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Author(s): Grant C. Sizemore and Martin B. Main
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Quality of Flooded Rice and Fallow Fields as Foraging Habitat for Little Blue Herons and Great Egrets in the Everglades Agricultural Area, USA

Grant C. Sizemore[1,2*] and Martin B. Main[3]

[1]Department of Wildlife Ecology and Conservation, University of Florida,110 Newins-Ziegler Hall, P.O. Box 110430, Gainesville, FL, 32611, USA

[2]Present Address: 8299 Grey Fox Dr., West Chester, OH, 45069, USA

[3]Department of Wildlife Ecology and Conservation, University of Florida, Southwest Florida Research and Education Center, 2685 State Rd. 29 North, Immokalee, FL, 34142, USA

*Corresponding Author; E-mail: gsizemore@alumni.ufl.edu

Abstract.—Wading birds have been observed foraging in agricultural wetlands worldwide where natural wetlands have become lost, degraded, or seasonally dry, yet the ability of wading birds to satisfy daily energy requirements in agricultural wetlands has been little studied. The ability to meet daily energy requirements for Little Blue Herons (*Egretta caerulea*) and Great Egrets (*Ardea alba*) foraging in flooded rice and fallow fields of the Everglades Agricultural Area (EAA) was evaluated during April-June 2008 and 2009. Focal samples were used to measure capture rates (captures/min), identify prey and estimate captured prey size, and calculate energy budgets for both species. Within flooded fields prey density was measured and foraging sites and random locations were compared. Habitat variables did not differ between foraging sites and random locations. Vegetation cover and prey abundance increased in rice fields over time and were greater in rice than fallow fields. Small prey, dominated by fish, were captured by both species and corresponded to prey sampled. Most wading birds in June were observed in newly flooded fallow fields despite lower prey densities. Little Blue Herons met daily energy requirements for both years; but Great Egrets did not, likely due to predominantly small prey, increasing vegetative cover in rice fields, and lower prey densities in newly flooded fallow fields. Although Great Egrets did not meet daily caloric requirements, the EAA may still function as an important transitional habitat at a time when foraging resources in the region are limited. *Received 5 October 2011, accepted 9 February 2012.*

Key words.—agricultural wetland, Ciconiiformes, Great Egret, Little Blue Heron, rice.

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Created wetlands may play an important ecological role as foraging habitat for wading birds, especially in areas where natural wetlands have been lost or degraded (Fasola 1986; Czech and Parsons 2002; White and Main 2005). The cultivation of rice, the world's most widespread crop (Forés and Comín 1992), is considered the most similar agricultural type to natural wetlands (Martínez-Vilalta 1996) and, therefore, may be of importance to conservation efforts (Elphick 2000; Stafford *et al.* 2010). For example, rice is grown in at least 21 countries in the western hemisphere, with production estimated at approximately 80,792 km^2 (Acosta *et al.* 2010), and rice production in China alone represents 6% of the world's wetland areas (Wood *et al.* 2010). Furthermore, flooded rice fields worldwide are reported to attract wading birds and other wetland species (Elphick *et al.* 2010; Stafford *et al.* 2010) and play vital conservation roles for wading birds in some areas (Fasola *et al.* 1996; Fasola and Brangi 2010). Flooded fallow fields (i.e. fields of many agricultural types not currently in production and covered in water) have also been reported to attract waterbirds (Sykes and Hunter 1978; Fujioka *et al.* 2001), and it has been suggested that some species prefer flooded fallow fields over rice fields (Maeda 2001).

Although wading birds are reported to use agricultural wetlands, information on the foraging quality of these wetlands is often conflicting and largely anecdotal. For example, some studies report that rice fields are superior to natural areas as foraging habitat (Hafner *et al.* 1986; Kazantzidis and Goutner 1996), while others report they are inferior (Fasola *et al.* 1996; Elphick 2000; Ma *et al.* 2004). Additionally, although various studies have been conducted to evaluate foraging quality of agricultural wetlands, information on whether wading birds actually obtain daily energetic requirements when feeding in flooded agricultural fields is virtually non-existent and is considered an important information gap (Elphick *et al.* 2010).

The Greater Everglades Ecosystem of South Florida has historically supported hundreds of thousands to millions of wading birds and continues to be cited as the most significant wading bird breeding area in North America (Robertson and Kushlan 1974; IUCN 2010). However, the conservation of these birds remains in doubt. Due primarily to the loss and degradation of foraging and nesting habitat, wading bird populations have declined 70-93% in the past century (Ogden 1994; Crozier and Gawlik 2003). Also, concerns exist regarding future potential effects of sea level rise due to global climate change that may alter freshwater wetland habitat in the Everglades (North American Bird Conservation Initiative, U.S. Committee 2010).

