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The Lesser Antillean Iguana on St. Eustatius: A 2012 Population Status Update and Causes for Concern

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Abstract.—To assess the status and current population densities of the endangered Lesser Antillean Iguana (*Iguana delicatissima)* on the island of St. Eustatius, we spent more than 80 h searching for iguanas and covered more than 63 km of trails and tracks — but found only 22 iguanas, for an overall average of 3.7 h per iguana. Overall population density was 0.35 iguanas per hectare, which represents 0.5–1.0% of densities documented elsewhere in healthy populations. Population densities have declined across all habitats since the last assessment in 2004. The lack of nesting sites and high iguana mortalities due to anthropogenic causes were the two core factors limiting recovery of iguanas on St. Eustatius. Our principal recommendations are to: (a) Train and equip border officials to prevent potential entry of mongooses and Green Iguanas from neighboring islands; (b) implement enforcement and upgrade protective legislation; (c) develop and maintain new additional nesting habitat, a measure that is both easy and inexpensive; and (d) establish a program to promote "iguana-friendly" gardens as the main means of reducing cumulative mortality. Finally, we propose the development of an *in situ* husbandry and breeding program to help bolster the overall recovery program, a move that also would benefit islanders by offering a relaxed setting in which they could better learn to appreciate this emblematic island species.

Keywords: Lesser Antillean Iguana, *Iguana delicatissima*, St. Eustatius, conservation, status

The Lesser Antillean Iguana, *Iguana delicatissima* (Laurenti 1768)(Fig. 1), has a very limited distribution in the Lesser Antilles and is gradually being extirpated throughout its range due to three principal causes: Invasive predators, habitat loss, and hybridization with invasive Green Iguanas (*I. iguana*). Of the six islands of the Dutch Caribbean, the species is today found only on St. Eustatius, where it is the largest native terrestrial animal and a prime emblem of the island's biodiversity. Populations have been extirpated on Antigua, Barbuda, St. Kitts and Nevis, Les Îles des Saintes, Marie Galante, as well as on St. Martin as recently as 1996 (Breuil 2002). Of the 13 remaining island populations, only two (Dominica and Guadeloupe) exceed the long-term minimum viable population (MVP) size of 5,000 individuals, and six are critically endangered. While the species' precarious status would appear to emphasize the need for scientific study, life history information on *I. delicatissima* remains very limited (Pasachnik et al. 2006, Knapp 2007).

Fig. 1. The Lesser Antillean Iguana (*Iguana delicatissima*) is gradually being extirpated throughout its range. Of the six islands of the Dutch Caribbean, the species is today found only on St. Eustatius, where it is the largest native terrestrial animal. Photograph © John S. Parmerlee, Jr.

