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Authors: Lehmicke, Anna Joy J., Bowman, Jacob L., Banning, Alison E., and Vasilas, Bruce L.

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Effect of Tide Level and Time of Day on Detection Rate and Abundance of Clapper Rails (*Rallus longirostris*) in a Mid-Atlantic Tidal Marsh System

Anna Joy J. Lehmicke[1,2], Jacob L. Bowman[1,*], Alison E. Banning[1,3] and Bruce L. Vasilas[1]

[1]Department of Entomology and Wildlife Ecology, University of Delaware, Newark, DE, 19716, USA

[2]Current address: D. B. Warnell College of Forestry and Natural Resources, University of Georgia, Athens, GA, 30602, USA

[3]Current address: DNREC Water Resources, Watershed Assessment Section, Silver Lake Office Plaza Suite 220, 820 Silver Lake Blvd., Dover, DE, 19904, USA

[*]Corresponding author; E-mail: jlbowman@udel.edu

Abstract.—Obligate marsh bird detection rates during surveys are affected by the time of day and the tide level, but previous research on both factors has produced conflicting results and no research has been conducted in east coast tidal marshes. Relative abundance and detection rate of Clapper Rails (*Rallus longirostris*) were compared between morning and evening surveys at high, medium, and low tide levels in Worcester County, Maryland, during 2006. The detection rate of Clapper Rails was greatest in the morning at the medium tide level ($\bar{x} = 0.69$, SE = 0.14, $F_{5,40} = 5.87$, $P = 0.001$). Morning surveys ($\bar{x} = 1.2$, SE = 0.14) resulted in a greater relative abundance of Clapper Rail detections compared to evening surveys ($\bar{x} = 0.8$, SE = 0.12, $F_{1,195} = 5.31$, $P = 0.022$), and surveys done at medium tide level ($\bar{x} = 1.3$, SE = 0.17) resulted in greater relative abundance than those conducted at low ($\bar{x} = 0.8$, SE = 0.15) or high levels ($\bar{x} = 0.7$, SE = 0.15, $F_{2,195} = 6.56$, $P = 0.002$). The results suggest that surveys should be conducted in the morning at medium tide to maximize detection rate of Clapper Rails. The detection rate of obligate marsh birds during surveys is affected by time and tide level so additional research is necessary to determine how these variables affect the detection rate of marsh birds other than Clapper Rails. *Received 29 December 2011, accepted 8 March 2013.*

Key words.—Clapper Rail, detection rate, marsh birds, *Rallus longirostris*.

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Many marsh birds are secretive and difficult to detect during surveys. Several factors affect detection rates, such as use of call-broadcast systems (Allen *et al.* 2004; Conway *et al.* 2004; Conway and Gibbs 2005), tidal level (Zembal and Massey 1987; Spear *et al.* 1999; Conway and Droege 2006), and time of day (morning vs. evening; Zembal and Massey 1987; Spear *et al.* 1999; Conway *et al.* 2004). Variation in tide level changes the immediate environment and time of day affects factors such as temperature and man-made noise levels (i.e., mornings have less human/boat activity than afternoons), which may affect detection rate. Determining the tidal level and time of day that result in the highest detection rate of marsh birds is important to increase the accuracy of marsh bird surveys. More effective standardization of marsh bird survey conditions would promote more accurate surveys leading to better population estimates, and, in turn, more effective management. Clapper Rails (*Rallus longirostris*) were chosen as a study species because they are a secretive marsh bird common within the study area. Clapper Rails are detected almost exclusively by calls, are rarely detected by sight, and are responsive to call-broadcast systems (Allen *et al.* 2004; Conway *et al.* 2004; Conway and Gibbs 2005).

