

## A post-Hurricane Ivan assessment of frog and reptile populations on Grenada, West Indies

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ON 7<sup>th</sup> September 2004, Hurricane Ivan, a Category 4 storm with winds in excess of 140 mph, made a direct hit on Grenada, the southernmost island in the Lesser Antilles. Over 90% of the homes and buildings on the islands are estimated to have sustained some damage, and many were completely destroyed. Utility poles and power lines were down, and (except for cell phones) the island was effectively isolated from the rest of the world.

With the exception of assessments of *Eleutherodactylus* and *Anolis* populations in post-Hurricane Hugo Puerto Rico (Reagan, 1991; Woolbright, 1991), we know remarkably little about the effects of tropical storms on West Indian frogs and reptiles despite their recurring and often devastating presence in the region. One of us (RWH) has a 15-year history of snake-related fieldwork on Grenada, and CSB initiated work on Grenadian *Eleutherodactylus* in 2003. With data on pre-hurricane numbers of certain species in hand, we were anxious to observe the effects of the hurricane on our current and previous study sites, and to assess the short-term impact of Hurricane Ivan on the herpetofauna.

Once the 1800-hour curfew was lifted, we made a short visit (10<sup>th</sup>–17<sup>th</sup> November 2004) to Grenada. The island is 310 km<sup>2</sup> in area (approximately 19 km east to west by 34 km north to south) and we drove more than 400 km visiting sites where we had previously worked. We tried to visit sites more than once, and by day and night. RWH last visited Grenada in June 2004, and CSB (with RWH) was last on the island in February

2004. We did not try to account for every species, as some were very rare prior to the hurricane (e.g., *Clelia clelia*), and others, because of their microhabitat, we assumed weathered the storm with relatively little difficulty (i.e., the litter dwelling lizards *Bachia heteropus* and *Gymnophthalmus underwoodi*, and the fossorial snake *Typhlops tasymicris*).

### Sites visited

*St. George: St. George's: Grounds of the Rex Grenadian Hotel on the Pointe Saline Peninsula* (3 m): Although the hotel sustained considerable damage, the largely treeless grounds were relatively clear of hurricane debris when we arrived.

*St. George: Mt. Hartman Estate* (5 m): This site is described in some detail in Henderson (2002) and Henderson *et al.* (1998). Although we did not visit the site in November 2004, while assessing the post-hurricane status of the Grenada Dove, Bonnie Rusk did encounter *Corallus grenadensis*.

*St. George: Westerhall Estate* (ca. 60 m): This is the site of RWH's *Corallus grenadensis* project in 1993 (Henderson & Winstel, 1995; Henderson *et al.*, 1998) and subsequent work (Yorks *et al.*, 2003). This site has to some extent been developed since earlier fieldwork. Houses in the area were damaged and much of the site was inaccessible because of treefalls (Fig. 1).

*St. David: Mt. William* (ca. 400 m; = Mt. Providence?). This site does not appear on a 1958 map, but does appear on a 1985 map [both maps

by Directorate of Overseas Surveys]. It should not be confused with the Mt. William that is near the northwest coast [Duquesne Bay] in St. Mark Parish); the forest here was hit extremely hard. Trees were downed or at sharp angles to the ground; many large branches were downed, and many standing trees were stripped of small branches and foliage. As elsewhere across the island, nutmeg trees (*Myristica fragrans*) were hit especially hard, and they had been common at this site. Some cacao (*Theobroma cacao*) remained standing, as did some tree ferns (*Cyathea* sp.).

*St. Andrew: Grand Etang National Park (525 m):* The forest here was devastated by the hurricane. Trees were snapped off at their trunks or completely uprooted. Others had large branches ripped off, and most trees were stripped of their foliage. What was once a closed-canopy forest with many trees attaining heights of 30 m (Beard, 1949) was now open and sun-drenched (Fig. 2). A data logger recorded temperature and relative humidity at this site during our February and November frog surveys. Despite the absence of canopy, the relative humidity at 0.5 m did not substantially differ between the two months (February: 83–100%; November: 86–100%). Air temperature in November was within the normal range (21.3–26.3°C) for Grand Etang (Henderson, 2002).