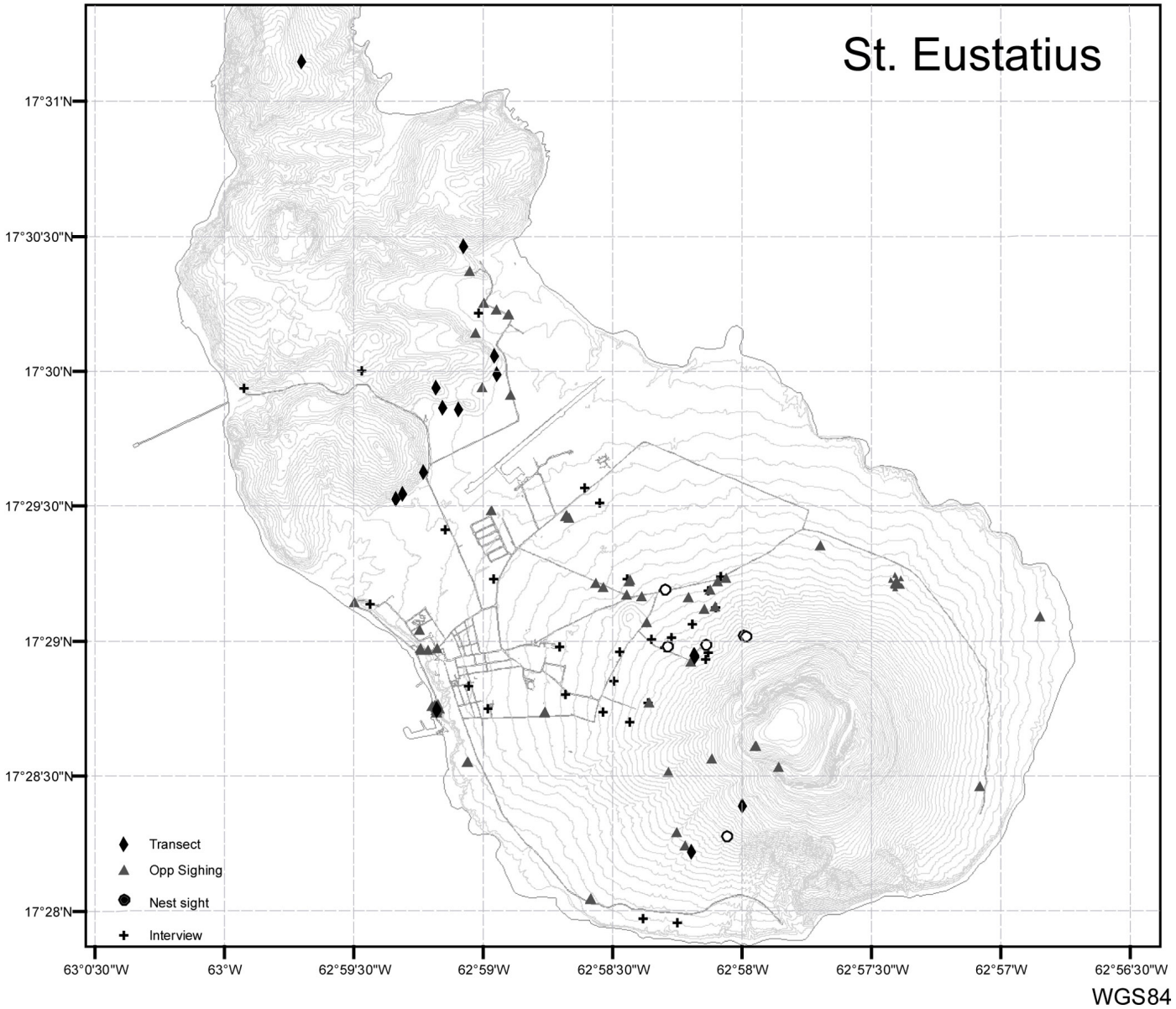

Fig. 2. Map of St. Eustatius showing 91 locations at which one or more iguanas were documented in 2012 during dedicated transect surveys (◊) (N = 14), during opportunistic sightings (Δ) (N = 47), from interviews (+) (N = 24) and as recent nest digging locations (○) (N = 6). Map © E. Dijkman.

Past population size estimates for St. Eustatius were about 300 animals in 1992, less than 300 animals in 2000, and about 425 (275–650) animals in 2004 (Fogarty et al. 2004). The species is listed by the IUCN as "endangered" (Breuil et al. 2010). In light of the growing list of declines and threats throughout its range, Powell and Henderson (2005) argued that, if not for scattered surviving populations on multiple islands, the status listing of "critically endangered" would necessarily apply. The objective of this study was to provide a new population assessment for this endangered species on St. Eustatius and provide conservation recommendations.

