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MONITORING THE DENSITY OF THE CUBAN ROCK IGUANA (*CYCLURA NUBILA NUBILA*) FROM PROTECTED AREAS IN SOUTHERN CUBA

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***Abstract.*—The Cuban Rock Iguana (*Cyclura nubila nubila*) inhabits coastal regions of Cuba and satellite cays surrounding the island. The species is considered Vulnerable according to International Union for Conservation of Nature (IUCN) Red List of Threatened Species criteria and the Libro Rojo de los Vertebrados de Cuba. The main threats to the species include the alteration and degradation of coastal habitat and, to a lesser extent, poaching. Though some populations have been studied in the past, information concerning biology, ecology, and the status of many populations remain unknown. For three years we monitored 12 iguana populations from six study sites (two populations each site), located within protected areas from three mainland and three offshore sites from southern Cuba. This study represents the longest continuous monitoring program for *C. nubila nubila* in Cuban protected areas, as well as the first study ever conducted at four of our sites. We recorded spatial and temporal trends in iguana density, sex ratio, and age structure. Our results suggest higher inter-annual density variation from sites located on the Cuban mainland than from offshore cays. Across all sites, sex ratios varied between the reproductive and post-reproductive seasons, while the number of non-adults identified in the surveys fluctuated by approximately 30%. Iguana monitoring programs located in protected areas are necessary to quantify population impacts from acute (e.g., fire, hurricane) or prolonged (e.g., human impacts) events in order to test the efficacy of protected areas in maintaining iguana populations. Management implications derived from our data are discussed.**

***Resumen.*—La Iguana Cubana (*Cyclura nubila nubila*) habita en las costas y en numerosos cayos que rodean a la isla de Cuba. La especie está considerada como Vulnerable de acuerdo con los criterios de la Lista Roja de Especies Amenazadas de la Unión Internacional para la Conservación de la Naturaleza (UICN) y el Libro Rojo de los Vertebrados de Cuba. La principal amenaza para esta especie ha sido la alteración y degradación de los hábitats costeros y, en menor medida, la caza furtiva. Aunque la especie ha sido objeto de estudio en el pasado, aún se desconocen importantes aspectos de su biología, su ecología y el estado de muchas de sus poblaciones. Durante tres años se monitorearon 12 poblaciones de iguana en seis sitios de estudio (dos poblaciones por sitio) localizadas en tres áreas protegidas de la isla principal y tres en cayos del sur de Cuba. Este estudio representa el programa de monitoreo continuo más extenso para *C. nubila nubila* en áreas protegidas cubanas, así como el primer estudio realizado en cuatro de estos sitios. Se obtuvieron tendencias espaciales y temporales de la densidad de iguanas, así como valores del cociente sexual y estructura de edades. Los resultados sugieren una mayor variación interanual de la densidad en sitios localizados en la isla de Cuba respecto a los localizados en los cayos. En todos los sitios, el cociente sexual varió entre las etapas reproductiva y post-reproductiva, mientras que el número de no adultos identificados fluctuó en aproximadamente 30%. Los programas de monitoreo de iguanas en áreas protegidas resultan necesarios para cuantificar impactos de eventos extremos (incendios, huracanes) o prolongados (impactos humanos) para probar la eficacia de las áreas protegidas en el mantenimiento de las poblaciones de iguanas. Se discuten algunas implicaciones para el manejo derivadas de los resultados.**

Key Words.—Caribbean; conservation; demography; Iguanidae; management; populations

INTRODUCTION

The Cuban Rock Iguana (*Cyclura nubila nubila*) is an endemic subspecies that was once common on the island of Cuba. It has, however, experienced recent population declines due to urbanization and indiscriminate hunting (Buide et al. 1974; Garrido and Jaume 1984; Berovides 1995). Nevertheless, the species is still relatively abundant in certain coastal sites on the mainland and associated offshore cays (Schwartz and Carey 1977), and is currently listed as Vulnerable by the International Union for Conservation of Nature (IUCN;

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Alberts and Perera 1996) and the Libro Rojo de los Vertebrados de Cuba (González et al. 2012). The species has a patchy distribution along nearly 2,573 km^2 of mainland coastline as well as from numerous offshore cays. These habitats are generally characterized by coastal xerophytc vegetation (Schwartz and Carey 1977; Schwartz and Henderson 1991; Rodríguez 2003). The only inland, remnant populations are found in the Pinar del Río Province from Sierra de Galeras and Sierra Derrumbada in Viñales.