The Everglades Agricultural Area (EAA) is an expansive agricultural landscape on deep peat soils created by draining the northern Everglades wetlands and diking the southern boundary of Lake Okeechobee (Light and Dineen 1994). Thousands of hectares of agricultural fields (primarily rice and fallow sugar cane) are flooded annually (Izuno and Bottcher 1994) and are used as foraging habitat by thousands of wading birds, particularly when water levels are drawn down for rice harvest in July and October (Pearlstine *et al.* 2004). The large size of the EAA, timing of flooding of rice and fallow fields, and proximity to the Everglades make the EAA a potentially important foraging area for wading birds, particularly when seasonal changes in water levels reduce the availability or foraging quality of natural wetlands during the late dry season-early wet season. Borkhataria (2009) reported that 36.5-47.4% of dispersing juvenile Wood Storks (*Mycteria amerciana*) moved from the Everglades into the EAA and surrounding agricultural wetlands of South and Central Florida. Similarly, Semones (2003) documented that dispersing juvenile White Ibises (*Eudocimus albus*) appeared to favor the EAA and its surrounding areas. However, whether flooded agricultural fields in the EAA support sufficient prey densities to enable wading birds to meet daily energetic requirements has not been investigated, and studies have suggested that the EAA may actually function as an ecological trap (Pearlstine *et al.* 2004; Borkhataria 2009). An ecological trap occurs when cues used by animals to select habitat no longer reflect the true conditions of that habitat. Our objectives were to test the hypothesis that two species of sight-foraging wading birds that differ substantially in size (Little Blue Heron, *Egretta caerulea*; Great Egret, *Ardea alba*) were able to meet daily, non-breeding caloric energy requirements while foraging in flooded rice and fallow agricultural fields in the EAA during the late dry-early wet season (April-June).

METHODS

Study Area

Our study area was located within the 283,000-ha EAA (Fig. 1), which consists of a mosaic of agricultural fields, canals, irrigation ditches and impoundments (Izuno and Bottcher 1994). The predominant crop is sugarcane, which constitutes 76% (122,700 ha) of all farming in the region. Rice represents approximately 5% of the cultivated landscape (9,600 ha) and is grown as a rotational crop (Izuno and Bottcher 1994; Snyder and Davidson 1994). Flooded fallow fields, which are used to cover vegetable and sugar cane fields following harvest for weed and pest control and soil retention, were estimated to cover 1% of the cultivated landscape (2,016 ha) during this study. Rice fields in the EAA are flooded and planted during late March-April, and fallow fields are flooded in late May-June (M. Ulloa, personal communication). These months typically correspond to the late dry and early wet season (Kushlan 1986) and the late breeding and immediate post-breeding period for Little Blue Herons and Great Egrets in South Florida (Frederick and Collopy 1989).

Foraging Success

We conducted focal observations (Altmann 1974) of foraging wading birds to quantify prey capture rates in flooded rice and fallow fields at least five days each week during April-June 2008 and 2009. A single flooded rice or fallow field (~15 ha) was selected opportunistically each day based on the presence of wading birds, and focal observations were conducted between 07:00-12:00 h when birds forage most actively (Kushlan 1978). Focal observations were not conducted in rain.

We observed wading birds from a distance of 2-400 m using 10 × 50 binoculars and a 40× spotting scope, and all observations were made from a vehicle to minimize disturbance. Focal observations were conducted only on Little Blue Herons (length: ~65 cm, weight: ~350 g; Rodgers and Smith 1995) and Great Egrets

