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# EFFECTS OF TEMPORAL AND ENVIRONMENTAL FACTORS ON THE PROBABILITY OF DETECTING CALIFORNIA BLACK RAILS

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Abstract.—During 1995–1996, we used tape playbacks of rail calls to study the effects of temporal and environmental factors on the probability of detecting California Black Rails (*Laterallus jamaicensis coturniculus*) at Suisun Bay, California. Detection probability was assessed in a relative sense from the number of rails detected per survey during surveys repeated over the same routes under differing temporal and environmental conditions. Detections were lower during winter compared to the breeding season, due to a decline in response (as opposed to a decline in number of rails). Temporal and environmental variables explained 15–20% of the variation in detection probability during the breeding season. Number of detections varied considerably among days on the same route. On average, detection probability was relatively stable between late-April and early June, but increased from mid-June to early July, probably because of the appearance of young-of-the-year. Detection probability was greatest, and variation least, from sunrise to about 1.5 h thereafter, and likewise for the 1.5-h period preceding sunset. Detections declined abruptly 0.75 h after sunset and were similarly low during the 1.5-h period before sunrise. Other variables having significant and independent effects on detection probability were tide height, moon phase, cloud cover, and air temperature; detections decreased with increase in tide height and cloud cover, and increased with increase in air temperature and moon light (during the preceding night). Time of day had the greatest effect on detection probability. Studies of relative abundance of California Black Rails should be designed to standardize environmental factors and be repeated over the same route during the breeding season before the appearance of fledglings.

### EFECTOS DE LOS FACTORES TEMPORALES Y AMBIENTALES EN LA PROBABILIDAD DE DETECTAR INDIVIDUOS DE *LATERALLUS JAMAICENSIS COTURNICULUS*

Sinopsis.—Usamos emisión de cantos de para estudiar el efecto de los factores temporales y ambientales en la probabilidad de detectar *Laterallus jamaicensis coturniculus* en la Bahía de Suisan, California, entre 1995 y 1996. La probabilidad de detección se hizo de forma relativa del total de individuos detectados por muestreo durante censos repetidos en las mismas rutas a través de diferentes condiciones temporales y ambientales. Las detecciones fueron menores en el invierno al compararse con el período reproductivo debido a una reducción en la frecuencia de respuesta de las aves (en vez de deberse a una reducción en el total de aves). Las variables temporales y ambientales explicaron el 15–20% de la variación en la probabilidad de detección durante el período reproductivo. El número de detecciones varió considerablemente entre días en la misma ruta. Por lo general, la probabilidad de detección fué relativamente estable de fines de abril a princios de junio, pero aumentó de mitad de junio a principio de julio, probablemente debido a la aparición de las crías de ese año. La probabilidad de detección fué mayor, y la variación menor, del amanecer hasta cerca de 1.5 horas después, y de igual forma, en las 1.5 horas antes de anochecer. Las detecciones se redujeron abruptamente 0.75 horas después del anochecer y fueron similarmente bajas durante las 1.5 horas antes del amanecer. Otras variables de efectos significativos e independientes en la probabilidad de detección fueron la altura de la marea, fase lunar, cubierta de nubes y temperatura del aire; las detecciones bajaron al aumentar la marea y la cubierta de nubes, y subieron al aumentar la temperatura del aire y la luz lunar (durante la noche anterior). La hora del día tuvo el mayor efecto en la probabilidad de detección. Estudios de abundancia relativa en esta especie deben diseñarse para estandarizar los factores ambientales y repetirse en la misma ruta por el período reproductivo antes de aparecer los volantones.

California Black Rails (*Laterallus jamaicensis coturniculus*) are difficult to study because of their small size and secretive habitats in marshes that are often difficult to access. Playback recordings are an effective way of detecting them and have been used to estimate relative abundance of several populations (Jurek 1975, Repking and Ohmart 1977, Manolis 1978, Evens et al. 1991).

Estimates of true abundance have not been possible because the proportion of Black Rails that respond when in range of call playbacks had not been studied until recently (Legare 1996). Estimating relative abundance has also been problematic because of the lack of quantitative information on factors that might affect spatial and temporal differences in detection probability. Yet, obtaining this information is a priority because of the importance of monitoring trends in abundance of these birds. Like many rail species (Brown and Dinsmore 1986, Eddleman et al. 1988), the California Black Rail has been, and is being, adversely affected by destruction and alteration of wetlands (Evens et al. 1991) to the point that it is presently listed as threatened in California (Calif. Fish and Game Dept. 1988), endangered in Arizona (Arizona Game and Fish Dept. 1988), and a Federal candidate for listing as threatened or endangered (U.S. Dept. Inter. 1989). Remnant populations occur in the less-altered tidal marshes remaining in the northern San Francisco Bay, Suisun Bay, Bodega and Tomales bays, Bolinas Lagoon, Salton Sea, Morro Bay, Coachella Canal, California, and lower Colorado River, California/Arizona (Jurek 1975, Repking and Ohmart 1977, Manolis 1978, Evens et al. 1991, Flores and Eddleman 1995).

