

Population Estimate, Habitat Associations, and Conservation of the St. Croix Ground Lizard *Ameiva polops* at Protestant Cay, United States Virgin Islands

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ABSTRACT.—The status of the endemic St. Croix Ground Lizard (*Ameiva polops*), listed by the United States Fish and Wildlife Service as an endangered species in 1977, has become precarious on Protestant Cay (1.2 ha), an islet in Christiansted Harbor just off the northeastern coast of St. Croix, US Virgin Islands. Surveys were conducted throughout Protestant Cay from April to June 2002 in 23 habitat sampling units composed mainly of landscaped areas. The maximum number from one of three replicated censuses within each unit was summed over all units to yield a probable minimum population estimate. Thirty *Ameiva polops* were present in 10 sampling units (dry forest, beach) which had a higher density of ground litter and taller shrubs than areas where lizards were absent. The total occupied area was 0.23 ha (one-fifth of Protestant Cay) and lizard density in this area was 128/ha (an average of 25/ha for the entire cay). The long-term decline (ca. 35 yr) of *A. polops* on Protestant Cay is associated with deleterious landscaping practices of the hotel, especially raking and removal of litter. A habitat conservation plan or safe harbor agreement for Protestant Cay, designated critical habitat under Section 7 of the Endangered Species Act of 1973, must be implemented to prevent extirpation of *A. polops* from one of only three islets where it still occurs.

INTRODUCTION

The endemic St. Croix Ground Lizard *Ameiva polops* (Cope) was once abundant along the coast (Baskin and Williams, 1966; Philibosian and Ruibal, 1971; Dodd, 1980), but is now reduced to isolated populations on three offshore cays. Two sites are natural islets (Green and Protestant cays) along the northeastern shore of St. Croix; the third site is along the southern shore on a dredged-material islet (Ruth Cay) where the species was introduced in the 1990s (Knowles, 1990, 1997). Green Cay (which contains the largest population; see discussion) became a U.S. Fish and Wildlife Service refuge in 1977 primarily to protect this species. Unlike Green and Protestant cays, Ruth Cay has not been designated critical habitat for the St. Croix Ground Lizard, which has been listed as an endangered species since 1977 (Furniss, 1984). The three cays are mongoose-free. The National Park Service has, apparently, recently eradicated the small Indian mongoose from Buck Island (Z. Tillis-Starr, pers. comm.; see Philibosian and Ruibal, 1971; Philibosian and Yntema, 1976; and Furniss, 1984 for details on earlier, failed efforts), the only other cay off St. Croix.

The reliability of past population estimates for Protestant Cay is questionable because counts were derived using unknown (Philibosian and Ruibal, 1976; Dodd, 1978) or uncertain methods (Furniss, 1984; Knowles, 1997). Nonetheless, data suggest that a steady decline has occurred since 200 animals were stated to be present in 1967 (Philibosian and Ruibal, 1976), one to two years before a hotel (Hotel on the Cay) was built in 1968-1969. The lizards were widely distributed on Protestant Cay before development, as they are now on undeveloped Green Cay.

Other than anecdotal accounts (e.g., Philibosian and Ruibal, 1971), the only detailed quantitative description of suitable habitat for the St. Croix Ground Lizard has been based at Green Cay (Wiley, 1982 unpubl. ms.; Meier et al., 1993), where vegetation and habitat have been described and classified by Woodbury and Vivaldi (1982).

