Journal of Herpetology, Vol. 46, No. 4, 578–586, 2012

Ecology and Conservation of the Turks Island Boa (*Epicrates chrysogaster chrysogaster*: Squamata: Boidae) on Big Ambergris Cay

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Abstract.—**The boid genus *Epicrates* contains 10 species in the West Indies, several of which are listed as threatened or endangered, whereas the status of the others remains unknown. Little is known about Turks Island Boas (*Epicrates chrysogaster chrysogaster*), a subspecies of the Southern Bahamas Boa endemic to the Turks and Caicos Islands, and no published ecological studies exist for this subspecies. A long history of human habitation, greatly exacerbated by exponentially increasing development in the last several decades, appears to be threatening the remaining populations of these boas. However, a lack of basic ecological information is holding back conservation efforts. Here we report on the first multiyear ecological study of Turks Island Boas, focusing on an important population located on the small island of Big Ambergris Cay in the southeastern margin of the Caicos Bank. Encounter rates of up to 3.5 snakes per person-hour make this population especially easy to study. We captured 249 snakes, 11 of which were recaptures. We provide basic natural history information including size, color pattern, girth, body temperature, abundance, diet, activity, diurnal refuge selection, and population size. We also clarify the known distribution and discuss the conservation concerns of this species. This study fills a gap in our ecological knowledge of Bahamian boas and will provide important baseline data for the Big Ambergris Cay population of Turks Island Boas as this small island undergoes extensive development over the next several decades.**

The genus *Epicrates* (Squamata: Boidae) is composed of 14 or 15 species, nine of which are restricted to single islands or island banks in the Greater Antilles and Bahama Archipelago (Schwartz and Henderson, 1991; Tolson and Henderson, 1993), with a likely 10th species in the Virgin Islands (Henderson and Powell, 2009; Hedges, 2010). The five mainland *Epicrates* species are distributed from Nicaragua to Argentina and on the continental islands of Trinidad, Tobago, and Margarita (Passos and Fernandes, 2008). The three subspecies of the Southern Bahamas Boa, *Epicrates chrysogaster*, occur on the Turks and Caicos Islands (*Epicrates chrysogaster chrysogaster*), Great Inagua (*Epicrates chrysogaster relicquus*), and the Crooked-Acklins Islands (*Epicrates chrysogaster schwartzi*) of the lower Bahama Archipelago (Schwartz and Henderson, 1991). Little has been published on the distribution and natural history of the Turks Island Boa, *E. c. chrysogaster* (Henderson and Powell, 2009). No previous study has investigated the characteristics of a single population; the most recent published study (Buden, 1975) relied on 53 specimens representing several localities, populations, and subspecies.

It has been demonstrated that human influences have and are continuing to cause drastic declines in island populations of some native reptile species in this region, such as the endemic iguana, *Cyclura carinata* (Iverson, 1978; Gerber and Iverson, 2000). There is reason to suspect that *E. c. chrysogaster* populations have been impacted similarly but conservation efforts have been hampered by a lack of basic ecology and natural history data. Here we present results of a multiyear natural history investigation of *E. c. chrysogaster* on a small island, Big Ambergris Cay and report on anthropogenic threats to this population. We present data on distribution, size, body temperature, diet, activity, refugia, coloration, and abundance, and discuss conservation concerns. Our intention is to characterize for the first time the natural history of this species, clarify its distribution in the archipelago, document the threats to and extirpations of this species, obtain estimates of population size, and discuss this information in the context of conservation in the region.

Materials and Methods

Study Site.—The small, privately owned island of Big Ambergris Cay is located approximately 21 km south of South Caicos (Lat: 21.299, Long: −71.633, max. elev. 32 m) on the southeastern end of the Caicos Bank in the Turks and Caicos Islands (Figs. 1, 2). Big Ambergris Cay is home to the largest remaining population of Turks and Caicos Iguanas (*Cyclura carinata*) and is thought to have the highest density of Turks Island Boas in the Turks and Caicos (Reynolds, 2011a). The 400-ha island consists of exposed limestone rock and sand interspersed with coppice, palm forest, and xeric scrub (sensu: Iverson, 1979) and is currently being developed with nearly two-thirds of the island slated to become vacation homes, dirt roads, an international airport, marina, country club, and support facilities (http://www.tcsportingclub.com). The island is considered a stronghold for *Cyclura* and *Epicrates*, as its remote location, and, until recently, lack of human inhabitants has so far spared it from large-scale introductions of cats or other nonnative mammals. The population of *C. carinata* is being monitored, and some individuals displaced by development have been used to re-establish the species on other islands (Mitchell et al., 2002; Alberts and Gerber, 2004; Gerber, 2007). This study was conducted near the beginning of large-scale construction on the island, when the population of Turks Island Boas was presumably minimally affected. The study will also serve as an important baseline assessment for future comparison after full development of the island.

Capture and Processing.—We conducted fieldwork during five trips to Big Ambergris Cay between 2007 and 2010. The first study period, conducted by RGR, occurred December 2007; the second and fourth, conducted by GPG, occurred in February 2008 and June 2009, respectively; and the third and fifth were joint trips in March 2009 and March 2010, respectively (Table 1). Volunteers trained in herpetological survey techniques generally assisted with fieldwork. Surveys were conducted between 0700 h and 0230 h, and most of the island was surveyed both diurnally and

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DOI: 10.1670/11-079

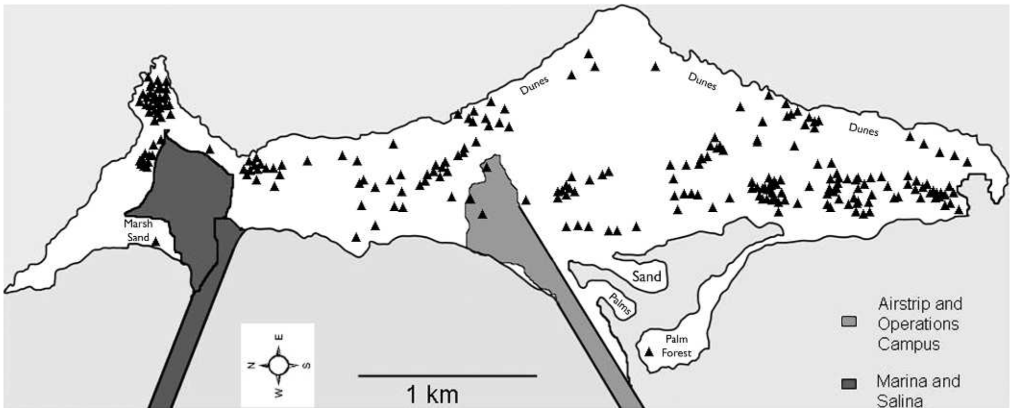

FIG. 1. Big Ambergris Cay, Turks, and Caicos Islands. Triangles represent captures of 249 individual *Epicrates chrysogaster chrysogaster*. The dark gray area on the north end of the island is the natural salina and the recently constructed harbor entrance, an unsuitable habitat for boas. Lighter gray near the center of the island represents the extent of the heavily developed operations campus, airport, and airstrip extending southwest. Boas are occasionally found in the operations campus area. Areas of sand and sandy palm forest do not appear to be preferred habitat for boas on Big Ambergris Cay, because they lack rocks to hide under and have much lower densities of some lizard species (*Leiocephalus*, *Aristelliger*).

nocturnally. Diurnal surveys included turning over and replacing cover objects such as rocks, logs, and palm fronds, whereas nocturnal surveys entailed walking in suitable habitat using battery powered headlamps and handheld flashlights or driving slowly along the island's many new dirt roads in golf carts.