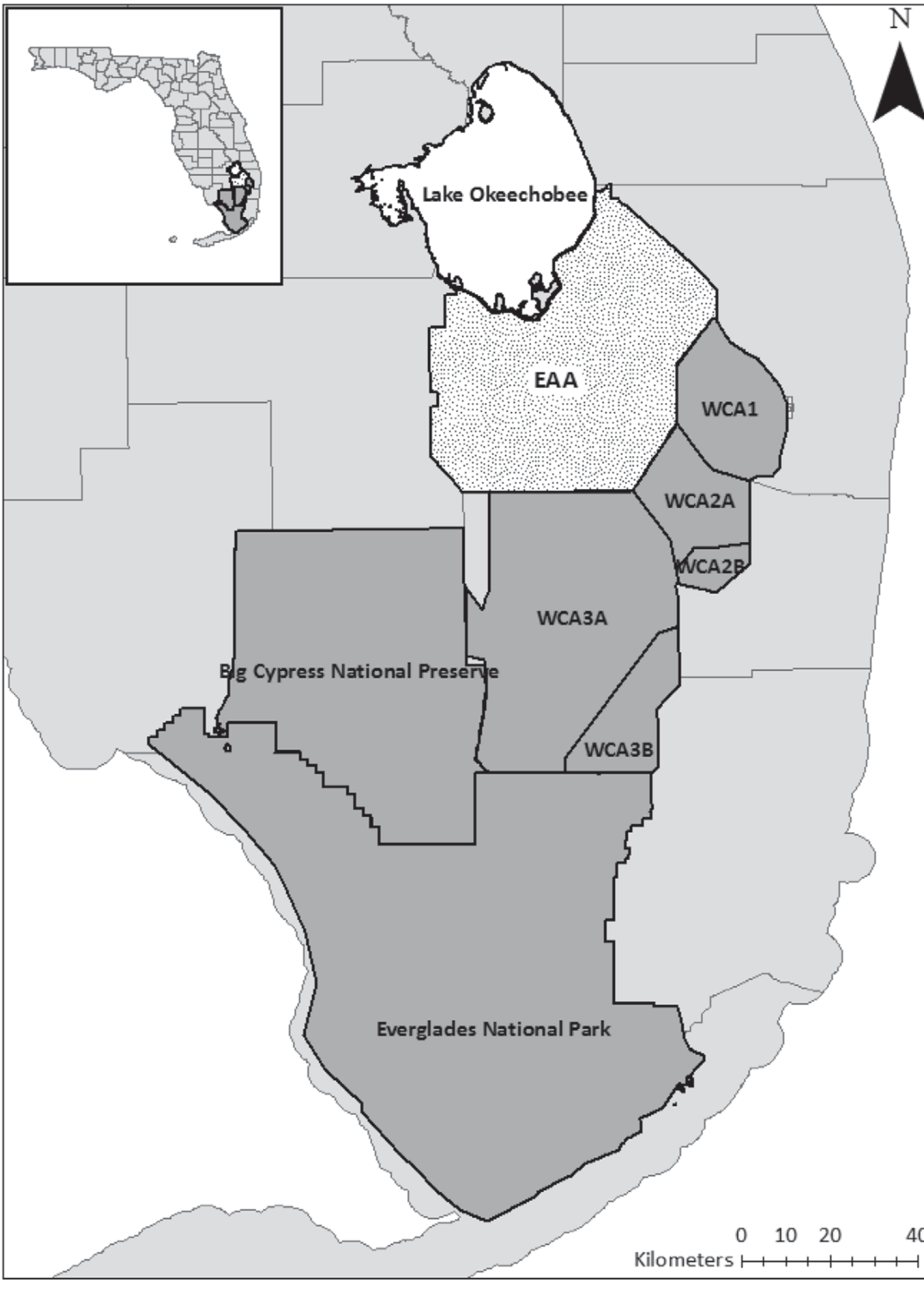

Figure 1. The Everglades Agricultural Area (EAA) is an intensively farmed region of South Florida that was formerly part of the Everglades wetlands, much of which is now managed as Water Conservation Areas (WCAs), and located at approximately 26° 36' N, 80° 36' W.

(length: ~100 cm, weight: ~1000 g; McCrimmon *et al.* 2001) because these species differ substantially in size and are common in the EAA (Townsend *et al.* 2006; Sizemore 2009). Focal sample intervals lasted a maximum of 10 min and were terminated early if the bird flew away, was lost from sight, or ceased foraging. We attempted to conduct two focal samples per hour for both wading bird species. We chose focal individuals from groups of wading birds that were actively foraging, randomly assigned the first species for observation, and then alternated between species to the extent possible, observing new individuals in each sample. We restricted focal observations to adults because juveniles are less successful at capturing prey (Recher and Recher 1969; Quinney and Smith 1980; Bildstein 1984). Adult Great Egrets were identified by presence of breeding plumes and Little Blue Herons by adult (i.e. blue) plumage.

During each focal sample, we recorded successful feeding attempts to quantify prey capture rate (captures/min). Successful strikes were recorded if a prey item was seen captured and swallowed, swallowing movements in the gular region occurred, or head movements by the individual indicated swallowing of prey (Gans 1961; Elphick 2000). Whenever possible, we identified prey from successful strikes as fish, amphibians, crayfish or insects. We used mean bill lengths reported for each species (Great Egrets = 109 mm, Little Blue Herons = 74 mm; Palmer 1962; Wetmore 1981) divided into fourths as a scale to visually estimate prey length (Quinney and Smith 1980; Campos and Lekuona 2001).

Habitat Variables

We measured water depth, water temperature, vegetation height, and vegetation density immediately following completion of focal observations to quantify habitat parameters at foraging sites and random locations in flooded fields where focal observations were conducted. At each foraging site, we identified three sampling locations by spinning and tossing a marker in random directions within a 30-m radius surrounding the area where birds were observed feeding. All samples were separated by ≥ 5 m and were considered independent (Heyer *et al.* 1994). Water depth and temperature were measured once for each sampling location within the foraging area. We quantified vegetation (i.e. vertical cover and structure) using a modified Robel pole method (Robel *et al.* 1970), where we sank a pole marked in 10-cm increments into the substrate, stood back a distance of 2 m, and from a height of 1 m recorded the lowest visible marking. We measured vegetation density by estimating the proportion of vegetative cover within 9 square grid cells (33 cm^2) in a 1-m^2 floating grid (Surdick 1998). Random samples were measured along a 100-m transect oriented perpendicular to the edge of the field for the first 50 m, parallel to the edge of the field for the last 50 m, and did not include nearby irrigation ditches. Along each transect, we recorded water depth and water temperature at 10-m intervals and vegetation height and density every 25 m using the same techniques and within the same field as for specific foraging locations.

Prey Abundance

We used a 1-m^2 throw trap (Kushlan 1981) to estimate abundance of fish, amphibians, and crayfish in flooded rice and fallow fields during May-June 2008 and April-June 2009. These taxa have been found to make up a large portion of wading bird diets (Frederick and Collopy 1989; Campos and Lekuona 2001). We included aquatic insects in prey sampling during 2009 using the same methods as for other prey and decided to include insects based on observations of wading birds capturing insects as prey during 2008. We estimated prey abundance in randomly selected flooded fields rather than at foraging sites because wading birds are able to deplete or disperse prey at foraging sites (Gawlik 2002). In each field, traps were thrown 15 times in random directions with sample locations separated by at least 5 m. A net was passed through the trap to collect prey species until three consecutive passes resulted in no prey captures. Although we did not determine detectability of prey, this method has been shown to be useful for studies of fish in shallow marshes (Kushlan 1981). All captured individuals were weighed to the nearest 1.0 g using a Pesola spring scale and total length was measured to the nearest 1.0 mm. Fish were identified to species (Hoyer and Canfield 1994). Crayfish were identified to genus (Franz and Franz 1990), and all amphibians captured were tadpoles and labeled as such. Aquatic insects were identified to order or family (Borror and White 1998). The total number of captured individuals for each prey category was divided by total area sampled to estimate relative prey density for each prey category by field.

