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Status of Breeding Reddish Egrets on Great Inagua, Bahamas with Comments on Breeding Territoriality and the Effects of Hurricanes

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Abstract.—The Commonwealth of the Bahamas is an important region to Reddish Egrets (*Egretta rufescens*); however, current status of this species in the Bahamas is lacking. From 2008-2010, a breeding survey of Reddish Egrets was conducted in Great Inagua to 1) document breeding status, 2) document breeding phenology, and 3) estimate the number of breeding pairs. A total of 87 Reddish Egret nests on Great Inagua over two breeding seasons were recorded; the proportion of white, dark and mixed-morph nesting pairs varied but averaged (±S.D.) 68.4 ± 7.5, 18.2 ± 2.4, and 13.4 ± 5.1%, respectively. Based on these surveys, the breeding season range extends from December to May, varying annually due to changes in precipitation. Territorial aggression of solitary nesting pairs in Reddish Egrets was observed, previously unreported for the Caribbean. Damage to mangrove islands from Hurricane Ike in September 2008 appeared to increase nesting concentrations on Lake Rosa; solitary nesting decreased from 36% before, to 10% after the hurricane. Because the surveys before and after the hurricane did not encompass the entire breeding seasons, increased concentration of nesting may have been influenced by other factors besides Hurricane Ike. Even with incomplete breeding season surveys, these estimates of nesting pairs indicate a >50% decrease in number of breeding pairs of Reddish Egret on Great Inagua since the 1980s; this is a conservation concern as the population is distinct. *Received 19 August 2010, accepted 4 December 2010.*

Key words.—Bahamas, Caribbean, hurricanes, nesting, Reddish Egret, territoriality.

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The Commonwealth of the Bahamas is recognized for its regional importance to many species of waterbirds (Sprunt 1984; Moore and Gape 2008). With over 700 islands and 2,000 cays and rocks, the Bahamas contains a variety of coastal and inland wetland habitats that are critical to different waterbird species, with usage varying seasonally and annually depending on climatic conditions. The Bahamas is of global importance to several species of waterbirds including American Flamingo (*Phoenicopterus ruber*), West Indian Whistling-Duck (*Dendrocygna arborea*), and Reddish Egret (*Egretta rufescens*, Moore and Gape 2008).

Reddish Egrets occur throughout the Bahamas, reportedly breeding on the islands of Grand Bahama, Andros, Acklins and Great Inagua (Lowther and Paul 2002; Green 2006); however, these reports vary. With the exception of recent surveys in the northern Bahamas (Kushlan and Steinkamp 2007), no systematic survey for the species has been conducted in this region during the last 25 years (Sprunt 1984). Historically, the largest population of breeding Reddish Egrets in the entire Caribbean has occurred at Lake Rosa on Great Inagua, and was last estimated at 200 breeding pairs (Scott and Carbonell 1986). The 2006 status report for Reddish Egrets revealed a lack of current breeding information on the species throughout the Caribbean (Green 2006).

In 2008, we initiated a survey of the Bahamas to document the breeding status of Reddish Egrets in the region. Since Reddish Egrets were surveyed in the northern Bahamas by Kushlan and Steinkamp (2007), we focused our efforts on the reportedly large number of nesting Reddish Egrets on Great Inagua. Our objectives of this survey for Reddish Egrets were to 1) document the breeding status, 2) document the breeding phenology and, 3) estimate the number of breeding pairs on Great Inagua.

Methods

Great Inagua Island (21.08°N, 73.50°W) is the southernmost island of the Bahamas and the nation's only Ramsar site—Inagua National Park. Most of the island's wetlands are under the jurisdiction of The Bahamas National Trust, protected within Inagua National Park (74,333 ha). The national park was created in 1965 due to its globally important American Flamingo colony, with current estimates of over 40,000 birds (Moore and

Gape 2008). Within the park, nesting by Reddish Egrets, American Flamingos, Tricolored Herons (*Egretta tricolor*) and Roseate Spoonbills (*Ajaia ajaja*) occurs primarily on Lake Rosa. Great Inagua is approximately 90 × 30 km with Lake Rosa occupying approximately 30% of the western end of the island (Moore and Gape 2008). Lake Rosa is a permanent, shallow (<1.5 m), brackish lake surrounded by open scrub habitat and seasonal marshes (Scott and Carbonell 1986). Mangrove islands consisting of both Black Mangrove *Avicennia germinans* and Buttonwood *Conocarpus erectus* provide the dominant nesting substrate for many species, including Reddish Egrets. The lake is not tidally influenced, and therefore is entirely dependent on seasonal precipitation.