St. Eustatius forms part of the inner volcanic arc of the Lesser Antilles and has a surface area of about 21 km^2. The capital and only town is Oranjestad with about 4,000 inhabitants. The island is situated roughly on a line between St. Kitts (about 15 km away) and Saba (about 25 km away). It lies in the northeastern trade winds and experiences hurricane conditions once every 4–5 years. Air temperatures on St. Eustatius average 26.9 °C, with the hottest temperatures (28.0 °C) occurring in July, August, and September. The annual average rainfall is about 990 mm/yr. The island consists of three main geomorphological zones: The northwestern hills, the central plains, and the Quill, a dormant volcano in the southeastern section of the island. The flora comprises about 505 species of plants, for which Freitas et al. (2013) recently described 13 (semi)natural vegetation types that are distributed in four main and 16 sub-landscape types. All areas continue to be heavily impacted by feral livestock. The island has three large terrestrial protected areas. Two of these are in the northwestern hills (Boven: 3.30 km^2 and Signal Hill:

Fig. 3. A female *Iguana delicatissima* adapted to the suburban life of St. Eustatius. Photograph © Hannah Madden.

0.44 km^2) and one circles the 600-m Quill, down to altitudes of about 250 m ASL for a total surface area of approximately 2.14 km^2. These protected park areas are all managed by the St. Eustatius National Parks Foundation (STENAPA) (MacRae and Esteban 2009), which was a key supporter of our iguana work.

Methods

Dedicated iguana surveys.—Iguana surveying methods remain problematic even in high density populations, leading to only rough estimates of population size and density (e.g., Lorvelec et al. 2007). We chose to apply a line transect method. The island was divided into "habitat" sectors following Fogarty et al. (2004). Iguana surveys were conducted between March and November 2012 at 1000–1400 h to coincide with peak daily activity (Pasachnik et al. 2002). We felt that in most habitats we could reliably find iguanas to 5 m on each side of the transect. In this, counts were conducted using 10-m wide transects of 50-m lengths. Replicate transects were separated by a minimum of 50 m. All positions were marked by GPS beginning and endpoints.

Field data were collected during a total of 39 excursions during which two to more than 10 transects were surveyed. Preliminary analyses indicated very low sighting frequencies, such that meaningful density estimates and statistical analysis were not possible using the small (50-m) transect method chosen. We therefore estimated density and calculated density indices by including the distances linking the (short) transects (i.e., all distance and time spent searching in the field). Densities were expressed both in terms of iguanas per unit time spent searching, following Fogarty et al. (2004) and Reichling (2000), and in terms of iguanas per hectare.

Questionnaire and opportunistic sightings.—Aside from directed iguana surveys, opportunistic sightings were solicited from inhabitants of the island, using a simple protocol to structure information collection. All such sightings, as well as sightings we made outside field sampling sessions, were mapped to provide additional indications of the distribution and abundance of iguanas on the island.

Results and Discussion

Documented distribution.—Figure 2 shows the locations of iguanas sighted during dedicated searches as well as all opportunistic sightings recorded. Our field surveys were conducted during 39 different survey sessions, during which a total

Table 1. Iguana sampling effort in the different areas of the island and the number of iguanas detected, expressed as iguanas per hour searched and search time per iguana detected. Results by Fogarty et al. (2004) are included for comparison.

Sector	Number of Visits	Time (h:min)	Distance (m)	Area (m^2)	Iguanas Seen	Iguanas /ha	Iguanas /h	h/ iguana	2004 h/iguana
Quill crater	2	3:15	1,400	14,000	0	0.00	0	indef.	—
Quill out. slopes	5	17:38	11,700	117,000	1	0.09	0.06	17.63	8.30
Quill foothills	6	9:03	5,250	52,500	1	0.19	0.11	9.05	—
Island estates	2	4:10	3,600	36,000	6	1.67	1.44	0.69	0.20
Central plains	4	3:35	6,500	65,000	0	0.00	0.00	indef.	—
Northern Hills	10	28:07	27,222	272,220	2	0.07	0.07	14.06	1.80
Border N. H.	6	9:49	6,500	65,000	9	1.38	0.92	1.09	—
Oranje Bay	4	4:40	1,500	15,000	3	2.00	0.64	1.56	0.40
Total	**39**	**80:21**	**63,672**	**636,720**	**22**	**0.35**	**0.27**	**3.70**	

63,672 m of trails and transects were walked and 80 h and 21 min were spent searching for iguanas in the field. Based on locations from which iguanas could be documented (either from transect counts, opportunistic sightings, from interviews, or as evidenced from recent nest digging activity), the species can be seen to be relatively widely distributed on the island (Fig. 2). Iguanas certainly are not relegated to faraway places; if essential conditions are met, they could thrive in the central inhabited part of the island (Fig. 3).

