J. Carib. Ornithol. 22:83-89, 2009

REPRODUCTION OF THE GREEN HERON (*BUTORIDES VIRESCENS*) IN BIRAMA SWAMP, CUBA

DENNIS DENIS, SUANY RODRÍGUEZ, OSLIBY ANTÚNEZ, AND HANSER FORTES

Facultad de Biología, Universidad de La Habana, Calle 23 e/ J e I, Vedado, Ciudad Habana, Cuba;
email: *dda@fbio.uh.cu*

Abstract: We studied the nest site selection and breeding biology of Green Herons (*Butorides virescens*) in Birama Swamp, eastern Cuba, during June and July 2006. We measured the height and diameter and recorded the contents of 53 nests, measured the minimum and maximum diameters of the eggs, and every 2 d measured the bill and tarsus lengths of nestlings. Nests were placed in Black Mangroves (*Avicennia germinans*), averaged 0.47 m above the water with an average diameter of 25±0.56 cm. Clutch size was 2.6±0.08 (2-4 eggs per nest) and eggs averaged 37.1 × 28.8 mm (n = 105). Egg size did not differ significantly by laying order. The interval between consecutive eggs being laid or hatching ranged from 0-7 d, with 2 d for 46% of the nests and the same day for 27%. All nests produced young during the study period with a 53.2% probability of each egg producing a fledgling. Bill and tarsus growth followed the Gompertz equation with very similar growth rates (k = 0.20 and k = 0.19, respectively). The reproductive strategies of the Green Heron may differ markedly from those of other ardeids, including the high incidence of synchronous (same-day) egg laying, the absence of significant intraclutch differences in egg size, the high rate of success per nest, and the absence of brood reduction.

Key words: Butorides virescens, Birama Swamp, Cuba, Green Heron, reproductive ecology

Resumen: REPRODUCCIÓN DEL AGUAITACAIMÁN (*BUTORIDES VIRESCENS*) EN LA CIÉNAGA DE BIRAMA, CUBA. El presente trabajo caracteriza el sitio de cría y los aspectos reproductivos del Aguaitacaimán (*Butorides virescens*) en la ciénaga de Birama, en el oriente de Cuba. Entre los meses de junio y julio del 2006 se marcaron 53 nidos a los cuales se les midió la altura, el diámetro y su contenido, y que fueron seguidos diariamente durante siete días. Se midió el diámetro menor y mayor de los huevos, y cada dos días el pico y tarso de los pichones para obtener las curvas de crecimiento. Los nidos se ubicaron sobre mangle prieto (*Avicennia germinans*) a una altura promedio de 0,47 m sobre el agua y su diámetro fue de 25±0,56 cm. El tamaño de nidada fue de 2,6±0,08 (2-4 huevos por nido) y las medidas de los huevos fueron de 37,11 × 28,8 mm (n = 105). No se encontraron diferencias estadísticas entre los huevos según el orden de puesta. El intervalo en que se observó la puesta o eclosión entre huevos sucesivos varió entre 0-7 días, en 46% de los casos fue de dos días y el 27% fueron sincrónicos. Todos los nidos fueron exitosos pero cada huevo tuvo una probabilidad del 53,2% de producir un volantón. El crecimiento del pico y del tarso siguió una ecuación de Gompertz, con velocidades similares (k = 0,20 y k = 0,19, respectivamente). La estrategia reproductiva del Aguaitacaimán parece diferir marcadamente de la de otros ardéidos, si se incluye la alta incidencia de puestas sincrónicas (el mismo día), la ausencia de diferencias intranidada significativas en la talla de los huevos, el elevado éxito por nido y la ausencia de reducción de nidada.

