BREEDING BIOLOGY OF THE CALIFORNIA CLAPPER RAIL IN SOUTH SAN FRANCISCO BAY

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Abstract: Nesting activities of the California clapper rail (*Rallus longirostris obsoletus*) were observed during April through August 1980 in three marshes in south San Francisco Bay. Fifty nests were found, primarily using rope drags, from 11 April through 14 July. Clutch size averaged 7.27 (SD = ±0.96) and hatching success was 38 percent for 26 nests. Predation by Norway rats (*Rattus norvegicus*) accounted for the failure of 24 percent of the nests. Based on the composition of their canopies, five nest types occurred: pickleweed (*Salicornia virginica*), Pacific cordgrass (*Spartina foliosa*), gumplant (*Grindelia humilis*), salt grass (*Distichlis spicata*) and wrack (drifting dead vegetation). Pickleweed and wrack provided the primary nesting cover at 58 and 20 percent, respectively, of the nests examined. Nests were found in greater numbers in the lower marsh zones where Pacific cordgrass and tidal sloughs were more abundant. In optimal habitat such as Dumbarton Point and Mowry Slough, breeding densities ranged from 0.90 to 1.60 rails/ha.

The California clapper rail (*Rallus longirostris obsoletus*) is indigenous to the tidal salt marshes of San Francisco Bay and several coastal marshes of central and northern California (Gill 1979). Since the mid-1800's, nearly 95 percent of San Francisco Bay's historic 73,500 ha of tidal marshlands have been lost to filling or converted through diking to form salt evaporation ponds and agricultural lands (Josselyn 1983). As a result, the subspecies was given federal endangered status in 1970 (USFWS 1973). The California State Fish and Game Commission also listed the rail as endangered in 1971. Breeding biology and nesting habitat of *R. l. obsoletus* have been investigated previously (e.g. Degroot 1927, Applegarth 1938, Zucca 1954, Gill 1973), but hatching success has not been reported. Some of these studies reported that predation of eggs by the Norway rat and inundation of nests by high tides caused nesting failure and nesting success may be declining (Wilbur and Tomlinson 1976). Based on surveys during the early 1970's, the total population of *R. l. obsoletus* was estimated at between 4,200 and 6,000 individuals, of which 55 percent occurred in south San Francisco Bay (Gill 1979). More recent surveys (Harvey and Kelly unpubl. data) indicate the total population may not exceed 1,500 individuals. The purpose of this study was to investigate the hatching success, nesting habitat and breeding densities of the California clapper rail in south San Francisco Bay during the 1980 breeding season.

MATERIALS AND METHODS

Study Area

South San Francisco Bay encompasses the bay shorelines of Alameda, Santa Clara, and San Mateo counties south of the Hayward-San Mateo Bridge (Figure 1). Breeding rails were surveyed in three south bay marshes in Alameda County where significant populations occurred (Gill unpubl. data). These marshes were Ideal Marsh (55.2 ha), Dumbarton Point (118.6 ha) and the marsh west of the mouth of Mowry Slough (153.7 ha) (Figure 1). All the marshes were adjacent to dikes which surround salt ponds or support railroad tracks.

These marshes contained two general vegetation zones whose approximate boundary was the mean high water line (Macdonald 1977). The upper marsh zone occurred over 60-80 percent of the marsh surface area and supported thick, low (< 1 m) cover. It consisted of pickleweed (*Salicornia virginica*) over 80-90 percent of its area and secondarily of saltgrass (*Distichlis spicata*), alkalai heath (*Frankenia grandifolia*) and *Jaumea carnosa*. The low marsh zone also supported pickleweed but was dominated (80-100 percent coverage) by Pacific cordgrass (*Spartina foliosa*). The landward limit of Pacific cordgrass is approximately the mean high water line. The lower marshes at Dumbarton Point and Mowry Slough supported a more extensive system of tidal sloughs than did the upper zones and also accumulations of wrack (drifting dead vegetation). Gumplant (*Grindelia humilis*) occurred frequently along the edges of larger tidal sloughs (> 1 m wide), while slough banks and the outer bayside marsh edges supported uniform stands of Pacific cordgrass 1-15 m wide. The upper marsh at Mowry Slough has numerous small ponds or salt pans which receive limited tidal action.

