Summer use of Rice Fields by Secretive Marsh Birds in the Mississippi Alluvial Valley of Northeast Louisiana

Jonathon J. Valente[1,2,*], Sammy L. King[3], and R. Randy Wilson[4]

Abstract - Many secretive marsh bird (SMB) species nest within rice fields, yet in most regions we do not understand the extent to which these birds use such habitats. In the summers of 2007 and 2008, we investigated summer use of rice fields by SMBs in northeast Louisiana and evaluated the local (within 100 m) and landscape (within 1 km) habitat characteristics influencing site selection. We did not encounter any SMB species in 2007, but we encountered low densities of *Ixobrychus exilis* (Least Bitterns), *Rallus elegans* (King Rails), and *Fulica americana* (American Coots) in mid-July of 2008. It is unclear whether or not the birds we detected were actually breeding in the rice fields, or merely using them as late summer foraging areas. When we combined detections of all species, we found that probability of occupancy was positively influenced by the proportion of the local habitat dominated by flooded ditches containing herbaceous emergent vegetation. Ditches likely provide refuge and resource alternatives that may be particularly important to these birds in the late summer when rice fields are drained and harvested. However, given that SMBs were detected at less than 10% of the 72 rice fields we surveyed, it appears as though Mississippi Alluvial Valley rice fields contribute very little toward supporting SMB populations.

Introduction

Greater than 50% of the wetlands in the lower 48 US states have been destroyed over the past two centuries (Dahl 1990), and conversion of wetlands for agricultural purposes has been implicated as one of the leading causes of this destruction (Tiner 1984). The connection between global wetland loss and rice agriculture is particularly evident; annually, rice occupies 1,500,000 km^2 of land worldwide, more than any other agricultural crop (Forĕs and Comín 1992), and an estimated 57% of global rice fields occupy former natural wetland areas (Lawler 2001). However, virtually all rice production involves field inundation at some point during the year (Chang and Luh 1991), and consequently these "agricultural wetlands" can provide habitat and resources for many of the same bird species that use natural wetlands (Lawler 2001).

Rice fields provide important foraging habitat for diverse and abundant avian communities in many of the most important rice-growing territories of the world, including Japan (Maeda 2001), the Mediterranean region of Europe (Fasola and

[1]School of Renewable Natural Resources, Louisiana State University, Baton Rouge, LA 70803. [2]Current address - US Army Engineer Research and Development Center, Environmental Laboratory, 3909 Halls Ferry Road, Vicksburg, MS 39180. [3]US Geological Survey Louisiana Cooperative Fish and Wildlife Research Unit, 124 School of Renewable Natural Resources, Louisiana State University, Baton Rouge, LA 70803. [4]US Fish and Wildlife Service, 6578 Dogwood View Parkway Suite B, Jackson, MS 39213. [*]Corresponding author - Jonathon.J.Valente@gmail.com.

Ruiz 1996, Fasola et al. 1996), the Central Valley of California (Day and Colwell 1998, Elphick and Oring 1998, Shuford et al. 1998), and the US Gulf Coastal Plain (Huner et al. 2002, Remsen et al. 1991). In fact, rice agriculture may be vital in maintaining bird populations in some places; rice fields support approximately 75% of wintering shorebirds in the Sacramento Valley of California (Shuford et al. 1998) and 50–100% of wading birds in the Mediterranean region during the peak of the breeding season (Fasola et al. 1996). The quality of these habitats is often comparable to more natural wetland systems (Elphick 2000, Helm et al. 1987), and as a result, some species select nesting locations based on their proximity to rice complexes (Tourenq et al. 2004).

For other species, such as secretive marsh birds (SMBs), rice fields can actually provide critical nesting habitat. SMBs are a group of wetland-obligate breeders that includes all rails, bitterns, moorhens, and gallinules (Conway 2009). Evidence suggests that many SMB species have suffered drastic population declines over the past 30 years (Eddleman et al. 1988, Timmermans et al. 2008), which may be primarily attributable to wetland loss (Conway et al. 1994, Eddleman et al. 1988). During the breeding season, rice fields exhibit many of the attributes commonly required by these species, including shallow water, dense emergent vegetation, and food resources like rice seeds, aquatic invertebrates, amphibians, and fish (Czech and Parsons 2002). Thus, maintaining rice fields with habitat features utilized by SMBs may be extremely important for conservation of these species in the future. The majority of the research on breeding SMB use of agricultural wetlands in the US has taken place on the Gulf Coastal Plain (GCP), where several species have been recorded nesting successfully in rice fields (Helm et al. 1987, Hohman et al. 1994, Pierluissi 2006, Pierluissi and King 2008), including *Rallus elegans* Audubon (King Rail), *Porphyrula martinica* L. (Purple Gallinule), *Gallinula chloropus* L. (Common Moorhen), and *Ixobrychus exilis* Gmelin (Least Bittern). These birds tend to prefer fields surrounded by ditches and landscapes with little tree cover (Pierluissi 2006) and can even achieve greater reproductive success in rice fields than in more natural systems (Helm et al. 1987). However, SMB habitat preferences may differ among regions because of differences in agricultural practices and available habitat features.