*St. Andrew: Spring Garden Estate (460 m):* A site comprised mainly of orchard trees (citrus, nutmeg, banana, cacao), it, like Grand Etang, sustained tremendous damage during the hurricane. We did not search for treeboas at this site since, as at Grand Etang, they are uncommon and most searches do not produce snakes (see Henderson, 2002).

*St. Andrew: Birch Grove (ca. 150 m):* A sprawling town on the leeward side of the central range of mountains, this was the only site where we routinely encountered *Leptodactylus validus* prior to Hurricane Ivan.

*St. Andrew: Balthazar Estate (75 m):* This site was dominated largely by orchard trees (see Henderson, 2002 for a description and photograph). We made a very brief visit on the night of 13<sup>th</sup> November. Many citrus trees were intact and heavy with fruit, but the trail was blocked by fallen trees.

*St. Andrew: Pearls (5 m):* This is RWH's current *Corallus grenadensis* study site. Upon our arrival at the site in November, we were unable to drive into the site because of trees and large branches felled by the hurricane (Fig. 3). Following the 520-m transect (established in 2002) was impossible, but we walked from one end to the other, either paralleling it or occasionally finding it among fallen trees and branches. The site had been chosen because it was navigable while searching for snakes, but the hurricane rendered it unworkable and future work will require a chainsaw to at least make a narrow path through the transect. We do not want to dramatically diminish the modifications made by Ivan.

### Species assessments

*Bufo marinus:* We were surprised that we did not encounter this species during our surveys. It was often observed at Pearls in the water-filled ruts of a dirt road or on the abandoned runway of the old airport (which is now used as a thoroughfare for cars, trucks, and cows). Imagining this species being deleteriously impacted by anything is difficult and its absence from our surveys is undoubtedly due to insufficient effort in appropriate situations.

*Eleutherodactylus euphronides:* This endemic frog was surveyed at Grand Etang and Mt. William. Although the absolute numbers counted during searches were comparable to those recorded during our February 2004 surveys, the encounter rates at specific transect sites were slightly higher in November. At Grand Etang in February, 27 *E. euphronides* were encountered along two 100-meter transects during 4 hours of timed searches (6.75 frogs/man hour). During November, 16 frogs were counted along these transects during 2 hours (8.0 frogs/man hour).

At Mt. William the encounter rate along a 50-meter transect in February was 2.0 frogs/man-hour. During November this transect yielded 3.0 frogs/man-hour during two 30-minute searches. This elevated encounter rate may be due to the fact that November is the wettest month of the year and February is one of the driest (Henderson, 2002).



**Figure 1.** Views along trail at Westerhall Estate, Grenada. The photograph on the left was taken in 1993 (© R. A. Winstel); the image on the right was taken in November 2004, two months after Hurricane Ivan had hit the island.



*Eleutherodactylus johnstonei*: This invasive frog species was previously found at every site that we visited in February 2004. It remains ubiquitous and numerous juveniles were observed. Similar to its congener, the absolute numbers of this species counted during timed searches were also comparable to those recorded during our February 2004 surveys, and the encounter rates at specific transect sites were slightly higher in November. At Grand Etang in February, 163 *E. johnstonei* were encountered along two 100-meter transects during 4 hours of timed searches (40.8 frogs/man hour). In November, 89 frogs were counted along these transects during 2 hours (44.5 frogs/man hour).

At Mt. William the encounter rate along a 50-meter transect in February was 5.5 frogs/man-hour. During November this transect yielded 19.0 frogs/man-hour during two 30-minute searches. In all likelihood these frogs were more numerous due to the influence of November's increased rainfall.

