

Natural history and morphometry of the Cuban iguana (*Cyclura nubila* Gray, 1831) in Cayo Sijú, Cuba

K. Beovides–Casas & C. A. Mancina

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Abstract

Natural history and morphometry of the Cuban iguana (Cyclura nubila Gray, 1831) in Cayo Sijú, Cuba.— The report presents data about the Cuban iguana population (*Cyclura nubila nubila*) inhabiting Cayo Sijú, an 88 ha island off the southwest coast of Cuba. Population densities estimated using strip transects were higher in xerophytic coastal scrub (6.72 ± 6.25 iguanas/ha) than in typical sand vegetation (3.63 ± 2.71 iguanas/ha) and mangrove forests (2.9 ± 2.9 iguanas/ha). The total population for the cay was estimated at 350 individuals with an adult biomass of approximately 11.67 kg/ha. Densities varied minimally between three habitat types and between the wet and dry seasons. No significant density fluctuations were found one month after Hurricane Ivan affected the cay. Iguana burrows were encountered most frequently in beach dunes. Analysis of 30 scat samples revealed eight species of plants, with the fruits of *Chrysobalanum icaco* and the leaves of *Batis maritima* being the most frequently identified items. The remains of crab (*Cardisoma guandhum*) and insects of the order Hemiptera were also present in scat samples. Sexual dimorphism was evident in this population, with males being significantly larger in eight morphological variables. The snout–vent length measurements were larger in this population than in those reported in two cays off the south coast of Cuba.

Key words: Cuban iguana, *Cyclura nubila nubila*, Ecology, Morphometry, Diet.

Resumen

Historia natural y morfometría de la iguana cubana (Cyclura nubila Gray, 1831) en Cayo Sijú, Cuba.— En este trabajo se presentan datos sobre una población de iguana cubana (*Cyclura nubila nubila*) que habita en Cayo Sijú. Este pequeño cayo, de aproximadamente 88 ha, se encuentra al sur de la costa más occidental de Cuba. La densidad de población, estimada mediante transectos, resultaba mayor en el matorral xeromorfo costero (6.72 ± 6.25 iguanas/ha) que en la vegetación típica de la costa arenosa (3.63 ± 2.71 iguanas/ha) y los manglares (2.9 ± 2.9 iguanas/ha). Estimamos que en el cayo existe una población total de 350 iguanas y una biomasa de iguanas adultas de unos 11.67 kg/ha. Las densidades mostraron poca variación entre los tres tipos de hábitat y entre las estaciones seca y húmeda. No se hallaron fluctuaciones significativas un mes después de que el huracán Iván afectara al cayo. Se encontró que la mayoría de los refugios de las iguanas estaba en las dunas de la playa. Se identificaron ocho especies de plantas en 30 muestras fecales analizadas, siendo los frutos de *Chrysobalanum icaco* y las hojas de *Batis maritima* los elementos más frecuentes; además se encontraron restos de cangrejos (*Cardisoma guandhum*) e insectos del orden Hemiptera. En esta población el dimorfismo sexual era evidente, siendo los machos mayores en ocho variables morfológicas. En ella se daban mayores valores de longitud hocico–cloaca que en otras que habitan en dos cayos de la costa sur cubana.

Palabras clave: Iguana cubana, *Cyclura nubila nubila*, Ecología, Morfometría, Dieta.

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Karen Beovides–Casas, Empresa para la Protección de la Flora y la Fauna, MINAGRI, Av. Boyeros esquina Capdevila # 12555, Municipio de Boyeros, Ciudad de La Habana, Cuba.— Carlos A. Mancina, Inst. de Ecología y Sistemática, CITMA, Carretera de Varona Km 3 ½, Capdevila, Municipio de Boyeros, Ciudad de La Habana, Cuba.

Corresponding author: Karen Beovides–Casas. E–mail: karen@ffauna.sih.cu

Introduction

West Indian rock iguanas (genus *Cyclura*) form a unique group of nine species and 15 subspecies inhabiting tropical dry forests in the Greater Antilles, Caiman Islands and the Bahamas (Etheridge, 1982; Alberts, 2000). These iguanas are among the world's most endangered lizards, primarily as a result of habitat degradation and the negative effects of exotic species (Henderson, 1992; Alberts, 2000). Rock iguanas are the largest native herbivores on many islands; they are therefore important elements of the ecosystems they inhabit for their high biomass and their role in dispersing seeds and enhancing seed germination (Hartley et al., 2000; Iverson, 1985).