Wiley (1982 unpubl. ms.) and Meier et al. (1993) proposed that key habitat characteristics for the St. Croix Ground Lizard include some bare ground (including sandy, exposed areas), leaf litter, tidal litter, woody debris, and high densities of woody stems (especially of trees). Meier et al. (1993) indicate that tree density is the habitat variable most closely associated with the number of lizards, which were most numerous on the leeward side of Green Cay (Knowles, 1997). Habitat must permit patches of direct sunlight and contain loose substrate that allows burrowing or contains crab burrows that these lizards use (Wiley, 1982 unpubl. ms.). Ground lizards are widely distributed on Green Cay (although scarce on the wind-swept northeastern end; Zwank, 1987) and two habitats are preferred: beaches (areas with tidal wrack without trees and areas with trees; Meier et al., 1993) and forest (especially Manchineel *Hippomane mancinella*-White Cedar *Tabebuia heterophylla*; Wiley, 1982 unpubl. ms.). No documentation exists for ground lizard habitat associations on Protestant Cay, where the natural and the exotic vegetation has not been well described. As a consequence, I investigated St. Croix Ground Lizard associations with vegetative characteristics of the habitat, in addition to lizard distribution and abundance on this cay. These data will hopefully help reverse the long-term population decline of St. Croix Ground Lizards on Protestant Cay, which is one of the top priorities of the St. Croix Ground Lizard Recovery Plan and the top priority for Protestant Cay (Furniss, 1984).

MATERIALS AND METHODS

Protestant Cay is natural except for a dredged area at its northwestern portion, where abandoned tennis courts are located. Habitat is subtropical dry forest (Ewel and Whitmore, 1973) severely disturbed by the introduction of exotic vegetation. The smallest resolution (0.4 ha) of the digital habitat classification scheme developed by the Nature Conservancy for the US Virgin Islands was too large to be useful for Protestant Cay (1.2 ha). Consequently, I used as

sampling units habitat blocks (e.g., separated by paved walkways and other man-made features) typically comprised of 30-35 year old landscaped areas created by hotel employees (Furniss, 1984; Meier et al., 1993). These units vary in size. Within each unit I randomly chose 1-3 points with a 3-m radius to measure habitat characteristics which were: a-c) percentage of bare ground, leaf and tidal litter and woody debris, and canopy cover (based on 13 ocular tube readings of the central point and three points along each cardinal direction; after James and Shugart, 1970), d-e) number of shrub (shrub = woody vegetation with dbh <7.5 cm) and tree (tree = woody vegetation with dbh \geq 7.5 cm) stems, f) total number of shrub and tree stems, and g-h) shrub and tree stem height (m). I used one-way ANOVA to examine the association between the presence or absence of lizards and vegetative characteristics of the habitat. The three habitat variables measured as percentages and the number of shrub, tree, and total stems were arcsine and log ($x + 1$) transformed, respectively, to meet the assumptions of parametric statistical tests, although untransformed values for all variables are presented for descriptive purposes. Statistical data are presented as means \pm 1 SD and all tests used $\alpha = 0.05$.

I counted lizards from early April to early June 2002 between 1000 to 1530 h, when these diurnal and heliophilic lizards are most active (Wiley, 1982 unpubl. ms.; Meier et al., 1993). I replicated counts within each unit three times (and more in three units where I suspected that Cattle Egrets were preying on these lizards, but did not include these extra surveys in summary totals). I slowly walked the entire area two or more times, and used dowel sticks to disturb litter and woody debris and to poke into difficult-to-access areas (e.g., vegetation on rock walls). Time was fixed within each unit but varied between units according to patch size and the difficulty of thoroughly searching the habitat. I was able to keep track of individual animals within each unit because numbers were low, so double-counting did not substantially influence the results. I selected

the count with the maximum number of lizards within each unit and summed these counts over all units to obtain a population estimate. In the absence of a mark-resight (or recapture) method, this population estimate probably represents the minimum number of animals (Vilella and Zwank, 1993) because these furtive lizards may retreat to burrows or hide under litter and rocks when disturbed.

Since lizards may not have occupied the entire units, I marked their peripheral locations with forestry flagging and calculated occupied areas by measuring distances between points on the perimeter and applying standard geometric equations. I summed these areas to obtain the total area (in ha) occupied by St. Croix Ground Lizards on Protestant Cay. Automatic calculations of the area within each perimeter track using a handheld Garmin Map 76 Global Positioning System instrument were less accurate for such small areas because measurement error of waypoints typically ranges up to ca. 5 m.

