# Influence of season and time of day on marsh bird detections

Author(s): Tyler M. Harms and Stephen J. Dinsmore
Source: The Wilson Journal of Ornithology, 126(1):30-38.
Published By: The Wilson Ornithological Society
DOI: http://dx.doi.org/10.1676/13-150.1
URL: http://www.bioone.org/doi/full/10.1676/13-150.1

*The Wilson Journal of Ornithology* 126(1):30–38, 2014

# INFLUENCE OF SEASON AND TIME OF DAY ON MARSH BIRD DETECTIONS

TYLER M. HARMS[1,2] AND STEPHEN J. DINSMORE[1]

ABSTRACT.—Call-broadcast surveys are frequently used to elicit responses of secretive marsh birds and produce greater detection rates than passive surveys. However, little is known about how detection rates of birds from these surveys differ by season and time of day. We conducted call-broadcast surveys for eight focal species at 56 wetlands throughout Iowa from 15 May–13 June 2010 (early season) and from 15 June–10 July 2010 (late season). Our focal species were Pied-billed Grebe (*Podilymbus podiceps*), American Bittern (*Botaurus lentiginosus*), Least Bittern (*Ixobrychus exilis*), King Rail (*Rallus elegans*), Virginia Rail (*Rallus limicola*), Sora (*Porzana carolina*), Common Gallinule (*Gallinula chloropus*), and American Coot (*Fulica americana*). Surveys were conducted in the early morning (30 mins before sunrise to 3 hrs after sunrise) and late evening (3 hrs before sunset to 30 mins after sunset) in accordance with the North American Marsh Bird Monitoring Protocol. We evaluated marsh bird detection rates as a function of a) time of day (morning and evening survey periods), b) season (early and late in the breeding season), and c) wetland size for four species with the greatest detection rates (Pied-billed Grebe, Least Bittern, Virginia Rail, and Sora). We also evaluated the above effects for two species groups; all eight species pooled and all rails pooled. We found significant ($P < 0.05$) effects on the number of detections for Pied-billed Grebe in response to time of day, time of season, and wetland size; Sora, Virginia Rail, all rails, and all species had an effect of time of season only. Understanding seasonal and time-of-day differences in detection rates, as well as area dependence of secretive marsh birds, will refine existing monitoring protocols by allowing researchers to maximize detection probabilities of target species. *Received 10 September 2013. Accepted 2 November 2013.*

Key words: bittern, call-broadcast, coot, detection, gallinule, Iowa, marsh bird, rail.

Secretive marsh birds (e.g., bitterns and rails) are some of the most inconspicuous birds in North America. These birds are difficult to monitor using conventional survey techniques, because they vocalize infrequently and tend to occupy habitats that are densely covered with emergent vegetation (Lor and Malecki 2002). In addition, their crepuscular habits require sampling to occur in the early-morning and late-evening hours. The North American Marsh Bird Monitoring Protocol (Conway 2007, 2011) was established to aid researchers in the development of standardized surveys to effectively monitor these secretive marsh birds. Call-broadcast surveys have been implemented in several studies to elicit responses from marsh birds (Johnson and Dinsmore 1986, Manci and Rusch 1988, Gibbs and Melvin 1993, Lor and Malecki 2002) and produce higher detection rates when compared to passive surveys (Gibbs and Melvin 1993, Erwin et al. 2002, Allen et al. 2004, Conway and Gibbs 2005, DesRochers et al. 2008). However, the effectiveness of call-broadcast surveys can vary temporally (Conway and Gibbs 2001, Rehm and Baldassarre 2007, Nadeau et al. 2008) and by species (Manci and Rusch 1988, Gibbs and Melvin 1993, Lor and Malecki 2002, Soehren et al. 2009). There is a need for additional information on seasonal variation in detection rates and whether detections vary between morning and evening. This information can aid in planning survey efforts to maximize detection probability of the target species.

The North American Marsh Bird Monitoring Protocol (Conway 2007, 2011) instructs researchers to conduct call-broadcast surveys in the morning or evening depending on when birds are most vocal in the study area. A single study found that vocalization probabilities of marsh birds are greater during morning surveys (Nadeau et al. 2008); other studies have shown that such probabilities are greater during evening surveys (Johnson and Dinsmore 1986, Conway et al. 2004). Environmental factors such as temperature, wind speed, and cloud cover may vary with time of day, potentially affecting the vocalization frequency of marsh birds (Nadeau et al. 2008). Vocalization frequencies may vary with time of day at both the individual or species level because of behavioral variation of individual birds, differences in species-specific preferences in timing of calling, and individual breeding status (Conway et al. 1993, Palmeirim and Rabaça 1994). To date, no research has been done to determine the best time of day for surveying marsh birds in the midwestern United States.