Snakes were hand captured, placed in cloth bags, processed, and released at the point of capture. Body temperature was measured in nocturnally active snakes to the nearest 0.1°C immediately after capture by insertion of a quick-reading cloacal thermometer anteriorly into the cloaca until a constant reading was obtained. Ambient air temperature at 1 m above the surface was recorded with the same thermometer. For snakes located under cover objects during diurnal surveys, note was made of the size (length and width in centimeters) and type of cover object used and air temperature 0.5 m above the surface (in the shade), and soil temperature 2 cm beneath cover objects were recorded to 0.1°C with a standard 6-inch soil thermometer. Mass was measured to the nearest gram with a spring scale, and snout–vent length (SVL) and tail length (TL) were measured to the nearest millimeter by stretching the snake along a ruler. Head width (widest point anterior to posterior margin of parietal scales) and head length (posterior edge of jaw to snout) were measured to 0.1 mm using vernier calipers. Body girth (circumference at widest point) was measured by wrapping a

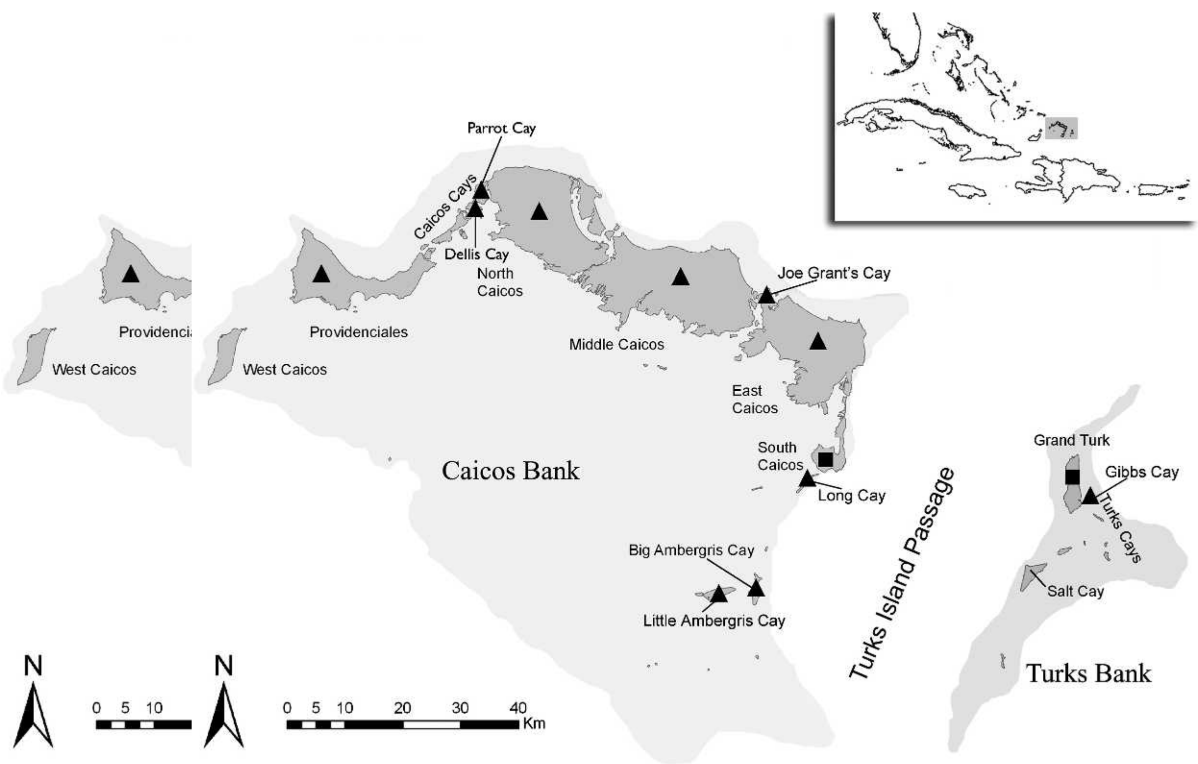

FIG. 2. Known distribution of *Epicrates chrysogaster chrysogaster* in the Turks and Caicos Islands. Triangles represent extant populations of boas, whereas squares denote probable extirpations. Shaded outlines indicate the approximate extent of the Caicos and Turks banks.

TABLE 1. Sampling effort and captures by date and moon phase for nocturnal and diurnal sampling.

Date	Moon phase	Nocturnal effort person/hours	# Nocturnal captures	Diurnal effort person/hours	# Diurnal captures	Captures per hour	
						Nocturnal	Diurnal
4 Dec 2007	Waning crescent	3	1	3	3	0.33	1
5 Dec 2007	Waning crescent	3	3	3	2	1	0.67
6 Dec 2007	Waning crescent	2	4	3	3	2	1
7 Dec 2007	Waning crescent	2	5	4	0	2.5	0
8 Dec 2007	Waning crescent	0	0	2	1	–	0.5
10 Dec 2007	New moon	6	9	1	1	1.5	1
11 Dec 2007	Waxing crescent	3	3	0	0	1	–
12 Dec 2007	Waxing crescent	3	3	1	0	1	0
13 Dec 2007	Waxing crescent	2	6	4	0	3	0
14 Dec 2007	Waxing crescent	2	7	3	0	3.5	0
22 Feb 2008	Full moon	6	5	0	0	0.83	–
23 Feb 2008	Full moon	3	2	0	0	0.67	–
24 Feb 2008	Full moon	3	4	0	0	1.3	–
17 Mar 2009	Waning gibbous	20	14	0	0	0.7	–
18 Mar 2009	Waning gibbous	21	22	2	1	1.05	0.5
19 Mar 2009	Third quarter	9	12	0	0	1.33	–
20 Mar 2009	Waning crescent	18	18	0	0	1	–
21 Mar 2009	Waning crescent	14	12	3	1	0.85	0.33
22 Mar 2009	Waning crescent	26	22	2	1	0.85	0.5
23 Mar 2009	Waning crescent	16	1	0	0	0.06	–
24 Mar 2009	Waning crescent	16	8	0	0	0.5	–
22 Jun 2009	New moon	9	6	0	0	0.67	–
7 Mar 2010	Waning gibbous	6	5	0	0	0.83	–
8 Mar 2010	Third quarter	11	5	0	0	0.45	–
9 Mar 2010	Third quarter	9	7	0	0	0.78	–
10 Mar 2010	Waning crescent	9	17	1	1	1.89	1
11 Mar 2010	Waning crescent	14	19	0	0	1.36	–
12 Mar 2010	Waning crescent	20	15	0	0	0.75	–
	Totals	256	235	32	14	0.92	0.44