Nest Searches

Nest searches were conducted an average of three times per week from the beginning of April through August 1980. Each survey was conducted during high tide conditions and averaged three hours in duration. Nests were found by walking parallel to and within 10 m of the edges of tidal sloughs. Areas supporting tall pickleweed, gumplant, dense stands of Pacific cordgrass or accumulations of wrack were visually inspected with the aid of a 1 m stick. Rope drag transects were also used (Gill 1973). The drag transects were made with 0.4 cm dacron rope 65 m long and averaged 55 m wide. Each drag was made on a course parallel to the banks of a tidal slough. The average area surveyed by a single rope drag transect was 4.4 ha. The likelihood of rails escaping detection by retreating into sloughs was minimized by

Table 1. Summary of California clapper rail nesting activities in three south San Francisco Bay marshes, April-August 1980.

When first nests found	11 April
Total number nests found	50
Number active nests monitored	26
Mean clutch size (n = 26)	7.27
Range of clutch sizes	6-9
Mean incubation period (days)(n = 5 nests)	24.2
Range of incubation periods (days)	22-29
Total number eggs	189
Known number of eggs hatched	71 (38%)
Eggs lost to rats	63 (33%)
Eggs left unhatched	34 (18%)
Eggs disappeared	21 (11%)
Number nests hatching successfully	28 (56%)
Number nests with hatching failure	16 (32%)
Number nests with outcome unknown	6 (12%)

Breeding Density

Breeding densities of clapper rails were estimated using rope drags and a call count method (Zembal and Massey 1981). The area covered by each drag, the origins of all flushed rails, and the locations of pairs or individuals calling within the immediate area covered by the transect were plotted on maps (1 in = 330 ft). Using a polar planimeter, the total area covered by each transect was measured and the number of rails per hectare was calculated.

The locations of individuals heard vocalizing in the study areas or flushed during rope drags and nest visits were plotted throughout the study. Generally, if one or two rails were noted at the same location on at least three occasions, a single pair was assumed to be present. Overlays were then used to map the total number of adults heard or observed in surveyed portions of the marshes. This technique provided a minimum population estimate for the areas actually surveyed and, by extension, breeding densities for entire marshes.

RESULTS

Nest Searches

The most effective method of locating rail nests was the rope drag transect which accounted for 28 of the 50 nests found. Between 1 and 10 rails were flushed on each drag. The mean number flushed per drag was six. Nearly 30 percent of the rails flushed led to the discovery of a nest, usually within 8 m of where the individual was first sighted. In most cases, rails flushed from a nest took flight immediately and flew ahead of the drag line. Of 50 nests located from 11 April through 14 July 1980 (Table 1), 27 were at Dumbarton Point, 18 at Mowry Slough, and five at Ideal Marsh.

Thirty-one contained eggs being incubated or in the process of hatching. Recently-vacated nests, judged to have produced young, were first discovered at Dumbarton Point during the fourth week of April. Assuming an incubation period of 23-29 days (Applegarth 1938, Zucca 1954), egg laying began during the fourth week of March. Active nests were found in the greatest number during the latter half of April through the first half of May and again from late June to early July (Figure 2).