Five SMB species are known to breed in natural wetlands of the Mississippi Alluvial Valley (MAV), including Common Moorhens, Least Bitterns, Purple Gallinules, *Fulica Americana* Gmelin (American Coot), and King Rails (Valente et al. 2011). However, little is known about how these birds use regional rice fields. In the MAV of Louisiana, rice fields tend to be located in landscapes dominated by non-flooded agriculture and remnant tracts of dense bottomland hardwood forest, whereas the GCP is comprised largely of rice, fallow rice fields, and coastal marsh. Farmers in the MAV also tend to use later planting dates, and different rice varieties and flooding regimes than those of the GCP. Moreover, the structure provided by ditch vegetation may be especially crucial for breeding SMBs in the MAV, where breeding can begin in early March (Meanley 1953), but rice does not mature until early May or June. To further our understanding of the role agricultural systems play in SMB conservation, we investigated breeding

SMB use of rice fields in the MAV of northeast Louisiana. The goals of our study were to determine which SMB species breed in rice fields and to identify the local and landscape-level habitat characteristics that attract those species.

Field-Site Description

Our study area encompassed most of the MAV in Louisiana north of 31°1'2" north latitude and east of 92°10'15" west longitude (Fig. 1). The region is located in the historic floodplain of the Mississippi River and was once dominated by dense bottomland hardwood forest, though an extensive levee system now isolates this area from floodwaters. In the past 200 years, more than 80% of this habitat has been altered (The Nature Conservancy 2009), and now the region is predominantly comprised of agricultural fields and remnant forest patches. Rice is not one of the primary crops grown in the MAV, so most of the fields surrounding our survey areas were cultivated in corn and soybeans.

Methods

Site selection

We were granted access to approximately 4000 ha of rice fields on seven private farms and approximately 140 ha on Grand Cote National Wildlife Refuge (NWR). In the spring of 2007, we digitized all rice fields on those properties using ESRI® ArcMap™ 9.1 (ESRI, Inc.). To reduce the probability of detecting the same bird at 2 different sites, we randomly placed 1 point on the perimeter of each rice field with the stipulation that all points had to be at least 700 m apart, a more conservative distance than the 400 m recommended by Conway (2009). We eliminated about one third of the resulting 113 rice fields for logistical reasons (e.g., location relative to other sites, distance from nearest lodging) and we randomly selected 37 from the remaining to be used as our study sites in 2007. These fields were distributed across four farms and one NWR. In 2008, we selected all new sites (n = 35) on four farms using the same procedure.

Bird sampling protocol

Four trained observers (three unique to each year) conducted morning and evening callback surveys between 20 March and 24 June 2007 and between 19 May and 22 August 2008. Pierluissi (2006) found that rice needed to be both flooded and approximately 65–70 cm tall before SMBs would begin nesting in it, and none of our sample fields had even been planted when we started our surveys in 2007. Yet, Meanley (1953) noted that King Rails utilized overgrown ditches around rice fields early in the breeding season in Arkansas, and thus the survey period in 2007 was designed to coincide with the approximate breeding phenology of target species (Valente et al. 2011) in order to detect birds that might be using those ditches; surveying was delayed in 2008 due to a lack of detections in 2007. In both years, we attempted to survey sites once or twice every 15 days (sampling period), although approximately 1 month elapsed between the last two sampling periods in 2008 due to personnel constraints. Survey procedures followed those outlined by the Standardized North American Marsh Bird Monitoring Protocols (Conway 2009); each survey included a 1-minute "settling" period, a 5-minute silent period, and a 6-minute callback period. The callback period consisted of playing 30 seconds of calls from 6 SMB species (Least Bittern, King Rail, *Botaurus lentiginosus* Rackett [American Bittern],