string around the body and recording this length to the nearest millimeter. Sex was determined by cloacal probing with ball-tipped probes. Color pattern for each individual was assessed and classified as one of six color morphs: single—single row of spots or saddles; pair—dorsolaterally paired spots; stripe—two or four dorsolateral stripes; little—little to no pattern present on ≥2/3 of the body length; broken stripe—stripes interrupted by paired spots or areas with no pattern; mixed—mixture of single, double, and saddle spots. For subsequent identification, each individual was implanted with a passive integrated transponder (PIT) tag (Trovan®). PIT tags were inserted subdermally on the left side approximately 5 cm anterior to the cloaca. Capture coordinates were recorded for each individual using a GPS.

All statistical analyses were performed with R 2.3.1 (R Development Core Team, 2010). Quantitative data are reported as means (±1 SD) and ranges. Normality of data was checked by comparing density plots and testing for equality of variance (*F*-test). Nonparametric Welch *t*-tests were used when morphometric or temperature data did not conform to a normal distribution nor had unequal variances. Otherwise, a Student's *t*-test was used to compare means of independent morphometric or temperature variables, or a paired Student's *t*-test was used for matched-pair data. For categorical encounter and capture data, a Pearson's χ^2-test or a *G*-test (likelihood ratio test) was used to test for statistical differences between observed and expected (i.e., null) frequencies. A two-sample test for equality of proportions was used to test for significance between proportions of observations between nocturnal and diurnal searching. In all tests, significance was determined by a Type I error of 0.05 or less. Population size was estimated using the R-package *Rcapture* (Baillargeon and Rivest, 2007) using Akaike's Information Criterion (AIC) model selection to select the abundance estimator that best fit the model based on a total of six sampling sessions. This method fits various log-linear models assuming a closed population.

RESULTS

Abundance.—In an estimated 288 person-hours of searching, we encountered 249 snakes, only 11 of which were recaptures. One boa was captured a total of three times. This represents an overall encounter rate of 0.86 snakes/person-hour. The nocturnal encounter rate was 0.92 snakes/person-hour ($N = 235$ encounters, 256 person-hours), significantly higher (two-sample test for equality of proportions $\chi^2 = 52.05$, df = 1, $P < 0.0001$) than the diurnal encounter rate of 0.44 snakes/person-hour ($N = 14$ encounters, 32 person-hours). The highest encounter rates observed for single searching sessions (both nocturnal) were 3.5 boas/person-hour, on 14 December 2007, when 7 boas were found in 2 person-hours of searching, and 3 boas/person-hour, on 13 December 2007, when 6 boas were encountered during 2 person-hours of searching (Table 1). Capture–recapture analysis yielded an estimated population size of 2,241 (±711) boas on Big Ambergris Cay under the *Mt*-model (Baillargeon and Rivest, 2007).

Recaptures.—Of the 11 recapture events, one individual was recaptured twice, and the other nine individuals were recaptured once. The average time between recaptures was 241.3 days (range = 2–466 days), and the average distance the individual moved between recaptures was 27.8 m (range = 9–73) (Table 2). Of those individuals measured when recaptured ($N = 9$), the average growth rate between recaptures was 0.15 mm/day SVL (Table 2), and no significant fit was found in a regression of growth rate and time between capture (slope = −1.16, $r^2 = 0.14$, $P = 0.78$).

TABLE 2. Recaptures of Turk's Island boas over the course of the study on Big Ambergris Cay, including distance, time, and growth between recapture events. Each individual is identified by an ID number corresponding to a PIT tag, and some individuals were recaptured more than once. Averages are given on the last line.

ID #	Distance between captures	Time between captures	Growth between captures (SVL)	Growth rate mm/day
29	11 m	2 days	–	–
29	19 m	74 days	26 mm	0.35
42	43 m	466 days	40 mm	0.086
51	24 m	390 days	–	–
71	24 m	462 days	14 mm	0.03
78	73 m	4 days	–	–
82	26 m	96 days	7 mm	0.07
85	27 m	96 days	50 mm	0.52
105	26 m	354 days	5 mm	0.014
116	9 m	356 days	11 mm	0.031
162	24 m	354 days	37 mm	0.1
AVG	27.8 m	241.3 days	23.8 mm	0.15

Activity.—All boas were encountered on the ground, either under cover during the day or abroad at night, with the exception of one snake found 2 m up a tree, one individual in a 1-m tall shrub, and two boas that were observed abroad after sunrise. Our sampling coincided with the full to waxing-crescent moon phases, with most sampling effort (144 person-hours) occurring during a waning-crescent phase. Boas were found during all six of these phases, and we found no significant difference between boas observed during each moon phase and what would be expected if there was no difference in captures between phases (Pearson's Chi-squared test $\chi^2 = 3.97$, df = 5, $P = 0.55$).

Sex Ratio.—The 249 captures represented 238 individual boas, of which 143 were male and 95 were female (Fig. 3), yielding a significantly different sex ratio of 1.5M:1F (*G*-test goodness of fit $G = 9.75$, df = 1, $P < 0.001$).

Diurnal Refugia.—The average estimated surface area of the rocks under which boas were taken was 1,562 cm^2, with a range of 500–3,248 cm^2, the largest being toward the upper limit of hand-movable rocks. Average soil temperature under the rocks was 27.5°C, 1.8°C less than the average ambient air temperature at the time of capture (Welch two-sample *t*-test $t = 1.9$, df = 18, $P = 0.07$).

Coloration and Pattern.—Of the 225 individuals assessed for color pattern on Big Ambergris Cay, we found 76 single individuals (32.9%), 69 paired individuals (30.7%), 24 striped individuals (10.7%), 17 little individuals (7.6%), 13 broken stripe individuals (5.8%), and 26 mixed individuals (11.6%). This significantly departs from an expectation of equal frequencies of each pattern in the population (*G*-test $G = 96.6$, $P < 0.001$).