RESULTS

The population estimate of the St. Croix Ground Lizard at Protestant Cay was 30 animals, based on the sum of maximum counts in the 10 (43 %) units where I found lizards (Table 1). Most lizards were concentrated at five contiguous units (A, B, C, E, and S) in dry forest that contained 22 (73 %) of the total number of lizards. The three other occupied areas, all beach habitat dominated by sea grape were disjunct; this included a single lizard on the east side of Protestant Cay (unit M), seen under wrack and woody debris beneath a low (<1.5 m) shrub along the beach. This was also the only animal seen in tidal litter on Protestant Cay.

Between the last survey in April and the first survey in May, lizards were virtually eliminated from unit A when one to three Cattle Egrets began foraging on the ground. Most birds had relocated their rookery (ca. 40 pairs) to trees in unit A by late March, probably in response to harassment by humans in an adjacent area. Cattle

TABLE 1. St. Croix Ground Lizards counted within 23 sampling units of habitat at Protestant Cay.

Sampling unit	Duration of survey (min)	Dates	Numbers (per survey)	Main habitat(s)
A	35	3, 10 Apr; 2, 8, 15 May; 6 June	6, 6, 0, 0, 1, 1	Dry Forest
B	20	10 Apr; 3, 15 May; 6 June	1, 4, 3, 3	Dry Forest
C	2	10, 24 Apr; 15 May	1, 0, 0	Dry Forest
D	5	10, 24 Apr; 24 May	0, 0, 0	Dry Forest
E	15	10 Apr; 2, 24 May	2, 5, 0	Dry Forest
F	25	15 Apr; 2, 22 May	0, 0, 0	Beach
G	20	15 Apr; 2, 22 May	0, 0, 0	Beach
H	4	15 Apr; 8, 22 May	0, 0, 0	Beach
I	10	15, 24 Apr; 22 May	0, 0, 0	Beach
J	4	15 Apr; 8, 22 May	0, 0, 0	Beach
K	15	15, 24 Apr; 22 May	0, 0, 0	Beach
L	10	15 Apr; 8, 22 May	0, 0, 0	Dry Forest
M	35	17 Apr; 2, 24 May	1, 0, 0	Dry Forest, Beach
N	30	17 Apr; 15, 24 May	0, 0, 0	Dry Forest
O	20	17 Apr; 8, 28 May	0, 0, 0	Dry Forest
P	30	17 Apr; 2, 22 May	1, 3, 1	Beach
Q	25	17 Apr; 3, 28 May	0, 0, 1	Beach
R	7	19 Apr; 8, 22 May	0, 0, 1	Beach
S	60	19 Apr; 8, 15 May; 6 June	6, 3, 6, 10	Dry Forest
T	6	19 Apr; 8, 24 May	0, 0, 0	Dry Forest
U	30	19 Apr; 8, 24 May	0, 0, 0	Dry Forest
V	25	3, 10 Apr; 2 May	0, 0, 2	Beach
W	60	24 Apr; 3, 28 May	0, 0, 0	Dry Forest

Egrets rarely foraged in units adjacent to A, and lizards did not decline in these areas (Table 1). The reduction of 5 or 6 individuals from unit A represents approximately 20 % of the estimated population.

St. Croix Ground Lizards were associated with a higher percentage of litter, woody debris, and shrubs with higher stem heights in occupied versus unoccupied areas (Table 2). Total habitat occupied was 0.23 ha (19.5 % of Protestant Cay), 0.16 ha of upland forest and 0.07 ha on the beach. Lizard density in occupied habitat ("ecological" density) was 128/ha: 135/ha in forest and 113/ha on the beach. Lizard density for the entire cay ("crude" density) was 25/ha.

DISCUSSION

The St. Croix Ground Lizard population on Protestant Cay is low and occurs in limited, disjunct areas. These lizards have declined for 30-35 years (Table 3), since the territorial government leased the cay for tourist development. This decline was not aided by the removal of 11 animals in 1990 (Knowles, 1997). A population on Ruth Cay has persisted for over 10 years after this translocation (Knowles, 1997; D. B. McNair and W. Coles, unpubl. data).