Cyclura nubila has two subspecies; *C. n. caymanensis* is native from two islands, Little Cayman and Cayman Brac, and *C. n. nubila* (wide) is distributed on Cuba. Mitochondrial DNA analysis, scale characters, color patterns, geographic and reproductive isolation, recently led Burton (2004) to propose that *Cyclura nubila lewisi* on Grand Cayman, can be considered a distinct species. The Cuban iguana is well distributed around Cuba (Rodríguez-Schettino, 1999), mainly in xerophilic coastal areas, but relatively safe populations are found only in some cays along the north and south and in isolated protected areas of the mainland. Although it is included in the IUCN Vulnerable category (Beovides et al., 1996; Alberts, 1999), *Cyclura nubila nubila* shows higher abundant populations than the other species of the genus; the total population of this subspecies in Cuba was estimated at 40,000 to 60,000 individuals (Perera, 2000). This subspecies has been also introduced on Islas Magueyes, southwest of Puerto Rico (Christian, 1986).

Given that relative healthy populations still exist in the wild, Cuban iguana can serve as a valuable model to develop conservation strategies for other endangered rock iguanas (Alberts, 2000). The goal of this study was to estimate the density and characterize the morphometry of the Cuban iguana population in Cayo Sijú, as well as to determine aspects of its natural history. This information could be essential for future conservation and management programs of the Cuban iguana on Cayos de San Felipe.

Material and methods

Study area

Cayos de San Felipe is a microarchipelago off the southwest coast of Cuba; it is comprised of 40 cays and islets with a total area of 42,900 ha (Snap, 2002). Cayo Sijú (fig. 1) is a small cay with an overall area of 88.25 hectares. This cay is characterized by three habitat types: mangrove forests, xerophytic coastal scrub, and sand vegetation. The mangrove forests cover 60% of the cay surface and the predominant plants are *Rhizophora mangle* and

Avicennia germinans. The xerophytic coastal scrub covers 25% and it is located in the central zone of the cay; scrub communities are represented primarily by *Chrysobalanum icaco*, *Metopium toxiferum*, and *Trinax radiata*. The rest of Cayo Sijú consists of beaches where sand vegetation prevails.

Methods

We visited Cayo Sijú in February, April, June, July and August, 2004. Twelve transects were made each month: two in the mangrove forest, five in the xerophytic coastal scrub, and five in the sand vegetation. The transects were used to determine the density of iguanas per habitat as well as burrow density; a total of 60 transects were run during the course of the study. The transect was 500 m long and 10 or 20 m wide, depending on the density of the vegetation; transects were made between 10:00 and 13:00 hrs. Density was estimated by dividing the number of iguanas observed by the area of the transect (Iverson, 1979: 334). A trip in October 2004 allowed us to determine the population status of the iguanas one month after the cay was damaged by Hurricane Iván. This hurricane was a category 5 of the Saffir-Simpson scale, with winds of up to 250 km/h, and a sea level increase of up to 2.5 m.

Thirty scat samples, corresponding to June 2004, were analyzed. The samples were examined under dissecting microscope, and the vegetable remains were compared with reference material collected in the study area.

Morphology

Forty-four individuals were captured (26 males and 18 females), by means of fishing nets or by noosing. All lizards were marked and released after measures. For all specimens, we recorded the following morphological variables to the nearest 0.1 mm: total length, snout-vent length (SVL), tail length, humerus length, femur length, head length, head width, and body mass to the nearest 0.1 kg. The sex of the iguanas was determined by secondary sexual characters and cloacal probing. All individuals without defined secondary sexual characters and those not reaching more than 23 cm of SVL were considered juvenile (Perera, 1984). The morphological analyses examining sexual dimorphism were restricted to adults (over 35 cm SVL in males, and 30 cm SVL in females; see Perera, 1984). Literature data of average snout-vent lengths of adult males and females were used to determine differences in size among four Cuban iguana populations (Cayo Sijú, Beovides-Casas & Mancina, this study; Cayo Rosario, González et al., 2001; Cayo Largo del Sur, Perera, 1984; Cayo Ballenato, Beovides, unpublished data). The SVL was used instead of body mass because the presence of eggs in females and fat bodies in either sex can affect estimates among populations. We used published data only if the mean, standard deviation, and sample size were available.