Energy Budgets

We calculated the amount of foraging time required to obtain daily, non-breeding energy needs for Great Egrets and Little Blue Herons (Frederick and Powell 1994) based on the proportion, size, and estimated caloric content of each prey type (i.e. fish, amphibians, crayfish, and insects) consumed by foraging individuals. We used non-breeding rather than breeding energy budgets because little nesting by wading birds occurs in the EAA (Townsend *et al.* 2006; E. Pearlstine, personal communication), and flooded agricultural fields were generally outside the typical range (5-10 km) of foraging flights for Great Egrets and Little Blue Herons from nesting areas in the Loxahatchee National Wildlife Refuge and Water Conservation Area 2 (Custer and Osborn 1978; Bancroft *et al.* 1994; Smith 1995). We calculated mean prey size for 2008 and 2009 based on focal observations and used length-mass equations from Kushlan *et al.* (1986) to assign a body mass based on mean prey sizes for each prey category. We used this approach rather than assign a mean body mass from throw trap sampling because it more accurately reflected the size of prey consumed by wading birds. Using caloric conversions for fish (Cummins and Wuycheck 1971), crayfish (Pope *et al.* 2001), amphibians (Evenson and Kruse 1982) and insects (Cummins and Wuycheck 1971), we calculated the amount of energy obtained for a capture of each prey type by size category and estimated the amount of usable energy at 80% (Kahl 1964). We multiplied capture rate for each wading bird species in both years by the proportional caloric values obtained based on prey consumption to estimate overall intake of calories/min foraging. We then compared these values to the non-breeding, daily energetic requirements for both Great Egrets (~168,000 cal/day) and Little Blue Herons (~77,000 cal/day) provided by Frederick and Powell (1994). From these comparisons, we calculated the amount of foraging time necessary for both species to meet daily energy requirements when foraging in flooded rice and fallow fields.

Data Analyses

We analyzed prey capture rate for Great Egrets and Little Blue Herons separately with general linear models (square-root transformed data) and tested whether capture rate was significantly influenced by year, month, month*field type, and among habitat variables. We created the combined month*field type variable to enable comparisons of prey capture rate among flooded rice and fallow fields during all months because flooded fallow fields were not flooded until June. We used a generalized linear model with a negative binomial distribution to determine whether the types and sizes of prey captured differed between Great Egrets and Little Blue Herons or among years, months, and month*field type.

We compared habitat variables between feeding sites and random locations in flooded fields among months and years using general linear models. We used the combined month*field type variable to enable comparisons of habitat variables among flooded rice and fallow fields during all months. Student's t-test was used to evaluate differences in habitat variables between foraging sites and random locations in flooded fields and analyzed by year and month*field type. Prey density was analyzed by year and month*field type using generalized linear models with a negative binomial distribution. All analyses were conducted using SAS/STAT software, version 9.2 (SAS Institute 2008).

Results

Foraging Success

We collected 256 focal samples spanning 260 days during April-June 2008 and 2009. Of these, 212 (82.8%) were Great Egrets and 44 (17.2%) were Little Blue Herons. Although a significantly larger number of observations occurred in rice than in fallow fields (χ^2_1 = 36.94; p < 0.01), the numbers of observed Great Egrets and Little Blue Herons did not differ significantly from the expected value (χ^2_1 = 0.39; p = 0.53), thus suggesting that field type had little effect on which species was observed. Great Egret focal observations included 17 observations in fallow fields and 65 in rice fields in 2008; 51 observations occurred in fallow fields and 79 in rice in 2009. Little Blue Heron focal observations included six observations in fallow fields and 16 in rice in 2008; six observations occurred in fallow fields and 16 in rice in 2009.

The mean overall capture rate (captures/min) during all months and both years was greater for Little Blue Herons ($\bar{x}$= 1 .32, SD = 1.59) than Great Egrets ($\bar{x}$ = 0.39, SD = 0.43), and these differences were significant ($F_{1,254}$ = 39.39; p < 0.01). Mean capture rate in rice fields did not differ by month for Little Blue Herons but did for Great Egrets ($F_{2,141}$ = 3.67; p = 0.03) and declined progressively during April ($\bar{x}$ = 0.59, SD = 0.67), May ($\bar{x}$= 0.41, SD = 0.37), and June ($\bar{x}$ = 0.16, SD = 0.21). When fallow fields were included in analyses, Little Blue Heron capture rates were marginally significant by month*field type ($F_{3,40}$ = 2.24; p = 0.10). Great Egret capture rates differed significantly by month*field type ($F_{3,208}$ = 4.13; p = 0.01), with mean capture rate in fallow fields during June ($\bar{x}$ = 0.32 ± 0.44) being twice as high as for rice fields in June.

