda, Frankenia,* and other characteristic uppermarsh species, is present along the marsh edges and on berms and isolated hummocks, the result of old dredging operations, in low/middle marsh. There are extensive mudflats and a strong tidal influence.

For many years the marsh has been subsiding, apparently as a result of oil extraction beneath the bay. A United States Coast and Geodetic Survey-National Geodetic Survey bench mark located on a highway bridge adjacent to the marsh was leveled at regular intervals between 1957 and 1970 and dropped 12.5 cm in elevation during that period. No data are available after 1970. Since an equal amount of time has now elapsed during which oil drilling has continued, we assume that subsidence may now have lowered the elevation as much as 25 cm below the 1957 datum. This phenomenon has had considerable impact on patterns of *Spartina* growth (see Discussion).

The Clapper Rail population of the bay has apparently dropped considerably since the 1960s when it was about 200 birds (Wilbur et al. 1979). For the 3 years of this study our estimates of numbers of nesting pairs were 23 (1979), 30 (1980), and 19 (1981). In 1982 there were an estimated 28 pairs.

Upper Newport Bay.—Upper Newport Bay is a state ecological reserve in Orange County under the jurisdiction of the California Department of Fish and Game. The total area of the reserve is 288 ha (721 acres) of which 100 ha (250 acres) are salt and freshwater marsh. The bay is long, narrow, and banked on both sides by bluffs 9–18 m high. Two creeks and many small seeps along the bluffs provide year-round freshwater influence. Stands of reeds (mostly *Scirpus* spp. and *Typha* spp.) line small ditches and ponds, and occur along much of the bay's edge. There is abundant low marsh with tall dense *Spartina foliosa* the dominant plant. Inundation of cordgrass is never complete, even at a 2.2 m tide (MLLW). The middle littoral zone is also well represented and diversely vegetated, but there is only a small amount of high marsh along the edges and on isolated hummocks and berms (Vogl 1966). There are extensive mudflats and a strong tidal influence.

The bay has a major siltation problem, exacerbated by heavy flows down the main inlet (San Diego Creek) during winter storms. Severe storms in January/February 1980 did considerable damage to low marsh, and to cordgrass in particular. Many *Spartina* stands were destroyed or badly damaged and a layer of silt covered the mudflats.

The bay hosts the largest population of Light-footed Clapper Rails in the state. Our estimates for 1979 and 1980 were 95 and 98 pairs; in 1981 the number declined to 66 pairs, but increased in 1982 to 103 pairs.

Our study was concentrated on 3 islands in the southern half of the bay in 1979 and 1980, and on 2 of the islands in 1981. There are approximately 37.2 ha (93 acres) of saltmarsh vegetation on the 3 islands, 21.4 ha (53.4 acres) on the 2 studied in 1981. *Spartina* belts rim the edges and border the maze of tidal creeks on the islands. We estimated (by planimeter measurements) that tall (>70 cm) *Spartina* covered 13 ha (32 acres) on the 3 islands, 7.6 ha (19 acres) on the 2 studied in 1981. The nesting population of Light-footed Clapper Rails was 38 pairs in 1979, 35 in 1980, and 20 pairs (2 islands) in 1981.

Tijuana Marsh.—Tijuana Marsh lies in San Diego County between Imperial Beach and the Mexican border. Three agencies have jurisdiction over various sections of the marsh, California Department of Parks and Recreation, U.S. Navy, and the National Wildlife Refuge system. The entire wetland covers 400 ha (1000 acres), of which 157 ha (392 acres) are saltmarsh vegetation. Freshwater input comes mostly from winter rains, with the surrounding flatlands providing little runoff. There are no dense stands of freshwater marsh vegetation directly associated with the saltmarsh. Freshwater from the large, perennial Tijuana River flows into the marsh only during periods of heavy rainfall.