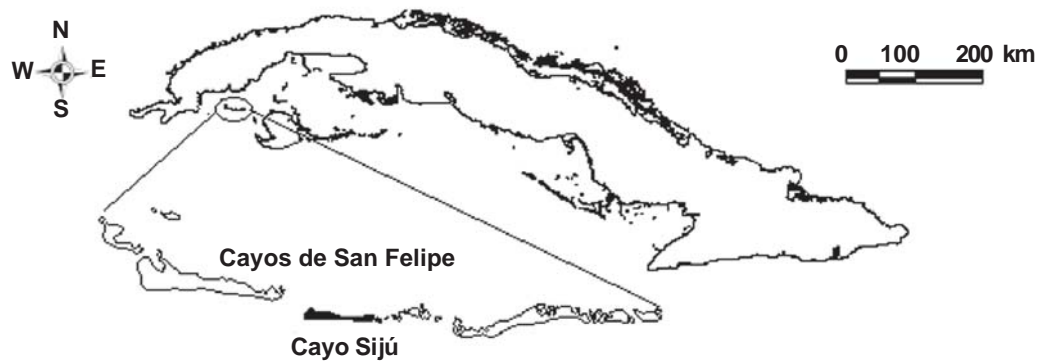


Fig. 1. Map of Cayos de San Felipe, southwest of Cuba.

Fig. 1. Mapa de los Cayos de San Felipe, al sudoeste de Cuba.

Statistics

A Kruskal–Wallis and Mann–Whitney U test were used to evaluate differences in the density between habitats and across two seasons, respectively. The seasonal analysis was performed combining the data of each month per season (dry: February and April, and wet: June, July and August). We used unpaired two-tailed t -tests to test for sexual size dimorphism; differences in the snout–vent length were estimated for four populations of Cuban iguanas using a one-way ANOVA as well as multiple t -tests (Tukey test). All statistical tests were conducted using Statistical v. 6.0 (StatSoft, 2001).

Results

The density of Cuban iguana on Cayo Sijú was 5.11 ± 5.04 iguanas/ha, varying between 2.43 ± 3.4 in February and 7.75 ± 6.7 in June. The iguanas were observed in the three available habitats, although the xerophytic coastal scrub showed the highest density. No significant differences were found between the three habitats ($H = 3.53$, $df = 2$, $p = 0.17$) (fig. 2). Contrary to the overall density, the density of juvenile iguanas showed significant differences among the habitats ($H = 8.89$, $df = 2$, $p = 0.011$), with higher values in the xerophytic coastal scrub (fig. 2). Based on the density data for each transect and the body mass of all adult

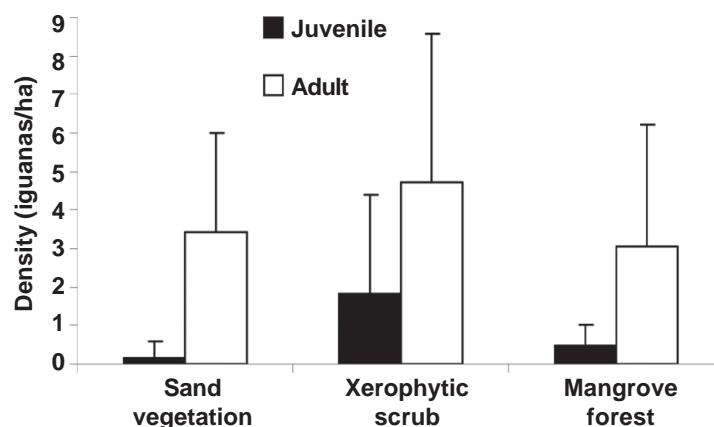


Fig. 2. Density of iguanas, *Cyclura nubila*, in three habitats on Cayo Sijú, Cayos de San Felipe, Cuba. Values are shown as the mean and the vertical line indicates the standard deviation.

Fig. 2. Densidad de iguanas, *Cyclura nubila*, en tres hábitats de Cayo Sijú, Cayos de San Felipe, Cuba. Las barras representan los valores medios y las líneas verticales la desviación estándar.

iguana captured (including both sexes), we estimated an adult biomass of approximately 11.67 kg/ha in the cay, with an estimate per habitat of about 13.88 kg/ha in the xerophytic scrub, 10.13 kg/ha in sand vegetation, and 9.03 kg/ha in the mangrove forests.

