GUANA
2007

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5 May 2008

Dr. Henry Jarecki
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Dear Henry:

The 2007 season was most productive in Guana research. Herewith my annual report, which I have had to cut off even as more material is coming in. That will go to next year's report; I am running late as it is. Here is a brief outline of all that follows; page numbers are top right.

ORNITHOLOGY

HERPETOLOGY

ENTOMOLOGY

That's it for now. Three more submitted and accepted typescripts, a frog note and two bird diet papers, came in after I had numbered the pages, so you'll get them next year after they are actually published. Meantime, I'll see you On Island!

Best wishes, Skip

James Lazell, Ph. D.

COVER STORY

Photo: Dr. Robert Powell

The Pearly-Eyed Thrasher (*Margarops fuscatus*, abbreviated PETH) is the most conspicuous bird on Guana Island, and widespread in the Antilles from the Bahamas to the Windward Islands. Over most of that range – which is expanding – PETHs seem to have adapted very well to living around human habitations and thus become abundant. A true PETH horror story involves the critically endangered Puerto Rican Parrot back in mid twentieth century. Initially the PETH and the Parrot's paths never crossed in nature, but when people began making trails into the forest and camping close to Parrot nests to monitor and, ostensibly, protect them, the PETHs moved in with the people. The result was terrible: PETHs became vigorous, vicious marauders of Parrot nests, eating both eggs and hatchling Parrots. In my 2005 book *Island* I discuss PETH predation on Guana (pp. 225-226).

But how much PETH predation is perfectly natural, an evolutionary selection pressure ultimately beneficial to the gene pools of PETH's prey species? This is a topic of lively debate around the dinner table on Guana during science months each year. We do have to control (er, read *kill*) some individual PETHs that interfere with other bird banding and/or vandalize the dining tables. We have begun a stomach contents collection and analysis. Soon we should have sufficient data to at least spell out what they usually eat. Meantime, the note on the following page chronicles the persistence and effort of one PETH in an apparently perfectly natural predatory encounter at Anegada House, Guana.

ANOLIS CRISTATELLUS (Crested Anole). **AVIAN PREDATION**. The Pearly-eyed Thrasher (*Margarops fuscatus*) opportunistically feeds on eggs and chicks of parrots and other forest birds (Arendt 2000. Ornithol. Neotropical 11:13–63; Lazell 2005. Island: Fact and Theory in Nature. Univ. California Press, Berkeley), and is a potent predator of other *Anolis* lizards (Waide and Reagan 1983. Amer. Naturalist 121(1): 133-138). Here I report its predation on the Crested Anole on Guana Island, British Virgin Islands (18°28'N, 64°35'W).

On 23 October 2007 around 6 pm, a young male anole jumped onto a roof (3 m long, 1 m wide, 2.5 m above ground, and in contact with the vegetation canopy alongside) often used by the species for basking. Unusually, it made a noisy landing. Anoles use flight behavior to deter snake predation (Leal and Rodriguez-Robles 1997. Anim. Behav. 54: 1147-1154). This anole quickly ducked under the eve of the roof, followed within 5 sec by the arrival of a thrasher. The bird appeared to be searching for the lizard, located it, but was not able to catch it. In the next few seconds, the bird ran quickly along the roof edge back and forth twice, head looking down, neck cocked sideways, and beak hung below the eve. It was apparently following the lizard under the eve. It eventually drove the anole out onto the wall. Whether the anole was herded or stopped from escaping by the bird was not clear because I could not see under the eve. Once in the open, the bird caught the lizard in its beak. The lizard struggled and the thrasher took at least 5 min to subdue and swallow it. In addition to the snake (*Alsophis portoricensis*), other predators such as Red-tailed Hawk (*Buteo jamaicensis*) and mongoose (*Herpestes javanicus*) also prey on the Crested Anole (Schwartz and Henderson 1991. Univ. Press Florida, Gainesville; Platenberg and Boulon 2006. J. Appl. Herpetol. 3(3): 215-235).

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ORNITHOLOGICAL MONITORING AND RESEARCH ON GUANA ISLAND, BRITISH VIRGIN ISLANDS

PROJECT REPORT 2007

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15 April 2008

Red-billed Tropicbird

ORNITHOLOGICAL RESEARCH AND MONITORING ON GUANA ISLAND, BRITISH VIRGIN ISLANDS: PROJECT REPORT 2007

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INTRODUCTION

Little ornithological research has been conducted in the Virgin Islands compared to the rest of the West Indies (Wiley 2000). Thus, ornithological work on Guana Island makes substantive contributions toward a better understanding of the Virgin Islands as stop-over habitat for migrant birds (McNair et al. 2002, Boal et al. 2006, Boal and Estabrook 2007) and the basic ecology of Caribbean birds (Chipley 1991). Components of avian research on Guana Island are the annual mist-netting and banding of neotropical songbirds that migrate through the Caribbean region during the autumn migration, and specific studies focusing on species resident to the island. The latter consists primarily of focused studies on population demography of bananaquits, distribution and habitat associations of mangrove cuckoos, and tracking relative abundance of resident species. Objectives for avian research during the 2007 Science Month on Guana Island were:

1. Operation of the banding station to monitor species diversity and abundance of neotropical migrant land birds using Guana Island during autumn migration.
2. Conduct point-count surveys at established locations to develop an understanding of species distribution and abundances across Guana Island, and how these parameters change in relation to climate patterns.
3. Continuation of the mark–recapture study of bananaquit population demography.
4. Continuation of the mangrove cuckoo study.

All of these objectives were satisfactorily met during the 2007 Science Month. Here I provide data and discussion of the results of the 2007 field season, a review of research productivity stemming from avian research on Guana Island, and plans for the 2008 Science Month.

RESULTS AND DISCUSSION

Mist-Netting

I conducted mist-netting from 8 to 26 October 2007. During a total of 450 net-hours I captured 347 total birds of 13 species. This exceeds trap effort from all previous years and resulted in the second-greatest number of birds captured in a year (Table 1). However, the capture rate was the second lowest since I started operating the banding station. It was also a very lackluster year in terms of species diversity. During 2003 to 2006, 20–25 species were captured each October. In contrast, only 13 species were captured in 2007. Diversity of neotropical migrant landbirds was especially poor in 2007. Whereas an average of 11 neotropical migrant species/year were captured from 2003 to 2006, the much-reduced capture of only 3 neotropical migrants species in 2007 (blackpoll warblers, yellow-billed cuckoos, and a single rose-breasted grosbeak) was similar to the 3.2 species/year experienced by the Sibley team from 1994 to 2003 (Table 2). However, I still captured 111 blackpoll warblers, the second-highest total number ever captured during a banding season on Guana Island.

It is interesting to note there have been 28 different neotropical migrant landbird species captured and banded on Guana Island since 1994, but no more than 13 species have been captured in any single year (Table 3). I am currently attempting to analytically assess annual species diversity and richness of neotropical migrant landbirds scaled to mist-netting efforts. I have to examine net locations and mist-netting efforts prior to my involvement in science month to insure consistency of net locations used in the data. I will then examine the data for correlations between species diversity and richness to weather patterns in the Caribbean and Atlantic seaboard. This may help explain patterns observed in the autumnal migration.

