SEASONAL CHANGES IN YUMA CLAPPER RAIL VOCALIZATION RATE AND HABITAT USE

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Abstract: Yuma clapper rails (Rallus longirostris yumanensis) are protected under the Endangered Species Act, and 90% of the U.S. population occurs within 2 wetland complexes. Assessment of impacts on, and mitigation measures for, Yuma clapper rails are required by law, yet managers lack quantitative information on habitat requirements. Seasonal habitat requirements provide resource managers with the information necessary to assess effects of development and water use practices on Yuma clapper rails in the Southwest. Playback recordings are commonly used to survey rail populations, yet their accuracy has not been evaluated. Consequently, we examined survey techniques and seasonal habitat requirements of Yuma clapper rails during 1985–87 on the lower Colorado River in southwestern Arizona to provide the recovery team and resource managers with reliable population estimates and habitat requirements. Response rates of radio-marked birds to playback recordings were highest ($P < 0.001$) in April–May (40%), then decreased drastically. Most birds did not respond to playback recordings. Habitat use by Yuma clapper rails changed seasonally, reflecting different nesting and foraging habitat requirements. Rails used complex marsh environments with areas of high water coverage, low stem densities, and moderate water depths for foraging and areas with shallower water for nesting. Low stem densities and little residual vegetation were considered year-round requisites of Yuma clapper rail habitat and habitat discrimination was greatest during early winter. Birds moved greater ($P < 0.05$) distances and used larger ($P < 0.05$) areas during winter. Our results suggest that future management plans, recovery efforts, assessment of impacts, and mitigation measures for Yuma clapper rails should stress winter habitat needs. We recommend active manipulation of marshlands on a 4- to 5-year cycle to ensure a complex mosaic of patchily distributed environments more similar to historic conditions along the Colorado River.

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Yuma clapper rails are one of 3 races of federally endangered western clapper rail populations. The Yuma race is unique among North American clapper rail subspecies because it uses freshwater marshes. Of the known U.S. breeding population (about 700 individuals), 90% exists in 2 wetland complexes, the lower Colorado River and Salton Sea (Powell 1990). Status and abundance of the rail population in Mexico are unknown. In accordance with the Endangered Species Act of 1973, proposed activities that alter Yuma clapper rail habitat or may result in incidental take often require an assessment of impacts and mitigation measures. Assessment of proposed activities and design of mitigation measures requires quantitative descriptions of the habitat of *yumanensis,* but this information is lacking (cf. Anderson and Ohmart 1985).

Qualitative studies of clapper rail habitat (Stewart 1951, Tomlinson and Todd 1973, Zembal et al. 1989) and surveys of *yumanensis* habitat (Gould 1975, Busch and Gomez 1983, Powell 1990) have led to conflicting opinions of habitat requirements. As water demands in the Southwest continue to increase, proper management of *yumanensis* habitat will depend on thorough knowledge of their seasonal requirements.

The ability to monitor rail populations effectively is critical to assessing habitat use and population status. Vocal responses of birds to playback recordings are used regularly to survey rail populations and to evaluate habitat suitability (Tomlinson and Todd 1973, Smith 1974, Bennett and Ohmart 1978, Meanley 1985, Todd 1986). Number of responding birds has been used as a direct estimate of breeding density for a variety of rails (Marion et al. 1981). However, the effectiveness of playback recordings in eliciting rail vocalizations has not been tested.

We examined habitat use by Yuma clapper rails to ascertain if microhabitats were used in proportion to their availability and if rails ex-

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hibited seasonal shifts in use of microhabitats. We also estimated the proportion of birds that responded to playback recordings and tested whether response rates differed among seasons. Based on this information, we offer management suggestions and future research directions for population recovery.