Palabras clave: Aguaitacaimán, *Butorides virescens,* ciénaga de Birama, Cuba, ecología reproductiva

Résumé : REPRODUCTION DU HÉRON VERT (*BUTORIDES VIRESCENS*) DANS LE MARAIS DE BIRAMA,À CUBA. Nous avons étudié la biologie de la reproduction et la sélection de sites de nidifiction chez le Héron vert (*Butorides virescens*) dans le marais de Birama, à Cuba en juin et juillet 2006. Nous avons mesuré la hauteur et le diamètre de 53 nids, les diamètres minimum et maximum des eoufs et tous les deux jours la longueur du bec et du tars des poussins. Les nids se trouvaient dans des palétuviers noirs (*Avicennia germinans*), en moyenne à une hauteur de 0.47 m et avec un diamètre de 25±0.56 cm. La taille de ponte était de 2.6±0.08 (2-4 œufs par nid) et les oeufs en moyenne de 37.1 × 28.8 mm (n = 105). La taille des œufs ne variait pas significativement en fonction du rang de ponte. L'intervalle entre des œufs pondus ou éclos consécutivement était de 0 à 7 jours avec 2 jours pour 46% des nids et le même jour pour 27%. Tous les nids ont produit des jeunes pendant la période de l'étude avec une probabilité de 53.2% pour chaque œuf de produire un poussin. La croissance du bec et du tarse suivait l'équation de Gompertz avec des taux de croissances très similaires (k = 0.20 et k = 0.19, respectivement). Notre étude suggère que la stratégie de reproduction du Héron vert dans la Caraïbe diffère sensiblement de beaucoup d'autres hérons par l'absence de réduction des couvées.

Mots clés: Butorides virescens, Cuba, écologie de la reproduction, Héron vert, marais de Birama

The Green Heron (*Butorides virescens*) is in many ways one of the best known of the herons (Meyerriecks 1960, 1962, Dickerman and Gavino 1969, Davis and Kushlan 1994, Kushlan and Hancock 2005), but the biology, status, and taxonomy of the populations in the Caribbean are poorly understood (Voous 1986, Hayes 2002, 2006). For example, the relationship between Caribbean and South American populations has been a matter of considerable debate (Payne 1974, Voos 1986, Hayes 2006). Furthermore, the species has recently been expanding its range, most recently, for example, into Bermuda (Wingate *et al.* 2009). A better understanding of the taxonomy and biology of these populations in support of their conservation is a high priority (Kushlan *et al*. 2002).

In the Caribbean region, the Green Heron nests solitarily, in small monospecific colonies or on the fringes of larger multispecific colonies. However, biological studies in the Caribbean have been limited (Denis *et al.* 1999a, 2000). In Cuba, the reproductive biology of Green Heron was first studied in Birama Swamp in 1998 (Denis *et al.*, 1999a), based on 17 nests located along a canal. In 2006 we located and monitored a relatively large colony of Green Herons in another location of Birama Swamp and obtained more consistent data to characterize the reproductive ecology of the species in natural mangrove swamps of the Caribbean.

STUDY AREA

Our study was conducted in the faunal refuge Delta del Cauto (20°28' N, 77°10' W), in the western side of Birama Swamp, Granma Province, Cuba, during June and July 2006. The breeding season of Green Heron in Cuba extends from March to September (Valdés 1984, Balat and González 1982, Raffaelle *et al.* 1998, Denis *et al.* 1999b). Birama Swamp, located in the Cauto River alluvial delta, is the second largest wetland system of the Caribbean and is characterized by coastal mangroves, inland lagoons, marshes, mudflats, and a complex network of interconnected ponds and canals. It encompasses 764 km^2 of permanent or seasonally flooded wetland ecosystems.

Our field work was conducted in the area between Las Playas Lagoon (20°32'23" N, 77°01'34" W), the shrimp pond facilities (20°33'06" N, 76°59'26" W), and El Mango Biological Station (20°32'39" N, 077°00'21" W). After surveying these areas, the main colony of Green Herons was located in an area behind the station, known as La Flora (20°32'16" N, 77°00'55" W) (Fig. 1). This locality is permanently flooded with shallow, brackish water and small Black Mangroves (*Avicennia germinans*).

Other species of birds breeding in the area include White-cheeked Pintail (*Anas bahamensis*), Least Bittern (*Ixobrychus exilis*), Snowy Egret (*Egretta thula*), Little Blue Heron (*E. caerulea*), Tricolored Heron (*E. tricolor*), Cattle Egret (*Bubulcus ibis*), White Ibis (*Eudocimus albus*), Snail Kite (*Rostrhamus sociabilis*), Common Moorhen (*Gallinula chloropus*), Black-necked Stilt (*Himantopus mexicanus*), and White-winged Dove (*Zenaida asiatica*).