Surveys

I conducted an island-wide bird survey that will be repeated annually. The methodological approach is similar to that used by Arendt (1995) and Wunderle (2001) during previous surveys on Guana Island. By conducting this survey each Science Month, changes in species abundance and distribution across the island and over time may be detected. I have developed 58 permanent survey points distributed along the Pyramid, Snake Transect, Lao Wei Ping, Long Man Point, Monkey Point, Sugar Loaf, and Palm Ghut trails, and in the vicinity of the Hotel and the Flat.

I detected 89 bananaquits and 86 thrashers among the 58 survey points, suggesting they remain the most abundant birds on Guana Island. Estimating population sizes is problematic due to differences in detectability of different species. For example, bananaquits were detected within the 25-m-radius perimeter of >70% of survey plots, whereas thrashers were detected within the 25-m radius at <50% of the plots (Figs. 1, 2). Detectability of bananaquits beyond 25 m decreases dramatically (<20% of plots), whereas detectability of thrashers remained at approximately 50% of plots (Fig. 3). I am attempting to use program DISTANCE to calculate reliable density estimates of common avian species on Guana Island. Results of this modeling attempt will be provided following the 2008 Science Month.

It is interesting to note that the average density of bananaquits in dry forest (1.53/survey point) was similar to that for the human-impacted area (orchard, flat, club; 1.54/survey point). Thrashers, however, increased from 1.34/survey point in the dry forest to 2.00/survey point in the human-impacted area. These are preliminary data that need to be rigorously assessed with detectability modeling, as is possible with program DISTANCE. However, as a cursory examination, it would suggest that the thrashers are either drawn to, or are more successful in association with, human activities.

Bananaquit Demography

To date, 739 bananaquits have been banded on Guana Island. Furthermore, I have 429 recaptures of banded bananaquits. This has provided a rich data set with which to apply contemporary mark–recapture modeling methods. I am using program MARK to develop sex- and age-specific survival estimates for bananaquits. The program also allows assessment of the influence of environmental factors on survival. I am attempting to use bananaquits as a representative species of passerine birds in the British Virgin Islands, and develop a better understanding of the potential impact of climate change on the species. I believe there are environmental factors influencing annual survival and reproduction. A preliminary analysis reveals dramatic year to year differences in not only the number of bananaquits captured on Guana Island, but in the ratio of adults to juveniles (Fig. 4). Modeling may reveal factors driving these patterns.

I am also investigating behavioral ecology and dispersal of bananaquits. To do this, I have banded 148 bananaquits with unique color-band combinations. This allows the identification of individuals without having to recapture them, and allows identification of mated pairs of birds and breeding territories, pair and site fidelity over time, and dispersal across the island. Because I have demonstrated that bananaquits can live at least 7 years (Boal et al. 2006), this is necessarily an ongoing and long-term component of the ornithological research on Guana Island.

Mangrove Cuckoo Ecology

The lead field investigator for this project is Tracy S. Estabrook (M.S.). The mangrove cuckoo is one of the least-studied North American birds and baseline population estimates and habitat requirements have been identified as among the most important research needs for the species. In 2005 we initiated a standardized call-playback survey along trails on Guana to try to establish baseline information on minimum number of individual cuckoos, pairs, and/or family groups present. A call-playback survey consists of broadcasting the call of the species over a loudspeaker. If an individual of the species is present, it may interpret the broadcast as the vocalization of a territorial intruder, and respond by approaching the surveyor while calling in response.

During the previous two years of surveys (2005 and 2006), we had become concerned about potential problems of double-counting birds at adjacent survey points, especially considering responsive cuckoos will sometimes approach or follow the surveyor. In addition, time constraints on-island had limited effective survey coverage of Guana Island's trails, resulting in a limited sample of the island's elevational and vegetative diversity. We therefore set 2 new goals for our 2007 mangrove cuckoo survey protocol: 1) reduce uncertainty related to potential problems with double-counting of birds at adjacent survey points, and 2) increase coverage of the Guana Island trail system to include all marked trails (not including un-maintained "research" trails on the east end of the island).

In 2007, we surveyed 86 points for mangrove cuckoos between 5 October and 25 October. We modified the survey points from 2006 by dropping 48 points (typically every other point along the original survey routes), effectively doubling the distance between survey points to ~200 m. This change resulted in higher surveyor confidence in distinguishing the responses of individual birds at adjacent survey points. We also added 24 new points on previously un-surveyed trails, to establish complete coverage of the marked Guana Island trail system. We obtained responses from cuckoos at 44 (51%) of survey points. At 3 (7%) of these 44 points we detected ≥2 cuckoos in close proximity, indicating possible pairs or related individuals. We are currently examining patterns of distribution across the island.

The relevancy of this study, in addition to acquiring basic biological information for the species, is its utility as a tool for conservation of mangrove cuckoos. The species is suspected of being substantially impacted by habitat loss and degradation due to conversion of low-lying vegetation areas on islands and in coastal regions throughout its range to urbanization, resorts, and agricultural production. Refinement of our survey protocol may enable detection, monitoring, and enhanced conservation of mangrove cuckoos not just in the Caribbean, but in coastal areas of North America.

Other Observations of Note

This year we had what appeared to be substantial fallout of migrating yellow-billed cuckoos. Our capture of only 5 individuals is misleading as to the actual number of yellow-billed cuckoos on Guana Island, as the size and behavior of the species makes it difficult to capture in mist-nets. Regardless of net captures, we observed and heard yellow-billed cuckoos across Guana Island and Tracy Estabrook observed one actual fallout during the morning of 17 October in which numerous individuals were arriving on the island and foraging in the canopies of the taller trees along the Liao Wei Ping trail above Quail Dove Ghut.

Bridled quail doves appear to be doing well. Although they were not noted to be as vocal as during previous years, numerous visual detections were made by several members of the Science Month team. They were regularly seen in the common areas, such as the work shop and orchard, but also along the shoreline of Monkey Point trail, along the trail to Sugar Loaf peak, in Palm Ghut, and on Long Man's Point (including Crab Cove trail); one was captured in a mist-net behind Anegada House.

A red-billed tropicbird nest was located just north of Crab Cove. The female was visually confirmed to be incubating eggs.

Project Productivity

Avian research is of little value if not made available to both the scientific community and the general public. Since engaging in avian research on Guana Island in 2003, I have published 2 manuscripts, have 2 accepted with anticipated publication in 2008, and have others in preparation. My colleagues and I have also made 4 presentations at meetings. Additional papers and presentations are anticipated as existing data are analyzed and new data are collected.

Publications

Boal, C. W., F. Sibley, T. S. Estabrook, and J. D. Lazell. 2006. Insular migrant species, longevity records, and new species records on Guana Island, British Virgin Islands. *Wilson Journal of Ornithology* 118:218–224.

Boal, C. W., and T. S. Estabrook. 2007. Occurrence and condition of migrant Swainson's thrushes in the British Virgin Islands. *Wilson Journal of Ornithology* 119:716–720.

Boal, C. W. 2008. Observations of an Antillean crested hummingbird (*Orthoryhncus cristatus*) attacking saddled anoles (*Anolis stratulus*). *Caribbean Journal of Ornithology*: Accepted.

Boal, C. W. 2008. Predation of a dwarf gecko (*Sphaerodactylus macrolepis*) by a bridled quail dove (*Geotrygon mystacea*). *Caribbean Journal of Ornithology*: Accepted.

Presentations:

Boal, C. W. 2003. Birds of prey in the British Virgin Islands. H. Levity Stoutt Community College, Roadtown, Tortola, British Virgin Islands.

Boal, C. W. 2005. Avian research on Guana Island: a decade in review. H. Levity Stoutt Community College, Roadtown, Tortola, British Virgin Islands.