Our general lack of life history and population-trend information for the iguana across its entire range hinders developing broad conservation strategies (Berovides 1980). Indeed, current population assessments for the Cuban Iguana are limited (but see González et al. 2001, 2004, 2007; Cobián et al. 2008; Collazo et al. 2010). These assessments are critical, especially given that coastal areas are particularly sensitive to acute human perturbations and the effects of global climate change (e.g., loss of wetlands and mangrove forests, saltwater penetration in the freshwater lens; IPCC 2007). Contemporary and future impacts will further reduce the effective area of distribution and quality of habitat for the Cuban Iguana. Moreover, limited ranges and reduced populations of iguanas could further impact coastal habitat and restrict restoration efforts because the iguana is a potentially important seed disperser for native plant species (Iverson 1985; Alberts 2000a; Grant and Alberts 2001).

Monitoring populations of species constitutes an essential component of wildlife management and conservation science (Witmer 2005; Marsh and Trenham 2008). Effective monitoring programs can provide basic information on species distributions, identify species that are at-risk due to small or declining populations, provide insight on how management actions affect populations, and evaluate population responses to landscape alteration and climate change (Lyons et al. 2008; Lindenmayer and Likens 2009). Monitoring programs for species of conservation concern therefore represent a major tool for setting and evaluating conservation action priorities.

Although the designation of protected areas has undoubtedly improved the conservation status of endangered species worldwide (Chape et al. 2005), monitoring populations within such areas is critical to ensure that they are serving their conservation objectives. The objectives of this study were to record densities, sex ratios, and demography (% non-adults) of the Cuban Iguana across six protected areas on the southern mainland coast and offshore cays of Cuba. Results will help confirm the efficacy of protected areas in maintaining iguana populations on Cuba, allow managers to better understand density and demographic differences between mainland and insular iguana populations, and inform site-specific management strategies.

MATERIALS AND METHODS

Study areas.—This study was conducted from 2011 to 2013 in six protected areas along the southern coast of Cuba (Fig. 1): Guanahacabibes National Park (GH), Delta del Cauto Fauna Refuge (DC), Desembarco del Granma National Park (DG), Cayos de San Felipe National Park (CSF), Cayos de Ana María Fauna Refuge (CAM) and Jardines de la Reina National Park (CJR). The first three areas are located on the mainland, while

