Time-activity Budgets of Yellowlegs in Managed Tidal Impoundments and Adjacent Tidal Marshes

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Abstract: Managed tidal impoundments are man-made wetlands constructed from natural tidal marshes and swamps with embankments and water control structures that manage water levels using tidal cycles. In South Carolina, 28,000 ha of managed tidal impoundments potentially provide important habitat for migrating and resident wildlife. The importance of traditionally-managed tidal impoundments relative to natural tidal marsh to migratory birds is poorly understood. Examining how birds allocate their time on managed tidal impoundments and natural tidal marshes can provide insight into whether birds are using these resources similarly or for different biological needs. We examined diurnal activity of greater yellowlegs (*Tringa melanoleuca*) and lesser yellowlegs (*T. flavipes*) to determine how these focal species used managed tidal impoundments and tidal marshes along the coast of South Carolina. Overall, frequency of behaviors differed between managed tidal impoundments and natural tidal marshes ($F = 6.5$, df = 5, 5; $P = 0.031$). Proportion of time yellowlegs moved (locomotion) was greater on tidal marshes ($F = 19.6$, df = 1, 69; $P < 0.001$), while proportion of time spent loafing ($F = 5.7$, df = 1, 69; $P = 0.019$) was greater on managed tidal impoundments. The greater proportion of time spent loafing on managed tidal impoundments suggests these wetlands provide body-maintenance opportunities not available in tidal marshes. Our results reveal the importance of managed tidal impoundments to migratory shorebirds within the coastal landscape. These managed habitats provide protected roosting sites and abundant, available food resources because of the controlled hydrological cycle.

Key words: managed tidal impoundment, shorebirds, tidal marsh, time-activity budget, yellowlegs

Journal of the Southeastern Association of Fish and Wildlife Agencies 3:220–224

Migratory waterbirds such as waterfowl (Anseriformes) and shorebirds (Charadriiformes) use the coastal marshes of South Carolina as wintering and stopover habitats. However, urban development continues to replace coastal marshes at an alarming rate. From the mid-1950s to the 1970s, the United States lost 185,000 ha of wetlands annually (Frayer et al. 1983). Between 2004 and 2009, the annual loss was reduced to 5590 ha, resulting in 44.6 million ha of wetlands in the conterminous United States in 2009 (Dahl 2010).

Other coastal marsh habitat has been surrounded by dikes and managed for various objectives, including rice production and mosquito management. Approximately 11% of the remaining 500,000 ha of marshes along the Atlantic Coast of the Southeastern United States are behind dikes and 60% of these marshes are in South Carolina (Montague et al. 1987). Many of the diked marshes, now referred to as managed tidal impoundments, are remnants of the rice-farming era of the 17th and 18th centuries. Most rice impoundments have been maintained and now are managed to attract wintering waterfowl for hunting opportunities (Montague et al. 1987, Tufford 2005). Approximately 28,000 ha of managed tidal impoundments occur along the South Carolina coast (Williams 1987) and these impoundments represent a substantial habitat resource for wintering and migrating waterfowl and shorebirds.

Managed tidal impoundments provide breeding, foraging, and roosting habitat for migratory and resident shorebirds (Boettcher et al. 1995, Weber and Haig 1996, Hunter 2002). When water levels in impoundments are drawn down in the spring to a shallow depth, shorebirds use this habitat for foraging and resting as stopover sites during migration or for nesting if the species is a resident. Because water levels can be maintained at a consistent depth, managed impoundments may allow shorebirds the opportunity to engage in multiple behavioral activities rather than foraging only in tidal marshes during falling and low tides. Therefore, managed tidal impoundments likely are important to shorebirds not only as additional foraging habitat, but also behavioral activities important for survival and reproductive success (Weber 1994, Boettcher et al. 1995, Weber and Haig 1997).