During the breeding seasons of 1995 and 1996, and winter of 1995–1996, we used tape-recorded calls of California Black Rails to conduct surveys in a tidal marsh located on the Concord Naval Weapons Station on the south shore of Suisun Bay, California, an area that supports a substantial population. Our objective was to contribute information towards development of a standardized methodology for assessing relative abundance of these rails.

## METHODS

*Study area and survey design.*—We conducted breeding season surveys for California Black Rails in an 81.2-ha tidal marsh at the Concord Naval Weapons Station, Suisun Bay, California on 11 days (14 June–29 June) in 1995, and 22 days (30 April–9 July) in 1996. We also conducted winter surveys on 6 days from 26 Dec. 1995 to 11 Jan. 1996. Four survey routes were designated such that they were of approximately equal distances apart, and spaced across the entire tidal marsh. The locations of survey stations along each route were selected at random using the "systematicdesign" (Hurlbert 1984). Specifically, each route was 450-m long, with 10 stations at 50-m intervals.

Six observers conducted surveys. Each of the 40 stations was marked with a yellow flag identifying route and station number. Equal numbers of surveys were conducted during morning and evening. Morning surveys began up to 1.5 h before sunrise and extended up to 2.5 h thereafter. Evening surveys began up to 1.5 h before sunset and extended up to 2 h following sunset. Two routes were surveyed simultaneously each morning and each evening by two observers. We avoided the problem of an observer mistaking the other's recorded calls for a rail by choosing routes separated by distances >300 m, which is greater than the maximum distance at which the call playbacks could be heard. Starting points were alternated at either end of each route each time a route was surveyed.

Surveys were conducted using California Black Rail "kik-kik-kerr" and "growl" calls recorded at the weapons station in 1985, and played from a Realistic cassette player (Model SCP-29) through a Realistic No. 4-1303 stereo-amplified speaker system at full volume. At each station, the Black Rail calls were broadcast for 5 min, with a 6 s sequence of calls repeated once per minute. "Duet" calls of the California Clapper Rail (*Rallus longirostris obsoletus*), recorded at the Palo Alto Baylands, were also broadcast at each station for an additional period of 5 min. The latter sometimes elicited calls from Black Rails.

Data recorded for each detection included time, station number, call type, compass bearing, and estimated distance to the bird. Because rails sometimes approached us during playbacks (see also Todd 1980, Evens and Page 1985, Evens et al. 1986, Flores and Eddleman 1995, Legare 1996), we followed Evens and Page (1985), and estimated distances based on the first call elicited by a rail (but see Discussion for assessment of the effect of rail movement towards the tape recorder before vocalizing). Simultaneous vocalizations and distances between call locations distinguished individuals (e.g., if two vocalizations occurred within ≤30 s of one another from locations separated by ≥50 m, we recorded them as representing two rails).

Weather, including wind speed and direction, air temperature, and cloud cover were recorded at the beginning and end of each survey. Surveys were not conducted, or were terminated, if winds exceeded 25 km/h.

Following Kepler and Scott (1981) and Evens and Page (1985), observers were trained to estimate detection distance using a recorder playing rail vocalizations at various distances from the observers. The practice sessions were conducted prior to the surveys.

*Calculation of detection distance.*—Estimating abundance of rails from call playback surveys requires the determination of the maximum range within which rails are detected with equal probability (see Buckland et al. 1993). The expected number of detections would increase in proportion with $\pi r^2$, where $r$ is the distance between the observer broadcasting the calls and the outer edge of the survey zone (i.e., the radius of the circular survey zone). Conformance in the number of rail detections with this relationship as $r$ is increased would indicate that rails were being detected at the greater distances as well as they were at shorter ones. However, a decrease in rail detections below that detected at shorter ranges would indicate that detection probability was negatively affected by the increase in $r$, either because the observer was hearing fewer of the responding rails, or if fewer rails responded.

*Analyses.*—Using the program STATA (Stata Corp. 1995), multiple regression analyses were used to examine the relationship of temporal and environmental variables with detection probability. We defined "detection probability" as the number of rails detected per station survey during surveys repeated on the same routes under differing temporal and environmental conditions. Hence, the sample unit was one station-survey, and the sample size for the breeding season included 30 surveys at each of the 40 stations, or 1200 surveys. Each station survey was independent from the others because each was spatially (see below for details) and temporally distinct (see Hurlbert 1984); that is, each station-survey was associated with a unique set of values representing a suite of temporal and environmental variables.