The portion of the marsh north of the ocean entrance was selected for study, as it had been previously determined that 90% of the Clapper Rails nested there (Jorgensen 1975). The study area has 82 ha (202 acres) of saltmarsh and 22 ha (55 acres) of tidal creeks and mudflats, as estimated by Jorgensen (1975). *Spartina* marsh covers about 15 ha (38 acres) but only 5.6 ha (14 acres) are classified as tall (>70 cm) *Spartina.* There are 55 ha (136 acres) of middle marsh and 11.4 ha (28 acres) of high marsh.

The nesting population in the study area was estimated at 29 pairs in 1974, and dropped to 10 pairs in 1979. In 1980, 1981, and 1982 there were 26, 31, and 25 pairs, respectively.

METHODS

The number of nesting pairs at each marsh was determined by a combination of vocalization censusing and nest searching. We found that by listening to the rails calling on spring evenings we could arrive at a population estimate that closely approximated the number of pairs documented by subsequent nest searching (Zembal and Massey 1981).

Nest searching was done in several ways, dictated by the terrain to be covered in each marsh. In Anaheim Bay, which has extensive low marsh habitat but very few stands of tall dense *Spartina,* we were able to search the entire marsh, covering a portion on each of several visits, all within a period of 1–2 weeks in April or early May. The process was repeated several times until it was apparent that the season was over, usually by the end of June. In Upper Newport Bay, the islands that constituted our study area were not large but were rimmed with dense cordgrass that was difficult to search, so that only 1–2 islands could be covered in a day. We searched each island bi-weekly throughout the season. In

Tijuana Marsh, the study area was searched in the same way as Anaheim Bay, with several visits needed to do the first systematic search in April. The search was repeated at least once more during the season. In some areas, a rope drag was used.

We counted only nests where rails were incubating. Clapper Rails build one or more brood nests immediately after the chicks hatch, usually broader and flatter structures than the incubation nest, and lacking both ramp and canopy (see description of Category 1 nest in Results). Brood nests are used for night roosting. Incubation nests are sometimes converted into brood nests, so nests found after hatching were included only if we were able to identify the incubation nest with certainty. Thus the nests found were sometimes fewer than the estimated number of breeding pairs.

A second nesting attempt in the same territory was fairly common. In several instances the original incubation nest was refurbished and used, presumably by the same pair. Reused nests were not counted twice. More often, however, a fresh nest was found, and as we could not be sure it was built by the same pair, it was counted as a new nest. Thus the number of nests found sometimes exceeded the estimated number of breeding pairs.

When an incubation nest was found, data were taken as to location in the marsh, type(s) of vegetation in which it was built, material used in construction, presence of a canopy (and material used, if present), ramp, and clutch size. If an empty incubation nest was found, we looked for evidence of hatching (shell fragments, food particles, or black chick down in the nest; presence of brood nests in the vicinity). Nests with eggs that were in accessible locations were checked regularly to determine hatching success or failure.

Vegetational data were taken after the 1979 nesting season at 17 nests in Anaheim Bay and 37 nests in Upper Newport Bay. We took data within a .25 m^2 area adjacent to the nest, as defined by a quadrat form. The numbers of live and dead *Spartina* stems were counted, and maximum height of *Spartina* was measured to the nearest centimeter. Percent cover of *Spartina* was estimated in 6 ranges: 0–5, 5–25, 25–50, 50–75, 75–95, 95–100.

Elevations were taken at 11 nests in Anaheim Bay and 31 in Upper Newport Bay with a Leitz automatic level, using USC & GS-NGS (Anaheim Bay) and Orange County (Upper Newport Bay) survey markers as reference points.

RESULTS

We found 208 incubation nests in 3 seasons of nest searching at the 3 marshes. This figure represents approximately 85% of the breeding pairs ascertained by listening to vocalizations. Nests were grouped into 5 categories.