Body Size and Sexual Dimorphism.—The average SVL and total length for snakes captured on Big Ambergris Cay was 677 ± 82.3 mm ($N = 237$, 416–1,028 mm) and 802.8 ± 92 mm ($N = 237$, 497–1,199 mm), respectively. Males averaged 667 ± 51.8 mm ($N = 142$, 489–865 mm) SVL with a tail length of 128.1 ± 10.2 ($N = 121$, 82–159 mm), and females averaged 692 ± 112.9 mm ($N = 95$, 416–1,028 mm) SVL with a tail length of 129.9 ± 17.1 ($N = 86$, 74–157 mm) (Fig. 3). Tail lengths include only individuals without damaged tails; 17% of male boas and 10.5% of female boas found had previously sustained tail damage. Females were significantly larger than males in SVL (Welch two-sample *t*-test $t = 2.03$, df = 119.3, $P = 0.04$) but not in TL (Welch two-sample *t*-test $t = 1.9$, df = 118.3, $P = 0.06$) (Table 3). However, the ratio of tail length to SVL for males (mean ratio = 0.193) and females (mean ratio = 0.189) did not differ significantly between the sexes (Welch two-sample *t*-test $t = 1.65$, df = 173.9, $P = 0.1$). Mass measurements were compromised for some of the individuals sampled, as a malfunction in one of the scales used was detected at a later date. However, of the individuals with reliable measurements, the average mass was 97 ± 51.7 g ($N = 187$, 17–390 g). Female mass (115 ± 76.4 g, $N = 65$, 17–390 g) was significantly greater than male mass (87.5 ± 27.6 g, $N = 122$, 29–197 g) (Welch two-sample *t*-test $t = 2.78$, df = 73.07, $P = 0.007$) (Table 3). A significant linear correlation was found for the ratio

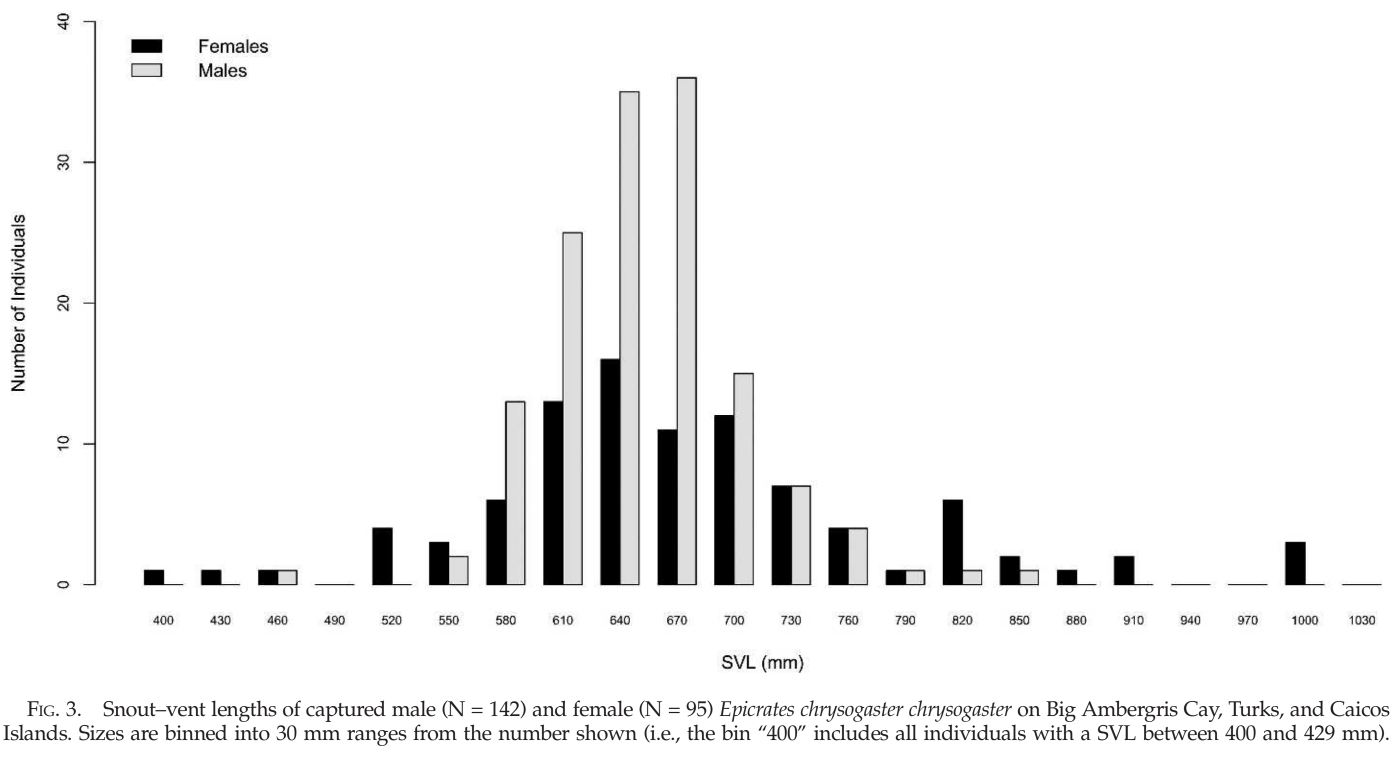

FIG. 3. Snout–vent lengths of captured male (N = 142) and female (N = 95) *Epicrates chrysogaster chrysogaster* on Big Ambergris Cay, Turks, and Caicos Islands. Sizes are binned into 30 mm ranges from the number shown (i.e., the bin "400" includes all individuals with a SVL between 400 and 429 mm).

TABLE 3. Summary of morphometric and temperature data for captured boas. Measurements were pooled and then partitioned by sex. Differences between the means for each sex were subjected to either a nonparametric Welch two-sample t-test (unequal variances) or a parametric Student's t-test (equal variances). Data includes the mean, standard deviation, number of observations, and range of observations. SVL indicates snout–vent length.