Hatching Success

Clutch size for 26 rail nests averaged 7.27 (SD = ±0.96) and ranged from six to nine eggs (Table 1). Hatching success was 38 percent for 26 monitored nests and the percentage of nesting attempts which I believed successfully hatched was 56 percent (28/50) (Table 1). Mammalian predation of eggs contributed significantly to hatching failure during this study (Table 1). Feral cats were observed occasionally on saltpond levees adjacent to marshes, but cat predation was not verified. However, tracks of Norway rats (*Rattus norvegicus*) were regularly observed along the banks of tidal sloughs in the vicinity of nests experiencing predation. Nests presumably depredated by rats usually had all their eggs broken and occasionally had slight damage to the canopy and nest platform. The eggs were often still lying in the nest, but were cracked in half on their long axes. Eggs at all stages of development were depredated. Of the 50 nests discovered, 12 (24 percent) presumably experienced predation by rats. Among the 26 active nets monitored, 33 percent (63/189) of eggs laid were lost to rat predation (Table 1). Although nests that experienced predation tended to be adjacent to each other, no relationship was observed between proximity to levees and increased predation. The mean distance to the nearest slough for successful nests in all marshes was 9.9 m whereas unsuccessful nests averaged 5.2 m from their adjacent sloughs. This difference was not statistically significant ($P > 0.20$). Hatching success was not found to differ significantly among the various nest types monitored, or between earlier or later nesting attempts.

Nesting Habitat

The majority of nests (30/50) were in the lower marsh zone and all were associated with tidal sloughs ranging 0.5 to 10 m wide (Table 2). Nests were a mean distance of 7.8 m (SD = ±8.9 m) from these sloughs. This association was most obvious in the lower marsh zone of Dumbarton Point which supported a profusion of small tidal sloughs and more nests than in the upper marsh. Six species of marsh vegetation encountered from sampling at nest sites were pickleweed, Pacific cordgrass, salt grass, alkalai heath, Juamea and gumplant. Pickleweed occurred at 96 percent of the 45 nest sites sampled. Wrack and Pacific cordgrass both occurred in 45 percent of the

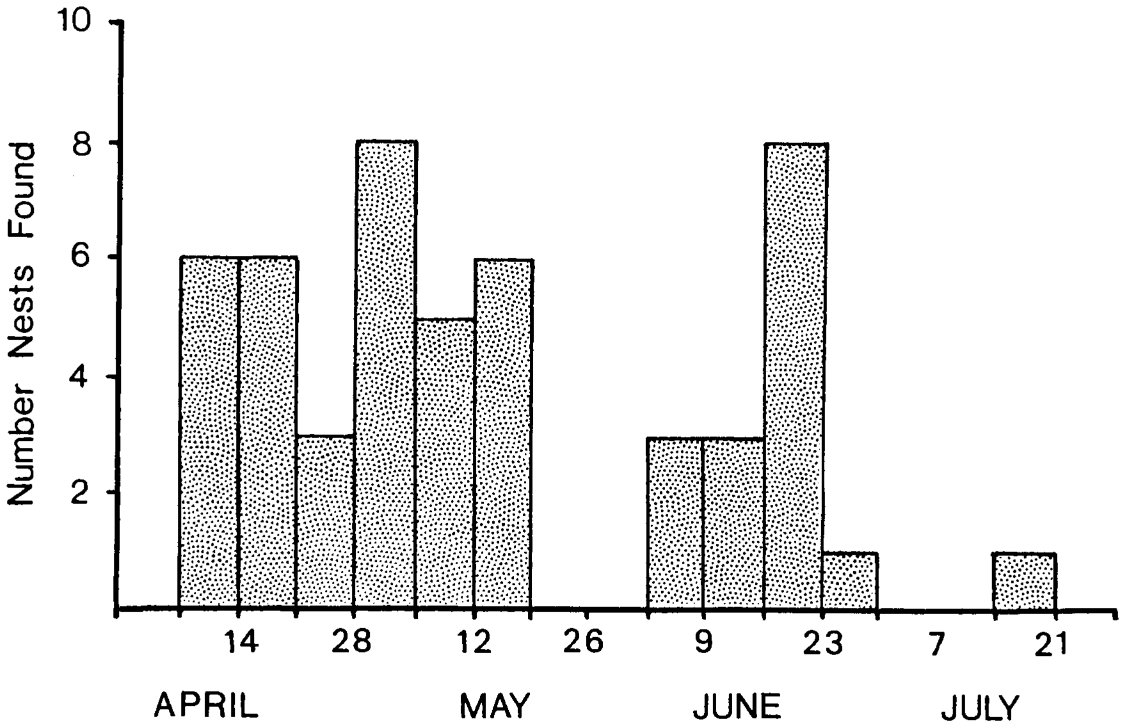

Fig. 2. Numbers of California clapper rail nests found in south San Francisco Bay and grouped by weeks during the 1980 breeding season.