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STUDY AREA

Our study area was in the northeastern portion of Mittry Lake Wildlife Management Area, Yuma County, Arizona. This shallow backwater of the Colorado River is fed by releases from Imperial Dam and underground seepage from the Gila Gravity Main Irrigation Canal. Water flows through the area slowly, with little scouring or mixing in the marsh interior. Water levels remained constant throughout the study period. The study site was 122 ha of wetland on the northern edge of the lake. The eastern boundary was a conspicuous gradation into dry, sandy-soiled upland. The remaining boundaries were defined by the area within which we could attain error polygons <400 m^2. Therefore, the outer boundary of the study area was not smooth and did not follow vegetational gradients usually associated with observer-designated boundaries. The sampling area was dominated by salt cedar (Tamarix chinensis), southern cattail (Typha domingensis), and arrow-weed (Tessaria sericea) interspersed with open water. Seven vegetative zones were distinguished by the dominant plant species. They were southern cattail, California bulrush (Scirpus californicus), three-square bulrush (*S.* americanus), salt cedar, arrow-weed, a mixed-shrub community, and open water. Latin names of plants follow Correll and Correll (1972).

METHODS

Playback Recording Surveys

We surveyed rails weekly from April 1985-December 1987 using playback recordings broadcast at 90 decibels on Johnny Stewart Game Callers to elicit responses from radio-marked birds. Male solicitation calls and paired duets were broadcast for 4 minutes from 18 fixed-call stations located systematically at approximately 115-m intervals along the east edge of the study area. During playback surveys, locations of radio-marked birds were determined by triangulation from 23 call stations using hand-held antennas. Locations of all radio-marked birds were plotted on area maps. We did not estimate error polygons for hand-held antenna locations, but if a response was elicited near a radio-marked bird, we assumed the response was given by that individual. Response rate is, therefore, a maximum estimate of actual response rate. When possible, observers recorded the habitat from which a responding bird vocalized. We compared response rates among seasons using Chi-square (Zar 1984).

Telemetry

Rails were captured for outfitting with transmitters with drop-door traps. Birds were funnelled into traps passively with leads constructed of plastic mesh netting stapled to 2-m wooden lath stakes. Trapped birds were fitted with USFWS aluminum bands, and 10-g radio transmitters (Model MPD-1440-LD, Wildlife Materials, Inc., Carbondale, 111.) were harnessed onto their backs. Radio transmitters were placed on 42 rails over a 32-month period from April 1985 to December 1987.

We mapped vegetation zones in the study area by examining enlarged color aerial photographs (scale = 1:2,000) and verifying vegetation by ground truthing. We calculated the proportion of each vegetative zone in the study area. Locations of radio-marked rails were plotted on the map, and each was assigned to a vegetative zone.

We monitored all 42 radio-marked birds from 4 fixed-tower null-peak receiving stations for 1-6 hours daily. Antennas were 6 m above the ground. A compass rosette and a needle affixed to the tower mast allowed reading the azimuth of antennas to the nearest 0.2 degrees. We obtained simultaneous azimuths from the 2 telemetry stations providing the best bearing intersection. Tower accuracy was determined by comparing telemetry locations to surveyed azimuths at 3-degree intervals in an arc around each tracking tower. We used the standard deviation of the differences between telemetry bearing and surveyed bearing to calculate error arcs for each tower (Saltzand White 1990, White and Garrott 1990). The error arcs were 0.20°, 0.58°, 0.80°, and 0.82 for the 4 telemetry stations.

We recorded 9,055 locations on 42 individuals during the 32 months. All telemetry locations had error polygons <400 m^2 and the average time between consecutive locations was 33 minutes. We took bearings on 3 reference transmitters each day to ensure that directional antennas and compass rosette pointers were aligned. Tracking sessions were stratified so that each period of the day was represented. We calculated 2 movement variables: daily and within-day movement. Daily movements were calculated from initial locations obtained on consecutive dates only. We calculated within-day movement as the maximum distance between any 2 locations during each tracking session. Data from sessions with <3 locations were not used in analyses. To eliminate potential seasonal bias caused by incubating birds, data from sessions with maximum movement <20 m were not used in analyses. We recorded 837 daily movement episodes and 1,096 within-day movements on 42 individuals.

We sampled microhabitat features by monitoring intensively an average of 3.2 individuals (range = 1–5) each month from May 1986 through December 1987. At the end of each month, heavy-use sites were identified as 20- x 20-m blocks of habitat that contained the greatest numbers of telemetry locations on each bird during 1 month of activity. Heavy-use sites contained an average of 10 telemetry locations (range = 4–45) out of an average of 75 total telemetry locations/bird-month (range = 24-138). Fifteen habitat measurements were recorded at 3–10 heavy-use sites and 10–30 random sites each month. Overall, we sampled vegetation structure at 96 heavy-use sites of Yuma clapper rails and 240 random sites during the 18 months. Random sites were located by placing randomly generated coordinates on the habitat map.