*Leptodactylus validus*: We had previously encountered this frog in numbers only in a roadside ditch in Birch Grove (June 2002, February 2003, February 2004) and heard it calling at one site each in St. George's and the Pearls area. Occasional individuals (never more than one) were found elsewhere during surveys conducted in June 2002

(Germano *et al.*, 2003). In November, we heard it calling day and night in every parish through which we passed (St. Andrew, St. George, St. David). It occurred in roadside ditches, in grass and water-filled depressions adjacent to pastures, and in the ruts created by vehicle tires on unpaved, muddy, roadways. Barbour (1914) reported this species from the shore of Grand Etang; in November we encountered it there for the first time despite having visited the area dozens of times over a 15-year period.

*Hemidactylus mabouia*: We encountered this human commensal every night (10<sup>th</sup>–14<sup>th</sup> November) at our guesthouse in Dunfermline (near Pearls in St. Andrew Parish).

*Thecadactylus rapicauda*: We observed this gecko active in the forest at Pearls at night on 10<sup>th</sup> November.

*Anolis aeneus*: This polychrotid was observed at every site we visited. At night, *A. aeneus* was often seen sleeping on dead branch and leaf surfaces, and its green coloration made it conspicuous against the brown of dead foliage. It remains ubiquitous and abundant.

*Anolis richardii*: Like *A. aeneus*, we observed this lizard at every site we visited; it remains ubiquitous and abundant.

*Anolis sagrei*: Two individuals of his recently introduced anole (Greene *et al.*, 2002) were observed at the Rex Grenadian Resort between 09:50 and 10:20 hrs on 11<sup>th</sup> November.

*Iguana iguana*: This large lizard was not observed, but it is infrequently encountered on Grenada. Although occasionally encountered at Pearls and near Levera Pond (St. Patrick Parish), its absence during our November surveys was undoubtedly due to insufficient effort in appropriate habitat rather than to the impact of Hurricane Ivan.

*Mabuya* sp.: This litter species is infrequently observed on Grenada. We assume that it was not severely impacted by the hurricane.

*Ameiva ameiva*: Prior to the hurricane, this species occurred in small enclaves in open, drastically altered habitats (e.g., grounds of resorts and guest houses). We found *A. ameiva* to be abundant on the grounds of the Rex Grenadian Resort. Between 09:50 and 10:20 hrs on 11<sup>th</sup> November, we observed 27 individuals representing all size classes. They were on the broad expanse of lawn, in flowerbeds, and on roads and walkways. We had never seen them in this abundance previously, nor as widely distributed throughout the resort grounds. This may be attributable to the resort being closed to guests because of hurricane damage. Because human activity was depressed, the lizards may have become bolder and expanded their areas of activity.

*Corallus grenadensis*: The distribution of this species on Grenada has been the focus of research since 1988, and a mark-recapture project was initiated at Pearls in 2002. Seven *C. grenadensis* were encountered at Pearls in 80 minutes (2.6 snakes/man-hour) on 10<sup>th</sup> November. Six of the snakes were young-of-the-year and one was a yearling. In comparison, in November 2003, treeboas were encountered at rates of 2.0–4.0/man-hour. *Corallus grenadensis* has been encountered at rates exceeding 10.0/man-hour (Henderson, 2002) at Pearls.



Figure 2. A cleared trail at Grand Etang National Park along which *Eleutherodactylus* surveys were conducted. Prior to Hurricane Ivan, this trail was under a closed canopy.

On 12<sup>th</sup> November at Mt. William, treeboas were seen foraging in the crowns of trees that were on the ground. Others were moving through leafless trees and in low shrubs above a roadcut. A 600-m transect was established along the road (narrow and infrequently used by vehicular traffic). Seven *C. grenadensis* were seen in 65 min (6.4 snakes/man-hour). They included young of the year and large (>1.25 m SVL) adults. On 14<sup>th</sup> November along the same transect, four treeboas were encountered in 52 min (4.6/man-hour). At this site in June 2004, eight treeboas were observed at the rate of 2.7/man-hour.