[1] Department of Natural Resource Ecology and Management, Iowa State University, 339 Science Hall II, Ames, IA 50011, USA.

[2] Corresponding author; e-mail: harmsy@iastate.edu

Another goal of call-broadcast surveys for marsh birds is to minimize temporal variation in detection probability (Conway and Gibbs 2001, 2005). In other words, surveys should be conducted during periods of peak detection probabilities with little variation during the survey season. The national monitoring protocol states that optimal timing of surveys should overlap with the breeding seasons of focal marsh bird species in the study area and suggests that surveys be conducted during a 45-day window that varies regionally based on average minimum temperatures in May (Conway 2007, 2011). However, research has found that these survey windows may not be long enough to include peak detection periods for all focal species (Rehm and Baldassarre 2007). In Iowa, for example, American Bitterns (*Botaurus lentiginosus*) and Soras (*Porzana carolina*) arrive and initiate breeding in mid- to late April (Kent and Dinsmore 1996), whereas Least Bitterns (*Ixobrychus exilis*) arrive in mid-May and initiate breeding in late May or early June (Weller 1961). Therefore, the suggested survey window for Iowa (15 Apr–30 May) may not include peak detection periods for all species of marsh birds, especially late breeders like Least Bitterns. An adjustment of survey timing at the regional level may be necessary to account for seasonal differences in detection of target species.

Our objective was to examine the effects of: (1) time of day, (2) time of season, and (3) wetland size on the detection rates of secretive marsh birds in Iowa. This information will help refine survey timing for secretive marsh birds in the midwestern United States.

## METHODS

*Study Area.*—We surveyed marsh birds at wetlands in the Des Moines Lobe of north-central and northwestern Iowa (Prior 1991; Fig. 1). We used the National Wetlands Inventory (NWI; U.S. Fish and Wildlife Service 2009) to select our sites. We considered both natural and constructed wetlands from the Aquatic Bed (AB), Emergent (EM), and Unconsolidated Bottom (UB) classes of the Palustrine system (Wilen and Bates 1995). Wetlands within these classes fit one or more of the following general habitat criteria required by our target species: (1) shallow water (<1 m deep), (2) closed basins (no inflow or outflow), (3) surrounded by few or no trees, and/or (4) the presence of emergent vegetation. Most wetlands were permanent or semi-permanent, although

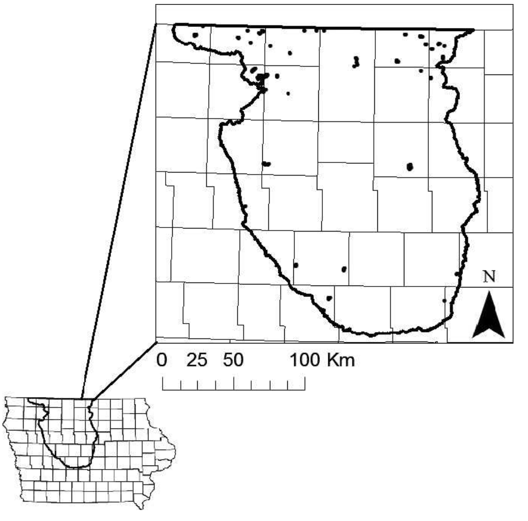


FIG. 1. Location of surveyed wetlands (points) within the Des Moines Lobe (bold line) region of Iowa, 2010.

some temporary or seasonal wetlands were also selected (Stewart and Kantrud 1971). Most wetlands contained a mix of emergent vegetation that included cattail (*Typha* spp.), sedge (*Carex* spp.), river bulrush (*Scirpus fluviatilis*), soft-stem bulrush (*Schoenoplectus tabernaemontani*), or reed canary grass (*Phalaris arundinacea*). Water depths ranged from 0–115 cm at survey points within wetlands.

*Site Selection and Surveys.*—Using Hawth's Analysis Tools for ArcGIS (Beyer 2004), we randomly selected wetlands from the NWI database. To facilitate access for surveys, we selected only wetlands that were on public lands. We stratified wetlands into six size classes based on area (≤5 ha, >5–10 ha, >10–20 ha, >20–30 ha, >30–40 ha, and >40 ha) to facilitate an equal representation of wetlands of different sizes and ensure that potential area-dependent species were sampled. We randomly selected 10 wetlands from each size class (Brown and Dinsmore 1986), with the exception of the 30–40 ha size class where only six wetlands were selected because of the small number ($n = 11$) of wetlands within that size class. We randomly assigned a fixed number of survey points 400 m apart to wetlands within each size class to allow for maximum coverage of each wetland and to minimize double-counting birds (Conway 2007, 2011). We assigned one point to both the <5 ha and >5–10 ha size classes, two points to the >10–20 ha size class, three points to the >20–30 ha size class, four points to the >30–40 ha size class, and five points to the >40 ha size class.