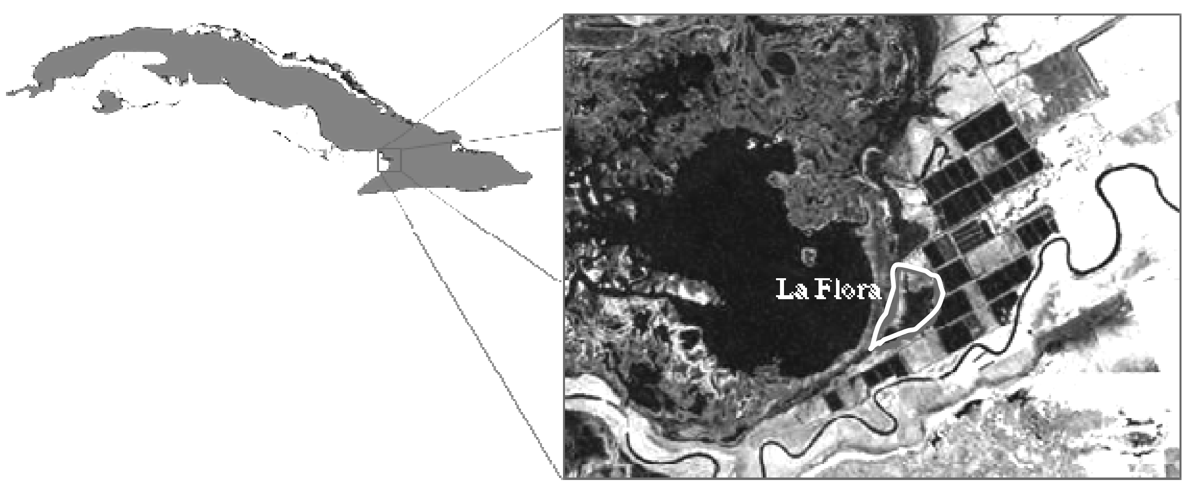

Fig. 1. Location of the Green Heron breeding area in eastern Birama Swamp, Cuba, in 2006.

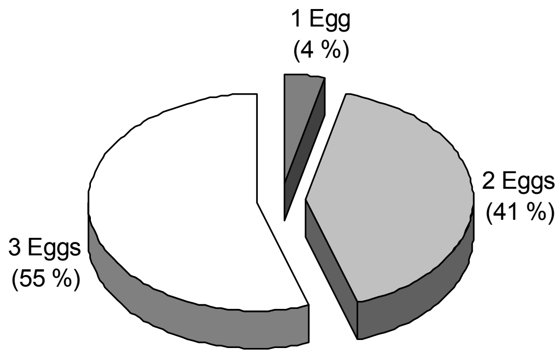

Fig. 2. Clutch size of Green Heron nests at Birama Swamp, Cuba, in 2006 (n = 53).

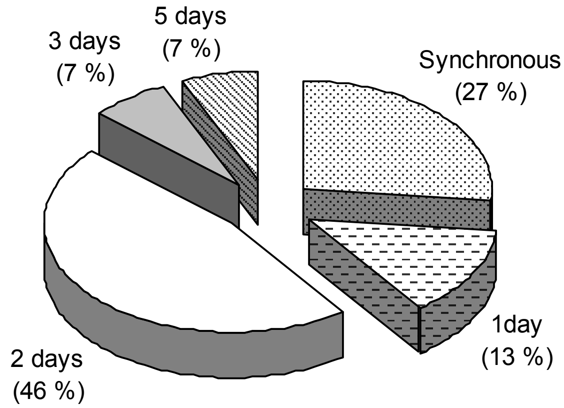

Fig. 3. Laying and hatching intervals between consecutive Green Heron eggs at Birama Swamp, Cuba, in 2006 (n = 25).