When Zwank (1987) had his maximum count on 22 April he still saw *A. polops* in all available habitats on most portions of Protestant Cay (see also Knowles, 1990). This included five lizards on the beach near the

only boat dock. A second concentration was under a tree at the northwestern corner of the island, where 3-5 animals were often seen foraging in the wrack. Other occupied areas included the steep slope along the eastern side of the island and the northwestern corner of the condominium (between the only pool and the service entrance). Lizards are now absent from the boat dock and the east slope.

Knowles (1997) stated the number of animals from 1994 to 1996 ranged from 53-88/ha (unadjusted counts) and concluded that the population was stable at least since 1980-1981. He considered that only 0.3 ha constituted "suitable" habitat on Protestant Cay, yet failed to apply this correction factor to the unadjusted count data; this instead yields population estimates from 16-26 animals. Knowles' description of occupied sites on Protestant Cay, which "includes the [west] slope below the main building running from the tool shed to the sea by the damaged tennis courts; areas adjacent to the sidewalks around the main building, areas along the fence around the [harbor-master] house and house yard and along the sea up to main building by yacht dock" (Knowles, 1997:6) is rather small and consistent with few animals. As with Zwank (1987), several of these areas no longer have ground lizards.

The lizard population on Green Cay is apparently stable, although the mark-resight fixed-width (10 m) belt transect method (Meier et al., 1993) is probably the

TABLE 2. One-way ANOVA of the association between presence and absence of St. Croix Ground Lizards from April to June 2002 and mean (\pm SD) vegetative characteristics within 3-m radii circles in habitat units at Protestant Cay.

Vegetative variable	<i>Ameiva polops</i>		One-way ANOVA	
	Present ¹	Absent ²	F	P
% Bare ground	81.7 \pm 20.3	76.3 \pm 34.9	0.09	0.76
% Litter and woody debris	49.1 \pm 29.5	12.5 \pm 20.0	24.18	<0.0001
% Canopy cover	43.6 \pm 30.0	29.5 \pm 34.9	1.90	0.18
No. shrub stems	43.5 \pm 65.6 ³	41.1 \pm 68.5 ⁴	0.68	0.42
No. tree stems	1.2 \pm 1.9 ⁵	1.0 \pm 1.7 ⁶	0.03	0.88
Total no. stems	44.7 \pm 65.2	42.1 \pm 68.1	0.61	0.44
Shrub stem height (m)	2.5 \pm 0.9	1.6 \pm 0.7	513.20	<0.0001
Tree stem height (m)	4.9 \pm 2.9	4.5 \pm 2.9	0.30	0.59

¹N = 21 (3-m radii circles), ²N = 24 (3-m radii circles), ³N = 913 (number of stems), ⁴N = 986 (number of stems), ⁵N = 25 (number of stems), ⁶N = 25 (number of stems).

TABLE 3. Numbers of St. Croix Ground Lizards compiled from results of other workers and my surveys from 1967 to 2002 on three cays off St. Croix.

Cay	Number	Year	Method	Source
Green Cay	300	1967	Not given	Philibosian and Ruibal, 1971
	200	ca. 1978	Not given	Dodd, 1978
	360-4300 ¹	1980-81	Mark and release ²	Furniss, 1984
	420-462 ³	1987	Transect ⁴	Meier et al., 1993
	375 (154-564) ⁵	1994-96	Count ⁶	Knowles, 1997
Protestant Cay	200	1967	Not given	Philibosian and Ruibal, 1971
	50-100	ca. 1978	Not given	Dodd, 1978
	50 ¹	1980-81	Mark and release ²	Furniss, 1984
	29 ⁷	1987	Count ⁸	Zwank, 1987
	23 (16-26) ⁵	1994-96	Count ⁶	Knowles, 1997
Ruth Cay	30	2002	Count ⁹	This study
	20	1996	Count ⁸	Knowles, 1997
	27	2002	Count ⁸	W. Coles, unpublished data