Three habitat variables were excluded from analyses because of high correlation (/r/ > 0.8) with other variables. The remaining 12 habitat variables included percent emergent basal coverage, percent residual basal coverage, percent ground coverage, percent water coverage, water depth, mean height of emergent vegetation, distance to vegetative edge (different vegetative zone), distance to open water, distance to upland vegetation, distance to dry ground, total stem density, and percent overhead cover. Distance to vegetative edge, distance to open water, and distance to upland vegetation were taken from digitized maps; all other variables were measured in the field using an average from 4 random points within the 20- x 20-m blocks. For a detailed description of how variables were measured see Conway (1990). Proportional use of vegetative zones was determined by the proportion of telemetric fixes in each zone. Proportion of each vegetative zone in the study area represented its availability to birds.

We divided the year into 5 seasons: late winter (Jan–Feb), early breeding (Mar–Apr), late breeding (May–Jul), post-breeding (Aug–Oct), and early winter (Nov-Dec); these divisions were based on breeding and migratory behavior and previous studies on seasonal habitat use by yumanensis (Anderson and Ohmart 1985). Because crayfish (Procambarus clarkii and Orconectes virilis) make up a large portion of the diet of Yuma clapper rails (Ohmart and Tomlinson 1977), we sampled crayfish weekly for 2.5 years to determine seasonal changes in prey availability. We subjectively placed baited minnow traps at 15 fixed stations in areas of preferred rail habitat based on densities of rails and our expertise. Traps were distributed proportionally in the 3 major vegetative zones on the study area. We set traps for 24 hours and recorded the number of crayfish in each trap.

We used the frequency of traps with zero crayfish as an index to crayfish abundance. The frequency of traps with zero catch is a less biased estimate of abundance than mean catch per trap night when sample distributions are heavily skewed; it also is the best untransformed predictor of abundance in constant-effort trapping where zero catch is common (Bannerot and Austin 1983). We compared crayfish abundance among seasons using a derivation of the Tukey multiple-range test for proportions (Zar 1984). The purpose of crayfish trapping was to ascertain if shifts in habitat use were correlated with changes in prey availability.

We determined sizes of areas used by using the harmonic mean method with a 95% utilization contour (Dixon and Chapman 1980, Samuel and Garton 1987) in program HOME RANGE (Ackerman and Samuel 1987). The program was run initially to identify outliers and determine appropriate grid size. Outliers are identified by program HOME RANGE as those locations that have bivariate normal weights <0.6, are considered outliers in a binomial density test, and have harmonic mean values markedly higher than other locations (Ackerman et al. 1989). Outliers received a weight of zero and the program was run again to estimate home-range size for each bird within each season. Data files contained an average of 166.7 telemetry locations (SD = 78.6, range = 33–298) during 36 daily tracking sessions (SD = 15, range = 8–65) and the program identified an average of 19.7 outliers (SD = 13.7, range = 0–47). We collected an average of 4.4 telemetry locations/animal during daily tracking sessions.

Statistical Analyses

To test for independence between consecutive telemetric locations we calculated Schoener ratios (Schoener 1981, Swihart and Slade 1985). We also calculated the arithmetic mean distance between focal center and each location, which is a measure of dispersion and can be used as an index of home-range size (Lair 1987). Home-range indices are free from distributional assumptions and are more easily adapted for comparisons among classes (Slade and Swihart 1983). We also calculated the distance between all consecutive locations. Pearson correlation coefficients (SAS Inst. Inc. 1985) were used to examine relationships among movement and home-range variables.

We used Chi-square (Zar 1984) to ascertain whether vegetative zones were preferred, avoided, or used in proportion to their availability (P = 0.01). Prior to intensive microhabitat sampling, vegetative zones that were avoided by rails were excluded from availability sampling so that we could identify critical microhabitat features within preferred zones.