The density of iguanas was higher in the surveys corresponding to the wet season in the three habitats (fig. 3), although only the sand vegetation showed significant differences in seasonal density ($U = 23.5$, $p = 0.017$).

When iguana density in August (before the Hurricane) was compared with that in October (one month after the Hurricane), no statistical differences were observed in the sand vegetation ($U = 4.4$, $p = 0.84$) or xerophytic coastal scrub ($U = 10.0$, $p = 0.67$). The mangrove forest was not compared statistically because in October only one transect was run; this transect however did show a high value of density (8 iguanas/ha).

The density of burrows was higher in the sand vegetation associated to the beaches (21.9 ± 7.4 burrows/ha) than in the xerophytic coastal scrub (7.1 ± 5.7 burrows/ha) ($U = 6.0$, $p = 0.001$); no burrows were observed in the mangrove forest. We examined two burrows; these were 12 m from the coastal line and at 0.5 meters up the sand dune. The length of the main galleries was 1.56 and 1.42 m respectively, there were no lateral galleries in either burrow, and both entrances were oriented southward.

Eight species of plants were found in the scat samples (table 1). Most of the scats (93%) had between one and three items; and only two presented four or five items. The fruits of *Chrysobalanum icaco* and the leaves of *Batis maritima* were the most frequently identified material. We found animal remains in 12 samples; the most frequent were the crab *Cardisoma guandhumi* (16.6%) and another unidentified crab (13.3%). Remains of insects of the order Hemiptera were also found.

The population of *Cyclura nubila* of Cayo Sijú showed a marked sexual dimorphism; all variables differed significantly between sexes (table 2). The males were greater than females in all the studied variables. We found an overlap in all corporal variables, although this was lower in the snout-vent length, body mass and head width.

Significant differences were found in the snout-vent length of males SVL ($F = 15.8$; $df = 3,69$; $p < 0.0001$) and females ($F = 5.65$; $df = 3,55$; $p < 0.0019$) among four Cuban iguana populations of cays (fig. 4). The males showed a higher variation than females in the SVL. The males of Cayo Sijú were larger in SVL than males of Cayo Rosario and Cayo Largo del Sur (Tukey test, $p < 0.001$), and they did not differ significantly in relation to those from Cayo Ballenatos (Tukey test, $p > 0.05$). Little variation was found in the females, although the females of Cayo Ballenatos were larger than Cayo Rosario females (Tukey test, $p < 0.001$).

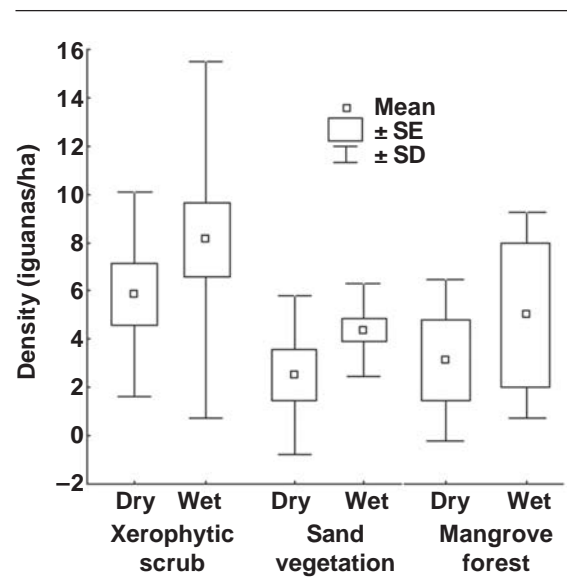


Fig. 3. Seasonal variation of the density of iguanas in three habitats on Cayo Sijú, Cayos de San Felipe, Cuba.

Fig. 3. Variación estacional de la densidad de iguanas en tres hábitats de Cayo Sijú, Cayos de San Felipe, Cuba.