Boal, C. W. 2006. New bird species in the British Virgin Islands: evidence for migration pattern changes? H. Levity Stoutt Community College, Roadtown, Tortola, British Virgin Islands.

Estabrook, T. S. 2005. Mangrove cuckoos: where the heck are they and what the heck are they doing? H. Levity Stoutt Community College, Roadtown, Tortola, British Virgin Islands.

FUTURE WORK

Avian study during Science Month in 2008 will essentially be continuation of the current projects. These are:

- Operation of the banding station to monitor species diversity and abundance of neotropical migrant land birds using Guana Island during autumn migration.
- Conduct point-count surveys at established locations to track species distribution and abundances across Guana Island, and how these parameters change in relation to climate patterns.
- Continuation of the color-banding mark–recapture program with bananaquits.

- Continuation, and possible expansion, of the mangrove cuckoo study.

ACKNOWLEDGEMENTS

First and foremost, I thank Dr. James Lazell and Dr. Gad Perry for continuing to facilitate avian research activities on Guana Island. I thank Gloria and Henry Jarecki for providing the opportunity for me and other researchers to conduct our studies on Guana Island. I thank the several people who assisted with ornithological studies on Guana Island during the 2007 season. Specifically, in 2007 these were Brent Bibles, Erin Estabrook, Tracy Estabrook, Susan Valentine, and Tom Willard. Funding for this research was provided by The Conservation Agency through a grant from the Falconwood Foundation and by the U.S. Geological Survey Texas Cooperative Fish and Wildlife Research Unit.

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Table 1. Species captured, new captures and recaptures of birds on Guana Island, British Virgin Islands, 2–28 October 2007.

Species	New captures in 2007	Recaptures	Total captures
American Kestrel	0	1	1
Wilson's Plover	1	0	1
Bridled Quail Dove	1	0	1
Zenaida Dove	8	4	12
Common Ground-dove	2	0	2
Yellow-billed Cuckoo	5	1	6
Mangrove Cuckoo	1	0	1
Green-throated Carib	3	0	3
Caribbean Elaenia	6	4	10
Pearly-eyed Thrasher	42	21	63
Blackpoll Warbler	111	2	113
Bananaquit	72	46	118
Rose-breasted Grosbeak	1	0	1
Black-faced Grassquit	7	8	15
Totals	260	87	347

Table 2. Comparison of mist-netting effort and capture rates at the Guana Island field site, British Virgin Islands, 2003–2007. Captures listed include both new birds captured and recaptures of previously banded birds.

Year	Net hrs.	Birds Captured	Birds /net hr.	Species Captured
2003	184	185	1.00	25
2004	218	168	0.80	20
2005	403	428	1.10	21
2006	400	284	0.71	24
2007	450	347	0.77	13

Table 3. Neotropical migrant landbirds captured and banded during mist netting on Guana Island, 1994–2007. Only neotropical landbirds are included. Yellow warblers are considered as resident species and are not included.

Species	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**TOTAL**
Yellow-billed Cuckoo	0	0	0	0	0	0	0	1	0	0	0	1	3	5	10
Belted Kingfisher	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Red-eyed Vireo	0	1	2	1	2	0	0	1	0	1	4	3	1	0	16
Black-whiskered Vireo	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Yellow-throated Vireo	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Barn Swallow	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Swainson's Thrush	0	0	0	0	0	0	1	0	0	1	0	26	0	0	28
Gray-cheeked Thrush	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2
Northern Parula	0	0	2	0	0	0	0	0	0	0	2	0	0	0	4
Golden-winged Warbler	0	0	0	1	0	0	0	0	0	0	0	1	0	0	2
Nashville Warbler	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
Magnolia Warbler	0	0	1	0	0	0	0	0	0	1	1	0	0	0	3
Cape May Warbler	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Black-throated Blue Warbler	0	0	2	0	0	0	0	0	0	0	0	0	1	0	3
Prairie Warbler	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Bay-breasted Warbler	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Blackpoll Warbler	0	11	27	9	83	0	5	16	8	19	7	176	63	111	535
Worm-eating Warbler	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Black-and-white Warbler	0	0	4	0	1	0	0	0	0	2	0	2	3	0	12
American Redstart	0	0	0	0	1	0	0	0	1	0	0	0	1	0	3
Ovenbird	0	0	0	0	3	0	0	0	0	2	1	0	1	0	7
Northern Waterthrush	0	0	3	0	2	0	0	0	0	0	0	0	0	0	5
Kentucky Warbler	0	0	1	0	0	0	0	0	0	1	1	0	0	0	3
Connecticut Warbler	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3
Hooded Warbler	0	0	0	0	0	0	0	0	0	1	0	0	3	0	4
Scarlet Tanager	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Rose-breasted Grosbeak	0	1	0	0	0	0	0	0	0	1	0	0	0	1	3
Indigo Bunting	0	1	0	0	0	0	0	0	0	1	3	0	3	0	8
Total	0	15	42	11	92	0	6	18	9	32	19	218	83	117	**662**
Total Species	0	5	8	3	6	0	2	3	2	12	7	12	13	3	**28**

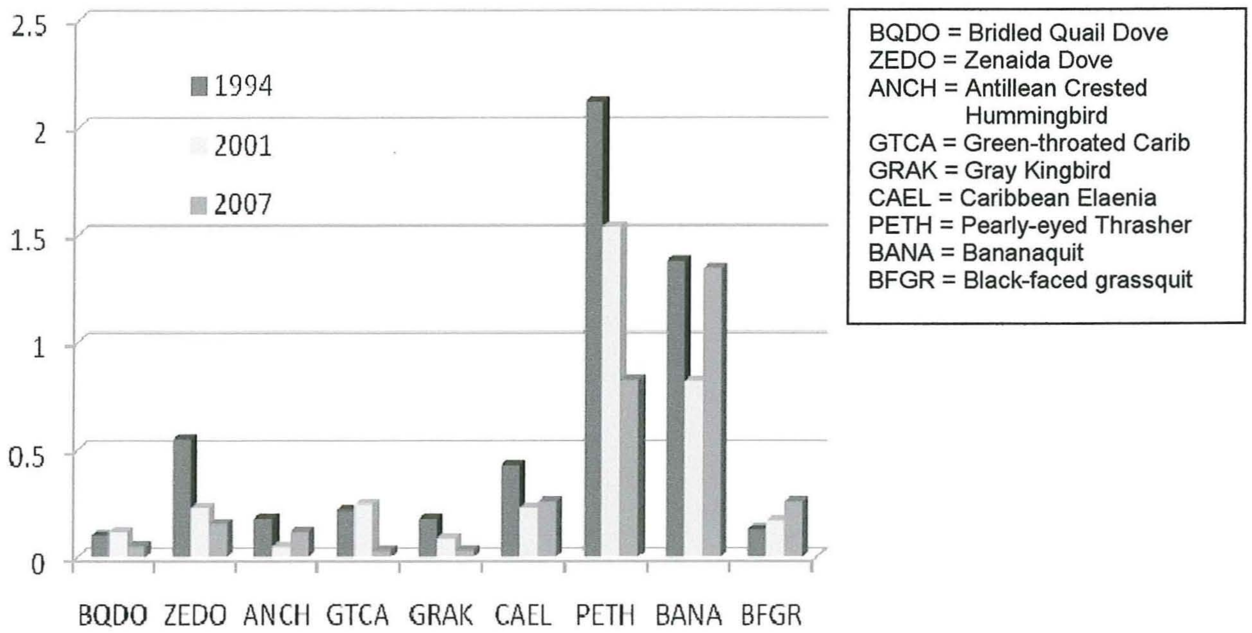


Figure 1. Average number of detections of common resident bird species within 25-m plots based on similar survey methods use by Arendt (1995), Wunderle (2001) and this study on Guana Island, BVI.