quadrats. Salt grass was in 18 percent of the samples, while gumplant, alkalai heath and Juamea were in less than 10 percent. All nests were under a canopy of vegetation or wrack which obscured the nest platform from above. Based upon the composition and structure of their canopies, five different types of nests were observed. These were the pickleweed, wrack, Pacific cordgrass, gumplant and salt grass nest types. Generally, nest platforms were one-third the height above ground as the tops of canopies (Table 2). While the range of canopy heights recorded for pickleweed, wrack, and salt grass nests was 25-65 cm, heights of canopies of nests in Pacific cordgrass ranged from 69-85 cm. Variation in the ages of individual gumplant bushes accounted for the great range in canopy height shown by these nests. Nest platform widths were fairly constant, while platform heights varied depending on the type of nest. In Pacific cordgrass nests, platform heights were no lower than 18 cm, which attests to the greater frequency of tidal flooding in the low-lying areas occupied by this vegetation. Pickleweed and wrack were the most commonly used materials, occurring at 80 percent of the 45 nests. Prior to mid-May, pickleweed, wrack, and gumplant evidently provided the most available cover for nesting rails. Pacific cordgrass, which was more commonly encountered in canopies later in the season, had not yet attained its full height of approximately 1 m. Pickleweed canopies, found in both the upper and lower marsh zones, comprised 58 percent (26/45) of the nest sites. They often consisted of a prominent clump of vegetation particularly in the low marsh zone, but occasionally in high marsh areas the pickleweed was of uniform height. At Dumbarton Point, the mean height of nest canopies (54.1 cm) exceeded the mean height of pickleweed stands (34.7 cm) encountered in transects (Harvey unpubl. data). At 20 percent (9/45) of the rail nests, wrack provided the dominant component of the canopy. Wrack canopies, usually consisting of small tree branches or stems of tules (*Scirpus acutus*)

Table 2. Dimensions of clapper rail nests (n = 45) and nest canopies in south San Francisco Bay, 1980. Sloughs ranged from 0.5-10 m in width.

Variable	Mean	SD	Range
Canopy height (cm)	57.1	15.2	25-109
Nest platform height (cm)	17.9	6.3	8-28
Nest platform width (cm)	21.1	2.8	17-32
Distance to nearest slough (m)	8.2	8.9	0.5-50

Table 3. California clapper rail 1980 breeding season density estimates for three south San Francisco Bay marshes using rope drag transects and combined rope drag and call count data.

Variable	Dumbarton Point	Mowry Slough	Ideal Marsh
Rope Drag Transects			
Total marsh area (ha)	118.6	153.7	55.2
Number of rope drag transects	5	14	2
Area covered by drags (ha)	24.2	53.8	18.5
Average rope drag density (rails/ha)	1.59	1.43	0.36
Range	0.98-2.22	0.76-2.94	0.31-0.41
Combined Rope Drag and Call Count Data			
Total area covered (ha)	68	117	55
Total number pairs present	50	52	19
Density (rails/ha)	1.47	0.89	0.69