Marsh bird surveys are typically conducted within a few hours of sunrise and sunset (Conway 2009), but studies comparing detection rates and abundance in morning vs. evening surveys have not had consistent results. Zembal and Massey (1987) found that Light-footed Clapper Rails (*R. l. levipes*) called more frequently during the last hour before sunset than they did in the first hour after sunrise, but Spear *et al.* (1999) found no difference between morning and evening detection in California Black Rails (*Laterallus jamaicensis coturniculus*). Nadeau *et al.* (2008) found that the mean number of all secretive marsh birds detected was greater in the morning than in the evening, but there was no difference in mean numbers of Clapper Rails between the two times. Additionally, Conway *et al.* (2004) found an increased detection rate in the evening when studying California Black Rails. These conflicting results suggest that timing sensitivities may vary by species and location.

Changing tides alter the resources immediately available to marsh birds and can, therefore, affect bird activity and detection rate (Burger *et al.* 1977; Colwell and Cooper 1993; Burton *et al.* 2004; Raposa *et al.* 2009). Conway (2009) recommended surveying for all marsh birds at the same tidal stage and suggested avoiding surveys during high or low tides. Additionally, the optimal tide level to maximize detection rate may vary among geographic regions (Conway 2009). As with time of day, research on the optimum tidal level for surveying marsh birds has not had consistent results. Clapper Rail surveys in the San Francisco Bay National Wildlife Refuge have been conducted at high tide since 1972 (Conway and Droege 2006), yet both Zembal and Massey (1987) and Spear *et al.* (1999) found that high tide levels resulted in decreased detection rates when compared to other tidal levels. Neither Zembal and Massey (1987) nor Spear *et al.* (1999) compared medium and low tide levels, and both considered tidal effects only after the research had been completed. Rush *et al.* (2009) found that detection of Clapper Rails increased with increasing tidal level. However, all surveys by Rush *et al.* (2009) were conducted from the water's edge, while marsh bird surveys are often conducted from the marsh-upland interface, due to ease of access. Further, the surveys took place in Gulf of Mexico coastal marshes, which have a different tidal regime than Atlantic marshes; tides are of much smaller magnitude and peak only once per day (Odum *et al.* 1995), as opposed to twice per day in Atlantic marshes (Bertness *et al.* 1992).

The objectives of this study were to: 1) determine the effect of time of day and tide level on detection rate of Clapper Rails; and 2) determine whether any combination of tidal level and time of day was optimal for marsh bird surveys to maximize detection rate.

Methods

Study Area

Bird surveys were conducted in tidal marshes in Worcester County, Maryland, during June-July of 2006. Salinity at the sites ranged from 19.8-24.2 ppt, classifying all sites as polyhaline (18-35 ppt; Wazniak *et al.* 2005). The dominant plant species are described in Banning *et al.* (2009). The average low and high daily temperatures were 17.4 °C and 26.6 °C in June 2006 and 19.5 °C and 29.3 °C in July 2006, and the total rainfall was 15.4 cm for June 2006 and 11.7 cm for July 2006 (National Oceanic and Atmospheric Administration 2007).

Clapper Rail Surveys

For site selection, tidal marsh areas inhabited by Clapper Rails in previous years were visited in early June 2006, and preliminary surveys were performed to test for rail presence. Nine final sites where Clapper Rails were detected during these preliminary surveys were chosen for use in the study. Confirming Clapper Rail presence at the sites allowed non-detections during the surveys to be attributed to the effect of tide or time of day rather than to absence of Clapper Rails. The nine sites were located in four different marsh complexes of varying size, on both public and private property. All sites were placed on the marsh-upland interface (both for ease of access and because marsh bird surveys are typically conducted at the marsh-upland interface), and the survey points were spaced at least 200 m apart to ensure independent samples (Conway 2009).

Tide charts (National Oceanic and Atmospheric Administration 2006) were consulted to determine low and high tide times. Low and high tide surveys were conducted from 1 hr before until 1 hr after the tide peak. Medium tide was any time that was not within 1.5 hr of the low or high tide peak. Morning surveys were conducted from sunrise until 09:00 hr, and evening surveys from 17:00 hr until sunset. The survey schedule was divided into four 11- or 12-day windows during June and July of 2006. During each of the four windows, each site was visited once at each of the six tide and time combinations (morning high, low and medium; evening high, low, and medium) giving four replicates of each tide/time combination at each site, except for three different sites where weather forced one survey cancellation that could not be rescheduled. Visits to the same site were spaced at least 24 hr apart to lessen the chance of the birds becoming desensitized to the callback method. After arriving at each site, a 3- to 5-min period was allowed to take weather readings and to allow the birds to acclimate to the presence of the surveyor.