Lake Rosa is 4x4 vehicle-accessible to within 1.5 km of Reddish Egret nests; therefore, all islands containing egret nests were only accessible by kayak or on foot. A total of approximately 26.5 km^2 of Lake Rosa was surveyed, encompassing all historical breeding areas as well as potentially suitable sites evaluated using satellite imagery of Lake Rosa. Because little information exists on nesting phenology of Reddish Egrets in the Bahamas, we conducted five surveys over the following time periods: 8-10 April 2008, 13-15 May 2008, 15-18 January 2009, 13-15 February 2009 and 8-10 March 2010. In 2008 and 2009, the start dates for the two surveys were ~30-36 days apart to allow for determination of nest success between survey periods and nesting phenology. Incubation period is approximately 27 days and time to fledge is approximately 42 days so our survey interval was well within the time interval to determine nest fate (Lowther and Paul 2002). Only one pair of nesting birds was found during 13-15 May 2008; therefore we subsequently report no nesting data for that time period.

During field surveys, we approached every island or cluster of mangrove by kayak, scanning the area for the presence of Reddish Egrets. In areas where we detected Reddish Egrets, more thorough surveys were conducted on foot to determine if nests were present. On Great Inagua, Reddish Egrets nest exclusively on scrubby stands of mangrove (<3 m tall) that are easily accessible. All nests found were 1-1.5 m above the ground and were very distinguishable because of their size (~0.5-1 m in diameter) and visibility in the thin clumps of mangroves. Potential differences in detection of white vs.dark plumaged birds are commonly reported in surveys (e.g. Green *et al.* 2008); this potential problem was not relevant in our study because surveys were done on foot and nests were easily found, even when no bird was seen in the area (e.g. abandoned nests). Upon discovery of a Reddish Egret nest, the number of nestlings and eggs was recorded and the breeding stage of the nest was estimated. All islands containing mangroves within our study site were surveyed and all nests were checked twice during the 3-day survey period. Breeding stages were defined as incubation, hatching and nestling. Incubation was classified by the presence of eggs over the observation period. In some cases, we found an incremental increase in clutch size between the two nest checks per survey; these nests were included in the incubation stage. Hatching was defined as presence of birds estimated to be ≤ 1 week old and nestling phase included all nests with young >1 week old. In cases where a nest with eggs was found during the first observation and hatchling(s) were found during the second observation, this nest was classified as hatching stage. In nests only containing eggs, color morphs of the parents were determined by observations of nest attendance. Mixed-morph nesting pairs were only documented and reported when both white and dark morph nestlings were observed in a single nest.

Latitude and longitude coordinates were recorded for all nests using a GPS (global positioning system) unit. To assess the degree of coloniality, we overlaid nest coordinates onto a 0.5 m resolution satellite image of Lake Rosa, Great Inagua (obtained from eMap International) and measured spatial distance between nests using ArcGIS 9.3.1 (ESRI, Redlands, CA, USA). We defined a breeding colony by the occurrence of ≥ 2 active nests within 200 m of one another on the same or adjacent mangrove islands; any active nest estimated to >200 m from all other nests was considered solitary. We recorded but did not include other waterbird species nesting in proximity to Reddish Egret nests as our study was focused on estimating the population of Reddish Egrets at Great Inagua.

RESULTS

We conducted two surveys in 2008 and again in 2009 and documented 38 and 49 active Reddish Egret nests on Great Inagua for each survey year, respectively (Tables 1 and 2). We conducted a follow-up survey in 2010 to assess any major changes since our initial survey in 2008; only two active nests were observed and any major pulse of nesting did not appear to have occurred due to extensive drought conditions. The 2010 survey data was removed from subsequent analyses of solitary vs. colonial nesting and white:dark morph ratios.