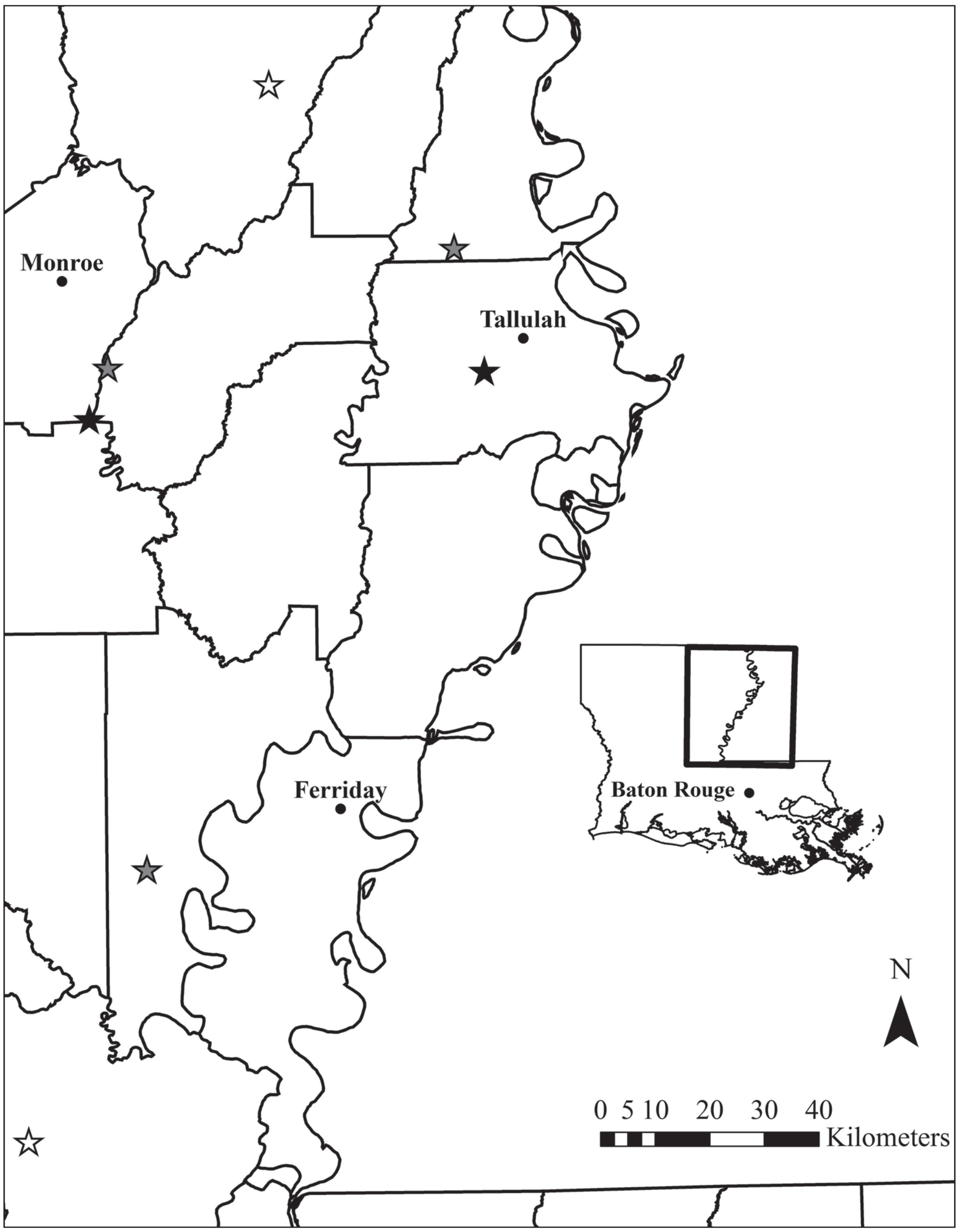

Figure 1. Locations of rice farms situated in Louisiana's Mississippi Alluvial Valley which were sampled for secretive marsh birds during the breeding seasons of 2007 and 2008. White stars represent farms sampled in 2007 only, black stars represent farms sampled in 2008 only, and gray stars represent farms sampled in both years.

Common Moorhen, Purple Gallinule, and American Coot, sequentially) followed by 30 seconds of silence. Pierluissi (2006) found that the American Bittern call elicits responses from King Rails, so we incorporated it into the study design despite the fact that Louisiana is outside its breeding range. Calls were played from an RP2700A portable CD player (RCA, Paris, France) and broadcast through 40-1434 portable folding speakers (RadioShack, Fort Worth, TX). Observers measured the distance from the sampling point to the approximate (because many detections were aural) location of each individual bird using Yardage Pro Sport 450 range finders (Bushnell, Overland Park, KS).

Local- and landscape-scale habitat

Each time we visited a rice field to conduct a bird survey, we recorded the mean rice height for the target field and whether or not the field was flooded. Local habitat surveys were conducted once at each site between 1 June and 7 June 2007, and between 19 August and 22 August 2008. For these surveys, we recorded the proportion of a 100-m radius circular plot around each sampling point covered by rice, flooded ditches, agriculture, grass and weeds, young trees (<3 m tall), and mature trees (≥3 m tall). These values summed to 1 for each plot. Ditches that did not contain any standing water were considered uplands (ditch flooding status remained fairly consistent throughout the duration of the bird survey period). Because ditch vegetation may be particularly important to breeding SMBs around rice fields, we further characterized the vegetation within the associated flooded ditches by recording each plant species present, and the proportion of the flooded ditch it covered. Submerged ditch areas that were not covered by vegetation, or were dominated by structurally insignificant floating plants such as *Lemna minor* L. (Lesser Duckweed) were considered open water.