A brief search was made at Westerhall Estate on 12<sup>th</sup> November, and we found one *C. grenadensis* in a 30 min search (1.0/man-hour). One treeboa was seen during a similarly brief visit in June 2004 (0.67/man-hour).

A 20-min search at Balthazar Estate on 13<sup>th</sup> November failed to yield any treeboas. This site



Figure 3. Trail at the Pearls *Corallus grenadensis* study site. Downed trees and branches made use of this trail impossible.

had not been searched since 2000 when *C. grenadensis* was encountered at the rate of 3.8/man-hour (Henderson, 2002). Our search was inadequate to assess the impact of the hurricane on treeboas at this site.

*Mastigodryas bruesi*: This colubrid was not encountered. It is not a common species on Grenada, but it was observed at Westerhall (D. Yorks, in litt.) and Morne Delice (St. David Parish; CSB, pers. observ.) in 2003. Its absence during our surveys can be attributable to lack of sufficient effort rather than consequences of the hurricane.

### DISCUSSION

The damage wrought on forest habitats by Hurricane Ivan was alarming to see and, undoubtedly, frogs, lizards, and snakes were killed during the hurricane due to high winds, falling trees and branches, and heavy rains. We were gratified, nonetheless, to find species of frogs and reptiles at the respective sites where they were last encountered prior to the hurricane, and in comparable numbers. Certainly the four species identified by Germano *et al.* (2003) as ubiquitous (*E. johnstonei*, *A. aeneus*, *A. richardii*, and *C. grenadensis*) remained so after Ivan.

The most obvious habitat alteration based on our observations was the physical restructuring of substrates for foraging by frogs, lizards, and snakes, and for calling by *Eleutherodactylus*. Structural habitat is critical in resource partitioning by species of *Anolis* and among different size classes of *Corallus grenadensis*. At many sites structural aspects of the habitat were dramatically altered and future fieldwork will examine how various species respond to those alterations.

Despite observing reassuring numbers of certain species, some localized populations of frogs and reptiles probably will be negatively impacted by the severe habitat alteration inflicted by Ivan. Our November visit occurred during the height of the rainy season and it is possible that dry season (December-May) conditions in previously forested (closed canopy) areas may have a deleterious impact on members of the herpetofauna. Conversely, this is not the first hurricane to hit Grenada, and frog and reptile populations on the island have undoubtedly been impacted by tropical storms for millennia and have managed to sustain viable populations. Whether West Indian animals are adapted to withstand the impact of something as unpredictable and intermittent as a hurricane is open to conjecture, but finding animals where they were prior to Hurricane Ivan should not be surprising. In fact, we would have been more surprised had we not found them. But, as noted by Tanner *et al.* (1991), determining the impact of hurricanes on animals in the Caribbean should be a top priority. We will continue to monitor *Eleutherodactylus* and *Corallus* populations in hurricane-altered habitats for the next several years.

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- Addendum:** We returned to Grenada during 8<sup>th</sup>–17<sup>th</sup> February 2005. *Eleutherodactylus euphronides* was encountered in numbers comparable to (Mt. William) or greater than (Grand Etang) what we observed in November 2004. At Pearls, *Corallus grenadensis* was encountered at the rate of 1.03/man-hour (10.28 man-hours of searching). Most snakes observed were juveniles in their first year; one presumed adult was seen from a distance. The study transect was, not surprisingly, more overgrown than in November 2004. We used a chainsaw in order to navigate about 370 m of the original 520 m transect. *Corallus* numbers have been declining at Pearls for several years (before the impact of Hurricane Ivan), and the encounter rate for February was about 50% lower than in November. In addition, adult *C. grenadensis* have become extremely rare at the site. At Mt. William, treeboas were encountered at the rate of 4.1/man-hour (1.03 man-hours of searching). Four out of five snakes observed were in their first year; the fifth snake was a yearling. A large adult (1600 mm SVL) was encountered outside of the 600 m transect. The February fieldwork was funded by the Windway Foundation.