were often mixed with pickleweed. Some nests were completely sheltered by tumbleweeds (*Salsola kali*), mats of tules and additional drift materials such as small pieces of wood, dried cordgrass stems, cattail (*Typha* spp.) stems, bamboo, tree bark, and plastic. Fewer nests were found with Pacific cordgrass, gumplant and salt grass as major components of the canopy. Four Pacific cordgrass nests were in sites dominated by this vegetation, such as shallow ponded depressions and tidal sloughs. The canopies of these nests resembled domes with live stems loosely intwined and converging over the nest platform. Even though most nests were under pickleweed or wrack-dominated canopies, Pacific cordgrass was either a canopy component or occurred within the immediate vicinity of 60 percent of the nests. The four gumplant nests were under bushes ranging from 55-109 cm in height adjacent to tidal sloughs. This plant provided complete coverage of the nest as well as partial support of the platform with its lower branches. The salt grass nests were in the high marsh zone under prominent clumps of vegetation. Dried Pacific cordgrass stems, 4-8 cm long, were the most widely used component of nest platforms, occurring in 60 percent of the nests. Platforms constructed of this material were often several meters from the nearest stand. Most nests lacking Pacific cordgrass as a nest material were in the upper marsh where it was less abundant. Pickleweed and salt grass were the next most commonly used platform materials, occurring in 26 and 12 percent, respectively. One nest was in the center of a tumbleweed which served as both nest canopy and platform.

Breeding Density

A total of 21 rope drags were conducted, covering a combined area of 96.5 ha in the three marshes surveyed (Table 3). The breeding densities (rails/ha) derived from these transects were similar in Dumbarton Point (1.59) and Mowry Slough (1.43). However, Ideal Marsh yielded a lower value (0.36). Using both rope drag and call count data, an overall density for all of Ideal Marsh was obtained (Table 3). Breeding densities for only 30-50 percent of the other two marsh sites were obtained with this method. At Dumbarton Point, the breeding density derived from rope drags alone (1.59) was similar to the value resulting from combining rope drag and call count data (1.47). However, a lower density for Mowry Slough and a higher value for Ideal Marsh resulted from the combined data.

DISCUSSION

Nesting Activity

The two observed nesting peaks, as shown by when the greatest numbers of active nests were found, have been reported previously (DeGroot 1927, Applegarth 1938, Zucca 1954, Gill 1973). While Zucca (1954) proposed that nesting peaks were timed to avoid extreme summer high tides, I saw no evidence to support this. The second nesting peak has been attributed to late-nesters (DeGroot 1927), or second attempts following nesting failure (Gill 1973). It may also represent multiple brooding, which is known to occur among clapper rails on the east coast (Blandin 1963). Mean observed clutch size compared closely with previous measurements of 7.92 (Applegarth 1938), 7.22 (Zucca 1954) and 6.83 (Gill 1979) for *R. l. obsoletus*. Hatching success from this study was lower than that recorded for *R. l. levipes* in three southern California marshes where it ranged from 55 to 84 percent (Jorgensen 1975, Massey et al. 1984). Also, the percentages of nesting attempts during three seasons which were successful ranged from 80 to 86 percent (Massey et al. 1984), exceeding the 56 percent (28/50) rate I observed. Finally, the rate of egg loss to predation I observed (33 percent) exceeded the 3-11 percent recorded by Massey et al. (1984) for *R. l. levipes*. Based on numerous sightings during high tide periods, the abundance of tracks and the extent of egg loss I encountered, rats appear to be abundant in the south bay marshes. For example, in a recent high tide survey of Greco Island (San Mateo County), 30 rats were encountered in two hours on a 50 ha portion of marsh. This area also yielded the greatest concentration of rails in the census and was adjacent to a solid waste landfill site (P. Kelly pers. comm.). Grinnell et al. (1918), DeGroot (1927) and Applegarth (1938) also attributed rats with the destruction of rail nests and eggs. DeGroot (1927) believed the construction of dikes adjacent to marshes was a significant factor in expanding the range of the Norway rat in the south bay. Further study is needed to define the severity of rat predation on nesting rails. In addition, the possible influence of researchers increasing the vulnerability of nests to predation should be considered during future nesting studies. Nests occurring closer to sloughs may be more vulnerable to disruption by high tides or rat predation. The extensive system of tidal sloughs, typical of those salt marshes most favored by rails, may also unfortunately provide foraging rats easy access to nests.