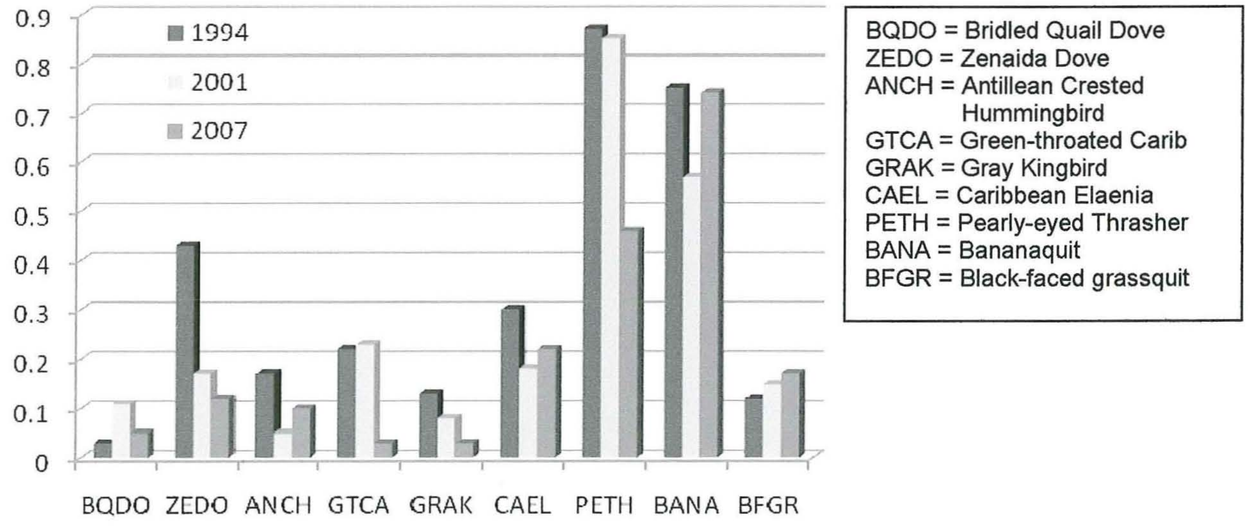
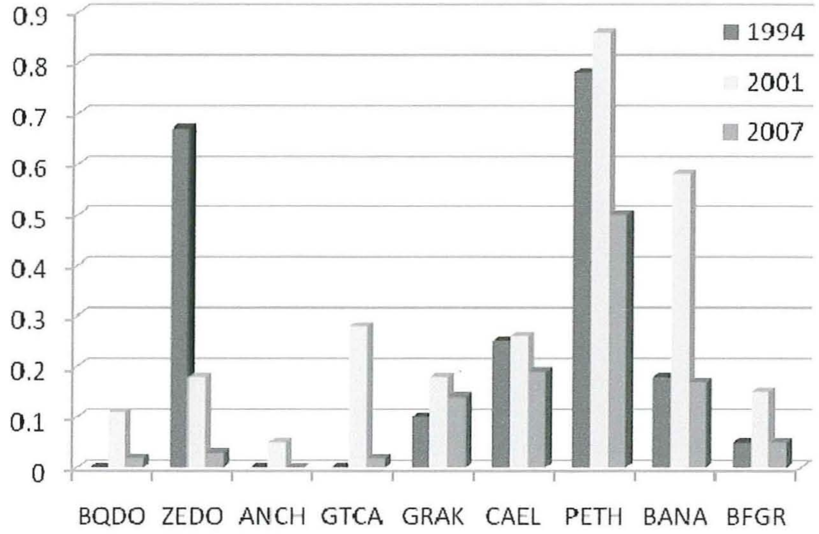


Figure 2. Proportion of 25-m plots in which a given species was located during surveys across Guana Island, BVI (Arendt 1995, Wunderle 2001, this study 2007), suggesting relative distributions among plots and, hence, across the island. For example, ZEDO was found at >40% of plots in 1994 but at <20% in 2001 and 2007.



BQDO = Bridled Quail Dove
ZEDO = Zenaida Dove
ANCH = Antillean Crested Hummingbird
GTCA = Green-throated Carib
GRAK = Gray Kingbird
CAEL = Caribbean Elaenia
PETH = Pearly-eyed Thrasher
BANA = Bananaquit
BFGR = Black-faced grassquit

Figure 3. Proportion of survey plots in which a given species was detected beyond the 25-m radius during surveys across Guana Island, BVI (Arendt 1995, Wunderle 2001, this study 2007), suggesting relative distributions among plots and, hence, across the island. For example, ZEDO was found at >60% of plots in 1994 but at <20% in 2001 and 2007.

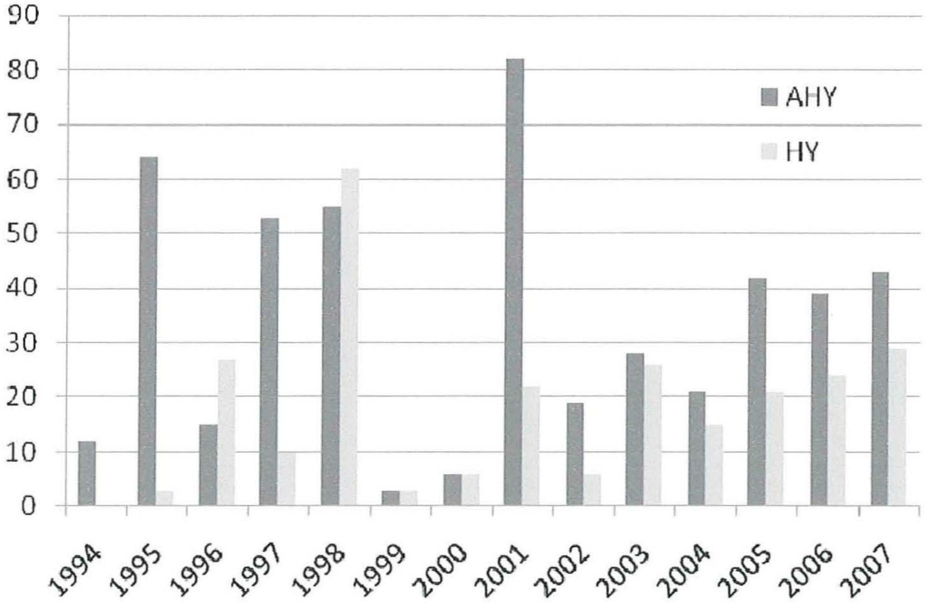


Figure 4. Abundance of adult (AHY) and juvenile (HY) bananaquits captured each October on Guana Island, BVI, 1994–2007. Net-hours vary among years so actual captures are not comparable among years, but ratio of AHY to HY is.

Images from Science Month 2007, Guana Island, BVI

An adult male Antillean Crested Hummingbird.

An adult Bananaquit providing food to a hungry nestling.

Assistant Erin Estabrook with one of the migrant Yellow-billed Cuckoos.

A rare capture; a Bridled Quail Dove captured in a mist-net very near the club.