(1) The classical nest was built in the low littoral zone in a stand of tall dense *Spartina*. The nest was constructed primarily of dead *Spartina*

stems, the platform built up from the ground or supported in the cordgrass, the rim level as high as 45 cm off the ground. A canopy of live *Spartina* stems was pulled over and entwined above the nest, hiding it completely from above. Tall *Spartina* not only provided cover but allowed the nest to float upwards in place during a high tide. A ramp of dead cordgrass stems led from the platform down and along the ground. This nest type is built by Clapper Rails in all coastal marshes in the U.S. where the birds have been studied, including New Jersey (Kozicky 1949, Johnson 1973, Mangold 1974), Alabama (Holliman 1978), and northern California (Applegarth 1938, Zucca 1954).

(2) Some nests were built in low marsh where the *Spartina* was not tall and dense enough to provide adequate cover. Dead *Spartina* stems were used in construction, but the nest was placed in or under a tumbleweed or other dead shrub that had lodged securely in the marsh, or in/on a mass of wrack lodged in the short cordgrass. The canopy for a tumbleweed nest was the tumbleweed itself. Some of the wrack nests were totally exposed, others had partial canopies of wrack that were usually gone by the time of hatching.

(3) Some nests were in upper marsh vegetation, but situated on a berm or hummock in low-to-middle marsh and cut off from the land and its predators. Dried *Spartina* stems were usually the dominant nest-building material, with stems or branches of *Salicornia, Distichlis,* and *Frankenia* also used. Most of the nests were in *Salicornia virginica,* with the plant providing a natural canopy.

(4) A true high-marsh nest was built in the upper littoral zone with a direct connection to the maritime zone and its predators. A shrub of *Salicornia virginica* was the usual site of this type of nest. It was constructed mostly from plant material other than *Spartina,* usually from stems available in the immediate vicinity.

(5) Some nests were in freshwater marsh vegetation. In Upper Newport Bay, where vigorous stands of *Scirpus robustus, S. californicus,* and *Typha* spp. grow along the edges, the rails built platform nests in the stands, using the dead stems as construction materials. There was no manufactured canopy; the dense cover provided by the living plants hid the nests completely.

Table 1 characterizes the 208 nests found in the 3 seasons of nest searching and shows the rails' strong preference for nesting in the lower littoral zones. Categories 1, 2, and 3 are all considered lower-marsh nests; they accounted for 92% of all nests. True high-marsh nests, Type 4, were rare (5%). Type 5 nests were found all 3 seasons in Upper Newport Bay, the only one of the 3 study sites with freshwater marsh habitat.

Most nests were of the classic type (Category 1, 53%). In Upper Newport Bay, where tall dense *Spartina* was most abundant, 72% of nests were of this type (Table 1). Even in Anaheim Bay, where habitat to support Type 1 nests was scarce, we found them wherever adequate *Spartina* stands were growing.

TABLE 1. Light-footed Clapper Rail nests grouped by category. Data compiled from 3 seasons of nest searching at 3 marshes. Nest categories are described in Results.

Location	Year	Nest categories 1	2	3	4	5	Total
Anaheim Bay	1979	6	10	1	0	0	17
	1980	7	10	7	6	0	30
	1981	1	5	4	0	0	10
	Total	14 (25%)	25 (44%)	12 (21%)	6 (10%)		57 (100%)
Upper Newport Bay	1979[a]	36	4	1	0	1	42
	1980[a]	21	2	10	1	2	36
	1981[b]	11	0	1	1	3	16
	Total	68 (72.3%)	6 (6.3%)	12 (13%)	2 (2.1%)	6 (6.3%)	94 (100%)
Tijuana Marsh	1979	11	0	5	0	0	16
	1980	5	9	9	1	0	24
	1981	12	2	2	1	0	17
	Total	28 (49%)	11 (19%)	16 (28%)	2 (4%)		57 (100%)
Total		110 (53%)	42 (20%)	40 (19%)	10 (5%)	6 (3%)	208 (100%)

[a] Three islands searched.
[b] Two islands searched.