All variables were tested for normality by examining normal probability plots, and skewness and kurtosis (SAS Inst. Inc. 1985). Distributions of all habitat variables were non-normal, but unimodal. Average daily movement and size of use area were normally distributed. We used the Mann-Whitney U-test (Zar 1984) to test for differences in habitat variables between used and random sites. The Kruskal-Wallis Chi-square approximation was used to test for seasonal differences in habitat variables (SAS Inst. Inc. 1985). Statistical significance levels were kept conservative ($P < 0.01$) in all comparisons among habitat variables to control for experimentwise Type I error rates (Zar 1984). Because of a lack of any seasonal differences ($P < 0.01$), random plots were pooled for comparisons with habitat use seasonally. We used analysis of variance and Tukey's multiple-range tests (SAS Inst. Inc. 1985) to test for seasonal differences in average daily movement, within-day movement, home-range size, and home-range indices.

Table 1. Vegetative types (%) available to, and used by, Yuma clapper rails in the lower Colorado River Valley, Arizona, 1986-87.

Vegetation type	Available (% of area)	Rail use (telemetry) $n = 9{,}055$	Rail use (playback) $n = 872$
Southern cattail	17.6	52.3'	63.3[ab]
California bulrush	4.9	7.8[a]	30.3[ab]
Three-square bulrush	1.7	2.9	4.5[ab]
Mixed-shrub community	2.1	2.2	0[ab]
Salt cedar	35.8	17.9	1.7[ab]
Arrow-weed	12.2	1	0.2[ab]
Open water	25.8	15.7	0[ab]

[a] Differed from available (χ^2, $P < 0.01$)
[b] Differed from telemetry (χ^2, $P < 0.01$).

RESULTS

Playback Recording Surveys

Most radio-marked birds did not respond to the recorded calls. Year-round response rate averaged 19.2%, but varied ($P < 0.001$) among seasons: 40% in early breeding (n = 80), 20% in late breeding (n = 168), 7% in post-breeding (n = 115), 10% in winter (n = 39). Winter seasons were combined because of low sample sizes. Rate of response was not consistent among days within each season (W. R. Eddleman, unpubl. data). Rail habitat use as ascertained by response to recorded calls indicated preference for cattail and bulrush and avoidance ($\chi^2 = 2{,}842$, $P < 0.001$) of other vegetative zones (Table 1).

Telemetry

Yuma clapper rails did not use vegetative zones in proportion to their availability (Table 1). Individuals showed preference for cattail and bulrush vegetative zones. Salt cedar, arrow-weed, and open water zones were avoided. Pooled across seasons, five of 12 habitat variables differed between used and available microhabitats, but seasonal differences ($P < 0.01$) existed in all

Table 2. Comparisons of habitat variables at random sites and those heavily used by Yuma clapper rails during each of 5 seasons in the lower Colorado River Valley, Arizona, 1986-87.

Habitat variable	Random sites n = 240	Heavy use sites (Z-values)[a] Late winter n = 18	Early breeding n = 17	Late breeding n = 51	Post breeding n = 41	Early winter n = 15
Stem density (stems/0.25 m^2)	49	−3.8'	−1.3	−0.7	−4.2*	−4.0*
Percent residual basal coverage	13	−2.4	−3.7*	−4.3*	−6.1*	−4.2*
Percent overhead cover	58	−3.7*	−2.5	−1.9	−3.9*	2.9*
Distance to vegetative edge (m)	34	2.5	−1.5	−4.4*	−5.3*	8.1*
Distance to upland (m)	168	−2.9*	0.0	2.6*	7.9*	5.1*
Percent ground coverage	32	0.2	−0.6	0.9	1.1	−4.9*
Percent water coverage	54	0.2	2.4	2.2	2.0	6.4*
Water depth (cm)	9	−0.1	1.1	−1.8	−2.7*	3.3*
Mean emergent height (cm)	212	−1.2	−2.3	−0.8	1.6	4.3*
Distance to open water (m)	37	−1.7	−3.3*	0.5	1.1	−5.2*
Distance to dry ground (m)	103	−1.1	0.1	−3.1*	0.0	5.5*
Percent emergent basal coverage	6	1.6	1.0	−0.9	−4.2*	−2.0

[a] Compared with random sites using normal approximation to the Mann-Whitney U-test.
* Differs from random ($P < 0.01$).