Sex	Mass (g)	SVL (mm)	Tail length (mm)	Girth (mm)	Head length (mm)	Head width (mm)	Body temp. (°C)	Air temp. (°C)
Combined	97 ± 51.7	677 ± 82.3	126.3 ± 15.6	51.9 ± 9.2	24.6 ± 3.7	14.7 ± 2.9	24.5 ± 1.6	23.5 ± 1.4
	$N = 187$	$N = 237$	$N = 236$	$N = 187$	$N = 187$	$N = 214$	$N = 147$	$N = 147$
	17–390	416–1028	56–171	22–90	15.5–44.2	9.2–30	21.2–29.8	19.8–26.4
Female	115 ± 76.4	692 ± 112.9	127.9 ± 18.3	53.9 ± 12.7	25.8 ± 5.3	15.8 ± 4.1	24.7 ± 1.9	24.6 ± 1.5
	$N = 65$	$N = 95$	$N = 93$	$N = 66$	$N = 65$	$N = 81$	$N = 53$	$N = 53$
	17–390	416–1028	74–171	22–90	15.5–44.2	9.2–30	21.5–29.8	19.8–26.4
Male	87.5 ± 27.6	667 ± 51.8	125.3 ± 13.5	50.8 ± 6.4	23.8 ± 2.3	14.0 ± 1.7	24.3 ± 1.3	23.4 ± 1.3
	$N = 122$	$N = 142$	$N = 142$	$N = 121$	$N = 122$	$N = 133$	$N = 94$	$N = 94$
	29–197	489–865	56–159	34–66	17.4–32.1	9.2–20.4	21.2–28.0	19.8–26
Difference between sexes	$t = 2.78$	$t = 2.03$	$t = 1.19$	$t = 1.86$	$t = 2.90$	$t = 3.66$	$t = 0.94$	$t = 0.77$
	df = 73.1	df = 119.3	df = 156.4	df = 83.3	df = 77.5	df = 96.8	df = 74.3	df = 145
	$P = 0.007$	$P = 0.04$	$P = 0.23$	$P = 0.066$	$P = 0.005$	$P = 0.0004$	$P = 0.35$	$P = 0.44$

of body mass to SVL in both males (slope = 1.6, $r^2 = 0.71$, $P < 0.001$) and females (slope = 0.58, $r^2 = 0.86$, $P < 0.001$).

Female head length for the Big Ambergris Cay population was 25.8 ± 5.3 mm ($N = 65$, 15.5-44.2 mm) and width was 15.8 ± 4.1 mm ($N = 81$, 9.2–30.0 mm), whereas male head length was 23.8 ± 2.3 mm ($N = 122$, 17.4–32.1 mm) and width was 14.0 ± 1.7 mm ($N = 133$, 9.2–20.4 mm). Head length (Welch two-sample t-test $t = 2.90$, df = 77.5, $P = 0.005$) and width (Welch two-sample t-test $t = 3.66$, df = 96.8, $P = 0.0004$) were significantly larger for females than males (Table 3).

Mean girth for captured snakes was 51.9 ± 9.2 mm ($N = 187$, 22–90 mm), with a mean female girth of 53.9 ± 12.7 mm ($N = 66$, 22–90 mm) and a mean male girth of 50.8 ± 6.4 mm ($N = 121$, 34–66 mm) (Table 3). Female girth did not differ significantly from male girth (Welch two-sample t-test $t = 1.86$, df = 83.3, $P = 0.066$).

Body Temperature.—Mean (cloacal) body temperature was 24.5 ± 1.6°C ($N = 147$, 21.2–29.8°C), relative to a mean ambient air temperature of 23.5 ± 1.4°C ($N = 147$, 19.8–26.4°C), for a mean BT/AT ratio of 1.03. Female BT averaged 24.7 ± 1.9°C ($N = 53$, 21.5–29.8°C) and was not significantly different (Welch two-sample t-test $t = 1.4$, df = 78.3, $P = 0.16$) than the average male BT of 24.3 ± 1.3°C ($N = 94$, 21.2–28.0°C). Mean female BT/AT ratio was 1.05 ± 0.07°C ($N = 53$, 0.96–1.30) and was not significantly larger (Welch two-sample t-test $t = 0.94$, df = 74.3, $P = 0.35$) than that for males (1.04 ± 0.04°C; $N = 94$, 0.95–1.2) (Table 3). Female (paired t-test $t = 2.8$, df = 21, $P = 0.01$) and male (paired t-test $t = 5.9$, df = 58, $P < 0.01$) body temperatures were significantly higher than ambient air temperatures.

Discussion

Abundance.—*Epicrates* in the Bahamas may be unhderstudied because of a perceived low abundance, which would make study of wild populations extremely time consuming (Henderson and Powell, 2007). However, some populations in the Greater Antilles are notable for their density. Tolson et al. (2007) suggest that *Epicrates monensis monensis* is fairly abundant in the tropical dry forest of Isla Mona, particularly in areas that have retained understory growth. Cave-associated *Epicrates inornatus* in Puerto Rico (Puente-Rolón and Bird-Picó, 2004) and *Epicrates angulifer* in Cuba (Hardy, 1957; Sheplan and Schwartz, 1974) may be found with some regularity, although their abundance outside of these feeding aggregations is difficult to assess. *Epicrates* are generally secretive snakes, are heavily persecuted, and are sensitive to invasive mammalian predators (Tolson and Henderson, 2006, 2011) and toxic introduced prey (Wilson et al., 2010). As such many populations require a great deal of effort to survey or locate non-road–killed individuals (Reynolds, 2011b; Reynolds et al., 2011). In contrast, we have found *E. c. chrysogaster* to be very abundant on Big Ambergris Cay and probably represents the densest population of *Epicrates* known in the Bahamian Archipelago, and possibly in the West Indies outside of the Puerto Rico Bank (U.S. Fish and Wildlife Service, 2005). Although capture–recapture estimates are based on only 11 recaptures over six sampling sessions, preliminary population size estimates are 2,241 (SE ± 711) individuals, yielding a density estimate of 5.04 snakes/ha assuming even distribution of appropriate habitat across the island. These data indicate that Big Ambergris Cay might have an extremely large population of boas given its relatively small area. It should be stressed, however, that the accuracy of this estimate would be much improved by additional sampling trips yielding more recaptures.

Recaptures.—Average distance between recaptures was relatively low, with an average movement distance of only 27.8 m (Table 2). Because these snakes were all captured when foraging, it is possible that the movement data indicates that the snakes have a relatively small foraging area; however, much more data are needed to characterize home ranges. Growth between recaptures varied considerably, with some individuals having growth rates of as low as 0.014 mm/day or as high as 0.52 mm/day (Table 2). This could indicate a high variation of foraging success or variation in reproductive investment among individuals, although additional data will be needed to understand variation in growth among individuals.

Activity.—Many large macrostoman snakes, including most members of the family Boidae, are ambush predators in that they select microhabitats in which to wait to ambush passing prey (Mushinsky, 1987). This behavior is associated with a suite of physiological characteristics, including up and down regulation of digestive functions and infrequent feeding (Secor and Ott, 2007). Several West Indian boas, including *Corallus* (Henderson, 2002), *Epicrates striatus warreni* (Tolson and Henderson, 1993), *Epicrates monensis monensis* (Tolson et al., 2007), and *Epicrates gracilis* (Tolson and Henderson, 1993), are active arboreal nocturnal foragers, in that they seek out inactive prey such as sleeping lizards and birds. However, few examples exist of terrestrial active foragers among the boas. Of the 249 boas captured on Big Ambergris Cay, 236 were found while nocturnally active, and two were found diurnally active.