METHODS

Each nest was labeled and its height and width (nearest 1 mm) were measured. The contents of all marked nests were noted during daily visits. Each egg was marked with non-toxic indelible ink and the length and width were measured (nearest 0.01 mm) with a Vernier caliper. On alternate days the tarsus and bill of 43 nestlings were measured (nearest 0.01 mm). Egg volume was calculated following Hoyt's equation (Hoyt 1979). Mean egg volume for 2-egg and 3-egg clutches were compared using the Mann-Whitney U test (Sokal and Rohlf 1981). Mean clutch size was calculated from nests observed unchanged for more than 5 d. A breakdown one-way analysis of variance (ANOVA) was used to test for intraclutch egg size differences by laying order. Nests were monitored daily between 0800-1100 and 1500-1800 hr to minimize the risk of causing heat stress or disrupting patterns of foraging behavior. Mayfield's (1961, 1975) methods were used to estimate reproductive success during egg and nestling stage of the nests, combining period estimates according to Hensler and Nichols (1981). An incubation period of 21 d and nestling period of 14 d were used in these calculations (Davis and Kushlan 1994). Nestling growth curves were fitted to the Gompertz equation following Ricklefs (1967).

RESULTS

We located 53 nests, all in Black Mangrove shrubs. The characteristics of the breeding area were similar to those of previous reports of Green Heron nest locations elsewhere. Distances to the nearest open water were 0.2 km to the shrimp ponds and 0.9 km to Las Playas lagoon. Nests were placed 0.1-0.9 m above water ($\bar{x}$ = 0.47±0.02 m, CV = 36%) and were loosely aggregated 1-6 m apart. The nests were scattered in loose aggregations, at distances ranging from 1-6 m apart, all in separate trees. They were constructed with thin mangrove sticks and were rounded with an average outer diameter of 25±0.56 cm (range 15-35 cm; n = 53). Clutch size averaged 2.6±0.08 eggs (n = 53 nests, 105 eggs). More than half of the nests had three eggs, but four eggs were encountered in only one nest (Fig. 2). The median laying or hatching interval between consecutive eggs was 2 days (Fig. 3).

Egg length and width averaged 37.11±0.18 mm (range = 28.70-41.20) and 28.80±0.139 mm (range = 24.40-38.20), respectively, and egg volume averaged 15.72±0.20 cm^3 (range = 10.67-30.53). The eggs were similar in size to the historical data from Cuba (Valdes 1984) and elsewhere (Hancock and Kushlan 1984). They were also similar to sizes recorded in previous years for Birama Swamp (Denis 2002).

Eggs from 2-egg clutches and 3-egg clutches did not differ in volume (U = 1076.5, P = 0.93), indicating no decline in nutrients in larger clutches. When only 3-egg clutches were considered, egg size appeared to increase with the order of egg laying (Fig. 4). Although the trend was not statistically significant, a breakdown one-way ANOVA (Table 2) revealed that the statistical power of the test is small (17%) and therefore inconclusive.

In all nests studied, at least one egg hatched and survived to fledge. In our sample, 4% of nests had an infertile egg. Daily survival probability calculated with an individual-case approach was 0.99±0.04% for eggs (n = 102) and 0.97±0.01% for nestlings (n = 34). The combination of both egg and