TABLE 2. Number of Light-footed Clapper Rail nests per year in 5 categories. Data pooled for 3 marshes. Nest categories are described in Results.

Nest category	Year			Total
	1979	1980	1981	
1	53 (71%)	33 (37%)	24 (56%)	110
2	14 (19%)	21 (23%)	7 (16%)	42
3	7 (9%)	26 (29%)	7 (16%)	40
4	0 (0%)	8 (9%)	2 (5%)	10
5	1 (1%)	2 (2%)	3 (7%)	6
Total	75	90	43	208

In Table 2 we pooled the data from 3 marshes by year to dramatize the shift towards nesting in upper marsh vegetation that occurred in 1980. In 1979 we found no nests in Category 4, and only 9% of the nests were in Category 3. In 1980 both nesting locales were used, and together they accounted for 38% of all nests. Special climatic factors in the winter of 1980 were probably responsible for the shift to nests in high-marsh vegetation (see Discussion). In 1981 there was a shift back to the classic nest (Category 1).

The finding of a nest in freshwater marsh vegetation in Upper Newport Bay in 1979 was unexpected. More were found in 1980 and 1981, and have been documented in other freshwater marshes in southern California (see Discussion). Their absence from Anaheim Bay and Tijuana Marsh reflect the lack of freshwater marsh vegetation in those places.

In general we found that Type 1 nests were proportional to the abundance of tall dense *Spartina* and Type 2 were most frequent when cordgrass alone did not provide adequate cover. Type 3 nests were most abundant during years and at marshes where lush *Spartina* stands were in shortest supply, whereas Type 4 nests were used only when all other possibilities were exhausted. Type 5 nesting locations were available only at Upper Newport Bay and were consistently used there; the cover provided by freshwater reeds was comparable to that provided by luxuriant cordgrass.

Clutch size was determined in 72 instances, and the data assembled and analyzed in 2 ways. Table 3 shows clutch size in relation to nesting category. Although Category 3 appears to have a somewhat larger clutch size than the others, the difference is not statistically significant (P = .186, one-way analysis of variance). Analysis by year, however, showed a significant increase in clutch size in 1980 and 1981 over 1979 (Table 3); P = .003 that the differences could be random; one-way analysis of variance, F ratio 6.14 with 2 and 69 degrees of freedom.

Recurrent nest checks in Anaheim Bay and Upper Newport Bay enabled us to tabulate hatching success at these marshes. We did not

TABLE 3. Clutch size for 72 Light-footed Clapper Rail nests.

	Number of nests	Clutch size x̄ ± SE	Range	95% confidence interval
Nest category[a]				
1	31	6.23 ± .21	4–9	
2	16	6.38 ± .27	5–8	
3	20	6.85 ± .29	4–8	
4	3	6.00[c]	5–7	
5	2	6.00[c]	5–7	
Year[b]				
1979	24	5.83 ± .23	4–8	5.36–6.31
1980	33	6.55 ± .19	5–8	6.16–6.93
1981	15	7.07 ± .28	5–9	6.46–7.68

[a] Data pooled for 3 years (1979–1981) at 3 marshes.
[b] Data pooled for 5 nesting categories at 3 marshes.
[c] Sample size too small for statistical analysis.

include data from Tijuana Marsh because the outcome at ⅔ of the nests was unknown. Hatching was considered successful if at least one egg hatched. We were able to document the outcome at 130 nests. Hatching success in relation to nesting category is shown in Table 4. Overall hatching success was 81%. The success rate was not different for Categories 1, 2, and 3, but was lower for Type 4 nests (using Fisher's exact probability test (*in* Sokal and Rohlf 1969) for 2 × 2 table, $P = .065$ that hatching failure in Type 4 nests was significantly greater than Type 1, 2, and 3 pooled). In terms of actual number of chicks, the contribution by Category 1 nests was far greater than any other nest type, even though the rate of success was not higher. Analysis of hatching success on a yearly basis, and without regard for nest type, showed no differences among the 3 years (Table 4).