¹Range; other values not given, ²Mark and release; no other details are available, ³Mean, ⁴Mark-resight searches within fixed-width (10-m) transects, ⁵Mean (range); other values can be calculated from raw data, ⁶Counts based on searches within fixed-radii (3-m) points along a grid, ⁷Maximum (in one and one-quarter hour), ⁸Counts based on searches within an undefined area, ⁹Counts based on searches within defined areas of varying size (see methods).

only fully satisfactory method to derive population estimates for this species on Green or the other two cays (Table 3). No population estimates exist for Ruth Cay since the last animal was introduced (from Green Cay) in 1995 (Knowles, 1997), although count data suggest that lizards have increased (Table 3).

Unlike Green Cay and perhaps Ruth Island, Protestant Cay is not an effective refugium for lizards despite seeming protection through designation as critical habitat (Furniss, 1984). The territorial government, which owns Protestant Cay, must require the owners of the hotel to comply with the Endangered Species Act so that the lizard's decline can be reversed. Compliance should include the creation of a habitat conservation plan or safe harbor agreement. In some areas, even the typically abundant and versatile generalist St. Croix anole *Anolis acutus* is scarce (McNair, unpubl. data), further suggesting how unattractive the habitat has become. As early as 1977, owners of the hotel were asked to stop raking litter in all areas, removing undergrowth, and undertaking other "beautification" measures (such as planting exotic vegetation) to avoid disturbing critical habitat (Dodd, 1978, 1980; Furniss, 1984).

Severe habitat disturbance continues to-

day (after censuses were completed), including the obliteration of all woody vegetation in the portion of unit S where lizards are concentrated. Restoration efforts should begin in areas surrounding the single upland area where lizards are concentrated and still occur at fair densities. Beach habitat away from the only swimming beach can be restored, especially in areas surrounding the abandoned tennis courts (which still have some lizards), and this area can be linked to the adjacent occupied upland area. The tennis courts should be removed and the area replanted with beach vegetation. Restoration should also include addition of leaf litter and woody debris, removal of unfavorable exotic vegetation (e.g., lilies), and replacement with native vegetation (including tall shrubs that shed more leaves and provide greater shade) associated with high lizard abundance (cf., Furniss, 1984). A semi-open mixture of shrubs and trees with high stem densities that allows sun and shade is required (Wiley, 1982 unpubl. ms.; Meier et al., 1993).

Disturbance caused by hurricanes is unlikely to have been responsible for the decline of lizards on Protestant Cay, since populations have not declined on Green Cay or Ruth Island (which is lower and

hence probably more vulnerable to hurricane effects). Predation by Cattle Egrets (which select other small lizards as preferred vertebrate prey on St. Croix; Gasset et al., 2000) has had an important impact on the lizards in unit A because the population has not recovered (McNair, unpubl. data). This demonstrates how vulnerable a declining population can become when faced with additional stress. Cattle Egrets should be prevented from roosting or nesting on Protestant Cay to reduce predation pressure. Great care should be taken to avoid introducing to the island the small Indian mongoose (which presumably exterminated the St. Croix Ground Lizard on St. Croix; Baskin and Williams, 1966; Philibosian and Ruibal, 1971; Philibosian and Yntema, 1976; Furniss, 1984; Henderson, 1992).

The initial success of translocated ground lizards to Buck Island (where mongooses were trapped and removed in the late 1960s to early 1970s), the lizard's persistence on Ruth Cay despite the small size of the founder population, and its continued though perilous existence in fragmented, highly disturbed habitat on Protestant Cay, suggest that *A. polops* is hardy and will thrive on mongoose-free islands if essential habitat components remain (even though island taxa are especially prone to extinction; Henderson, 1992). Now that Buck Island is apparently mongoose-free (which needs to be confirmed by a follow-up survey), translocation of lizards from Green Cay (and possibly Ruth Island) should proceed quickly due to compensate for the precarious status of this species on Protestant Cay.

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