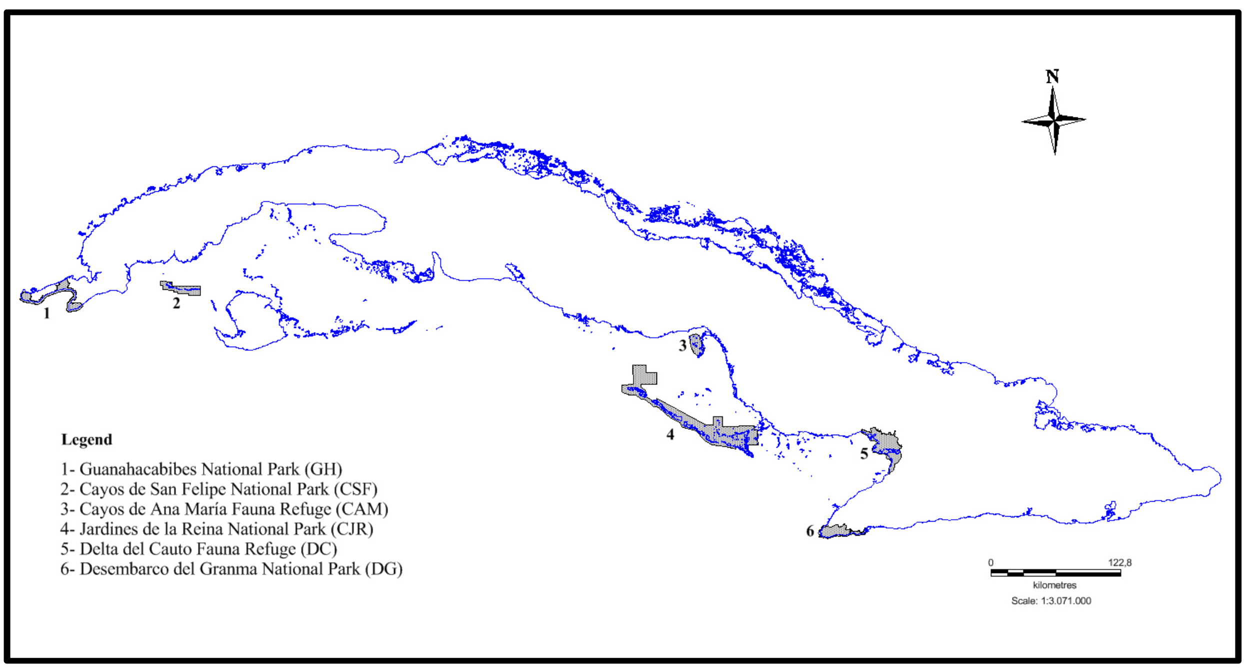

FIGURE 1. Geographic location of the six study sites for *Cyclura nubila nubila* in Cuba.

the other three are located on offshore cays. We defined each protected area as a study site. National parks in Cuba are generally extensive natural areas with scarce or no human population that aim to protect the representative landscapes, ecosystems, communities, and species in their natural habitats of national, regional, or international importance. Fauna refuges aim to protect and maintain populations of species, zoological communities, and habitats of autochthonous fauna that have regional, national, or local significance. Fauna refuges are generally less extensive areas than national parks, and are not always completely natural territories.

Study sites differed in size, geomorphology, and vegetation type (Table 1). Five vegetation formations, as described by Capote and Berazaín (1984), were represented at the study sites: (1) mangrove forests (MF) comprising of four characteristic species that can reach up to 15 m high including *Rhizophora mangle*, *Avicennia germinans*, *Laguncularia racemosa*, and *Conocarpus erectus*; (2) sandy coastal vegetation (SC) with herbaceous plants such as *Sesuvium maritimum*, *Suriana maritima*, *Uniola paniculata*, and *Tournefortia gnaphalodes*, and tree species such as *Coccoloba uvifera* and *Coccothrinax littoralis*; (3) rocky coastal vegetation (RC) on limestone substrates, with ≥ 50 cm high shrubs such as *Oplonia tetrastichia* and *Flaveria linearis*; (4) coastal and subcoastal xeromorphic shrub (CX) communities with esclerofic shrubs, palms, and lianas such as *Croton micradenus*, *Calliandra colleticides*, *Neea shaferi*, and *Phyllostylon brasiliense*, and cactus species such as *Dendrocereus nudiflorus* and *Consolea macracantha*; and (5) microphyllous evergreen forest (MEF) with deciduous species up to 15 m high, spinous shrubs, lianas, and epiphytes such as *Bursera glauca*, *Drypetes mucronata*, *Amyris balsamifera*, and *Diospyros grisebachii.*

Although the level of anthropogenic disturbance in protected areas is generally low compared to non-protected areas, disturbance may occur in these areas. For example, in mainland national parks such as GH and DG, public activities for nature leisure and entertainment are allowed, such as birdwatching. The offshore protected areas (CSF, CAM, and CJR) are located within areas with active fishing boats and permanent fishing.

TABLE 1. General characteristics of study sites and survey design for monitoring Cuban Iguanas inhabiting protected areas of Cuba. Total and terrestrial area of sites, and surveyed area per site are indicated. Vegetation types include: MF (mangrove forests); SC (sandy coastal vegetation); RC (rocky coastal vegetation); CX (coastal and subcoastal xeromorphic shrub); and MEF (microphyllous evergreen forest).

Study site	Area (ha): Total Terrestrial Surveyed	Geo-morphologic structure	Vegetation types	Transect size (m): Length, min–max; Width	# of transects	# of walks (monthly mean and range)	# of maximum density estimates	Years and months surveyed		
								2011	2012	2013
Guanacahabibes National Park (GH)	39,830 23,880 842	Limestone	SC CX MEF RC	700–1,800 10	19	684 (28, 27–30)	26	Apr, Jun, Jul, Aug	Apr, May, Jun, Jul, Oct	Apr, Jun, Jul, Aug
Delta del Cauto Fauna Refuge (DC)	66,370 53,830 5,724	Delta River System	SC MF	400–1,500 10	9	224 (37, 12–68)	134	All 12 months	All 12 months	All 12 months
Desembarco del Granma National Park (DG)	32,576 26,180 443	Limestone	SC CX MEF RC	50–2,500 5	6	85 (44, 31–56)	41	-	Mar, May, Jul, Aug, Sep	Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov
Cayos San Felipe National Park (CSF)	26,250 2,041 234	Beaches and Sand Dunes	SC CX MF	800 10	4	112 (13, 6–16)	22	Jun, Sep, Dec	Mar, Jun, Sep, Dec	Mar, Jun, Sep, Dec
Cayos Ana María Fauna Refuge (CAM)	19,100 980 190	Beaches and Sand Dunes	SC MF	50–200 10	46	158 (53, 32–90)	28	Apr, May, Jun	Jul, Aug, Sep	Mar, Jun, Sep
Cayos Jardines de la Reina National Park (CJR)	217,036 16,079 4,670	Beaches, Limestone, and Sand Dunes	SC CX MF	500–1,000 10	20	112 (37, 25–60)	24	Apr, Jun, Sep	Mar, Jun, Oct, Nov	May, Nov