We collected landscape-scale habitat information by centering a 1-km radius circular plot (Pierluissi and King 2008) on each sampling point, and overlaying that on digital orthophotos taken in 2007 as part of the US Department of Agriculture's National Agriculture Imagery Program. We printed the image of each plot and classified all parts of the landscape into one of five categories in the field: 1) agriculture (including rice); 2) residential, grassland, or pasture; 3) wetland or permanent water; 4) young trees (<3 m); or 5) mature trees (≥3 m). We then digitized these 1-km landscapes using ArcMap™ and calculated the proportion of each that was comprised of those habitat features.

Data analyses

Initial review of our data indicated that no SMB individuals were ever detected in our study fields (or surrounding ditches) when the rice was <65 cm tall, a finding that has been echoed in previous studies (Pierluissi 2006). Thus, we assumed that fields in which the rice never reached 65 cm during our survey period (n = 30) were not even available for use by SMBs, and those were eliminated from our habitat analyses. It should be noted that the rice in all of these fields probably reached a height of >65 cm at some point after our surveys concluded, and if we had included them in our habitat models then they would have been considered "unoccupied," when in fact they may have become occupied once the rice was tall enough.

We initially planned to use a likelihood-based approach to model site occupancy for each species separately as a function of measured habitat variables while simultaneously accounting for detection probability (MacKenzie et al. 2002). However, because occupancy appeared to be highly dependent on rice height, which varied greatly over the course of our survey period, our data almost certainly violated the "closure" assumption (i.e., if a site is occupied during any survey then it is assumed to be occupied during all surveys) that is fundamental to this modeling technique. Additionally, the extremely low number of bird detections forced us to combine all species into a single habitat analysis. Thus, each of the sites that were surveyed after the rice reached 65 cm were deemed "occupied" if any SMB individual was ever detected within 250 m of the survey point; all other sites were deemed "unoccupied". Because there was no site replication between years, we pooled all data for habitat models in order to augment sample size.

We combined the habitat information we recorded into 9 local-scale variables and 4 landscape-scale variables that we thought could plausibly influence SMB site occupancy based on previously published accounts and our own field observations (Table 1). Rather than model occupancy as a function of all possible combinations of these 13 variables (8192 models), we chose to first reduce the number of variables to be included in a global model. To do this, we constructed models (PROC LOGISTIC, SAS v. 9.2, SAS Institute, Cary, NC) that included each of the habitat variables individually (models of interest), and then compared them to an intercept-only model (null) using Akaike's information criterion corrected for small sample sizes (AIC_C; Burnham and Anderson 2002:66). If there was no reduction in the AIC_C value associated with a model of interest (i.e., not an improvement over the reduced model), then the habitat variable was eliminated from further consideration. When 2 of the retained variables were highly correlated (i.e., Pearson correlation coefficient $|r| \geq 0.7$), we compared the models of interest containing those 2 variables and eliminated the one that had the larger AIC_C value. We then constructed a global habitat model that included all retained habitat variables, and compared it to models containing all possible combinations of those retained variables using AIC_C and Akaike weights (ω_i; Burnham and Anderson 2002:75); we also performed a Hosmer and Lemeshow goodness-of-fit test (Hosmer and Lemeshow 2000) on each of these models to ensure they fit the data ($\alpha = 0.05$). We accepted the variables in the most parsimonious model (i.e., the model with the lowest AIC_C value) as the best predictors of SMB occupancy.

Results

In 2007, we conducted 259 bird surveys (7.0 surveys/site) and detected 16 total SMB individuals. Fifteen of these birds (8 American Coots and 7 Common Moorhens) were actually located in natural wetlands adjacent to the target rice fields. The only SMB individual we actually detected using one of our surveyed agricultural areas in 2007 was an American Bittern detected on 3 April. Because our study area is outside of the breeding region for this species, we assumed it was a transient migrant. Thus, no breeding SMBs were detected using our rice sites in 2007. In 2008, we conducted 248 surveys (7.1 surveys/site) and detected 13 total SMB individuals, including 1 American Coot, 3 King Rails, and 9 Least Bitterns. These birds were detected at 7 different sites, and all were located within the agricultural matrix we were surveying. Interestingly, all of these individuals were encountered between 11 July and 17 July, which is approximately 2.5 months after breeding behavior had been documented in the region (Valente et al. 2011).

In both years, farmers began planting rice in early April and continued until the first week of May. Fields planted earliest began to germinate during the first 2 weeks of May, and fields with emergent rice were flooded anywhere from the second week of May to the last week of June. Draining the fields for harvest began in early August. Rice was generally not tall enough to support nesting (≈65 cm) until early to late June in either year. Thus, rice reached a height of ≥65 cm during our sampling period in only 7 of the 37 sites in 2007 but in all 35 sites in 2008. Data collected at these 42 combined sites (7 occupied) were used in our habitat models.