Vegetational data taken at nests in Anaheim Bay and Upper Newport Bay showed that patterns of *Spartina* growth were different in the 2 bays. Although actual density (number of stems) was the same, both height and cover were much greater in Upper Newport Bay (Table 5). Nest elevations were also higher; the mean for 31 nests in Upper Newport Bay was 141 cm above MLLW; in Anaheim Bay the mean height above MLLW for 11 nests was 114 cm.

Causes of nest failure were determined in 18 instances. Flooding and predation were the major causes of failure; 9 nests built in low marsh (Types 1 and 2) washed out during high tides, and 6 nests built in upper-marsh vegetation (Types 3 and 4) were victims of predation. Abandonment occurred in 3 instances, causes unknown.

DISCUSSION

Until 1975, very little information was available on the nesting behavior and habitat of the Light-footed Clapper Rail. We have been able

TABLE 4. Hatching success for 130 Light-footed Clapper Rail nests analyzed by year and by nest category.

	Success	Failure	Outcome unknown	Total
Year[a]				
1979	43 (82.7%)	6 (11.5%)	3 (5.8%)	52
1980	45 (80%)	11 (19%)	1 (2%)	57
1981	18 (85.7%)	1 (4.8%)	2 (9.5%)	21
Nest category[b]				
1	60 (83%)	7 (10%)	5 (7%)	72
2	21 (81%)	4 (15%)	1 (4%)	26
3	19 (83%)	4 (17%)	0	23
4	4 (57%)	3 (43%)	0	7
5	2 (100%)	0	0	2
Total	106 (81%)	18 (14%)	6 (5%)	130 (100%)

[a] Data pooled for 5 nesting categories.
[b] Data pooled for 3 years (1979–1981) at 3 marshes.

to find only anecdotal information in Bent (1926), and field notes on egg records from the Western Foundation for Vertebrate Zoology, to indicate what nesting patterns might have been early in the century. Both sources suggest that rail nests were looked for, and found, in *Salicornia* on high ground in the marshes. In 1974 Jorgensen did the first comprehensive study of the Light-footed Clapper Rail in Tijuana Marsh and identified tall dense *Spartina foliosa* as the preferred nesting habitat. Of the 34 nests he found during the 1974 breeding season, 18 (53%) were in tall *Spartina*, 4 (12%) in short *Spartina*, and the rest in middle or high marsh (Jorgensen 1975). In the present study, 53% of all nests were in tall dense *Spartina* (Category 1) and 20% in short *Spartina* (Category 2) (Table 1). Cordgrass was the preferred nesting habitat not only in Tijuana Marsh, but in Upper Newport Bay and Anaheim Bay.

The most productive rail habitat identified during this study was in Upper Newport Bay, where we found nearly half the state's population (Zembal and Massey 1981). Of the 3 marshes studied, Upper Newport Bay had the greatest abundance of tall dense cordgrass (about 26 ha compared to 2 ha at Anaheim Bay and 15 ha in Tijuana Marsh), plus the exclusive advantage of the physiognomically similar stands of fresh-water reeds. The densest concentration of Clapper Rails was in an 8 ha stand of *Spartina* at the north end (outside of the study area) where almost half of the bay's population nested. The rails' preference for *Spartina*-marsh nesting was also manifest in the study area. Cordgrass comprised only 34% of the available habitat on the islands but was the site of 79% of the incubation nests, and all but 2 (98%) were in or directly adjacent to tall dense *Spartina*.

A similar pattern of nesting was evident at Tijuana Marsh, where 28/

TABLE 5. Average density, cover, and height of *Spartina foliosa* at Light-footed Clapper Rail nest sites in Anaheim Bay and Upper Newport Bay, June 1979.