There is also a strong fishing presence at DC, an area located on the mainland but in the Cauto River Delta. In general, however, the greatest anthropogenic disturbance in protected areas occurs on the mainland because they are easier to access than offshore cays.

At sites with large geographic areas, iguanas were monitored in two populations per study site, separated by distances of 1 to 25 km. At our DG site, however, we conducted surveys in six areas because of habitat patchiness. Our offshore sites represent multiple smaller cays. For example, our CSF site includes two cays (88.2 and 146.0 ha), our CAM survey locations include nine cays (3.0 to 86.0 ha), while our CJR site included seven cays (9.0 to 861.0 ha). The total area surveyed per site varied from 190.2 ha in CAM to 5,724.1 ha in DC (Table 1).

Transect and survey methodology.—Transects were walked through homogeneous habitats, following Iverson (1979), Perera (1985), Hayes and Carter (1996), and Berovides et al. (2005) methodologies. Table 1 summarizes the characteristics of transects and surveys per study site. Transect number and size differed according to the geographic structure, total area, accessibility, and vegetation type at sites. Number of transects varied from 9 to 46 per site, for a total of 104 throughout all sites. Transect size varied from 50 to 1,800 m in length, and from 5 to 10 m in width (Table 1). Transects were fixed at all sites except for CAM and CJR, which were random due to small area size and patchy habitat, respectively. In all cases transects were separated at least 20 m from each other. A total of 21 observers (three per site) with similar experience working with Cuban Iguanas participated in the surveys. When under study, sites were visited from one to three times per month (mean = 1.4 ± (SD) 1.1 monthly walks). A total of 1,375 transects was walked during the study.

Sex and age structure (adult, non-adult) were recorded from two offshore sites (CSF and CJR), and two inland sites (GH and DC). Adult males and females were differentiated based on sexual dimorphism and secondary sexual traits described by Schwartz and Carey (1977) such as relative head size, length of dorsal crest scales, and gular fold (more conspicuous in males than in females). Individuals were identified as adults and non-adults based on body size and the presence of a dorsal chevron pattern in non-adults.

Surveys were conducted in different months of the year to include the reproductive and non-reproductive seasons. Based on information from other *Cyclura* species (Alberts 2000b) and our own experience with the Cuban Iguana, we performed pre-nesting surveys from March to May (courtship and copulation), reproductive surveys from June to August (oviposition and hatching), and post-reproductive surveys from September to February (absence of reproductive activity). We constrained our transect walks to times of maximum iguana activity (0930 to 1430; Perera 1985) and sunny days with little to no wind.

Data analyses.—To focus on the reproductively active population, we used only adult iguana sightings in our density analyses. Whenever possible, populations were visited in as many months as logistically feasible. Maximum number of adults observed per transect was recorded monthly, and data from each population were combined per site. To reduce the chance of artificially inflating or deflating population estimates based on seasonal fluctuations, total density per site was computed as the average of all monthly density estimations expressed as iguanas/ha, considering:

$$d = \frac{\sum_{i=1}^{n} D}{n}$$

where d = mean of all density estimations per transects expressed as iguanas/ha; D = density estimation per individual transect expressed as iguanas/ha; and n = number of ha.

We analyzed density by year, season, and site; however, one study site (DG) was not sampled in 2011. Additionally, sex ratio and age structure were not obtained in only one of the populations at the DC site due to reduced visibility of individual characteristics in that habitat. We used non-parametric statistics because our dependent variable (density) was not normal after transformation. To evaluate spatial (among sites) and temporal (among the different years of study) density differences, we used Mann-Whitney and Kruskal-Wallis tests (Siegel and Castellan 2001). Finally, we used chi-squared tests to analyze sex ratio (% of females) and age structure (% of non-adults) per year, season, and site. We used the Bonferroni correction to reduce the familywise error rate for multiple comparisons. Therefore, the significance level was set at $\alpha = 0.003$ throughout the paper.