Habitat Variables

Water depth ($F_{3,58}$ = 9.00; p < 0.01), water temperature ($F_{3,55}$ = 7.56; p < 0.01), vegetation height ($F_{3,58}$ = 15.39; p < 0.01), and vegetation density ($F_{3,58}$ = 74.03; p < 0.01) all differed significantly by month*field type (Figs. 2 and 3). All month*field type values differed significantly from one another except water depth, which did not differ between May rice fields and June rice fields. No differences were found in habitat variables compared between wading bird foraging sites and random locations in flooded fields where focal observations were recorded.

Water temperature (mean monthly temperature = 28-33 °C) and depth (mean monthly water depth = 7-15 cm) varied slightly throughout the study (Fig. 2). Vegetation height and density in rice fields increased progressively during April-June (Fig. 3). The only significant relationships between either vegetation height or density and capture rate for either species was found for Little Blue Herons, whose capture rates were negatively influenced by both vegetation height and density in rice fields during May (Table 1).

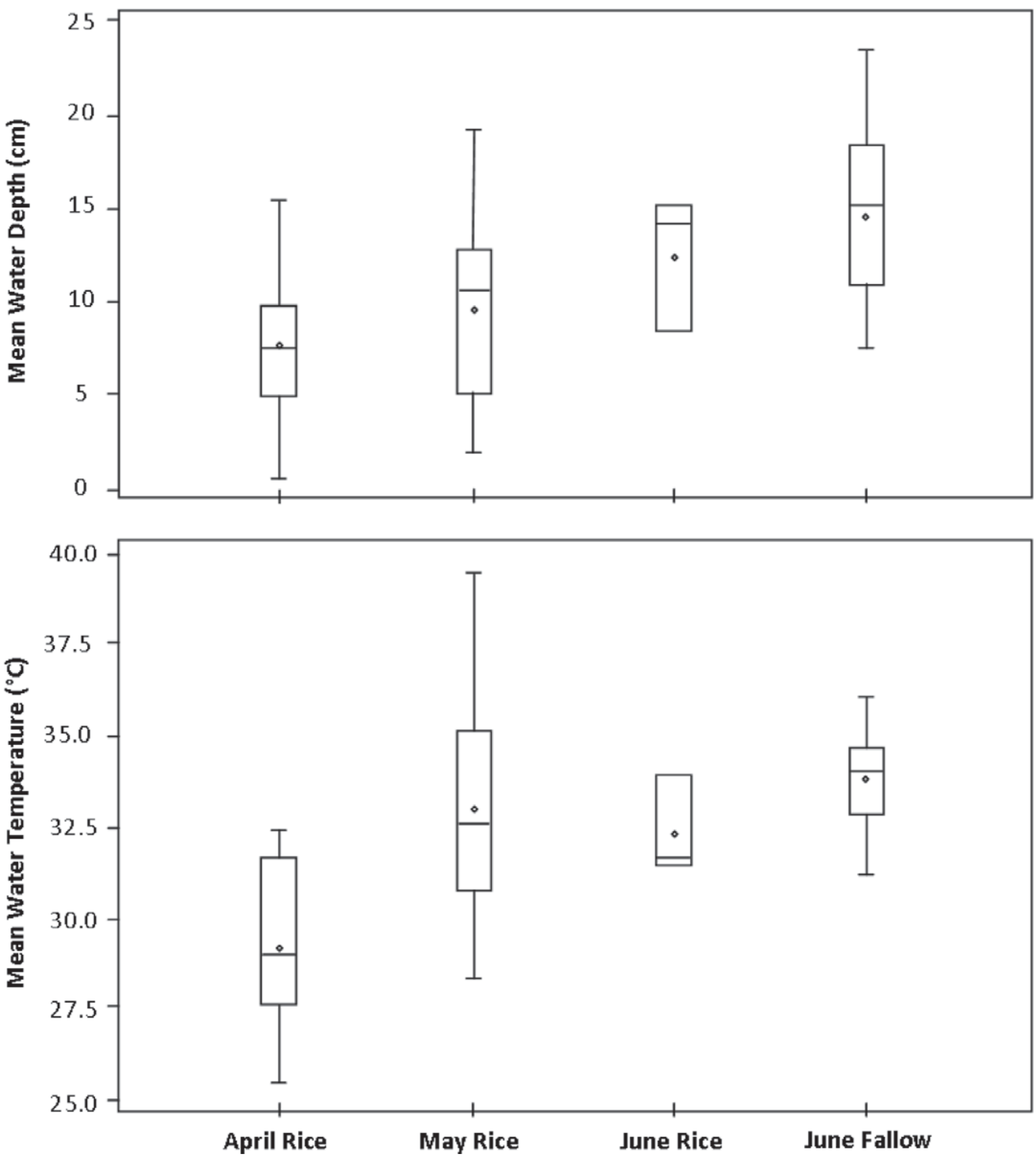

Figure 2. Water depth and temperature by month in flooded rice (April-June) and fallow fields (June) of the Everglades Agricultural Area (arms represent minimum and maximum values, box bottom and top correspond to first and third quartile, horizontal bar within box is median, and dots represent means).