Discussion

The densities of iguanas in Cayo Sijú were in the range of other populations of Cuban iguana (Perera, 1985a; González et al., 2001; Alberts et al., 2002) and other rock iguanas of the genus *Cyclura* (Carey, 1975; Gicca, 1980). The higher density of juvenile iguanas in the xerophytic coastal scrub could be related to ecological factors such as the high diversity of food resources and roost sites that would make them less vulnerable to predators. In this cay, eight egret species, two birds of prey (Common Black-Hawk, *Buteogallus anthracinus*, and American Kestrel, *Falco sparverius*) and one species of colubrid snake (*Alsophis cantherigerus*) have been observed (Mancina & Beovides, 2005), all potential predators of hatchling and juvenile iguanas (Henderson & Sajdak, 1996; Alberts, 2000).

Our estimates of biomass of iguanas in Cayo Sijú were similar to those found for other *Cyclura* species; i.e. 17.01 kg/ha in *Cyclura carinata* on Caicos Island (Iverson, 1979), and 11.6 kg/ha in *Cyclura pinguis* on Anegada, Virgin Island (Carey, 1975). Other estimates show higher values of biomass for *Cyclura cyclura* on Exuma Cays, Bahamas (Carey, 1976) and *Cyclura rileyi nuchalis* on Acklin Bight, Bahamas (Hayes et al., 2004), although these studies combined juveniles and adult iguanas.

Table 1. Items found in 30 scat samples of *Cyclura nubila* collected on Cayo Sijú, Cayos de San Felipe, Cuba. All samples were collected during the month of June, 2004: ¹ Previously reported in the diet of Cuban iguana, *Cyclura nubila nubila*; ² Number of scat samples where the item was found; L. Leaves; F. Fruit.

Tabla 1. Elementos encontrados en 30 muestras fecales de *Cyclura nubila* recolectadas en Cayo Sijú, Cayos de San Felipe, Cuba. Todas las muestras corresponden al mes de junio del 2004: ¹ Encontrada anteriormente en la dieta de la iguana de Cuba, *Cyclura nubila nubila*; ² Número de muestras fecales en las que se encontró el elemento; L. Hojas; F. Fruto.

Plant species	L	%	F	%
<i>Chrysobalanum icaco</i> ¹			29 ²	96.7
<i>Batis maritima</i>	18	60		
<i>Strumphia maritima</i> ¹	1	3.3	2	6.6
<i>Sorghum halepense</i>	1	3.3		
<i>Sesuvium portulacastrum</i>	1	3.3		
<i>Conocarpus erectus</i> ¹	1	3.3	1	3.3
<i>Metopium toxiferum</i> ¹	1	3.3	1	3.3
<i>Erithalis fruticosa</i> ¹	1	3.3		

The lower values of density observed in the dry season (February and April) may be related to changes in the thermoregulatory behavior of these iguanas. The lowest environmental temperatures were registered during this season (between 13°C–25°C), the rock iguanas, like other ectothermic vertebrates (Bennett, 1983; Christian et al., 1986) could decrease their activity levels during the coldest months being less conspicuous. On the contrary, during the wet months the iguanas show a high activity in relation to breeding behavior. Perera (1985a) found no seasonal difference in the density of iguanas in Cayo Largo del Sur, and he related this to the absence of any marked changes in temperature during the study time.

The higher density of burrows excavated in the beach as compared to other habitats could be related to the development of the dune, the soft soil and moisture in this area, and to a more compact soil in the rest of the key. Burrows for most of the iguanas of Cayo Sijú are concentrated on the beach dune, and when the foraging period starts individuals move to different areas. In Cayo Real, a cay located to the west of Cayo Sijú, the burrows were scarce along the beach (Beovides & Mancina, obs. pers.). In this cay we observed a dune of smaller proportions while the rocks are typically exposed in many parts of the shore, offering natural roosts for the iguanas. Perera (1985a) found that in an area where sandy and rocky soil were available for the iguanas, the reptiles preferred the latter, apparently related with minimizing the energy expenditure in the construction of the burrow.

Table 2. Summary of sexual dimorphism in morphological traits (lengths in mm) in *Cyclura nubila nubila* from Cayo Sijú, Cayos de San Felipe, Cuba. The last column presents the results from unpaired two-tailed *t*-tests for sexual size dimorphism.

Tabla 2. Resumen del dimorfismo sexual según las variables morfológicas (longitudes en mm) de *Cyclura nubila nubila* de Cayo Sijú, Cayos de San Felipe, Cuba. La última columna muestra el valor del estadístico *t* y el nivel de significación.