We conducted unlimited-radius point counts with call-broadcast surveys from 15 May–10 July 2010. We conducted surveys for eight focal species of marsh birds in accordance with the North American Marsh Bird Monitoring Protocol (Conway 2007, 2011). The eight focal species included Pied-billed Grebe (*Podilymbus podiceps*), American Bittern, Least Bittern, King Rail (*Rallus elegans*), Virginia Rail (*Rallus limicola*), Sora, Common Gallinule (*Gallinula chloropus*), and American Coot (*Fulica americana*). Using an MP3 player (SanDisk Sansa Clip 1 GB, SanDisk Corporation, Milpitas, CA, USA) attached to a pair of amplified speakers (Panasonic Model RPSPT70, Panasonic Corporation, Secaucus, NJ, USA), we broadcast the call sequence at 90 dB 1 m from the source (Conway 2007, 2011). We placed the speakers 0.5 m from the substrate (ground or water surface) and pointed them towards the interior of the wetland. The call-broadcast sequence was obtained from the North American Marsh Bird Monitoring Program coordinator (Conway 2007, 2011) and consisted of a 5-min passive listening period followed by 8 min of vocalizations. Each minute of the 8-min call-broadcast period corresponded to one species and consisted of 30 secs of vocalizations followed by 30 secs of silence. Vocalizations were ordered by species dominance (Least Bittern, Sora, Virginia Rail, King Rail, American Bittern, Common Gallinule, American Coot, Pied-billed Grebe) to minimize scaring birds prior to their respective sequence (Conway 2007, 2011). We recorded all visual and aural detections of all focal species at each survey point. Using a laser rangefinder, we measured the linear distance to each individual bird when it was first detected. We refrained from conducting surveys during periods of rain or when wind speeds exceeded 12 km/hr. Most survey points were accessed by foot, although we used a canoe to reach points on some larger wetlands.

To assess time-of-day differences in detection rates, we conducted paired surveys at each wetland during both morning (30 mins before sunrise to 3 hrs after sunrise) and evening (3 hrs before sunset to 30 mins after sunset) survey periods. We conducted surveys during consecutive survey periods (morning-evening or evening-morning) to minimize any daily variation in detections of birds (Nadeau et al. 2008), and the order in which we conducted morning and evening surveys was varied so that one survey was not always conducted prior to the other (Conway et al. 2004). We split the survey season into early season (15 May–14 Jun) and late season (15 Jun–14 Jul) and conducted paired surveys at each wetland during both seasons. The early survey season encompassed both survey windows (15 Apr–31 May and 1 May–15 Jun) established for Iowa in the North American Marsh Bird Monitoring Protocol (Conway 2007, 2011) and the late season included the 1-month period after established survey windows during which we hypothesized birds were still vocal. This allowed us to compare the number of marsh bird detections between surveys conducted during the established survey windows and after the established survey windows. To standardize the time between surveys, we conducted late-season surveys about a month (within 3 days) after early-season surveys. We randomized the order in which points were surveyed at each visit to minimize variation in vocalization frequency of individual birds at survey points and minimize dependence among survey points.

*Statistical Analyses.*—Using generalized linear mixed-effects models (PROC GLIMMIX; SAS Institute 2002) we examined the effects of time of day (TIME OF DAY), time of season (TIME OF SEASON), and wetland size (WETSIZE) on the number of detections at each survey point. We included wetland size in our analyses because some marsh bird species are area-dependent and because wetland size could influence the number of detections at the wetland because of density-dependence effects (Brown and Dinsmore 1986, 1988; Grover and Baldassarre 1995; Rehm and Baldassarre 2007; Harms and Dinsmore 2013). Because our data were over-dispersed counts, we fit models using a Poisson-log normal probability distribution and a log (ln) link function (P. M. Dixon, pers. comm.). Also known as mixed Poisson regression models, these models assume that the conditional distribution of the response is Poisson distributed with a random mean, which is dependent on the normally-distributed random effects (Weems and Smith 2004). We included a random effect on each individual visit to each wetland (WETLAND*TIME OF DAY*TIME OF SEASON) and random effects on wetland (WETLAND), survey point (POINT), the interaction of wetland and time of day (WETLAND*TIME OF DAY), and the interaction of wetland and time of season (WETLAND*TIME OF SEASON) to

TABLE 1. Number of detections of marsh bird species and species groups by survey period during call-broadcast surveys in Iowa, 2010.

| Species | Early season | | Late season | | Total |
|---|---|---|---|---|---|
| | Morning | Evening | Morning | Evening | |
| Pied-billed Grebe | 48 | 54 | 49 | 10 | 161 |
| Least Bittern | 22 | 17 | 13 | 28 | 80 |
| Virginia Rail | 54 | 55 | 40 | 36 | 185 |
| Sora | 35 | 23 | 5 | 1 | 64 |
| Rails | 95 | 80 | 51 | 38 | 264 |
| All species | 180 | 199 | 126 | 91 | 596 |

further account for variation in the model. Models rarely considered more than two of the random effects as having a significant contribution to variance in the data. We considered effects significant at $P \leq 0.05$. For those models that yielded a significant interaction between time of season and time of day, we conducted additional analyses to explore the interaction by splitting the dataset into early and late season detections and then evaluating the time-of-day effect on detections from each season.