Variables included time of day (hereafter "survey timing"), morning vs. evening, moon phase, tide height at time of survey (hereafter "tide height"), duration after last high and low tides, height of last low and high tides, air temperature, wind speed, and cloud cover. Survey timing, analyzed on a station-to-station basis, was the number of min before or after sunrise or sunset. Moon phase was coded on a scale of zero (= day of new moon with no moon light) to day 15 (full moon). Days 14 to 1 reflect the progressive decrease in moonlight during waning and, inversely, days 1 to 14 reflect the progressive increase in moonlight during waxing. Variables related to tide were from Natl. Oceanic and Atmospheric Admin. tidelogs. Each station value of tide height, temperature, wind speed, and cloud cover, was extrapolated between the values recorded at the beginning and end of each route surveyed. Other variables included in multiple regression models were those inherent to the sampling design (survey route, station number, route direction for a given survey, and observer effects) and large scale temporal variables (year and Julian date).

Because rails were recorded to distances up to 120 m, we could have recorded the same rail from more than one station because our stations were 50 m apart. To eliminate this problem, we grouped the data into paired sets where each set of stations was 200 m apart. One set included stations 1, 5, and 9; the other included stations 2, 6, and 10. Hence, data from stations 3, 4, 7, and 8 were excluded. Thus, 360 station surveys were included within each data subset. Apart from maintaining spatial independence among samples, this allowed us to compare consistency of the results from parallel analyses.

All variables were entered into each regression model and analyzed using forward stepwise selection (Seber 1977) of significant variables ($P < 0.05$). We then re-entered into the model, one at a time, each variable having an insignificant effect in the forward procedure. Any of these variables now having a significant effect (i.e., when all insignificant terms had been removed) was retained. Neither log nor square-root transformation normalized the residuals produced in the regression models (Skewness/Kurtosis Test for Normality of Residuals, $P > 0.05$). Least-squares regression analysis (ANOVA) is considered a robust procedure with respect to non-normality (Seber 1977, Kleinbaum et al. 1988). Although these analyses yield the Best Linear Unbiased Estimator relating detection probability to independent variables even in the absence of normally distributed residuals, $P$-values at the lower levels of significance must be regarded with caution (Seber 1977).

All variables except route and observer were analyzed as continuous. Nonlinearity in the relation between detection probability and independent variables was tested by including second- and third-order polynomials in the models. Interactions among the effects (on detection probability) of survey route, route direction, and station number were also tested. When a significant effect of a categorical variable (route or observer) was indicated, Sidak multiple comparisons tests (an improved version of the Bonferroni test; SAS Inst., Inc. 1985) were used to examine component differences. Log-likelihood Ratio ($G$) tests were used to examine proportional differences. Means ± one standard error (SE) are given. Data from the two parallel data subsets were grouped for the purposes of graphical display.

## RESULTS

*Detection distance.*—Only 35 (3.6%) of the 960 rail detections were estimated to have been of rails 101–120 m from the observer (Fig. 1a,c).

During the breeding season, the number of rails detected relative to number expected showed a linear decline beyond 10 m from the observer (Fig. 1a,b). Based on maximum detection probability at a distance of 1–10 m, the number of rails detected at distances of 11–20 m was 86% of that expected, 61% to 63% at distances of 21–30 m and 31–40 m, respectively, and 49% to 45% of the expected number at 41–50 m and 51–60 m. The marked increase in the number detected at 91–100 m (though lower than expected) compared to 71–80 and 81–90 m, was due to difficulty in estimating distances beyond 60 m, where observers began using a "catch-all" value of 100 m (Fig. 1a; this problem reviewed in Scott et al. 1981).

During winter, the decline with distance in number of detections relative to that expected was even more marked than during the breeding season (Fig. 1c, d). The number detected at 11–20 m was 56% of the number expected (compared to 86% during the breeding season); and only 24% of the number expected were detected at 21–30 m (compared to 61% during the breeding season). Not surprisingly, the number of rail detections per survey during winter ($0.42 \pm 0.077$, $n = 120$ surveys) was significantly lower than during summer ($0.73 \pm 0.034$, $n = 720$ surveys; unpaired $t$-test $= 3.44$, df $= 838$, $P < 0.001$). However, the number de-