The U.S. Shorebird Conservation Plan includes a management goal of providing quality managed habitat to support successful

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migration and overwintering within the Southeast Region (Hunter 2002). The Atlantic Flyway Shorebird Initiative (Andres et al. 2015) stresses the need for greater understanding of impoundments' provision of shorebirds' requirements during their annual cycle. Our study sought increased understanding of management needs for impoundments to enhance habitat for migrating shorebirds to meet this goal. We compared shorebird use of managed tidal impoundments and unmanaged tidal marsh. Results of our study provide guidance to public and private land managers regarding management strategies for impoundments that consider migratory shorebird needs (Hunter 2002) without compromising habitat needs of waterfowl and other marsh birds. Approximately 2.4 million shorebirds, or half of peak numbers during migration, use inland and managed wetlands in the Southeast Region (Hunter 2002). Providing appropriate habitat within managed tidal impoundments could be critical to reversing decreasing trends in shorebird populations by providing resources needed by long-distance migrants.

Time-activity budgets (TAB) provide information on how birds allot time to different behaviors in their daily cycle. Field studies of species' TABs reveal site selection relative to daily behaviors. The two focal species in our study were greater yellowlegs (*Tringa melanoleuca*) and lesser yellowlegs (*T. flavipes*). These species are dependent on shallow water wetlands (≤20 cm) and are common wintering and migratory species in coastal South Carolina; therefore, they are appropriate representatives of migratory shorebirds within the Atlantic Flyway. They use similar habitats, often simultaneously, and an array of foraging behaviors (Elphick 2000). Our study elucidated how management activities affect their use of habitats. We conducted a TAB field study to understand how these focal species use managed impoundments and tidal marshes, hypothesizing that they use them most frequently for foraging and loafing.

Study Area

Research was conducted on the Ernest F. Hollings Ashepoo-Combahee-Edisto (ACE) Basin National Wildlife Refuge (ACE-NWR) and the privately owned Nemours Wildlife Foundation (Nemours) in Yemassee, Beaufort County, South Carolina. Both ACE-NWR and Nemours are in the ACE Basin (141,640 ha) composed of the Ashepoo, Combahee, and Edisto river basins, one of the largest, relatively undeveloped estuaries on the East Coast with >40,450 ha of protected land (Tufford 2005). The ACE Basin was the flagship project of the Atlantic Coast Joint Venture of the North American Waterfowl Management Plan and is part of the "Lowcountry Initiative," a nationally important wetlands conservation and perpetual management effort (Williams et al. 1998). Established in 1990, the ACE-NWR encompasses 4781 ha of diverse habitat, including 1599 ha of tidal marsh and 1214 ha of managed wetland impoundments. Salinities within the impoundments and tidal marshes at the ACE-NWR range from 0-5 ppt, except during drought when salinities rise. The American Bird Conservancy recognizes the NWR as a Globally Important Bird Area and the NWR has met the habitat protection goals of the North American Waterfowl Management Plan.

Nemours is adjacent and south of ACE-NWR. The water is brackish to saline (5–30 ppt). Nemours includes 3986 ha of diverse habitat, 748 ha of which are managed tidal impoundments, 124 ha are brackish and freshwater marshes, and the remaining are upland pine and hardwood forests, bottomland hardwoods, and cypress (*Taxodium* sp.)/tupelo (*Nyssa* sp.) swamps.

Methods

Experimental units were managed tidal impoundments, separated from others by water control structures and dikes, and open, tidal marshes accessible to survey by kayak or from a blind on adjacent upland. Small impoundments and tidal marshes (approximately 9 to 13 ha each) contained one survey plot, while larger impoundments (approximately 50–60 ha each) and the largest tidal marsh (approximately 75 ha) were separated into two to three survey plots each, using ditches, sloughs, or other conspicuous landscape features that were regularly present and visible by observers. We did not measure the survey plots for exact area, and we only conducted surveys on birds that could been seen clearly through a spotting scope.