As we were interested in determining the degree to which birds vocalize diurnally and seasonally, we used the total number of detections as our response variable. This means that we included all vocalizations in the analyses whether it was one bird vocalizing three times or three individual birds vocalizing once. Although this approach does not account for the number of birds at each survey point, we were careful not to double count birds at each survey point. This was a relatively easy task because only rarely were there $>3$ detections of a species at one point. We attempted to estimate mean patch abundance and detection probabilities using the model framework outlined by Royle and Nichols (2003). However, our data did not work well with this model and we rarely obtained numerical convergence. We assumed that detection probability was increased in our study by the use of call-broadcast surveys (Gibbs and Melvin 1993, Conway and Gibbs 2005). We also assumed constant detection probability across survey sites, because sites contained similar habitat and because habitats were open with little vegetation to act as a barrier to bird detections. Time of day and time of season were categorical variables (1 or 2) corresponding to morning and evening survey periods and early and late in the survey season, respectively.

We modeled the number of detections versus fixed effects for four of our focal species. We chose these species to compare results between three breeding species (Pied-billed Grebe, Least Bittern, and Virginia Rail) and a migrant (Sora). Each fixed effect was modeled on the number of detections individually; we did not consider a full model that included all fixed effects on the number of detections. Because of the low number of detections ($<10$), we could not model the number of detections for American Bittern, King Rail, or Common Gallinule. We chose not to include American Coot, because many individuals were visually detected and their response to call-broadcasts was problematic. We also modeled the number of detections for all rails combined (King Rail, Virginia Rail, Sora, and Common Gallinule) and for all eight species pooled.

## RESULTS

We surveyed a total of 56 wetlands (136 points) from both 15 May–14 June (early season) and 15 June–10 July (late season) 2010 (Fig. 1). The number of detections was greater during the early season ($n$ = 379) than during the late season ($n$ = 217), and we had more detections during morning survey periods ($n$ = 306) than during evening survey periods ($n$ = 290; Table 1).

We found that for three species (Pied-billed Grebe, Virginia Rail, and Sora) and both species groups, birds were more vocal early in the survey season than late in the survey season (Table 2). For Pied-billed Grebes and all species pooled, we found wetland size to have a significant positive effect on species detection rates, with detection rates of birds greater at larger wetlands than at smaller wetlands. However, the overall effect of wetland size on detection rates was small. We also found a significant effect of the interaction of time

TABLE 2. Individual model estimates (95% CI) for each fixed effect by marsh bird species and species groups from call-broadcast surveys in Iowa, 2010. Significant effects ($P < 0.05$) denoted with *. For time of season, we report the effect of early season compared to late season. For time of day, we report the effect of morning survey period compared to evening survey period.

| Species | Time of season | Time of day | Wetland size |
|---|---|---|---|
| Pied-billed Grebe | 0.55 (0.23, 0.87)* | 0.20 (−0.07, 0.47) | 0.01 (0.001, 0.013)* |
| Least Bittern | −0.14 (−0.56, 0.26) | −0.30 (−0.69, 0.10) | 0.005 (−0.002, 0.01) |
| Virginia Rail | 0.38 (0.12, 0.65)* | −0.19 (−0.45, 0.07) | 0.003 (−0.002, 0.01) |
| Sora | 1.87 (1.17, 2.56)* | 0.26 (−0.19, 0.72) | 0.01 (−0.006, 0.01) |
| Rails | 0.63 (0.37, 0.88)* | −0.04 (−0.26, 0.18) | 0.01 (−0.002, 0.01) |
| All species | 0.59 (0.42, 0.76)* | −0.02 (−0.16, 0.12) | 0.01 (0.002, 0.012)* |

of season and time of day on all individual species except Least Bittern, and for both species groups. Further analysis of the interaction term for these species and species groups only yielded a significant effect of time of day late in the survey season for Pied-billed Grebes ($P = 0.014$). Pied-billed Grebes were more vocal during the morning survey period than the evening survey period ($\beta_{Morning} = 0.23$, 95% CI 0.05, 0.42; Table 3). We found no significant effects of time of day by season for any other species or species group, although these effects were poorly estimated (Table 3).