Dedicated iguana sightings and relative density.—We detected only 22 iguanas for an average effort of 3.70 h for each iguana detected (Table 1). Fogarty et al. (2004) spent no time sampling directly in either (a) the lower Quill foothills, (b) the border region between the northern hills and the central plain, or (c) the central plains (Cultuurvlakte). We did conduct directed sampling in all three of these habitat zones. We further sampled the escarpments of Lower Town (Oranje Bay) as a distinct habitat, whereas Fogarty et al. (2004) labeled this area as part of the "central plains."

Fig. 4. The favorite natural iguana habitat on St. Eustatius is an ecological discontinuity where the northern hills abut onto the central plains. Photograph © Adolphe Debrot.

Iguanas were not detected in the Quill crater or on the central plains, and these results correspond closely to the findings/observations of Fogarty et al. (2004). The Quill crater ridge lies at a minimum altitude of 378 m, whereas the crater floor lies at about 278 m above sea level. These areas often are covered in clouds and fog, and according to Veenenbos (1955), the amount of rainfall on the Quill (above 400 m) averages 1,500–2,000 mm per year. The moisture and lower temperature probably makes this habitat less than ideal for iguanas. The central plains consist of areas with low shrubs and grassland that provided iguanas with few refugia in the form of either high vegetation or boulder fields with crevices. Although the habitat would otherwise be suitable, iguanas appear not to occur in these areas.

The lower foothills of the Quill were not sampled by Fogarty et al. (2004). However, we spent 9 h and 3 min searching in these areas and found only one iguana, leading to the conclusion that iguanas do occur here but at exceedingly low densities (Table 1). As Fogarty et al. (2004) indicated, the northern hills are particularly important iguana habitat; consequently, we spent more than 28 h during 10 different excursions into the area and included both hills sampled by them (Boven and Gilboa) in addition to Signal Hill and natural habitat within the NUSTAR industrial complex. However, again, we found very few animals.

One important natural iguana habitat was the zone with vegetated and boulder-strewn slopes where the northern hills abut onto the central plains (Fig. 4). These areas had the

Fig 5. Hatchling *Iguana delicatissima* predation by the native Red-bellied Racer (*Alsophis rufiventris*). St. Eustatius, January 2008. Photograph © Hannah Madden.

third-highest estimated iguana densities (1.38 iguana/ha) and second-highest encounter rates (1.09 h/iguana) of all habitats studied. These areas essentially constitute a band not much more than 100 m wide running along the base of the hills from Signal Hill in the west to Gilboa in the central-eastern part of the island. Iguanas often exploit and seek out discontinuities in habitats, and this area apparently offered the iguana the best of both the plains (sun and potential nesting sites) and the hills (escarpments and crevices for escape and shelter). These areas also had plenty of Acacia Trees (*Vachellia*), which iguanas cherish as food (particularly the flowers), as well as dense Calabash Tree (*Crescentia cujete*) groves in which they like to hide and where they were frequently seen.

The highest iguana densities and sighting rates were found in the estate subdivisions concentrated along the northwestern lower flanks of the Quill and along the escarpment and cliffs between the Oranjestad harbor and the town located above the cliffs. In the latter area, the relatively high density (2.00 iguanas/ha) and sighting frequency (1.56 iguana/h) was largely due to a small concentration (possibly up to seven different iguanas) living between the STENAPA office in the harbor and the Roman Catholic church directly above on the cliff. In the rest of the area, iguanas were virtually absent.