12 habitat variables at sites of heavy rail use (Table 2).

We discerned several patterns of non-random use of available habitat across seasons (Table 2). We considered habitat features that differed from available habitat in ≥3 seasons and showed a consistent trend in all 5 seasons to be year-round requisites of rail habitat. Low stem densities and little residual vegetation were features of rail habitat year-round.

Other features were consistently important components of rail habitat, but showed seasonal shifts. Rails used areas with low overhead cover during late winter and post-breeding, but used areas with dense overhead cover during early winter. During late breeding and post-breeding seasons, rails used areas close to a vegetative edge, but switched to areas far from a vegetative edge during early winter. Rails used areas far from upland during late breeding through early winter, but used areas close to upland during late winter.

Habitat discrimination by Yuma clapper rails was clearly greatest during the early winter season, when rail habitat differed from available habitat in 11 of 12 features measured (Table 2). Rails showed distinct shifts in 8 habitat features during early winter (Table 2). Birds used areas with dense overhead cover, low ground coverage, high water coverage, deep water, and tall vegetative height. In addition, these early winter use areas were far from a vegetative edge, close to open water pools, and far from dry ground (Table 2).

Consecutive telemetry locations were autocorrelated ($T^2/R^2 = 0.566 \pm 0.331$, Schoener 1981), but time between consecutive locations did not differ seasonally ($P = 0.753$). Rails moved greater ($P < 0.05$) daily distances and occupied larger ($P < 0.05$) home ranges during the late winter season (Table 3). They moved greater ($P < 0.05$) within-day distances during the early breeding and 2 winter seasons. Rails moved least ($P < 0.05$) and covered a smaller ($P < 0.05$) area during the late breeding season. The home-range index was greatest ($P < 0.05$) during late winter and post-breeding seasons and lowest ($P < 0.05$) during the late breeding season (Table 3). Home-range indices were positively correlated ($r = 0.78$, $n = 49$, $P < 0.001$) to estimates of home-range size. Number of relocations per data set was positively correlated ($r = 0.39$, $n = 50$, $P = 0.005$) to the degree of autocorrelation, but was not correlated with either home-range estimates ($r = 0.20$, $n = 49$, $P = 0.160$) or home-range indices ($r = 0.03$, $n = 50$, $P = 0.853$). Degree of autocorrelation was positively correlated with home-range size ($r = 0.41$, $n = 49$, $P = 0.003$) and home-range index ($r = 0.43$, $n = 50$, $P = 0.002$). Distance between consecutive locations was positively correlated with home-range index ($r = 0.49$, $n = 50$, $P < 0.001$), but only marginally correlated with home-range size ($r = 0.34$, $n = 49$, $P = 0.019$).

Crayfish showed an annual peak during the late breeding season, corresponding to the hatching and brood rearing stages of Yuma clapper rails (Table 4). Mean crayfish per trap night averaged 1.32, 1.55, 1.99, 1.92, and 1.56 during late winter, early breeding, late breeding, post-

Table 3. Mean movement and home-range characteristics of Yuma clapper rails, lower Colorado River Valley, Arizona. 1985-87.

Season	Daily movement (m)	Within-day movement (m)	Home-range size (ha)	Home-range index[a] (m)
Late winter (Jan–Feb)	224 A[h] (n = 77)	140 AB (n = 88)	24 A (n = 6)	225 A (n = 6)
Early breeding (Mar–Apr)	157 BC (n = 124)	155 A (n = 151)	8 B (n = 5)	147 AB (n = 5)
Late breeding (May-Jul)	126 C (n = 374)	111 C (n = 495)	7 B (n = 18)	105 B (n = 18)
Post breeding (Aug–Oct)	139 BC (n = 220)	121 BC (n = 305)	15 AB (n = 16)	195 A (n = 17)
Early winter (Nov-Dec)	181 AB (n = 42)	161 A (n = 57)	9 AB (n = 4)	179 AB (n = 4)
Annual average	146 (n = 837)	125 (n = 1,096)	12 (n = 49)	160 (n = 50)