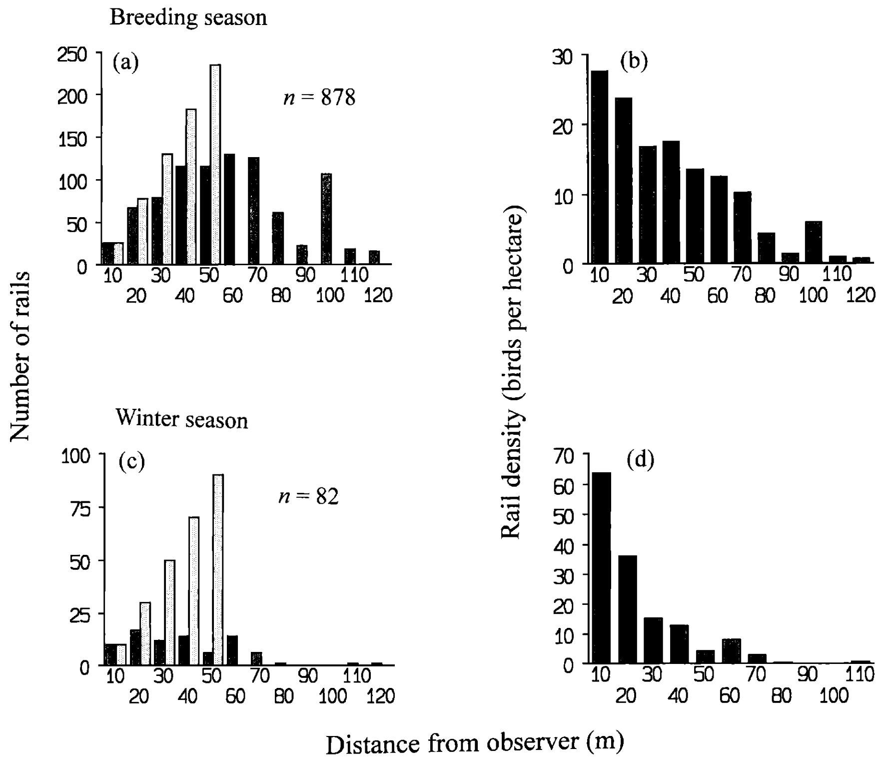



FIGURE 1. Number of Black Rails detected (dark bar), and number of detections expected (light bar), at various distance intervals from the observer during the breeding season (a) and winter season (c). Calculations of number of rail detections expected at various radii were based on the assumption that 100% of the rails within the radius of 1–10 m were detected. Number expected to have been detected within the area between 11–20 m then, was rail density (rails per unit area) observed within a radius of 10 m multiplied by the surface area lying between radius of 11 and 20 m. Figures (b) and (d) show rail densities detected within respective increments of distance from the observer.

tected per station within 10 m was over twice as great during winter compared to summer, and was similar at 20–30 m (Fig. 2a). Hence, the decline in response frequency during winter occurred primarily among rails at distances >60 m. The lower density recorded during winter, therefore, reflected a decline in responsiveness, rather than a decline in number of rails.

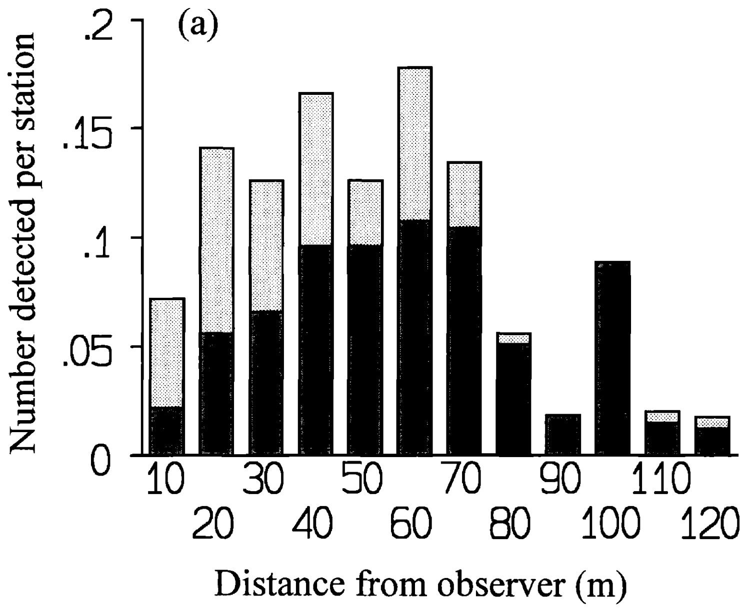
The lower number of detections per survey during winter was related to the less frequent use of the kik-kik-kerr, in combination with more frequent use of the growl and "churt" (Fig. 2b). The growl and churt (maximum detection distance = 60 m) did not carry as far as the kik-kik-kerr (maximum detection distance = 120 m), When considering only the detections within 60 m, and assuming that all vocalizations ≤60 m were heard, rails used the growl/churt proportionately more often during winter than summer, when the kik-kik-kerr predominated ($G = 25.53$, df = 1, $P < 0.001$, Fig. 2b).