Prey Abundance

We conducted aquatic prey sampling in 44 fields during the 2008-2009 field seasons (Table 2). For all sampled prey from 2008-2009, mean prey length was 15.9 ± 7.7 mm. Five species of fish were identified during both years of prey sampling. Species captured and their relative abundances included, from most to least abundant, Least Killifish (*Heterandria formosa*; 56%), American Flagfish (*Jordanella floridae*; 21%), Eastern Mosquitofish (*Gambusia holbrooki*; 19%), Golden Topminnow (*Fundulus chrysotus*; 3%) and Bluefin Killifish (*Lucania goodie*; 2%). All amphibians captured were tadpoles, and only a single crayfish (*Procambarus* spp.) was captured. Insects captured included diving beetles (Family Dytiscidae), dragonfly nymphs (Order Odonata), backswimmers (Family Notonectidae) and giant water bugs (Family Belostomatidae). No dif-

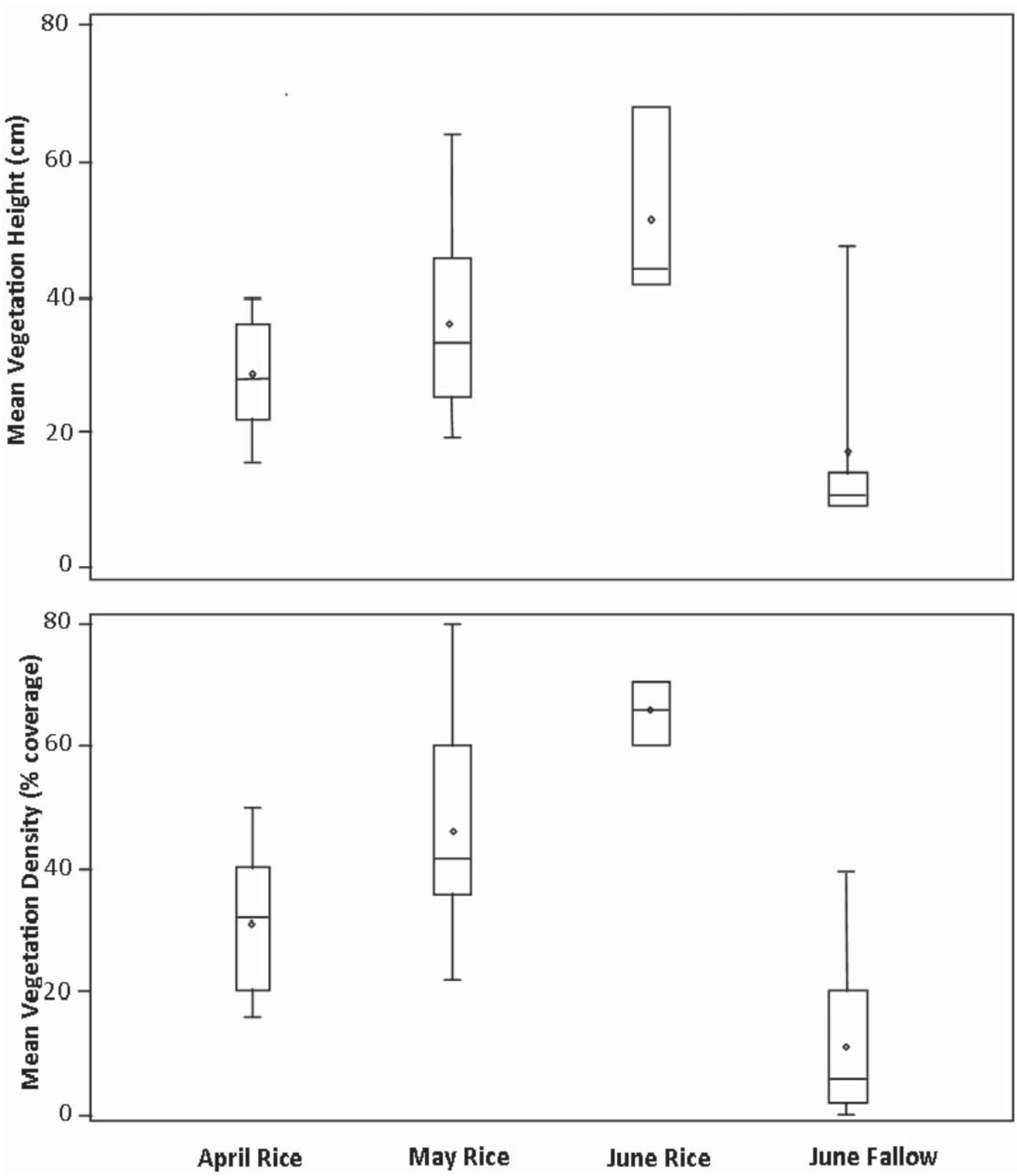

Figure 3. Vegetation height and density by month in flooded rice (April-June) and fallow fields (June) of the Everglades Agricultural Area (arms represent minimum and maximum values, box bottom and top correspond to first and third quartile, horizontal bar within box is median, and dots represent means).

ference in prey densities (prey/m^2) existed between years and, for both years combined, mean prey density was significantly different by month*field type ($F_{4,38} = 6.82$, $p < 0.01$). From highest to lowest, mean prey densities were greatest in rice fields during June ($\bar{x} = 0.95$, SD = 0.05), followed by May ($\bar{x} = 0.30$, SD = 0.73), and April ($\bar{x} = 0.05$, SD = 0.11). Mean prey densities were lowest in fallow fields in June ($\bar{x} = 0.03$, SD = 0.05).