[a] Mean distance between focal center of 95% utilization contour and each telemetry location.
[b] Means sharing capital letters within a column do not differ ($P > 0.05$): Tukey's studentized multiple-range test.

breeding, and early winter, respectively. Crayfish abundance was lowest during the **2** winter seasons (Table **4).**

DISCUSSION

Playback Recording Surveys

The response rate or Yuma clapper rails has been estimated as **70–95%** in previous studies (Smith **1975,** Bennett and Ohmart **1978),** but response rates below **50%** have been reported for other populations of clapper rails (Mangold **1974,** Meanley **1985).** Rail populations with lower densities appear to have lower response rates (Zembal and Massey **1981).** A seasonal change in response rate has been reported for other races of clapper rails (Gill **1979,** cf. Tomlinson and Todd **1973)** and response rate also varies within seasons for other races (Mangold **1974,** Meanley **1985,** Zembal et al. **1985).**

Telemetry

Yuma clapper rails did not use vegetative zones in proportion to their availability, and seasonal changes in use of microhabitats may be explained by changes in prey availability and the rail's reproductive state. Similar changes in use of available habitat by Yuma clapper rails during winter have been demonstrated in previous studies (Anderson and Ohmart **1985).** This change in winter habitat use may act to reduce predation and to increase foraging efficiency during a period of reduced prey abundance (Table **4;** also see Anderson et al. **1982,** Rosenberg et al. **1982,** Anderson et al. **1983)** and high predation risk (Eddleman **1989,** Zembal et al. **1989).** Increased daily movements, within-day movements, and home ranges during winter also may be responses to decreased prey availability. We believe that by moving to areas close to open water, yet far from dry ground, upland vegetation, and vegetative edge, rails gain increased foraging opportunities with decreased predation risks.

During late- and post-breeding seasons, ***yumanensis*** used areas with habitat features that may enhance the ability of precocial young to forage and move quickly through vegetation surrounding the nest (also see Smith **1975).** Distance from upland vegetation may reduce frequency of encounters with mammalian predators, an important feature of preferred habitat

Table 4. Seasonal records of crayfish captured in 24-hour sample periods in the lower Colorado River Valley, Arizona, 1985-87.

No crayfish captured	Weekly samples containing crayfish (%)[a]				
	Late winter n = 255	Early breeding n = 375	Late breeding n = 540	Post breeding n = 420	Early winter n = 225
0[b]	50.2 A	30.8 B	18.6 C	31.6 B	50.8 A
1	19.6	19.2	22.8	19.6	15.8
2	7.1	17.1	16.9	10.0	14.2
3	8.0	12.9	14.7	14.8	5.0
4	5.8	9.2	8.9	9.1	5.8
5	2.7	5.8	6.4	4.3	2.5
6	4.4	0.4	5.6	4.3	4.2
7	1.8	1.7	2.5	2.4	0.8
>7	0.9	2.9	3.6	3.8	0.8

[a] Percentage of traps which contained a given number of crayfish.
[b] Percentages sharing capital letters within the row do not differ ($P > 0.001$); Tukey's multiple-range test for proportions.

for light-footed clapper rails (***R.***1. levipes) (Zembal et al. 1985).

Rails commonly used areas with low stem densities and little residual vegetation. These same habitat features have been found in preferred clapper rail habitat in other studies (Smith 1975), and may be critical habitat elements for Yuma clapper rails. Low vegetation density, high water coverage, and reduced residual vegetation are characteristic of young marsh vegetation or regrowth of scoured or burned marshlands. Marshlands with these characteristics probably were abundant along the lower Colorado River prior to construction of water control structures. Regular spring floods scoured old marshlands, and periodic drops in water flow dried backwaters, stimulating regrowth of young marsh vegetation (Ohmart et al. 1975). In contrast, old marshes with dense residual vegetation and high stem densities are now common in unmanaged marshlands and provide less suitable habitat for clapper rails.