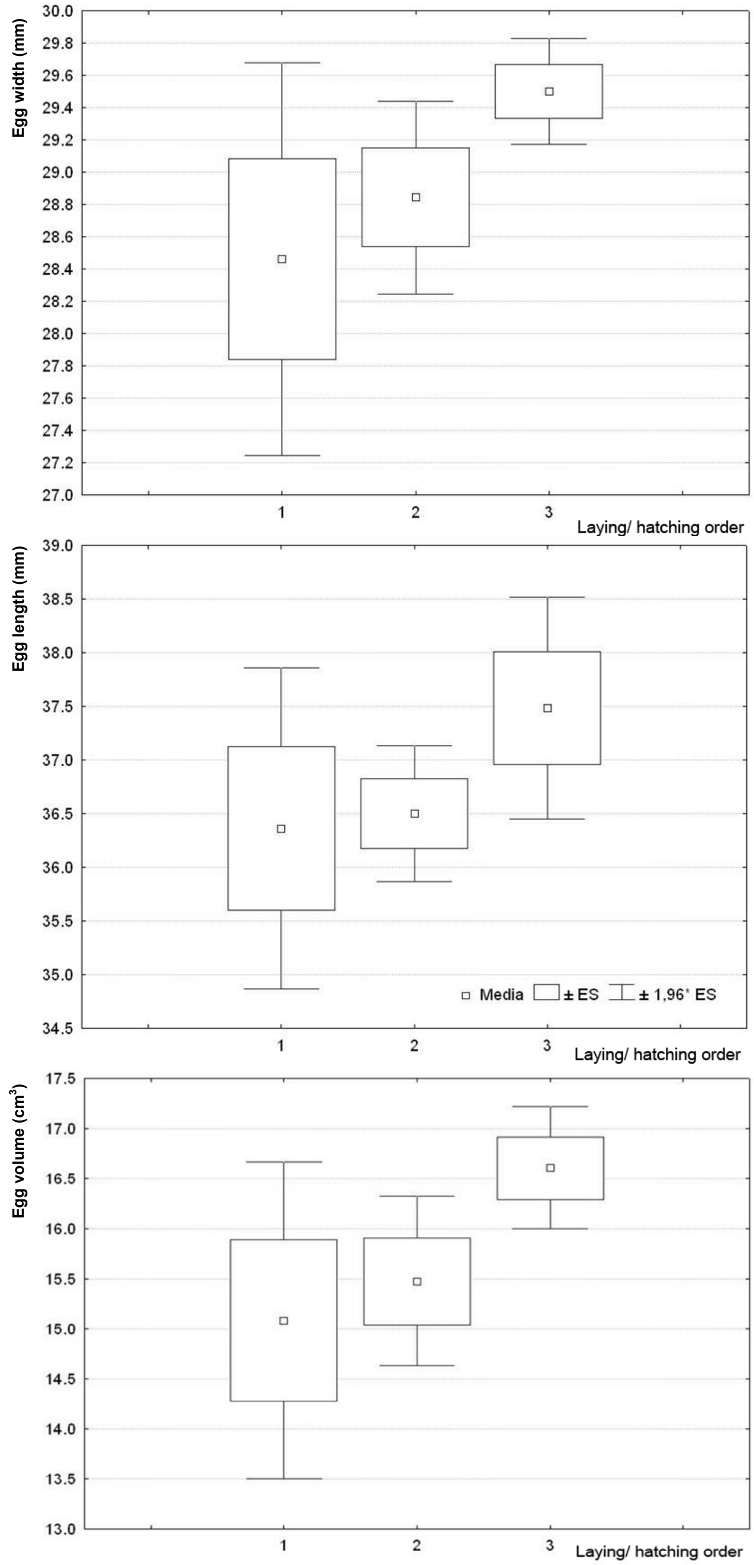

Fig. 4. Intraclutch egg size variation in the Green Heron at Birama Swamp, Cuba, in 2006.

Table 2. One-way ANOVA results for egg size by laying order of Green Heron in Birama Swamp, Cuba, in 2006.

	SS effect	df	MS effect	SS error	df	MS error	*F*	*P*
Egg length (mm)	4.86	2	2.43	45.31	18	2.52	0.97	0.40
Egg breadth (mm)	3.71	2	1.86	26.34	18	1.46	1.27	0.31
Volume (cm^3)	8.27	2	4.13	47.44	18	2.64	1.57	0.24

fledgling periods revealed an overall survival of 0.53 (53.2%; n = 53 nests), meaning that only slightly more than half of the eggs produced a fledgling. No cases of predation were observed.

At hatching, bill length averaged 0.7±0.28 mm and tarsus length averaged 6.0±0.62 mm, similar to the values reported by Denis *et al.* (1999a). In the present study, growth curves of bill and tarsus fitted best to a Gompertz's equation (Fig. 5). Bill growth rate (k) was 0.20 and tarsus growth rate was 0.19. These growth rates are higher than those found by Rodriguez (2001), 0.01 and 0.17 for bill and tarsus, respectively (modeled on the Von Bertalanffy equation). Differences could be due to small sample sizes used for older nestlings. At hatching, bill length averaged 0.7±0.28 mm and tarsus length averaged 6.0±0.62 mm, similar to the values reported by Denis *et al.* (1999a).