Comparison to the 2004 survey.—In 2004, Fogarty et al. saw more iguanas during considerably less time spent in dedicated surveys. Across the board, our indices of density were much lower than those of Fogarty et al. (2004), suggesting lower densities of iguanas across the island (Table 1). Whereas Fogarty et al. (2004) indicated that their lack of experience in spotting iguanas possibly meant that their relative density estimates might have been on the low side, in our case, both researchers are good iguana-spotters, the lead author having more than 40 years of iguana-spotting experience. While possible that we actually missed animals (particularly juveniles) in the narrow transects we surveyed, we tended to sample in the best habitats available to iguanas in the chosen areas, and likely included iguanas that fell just outside the 10-m transect width when they were observed. Therefore, we believe that our density estimates are most likely to err on the high side and feel confident in concluding that iguana numbers on Statia have taken a turn for the worse since the survey by Fogarty et al. (2004).

The Smoke Alley population described by Fogarty et al. (2004) as flourishing, and then numbering between 10 and 50 animals is no longer present. This population used to be situated around the Kings Well Hotel, which started a

breeding population that was subsequently released around 2000. While at least one animal is present at the Old Gin House and was observed opportunistically during this study, and about seven individuals still inhabit the cliffs behind the STENAPA headquarters, this once promising population has all but disappeared. The habitat quality of this erosion-prone escarpment area has all but been destroyed by extensive mats of the invasive Mexican Creeper vine (*Antigonon leptopus*), locally known as "Corallita." These areas, formerly without Corallita, would have been among the best nesting habitat available to iguanas in the central section of the island. The available habitat also is very narrow, pinned in between the busy harbor road along the waterfront and the town directly above and along the cliff edge. The area is prime waterfront and in the long-term will be used for waterfront real estate development. Its long-term prospects as iguana habitat are limited.

In contrast, the estates development area of the island continues to harbor substantial numbers of iguana. This area showed the overall highest encounter rate (0.69 h/iguana) and second-highest density estimate (1.67 iguana/ha). It is characterized by spacious villas situated on large lots. Many vacant lots remain undeveloped and have high semi-natural dry-evergreen vegetation. At least 50% of the villas are not permanently occupied, inhabited only 3–6 months of the year by foreign owners. Iguanas appear largely absent from lots with dogs, and about 50% of estate owners (10 of 19) kept dogs. At least one lot was observed to have iguanas despite a dog being present; iguanas stayed near the fence-line and could escape from the dog by climbing up or going through the fence. The importance of the estates area as a refuge for iguanas is hence dependent largely on the happy circumstance of undeveloped lots, which serve as the main habitat refuge, and a number of villa owners who do not keep dogs and/or are iguana-aware. Suitable nesting habitat was very scarce in the estates area.

Population densities and size.—Under favorable circumstances, iguana populations can attain densities in excess of 30/ha (Breuil 2002, Knapp and Perez-Hydrich 2012). Our density estimates for St. Eustatius varied between zero and a maximum of 2.00 for an overall average of 0.35 iguanas/ha. These densities are clearly very low (0.5–1.0%) compared to potential densities under ideal circumstances. Iguanas generally are gregarious animals, and probably thrive best under higher densities than observed in St. Eustatius. Aside from being a major threat to the species, these low densities, make density estimates and analyses problematic (too many zeros), and constitute a major impediment for studies of critical aspects of the biology and ecology of the species. Our results show that compared to 2004, when the population was estimated to number 425 (275–650) animals (Fogarty et al. 2004), current population size certainly lies on the low side of this range. It is in any case far below the required minimum viable population size (MVP) of 5,000 animals and means that the iguana is critically endangered on St. Eustatius. Nevertheless, islanders still report seeing iguanas relatively regularly. Of the 53 islanders interviewed, 30 persons (56%) reported seeing iguanas at or near their residence within the last three months and 14 (26%) within the last week. This could be based on a small number of mobile animals seen by many people, resulting in a false sense of abundance — and could undermine any local sense of the real urgency required for effective conservation and recovery of this species.