The proportion of white, dark, and mixed-morph nesting pairs varied but averaged (±S.D.) 68.4 ± 7.5, 18.2 ± 2.4, and 13.4 ± 5.1%, respectively; the occurrence of mixed-morph nests was almost as commonplace as dark morph nests. Of the 87 total nests documented on Lake Rosa, ~75% of the nests (65 of 87) were concentrated within 0.75 km of one another on the same or adjacent group of mangrove islands. The percentage of Reddish Egret nests occurring <0.75 km of one another varied across surveys with APR08 having the fewest nests occurring within 0.75 km of one another (14 of 38 nests, 36.8%) compared to 85.0 (33 of 39 nests) and 83.6 (41 of 49 nests) % of nests concentrated within 0.75 km for the JAN09 and FEB09 surveys, respectively. Solitary nesting (>200 m apart) did occur and varied between 36.8, 10.0, and 7.7% for the APR08, JAN09, and FEB09 surveys, respectively.

Table 1. Minimum number of Reddish Egret nesting pairs, by nesting stage, observed on Great Inagua, Bahamas, 2008. Nesting stages defined as incubation (eggs present, no change in clutch size between observations), hatching (chicks ≤ 1 weeks old), nestling (chicks > 1 weeks old). Renest determined by presence of active nest in both survey periods with no change in stage. Success based on average time till fledging (27 day incubation + 28 day young in nest) and empty nest on second survey. Failure based on average time till fledging (27 day incubation + 28 day young in nest) and presence of dead nestlings or unhatched eggs in nest on second survey.

Date	Color Morph	Incubating	Hatching	Nestling	Success	Failure	Total
08-10 April 2008	Dark	1	3	2	N/A	N/A	6
	White	15	3	11	N/A	N/A	29
	Mixed	1	1	1	N/A	N/A	3
	Total	17	7	14	N/A	N/A	38
13-15 May 2008	Dark	0	0	0	5	1	6
	White	0	1	0	14	14	29
	Mixed	0	0	0	2	1	3
	Total	0	1	0	21	16	38

Within color morphs, the white morph was the least gregarious with solitary nesting occurring 41.4 (twelve of 29 nests), 12.5 (three of 24 nests), and 9.1 (three of 33 nests) % for the APR08, JAN09, and FEB09 surveys, respectively. For dark morphs, only one of the 15 nests (6.7%) documented between both years was solitary. For mixed morph nests, two of ten nests (20.0%) were solitary, both occurring during the APR08 survey.

DISCUSSION

We documented <50 active Reddish Egret nests for each of the two breeding seasons (2008-2009), suggesting the number of Reddish Egrets nesting on Great Inagua has decreased by >50% since the 1980s (Scott and Carbonell 1986). Surveys last done in the 1980s were usually done in April-May time period in conjunction with American Flamingo surveys and provided a snapshot of Reddish Egret nesting. The timing of our surveys was often constrained by logistics and field schedules and therefore did not encompass the entire potential breeding season. However, even with a prolonged breeding season (December-May) and the possibility of two breeding pulses, it seems unlikely that we missed >50% of the nesting attempts between our two survey periods per season. An inability to detect the presence of active Reddish Egret nests seems unlikely in our study as habitat consisted of scrub mangrove and nests were very conspicuous in stands of mangroves, even when no birds

Table 2. Minimum number of Reddish Egret nesting pairs, by nesting stage, observed on Great Inagua, Bahamas, 2009. Nesting stages defined as incubation (eggs present, no change in clutch size between observations), hatching (chicks ≤ 1 weeks old), nestling (chicks > 1 weeks old). Success (apparent) based on average time till fledging (27 day incubation + 28 day young in nest) and empty nest on second survey. Failure based on average time till fledging (27 day incubation + 28 day young in nest) and presence of dead nestlings or unhatched eggs in nest on second survey. Renest determined by presence of active nest in both survey periods with no change in stage. New nest is presence of active nest during second survey that was not established during first survey period.

Date	Color Morph	Incubating	Hatching	Nestling	Success	Failure	Total	Renest	New Nest
15-18 January 2009	Dark	6	2	0	N/A	N/A	8	N/A	N/A
	White	19	1	4	N/A	N/A	24	N/A	N/A
	Mixed	4	1	2	N/A	N/A	7	N/A	N/A
	Total	29	4	6	N/A	N/A	39		
13-15 February 2009	Dark	1	1	1	0	6	9	1	1
	White	9	1	4	5	14	33	2	9
	Mixed	0	0	1	2	4	7	0	0
	Total	10	2	6	7	24	49		

were observed. Furthermore, because of the habitat and surveys were all done on foot, potential differences in detection between white and dark morph birds also seems unlikely. We found only one active nest in May 2008, suggesting the breeding season is approaching its end by early May. Additionally, during our January survey, we only found two nests with young close to fledging, suggesting we did not miss a substantial number of active nests during November and December. In 2010, our surveys during March yielded only two active nests with no signs of impending nesting by other pairs; we infer that the nesting season may be protracted or contracted based on changes in annual precipitation. Lake Rosa undergoes natural drying and subsequent drawdown during late spring and early summer and water levels do not increase substantially again until late fall and early winter; this lack of water presumably limits the breeding season to December-May.