Nesting Habitat

Several researchers have reported the tendency of California clapper rails to construct nests near tidal sloughs (Taylor 1894, Adams 1900, DeGroot 1927, Evens and Page 1982). Evens and Page (1982) reported that 17 rail nests at Corte Madera (Marin County) ranged from 1.5 m to 3.0 m from tidal sloughs. The association of nests with tidal sloughs at Corte Madera may be related to the predominant use of gumplant which frequently occurs along the raised banks of sloughs (MacDonald 1977). Tidal sloughs are an important factor in nest site selection because they provide rails a protected route for movement within the marsh, easy access to foraging habitat, and a nearby avenue of escape, particularly for flightless young. The frequent occurrence of Pacific cordgrass in nest canopies and the proximity of nest sites to Pacific cordgrass stands and tidal sloughs attest to the importance of the low marsh zone for nesting rails. Zucca (1954) and Gill (1973) also reported that most of their nesting pairs utilized cordgrass as a canopy and nest platform material. Clearly, the more continuous, taller cover provided by dense stands of Pacific cordgrass (Jorgensen 1975) and its proximity to foraging areas account for the continued preference of rails for this nesting habitat. In summary, based on these results and other sources (Harvey unpubl. data), at least four features characterize optimal California clapper rail habitat in south San Francisco Bay: (1) a system of tidal sloughs providing direct tidal circulation throughout the marsh, (2) predominant coverage by pickleweed with extensive stands of Pacific cordgrass in the lower marsh zone, (3) high marsh cover consisting of tall stands of pickleweed, gumplant, and wrack, and (4) abundant invertebrate populations as evidenced by the presence of *Ischadium demissum* and *Hemigrapsus orgonensis*.

Breeding Density

Several factors may have contributed to the lower breeding density encountered using rope drags at Ideal Marsh. During the 1940's, the site of this marsh supported a salt pond, and the eroded remnants of an outer bayside levee are still recognizable. This may have impeded the development of tidal sloughs and thus affected the quality of the habitat. In general, the height of the vegetation cover at Ideal Marsh is lower that at the other marshes surveyed (Harvey unpubl. data). In addition, during extreme high tides (9.7 ft above mean sea level), this marsh is completely submerged. The relatively lower value determined for Mowry Slough by combining rope drag and call count data in contrast to the two similar values for Dumbarton Point may have been due to the following reasons: (1) the majority of call counts in this area were conducted later in the breeding season (June) when rails vocalized less frequently, (2) an extensive system of tidal sloughs that characterizes prime rail habitat, is less developed at Mowry Slough, and (3) Dumbarton Point, with an average width of 760 m, is one of the largest expanses of clapper rail habitat remaining in San Francisco Bay and supports the greatest individual population of the subspecies (Harvey unpubl. data). Population studies by Applegarth (1938) and Gill (1979) in south San Francisco Bay provided comparable data on population densities during the breeding season. Applegarth (1938) encountered breeding densities of 1.59, 4.35 and 1.69 rails/ha for three study sites. Gill (1979) estimated that the clapper rail breeding density for the south bay during 1971-1975 averaged 1.6 rails/ha. Evens and Page (1982) reported an average year-round density of 1.3 rails/ha at Corte Madera, Marin County. The densities encountered in this study are similar to those reported by Gill (1979) for the south bay. This suggests that optimal south bay, such as Dumbarton Point, supported populations in 1980 which were comparable to the early 1970's. In general, the methods employed to estimate population sizes and breeeding densities were considered appropriate for south San Francisco Bay. The large widths of the marshes and difficulties in gaining access precluded exclusive censusing by call counts (Zembal and Massey 1981). Prior to Pacific cordgrass attaining its full height (1.0-1.2 m), rope drag transects early in the breeding season and during high tides were particularly useful in locating nests and estimating breeding densities.

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