Fig. 6. The most common form of fencing used on St. Eustatius and quite dangerous to adult gravid female iguanas, whereas less expensive wide-meshed "goat wire" would be equally suitable Photograph © Adolphe Debrot.

Conclusions and Recommendations

The numbers of iguanas on St. Eustatius remain disappointingly low. After an apparent upturn between 1999 and 2004 (Fogarty et al. 2004), the status of the species has quite convincingly taken a turn for the worse. While natural mortality certainly includes predation by native predators such as Red-tailed Hawks (*Buteo jamaicensis*), American Kestrels (*Falco sparverius*), or Red-bellied Racers (*Alsophis rufiventris*; Fig. 5), the principal problems faced by iguanas on St. Eustatius appear to be high levels of human-induced mortality, notably dogs, entanglement in fencing (Fig. 6), abandoned cisterns, and traffic (Debrot and Boman 2013b), as well as low availability of nesting habitat (Debrot et al. 2013). However, several measures were identified that, if implemented, could certainly help safeguard or even improve the situation of the species.

Two massive threats to iguanas elsewhere, and the most important causes for the species' extirpation on islands throughout its current and former range, are predation by invasive Small Indian Mongooses (*Herpestes javanicus*), and hybridization with Green Iguanas (*Iguana iguana*). Green

Fig. 7. The *Pandanus,* a hardy garden ornamental with sharply serrated leaves, is cherished by iguanas as a shelter site. Photograph © Adolphe Debrot; insert © Robert Powell.

Iguanas are present and abundant on Saba (which supports an endemic population of that species) and St. Maarten (where the niche formerly occupied by native Lesser Antillean Iguanas has been occupied by introduced Green Iguanas), whereas mongooses are abundant on both St. Kitts and St. Maarten. St. Eustatius has regular inter-island traffic with all three of these islands, and the risk of accidental introductions of either of these two scourges is high. Keeping them out of St. Eustatius in the long-term can only be achieved with better legislation, awareness, and training of and control by border and customs personnel. Currently, no legislation prevents the importation of Green Iguanas or mongooses. Therefore, legislating the prohibition of importing either species is critical.

The Lesser Antillean Iguana has been listed as a protected species in the "Statia Flora and Fauna Ordinance" of 1997 (MacRae and Esteban 2009), which stipulates maximum penalties of up to 1 month of incarceration and fines up to 5,000 guilders per infraction. While hunting is only a small problem (Debrot and Boman 2013), the number of animals on the island is so small that no hunting can be warranted. With compliance already high (hunting is very limited and hardly profitable), renewed enforcement of the legislation should be preceded by an information campaign to give due warning.

Debrot et al. (2013) confirmed a virtual lack of suitable nesting sites in most areas of the island. Those sites that are present are additionally vulnerable to large numbers of trampling livestock or potential nest predators. Good nesting sites are relatively easy to establish, maintain, and protect. They also can form pivotal sites for research and serve as a source of young animals for headstarting, breeding, and other studies. STENAPA currently is using the recommendations of this study to advise estate developers on the need to provide safe nesting sites for iguanas.

Knapp and Perez-Heydrich (2012) noted that, if factors such as degraded nest sites and killing by non-native