For focal birds during both years combined, fish constituted the largest percentage (65%) of prey captured. Amphibians, represented almost entirely by tadpoles, comprised 13% and crayfish 9% of total prey captured during both years. Insects

Table 1. Comparison of the influences of vegetation height and density on the capture rates of Great Egrets and Little Blue Herons foraging in rice fields in the Everglades Agricultural Area during April-June 2008 and 2009.

			Vegetation Height		Vegetation Density	
Species	Month	n	F	P	F	P
Great Egret	April	22	0.69	0.42	0.32	0.58
	May	113	0.87	0.35	2.23	0.14
	June	9	1.00	0.35	0.06	0.81
Little Blue Heron	April	7	0.30	0.61	0.40	0.55
	May	23	36.34	<0.01	11.85	<0.01
	June*	2				

*Insufficient numbers of Little Blue Herons were observed in June for statistical calculations.

constituted 13% of prey captured during 2009. The difference in the number of fish consumed by Great Egrets and Little Blue Herons was marginally significant ($F_{1,254}$ = 2.69, p = 0.10), with Great Egrets consuming more fish per individual ($\bar{x}$ = 0.34, SD = 1.31) than Little Blue Herons ($\bar{x}$ = 0.11, SD = 0.32). Conversely, Little Blue Herons consumed more crayfish per individual ($\bar{x}$ = 0.23, SD = 0.64) than did Great Egrets ($\bar{x}$ = 0.01, SD = 0.07), and this difference was significant ($F_{1,254}$ = 12.07, p < 0.01).

Both Great Egrets and Little Blue Herons primarily consumed small prey. For Great Egrets, 61.7% of prey captured were one-quarter bill length in size, 30.4% were half bill length, 6.1% three-quarter bill length, and 1.9% one whole bill length, which corresponded to prey lengths of up to approximately 27, 55, 82, and 109 mm, respectively. For Little Blue Herons, 37.8% of prey captured were one-quarter bill length, 35.1% half bill length, 21.6% three-quarter bill length, and 5.4% one whole bill length, which corresponded to prey lengths up to approximately 19, 37, 56, and 74 mm, respectively. Prey sizes consumed were not influenced by month*field type for Great Egrets or Little Blue Herons.

Energy Budgets

Little Blue Herons foraging in flooded agricultural fields were able to meet their daily energy requirements given a reasonable amount of time, but Great Egrets were not. We calculated that Little Blue Herons acquired a mean of 243 cal/min when foraging in 2008 and 1262 cal/min in 2009. Given these rates, Little Blue Herons met daily non-breeding energy requirements by foraging 5.3 h/day in 2008 and 1.0 h/day in 2009. We calculated that Great Egrets acquired a mean of 159 cal/

Table 2. Mean prey density (±S.D.) in agricultural wetlands within the Everglades Agricultural Area during May-June 2008 and April-June 2009.

Year	Month	Habitat	Fields	Fish/m²	Amphibians/m²	Crayfish/m²	Insects/m²	Total Prey/m²
2008	May	Rice	8	0.03 ± 0.03	0.01 ± 0.02	0.01 ± 0.02	NA	0.04 ± 0.05
		Fallow	0	NA	NA	NA	NA	NA
	June	Rice	4	0.32 ± 0.28	0.02 ± 0.03	<0.01 ± <0.01	NA	0.33 ± 0.27
		Fallow	2	0.07 ± <0.01	<0.01 ± <0.01	<0.01 ± <0.01	NA	0.07 ± <0.01
2009	April	Rice	10	0.03 ± 0.07	0.01 ± 0.04	<0.01 ± <0.01	0.03 ± 0.07	0.08 ± 0.17
		Fallow	0	NA	NA	NA	NA	NA
	May*	Rice	8	0.59 ± 1.03	<0.01 ± <0.01	<0.01 ± <0.01	0.07 ± 0.07	0.66 ± 1.00
		Fallow	2	0.10 ± 0.14	0.17 ± 0.24	<0.01 ± <0.01	<0.01 ± <0.01	0.27 ± 0.38
	June	Rice	4	1.58 ± 0.66	<0.01 ± <0.01	<0.01 ± <0.01	0.03 ± 0.05	1.60 ± 0.71
		Fallow	6	0.02 ± 0.05	<0.01 ± <0.01	<0.01 ± <0.01	0.06 ± 0.08	0.08 ± 0.08
		Total	44	0.30 ± 0.64	0.01 ± 0.06	<0.01 ± 0.01	0.04 ± 0.07	0.34 ± 0.64

*Two fallow fields were flooded at the end of May 2009 and prey densities were estimated. No focal observations were conducted in these fields.

min when foraging in 2008 and 226 cal/min in 2009. Given these rates, Great Egrets would have needed to forage 17.7 h/day in 2008 and 12.4 h/day in 2009 to meet their daily non-breeding energy requirements.

DISCUSSION

Daily energy budgets calculated from prey size and capture rates revealed that the quality of foraging habitat provided by flooded agricultural fields in the EAA during April-June differed for Little Blue Herons and Great Egrets. During 2008 and 2009, Little Blue Herons were able to meet daily energy requirements by foraging between 1.0-5.3 hours per day, whereas Great Egrets would have needed to actively forage for 12.4-17.7 hours each day to meet their daily energy requirements. Therefore, our results supported the hypothesis that Little Blue Herons met daily, non-breeding caloric energy requirements while foraging in flooded agricultural fields in the EAA during the late dry-early wet season, but Great Egrets did not.