In 2007 we captured 111 Blackpoll Warblers, the second-highest capture year on Guana Island (2005 was the record with 176).

The Rose-breasted Grosbeak, one of the few migrants captured in 2007. This female demonstrated the power (and hence her name) of her beak and her displeasure of being captured by biting chunks out of the bander's fingers.

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The Wilson Journal of Ornithology 118(2):218–224, 2006

INSULAR AND MIGRANT SPECIES, LONGEVITY RECORDS, AND NEW SPECIES RECORDS ON GUANA ISLAND, BRITISH VIRGIN ISLANDS

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ABSTRACT.—We conducted mist netting each October from 1994 to 2004 on Guana Island, British Virgin Islands, and recorded bird sightings to develop a more complete inventory of the island's resident and migrant species. During our study, we recorded four new species for the British Virgin Islands: Magnolia Warbler (*Dendroica magnolia*; 1996), Golden-winged Warbler (*Vermivora chrysoptera*; 1997), Swainson's Thrush (*Catharus ustulatus*; 2000), and Red-necked Phalarope (*Phalaropus lobatus*; 2004). Blackpoll Warbler (*Dendroica striata*) was the most frequently captured Neotropical migrant landbird, despite only being first detected in the region in 1989. Captures and detections of other Neotropical migrant landbirds suggest that many species may be more common in the region than previously believed, or, as speculated by other researchers, that migrant routes may be shifting eastward due to habitat degradation on western Caribbean islands. We also used recapture data to establish longevity records of resident species, including Caribbean Elaenia (*Elaenia martinica*; ≥7 years), Bananaquit (*Coereba flaveola*; 7 years), Black-faced Grassquit (*Tiaris bicolor*; ≥9 years), and Zenaida Dove (*Zenaida aurita*; 5 years). Longevities of other resident species were similar to, or slightly less than, those reported elsewhere. *Received 22 February 2005, accepted 30 November 2005.*

Ornithological research conducted in the West Indies has covered an array of topics, including avian species occurrence and distribution, ecology of individual species, effects of hurricanes on island bird populations, migration patterns, and community dynamics (Wiley 2000). In the Virgin Islands region, researchers have addressed avifaunal occurrence and distribution (LaBastille and Richmond 1973, Mirecki et al. 1977, Norton et al. 1989), and species ecologies (Askins and Ewert 1991, Chipley 1991, Mayer and Chipley 1992, McNair et al. 2002); however, considerably less ornithological study has been conducted in the Virgin Islands—especially the British Virgin Islands (BVI)—than in other areas of the West Indies. In a bibliography consisting of 11,648 entries for ornithological work conducted in the West Indies from 1750 to 1994, only 7.5% of the entries included information for the Virgin Islands; only the extralimital islands of San Andres, Providencia, and the Swans have received less attention (Wiley 2000).

We conducted mist netting on Guana Island, BVI, each October from 1994 to 2004. To our knowledge, the Guana Island station is the only current and consistently operated banding station in the British Virgin Islands and one of only three in the eastern Caribbean (St. Martin and Barbados being the others). Previously, information from the island has proven important in developing a better understanding of Neotropical migrant bird use of the region during the autumn migration (McNair et al. 2002). However, our data on species frequency of occurrence, which could be helpful in this effort, have not been made available until now. For example, Faaborg and Terborgh (1980) considered the Red-eyed Vireo (*Vireo olivaceus*) as a rare transient migrant encountered only in the Greater Antilles. In a status review of migrant landbirds in the Caribbean, Arendt (1992) did not list Red-eyed Vireos as even occurring in the British Virgin Islands. Indeed, Norton (1996) noted an account of a Red-eyed Vireo in Puerto Rico as one of only a few confirmed records for the species on the Puerto Rico Bank. The regular occurrences of Red-eyed Vireos at Guana Island (CWB and FCS unpubl. data), however, suggest that the species uses the Virgin Islands as a migration stopover more than previously believed.

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Here, we present an account of resident and migrant species banded during October each year for 11 years on Guana Island. For some species, we report longevity records based on recaptures of banded individuals. Additionally, we provide accounts of new or rarely reported species based on both banding and site records.

METHODS

The Virgin Islands, including both the U.S. Virgin Islands and the BVI, are a chain of approximately 76 islands and cays located 100–150 km east of Puerto Rico. Guana Island (18° 30′ N, 64° 30′ W) lies immediately north of Tortola, the largest of the BVI islands. Within the BVI, Guana Island is relatively small (3 km^2) compared with other inhabited islands, such as Tortola (54 km^2), Virgin Gorda (21 km^2), and Jost Van Dyke (10 km^2). The BVI has a subtropical climate tempered by northeasterly trade winds, with temperatures normally ranging from 28 to 33° C, and fairly constant humidity levels (~78%) throughout the year (Lazell 2005). Annual mean rainfall for Guana Island is estimated at 92 cm (Lazell 2005), but data are limited and the long-term average may be lower.

Guana Island is topographically rugged, with elevations ranging from sea level to 246 m. Approximately 90% of the island is covered by subtropical dry forest, with ghut forests (mesic forest; 5%) present in some drainages; miscellaneous covers include human-altered areas (3%), mangroves (1%), and beach (1%) (Lazell 1996; CWB unpubl. data). Lazell (1996) lists the primary native vegetation on Guana Island as tabebuia (*Tabebuia heterophylla*), gumbo-limbo (*Bursera simaruba*), loblolly (*Pisonia subcordata*), buttonwood (*Conocarpus erectus*), frangipani (*Plumeria alba*), acacia (*Acacia muricata*), and sea grape (*Coccoloba uvifera*). Tam-tam (*Leucaena leucocephela*) is common in disturbed areas. Introduced species include coconut (*Cocos nucifera*), tamarind (*Tamarindus indica*), and royal poinciana (*Delonix regia*).

We operated a mist-netting station each October from 1994 to 2004. Nets were located primarily along a northeast–southwest ridge and southeast-facing slope of a mountain on the island's west side. The majority of nets were in subtropical dry forest areas, but each year we placed 2–3 nets in human-altered areas along the ridge, all at approximately 100-m elevation. For one afternoon each year, we also netted along the shore of a salt pond to sample the shorebirds present. We attempted to use the same net locations each year, but during the earlier years of the project we conducted some "exploratory netting" in other areas. Duration of mist-netting operations and number of nets operated were subject to local weather conditions, the number of assistants available, and the amount of time we were allowed access to the island by its owners; thus, the number of nets used (mean = 8.1 ± 0.9 SE) and mist-netting days (mean = 8.8 ± 1.3 SE) varied annually. Weather permitting, nets were opened at 06:30 AST and closed between 10:00 and 11:00; occasionally, mist-netting was also conducted in the afternoon.

We identified all birds captured to the species level, and, when possible, determined their sex and age (Raffaele 1989, Pyle 1997, Raffaele et al. 2003). We recorded weight (g), length of wing chord (mm), and banded each bird with a federal aluminum leg band. We did not conduct systematic avian surveys (e.g., point counts), but we did record species encountered while engaged in other studies and activities on the island. Combined, our observation records and mist-netting efforts allowed us to compile an annual species list for the island and document occurrences of species previously unrecorded on the island and/or the BVI. We compiled recapture records to determine longevity for both resident and migrant species. We considered all after-hatching-year birds (AHY) to be 1 year old at time of initial capture.