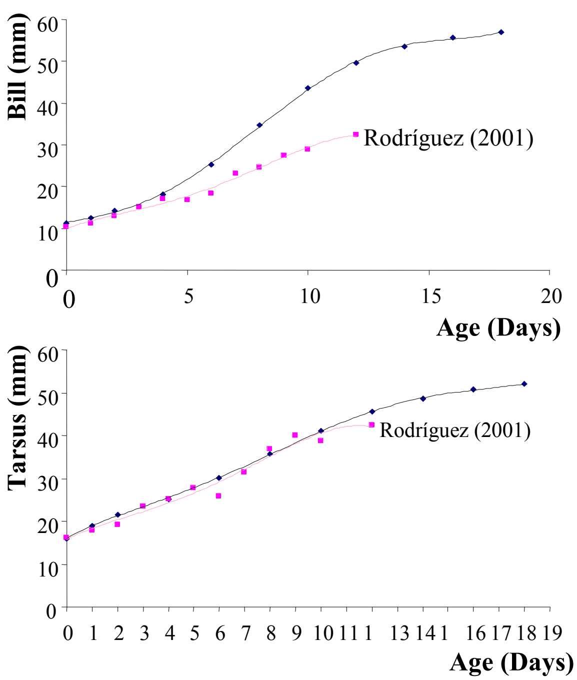

Fig. 5. Growth curves of bill and tarsus of Green Heron in Birama Swamp, Cuba, in 2006, compared with Rodríguez (2001).

DISCUSSION

The nest characteristics of Green Heron in Birama Swamp were basically similar to other localities in the Neotropics. The nests were placed somewhat lower (0.47±0.02 m) than found in two previous studies in Cuba, which reported average heights above water of 1.5±0.7 m in 17 nests (Denis *et al*. 1999a) and 1.72±0.73 m in 12 nests (Rodriguez 2001). In North America, reports of nest height varied greatly, ranging from 3.0-9.1 m (Harrison 1978) to 10-20 m above water (Wheelock 1906, Huey 1915, Mousley 1945, Meyerriecks 1962, Coffey 1981). In Mexico, the mean nest height above water was 0.68 m in 182 nests (Dickerman and Gavino 1962). Nest site placement in this species is clearly related to the structure of available habitat.

Nest size was similar (25±0.56 cm) was similar to that of other localities: 23 cm in 119 nests in Mexico, (Dickerman and Gavino 1969), 30 cm (no error estimates given), and 26.1±3.24 cm in 16 nests in Cuba (Denis *et al.* 1999a). The sizes of Green Heron nests may be similar throughout their range.

The eggs were similar in size to the historical data from Cuba (Valdes 1984) and elsewhere (Hancock and Kushlan 1984). They are also similar to sizes recorded in previous years for Birama Swamp (Denis 2002). Clutch sizes and hatching rate appear to be higher in Cuba than in North American studies. It seems likely that our results for clutch size (2.6±0.08 eggs) are accurate as similar clutch sizes were reported in this wetland in previous years: 2.45±0.5 eggs per nest (n = 29; Rodriguez 2001) and 2.2±0.11 (n = 17; Denis *et al*. 1999a). These clutches tend to be slightly smaller than those reported for continental areas, which average > 3 eggs (e.g., Harrison 1978, Kaiser and Reid 1987). The rate of egg hatching in our study appears to be higher than those in studies in North America. Meyerriecks (1962), for example, found that eggs hatched in 67% of nests (n = 76) in Massachusetts. Related to this finding, there was a higher incidence of infertility in the North American study. Infertile eggs were found in 10.5% of nests of the Massachusetts colony, a proportion higher than in La Flora.

The laying interval in our study was similar to that reported in San Blas, Mexico, where 60% of eggs were laid 2 d apart (Dickerman and Gavino 1969). This is the usual laying interval described for Ardeids (Custer and Frederick 1990). Our finding of a high proportion of synchronous (same day) laying is unusual for the species, and for herons in general (Kushlan and Hancock 2005). The biological implications of this finding and the possibility of interpopulation differences deserves additional study. Our nesting success (100%) was relatively high. In Missouri, 78% of nests successfully fledged young, a proportion substantially lower than in our study (Kaiser and Reid 1987).

Egrets and herons are facultative brood reductionist species and a decrease in egg size with laying order has been described in other species (Custer and Frederick 1990). The increase of egg size as eggs are laid is a very common pattern among small altricial birds with asynchronous hatching but better explained by the nest-failure hypothesis (Clark and Wilson 1981).

Our study suggests that reproductive parameters, including clutch size, reproductive success, and growth rates in this species are in part a reflection of local conditions. However, of more profound interest are the findings that such parameters as clutch size, infertility rate, hatching rate, and success differ markedly in Cuba from those found in studies on the North American continent. These findings suggest the possibility of interpopulation differences between continental and Caribbean populations that deserve additional.