Only 3 models containing individual habitat variables showed improvement over the null model (Table 1). NR_HERB_DITCH was eliminated from further consideration due to high correlation ($r = 0.996$) with HERB_DITCH. This extremely high correlation stems from the fact that HERB_DITCH was calculated as the sum of NR_HERB_DITCH and ROBUST_DITCH, and only 1 site had a value >0 zero for ROBUST_DITCH. Thus, only 2 habitat variables were included in our global habitat model.

We constructed four models containing all possible combinations of these retained variables (Table 2). The best model based on AIC_C included only one variable, HERB_DITCH; no other model had substantial support (Burnham and Anderson 2002:70). HERB_DITCH had a significant ($\alpha = 0.05$) positive effect on probability of occupancy in both models in which it was included. DITCH100M had a positive effect when included as the only explanatory variable and a negative effect in the global model, but the parameter estimate was not significantly different from 0 ($\alpha = 0.05$) in either case. There was no evidence for lack of fit in any of the models tested.

Discussion

The most significant finding from our study is that we only recorded potentially breeding SMBs at less than 10% of the rice fields we surveyed over 2 years. MAV rice fields appear to support extremely low densities of SMBs during this time period when compared with other rice-growing regions in the Southeast. Pierluissi (2006) searched fields for breeding SMBs on the Gulf Coastal Plain and found that a large percentage of them contained Purple Gallinule (≥50%), King

Table 1. The change in AIC_C values resulting from individually adding local (within 100 m) and landscape (within 1 km) habitat variables to an intercept-only logistic model of secretive marsh bird occupancy of rice fields surveyed in northeast Louisiana in 2007 and 2008. Values in bold indicate variables that improved the model when included. An asterisk indicates that the variable was not included in the global occupancy model due to high correlation with another variable that was included.

Variables	Dominant land cover	Description of habitat	ΔAIC_C
Local Habitat			
RICE100M	Rice agriculture	All active, planted rice fields	2.14
TREES100M	All trees	Predominantly mature forest	2.21
AG100M	Agriculture	All active and fallow agricultural fields, including rice	0.99
DITCH100M	Ditches	Irrigation ditches containing standing water	**-1.50**
ROBUST_DITCH	Ditch supporting robust herbaceous emergent vegetation	*Typha* spp.	-
NR_HERB_DITCH	Ditch supporting non-robust herbaceous emergent vegetation	*Echinodora* spp., *Sagittaria* spp., *Alternanthera philoxeroides* Grisebach, etc.	**-7.67***
HERB_DITCH	Ditch supporting all herbaceous emergent vegetation	Sum of ROBUST_DITCH and NR_HERB_DITCH	**-7.68**
WOODY_DITCH	Ditch supporting woody emergent vegetation	*Brunnichia* spp., *Salix nigra* Marshall, *Cephalanthus occidentalis* L., etc.	2.19
OPEN_DITCH	Open water ditches	Open water, *Lemna minor* L., etc.	2.15
Landscape			
WATER1KM	Water	Lakes, rivers, streams, and wetlands	1.66
TALLTREES1KM	Trees ≥3 m	Predominantly mature forest	1.15
TREES1KM	All trees	Mature forest and young reforested areas	1.16
AG1KM	Agriculture	All active and fallow agricultural fields	0.65

Table 2. Comparison of logistic habitat models constructed to explain secretive marsh bird occupancy of rice fields in northeast Louisiana in 2007 and 2008. Model variables are defined in Table 1.

	Parameter estimate (SE)			Odds ratio estimate		Model selection			Goodness of fit		
Model	Intercept	HERB_DITCH	DITCH100M	HERB_DITCH	DITCH100M	AIC_C	ΔAIC_C	ω_i	χ^2	df	*P*
HERB_DITCH	-1.95 (0.54)	1.62 (0.68)	-	5.06	-	32.26	0.00	0.72	3.92	4	0.42
HERB_DITCH, DITCH100M	-1.97 (0.55)	1.73 (0.84)	-0.17 (0.74)	5.63	0.84	34.53	2.27	0.23	4.55	7	0.71
DITCH100M	-1.77 (0.46)	-	0.75 (0.41)	-	2.10	38.45	6.19	0.03	3.68	4	0.45
Null (intercept-only)	-1.61 (0.41)	-	-	-	-	39.95	7.68	0.02	-	-	-

Rail (≥40%), Common Moorhen (≥26%), and Least Bittern (≥7%) nests. Meanley (1953) also frequently recorded King Rails nesting in and around rice fields on the Grand Prairie. Given the fact that the MAV was historically dominated by forested floodplains and is located several hundred kilometers from high-density SMB breeding habitat on the coast, it is possible that the area has never been important for supporting SMBs in the summer. However, data from other parts of the MAV indicate that SMBs do breed in the region (Budd and Krementz 2011). Additionally, we found that many of these birds are, indeed, locally abundant, as we detected one or more species at greater than 35% of the more natural wetlands surveyed in our study region during the same time period (Valente et al. 2011). In fact, when appropriate breeding habitat was available (i.e., flooded patches of robust emergent vegetation ≥ 0.04 ha), over 80% of these wetlands were occupied by at least one individual. Thus, we suggest that the MAV rice fields we surveyed support very low densities of breeding SMBs primarily because of the paucity of available early season nesting habitat.