RESULTS

Banding.—We conducted mist netting for a mean of 252 ± 53 SE net-hr each October from 1994 through 2004. During the study period, we captured 1,410 birds, 188 (13%) of which were recaptures of birds banded in previous years (Table 1). These numbers do not include captures of birds that we did not band, such as the Green-throated Carib (*Eulampis holosericeus*) and the Antillean Crested Hummingbird (*Orthorhyncus cristatus*). We captured 44 species, the most common of which was the resident Bananaquit (*Coereba flaveola*; 676 captures). Other frequently captured

TABLE 1. Species and numbers of birds captured and banded at Guana Island, British Virgin Islands, 1994–2004.

Species	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	*n*	Percent recaptured
American Kestrel (*Falco sparverius*)	0	0	1	0	4	0	0	0	1	4	0	10	10
Wilson's Plover (*Charadrius wilsonia*)	0	0	8	0	3	10	2	2	1	0	2	28	29
Semipalmated Plover (*Charadrius semipalmatus*)	0	0	0	0	0	0	1	0	0	1	1	3	0
Black-necked Stilt (*Himantopus mexicanus*)	0	0	0	7	0	2	1	2	0	0	0	12	8
Lesser Yellowlegs (*Tringa flavipes*)	0	0	2	0	0	1	0	0	1	0	1	5	0
Solitary Sandpiper (*Tringa solitaria*)	0	0	0	0	0	0	1	0	0	0	0	1	0
Spotted Sandpiper (*Actitis macularius*)	0	0	6	2	2	2	0	0	0	0	3	15	7
Ruddy Turnstone (*Arenaria interpres*)	0	0	0	1	5	2	0	0	3	3	0	14	0
Semipalmated Sandpiper (*Calidris pusilla*)	0	0	2	0	2	3	2	1	1	0	1	12	0
White-rumped Sandpiper (*Calidris fuscicollis*)	0	0	0	0	0	0	0	0	0	2	0	2	0
Stilt Sandpiper (*Calidris himantopus*)	0	0	0	1	0	0	0	0	0	0	0	1	0
Scaly-naped Pigeon (*Patagioenas squamosa*)	0	0	0	0	1	0	0	0	0	0	0	1	0
Common Ground-Dove (*Columbina passerina*)	1	0	9	1	9	0	0	5	1	1	0	27	11
Zenaida Dove (*Zenaida aurita*)	0	1	3	4	8	5	0	26	4	1	5	57	14
Yellow-billed Cuckoo (*Coccyzus americanus*)	0	0	0	0	0	0	0	1	0	0	0	1	0
Mangrove Cuckoo (*Coccyzus minor*)	0	0	1	0	1	0	0	1	0	0	2	5	0
Caribbean Elaenia (*Elaenia martinica*)	0	4	5	4	11	0	0	7	1	6	5	43	11
Gray Kingbird (*Tyrannus dominicensis*)	0	0	0	0	3	0	0	7	1	0	0	11	0
Yellow-throated Vireo (*Vireo flavifrons*)	0	0	0	0	0	0	0	0	0	1	0	1	0
Red-eyed Vireo (*Vireo olivaceus*)	0	1	2	1	2	0	0	1	0	1	4	12	0
Swainson's Thrush (*Catharus ustulatus*)	0	0	0	0	0	0	1	0	0	1	0	2	0
Pearly-eyed Thrasher (*Margarops fuscatus*)	3	0	21	2	13	5	1	21	0	12	15	93	4
Golden-winged Warbler (*Vermivora chrysoptera*)	0	0	0	1	0	0	0	0	0	0	0	1	0
Northern Parula (*Parula americana*)	0	0	2	0	0	0	0	0	0	0	2	4	0
Yellow Warbler (*Dendroica petechia*)	0	0	0	0	0	1	0	0	0	0	0	1	0
Magnolia Warbler (*Dendroica magnolia*)	0	0	1	0	0	0	0	0	0	1	1	3	0
Cape May Warbler (*Dendroica tigrina*)	0	1	0	0	0	0	0	0	0	0	0	1	0
Black-throated Blue Warbler (*Dendroica caerulescens*)	0	0	2	0	0	0	0	0	0	0	0	2	0
Blackpoll Warbler (*Dendroica striata*)	0	11	27	9	83	0	5	16	8	19	7	185	0
Black-and-white Warbler (*Mniotilta varia*)	0	0	4	0	1	0	0	0	0	2	0	7	0
American Redstart (*Setophaga ruticilla*)	0	0	0	0	1	0	0	0	1	0	0	2	0
Worm-eating Warbler (*Helmitheros vermivorum*)	0	0	0	0	0	0	0	0	0	1	0	1	0
Ovenbird (*Seiurus aurocapilla*)	0	0	0	0	3	0	0	0	0	2	1	6	0
Northern Waterthrush (*Seiurus noveboracensis*)	0	0	3	0	2	0	0	0	0	0	0	5	0
Kentucky Warbler (*Oporornis formosus*)	0	0	1	0	0	0	0	0	0	1	1	3	0
Hooded Warbler (*Wilsonia citrine*)	0	0	0	0	0	0	0	0	0	1	0	1	0
Bananaquit (*Coereba flaveola*)	12	68	50	85	145	9	16	131	45	72	43	676	20
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)	0	1	0	0	0	0	0	0	0	1	0	2	0
Indigo Bunting (*Passerina cyanea*)	0	0	1	0	0	0	0	0	0	1	3	5	0
Black-faced Grassquit (*Tiaris bicolor*)	11	6	26	9	18	2	11	16	8	11	30	148	13
Lesser Antillean Bullfinch (*Loxigilla noctis*)	0	0	0	0	1	0	0	0	0	0	0	1	0
Totals	27	93	177	128	317	42	41	237	76	145	127	1,410	

TABLE 2. Longevity records for species ≥4 years old on Guana Island, British Virgin Islands, 1994–2004.

Species	Age[a]	Sex	Year captured	Last recapture	No. of recaptures	Minimum age (years)
Wilson's Plover	AHY	F	1996	1999	2	4
	AHY	M	1996	1999	1	4
	AHY	U	1996	1999	1	4
	AHY	M	1996	1999	2	4
Black-necked Stilt	AHY	F	1997	2001	1	5
Spotted Sandpiper	HY	U	1998	2004	2	6
Common Ground-Dove	AHY	F	1998	2001	1	4
Zenaida Dove	AHY	M	1997	2001	2	5
	AHY	M	1998	2001	1	4
	AHY	M	2001	2004	1	4
Caribbean Elaenia	Unk	U	1996	2003	1	7
	Unk	U	1996	2001	1	5
Pearly-eyed Thrasher	AHY	U	1998	2001	1	4
Black-faced Grassquit	AHY	F	1996	2004	2	9
	AHY	F	1998	2004	1	7
	AHY	M	1998	2003	1	6
	HY	U	1998	2003	1	5
	AHY	F	2000	2004	2	5
	AHY	M	1996	2000	1	5
Bananaquit	AHY	M	1995	2001	3	7
	AHY	M	1997	2003	2	7
	HY	F	1998	2004	2	6
	AHY	M	1998	2002	2	5
	AHY	M	1997	2001	2	5
	AHY	F	1997	2001	1	5
	HY	M	1998	2003	2	5
	AHY	M	2001	2004	3	5
	AHY	M	1997	2000	1	4
	AHY	M	1995	1998	2	4
	AHY	M	1995	1998	3	4
	HY	F	1997	2001	2	4
	AHY	M	2000	2004	2	4
	AHY	M	2001	2004	2	4
	AHY	M	1994	1997	2	4
	HY	F	1998	2002	2	4
	HY	M	1998	2002	2	4
	AHY	M	1998	2001	1	4
	AHY	M	1998	2001	1	4

[a] AHY = after-hatching-year, HY = hatching-year, Unk = unknown age.

resident species were Black-faced Grassquit (*Tiaris bicolor*; 148 captures) and Pearly-eyed Thrasher (*Margarops fuscatus*; 93 captures). These three species are among the most abundant residents on Guana Island. We also captured 20 species of Neotropical migrant landbirds, the majority of which were warblers (Table 1). The Neotropical migrant captured most frequently was the Blackpoll Warbler (*Dendroica striata*; 185 captures), followed by the Red-eyed Vireo (12 captures, multiple additional sightings). Other Neotropical migrants encountered included many species (e.g., Yellow-throated Vireo, *Vireo flavifrons*; Table 1) previously reported only from the western Greater Antilles or for which there were no records from the BVI or the Lesser Antilles (Faaborg and Terborgh 1980, Arendt 1992).