Individuals were observed to slowly investigate cracks and crevices in rocks, presumably seeking out sleeping lizards. Two individuals were found foraging arboreally: one was found 2 m up a 4-m tall tree; and another was found 0.5 m high in a 1-m high shrub, indicating that individuals of this population might occasionally leave the ground to pursue sleeping *Anolis* or active *Aristelliger*. Hence, we argue that *E. c. chrysogaster* is an uncommon example of an active terrestrial foraging boid.

Sex Ratio.—Although the observed sex ratio of 1.5 males to 1 female indicates that significantly more males were encountered than were females, it is unclear whether this represents a biased sex ratio or merely sampling error. Most of our sampling took place in March, when males begin to actively search for mates; thus, it is possible that males were more active than females and, hence, more commonly encountered.

Juveniles.—Few juveniles were detected during field surveys on Big Ambergris Cay, and little information exists on the growth rate of juveniles or the size of Turks Island Boas at maturity. In a large congeneric species, *Epicrates inornatus*, females are thought to mature at a minimum SVL of 1,350 mm (Huff, 1978), whereas adult female *E. m. monensis* average 963.8 mm SVL and 230.8 g (Tolson et al., 2007). Both of these species are much larger than *E. chrysogaster.* Turks Island Boas are thought to be biennially reproductive (Tolson and Henderson, 1993), and a gravid female collected from North Caicos in the early summer gave birth during early fall (Buden, 1975), whereas other gravid females taken from the wild gave birth in July and September (Reynolds and Deal, 2010). Tolson (1980) reported the mass from neonates from a single litter weighed as between 7.3 and 8.4 g. Reynolds and Deal (2010) measured a litter of 17 one-month-old neonates from a dam on Providenciales, obtaining an average SVL of 297.7 mm and an average mass of 6 g. These authors also estimated growth rates of 20.4 mm SVL per month from parturition to 9 months of age based on measurements of newborn and young-of-year snakes from other islands. Therefore, we expect that the four individuals smaller than 500 mm SVL that we encountered represent young-of-year individuals. Based on these estimates, our data suggest that only four obvious juveniles were captured on Big Ambergris Cay in this study (Fig. 3). The smallest juvenile found, a female, was 416 mm SVL, 261 mm shorter than the mean SVL for both sexes. Low juvenile recruitment and a sampling bias toward larger individuals may be responsible for the low number of juvenile encounters, which represent less than 2% of the snakes captured. A further possibility is that young boas might be more fossorial, arboreal, or even subterranean, because juvenile habitat has not been characterized although several observations on North Caicos and Big Ambergris Cay suggest that juveniles are surface active at night and use diurnal refugia similar to adults (Reynolds and Deal, 2010).

Diurnal Refugia.—Refugial site selection might have significant effect on fitness in snakes (Webb et al., 2004; Shoemaker et al., 2009); hence it is important to characterize what constitutes good refugial habitat. Palm litter (Buden, 1975), fallen logs (Sheplan and Schwartz, 1974), and rock walls (Tolson and Henderson, 1993) all are regarded as potential refugia for this species. However, boas located under cover diurnally during our surveys ($N = 14$) were found exclusively beneath medium to large flat limestone rocks, especially on hillsides (see Fig. 4A,B). No specimens were found in palm litter, though this might still represent a good refugial site (Greene, 1997), and fallen logs are a rarity on this island. All rocks serving as refugia were laying flat on the substrate or only partially buried and usually less than 0.5 m from the nearest vegetation. Additionally, the limestone substrate of Big Ambergris Cay is conducive to the formation of underground passageways, interstices, and undercut boulders, providing a great deal of subterranean habitat, which the boas might be using. Particularly high densities of boas, especially large females, were encountered in the vicinity of shallow caves and large jumbles of limestone.

Coloration and Pattern.—Coloration in *E. chrysogaster* is generally light gray to brown with darker colored patterns on the dorsum, although occasional individuals on North Caicos and Providenciales retain juvenile coloration and are burnt orange with little dorsal patterning. Previous authors report two color morphs in *E. c. chrysogaster*: spotted and striped, with the striped morph suspected to be less common and restricted to the Caicos Bank (Sheplan and Schwartz, 1974; Buden, 1975). The patternless morph was described previously (Sheplan and Schwartz, 1974) based on an incomplete preserved individual but is not mentioned in Schwartz and Henderson (1991) or Tolson and Henderson (1993). We found considerable variation in the dorsal patterning of boas on Big Ambergris Cay and chose to use six pattern classes instead of two or three. Single and pair morphs are different examples of spotting patterns, whereas broken stripe and stripe more accurately describe striped morphs. Mixed morphs display a combination of stripe, broken stripe, and single or paired spots, while little pattern morphs range from much reduced amounts (patterning on less than one-third of the body length) of the above patterns to almost no pattern at all.

Body Size and Sexual Dimorphism.—It appears that the maximum body size of *E. c. chrysogaster* on small islands is smaller than on large islands such as North and Middle Caicos. The maximum SVL of wild individuals of this species is 1,321 mm (1,549 total length) or more, with some wild-caught captives reaching 1,540 mm (1,765 total length) (Reynolds et al., 2011). All of these size records originated from North Caicos, where the senior author has consistently found the largest snakes in remnant tropical dry forest habitat. It is commonly thought by most in the Turks and Caicos that female boas are consistently larger than males. This appears to be the case in terms of the upper size range, because the eight largest specimens (SVL 1,115–1,540 mm) examined by the senior author on North Caicos and Providenciales were female, as were the largest snakes captured on Big Ambergris Cay (SVL 1,003, 1,006, and 1,028 mm; 138, 141, and 163 mm longer than the largest male, respectively). In the Big Ambergris Cay population, mean female SVL is significantly larger than that for males (Table 3).

Body Temperature.—Body temperatures (BT) and body temperature to air temperature ratios (BT : AT) have not been reported previously for *E. chrysogaster*, although thermal biology is crucial for an understanding of snake ecology (Peterson et al., 1993). We found a mean ratio of BT : AT of 1.03, indicating that on average snakes maintain body temperatures higher than ambient air temperatures, and paired *t*-tests revealed a significantly higher body temperature for both male and female snakes relative to ambient air temperature. Although Peterson et al. (1993) point out that cloacal, ambient, and substrate temperature measurement might inadequately characterize thermal biology and thermal environment, we believe that these measurements serve as an effective approximation of these parameters. Our data collection on Big Ambergris Cay took place when females were not gravid; hence we did not expect nor did we find evidence of higher BT : AT ratios in female snakes relative to males.