Using 50-m fixed-radius point count surveys, every bird detected from the survey point during a 15-min survey period was recorded (Conway 2009). Each 15-min survey period began with a 5-min passive segment during which any bird that was visible or audible within the survey plot was recorded. During the next 10 min, callback tracks of secretive marsh birds were played, and all birds detected in the plot were recorded. The callback system (Johnny Stewart Power Pro Convert-A-Caller, Hunter's Specialties) was on the ground with the speaker pointed toward the marsh. The calls of 10 local species were surveyed in order to determined what local species were present (Conway 2009). Each callback track contained 30 sec of primary advertising calls followed by 30 sec of silence. Surveys were not conducted if the wind was consistently above 15 km/hr, during heavy rain, if thunder was audible, if thick fog interfered with visibility, or if man-made noise was loud enough to inhibit detection of marsh birds.

Statistical Analysis

Analyses were performed using SAS (SAS Institute, Inc. 2006) with an alpha level of 0.05. To test for differences in detection rate, the proportion of surveys at each site and each treatment during which at least one Clapper Rail was detected was calculated. The mean detection rates were then calculated for each tide and time combination across the nine sites and the means were compared using a one-way ANOVA, blocking on site. To analyze the effects of tide and time on Clapper Rail relative abundance, the number of rails detected at each survey during each treatment was compared. To determine if abundance differed between the six tide and time combinations, a two-way ANOVA was used, blocking on site. No two-way interaction was found for time and tide, so the effects of time and tide individually were then tested using a one-way ANOVA, blocking on site. If significance was detected, a Least Significant Differences analysis was used as a mean separation test (Sokal and Rohlf 1995).

RESULTS

The combination of tide level and time of day affected the detection rate of Clapper Rails ($F_{5,40}$ = 5.87, P = 0.001). Surveys conducted in the morning at medium tide had the greatest rate of detecting Clapper Rails, while surveys in the evening at low or high tide had the lowest detection probability (Fig. 1). The tide level during the survey also affected the relative abundance of Clapper Rails ($F_{2,195}$ = 6.56, P = 0.002). Surveys conducted at medium tide resulted in the greatest abundance ($\bar{x}$ = 1.3, SE = 0.17), while surveys at low ($\bar{x}$ = 0.8, SE = 0.15) and high tides ($\bar{x}$ = 0.7, SE = 0.15) had similar but lower relative abundances. The time of the survey also affected relative abundance ($F_{1,195}$ = 5.31, P = 0.022), with morning surveys ($\bar{x}$ = 1.2, SE = 0.14) resulting in greater