## DISCUSSION

Our work has shown that marsh bird response rates vary seasonally, by time of day, and in response to wetland size, although these patterns were not consistent across species. This has important implications for designing future marsh bird surveys, especially with regard to survey windows for each species. Seasonal differences in detection rates have been observed for several species of marsh birds (Spear et al. 1999, Rehm and Baldassarre 2007). These differences, however, can vary geographically (Rehm and Baldassarre 2007). In this study, birds vocalized more frequently early in the survey season than late in the survey season. The explanation for this finding varies by species. Pied-billed Grebes and Virginia Rails are regular breeders in Iowa and their peak breeding seasons overlap with the early portion of the survey period. Virginia Rails frequently vocalize during the breeding season (Glahn 1974, Conway 1995), but are mostly silent during migration (Griese et al. 1980, Kaufmann 1989). Similarly, Pied-billed Grebes frequently vocalize during the breeding season when establishing territories and during courtship (Glover 1953, Muller and Storer 1999), but vocalize less frequently outside of the breeding season depending on geographic location (Palmer 1962, Muller and Storer 1999). We expected the distribution of detections of both Pied-billed Grebes and Virginia Rails to be non-linear. That is, birds vocalize frequently during the breeding season, infrequently when on the nest or with young and more often again later in the survey season at the potential start of a second nesting attempt. Gibbs and Melvin (1993) found that the probability of response for both Pied-billed Grebes and Virginia Rails peaked from 16–31 May, decreased from 1–30 June, and then increased again from 1–15 July. If a similar pattern occurs in Iowa, it could diminish our ability to find differences in the detection rate between early and late in the survey season. Detections for both Pied-billed Grebes and Virginia Rails peaked early in the survey season and decreased over time with no evidence of an increase late in the survey season. Soras commonly vocalize during migration (Kaufmann 1983, 1989; Johnson and Dinsmore 1986) and are common migrants throughout Iowa but only

TABLE 3. Model estimates (95% CI) of the effect of morning survey period compared to evening survey period for both early and late season. Only those species and species groups with a significant ($P < 0.05$) effect in the individual model of the interaction of time of season and time of day are displayed. Significant ($P < 0.05$) effects from the model that included only season and time of day are denoted with *.

| Species | Early season | Late season |
|---|---|---|
| Pied-billed Grebe | −0.17 (−0.51, 0.18) | 0.87 (0.38, 1.36)* |
| Virginia Rail | −0.28 (−0.62, 0.06) | −0.06 (−0.47, 0.34) |
| Sora | 0.21 (−0.28, 0.71) | 0.56 (−0.67, 1.79) |
| Rails | −0.09 (−0.36, 0.19) | 0.06 (−0.32, 0.43) |
| All species | −0.10 (−0.28, 0.08) | 0.13 (−0.11, 0.37) |

infrequently breed in the northern half of the state (Melvin and Gibbs 1996). This explains why the detection rate of Soras met our *a priori* expectations of strong seasonal variation in detection rates, with a peak early in the survey season and a steady decline thereafter.

Our data indicate that time of day alone did not affect the detection rate of most species of marsh birds. We were surprised by this result, because other studies have found that vocalization frequencies of marsh birds vary by time of day (Johnson and Dinsmore 1986, Conway et al. 2004, Nadeau et al. 2008). Variation in vocalization frequency of marsh birds is often attributed to temperature (Spear et al. 1999, Nadeau et al. 2008), because higher temperatures during the evening survey period may decrease activity levels of birds (Robbins 1981). We found a time-of-day effect on the number of detections for Pied-billed Grebes only, but this effect was significant only late in the survey season. As expected, the number of detections of Pied-billed Grebes was greater during the morning survey period than the evening survey period but only during late season. Gibbs and Melvin (1993) also observed that detection probabilities of Pied-billed Grebes were relatively high during morning surveys, although no previous studies have compared detection probabilities of Pied-billed Grebes between morning and evening survey periods. We attribute increased detections of Pied-billed Grebes during the morning survey period late in the season to weather conditions. Late in the survey season, temperatures ranged from 12.3–25.4 °C during morning survey periods and 19.4–33.0 °C during evening survey periods with a mean difference of 6.6 °C. This suggests that Pied-billed Grebes are most active and vocal during cooler times of the day (e.g., morning hours) late in the season because of generally warmer temperatures during this time of year. It is difficult to ascertain why higher evening temperatures affect the detection rate of Pied-billed Grebes and not that of other species. Pied-billed Grebes spend a majority of their time on open water, whereas bitterns and rails spend their time in dense, tall stands of emergent vegetation (TMH, pers. obs.).