Data for diurnal TABs were collected using focal animal, time-based sampling methods (Martin and Bateson 1993) during spring migration (1 March–10 May), based on migration chronology (Elphick and Tibbits 1998, Tibbits and Moskoff 1999). Categories of behavioral activities were based on Hohman and Rave (1990): loaf—inactive or sleeping; alert—vigilant with head off shoulders; locomotion—walking, swimming (not in pursuit of food), or flying; agonistic—threats or aggressive interactions with other birds; preen—behavior associated with body maintenance; and foraging—behavior associated with food search, capture, and handling. Data for TABs were collected on focal species within managed impoundments and tidal marshes within our experimental units from one hour before peak high or dead low tides to one hour after (Burger et al. 1977, Weber and Haig 1997). Data collection was timed relative to tidal cycles because wildlife activities on tidally influenced habitat are affected by tides more than time of day.

If there were ≤5 focal birds on a plot, we obtained a TAB on all birds. If >5 birds were present, we started with the bird farthest to the left and recorded data on as many birds within a flock as

possible without repeating individual birds. Shorebirds tended to be dispersed, not in tight flocks; TABs were possible on most yellowlegs in a plot at one time. A focal bird was observed for 5 min or until it was out of view, whichever came first. Using a clock on a digital recorder, focal birds' behaviors were noted every 20 sec during the 5-min sampling period (Paulus 1984, Adams et al. 2000). Hence, there were 16 instantaneous observations of behavior of a focal bird in each 5-min sampling period. Activities were recorded on a Sony ICD-8300 handheld digital recorder.

We divided the number of instantaneous observations for each behavior category by the total number of observations to get proportion of observations allocated to each behavior category. These data were summarized by species within managed tidal impoundments and tidal marshes. The proportion of observations allocated to each behavior was arcsine square-root transformed before analysis (Rave and Baldassarre 1989, Hepworth and Hamilton 2001, McKinney and McWilliams 2005). We used a repeated measures analysis of variance (ANOVA) to detect differences among proportions of observations in behavior categories between wetland types (managed tidal impoundments and unmanaged tidal marshes) because of dependence in the data. The *a priori* level of significance was set at $\infty = 0.05$ for all tests.

Results

During March–May in 2007 and 2008, we recorded 71 TABs from yellowlegs on five managed impoundments and two tidal marshes. Within managed tidal impoundments (n = 40 TAB), foraging (42.4%) and loafing (19.5%) behaviors were most frequent, followed by alert (14.9%), locomotion (14.7%), preening (7.6%), and agonistic (<1%) behaviors (Table 1). Within tidal marshes ($n = 31$ TAB), foraging (43.1%) and locomotion (35.0%) were the most common behaviors, followed by alert (15.3%), preening (4.2%), loafing (2.0%), and agonistic (<1%) behaviors (Table 1). The frequency with which yellowlegs moved (locomotion) was greater on tidal marshes ($F = 19.6$, df = 1, 69; $P < 0.001$), while frequency of loafing ($F = 5.7$, df = 1, 69; $P = 0.019$) was greater on managed tidal impoundments. Frequencies of feeding ($F = 0.247$, df = 1, 69; $P = 0.621$), preening ($F = 0.528$, df = 1, 69; $P = 0.47$), alert ($F = 0.20$, df = 1, 69; $P = 0.656$), and agonistic ($F = 0.441$, df = 1, 69; $P = 0.509$), were not different between managed tidal impoundments and tidal marshes.

Table 1. Mean frequency of behaviors exhibited by yellowlegs ($n = 71$) within managed tidal impoundments ($n = 40$ TAB) and unmanaged tidal marshes ($n = 31$ TAB) at the Nemours Wildlife Foundation and ACE Basin National Wildlife Refuge, Yemassee, South Carolina, 2007 and 2008.

	Managed[a] ($n = 40$)		Unmanaged[b] ($n = 31$)	
Behavior	**Mean**	**SE**	**Mean**	**SE**
Loafing	0.20	0.06	0.02	0.02
Alert	0.15	0.04	0.15	0.03
Locomotion	0.15	0.02	0.35	0.05
Agonistic	0.01	0.01	0.00	0.00
Feeding	0.42	0.06	0.43	0.05
Preening	0.08	0.03	0.04	0.02