Distribution.—Previous workers have reported *E. c. chrysogaster* from North Caicos, Middle Caicos, Long Cay off South Caicos, and Big and Little Ambergris Cays (Sheplan and Schwartz, 1974;

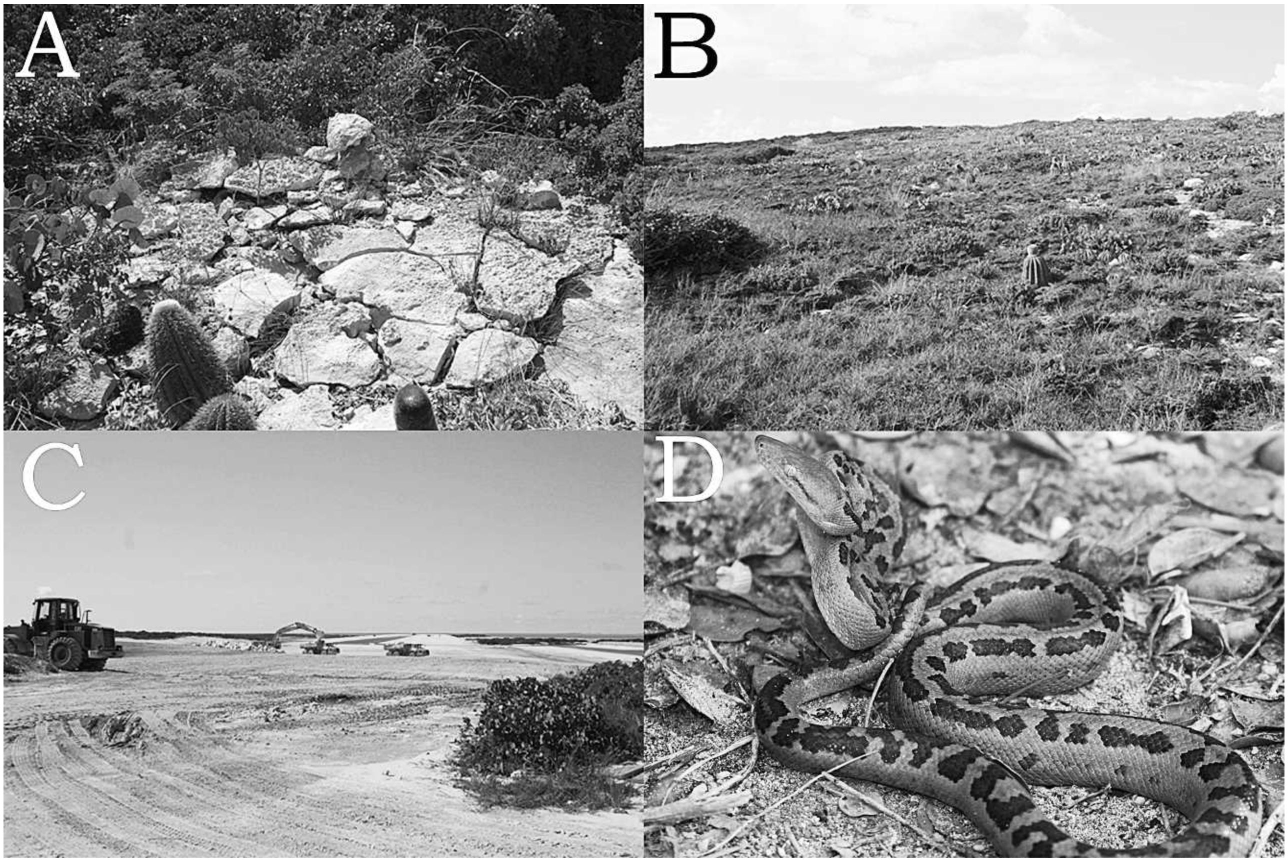

FIG. 4. (A) Typical diurnal refugium of *Epicrates chrysogaster chrysogaster* on Big Ambergris Cay, Turks, and Caicos Islands. Note large, flat rocks in a clearing, with vegetation less than a few meters away. (B) Astwood Ridge, Big Ambergris Cay, Turks, and Caicos Islands. This side of the hill, slated to be developed into 16 vacation homes, was found to contain many diurnal refugia for *E. c. chrysogaster*. Within the fore- to midground of this photo, seven individual boas were found during diurnal surveys, and an additional six individuals were found active at night. (C) Development of the airstrip and airport areas of Big Ambergris Cay, adjacent to the Operations Campus. (D) Adult male *E. c. chrysogaster* from Big Ambergris Cay. (Photographs by R. Graham Reynolds, 7 December 2007).

Buden, 1975; Schwartz and Henderson, 1991; Tolson and Henderson, 1993). Mitchell (2000) also reported an individual from the small island of Joe Grant's Cay, located at the north end of the shallow channel between East and Middle Caicos. Joe Grant's Cay could be treated as being a part of East Caicos, because the two islands are separated by only a shallow tidal flat, but we follow the precedent set by Mitchell (2000) and consider it separately. Buden (1975) suggested that boas might occur on Providenciales, Pine Cay, and East Caicos. It is now known that this species does occur on Providenciales (McCloud, 2008; Reynolds, 2011a,b), East Caicos (N. Manco, pers. comm., 2009), and Parrot Cay (Caicos Cays; N. Manco, pers. comm., 2011). Although records are lacking for most of the other Caicos Cays in spite of intensive searching by the authors and others (e.g., Iverson, 1986), the senior author recently received a report and photograph of an individual from Dellis Cay (courtesy of M. McGiffin) in the Caicos Cays, another private island currently under heavy development, with further anecdotal reports of sightings there from construction workers. This report, plus the suitability of the habitats, indicates that populations likely exist on other Caicos Cays even though cats are abundant on many of the islands. Thorough surveys of South Caicos in 1973–1975 (Iverson) and 2008 (RGR) have also failed to yield any specimens, although populations likely occurred there prior to destruction of the native vegetation by centuries of grazing domestic stock and the presence of feral predators (Reynolds, 2011a). More important, Reynolds (2011a,b) and Reynolds and Niemiller (2010) report a new population located on Gibbs Cay, a very small island located adjacent to Grand Turk. This extends the known range back to the Turks Bank, where the original holotype of the species purportedly was obtained on Grand Turk. The species has likely been extirpated from Grand Turk (Reynolds, 2011a), but it is possible that this species occurs on other islands on the Turks Bank (Buden, 1975), although surveys by RGR and M. Niemiller suggest that it does not occur on Grand Turk or Salt Cay, which are both highly modified habitats with a long history of human occupation (Mills, 2008). Therefore, the known range of extant populations of *E. c. chrysogaster* encompasses a total of 11 islands on the Turks and Caicos Banks, although they almost certainly occur on others (see Fig. 2).