Perhaps Pied-billed Grebes are most active during cooler, morning hours because they are more exposed to direct sunlight. Rails and bitterns are protected from the sun by tall vegetation, and therefore can remain active during the warmer hours of the day. In addition to our findings for Pied-billed Grebes, we found a significant effect of the interaction of time of season and time of day for Virginia Rails, Soras, all rails, and all species pooled, although when modeled separately, the effect of time of day by season for these species and species groups was not significant. Our results illustrate that time of season alone affected detection rates for all species except Least Bittern and both species groups. Therefore, time of season is driving the significance of the interaction and not time of day. Examination of these effects showed that detection rates were higher in the morning during both seasons for Soras, were higher in the evening during early season and in the morning during late season for all rails and all species, and higher in evening during both seasons for Virginia Rails. We conclude that the non-significance of these effects is a result of poor estimation of the time-of-day effects. However, they still demonstrate that most birds are more vocal in the morning late in the season, probably to avoid warmer temperatures (Spear et al. 1999, Nadeau et al. 2008). In contrast, Virginia Rails are more vocal in the evening both early and late in the season. Virginia Rails are often most vocal during a 3-hr period surrounding both dawn and dusk, and will also vocalize throughout the night during the peak of the breeding season (Conway 1995). This result coincides with that of Johnson and Dinsmore (1986) who found that night counts produced greater response rates for Virginia Rails during the breeding season.

We did not find effects of time of season or time of day on the detection rate for Least Bitterns. Least Bitterns vocalize infrequently (Bogner and Baldassarre 2002b), and it is debatable whether call-broadcast surveys are effective at increasing detection probabilities of these birds. Some studies have shown that call-broadcasts are effective at eliciting responses of Least Bitterns (Swift et al. 1988, Gibbs and Melvin 1993, Bogner and Baldassarre 2002b), whereas other studies have shown call-broadcasts to be ineffective (Manci and Rusch 1988, Tozer et al. 2007). Although we did not address the effectiveness of call-broadcasts at increasing detections of Least Bitterns in this study, the number of detections ($n$ = 80) was relatively low compared to other species. In addition, Bogner and Baldassarre (2002b) suggested that call-broadcast sequences consist of >1 min of calls by Least Bitterns to effectively stimulate the bitterns to respond. Our call sequence contained 30 secs of calls by Least Bitterns. The unknown effectiveness of call-broadcast surveys and our small sample size could explain why we did not find any seasonal or time-of-day effects on the number of detections of Least Bitterns.

Wetland size significantly affected our detection rates of Pied-billed Grebes and all species pooled, indicating that detection rates were greater at larger wetlands than at small wetlands. We suspect this may be a result of density-dependent effects for at least some species, with larger wetlands perhaps having more individuals and territorial interactions that led to increased vocalization rates and greater detection probability. Studies have found that some species of marsh birds, including Pied-billed Grebes (Brown and Dinsmore 1986, Osnas 2003) and Least Bitterns (Brown and Dinsmore 1986, Moore et al. 2009, Harms and Dinsmore 2013), are area-dependent, while other species such as Virginia Rails and Soras are area-independent (Brown and Dinsmore 1986). Larger wetlands provide desired habitat characteristics for some species (e.g., deeper water for Pied-billed Grebes), support greater densities of breeding pairs (Bogner and Baldassarre 2002a), and foster increased species diversity (Brown and Dinsmore 1986, Fairbairn and Dinsmore 2001, Craig 2008). Because we surveyed an equal number of wetlands within each size class and surveyed all wetlands during both times of day and both seasons, we do not expect wetland size to compound effects of time of day or time of season. Larger wetlands likely harbor more birds, thus increasing the detection rates of different species.

The North American Marsh Bird Monitoring Protocol (Conway 2007, 2011) suggests a survey window of 15 April–30 May for Iowa based on average minimum temperatures in May. We extended our survey season to 10 July to determine if there was a justification for extending the survey window for Iowa. As a result, we detected nearly half of the total number of birds ($n$ = 296) after 30 May, illustrating that the survey window for Iowa can be extended to increase detections of target species. Rehm and Baldassarre (2007) found similar results in their study based in New York and also suggested that the survey window be extended to incorporate peak detection periods for all species.

Interspecific seasonal variation of peak detection periods should be considered when conducting call-broadcast surveys, especially when surveying for both breeding species and migrants. If time is a limiting factor, surveys should be conducted early in the survey season, because this is when marsh birds are most vocal and detections of target species can be increased. However, caution should be used as undersampling of some species may still occur. Surveys for Pied-billed Grebes should also be limited to the morning survey period. In Iowa, we suggest extending the survey window past that recommended by the North American Marsh Bird Monitoring Protocol to increase the number of detections of marsh birds. Minimally, this period should be extended to 15 June, although the exact date will depend on the species being surveyed, average temperatures that affect arrival times and breeding phenology of birds, and the time available for conducting surveys.