The ability for Little Blue Herons and Great Egrets to meet daily caloric needs may have been influenced by multiple factors, including species-specific daily caloric requirements, prey size, and capture rate. Little Blue Herons are approximately one-third the size of Great Egrets (Rodgers and Smith 1995; McCrimmon *et al.* 2001) and have < 50% of the daily, non-breeding energy requirements (Frederick and Powell 1994). Additionally, our sampling indicated that aquatic prey in flooded agricultural fields during April-June were predominantly small ($\bar{x}$= 15.9 ± 7.7 mm). From focal observations we determined that 73% of prey captured by Little Blue Herons were ≤ 37 mm and that 62% of prey captured by Great Egrets were ≤ 27 mm. Capture rates also differed substantially between species. Little Blue Heron capture rates were more than 300% greater than observed Great Egret capture rates, possibly because Little Blue Herons actively hunt smaller prey (Willard 1977). Great Egret capture rates, though lower than those for Little Blue Herons, were comparable to observations from other studies (Table 3).

Flooded agricultural field characteristics (i.e. habitat variables) also influenced foraging success. Individual flooded rice and fallow fields are laser-leveled and essentially homogeneous in terms of habitat features. This lack of diverse conditions within a field does not promote the concentration of prey, and fish density in the flooded agricultural fields of the EAA was lower than Everglades natural areas by orders of magnitude (Loftus and Eklund 1994; Jordan 1996). Water temperatures varied little, and depths averaged less than 15 cm throughout the study period (Fig. 2), which is below the reported maximum foraging depth for Little Blue Herons and Great Egrets (Powell 1987). However, both vegetation height and density steadily increased in rice fields during April-June (Fig. 3), capture rates declined despite an increase in prey densities, and wading birds shifted their foraging activities to newly flooded and devegetated fallow fields (Sizemore 2009). The avoidance of dense vegetation in rice fields was consistent with observations by Bancroft *et al.* (1994) and Fujioka *et al.* (2001) who report wading birds avoid foraging in dense grass. Our observations were also consistent with studies that report prey density in rice fields increases over time (DeAngelis *et al.* 1997; Maeda 2001).

Although wading birds forage in flooded fields of the EAA during the late dry-early wet season, the quality of these areas as foraging habitat has been questioned (Pearlstine *et al.* 2004; Townsend *et al.* 2006; Borkhataria 2009). The presence of Great Egrets foraging in flooded agricultural fields of the EAA during April-June and observed inability to meet daily caloric needs suggests that these artificial wetlands may function as an ecological trap for Great Egrets. Conversely, the EAA provided adequate foraging habitat for Little Blue Herons because of their ability to meet caloric requirements. Great Egrets might be subject to such traps because they are reported to be persistent in exploiting foraging sites even when prey densities are low (Gawlik 2002), such as occurred in the EAA.

The late dry-early wet season (April-June) is a transitional period in South Florida when foraging conditions in natural

Table 3. Mean capture rates (captures/min) for Great Egrets and Little Blue Herons compared between studies in the Everglades Agricultural Area (this study, capture rates pooled across habitats and months), other regions of Florida, and New Jersey.

Species	Location	Study	Capture rate
Great Egret	Florida	This study	0.46 (2008)
			0.34 (2009)
		Rodgers (1983)	0.21
		Erwin (1985)	0.50
		Surdick (1998)	0.40 (1996)
			0.20 (1997)
	New Jersey	Erwin (1985)	0.50
Little Blue Heron	Florida	This study	1.70 (2008)
			0.94 (2009)
		Rodgers (1983)	0.48

wetlands are often poor and many wading birds may become highly mobile in search of new foraging sites (Kushlan 1980, 1986; Frederick and Collopy 1989; Frederick *et al.* 2009). Even while not meeting total caloric needs, Great Egrets did capture and consume prey that contributed to fulfilling those needs. Great Egrets may use flooded fields in the EAA as a transitional foraging habitat that enables them to slow declines in body condition until foraging conditions improve elsewhere, such as occurs with the rehydration of natural wetlands or annual drydown of rice fields in July (Townsend *et al.* 2006). Furthermore, although 67% of wading birds were observed in flooded agricultural fields (Sizemore 2009), additional foraging opportunities existed in deeper irrigation ditches and perimeter canals. These deeper waters may provide opportunities for wading birds to capture larger prey items.

Enhanced wading bird conservation in the EAA may be accomplished through further research and management of flooded agricultural fields. Future studies should attempt to identify how wading birds use the EAA year-round in order to better understand the region's overall conservation potential. Rice and, in particular, fallow fields could be flooded earlier in the season. Other studies have also reported small prey in rice fields and a lag between the initiation of flooding of a wetland after drydown and fish population recovery, particularly with larger size classes (Lane and Fujioka 1998; Gaff *et al.* 2000; Richardson *et al.* 2001). By flooding fields earlier, greater prey densities, larger prey sizes, and higher quality foraging habitat for wading birds may be achieved during the late dry-early wet season transitional period.

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