Longevity.—We determined longevity for all species recaptured on the island, and provide data for those older than 3 years (Table 2). Among shorebirds, the longevity records were 5 years for Black-necked Stilt (*Himantopus mexicanus*), 6 years for Spotted Sandpiper (*Actitis macularius*), and 4 years for

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Wilson's Plover (*Charadrius wilsonia*); however, our recapture rate for these species was low and we suspect that our longevity estimates, especially for the resident Wilson's Plover, may be substantially lower than actual longevity. Among Columbiformes, our longevity records were 4 years for Common Ground-Dove (*Columbina passerina*) and 5 years for Zenaida Dove (*Zenaida aurita*). Among resident passerines, we recaptured Caribbean Elaenias (*Elaenia martinica*) that were ≥7 and ≥5 years old, and we recaptured a 4-year-old Pearly-eyed Thrasher. Among the 19 recaptured Bananaquits, two were 7 years old, one was 6 years old, and the others were 5 and 4 years old. The oldest bird recaptured was a ≥9-year-old female Black-faced Grassquit; we also recaptured one 6-year-old and three 5-year-old grassquits.

New species records.—During the course of our netting operations and surveys, we obtained species records for Guana Island and, in some cases, the British Virgin Islands. Our captures of a Magnolia Warbler (*Dendroica magnolia*) in 1996 and a Golden-winged Warbler (*Vermivora chrysoptera*) in 1997 were first records for the BVI. More significant, however, was our capture of a Swainson's Thrush (*Catharus ustulatus*) in 2000, the first record for the Virgin Islands and only the second from east of Cuba (McNair et al. 2002). In 2003, we captured another Swainson's Thrush and obtained a visual sighting of a second, unbanded individual. Finally, our observation of a hatching-year Red-necked Phalarope (*Phalaropus lobatus*) on the salt pond of Guana Island in October 2004 represented a first record for that species in the Virgin Islands.

DISCUSSION

Deriving longevity estimates from survivorship models is preferable to using simple longevity records (Krementz et al. 1989). The reliability of survival estimates, however, depends upon robust recapture data (e.g., Burnham et al. 1987), which often are not available for many species. Longevity records, therefore, are still valuable for providing some basic life-history information on little-studied species. This may be especially true for island settings, where longer-lived species are at lower risk of localized extinction (Newton 1998). Although longevity records have been reported for many North American bird species (e.g., Kennard 1975, Klimkiewicz et al. 1983), little information is available on the life spans of tropical birds (Snow and Lill 1974, Faaborg and Winters 1979, Johnston et al. 1997). The few Caribbean bird species for which there are longevity records are primarily Puerto Rican (Faaborg and Winters 1979, Woodworth et al. 1999), and there is virtually no published information on the longevity of birds in the eastern Caribbean. Thus, our data provide new age records for several Caribbean species. In Puerto Rico, Faaborg and Winters (1979) recaptured 36 of 219 Bananaquits, the oldest of which was 4 years and 7 months. Outside of the Caribbean, de Souza Lopes et al. (1980) reported a 4-year, 8-month-old Bananaquit from their study in Brazil. Our longevity record of 7 years for Bananaquits exceeds previous reports by a minimum of 2 years. Furthermore, our Bananaquit data suggest that ages of 4 and 5 years are not uncommon. Perhaps most unusual is our 9-year-old age record for a Black-faced Grassquit, with additional individuals aged 6 and 5 years. These far exceed the previous report of 2 years and 11 months (Faaborg and Winters 1979). The 4-year-old Common Ground-Dove in our study is similar to the longevity records of 4 years and 4 years and 1 month from Puerto Rico (Faaborg and Winters 1979). However, the 5-year, 5-month-old Pearly-eyed Thrasher reported by Faaborg and Winters (1979) exceeds our oldest known thrasher by 1 to 2 years. We found no reports of longevity for Caribbean Elaenia with which to compare our records; however, our records of 7- and 5-year-old Caribbean Elaenia are similar to those reported for unspecified *Elaenia* spp. in Brazil (6 years and 3 months, and 5 years; de Souza Lopes et al. 1980) and substantially exceed ages recorded for Yellow-bellied Elaenia (*E. flavogaster*; 2 years and 11 months) and Mountain Elaenia (*E. frantzii*; 3 years and 9 months) in Panama (Loftin 1975). We believe that the 5-year-old Zenaida Dove from our study also represents a longevity record for that species, as we could find no reports with which to compare our data.

Many of the Neotropical migrants captured or sighted during our study are known to occasionally occur in the BVI. Some of our sightings and captures, such as Hooded Warblers (*Wilsonia citrina*) and Worm-eating Warblers (*Helmitheros vermivorum*), are unusual for the BVI. Still others, including Magnolia Warbler, Golden-winged Warbler, Swainson's Thrush, and Red-necked Phalarope, provide new records for the BVI. Detections of Swainson's Thrush and Red-necked Phalarope were particularly interesting. Within the Caribbean region, Raffaele et al. (2003) indicated that Swainson's Thrush was found only rarely in the western Greater Antilles and only during migration; thus, detections of Swainson's Thrush in 2 different years on Guana Island was notable. Raffaele et al. (2003) also indicated that Red-necked Phalarope is a very rare migrant in the Bahamas, Cuba, and Hispaniola (e.g., Greater Antilles); in Puerto Rico, the species has been recorded only twice (Raffaele 1989). In September 2003, however, a Red-necked Phalarope was reported on Guadaloupe Island (Norton et al. 2003), which lies 400 km southeast of Guana Island.

Our detections of Blackpoll Warbler and Red-eyed Vireo, and our consistent detections of other, less common species—such as Yellow-throated Vireo, Swainson's Thrush, Indigo Bunting (*Passerina cyanea*), and numerous warbler species—indicate that they may be more common in the eastern Caribbean during migration than previously believed due to a lack of searching or banding efforts in that region. For example, Blackpoll Warbler, the most common warbler encountered on Guana Island and the second-most frequently captured species overall, was not reported in the BVI until 1989 (Norton 1990); it had been considered a common Neotropical migrant through the Greater Antilles but uncommon to rare on other islands (Arendt 1992, Raffaele et al. 2003). Similarly, Red-eyed Vireo was thought to be very uncommon or vagrant in the Lesser Antilles (Faaborg and Terborgh 1980, Arendt 1992, Norton 1996, Raffaele et al. 2003); however, our regular sightings and captures of Red-eyed Vireos suggest that the species may be a more common migrant in the BVI than previously believed.