## ACKNOWLEDGMENTS

This project was funded by the Iowa Department of Natural Resources State Wildlife Grant (# T-1-R-20) and Small Wildlife Diversity Program Research Grant. We would like to thank field technicians E. Spinney and J. Lautenbach for assistance with data collection. Biologists from the Iowa Department of Natural Resources and refuge managers from the U.S. Fish and Wildlife Service provided logistical support. Special thanks to T. Hanson for ArcGIS support, to P. M. Dixon for statistical advice, and to R.R. Koford for careful edits to this manuscript.

## LITERATURE CITED

ALLEN, T., S. L. FINKBEINER, AND D. H. JOHNSON. 2004. Comparison of detection rates of breeding marsh birds in passive and playback surveys at Lacreek National Wildlife Refuge, South Dakota. Waterbirds 27:277–281.

BEYER, H. 2004. Hawth's Analysis Tools for Arc GIS. www.spatialecology.com/htools/ (accessed 14 Aug 2009).

BOGNER, H. E. AND G. A. BALDASSARRE. 2002a. Home range, movement, and nesting of Least Bitterns in western New York. Wilson Bulletin 114:297–308.

BOGNER, H. E. AND G. A. BALDASSARRE. 2002b. The effectiveness of call-response surveys for detecting Least Bitterns. Journal of Wildlife Management 66:976–984.

BROWN, M. AND J. J. DINSMORE. 1986. Implications of marsh size and isolation for marsh bird management. Journal of Wildlife Management 50:392–397.

BROWN, M. AND J. J. DINSMORE. 1988. Habitat islands and the equilibrium theory of island biogeography: testing some predictions. Oceologica 75:426–429.

CONWAY, C. J. 1995. Virginia Rail (*Rallus limicola*). The birds of North America. Number 173.

CONWAY, C. J. 2007. Standardized North American Marsh Bird Monitoring Protocols. U.S. Geological Survey, Wildlife Research Report #2008-01. Arizona Cooperative Fish and Wildlife Research Unit, Tuscon, USA.

CONWAY, C. J. 2011. Standardized North American Marsh Bird Monitoring Protocol. Waterbirds 34:319–346.

CONWAY, C. J., W. R. EDDLEMAN, S. H. ANDERSON, AND L. R. HANEBURY. 1993. Seasonal changes in Yuma Clapper Rail vocalization rate and habitat use. Journal of Wildlife Management 57:282–290.

CONWAY, C. J. AND J. P. GIBBS. 2001. Factors influencing detection probabilities and the benefits of call-broadcast surveys for monitoring marsh birds. U.S. Geological Survey, Final Report, Patuxent Wildlife Research Center, Laurel, Maryland, USA.

CONWAY, C. J. AND J. P. GIBBS. 2005. Effectiveness of call-broadcast surveys for monitoring marsh birds. Auk 122:26–35.

CONWAY, C. J., C. SULZMAN, AND B. E. RAULSTON. 2004. Factors affecting detection probability of California Black Rails. Journal of Wildlife Management 68:360–370.

CRAIG, R. J. 2008. Determinants of species-area relationships for marsh-nesting birds. Journal of Field Ornithology 79:269–279.

DESROCHERS, D. W., H. K. W. GEE, AND J. M. REED. 2008. Response of Hawaiian Moorhens to broadcast of conspecific calls and a comparison with other survey methods. Journal of Field Ornithology 79:448–457.

ERWIN, R. M., C. J. CONWAY, AND S. W. HADDEN. 2002. Species occurrence of marsh birds at Cape Cod National Seashore, Massachussetts. Northeastern Naturalist 9:1–12.

FAIRBAIRN, S. E. AND J. J. DINSMORE. 2001. Local and landscape-level influences on wetland bird communities of the prairie pothole region of Iowa, USA. Wetlands 21:41–47.

GIBBS, J. P. AND S. M. MELVIN. 1993. Call-response surveys for monitoring breeding waterbirds. Journal of Wildlife Management 57:27–34.

GLAHN, J. F. 1974. Study of breeding rails with recorded calls in north-central Colorado. Wilson Bulletin 86:206–214.

GLOVER, F. A. 1953. Nesting ecology of the Pied-billed Grebe in northwestern Iowa. Wilson Bulletin 65:32–39.

GRIESE, H. J., R. A. RYDER, AND C. E. BRAUN. 1980. Spatial and temporal distribution of rails in Colorado. Wilson Bulletin 92:96–102.

GROVER, A. M. AND G. A. BALDASSARRE. 1995. Bird species richness within beaver ponds in south-central New York. Wetlands 15:108–118.