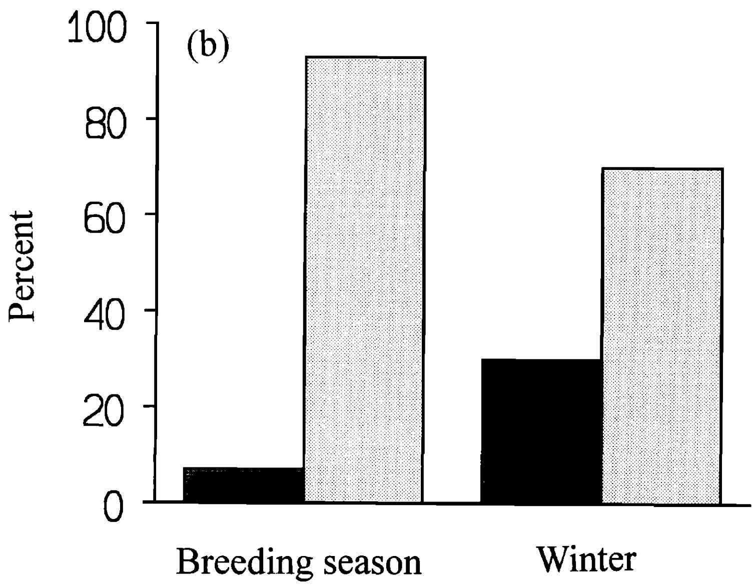
*Breeding season: Effects of survey design, temporal, and environmental factors.*—Number of rails detected on a given route varied considerably between surveys, even within a few days. The effects of sampling, temporal, and environmental variables explained 29.9 and 24.5%, respectively, of the variability in the two models (i.e., the split data set) for detection probability (Table 1). After sampling effects were removed from the models, temporal and environmental effects explained 20.3% and 15.3% of the variation. The relation of detection probability with environmental and sampling variables was consistent between the two data sets. Of the nine variables having an independent and significant effects on detection probability (i.e., with all variables included in the same model), only cloud cover and station number (see below) did not contribute significantly in both. The sign of the regression coefficients for any given variable did not differ between the two models.

Detection probability differed significantly among routes (Table 1) and, for a given route, increased with station number in the first parallel analysis. (The latter result was probably due to differences in the flora along each route, Spear et al., unpubl. data). Observer differences also had an insignificant effect on detection probability. A significant interaction between route and survey direction reflected a higher detection probability of observers moving from stations 1 to 10 along route one (vs. the direction 10 to 1), in contrast to other routes where survey direction was not related to detection probability.

Detection probability increased with year during the breeding season (1995, $\bar{x} = 0.65 \pm 0.048$, $n = 240$ stations sampled; 1996, $\bar{x} = 0.76 \pm 0.042$, $n = 480$) and date (Table 1). The seasonal increase occurred mostly after mid-June (Julian date 165; Fig. 3).

Other temporal and environmental variables having significant and independent effects on detection probability were survey timing, moon phase, tide height, air temperature, and cloud cover (Table 1). Detection probability during morning surveys did not differ from that of evening surveys. A quadratic relation between detection probability and survey timing in both morning and evening reflected higher counts to 1.5 h after sunrise, and higher counts 0.75 h preceding sunset (Fig. 4a,b). Counts were lowest prior to sunrise and about 1 h following sunset, and 2 h after sunrise. Detection probability increased significantly with increase in moonlight (Fig. 4c). Thus, rails vocalized more following the night of a bright moon. Detection probability also increased significantly with decrease in tide height and cloud cover, and with increase in air temperature (Fig. 4d,e,f). Duration after last high tide and last low tide, height of last low and high tide, and wind speed were not related to detection probability. Of the significant temporal and environmental variables, survey timing had the greatest and most consistent effect on detection probability (Table 1).


(a)
Number detected per station
.2
.15
.1
.05
0
10
20
30
40
50
60
70
80
90
100
110
120
Distance from observer (m)


(b)
Percent
100
80
60
40
20
0
Breeding season
Winter

DISCUSSION

*Detection distance.*—Only 3.6% of the rails we detected were estimated to have been >100 m distant. This result is similar to that of Repking and Ohmart (1977; 92 m maximum) and Legare (1996; maximum distance = 100 m).

The decline in detection probability with increased detection distance to a range of 50 m probably resulted, at least in part, from the rails moving towards the playbacks before they vocalized (Legare 1996). Based on distances between series of detections of California Black Rail, Evens et al. (1986) estimated that, on average, the rails moved 6.2 m closer to the playback before vocalizing (see also Emlen 1971, Evens and Page 1985, Granholm 1983). To validate the proposed correction factor, we added 6.2 m to our rail detection distances (Fig. 5). After adjustment, the detection frequency for 10-m detection distance increments showed a high degree of conformance with the expected number (Fig. 5) at 50 m.

*Effect of temporal and environmental factors on detection probability of breeding California Black Rails.*—During the breeding season, there was marked between-day variation in number of rails detected per survey on the same survey route. Although this variation may have been related to movements of unpaired males (W. R. Eddleman, pers. comm.), this factor would not likely, in itself, have accounted for the magnitude of the between-day variations in number of detections. Furthermore, movement of breeders is an unlikely explanation because they are territorial during the breeding season (Flores and Eddleman 1993, Legare 1996). This suggests that most of the variation in between-day responses of the rails resulted from factors other than variation in the number of rails available to be detected, a conclusion consistent with that of Bart et al. (1984) during surveys of Yellow Rails (*Coturnicops noveboracensis*) and Conway et al. (1994) in studies of radio-tagged Yuma Clapper Rails (*R. longirostris yumanensis*).