RESULTS

Density patterns.—Density of iguanas per year and site are shown in Table 2. We recorded the highest densities at the CSF (32.6 iguanas/ha) and CAM (26.9 iguanas/ha) sites, and the lowest density at GH (1.9 iguanas/ha). Mean density with all years combined differed statistically among sites ($H = 135.37$, df = 5, $P < 0.0001$; $n = 274$) and between combined mainland and combined offshore areas ($U = 2395.00$, $P < 0.0001$; $n = 274$).

We noted two sites with statistically significant differences in densities among the three years. In 2013, density decreased at the CSF site ($H = 15.59$, df = 2, $P = 0.0004$; $n = 22$), while density increased at the DC site ($H = 25.43$, df = 2, $P < 0.0001$; $n = 134$). Among

TABLE 2. Density (adults/ha) of *Cyclura nubila nubila* from six protected areas in Cuba. Mean and coefficient of variation (CV) are reported per year and for the entire study. *n* is the number of maximum density estimates.

Study Site	Year	Density	CV	*n*	Total Density	Total CV	Total *n*
Guanahacabibes (GH)	2011	1.9	44.4	8	1.9	42.2	26
	2012	1.8	43.9	10			
	2013	1.9	44.4	8			
Delta del Cauto (DC)	2011	5.3	95.2	51	8.3	98.8	134
	2012	6.7	100	53			
	2013	12.7	67.4	30			
Desembarco del Granma (DG)	2011	-	-	0	9.2	60.2	41
	2012	9.2	92.3	9			
	2013	9.2	60.3	32			
Cayos San Felipe (CSF)	2011	34.7	7.9	6	32.6	17.4	22
	2012	37.5	5.9	8			
	2013	26.2	12.0	8			
Cayos Ana María (CAM)	2011	26.7	19.9	7	26.9	17.0	28
	2012	31.5	6.0	6			
	2013	25.1	15.2	15			
Cayos Jardines de la Reina (CJR)	2011	4.9	57.5	8	7.2	88.9	24
	2012	6.0	57.7	6			
	2013	9.8	90.6	10			

the offshore sites, variability in densities (as recorded using the coefficient of variation) was higher in the CJR site relative to the CSF and CAM sites (Table 2).

Density did not differ by season (H = 6.19, df = 2, P = 0.069; n = 274), although monthly densities showed a variable pattern. Density of iguanas per month at two representative mainland and offshore study sites are shown in Fig. 2. Mainland areas showed density peaks that varied annually (at GH), or were consistent over time (June at the DC site; Fig. 2). Density estimates for iguanas inhabiting offshore protected areas (CSF and CAM) showed no monthly peaks (Fig. 2). Using our density estimates for each study site and all years, we estimate the population's size to be: 1,490.3 ± 123.0 iguanas at GH; 7,634.9 ± 719.4 iguanas at CSF; 5,116.4 ± 221.1 iguanas at CAM; 8,437.8 ± 1,212.2 iguanas at CJR; 8,818.8 ± 990.9 iguanas at DC; and 8,852.0 ± 1,022.2 iguanas at DG.

***Sex ratio (% females) and age structure (% non-adults) patterns*.**—We recorded sex ratio and age structure at four sites (GH, CSF, CJR, and DC) over the entire three-year study (Fig. 3). Percent females averaged 52.9 ± 5.7% (range, 38.9–84.0%). Across all years and seasons, sex ratios were equivalent between males and females (minimum χ^2 = 0.19, df = 2, all P > 0.003; Table 3). Age structure (% non-adults) averaged 30.8 ± 11.0% (range, 13.3–89.9%) for the