HARMS, T. M. AND S. J. DINSMORE. 2013. Habitat associations of secretive marsh birds in Iowa. Wetlands 33:561–571.

JOHNSON, R. R. AND J. J. DINSMORE. 1986. The use of tape-recorded calls to count Virginia Rails and Soras. Wilson Bulletin 98:303–306.

KAUFMANN, G. W. 1983. Displays and vocalizations of the Sora and Virginia Rail. Wilson Bulletin 95:42–59.

KAUFMANN, G. W. 1989. Breeding ecology of the Sora, *Porzana carolina*, and the Virginia Rail, *Rallus limicola*. Canadian Field-Naturalist 103:270–282.

KENT, T. H. AND J. J. DINSMORE. 1996. Birds in Iowa. Published by the authors, Iowa City, Iowa, USA.

LOR, S. AND R. A. MALECKI. 2002. Call-response surveys to monitor marsh bird population trends. Wildlife Society Bulletin 30:1195–1201.

MANCI, K. M. AND D. H. RUSCH. 1988. Indexes to distribution and abundance of some inconspicuous waterbirds on Horicon Marsh. Journal of Field Ornithology 59:67–75.

MELVIN, S. M. AND J. P. GIBBS. 1996. Sora (*Porzana carolina*). The birds of North America. Number 250.

MOORE, S., J. R. NAWROT, AND J. P. SEVERSON. 2009. Wetland-scale habitat determinants influencing Least Bitterns use of created wetlands. Waterbirds 32:16–24.

MULLER, M. J. AND R. W. STORER. 1999. Pied-billed Grebe (*Podilymbus podiceps*). The birds of North America. Number 140.

NADEAU, C. P., C. J. CONWAY, B. S. SMITH, AND T. E. LEWIS. 2008. Maximizing detection probability of wetland-dependent birds during point-count surveys in northwestern Florida. Wilson Journal of Ornithology 120:513–518.

OSNAS, E. E. 2003. The role of competition and local habitat conditions for determining occupancy patterns in grebes. Waterbirds 26:209–216.

PALMEIRIM, J. M. AND J. E. RABACA. 1994. A method to analyze and compensate for time-of-day effects on bird counts. Journal of Field Ornithology 65:17–26.

PALMER, R. S. (Editor). 1962. Handbook of North American birds. Volume 1. Yale University Press, New Haven, Connecticut, USA.

PRIOR, J. C. 1991. Landforms of Iowa. University of Iowa Press, Iowa City, USA.

REHM, E. M. AND G. A. BALDASSARRE. 2007. Temporal variation in detection of marsh birds during broadcast of conspecific calls. Journal of Field Ornithology 78:56–63.

ROBBINS, C. S. 1981. Bird activity levels related to weather. Studies in Avian Biology 6:301–310.

ROYLE, J. A. AND J. D. NICHOLS. 2003. Estimating abundance from repeated presence-absence data or point counts. Ecology 84:777–790.

SAS INSTITUTE. 2002. SAS for Windows. Version 9.2. SAS Institute, Cary, North Carolina, USA.

SOEHREN, E. C., J. W. TUCKER JR., AND D. G. CROW. 2009. Effectiveness of call-broadcast surveys for breeding marsh birds along coastal Alabama. Southeastern Naturalist 8:277–292.

SPEAR, L. B., S. B. TERRILL, C. LENIHAN, AND P. DELEVORYAS. 1999. Effects of temporal and environmental factors on the probability of detecting California Black Rails. Journal of Field Ornithology 70:465–480.

STEWART, R. E. AND H. A. KANTRUD. 1971. Classification of natural ponds and lakes in the glaciated prairie region. U.S. Department of the Interior, Fish and Wildlife Service, Research Publication 92, Washington D.C., USA.

SWIFT, B. L., S. R. ORMAN, AND J. W. OZARD. 1988. Response of Least Bitterns to tape-recorded calls. Wilson Bulletin 100:496–499.

TOZER, D. C., K. F. ABRAHAM, AND E. NOL. 2007. Short call-broadcasts fail to detect nesting Least Bitterns (*Ixobrychus exilis*). Northeastern Naturalist 14:637–642.

UNITED STATES FISH AND WILDLIFE SERVICE. 2009. National Wetlands Inventory. www.fws.gov/wetlands/Data/wetlandcodes.html (accessed 6 Aug 2009).

WELLER, M. W. 1961. Breeding biology of the Least Bittern. Wilson Bulletin 73:11–35.

WEEMS, K. S. AND P. J. SMITH. 2004. On robustness of maximum likelihood estimates for Poisson-lognormal models. Statistics and Probability Letters 66: 189–196.

WILEN, B. O. AND M. K. BATES. 1995. The U.S. Fish and Wildlife Service's National Wetlands Inventory Project. Vegetatio 118:153–169.