Based on known hatching dates observed during our surveys, egg laying and subsequent incubation is occurring by early December and possibly earlier. Conversely, we documented recently laid eggs as late as 8-10 April (during the 2009 survey), which suggests brood rearing may continue into mid and late May. We conducted one survey during May (13-15 May 2008) and only found one nest with hatchlings; the remainder of nests that were active in April were completed or failed by the May survey period. The extended breeding season (December-May) observed is similar to the nesting phenology reported in the Florida Keys (Lowther and Paul 2002) and is not unexpected since Great Inagua is only ~4 degrees south of this location. It is unclear if the nesting season is bimodal as observed in the Florida Keys, but our data is suggestive of such; large number of birds hatched in early February (2009) and mid April (2008). However, annual differences in nesting phenology, instead of bimodal nesting, may be the underlying reason for our observations.

Colonial waterbirds often defend nesting territories at a display site, but the defended radius is small and constrained to the immediate area around the nest, especially as the density of breeding birds in the colony increases. On Great Inagua, the occurrence of solitary nesting varied, but was as high as ~36% of all nests counted. Upon approaching the suspected nesting area of an observed bird, we observed territorial aggression by adult Reddish Egrets on numerous occasions; this behavior was only observed on birds with nests >200 m from other active Reddish Egret nests. Aggressive behavior was characterized by an adult (sex unknown) flying toward and circling the observers while vocalizing its characteristic "crog" call. Territorial behavior of solitary pairs has been reported in Florida Bay (Lowther and Paul 2002) and is now confirmed to occur on Great Inagua, Bahamas.

Storms and hurricanes are known to have considerable influences on the nesting ecology of waterbirds (Shepherd *et al.* 1991; Leberg *et al.* 2007). On 7 September 2008, Hurricane Ike passed over Great Inagua as a Category 4 hurricane on the Saffir-Simpson scale with sustained winds near 217 km/hr. In spring 2008, ~36% of nesting Reddish Egrets occurred as solitary nests (>200 m) whereas during the breeding season following Hurricane Ike, solitary nesting was <10%. Additionally, ~85% of all nests were concentrated in one main cluster of mangrove islands (within a radius of 750 m) in 2009 following the hurricane; less than 36% of nests occurred in this same area in the preceding year. Nesting surveys in 2009 revealed considerable structural damage to mangrove islands on Lake Rosa that contained nests in 2008, presumably resulting in the greater concentration of nesting on less impacted islands. However, the lack of surveys conducted throughout one complete breeding season limits the inferences we can draw from our results. It is possible that nest spacing varies seasonally and our results are reflective of seasonal differences and not the effects of Hurricane Ike; however storm damage (i.e. downed mangroves) was commonplace among most of the islands in the study site and we found no evidence of early season nesting (e.g. empty nests) prior to our surveys. If impacted by hurricanes, our results

are similar to nesting dynamics reported in Louisiana following Hurricanes Katrina and Rita where colony sites less affected by wind damage exhibited substantial increases in the number of nesting pairs the following nesting season (Leberg *et al.* 2007).

The apparent sharp decrease in the estimated number of Reddish Egret nests is of considerable conservation concern; the Great Inagua population is considered a key area for the global population of the species (Lowther and Paul 2002; Green 2006). Furthermore, the breeding population at Lake Rosa exhibits significant genetic differentiation from populations in Florida, Texas and Mexico and should be considered a distinct population (Hill 2009); however potential gene flow between the Great Inagua population and nearby Cuba is unknown. Continued monitoring and management of the Inagua population is important to regional and global conservation of the species. Also, it is important to examine the relationship between the Great Inagua population and other Caribbean populations (e.g. Cuba) to better understand connectivity and the status of Great Inagua as a distinct population.

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