	Adult male			Adult female			Two-tailed <i>t</i> -tests
	N	Mean±SD	Range	N	Mean±SD	Range	
Total length	26	1000.8±110.3	710–1119	18	824.3±62.9	690–910	<i>t</i> = 5.6, <i>p</i> < 0.001
Snout–vent length	26	451.3±46.6	370–520	18	340.0±24.4	305–370	<i>t</i> = 9.1, <i>p</i> < 0.001
Tail length	26	560.7±89.1	320–730	18	485.5±57.2	320–560	<i>t</i> = 2.8, <i>p</i> < 0.006
Humerus length	26	64.5±7.3	49.2–80	18	49.3±3.5	43–55.5	<i>t</i> = 7.7, <i>p</i> < 0.001
Femur length	26	102.9±11.3	80.5–122	18	78.5±6.04	66.6–90	<i>t</i> = 8.1, <i>p</i> < 0.001
Head length	26	103.5±17.2	71.1–123	18	72.5±5.5	61.8–83.1	<i>t</i> = 6.8, <i>p</i> < 0.001
Head width	26	63.8±8.7	48.9–75.8	18	43.3±3.9	35.7–51.6	<i>t</i> = 9.1, <i>p</i> < 0.001
Body mass (kg)	26	4.1±1.08	2.04–5.5	18	1.7±0.4	1.05–2.4	<i>t</i> = 8.1, <i>p</i> < 0.001
(Body mass/ SVL)*100	26	0.89±0.1	0.53–1.19	18	0.43±0.1	0.34–0.64	<i>t</i> = 7.8, <i>p</i> < 0.001

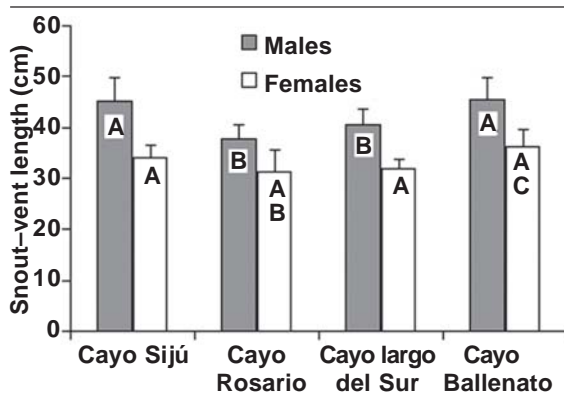


Fig. 4. Variation in snout-vent length in four populations of *Cyclura nubila nubila* from Cuba. Values indicate the mean and the vertical line indicates standard deviation; the letters indicate the significant differences using a Tukey Test to $p < 0.01$.

Fig. 4. Variación de la longitud hocico-cloaca en cuatro poblaciones de *Cyclura nubila nubila* de Cuba. Las barras representan los valores medios y las líneas verticales la desviación estándar; las letras indican las diferencias significativas utilizando un test de Tukey con $p < 0.01$.

Hurricanes are very frequent catastrophic disturbances in the West Indies and they play an important role in the structure of animal communities (Wunderle et al., 1992; Spiller et al., 1998; Jones et al., 2001). On September 12th, 2004, Hurricane Ivan, a category 5 cyclone on the Saffir-Simpson scale, hit the west of Cuba, including Cayos de San Felipe. This hurricane notably changed the physiognomy of the cay; the xerophytic coastal scrub was covered by sand in a large area and vegetation was destroyed. Contrary to what was expected, no significant variation was detected in the density of iguanas when we compared iguana populations before and after this climatic event.

Short-term affectation of the iguana population after hurricane could be related to several characteristics of the species: like other lizards, rock iguanas exhibit low resting levels of oxygen consumption compared to mammals and birds. This low rate of energy demand has the advantage of permitting survival on very little food and enabling periods of tolerance to the limited availability of food (Bennett, 1983). Furthermore, they are herbivorous lizards. We observed that the mangrove forest was the vegetation least affected by the hurricane; it could therefore represent an important roosting and feeding area for the iguanas during stressful times. We did not find scat