Effects of temporal and environmental variables (Julian date, survey timing on a given day, moon phase, tide height, air temperature, and cloud cover) explained 15–20% of the variation in detection probability. The marked increase in detection probability after mid-June (see Flores and Eddleman 1991, Legare 1996 for similar results) was likely related to the vocalizations by young-of-the-year. On several occasions during the latter part of the breeding season, groups of up to six Black Rails were encountered within a radius of 5–10 m. The higher pitched, less defined calls of some of these birds suggested the presence of juveniles. Hatching

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FIGURE 2. (a) Mean number of Black Rails detected per station during the breeding season (dark bar) and during the winter season (light bar) at various distances from the observer. (b) Percent of detections occurring as a result of growl/churt calls (dark bar) vs. kik-kik-kerr calls (light bar) during the breeding season and during the winter season. Number of rails detected was 878 during the breeding season and 82 during winter.

TABLE 1. Multiple regression models for the effect of environmental variables and variables related to survey design on detection probability (number of rails detected per station-survey) of California Black Rails at Suisun Bay, California, 30 April to 9 July, 1995–1996. Only those variables having a significant effect are reported. Main effects of variables with quadratic effects were calculated after quadratic terms were removed from the model. Numbers separated by/report on the parallel (separate) analyses on the split data set. Sample size for each model was 360 station-surveys.

| Term | Regression coefficient | SE | $F$ | $P$ | df |
|---|---|---|---|---|---|
| Survey design | | | | | |
| Survey route | —/— | —/— | 15.59/11.59 | <0.001/<0.001 | 3 |
| Station | 0.030/0.026 | 0.013/0.014 | 5.41/3.50 | <0.03/<0.07 | 1 |
| Survey route × route direction | —/— | —/— | 0.38/3.42 | ns/<0.02 | 3 |
| Environmental variables | | | | | |
| Julian date | 0.0049/0.0083 | 0.0019/0.0021 | 6.40/16.03 | <0.02/<0.001 | 1 |
| Year | 0.25/0.40 | 0.12/0.13 | 4.71/9.98 | <0.03/<0.01 | 1 |
| Survey timing | | | | | |
| linear | 0.0044/0.0034 | 0.0009/0.0010 | 24.28/11.79 | <0.001/<0.001 | 1 |
| quadratic | $-3.10e^{-05}/-3.31e^{-05}$ | $9.06e^{-06}/1.10e^{-05}$ | 11.78/10.95 | <0.001/<0.001 | 1 |
| Moon phase | 0.035/0.021 | 0.009/0.010 | 14.46/4.46 | <0.001/<0.04 | 1 |
| Tide height | −0.026/−0.021 | 0.083/0.099 | 9.54/4.69 | <0.01/<0.03 | 1 |
| Cloud cover | −0.037/0.002 | 0.015/0.017 | 6.12/0.02 | <0.02/ns[a] | 1 |
| Air temperature | 0.026/0.035 | 0.011/0.011 | 5.82/9.28 | <0.02/<0.01 | 1 |

[a] $P > 0.1$.

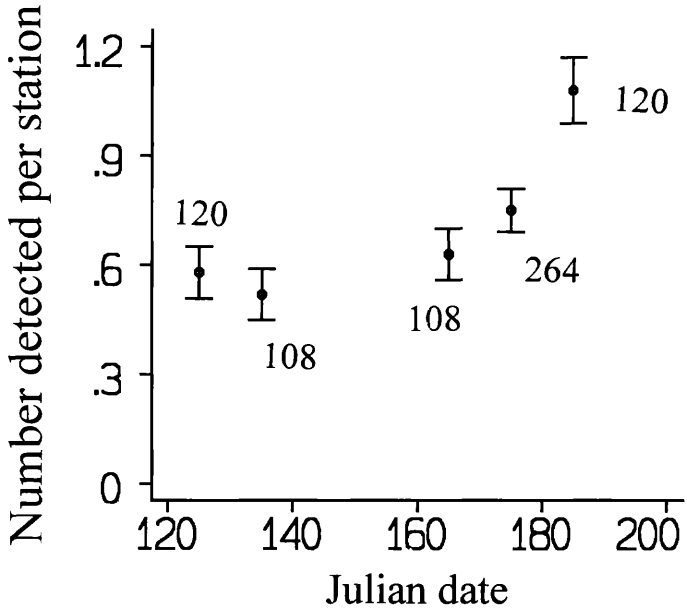


FIGURE 3. Relation between detection probability (number detected per station survey) of Black Rails and Julian date; where Julian date 120 = 30 April and Julian date 200 = 19 July.

dates in six nests at Mittry Lake, Arizona, were between 18 April and 23 July (Flores and Eddleman 1993), indicating a prolonged breeding season. In contrast, we did not record family groups before mid-June, suggesting a more synchronized breeding season at Suisun Bay (see Huey 1916, Wilber 1974, for similar results). Flores and Eddleman (1993) suggested that a shorter breeding season in coastal areas may "reflect selection against nesting during the high summer tides of June and July." In terms of survey design, surveys in the San Francisco Bay region between early May to mid-June would be least biased by effects of breeding productivity, which could vary annually and, in turn, yield invalid indices for abundance of breeding birds.