Our findings also suggest that the reproductive strategies of the Green Heron may differ markedly from those of other ardeids. These include the high incidence of synchronous (same-day) egg laying, the absence of significant intraclutch differences in egg size, the high rate of success per nest, and the absence of brood reduction. Kaiser and Reid (1987) suggested that Green Herons may alter nesting strategies in response to environmental conditions, specifically the defensibility of food resources. In their opinion this flexibility may have contributed to the success of the species as a habitat generalist.

So it appears that there may be both geographic and ecological influences on the reproductive strategy of the Green Heron. Clearly, additional data are needed to reveal the relative influence of these two factors. Further study of Green Heron populations in the Caribbean may facilitate a better understanding of the significance of variation in breeding biology within the species and, perhaps, among other species of Ardeidae.

ACKNOWLEDGMENTS

We thank F. E. Hayes and J. A. Kushlan for reviewing the manuscript and improving the English, and Omar Labrada, the Specialist of the Protected Area, for supporting our field work.

LITERATURE CITED

BALAT, F., AND H. GONZÁLEZ. 1982. Concrete data on the breeding of Cuban birds. Acta Scientarum Naturalium Academiae Scientiarum Bohemicae Brno 16(8):1-46.

BROWN, L. H., E. K. URBAN, AND K. NEWMAN. 1982. The birds of Africa, vol. 1. Academic Press, New York.

CLARK, A. B., AND D. S. WILSON. 1981. Avian breeding adaptations: hatching asynchrony, brood reduction and nest failure. Quarterly Review of Biology 56:253-277.

COFFEY, B. B., JR. 1981. A past Green Heronry colony in Memphis. Migrant 52:44.

CUSTER, T. W., AND P. C. FREDERICK. 1990. Egg size and laying order of Snowy Egrets, Great Egrets, and Black-crowned Night-Herons. Condor 92:772-775.

DAVIS, W. E, JR., AND J. A. KUSHLAN. 1994. Green Heron (*Butorides virescens*). *In* The birds of North America, no. 129 (A. Poole and F. Gill, Eds.). Academy of Natural Sciences, Philadelphia, PA.

DENIS, D. 2002. Ecología reproductiva de siete especies de garzas (Aves: Ardeidae) en la ciénaga de Birama, Cuba. Tesis en opción del grado científico de Doctor en Ciencias Biológicas, Universidad de La Habana, Cuba.

DENIS, D., L. MUGICA, AND M. ACOSTA. 2000. Morfometría y alimentación del Aguaitacaimán (*Butorides virescens*) en las arroceras del Sur del Jíbaro. Biología 14:133-140.

DENIS, D., L. MUGICA, M. ACOSTA, AND L. TORRELLA. 1999a. Algunos aspectos sobre la ecología reproductiva del Aguaitacaimán *Butorides virescens* en la Ciénaga de Birama, Cuba. Biología 13: 117-124.

DENIS, D., L. MUGICA, M. ACOSTA, AND L. TORRELLA. 1999b. Nuevos reportes sobre la época reproductiva de aves acuáticas coloniales en Cuba. Pitirre 12:7-9.

DICKERMAN, R. W., AND G. GAVINO. 1969. Studies of a nesting colony of Green Herons at San Blas, Nayarit, Mexico. Living Bird 8:95-111.

GARRIDO, O. H., AND F. GARCÍA. 1975. Catálogo de las aves de Cuba. Academia de Ciencias, La Habana.

GONZÁLEZ-MARTÍN, M., AND X. RUIZ. 1996. Brood parasitism in herons. Colonial Waterbirds 19:31-38.

GRABER, J. W., R. R. GRABER, AND E. L. KIRK. 1978. Illinois birds: Ciconiiformes. Biological Notes 109:1-80.

HANCOCK, J., AND J. A. KUSHLAN. 1984. The heron handbook. Harper and Row, New York.

HARRISON, C. 1978. Field guide to the nests, eggs, and nestlings of North American birds. Collins, London.

HAYES, F. E. 2002. Geographic variation, hybridization, and taxonomy of New World *Butorides* herons. North American Birds 56:4-10.