	Upper Newport Bay	Anaheim Bay
Number of nest sites sampled	37	17
Number of live *Spartina* stems per 0.25 m^2 (min.–max.)	79 (6–121)	69 (3–112)
Number of dead *Spartina* stems per 0.25 m^2 (min.–max.)	20 (0–45)	33 (0–74)
Total number of *Spartina* stems per 0.25 m^2 (min.–max.)	99 (6–138)	102 (3–145)
Maximum height of *Spartina* in cm (range)	92 (60–110)	57 (43–76)
Percent cover of *Spartina* (min.–max.)[a]	91 (15–98)	58 (2–85)

[a] Cover class midpoints were averaged.

57 nests (49%) were located in dense cordgrass, although it constituted only 7% of the saltmarsh vegetation available.

In Anaheim Bay, *Spartina* was abundant, but tall dense stands were rare. Type 1 nests were found in only 6 different sites in the bay, where the cordgrass was adequate to support them. The birds nevertheless exhibited a strong preference for nesting in low marsh, using tumbleweeds and tide-deposited wrack for cover in lieu of *Spartina*. Type 2 nests predominated in the bay (Table 1). There was far greater use of this type of nest in Anaheim Bay (44% of all nests) than in either Newport (6%) or Tijuana Marsh (19%) (Table 1).

The relative lack of vigorous *Spartina* in Anaheim Bay is probably attributable to several factors. One is lack of fresh water except for winter rains. Cordgrass reportedly grows better at low salinities under both laboratory (Mahall and Park 1976) and field (Zedler 1982) conditions. In 1979 we measured ground water salinities along vegetational transects in Anaheim Bay and Upper Newport Bay and found consistently higher salinities in Anaheim Bay.

Another factor is subsidence. *Spartina* stands in Anaheim Bay are growing at lower elevations than in Upper Newport Bay. They are totally immersed by only moderately high tides (1.8 m MLLW), and are thus under water much more frequently than in Upper Newport Bay. Prolonged immersion reduces both the availability of oxygen to the roots and sunlight to the stems. Hubbard (1969) noted a distinct change in morphology of *Spartina anglica* associated with elevation, with diminution in height and decrease in diameter of stems at lower elevations in British marshes. We found a similar pattern of growth in Anaheim Bay, with *Spartina* reduced both in height and percent cover from levels found in Upper Newport Bay. The shortness of the *Spartina* results in lower elevation of nests in Anaheim Bay, and makes them more prone to flooding.

With the generally reduced availability of classical nest sites in *Spartina* in 1980, the rails shifted towards Type 2, 3, and 4 nests, but particularly Type 3. There is an abundance of high-marsh habitat at all 3 marshes, but most of it is land-connected, and the isolated berms and hummocks that support Type 3 nests are not plentiful anywhere. In 1980 most of the Type 3 nesting locations were used while only a few of the many possible Type 4 sites had nests. In Anaheim Bay in particular, most of the upland/marsh interface is characterized by a dense growth of *Salicornia virginica* and other high-marsh plants that should provide a large number of nest sites. But this land-connected nesting habitat is subject to severe predation and is used infrequently.

The shift to Category 3 nests during 1980 at all 3 marshes appeared to be brought on by weather-related factors that were devastating to the low marsh. An unusual series of consecutive storms during January–February 1980 resulted in the highest peak and sustained flood flows on record in both San Diego Creek, which empties into Upper Newport Bay, and the Tijuana River (Wahl et al. 1980). The lower marsh was most affected by the storm tides and heavy runoff, and many stands of cordgrass were totally removed or left matted and rendered useless for rail nesting. In Anaheim Bay, buffeting by storm tides and by wind-driven flotsam was apparently sufficient to damage the already tenuous stature of the few tall *Spartina* patches. In Upper Newport Bay, heavy sedimentation has been an ongoing problem and the silt deposition caused by the storms (Wahl et al. 1980) was probably responsible for the slow recovery of the *Spartina* that spring.