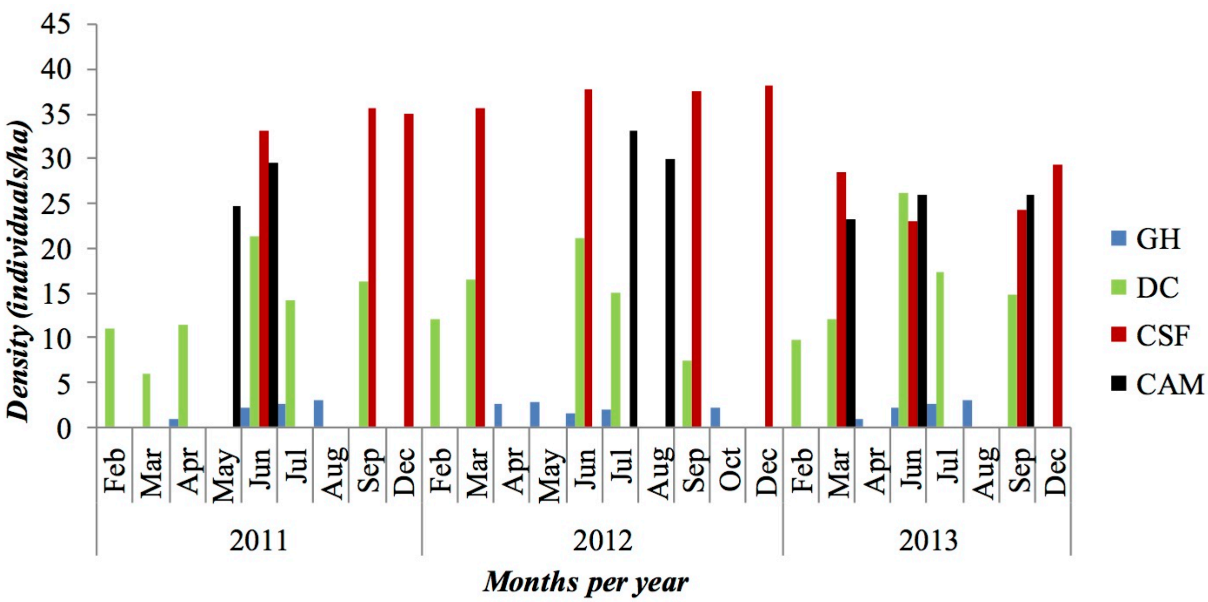

FIGURE 2. Seasonal changes in density (individuals/ha) of *Cyclura nubila nubila* in four sites in Cuba: Guanahacabibes (GH), Delta del Cauto (DC), Cayos de San Felipe (CSF), and Cayos de Ana María (CAM).

TABLE 3. Mean sex ratio (% females) and age structure (% non-adults) of Cuban Iguanas reported by season identified in this study. Standard deviation (SD) and coefficient of variation (CV) are reported. *n* is the number of maximum density estimates.

Season	Sex ratio (% females)				Age structure (% non-adults)			
	Mean	SD	CV	*n*	Mean	SD	CV	*n*
Pre-nesting	53.8	17.2	31.9	11	31.1	12.8	41.2	11
Reproductive	64.6	15.7	24.4	22	29.1	11.6	39.8	13
Post-reproductive	65.3	8.6	13.1	6	44.3	20.7	46.8	13

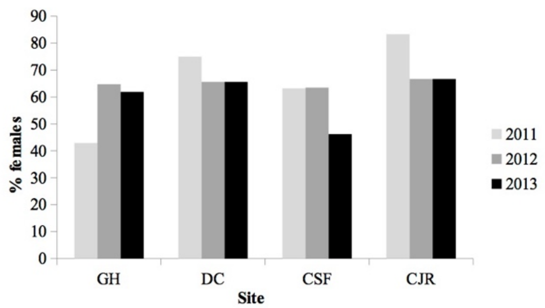

FIGURE 3. Sex ratio (% females) for *Cyclura nubila nubila* across three years at four study sites in Cuba: Guanahacabibes (GH), Delta del Cauto (DC), Cayos de San Felipe (CSF), and Cayos Jardines de la Reina (CJR).

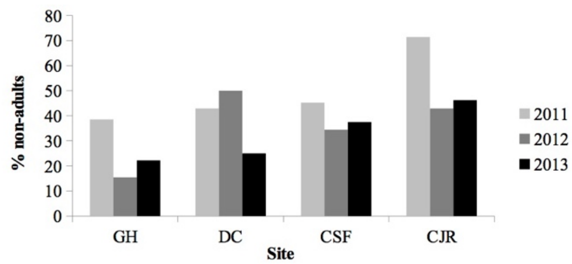

FIGURE 4. Age structure (% non-adults) for *Cyclura nubila nubila* across three years at four study sites of in Cuba: Guanahacabibes (GH), Delta del Cauto (DC), Cayos de San Felipe (CSF), and Cayos Jardines de la Reina (CJR).

three years at the four study sites (Fig. 4). Across all years and seasons, there was a general trend towards a decrease from 2011 to 2013 (Fig. 4) and an increase in the post-reproductive season (Table 3) of non-adult iguanas detected, although not statistically significant (all $P > 0.003$).