HAYES, F. E. 2006. Variation and hybridization in the Green Heron (*Butorides virescens*) and Striated Heron (*B. striata*) in Trinidad and Tobago, with comments on species limits. Journal of Caribbean Ornithology 19:12-20.

HENSLER, G. L., AND J. D. NICHOLS. 1981. The Mayfield method of estimating nesting success: a model, estimators and simulation results. Wilson Bulletin 93:42-53.

HOYT, D. 1979. Practical methods of estimating volume and fresh weight of bird eggs. Auk 103:613-617.

HUEY, L. M. 1915. Random notes from San Diego. Condor 17:59-60.

HUEY, L. M. 1926. A prolific Anthony Green Heron. Condor 28:94-96.

KAISER, M. S., AND E. K. FRITZELL. 1984. Effects of river recreationists on Green-backed Heron behavior. Journal of Wildlife Management 48: 561-567.

KAISER, M. S., AND F. A. REID. 1987. A comparison of Green-backed Heron nesting in two freshwater ecosystems. Colonial Waterbirds 10:78-83.

KUSHLAN, J. A., AND J. A. HANCOCK. 2005. The herons. Oxford University Press, Cambridge, UK.

KUSHLAN, J. A., M. J. STEINKAMP, K. C. PARSONS, J. CAPP, M. ACOSTA, M. COULTER, I. DAVIDSON, L. DICKSON, N. EDELSON, R. ELLIOT, R. M. ERWIN, S. HATCH, S. KRESS, R. MILKO, S. MILLER, K. MILLS, R. PAUL, R. PHILLIPS, J. E. SALIVA, B. SYDEMAN, J. TRAPP, J. WHEELER, AND K. WOHL. 2002. El plan para la conservación de aves acuáticas de Norteamérica, ver. 1. Waterbird Conservation for the Americas, Washington, DC.

MEYERRIECKS, A. J. 1962. Green Heron. Pp. 419-426 *in* Handbook of North American birds, vol. 1 (R. S. Palmer, ed.). Yale University Press, New Haven, CT.

MOSSO, E. D., AND A. H. BELTZER. 1992. Nuevos aportes a la biología reproductiva de la Garcita Azulada *Butorides striatus* (Aves: Ardeidae). Hornero 13:236-237.

MOUSLEY, H. 1945. The nesting of the Eastern Green Heron, *Butorides virescens virescens* (Linn.) in the province of Quebec, May, 1942. Canadian Field-Naturalist 59:51-52.

PAYNE, R. B. 1974. Species limits and variation of the New World Green Herons *Butorides virescens* and Striated Herons *B. striatus*. Bulletin of the British Ornithologists' Club 94:81-88.

RAFFAELLE, H., J. WILEY, O. GARRIDO, A. KEITH, AND J. RAFFAELLE. 1998. A guide to the birds of the West Indies. Princeton University Press, Princeton, NJ.

RICKLEFS, R. E. 1967. A graphical method of fitting equations to growth curves. Ecology 48:978-983.

RODRÍGUEZ, P. 2001. Patrones de crecimiento postnatal de cuatro especies de garzas (Aves: Ardeidae) en la ciénaga de Birama, Cuba. Tesis de Diploma. Universidad de La Habana, Cuba.

SOKAL, R. R., AND F. J. ROHLF. 1981. Biometry. 2nd edn. H. Freeman and Co., New York.

TELFAIR, R. C. 1987. The Cattle Egret: a Texas focus and world view. Texas Agricultural Experiment Station, Texas A & M University, College Station, TX.

VALDÉS, V. 1984. Datos de nidificación sobre las aves que crían en Cuba. Poeyana 282:1-27

VOOUS, K. H. 1986. Striated or Green Herons in the south Caribbean Islands? Annalen des Naturhistorischen Museum zu Wien (B) 88/89:101-106.

WHEELOCK, I. G. 1906. Nesting habits of the Green Heron. Auk 23:432-436.

WINGATE, D. B., J. L. MADEIROS, AND J. A. KUSHLAN. 2009. Green Heron colonizes Barbados. Waterbirds 32:162-168.

YLIMAUNU, J., AND A. JARVINEN. 1987. Do Pied Flycatchers *Ficedula hypoleuca* have a brood-survival or brood-reduction strategy? Ornis Fennica 64:10-15.