Rice fields in the MAV tend to be planted relatively late in the season, and the rice does not reach an appropriate height to support breeding SMBs until late June. In addition, the ditches surrounding our target rice fields did not exhibit characteristics that would make them attractive to early season breeders. Meanley (1953) noted that King Rails primarily utilized overgrown ditches around rice fields in Arkansas during the months of March through May, building nests in dense stands of *Typha latifolia* L. (Cattail), *Juncus effusus* L. (Soft Rush), and *Carex hyalinolepis* Steudel (Shoreline Sedge). Similarly, Pierluissi (2006) found a positive association between the proportion of rice fields lined by ditches and the density of King Rail and Purple Gallinule nests in those fields. These researchers have suggested that ditches provide supplemental resources, refuge from agricultural disturbances, and more sufficient nesting structure early in the growing season for breeding birds. The irrigation ditches near the rice fields we surveyed tended to be well manicured (i.e., mowed or treated with herbicides) and dominated by open water or less robust wetland vegetation such as *Echinodora* spp. (burhead), *Sagittaria* spp. (arrowhead), *Alternanthera philoxeroides* Grisebach (Alligator Weed), and *Polygonum hydropiperoides* Michaux (Smartweed), that would likely provide poor quality cover or nesting structure for SMBs in the absence of mature rice.

As the rice grew taller, availability of ditch habitat did become an important factor in predicting SMB occupancy. In fact, the only habitat variables we measured that seemed to have any influence on site occupancy were the proportion of the local survey area dominated by flooded ditches (DITCH100M), and flooded ditches supporting herbaceous emergent vegetation (HERB_DITCH). Our models yielded inconclusive results about the effect of DITCH100M on occupancy, as it had a positive influence in one model and a negative influence in another. The fact that DITCH100M was included in the global model at all may be due to the fact that it was moderately correlated with HERB_DITCH ($r = 0.64$). The only model we tested that had substantial support included HERB_DITCH alone as an explanatory variable with a positive effect on SMB occupancy. Indeed, 4 of the

13 (31%) birds we detected within the agricultural matrix were located in ditches rather than in the rice field itself. Flooded ditches may be particularly important to SMBs occupying MAV rice fields in the late summer because they can provide flooded refuges when the fields are drained in early August. We never detected any SMBs in our target fields in the absence of mature rice or standing water, and both of these factors were extremely temporally and spatially variable among the fields and farms we surveyed. Thus, it may be that mature rice and available refuges (i.e., flooded ditches) are the overwhelming factors influencing SMB site selection in the MAV, and birds simply choose areas with these traits regardless of other habitat features. However, it should be noted that the average landscape around our survey points was comprised of 90% agriculture, so there was very little variability in landscape-level habitat characteristics.

Most SMB species are suspected of rearing multiple broods in a single season, especially in the southern US, which is closer to the wintering grounds for migrants and has a long growing season (Bannor and Kiviat 2002, Meanley 1992). It is possible that MAV rice fields provide habitat for late season breeders or birds rearing a second brood. This resource may be particularly important for the King Rail, which has suffered large population declines throughout its range over the past 40–50 years (Cooper 2008, Meanley 1992). Estimates based on our data and incidental field observations suggest that King Rails were at least twice as abundant in MAV rice fields throughout June and July than in more natural systems during the same time period (Valente et al. 2011). However, the seemingly late season arrival of SMBs, in conjunction with the fact that we never observed any nests or breeding behavior during our surveys, makes us question whether the birds we detected were actually breeding in our target rice fields. Indeed, there may not be enough time for birds arriving in the late summer to fledge a successful nest, as most of the rice fields we surveyed were drained in preparation for harvest within 2 to 3 weeks after the majority of the birds were first detected. Another possible explanation for the pattern observed is that SMBs tend to select more natural wetlands in the area for breeding (Valente et al. 2011) and only use mature rice fields late in the summer as they disperse when breeding is complete. While post-breeding dispersal has not, to our knowledge, been documented in any of the SMB species we detected, it is common among many birds with diverse life-history characteristics (e.g., Pagen et al. 2000, Rosier et al. 2006, Shealer and Kress 1994).