mammalian predators are mitigated, moderately disturbed, human-occupied areas can be managed as corridors or buffer zones for *I. delicatissima* in increasingly fragmented landscapes. Along those lines, one of the important habitat areas for the iguana at present is the estates development area of the island. The owners of these estates are largely retirees, many of whom, with the right information, might be willing to devote a little attention to the critical matter of survival of the largest and most spectacular native terrestrial vertebrate of Statia. One measure might be to phase out the use of harmonica-wire (chain-link) fencing, which is dangerous to iguanas due to the threat of entrapment (Debrot and Boman 2013b). In response to our findings, the Department of Agriculture Animal Husbandry and Fisheries (LVV) of St. Eustatius has already started to phase out its use of this type of wire fencing (Director R. Hensen, pers. comm.). We hope that private citizens will follow suit. The habitat value of the estates area can also be improved simply and inexpensively by creating suitable nesting habitat for resident iguanas (fenced-off to keep dogs out) and by encouraging owners to plant suitable bushes near fence lines (so iguanas can more easily escape predators). Suitable plants would include dense, thorny ornamental *Pandanus* (Fig. 7), which in several gardens was documented as night-time iguana shelter sites. An "iguana-friendly yard" program with annual awards for the best new yards, iguana numbers, or proof of nesting could stimulate and encourage estate owners to adopt practices favoring better iguana stewardship.

In casual conversations with many native Statians, little real appreciation for the uniqueness of Statian iguanas was evident. Most inhabitants are not even aware that Green Iguanas, so common elsewhere, are a separate species that is not threatened, and several individuals believed that different "kinds" of iguanas occurred on the island. This overall lack of understanding detracts from the resident public's sense of urgency for protection. People experience iguanas as being relatively "abundant" (also elsewhere) and conservation concerns are believed to have been exaggerated by "over-zealous" environmentalists.

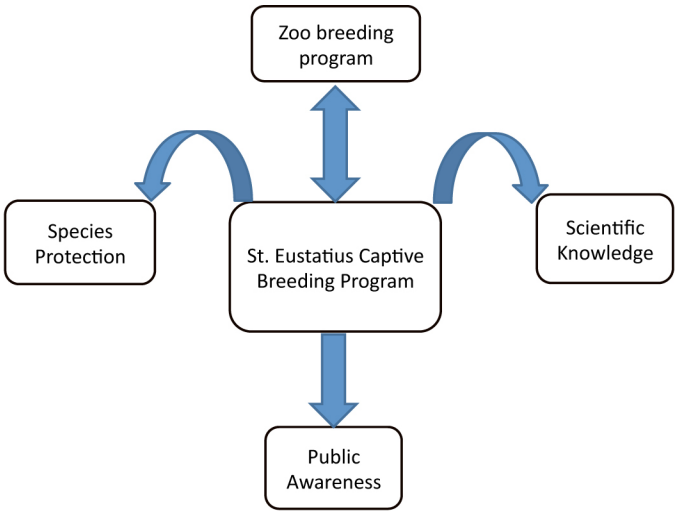

Fig. 8. Local captive husbandry, with breeding as the ultimate goal, could provide pivotal support toward core *I. delicatissima* conservation objectives. Figure © Adolphe Debrot.

A second aspect of awareness is that in general, iguanas evoke fear and disgust in many local inhabitants. Very few have experienced iguanas as gentle and beautiful animals that deserve a safe spot in every yard. Awareness can best be stimulated by taking tame pet iguanas to schools for children to experience first-hand. Therefore, current educational efforts by STENAPA include the species, and these should be funded and preferably formalized as part of the educational curriculum.

Finally, establishing a small local husbandry project could play a decisive role in supporting an iguana action plan (Fig. 8). Captive husbandry and/or breeding and the facilities entailed could provide not only a venue for critical scientific studies but also function as an ideal setting from which to promote awareness of school children and the general public via direct contact with tame animals. So, local husbandry could not only provide a means of propagating animals and increasing population size but also could promote the development of vital knowledge about the species, especially considering the low number and low population density of wild and/or semi-wild iguanas on Statia. Such facilities also could be used to house animals in need of rehabilitation due to injuries or acute situations arising after certain types of hurricane scenarios. For optimum results, on-island efforts could also be coupled with an *ex-situ* zoo-breeding program. Finally, by making tame animals available for interactions with the public in a relaxed setting, captive breeding should allow the public to develop a new appreciation for the species. An on-island husbandry program could probably be established at relatively low cost and managed by expanding existing efforts by STENAPA. A small-scale program existed previously but was never formally documented or professionally managed.

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