Black Rails responded with similar probability during morning and evening, but detection probability differed with time of day. Indeed, of the temporal and environmental variables, survey timing had the greatest and most consistent effect on detection probability. The period when detection probability was greatest was the 1.5-h period following sunrise, and the 1.5-h period preceding sunset. Similar patterns were observed in the Light-footed Clapper Rail (*L. l. levipes*; Zembal et al. 1989), and during morning hours in the Virginia Rail (*Rallus limicola*), although response rate of Soras (*Porzana carolina*) varied little with survey timing (Gibbs and Melvin 1993). We did not conduct surveys during midday,

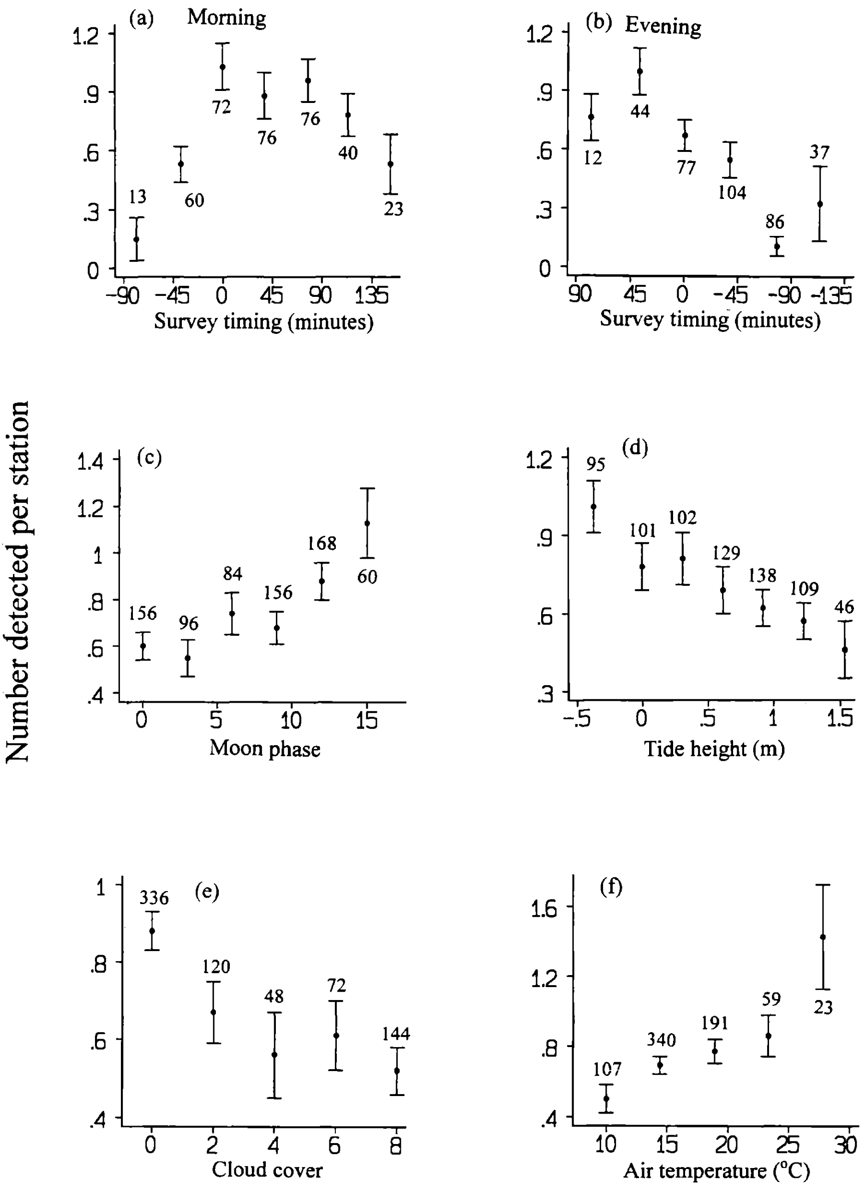


FIGURE 4. Relation between detection probability of (number detected per station survey) and environmental parameters. Survey timing (minutes) of zero = sunrise (morning) or sunset (evening); negative values denote surveys occurring before sunrise or after sunset. Moon phase of zero = new moon; 15 = full moon. See Methods, for definitions of environmental variables.