While we were not able to account for detection probability in our models, we feel confident in our conclusion that MAV rice fields are not used by SMBs until relatively late in the breeding season, as the earliest we ever incidentally detected any of these birds was 3 June (King Rail). The latest we ever detected any SMBs in rice areas was 17 July, yet we cannot account for the time between mid-July and mid-August because we did not conduct any surveys during that time period. More frequent sampling during July and August is necessary to determine exactly how long these birds are present and whether that allows for enough time for breeding. Additionally, probability of detection decreases for many SMB species later in the summer (Conway 2009), so it is likely that we underestimated true abundance and distribution. Future studies of SMB use of rice fields in this region should consider incorporating a variety of sampling techniques including callback surveys, transect surveys, and nest searching to accurately estimate population parameters, and to help determine whether birds actually breed in these rice fields. Lastly, we combined occupancy data for all SMB species in this study in order to augment sample size. This approach is justified because this group of species shares many common life-history traits and habitat requirements (Eddleman et al. 1988). However, it is probable that each species exhibits unique habitat preferences that we were not able to identify due to our low number of detections. More frequent late summer sampling over a larger number of sites is necessary to help understand idiosyncratic resource needs.

At present, MAV rice fields probably contribute very little toward maintaining or augmenting population sizes for SMBs. Yet research has shown that agricultural habitats like these can support breeding individuals when conditions are appropriate for nesting (Helm et al. 1987, Hohman et al. 1994, Meanley 1953, Pierluissi 2006, Pierluissi and King 2008). Budd (2007) suggested that land managers in the Arkansas Delta could potentially improve SMB habitat by limiting management in irrigation ditches and allowing establishment of emergent vegetation, and our results support that conjecture. Increasing the abundance of overgrown ditches around MAV rice fields may help attract more nesting individuals by providing critical early breeding season habitat.

Acknowledgments

We kindly thank L. Philley, E. Davis, and Grand Cote National Wildlife Refuge for allowing us to use their farms for our study. We also thank J.A. Nyman, P. Stouffer, K. McCarter, and B. Strader for their intellectual contributions. Reviews provided by S. Pierluissi, D. Krementz, P. Leberg, and two anonymous reviewers helped improve this manuscript. Lastly, we thank C. Duplechain, D. Crawford, E. DeLeon, T. Gancos, E. Hunter, J. Unger, J. Keiser, M. Osinskie, J. Russell, R. Villani, H. Gee, B. Pickens, P. Newell, S. R. Kang, and J. Davis for their assistance. This project was funded by US Fish and Wildlife Service State Wildlife Grant T-41-R, which was administered by the Louisiana Department of Wildlife and Fisheries. The use of trade, product, or industry firm names or products is for informative purposes only and does not constitute an endorsement by the US Government or the US Geological Survey.

Literature Cited

Bannor, B.K., and E. Kiviat. 2002. Common Moorhen (*Gallinula chloropus*). No. 685, *In* A. Poole, P. Stettenheim, and F. Gill (Eds.). The Birds of North America. The Birds of North America, Inc., Philadelphia, PA.

Budd, M.J. 2007. Status, distribution, and habitat selection of secretive marsh birds in the Delta of Arkansas. M.Sc. Thesis. University of Arkansas, Fayetteville, AR. 126 pp.

Budd, M.J., and D.G. Krementz. 2011. Status and distribution of breeding secretive marshbirds in the Delta of Arkansas. Southeastern Naturalist 10:687–702.

Burnham, K.P., and D.R. Anderson. 2002. Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach, 2nd Edition. Springer Science+Business Media, New York, NY. 488 pp.

Chang, T.T., and B.S. Luh. 1991. Overview and prospects of rice production. Pp. 1–11, *In* B.S. Luh (Ed.). Rice Production, 2nd Edition. Van Nostrand Reinhold, New York, NY. 437 pp.

Conway, C.J. 2009. Standardized North American marsh bird monitoring protocols. Wildlife Research Report #2009-02. US Geological Survey, Arizona Cooperative Fish and Wildlife Research Unit, Tucson, AZ. 57 pp.

Conway, C.J., W.R. Eddleman, and S.H. Anderson. 1994. Nesting success and survival of Virginia Rails and Soras. Wilson Bulletin 106:466–473.

Cooper, T.R. (Plan Coordinator). 2008. King Rail Conservation Plan, Version 1. US Fish and Wildlife Service, Fort Snelling, MN.

Czech, H.A., and K.C. Parsons. 2002. Agricultural wetlands and waterbirds: A review. Waterbirds 25:56–65.

Dahl, T.E. 1990. Wetlands losses in the United States 1780s to 1980s. US Department of the Interior, Fish and Wildlife Service, Washington, DC.

Day, J.H., and M.A. Colwell. 1998. Waterbird communities in rice fields subjected to different post-harvest treatments. Colonial Waterbirds 21:185–197.

Eddleman, W.R., F.L. Knopf, B. Meanley, F.A. Reid, and R. Zembal. 1988. Conservation of North American rallids. Wilson Bulletin 100:458–475.