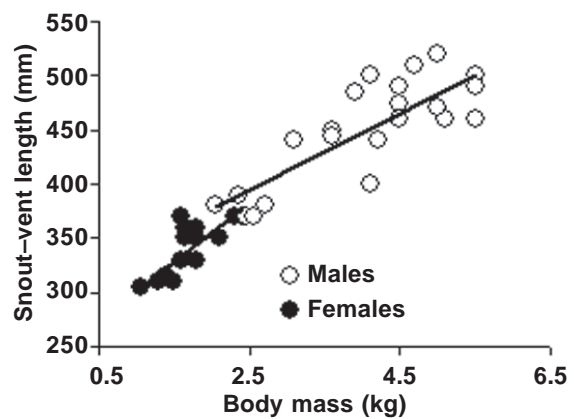


Fig. 5. Sexual dimorphism in two morphological variables of Cuban iguana, *Cyclura nubila*, on Cayo Sijú, Cayos de San Felipe, Cuba.

Fig. 5. Dimorfismo sexual en dos variables morfológicas de la iguana cubana, *Cyclura nubila*, en Cayo Sijú, Cayos de San Felipe, Cuba.

samples during the month of October; but Perera (1985b) found remains of leaves and flowers of the two species of mangroves (*Rizophora mangle* and *Avicenia germinans*) in the scat samples of *Cyclura nubila* on cays near Cayo Largo del Sur. The damage observed in the xerophytic coastal scrub could cause long term changes in the population structure as this habitat is apparently an important site for the survival of juvenile iguanas. Future studies are necessary to determine the effect of this natural disturbance on the population of Cuban iguana on Cayo Sijú.

The Cuban iguana is a generalist phytophagous animal, and its diet depends on the floristic composition of each locality (Perera, 2000). Sixty-two percent of the species of plant that we found in the scat samples had been reported in the diet of the Cuban iguana in other cays of the Cuban archipelago (Perera, 1985b; González et al., 2001). The iguana could exploit the peak of productivity of some plants; for example in June, 96% of 30 scat samples presented remains of *Chrysobalanum icaco* and this month coincides with the fructification peak of this plant (Beovides, pers. obs.). Animal matter has been found in the diet of the Cuban iguana (Perera, 1985b) and this could be an important source of nitrogen.

The presence of sexual dimorphism (males larger than females) in the Cuban iguana has been observed by Perera (1984) and González et al. (2001). In Cuban iguanas at Guantánamo Bay, Alberts et al. (2002) found no differences in body mass between nonranking males and females. We found a light overlap of the body mass be-

tween sexes in the population of Cayo Sijú, although with approximately the same body mass, the males have a longer snout–vent (fig. 5). In other species of rock iguanas, sexual dimorphism has been previously documented for *Cyclura carinata* (Iverson, 1979), *Cyclura collei* (Vogel, 2000) and *Cyclura cornuta* (Ottenwalder, 2000). This sexual difference has been related mainly with the home range, territoriality and the mating systems (Stamps, 1983). We observed frequently aggressive behavior among males in all months, although it increased in the reproductive season. Males with missing fingers were observed, and two individuals had a forearm completely mutilated. We found an iguana phalange in one scat sample. Such agonistic interaction has been observed in other herbivorous iguanids and it has been related with territoriality (Stamps, 1983; Alberts et al., 2002).

The variation in the snout–vent length in both sexes of the Cuban iguana could be related with variability of the species across a wide geographic range (Rodríguez–Schettino, 1999). However, the higher differences in the males may be the result of collecting bias. In the population of Guantánamo Bay, Alberts et al. (2002) found significant differences in the SVL among males of different social rank; the high–ranking males were larger in SVL than both low and nonranking males. The larger SVL observed in the population of Cayo Ballenato may be the result of higher levels of heterozygosity; in this cay the iguanas were likely reintroduced from nearby coastal zones. Although we have no evidence of such, it is possible that iguanas on cays have a smaller effective population size than on the main island. On the cays, the populations could present lost genetic variation as a consequence of genetic drift (Frankham, 1997; Lacy, 1987), which would account for smaller sizes (e.g. lower SVL) among other effects (Harris & Allendorf, 1989). Ecological factors such as the density of iguanas and the food resource abundance could also explain the differences observed among the populations.

We consider that it would be interesting to carry out studies on the genetic structure of the populations of the Cuban iguana. This would allow us to determine the genetic flow of the species, and the presence of isolated subpopulations could play a major role in conservation management of the Cuban iguana in Cuba.

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