Freshwater marsh is not a habitat usually associated with the coastal races of the Clapper Rail. On the contrary, where Clapper and King (*R. elegans*) rails occur sympatrically, choice of nesting habitat has been used as one criterion for differentiating between them, as Clapper Rails were presumed to nest only in saltmarsh (Meanley 1969, Ripley 1977). There are a few anecdotal accounts of Light-footed Clapper Rails nesting in freshwater marshes. Willet (1906) found a nest in reeds in an inland marsh in Los Angeles County, and van Rossem found one "in a clump of spear grass (*Scirpus*)" (*in* Bent 1926), both considered unusual enough occurrences for special comment. Since finding the first freshwater marsh nest in 1979, we have searched for, and found, Light-footed Clapper Rails in several other freshwater marshes. Our most recent census data from the spring of 1982 showed 22% of the state's population nesting in freshwater marsh or stands of freshwater reeds fringing saltmarshes. In addition to providing nesting habitat, freshwater marsh in Upper Newport Bay is used regularly by rails for foraging and roosting. Small patches scattered along the bay's edges also serve as refuges during high tides and when alarm signals are given by other birds.

We do not understand the increase in clutch size in 1980. The mean clutch size for this subspecies has not been established; until we have more data over a large number of seasons, we cannot know if the increase was a recovery from a below average season in 1979 or a rise to above normal.

Several saltmarshes in southern California that have little or no *Spartina* nevertheless have resident populations of Light-footed Clapper Rails. The 4th largest population in the state during 1982 was in Carpinteria Marsh, Santa Barbara County, where *Salicornia virginica* is dominant and there is no cordgrass (Zembal and Massey, field notes). Rail nests were all Type 3. A *Salicornia* marsh with good tidal flushing and nest sites that afford protection against predators can provide adequate nesting habitat. Such marshes are by no means as desirable as one like Upper Newport Bay with its full range of habitats for the rails, but they do provide options during the current critical shortage of *Spartina* habitat.

The limited occurrence of tall, dense *Spartina foliosa* is a major factor restricting Light-footed Clapper Rail populations. In the absence of habitat which will support the classical Type 1 nest, breeding rails are faced with several choices. If they build in low sparse cordgrass, their nests are in danger of destruction by high tides; if they choose high ground that is land-connected, predation is a problem. The remaining choice, a hummock of high ground out in the low marsh, appears to be the most successful alternative, but is in short supply. Nesting hummocks are not difficult to create, and we have begun to experiment with them. Five were built in Anaheim Bay in early 1982 and planted with upper-marsh vegetation. Similar projects could be done at other marshes. The long-term solution to the rails' nesting problem, however, is full-scale restoration of coastal saltmarshes, with particular emphasis on *Spartina foliosa*.

SUMMARY

Nesting activities of the Light-footed Clapper Rail (*Rallus longirostris levipes*) were observed for 3 seasons in 3 southern California coastal saltmarshes. We found 208 nests, representing about 85% of the breeding pairs in the study areas. Nests were grouped into 5 categories. The rails' preferred breeding habitat was tall, dense *Spartina foliosa* in the low littoral zone, where they built platform nests out of dead *Spartina* stems. Where (or when) such habitat was not available, the birds still nested preferentially in low marsh, using tide-deposited materials as nesting cover. Nests were also built in *Salicornia virginica* and other upper-marsh plants on hummocks of high ground surrounded by low marsh. Only rarely did the rails nest in high marsh that was contiguous with uplands. Stands of freshwater reeds were present at one marsh and were used regularly for nesting, as well as foraging and roosting. Clutch size, hatching success, and causes of nest failure were documented whenever possible. Major causes of nest failure were flooding of nests in low marsh and predation of high-marsh nests. The dearth of suitable nesting habitat in the coastal marshes of southern California is a severely limiting factor to the growth of the Light-footed Clapper Rail population.

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