Estimates of home-range size increased in winter and were larger ($\bar{x} = 11.75$ ha) than estimates from previous studies (Tomlinson and Todd 1973, Smith 1975, Bennett and Ohmart 1978, Todd 1986). Previous estimates ranged from 0.12 to 3.59 ha, but these were limited to the breeding season and based on vocalizations, which may not be an effective method of evaluating sizes of areas used by clapper rails. Other races of clapper rails increase movements after breeding (Orr 1939, Roth et al. 1972, Zembal et al. 1985) and show seasonal changes in activity patterns and home-range size (Roth et al. 1972). Increased movement and use of different habitats may cause increased predation during winter (Eddleman 1989, Zembal et al. 1989).

Our use of autocorrelated radiolocation data to calculate home-range size presents some problems: estimates of home-range size usually increase with number of locations used to estimate home range (Voight and Tinline 1980, Andersen et al. 1990); a moderate number of locations is required to adequately describe a bird's home range, and autocorrelation effectively reduces the number of data points used to calculate home range (Swihart and Slade 1985, Andersen et al. 1990). However, we do not believe our results are severely biased because we found no correlation between sample size and either our estimates of home-range size or our home-range indices, and we used sufficiently large sample sizes (Andersen et al. 1990, Gese et al. 1990) and compared results between 2 independent estimates of home range. Recent studies have demonstrated that home-range estimates based on 30-minute relocation intervals are similar to estimates based on random relocations and autocorrelated data resulting from "bursts" of telemetry relocations need not be disregarded from home-range analyses (Andersen and Rongstad 1989, Gese et al. 1990).

MANAGEMENT AND RESEARCH IMPLICATIONS

Yuma clapper rails should be surveyed only during the early nesting season because their rates of response to taped calls decrease significantly thereafter. Managers should survey areas several times to improve density estimates. However, use of taped recordings on repeated visits could cause individuals to alter their behavior (Robbins 1978). Moreover, response rates in the early nesting season were below 50%, and thus, population estimates from vocalizations may need to be adjusted to estimate rail abundance. Correction factors have been used with playback surveys to estimate population size for species with low response rates (Johnson et al. 1981).

Quantifying rail habitat use with response to playback recordings did not agree with telemetry results. Use of preferred vegetation (cattail and bulrush) was exaggerated and use of other vegetation was understated. Observers may be biased in assigning vocalizing birds to habitats presumed optimal from previous studies. Using playback surveys to quantify rail habitat also may exaggerate use of habitats near call stations. Other factors that may influence rail calling rates, such as the effects of vegetation complexity and rail densities, need to be addressed. Researchers using playback surveys to quantify rail habitat should be aware of these potential biases.

Foraging and nesting habitats differ for clapper rails (also see Zembal et al. 1989), and management strategies should incorporate both. Densely vegetated marshes with shallow water are common along the Colorado River and provide nesting habitat for Yuma clapper rails, but interior marshlands with low basal cover and deep water are uncommon (C. J. Conway, pers. observ.) and provide a minimum of winter (and possibly foraging) sites for rails.

Conservation and recovery of endangered species depend on identification of critical habitat features and effective management must address habitat needs during all seasons to ensure long-term species survival. Dam operational criteria result in low winter flows in most years on the lower Colorado River (Boner et al. 1990), which drain many riverine wetlands. This wetland drainage reduces available habitat for Yuma clapper rails and may force rails to disperse in search of deeper water habitats. This forced dispersal may increase predation risk and mortality.

Wetlands should be managed to duplicate habitat conditions in natural marsh ecosystems. Marsh habitats on the lower Colorado River prior to construction of extensive water control structures probably fluctuated radically both seasonally and annually (Sykes 1937a,b; Ohmart et al. 1975). A mosaic of variable-aged stands of emergent vegetation interspersed with shallow open-water pools are necessary for year-round clapper rail habitat. Variable water depths within each marshland would provide rails with nesting and wintering habitat.

Periodic burning and flooding of small tracts of marshlands on a 4- to 5-year cycle within a larger wetland complex may provide the best year-round habitat for Yuma clapper rails. Managing wetlands to increase crayfish abundance also may benefit rail populations. Additionally, managing for winter habitat needs of the Yuma clapper rail may prove to be most successful given the more specialized winter habitat needs and increased home ranges noted in our study and others.

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