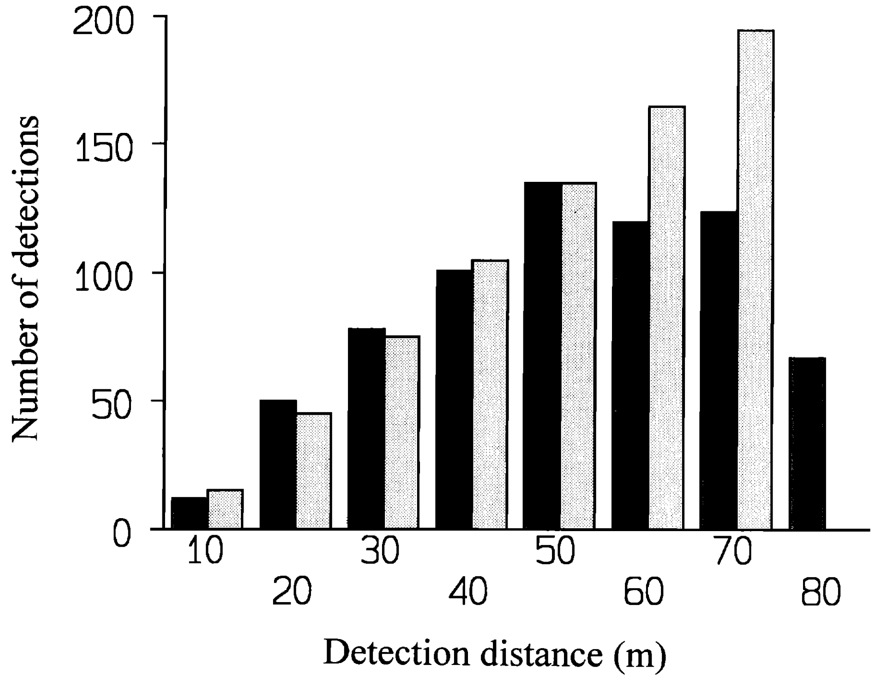


FIGURE 5. Number of Black Rails detected ($n$ = 878 detections) during the breeding season (dark bar), and number of detections expected (light bar), at various distances from the observer when adding a value of 6.2 m to the estimated detection distance recorded during rail surveys. Number of rails expected was calculated using a 50 m maximum detection range cutoff.

although low counts during mid-morning and early evening indicated that detection probability would have been lower during midday. This pattern is the norm in diurnal avian species (Robbins 1981).

Tide-height and especially air temperature and cloud cover are not easily controlled during rail surveys, but attempts to conduct surveys during lower tides, and on warm, clear days should help to provide maximum detection consistency and probability. Lack of an effect of wind speed on detection probability confirmed the conclusion of Evens et al. (1991), that the negative effect of background noise from the wind can be reduced to an insignificant level if one does not conduct surveys when winds exceed 25 km/h.

*Other factors affecting detection probability.*—We are aware of only one study (Legare 1996) of the proportion of Black Rails that respond when within range of playback broadcasts. Legare, studying breeding, radio-tagged Black Rails in Florida, found that, on average, 50% of the males but only 20% of the females responded. Legare (1996) also found that the kik-kik-kerr call was used almost exclusively by males, a result consistent with those of other studies (Reynard 1974, Repking 1975, Flores and Eddleman 1991).

Detection probability of California Black Rails was lower during winter than in summer, a finding consistent with results obtained in studies of other nonmigrant rallid populations, including Black Rails on the lower Colorado River (Repking and Ohmart 1977) and in Florida (Legare 1996), and Yuma Clapper Rails (Conway et al. 1993). The winter decline in detection probability we observed was apparently not a result of rail movement out of the study area, but instead was due to a decline in the use of the kik-kik-kerr call.

*Conclusion.*—The high day-to-day variation in response tendency of California Black Rails surveyed repeatedly on the same route during the breeding season at Suisun Bay, California, attests to the need for repeated surveys of a given area in studies designed to monitor populations of these birds. Studies of the relative abundance of California Black Rails also should be designed to standardize temporal and environmental factors, and be repeated over the same route during the pre-hatching period. In the San Francisco and Suisun Bay area, this period is early May to mid-June. A 50-m detection range was indicated as the appropriate cutoff, if one adjusts for rail movement using the correction factor (6.2 m) estimated by Evens et al. (1986).

The possibility that California Black Rails have similar, sex-related response rates as do Black Rails in Florida (see Legare 1996) requires testing. As these studies would involve trapping, sexing, and radio-tagging of a rare taxon, the risks (i.e., potential increase in mortality and nest abandonment in radio-tagged birds; Johnson and Dinsmore 1985, Bookhout and Stenzel 1987, Conway et al. 1994) should be weighed against potential gains accrued from assessment of true population numbers vs. relative numbers monitored for estimating population trends over time.

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