Diet.—*Epicrates chrysogaster* feeds on small introduced rodents such as rats and mice (*Rattus*, *Mus*), as well as the chicks and eggs of introduced birds such as chickens (*Gallus*) (Sheplan and Schwartz, 1974; Buden, 1975; Schwartz and Henderson, 1991; Tolson and Henderson, 1993; Henderson and Powell, 2009). Other snakes in this genus are commonly called "fowl snakes," an apparent reference to their proclivity for domesticated gallinaceous birds (Sheplan and Schwartz, 1974). However, prior to 1997, none of these prey items occurred on Big Ambergris Cay except for a small population of introduced guinea fowl (*Numida*), although chickens have been introduced subsequently. Saurophagy in juveniles has been described (Sheplan and Schwartz, 1974; Buden, 1975), and Reynolds and Niemiller (2011) described saurophagy in the Gibbs Cay population of *E. c.*

chrysogaster, where an adult male ate an adult Turks and Caicos Curly-tailed Lizard (*Leiocephalus psammodromus*). On Big Ambergris Cay, we have found boas consuming lizards of four species (*Cyclura carinata*, *Leiocephalus psammodromus*, *Anolis scriptus*, and *Aristelliger hechti*), as well as stalking a sleeping *Mabuya sloanii*. Because many smaller islands in the Turks and Caicos lack gallinaceous birds or rodents, it is probable that the majority of the diet of small island populations of this boa consists of lizards.

Puerto Rican Boas, *E. inornatus*, have been observed consuming dead bats (*Erophylla*) under active colonies, including dried out and presumably long dead individuals (Rodríguez-Durán, 1996). In addition to live saurian prey, *E. c. chrysogaster* has been found to also readily consume carrion. During the course of our fieldwork, we discovered three boas feeding on adult road-killed Curly-Tailed Lizards, perhaps the second known record of necrophagy in the genus *Epicrates*. These carcasses were considerably degraded and dried out, having been run over repeatedly by vehicles. In addition, two individual boas were found on successive nights feeding on the same rotting road-killed carcass of a medium-sized female Rock Iguana (*Cyclura carinata*). One individual was attempting to consume a 15-cm piece of the carcass that had been torn off by Curly-Tailed Lizards during the day.

Conservation.—The West Indies is among the world's recognized biodiversity hotspots (Myers et al., 2000; Smith et al., 2005). The region's native reptiles and amphibians are of particular conservation concern because of their high diversity and endemism and extreme vulnerability to anthropogenic threats such as the direct destruction of habitat and the introduction of alien species, including potential competitors (Henderson and Powell, 2009; Hailey et al., 2011) as well as damaging predators such as feral cats (*Felis catus*), Indian Mongoose (*Herpestes auropunctatus*), and Black Rats (*Rattus rattus*) (Iverson, 1978; Corke, 1992; Smith et al., 2005; Tolson and Henderson, 2006, 2011). Conservation efforts in the region are also hampered by the paucity of published information on many taxa, resulting in a lack of ecological and natural history knowledge needed for sound management. Although some species of *Epicrates* in the West Indies have been better studied (e.g., Henderson and Powell, 2009), little is known about Bahamian *Epicrates* (Knapp and Owens, 2004; Henderson and Powell, 2009).

Our study of the population of Turks Island Boas on Big Ambergris Cay yielded important information about the demography and ecology of these animals that will serve to inform conservation workers in the region. Big Ambergris Cay is unique for two reasons: it is home to an extraordinarily dense population of *E. c. chrysogaster* and it is in the early stages of significant anthropogenic modification (Fig. 4C). Although the developers have thus far been cooperative and earnest in their desire to mitigate impacts of development for the local wildlife, lack of natural history information for many species has slowed implementation of protective measures. We feel confident that we have characterized the microhabitat of boas on the island, especially diurnal refugia, and can use this information to assist the developers in preserving important sites (e.g., Gerber, 1998). For instance, Astwood Ridge, a relatively large ridge (8–12 m) oriented N–S on the island, has many diurnal refugia on its eastern slope (Fig. 4A,B). This prompted us to request that home construction on the ridge minimize sloughing of materials or modification of the habitat downslope from the construction site.

The Turks and Caicos Islands are in the midst of a huge developmental expansion to accommodate an increasing tourist market. Tourism increased nearly 90% between 1995 and 2005, and in the rush to accommodate these visitors, more than 20 resorts opened during the same period on the island of Providenciales alone (Tsui, 2005). Incredibly, Providenciales has become so crowded in the last 15 years that new developments are moving to neighboring islands in the archipelago. In addition, small islands, such as Big Ambergris Cay, are being bought by foreign development companies and turned into exclusive vacation areas. It is our hope that mediation procedures based on ecological information such as that reported here will greatly increase the ability of workers to minimize the impact of rapid development on local fauna in the region.

We have attempted to augment information about natural history, distribution, and ecological attributes of the Turks Island Boa (*E. c. chrysogaster*). This basic information will form the foundation for future conservation efforts as the region continues to experience increased growth and development. Knowledge of the distribution, habitat preferences, and diet are critical to designing appropriate conservation measures (Gerber, 1998). Based on our research, future workers in the region should be able to identify probable microhabitats for this species and will hopefully be capable of guiding developers in decisions about sighting of current and future projects.

Acknowledgments.—We are extremely appreciative of the assistance of the following individuals in the field on Big Ambergris Cay (alphabetical order): K. Bradley, J. Burgess, M. Emery, Z. Harlow, T. J. Jett, C. Knapp, L. Mensen, T. Wagner, G. Waters, and M. Wilson. For field assistance on other islands, we thank C. Deal, B. N. Manco, and M. Niemiller. We thank the Turks and Caicos Sporting Club at Ambergris Cay for access, air transportation, and logistical support, and the Department of Environment and Coastal Resources, Turks and Caicos Islands, for scientific research permits. Financial support for this project was provided by the Mohamed bin Zayed Species Conservation Fund (RGR), the Department of Ecology and Evolutionary Biology, University of Tennessee, Knoxville Summer Research Grant Program (RGR), and the San Diego Zoo Institute for Conservation Research and the Offield Family Foundation (GPG). Methods involving animals used in this study have been approved by the University of Tennessee Institutional Animal Care and Use Committee (IACUC), Protocol no. 1701-0408. This work was authorized by scientific research permits (1–4 RGR) from the Department of Environment and Coastal Resources, Turks and Caicos Islands Government. G. Burghardt and A. Echternacht provided valuable comments on the manuscript, and we are grateful for comments from Bob Henderson, an anonymous reviewer, and the associate editor.

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Accepted: 15 September 2011.