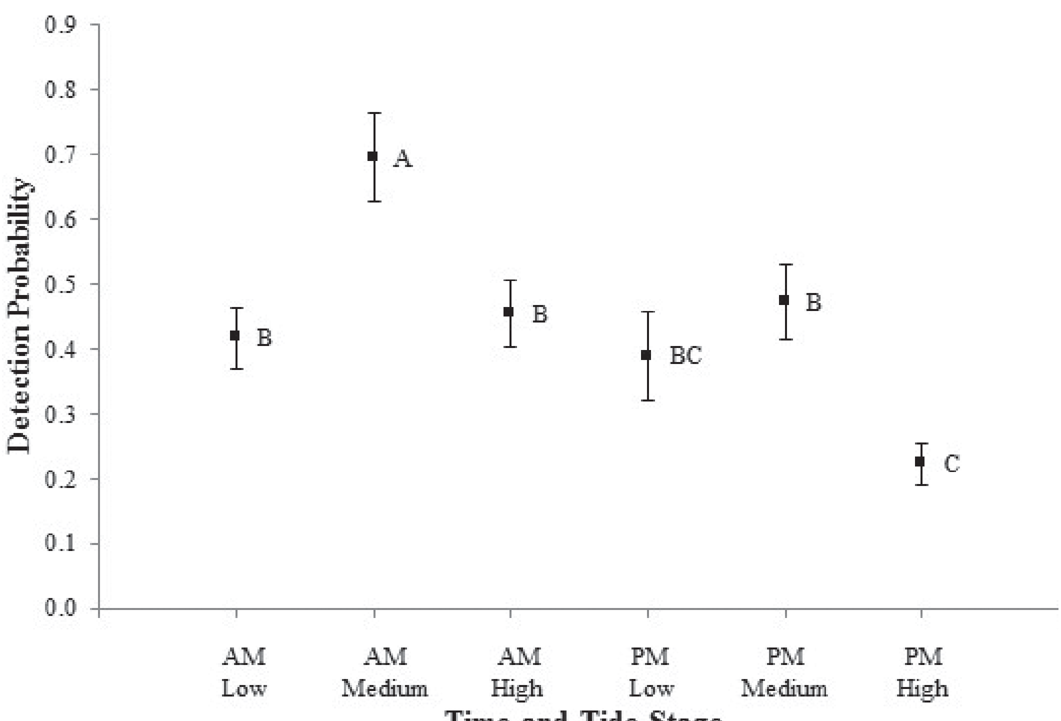

Figure 1. Mean (± SE) detection probability of Clapper Rails by time of day and tide stage in Worcester County, Maryland, June-July of 2006. Values sharing the same letter are not statistically different.

relative abundance than evening surveys ($\bar{x}$ = 0.8, SE = 0.12).

DISCUSSION

There are several potential reasons why morning surveys resulted in a higher detection probability. Afternoon surveys had a greater average temperature (25.9 °C in the evening vs. 22.3 °C in the morning; $t_{231} = 8.36$, $P < 0.0001$), which could lead to decreased bird activity and, therefore, decreased detection. Robbins (1981) said that some bird species decrease their activity during times of extreme temperature (> 25 °C). Because surveys were conducted in a heavily populated area, human activity also may have affected detection probability. The surveys were conducted at the marsh-upland interface and were, therefore, more proximate to human activity such as traffic and recreational activities (e.g., people fishing, crabbing, or swimming). Evening surveys often had an increased human presence in the form of people fishing, crabbing, or swimming in water near the survey points, which could have led to a decreased ability to detect birds or could have affected the birds directly, leading to decreased detections.

Tide levels affect resource availability of mudflat foraging areas and, therefore, influence bird activity as well (Burger *et al.* 1977; Colwell and Cooper 1993; Burton *et al.* 2004; Raposa *et al.* 2009). During high tide, many of the mudflats used for foraging are covered with water, which likely causes a decrease in overall activity of Clapper Rails reducing detection probability.

The birds also may have moved out of the area, making them unavailable for detection. At low tide, more mudflat areas were exposed increasing the foraging opportunities for Clapper Rails in these areas; however, these mudflat areas were farther from the marsh-upland interface so rails were farther away from the survey points, which likely affected the surveyor's ability to detect them. During medium tide levels, the exposed resources are closer to the marsh-upland interface and, therefore, rails likely were more active in areas that fell within our 50-m radius plots.

Our study used tide tables to determine the timing of the tide, but season, moon phase, and weather are known to influence tide height. We suggest that future research include a measure of tide height at the survey point to account for variables that influence tides. Additionally, our study did not differentiate between a medium tide that was rising vs. one that was falling so we suggest future research differentiate between the rising and falling tides.

Based on these results, we recommend that, when surveys are conducted from the marsh-upland interface, marsh bird monitoring in Mid-Atlantic tidal marshes be conducted during the morning hours at medium tide levels. While our results may be extended to other secretive marsh birds within the Mid-Atlantic, similar studies should be conducted for various geographic areas as optimal time of day and tide level for marsh bird monitoring may vary by region.

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