Elphick, C.S. 2000. Functional equivalency between rice fields and seminatural wetland habitats. Conservation Biology 14:181–191.

Elphick, C.S., and L.W. Oring. 1998. Winter management of California rice fields for waterbirds. The Journal of Applied Ecology 35:95–108.

Fasola, M., and X. Ruiz. 1996. The value of rice fields as substitutes for natural wetlands for waterbirds in the Mediterranean region. Colonial Waterbirds 19 (Special Publication 1):122–128.

Fasola, M., L. Canova, and N. Saino. 1996. Rice fields support a large portion of herons breeding in the Mediterranean region. Colonial Waterbirds 19 (Special Publication 1):129–134.

Forěs, E., and F. Comín. 1992. Ricefields, a limnological perspective. Limnetica 8:101–109.

Helm, R.N., D.N. Pashley, and P.J. Zwank. 1987. Notes on the nesting of the Common Moorhen and Purple Gallinule in southwestern Louisiana. Journal of Field Ornithology 58:55–61.

Hohman, W.L., J.L. Moore, T.M. Stark, G.A. Weisbrich, and R.A. Coon. 1994. Breeding waterbird use of Louisiana rice fields in relation to planting practices. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 48:31–37.

Hosmer, D.W., and S. Lemeshow. 2000. Applied Logistic Regression, 2nd Edition. John Wiley and Sons, New York, NY. 373 pp.

Huner, J.V., C.W. Jeske, and W. Norling. 2002. Managing Agricultural Wetlands for Waterbirds in the Coastal Regions of Louisiana, USA. Waterbirds 25 (Special Publication 2):66–78.

Lawler, S.P. 2001. Rice fields as temporary wetlands: A review. Israel Journal of Zoology 47:513–528.

Mackenzie, D.I., J.D. Nichols, G.B. Lachman, S. Droege, J.A. Royle, and C.A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology 83:2248–2255.

Maeda, T. 2001. Patterns of bird abundance and habitat use in rice fields of the Kanto Plain, central Japan. Ecological Research 16:569–585.

Meanley, B. 1953. Nesting of the King Rail in the Arkansas rice fields. The Auk 70:261–269.

Meanley, B. 1992. King Rail (*Rallus elegans*). No. 3 *In* A. Poole, P. Stettenheim, and F. Gill (Eds.). The Birds of North America. The Birds of North America, Inc., Philadelphia, PA.

Pagen, R.W., F.R. Thompson III, and D.E. Burhans. 2000. Breeding and post-breeding habitat use by forest migrant songbirds in the Missouri Ozarks. The Condor 102:738–747.

Pierluissi, S. 2006. Breeding waterbird use of rice fields in southwestern Louisiana. M.Sc. Thesis. Louisiana State University, Baton Rouge, LA. 92 pp.

Pierluissi, S., and S.L. King. 2008. Relative nest density, nest success, and site occupancy of King Rails in southwestern Louisiana rice fields. Waterbirds 31:530–540.

Remsen, J.V., Jr., M.M. Swan, S.W. Cardiff, and K.V. Rosenberg. 1991. The importance of the rice-growing region of south-central Louisiana to winter populations of raptors, waders, and other birds. Journal of Louisiana Ornithology 1:35–47.

Rosier, J.R., N.A. Ronan, and D.K. Rosenberg. 2006. Post-breeding dispersal of Burrowing Owls in an extensive California grassland. American Midland Naturalist 155:162–167.

Shealer, D.A., and S.W. Kress. 1994. Post-breeding movements and prey selection of Roseate Terns at Stratton Island, Maine. Journal of Field Ornithology 65:349–362.

Shuford, W.D., G.W. Page, and J.E. Kjelmyr. 1998. Patterns and dynamics of shorebird use of California's Central Valley. The Condor 100:227–244.

Timmermans, S.T.A., S.S. Badzinski, and J.W. Ingram. 2008. Associations between breeding marsh bird abundances and great lakes hydrology. Journal of Great Lakes Research 34:351–364.

Tiner, R.W., Jr. 1984. Wetlands of the United States: Current status and recent trends. US Fish and Wildlife Service, Newton Corner, MA.

The Nature Conservancy. 2009. Bottomland hardwood forests: An imperiled national treasure. Available online at http://www.nature.org/ivorybill/habitat/forests.html. Accessed 4 March 2009.

Tourenq, C., S. Benhamou, N. Sadoul, A. Sandoz, F. Mesléard, J.L. Martin, and H. Hafner. 2004. Spatial relationships between tree-nesting heron colonies and rice fields in the Camargue, France. The Auk 121:192–202.

Valente, J.J., S.L. King, and R.R. Wilson. 2011. Distribution and habitat associations of breeding secretive marsh birds in Louisiana's Mississippi Alluvial Valley. Wetlands 31:1–10.