a. Managed = managed tidal impoundment
b. Unmanaged = unmanaged tidal marsh

Discussion

Assessments of TAB data found that yellowlegs used managed tidal impoundments and tidal marshes differently. While both habitats were used for foraging, in tidal marshes, locomotion was the second most predominant behavior, but in managed tidal impoundments, loafing was the second most frequent behavior. Yellowlegs exhibited diverse behavioral activities in managed tidal impoundments. We expected that foraging and loafing behaviors would be predominant because from winter through spring, yellowlegs must build and store fat reserves for migration to nesting grounds (i.e., Vézina et al. 2007, Andrei et al. 2009, Ranalli and Ritchison 2012). Yellowlegs use tidal marshes for foraging when water levels are shallow (<10 cm; Elphick and Tibbits 1998, Tibbits and Moskoff 1999), and then leave as tides rise. In impoundments, the consistent water levels maintained by managers provide foraging as well as roost sites; hence, yellowlegs exhibit multiple behavioral activities in impoundments. Further, the uneven beds of impoundments provide multiple water depths that are used for foraging (Boettcher et al. 1995, Weber and Haig 1996).

The finding that foraging behavior was predominant in tidal marshes is likely attributable to birds trying to optimize feeding opportunities before rising tidewater inundates mudflats, making the foraging substrate and prey items inaccessible. Yellowlegs typically were dispersed across a mudflat during foraging behavior. The dispersed behavior of yellowlegs accounts for their need to move around (locomotion) frequently. Additionally, yellowlegs frequently target mobile prey items (e.g., fish and invertebrates; Weber and Haig 1997, Andrei et al. 2009, Nareff et al., unpublished data), which necessitates movement. Greater vegetation coverage within managed tidal impoundments may concentrate prey items, allowing birds to forage longer in one spot. Further, yellowlegs may move more frequently on tidal marshes to avoid competition among shorebirds for space and feeding resources while time was limited when tidal water levels were optimum (2–15 cm; Weber and Haig 1996, Isola et al. 2000). Shorebirds can deplete prey (Weber 1997, Weber and Haig 1997) and will move from spot to spot to avoid competitive exclusion and depleting a resource (Burger et al. 1977).

With consistent water levels in managed tidal impoundments and thus more time available for foraging than in tidal marsh,

yellowlegs were able to spend a greater proportion of time in activities such as loafing. The greater frequency of loafing behavior in managed tidal impoundments could benefit birds by reducing their energy expenditure and improving body condition as they prepare for migration and subsequent breeding attempts. Also, the time devoted to activities other than foraging in managed tidal impoundments suggest these habitats provided adequate shelter and escape cover. We commonly observed large (>100) flocks of dowitchers (*Limnodromus* sp.) sleeping, in head-tucked position, on managed tidal impoundments. Additionally, several black-necked stilt (*Himantopus mexicanus*) nests were located in the same wetlands, lending further evidence to the importance of managed tidal impoundments and how they offer shorebirds opportunities they cannot obtain in an unmanaged, natural tidal marsh.

Managed tidal impoundments can be a significant resource for migrating shorebirds because water levels can be held at optimum levels for extended periods of time, unlike tidal marsh where water fluctuation is constant. With 28,000 ha of managed tidal impoundments along the South Carolina coast, this habitat represents a significant resource. Further, because these impoundments are maintained primarily for waterfowl hunting, they are likely to be kept intact across this coastal landscape and well managed far into the future. Thus, continued emphasis on sustaining these unique habitats, and encouraging multi-species management would greatly aid in the conservation of a suite of wetland-dependent wildlife.

Focal species sampling in our study was limited by accessibility to natural tidal marshes within the study area with yellowlegs present. Thus, with only two natural tidal marshes in the design, our analyses are on multiple birds nested within the same wetlands. We recommend further study with a greater number of experimental units for comparison to avoid pseudoreplication. Further study should also focus on food availability, abundance, and type between natural tidal and impounded wetlands.

Acknowledgments

This study was made possible by funds from the National Fish and Wildlife Foundation and the Nemours Wildlife Foundation. Nemours provided housing and equipment. The USFWS and Hobonny Plantation provided access to field sites. R. Klimstra, J. Hollis, and D. Barrineau provided field assistance.

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