DISCUSSION

Density patterns.—This study represents the longest, continuous monitoring effort for the Cuban Rock Iguana inhabiting Cuba. The work is significant, especially because four of the six study sites (CAM, CJR, DC, and DG) had never been surveyed prior to this study. Results suggest that iguana densities vary depending on geography and location (mainland or offshore). The offshore sites, including Cayos de San Felipe National Park (CSF) and the Cayos de Ana María Fauna Refuge (CAM), supported the highest densities of iguanas (32.6 and 26.9 iguanas/ha, respectively). Relatively high densities for rock iguanas inhabiting smaller cays (higher than 26.9 iguanas/ha) have also been documented in The Bahamas. For example, the Allen Cays Rock Iguana (*Cyclura cychlura inornata*) can reach densities of 150.0 iguanas/ha (Iverson et al. 2006), while the Acklins Rock Iguana (*Cyclura rileyi nuchalis*) can reach densities of 92.7 iguanas/ha (Iverson et al. this volume). The higher densities reported at two of our offshore sites may be influenced by constrained geographic area and subsequent higher detection probabilities, lack of predators, and relatively less human disturbance. Interestingly, iguana densities were low (7.2 iguanas/ha) in the offshore Jardines de la Reina National Park (CJR). This density estimate is equivalent to our mainland populations, and may be influenced by the larger area of cays, higher prevalence of patchy vegetation structure, higher tourism and poaching pressure during the 1990s (G.R. Abad, pers. comm.), and habitat alteration due to recent natural events (hurricanes).

Our mainland sites, Guanahacabibes National Park (GH), Delta del Cauto (DC), and Desembarco del Granma National Park (DG), supported the lowest densities (1.9, 8.3, and 9.2 iguanas/ha, respectively). In general, mainland sites (i.e., larger islands) with rock iguanas typically support lower densities. For example, densities of *C. cychlura cychlura* from Andros Island (6,000 km^2) reach 2.5 adults/ha and up to 150 adults/ha for *C. cychlura inornata* inhabiting the Exuma Cays (4 ha; Knapp et al. 2006). The lower reported densities from mainland sites may be the result of increased predation pressure from a higher diversity and density of predators (e.g., snakes and birds). Indeed, snakes have been reported to be the most significant predators of iguana hatchlings from other islands (Knapp et al. 2010) and may be absent from some offshore cays. Lower overall density estimates, as well as higher seasonal and annual variability in densities, at the three mainland sites could also be driven by unconstrained space and a resultant increase in seasonal mobility, as well as lower detection rates.

Anthropogenic pressure may also influence iguana density and variability at mainland sites on Cuba. The mainland protected areas in our study are subject to measured levels of human visitation and feeding because of public access and the use of recreation facilities. Elsewhere on Cuba, negative effects of anthropogenic activities have been documented for *C. nubila,* including more intense social interactions and aggressive behavior among individuals (Alberts et al. 2001, Lacy and Martins 2003). Anthropogenic threats from roads are multifaceted and often relate to a species' specific ecological and life-history traits, behaviors, and movement patterns (Forman et al. 2003). Iguanas, in particular, are susceptible to road mortality (see Knapp et al. this volume), and a relatively recent constructed road at our mainland GH site may be responsible for the low iguana density and lack of observed monthly density peaks (Fig. 2). Subsequent to a road being built through the GH site in 2004, iguana density decreased from 8.9 iguanas/ha to 4.3 iguanas/ha in 2006 (Cobián et al. 2008). Iguana densities were consistently lower at this study site (1.9 iguanas/ha) over three years (Table 2). Our long-term density estimates in the Cayos de San Felipe National Park (CSF) suggest a decrease in 2013, which coincides with a fire that same year. Alternatively, our estimates at the Delta del Cauto Fauna Refuge (DC) site suggest an increase, which may be attributed to effectiveness of protective measures such as an increase in the number of rangers, with the consequent decrease in illegal hunters and fishermen in the area. Although longer time scales are necessary for confident inferences, our collective monitoring efforts suggest that long-term surveys have potential to detect both acute and persistent perturbations, as well as assess the efficacy of protection efforts.

Previous research on *C. nubila nubila* throughout Cuba from 2001 to 2006 also explored spatial and temporal trends in population densities from several populations (González et al. 2007; Table 4). The authors surveyed 16 populations inhabiting a group of cays in northern Cuba (Sabana-Camagüey Archipelago), a population in Guanahacabibes National Park, three populations on cays in the south of Cuba (Los Canarreos Archipelago), six populations in the Jardines de la Reina Archipelago, three populations in the eastern part of mainland Cuba, and one population in southern Sancti Spiritus Province. The study revealed a similar density pattern for mainland and offshore populations (González et al. 2007; Table 4). Future research should evaluate body size among mainland and offshore iguana populations to determine if proximate environmental effects (e.g., plant species diversity, rainfall, etc.) influence body size, growth rates, fecundity, and age to maturity as seen in other rock iguanas such as *Cyclura cychlura* inhabiting large and small islands (Knapp et al. 2006). A better understanding of site-specific ecology for the species would be useful for effective management and conservation across its range.

Sex ratio (% females) and age structure (% non-adults) patterns.—Unexpectedly, sex ratios did not differ significantly among seasons throughout the study. We suspected that our sex-specific detection probabilities might differ between seasons because of potentially variable movement patterns between the sexes. Knapp and Owens (2005) reported that home ranges expanded and movement increased for males during the pre-reproductive and reproductive seasons as males searched for mating opportunities. Home ranges and movements, however, decreased for females during the same seasons as they oviposited and guarded their nest sites. It is possible that we were not 100% accurate with determining the sex of observed individuals, or females and males may have unique movement and nest guarding behavior relative to their populations, and other species. The possible increase in non-adult iguanas observed in the post-reproductive season most likely is attributed to a pulse of hatchlings from the previous nesting season. Over time, these individuals can be removed from the population through natural (Knapp et al. 2010), or un-natural predation from invasive mammalian species (Wiewandt and García 2000, Pérez-Buitrago 2007, Pérez-Buitrago et al. 2008).

Implications for management.—As the potential for anthropogenic impacts increases within Cuban protected areas, long-term monitoring is crucial to rapidly detect perturbations and apply effective mitigation strategies targeted for specific populations. Rapid detection is especially critical at insular sites, which are constrained in area yet support highly dense populations. Impacts may take longer to manifest in mainland protected areas but these areas are more likely subject to persistent pressures over time. Long-term density data derived from monitoring allow managers to quantify impacts of acute perturbations such as fire (e.g., Cay Sijú in 2013) or the potential introduction of non-native mammals (e.g., feral cats). Long-term monitoring data also can quantify impacts that take longer to reveal such as human encroachment on sensitive areas, periodic

TABLE 4. Minimum and maximum values of density (adults/ha) obtained in this and a previous study of *Cyclura nubila nubila* throughout Cuba.

Geographic area	Minimum density	Maximum density	Source
Cays on northern shore	5.6	35.0	González et al. (2007)
Cays on southern shore	6.5	37.5	González et al. (2007)
Cays on southern shore	7.2	32.6	this study
Island of Cuba	2.6	24.2	González et al. (2007)
Island of Cuba	1.8	9.2	this study

poaching, or iguana behavior changes associated with human interactions.

The National System of Protected Areas of Cuba has technical, capable, and professional personnel mandated with managing and protecting the flora and fauna within the System. There is substantial opportunity to conduct simultaneous monitoring with standardized protocols throughout the country. The challenge is to retain consistent funding and equipment for long-term, simultaneous monitoring efforts. This study should justify the benefits of such a program.

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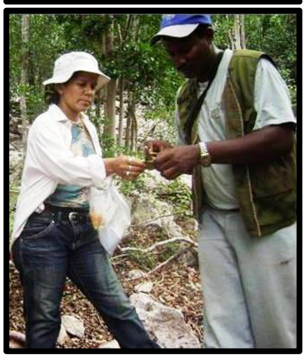

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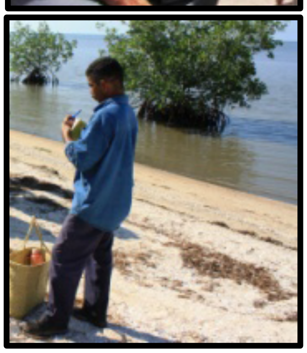

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