Overall, our detections of species previously believed to be uncommon or not present within the BVI may have been due to a lack of field surveys and banding efforts throughout most of the Virgin Islands and Lesser Antilles. Alternatively, our detections may be related to changes in habitat conditions in the western Caribbean islands. As habitat availability decreases in the western islands, some migrant species might be shifting their migration routes eastward (Arendt 1992). Regardless of possible shifts in migration routes, it appears that Guana Island—a functional ecosystem protected as a nature preserve (Lazell 1996)—provides important habitat for both resident and transient migrant species. A low-occupancy, private resort occupies less than 2% of the surface area of Guana Island; the remainder of the island is almost completely free of direct human impacts and exists in a near-natural state (Lazell 1996). Furthermore, exotic herbivores and carnivores, which are a severe problem throughout much of the Caribbean, occur at very low densities and are heavily controlled on the island.

As larger islands in the Virgin Islands (e.g., Tortola, St. John, Virgin Gorda) continue to undergo deforestation and development (e.g., Arendt 1992), smaller islands maintained in primarily natural states are likely to become increasingly important for conservation of both resident and migrant birds. However, small islands, such as Guana Island, may not provide a full range of landscape characteristics required for some migrant or wintering Neotropical songbirds. For example, Northern Parula (*Parula americana*) and American Redstart (*Setophaga ruticilla*), both common nonbreeding residents in the Virgin Islands (Raffaele et al. 2003), are seldom detected on Guana. Further examination of resource use and spatial needs of Neotropical songbirds migrating through or wintering in the BVI is needed to facilitate conservation efforts.

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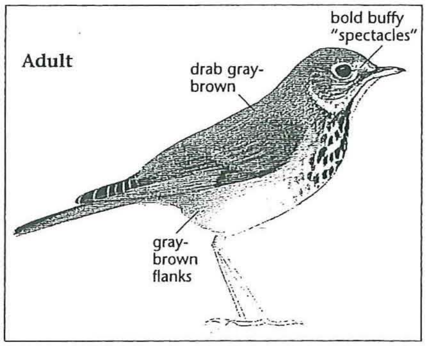

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Occurrence and Condition of Migrating Swainson's Thrushes in the British Virgin Islands

Clint W. Boal[1,3] and Tracy S. Estabrook[2]

ABSTRACT.—Swainson's Thrushes (*Catharus ustulatus*) migrate widely throughout North and Middle America. In the Caribbean, the species is known to occur only in the western-most Greater Antilles, and there only as a rare migrant. We captured and visually detected migrant Swainson's Thrushes beginning in 2000 at a banding station on Guana Island, British Virgin Islands. The majority of thrushes captured were adults (79%) and most had no (71%) or little fat (12%) reserves at time of capture; 61% were classified as being in emaciated or poor condition. The poor physiological conditions may have resulted from longer over water flights rather than island hopping. *Received 8 September 2006. Accepted 8 January 2007.*

The Swainson's Thrush (*Catharus ustulatus*) is a neotropical migrant passerine broadly distributed across the forested north and mountainous west of North America (Mack and Wang 2000). Population trends across the species' breeding distribution are inconsistent and difficult to interpret (Mack and Wang 2000), but there is evidence to suggest long-term declines in eastern North America (Holmes and Sherry 1988, Hill and Hagen 1991, Buckelew and Hall 1994). Recent analysis of Breeding Bird Survey (BBS) data indicates a declining trend (-0.83; $P = 0.09$) in the eastern United States (Sauer et al. 2005). Site-specific factors associated with breeding habitat may be influencing population trends (Sauer et al. 1997, Mack and Wang 2000), but population declines may also be related to factors occurring outside the breeding season (Petit et al. 1995, Mack and Wang 2000, Greenberg and Marra 2005). In particular, birds encounter a host of obstacles to survival during migration (Moore et al. 2005). The ecology of *en route* migrants is poorly understood (Heglund and Skagen 2005), which has been a major obstruction to progress on conservation of neotropical migrant birds (Cochran and Wikelski 2005).

An understanding of migration routes is nec-

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essary before assessing stopover habitat availability or distribution along migration routes. The known fall migration routes to wintering areas in southern Mexico, Central America, and northern South America differ between western and eastern populations of Swainson's Thrushes (Mack and Wang 2000). The eastern population appears to use different routes in autumn than in spring. The higher proportion of individuals on the eastern coast in autumn than spring may be indicative of more individuals making trans-gulf migrations during autumn, but circum-gulf migrations in spring (Child 1969, Rappole et al. 1979, Mack and Wang 2000, Reugg and Smith 2002). There also may be age-related differences in survival of Swainson's Thrushes migrating over open-water routes. Woodrey and Moore (1997) reported after-hatch-year (AHY) Swainson's Thrushes on the Alabama coast had sufficient energy stores to complete trans-gulf crossings, but hatch-year (HY) birds likely could not do so under still-air conditions.

The islands of the Caribbean have received little attention as a possible migration pathway for Swainson's Thrushes. The Swainson's Thrush within the Caribbean is considered a rare migrant in Cuba, Jamaica, the Cayman Islands, and northern Bahamas (Arendt 1992, Raffaele et al. 2003). This species was not listed in Raffaele's (1989) guide to birds of Puerto Rico and the Virgin Islands. Boal et al. (2006) reported capturing and banding the first Swainson's Thrushes reported for the Virgin Islands, approximately 1,300 km east of Jamaica. The objectives of this paper are to: (1) report the age and physical condition of autumn-migrating Swainson's Thrushes in the eastern Caribbean, and (2) examine the possible relevance of the increasing number of Swainson's Thrushes detected at our banding station.

METHODS

Our study site was on Guana Island (18° 30′ N, 64° 30′ W), immediately north of Tortola, the largest of the British Virgin Islands (BVI). The BVI, along with the U.S. Virgin Islands (USVI), are a chain of approximately 76 islands and cays. Guana Island is relatively small (3 km^2) compared to other inhabited islands such as Tortola (54 km^2) and Virgin Gorda (21 km^2). The British Virgin Islands have a subtropical climate tempered by northeasterly trade winds with temperatures ranging from 28 to 33° C and humidity levels ~78% throughout the year (Lazell 2005). The annual mean rainfall for Guana Island is estimated at 92 cm (Lazell 2005).

Guana Island is topographically rugged with elevations ranging from sea level to 246 m. Approximately 90% of the island is subtropical dry forest with mesic 'ghut' forests (5%) present in some drainages, and lesser amounts of human-altered areas (3%), mangroves (*Laguncularia* spp.) (1%), and beach (1%) (Lazell 1996). The primary native vegetation on Guana Island is tabebuia (*Tabebuia heterophylla*), gumbo-limbo (*Bursera simaruba*), loblolly (*Pisonia subcordata*), buttonwood (*Conocarpus erectus*), frangipani (*Plumeria alba*), acacia (*Acacia muricata*), and sea grape (*Coccoloba uvifera*). Tam-tam (*Leucaera leucocephela*) is common in disturbed areas. Introduced species include coconut (*Cocos nucifera*), tamarind (*Tamarinda indica*), and royal poinciana (*Delonix regia*) (Lazell 1996).

A banding station has been in operation on Guana Island each October from 1994 through 2006. Net locations were primarily along a northeast–southwest ridge and the southeast-facing slope of a mountain on the west side of the island. The majority of nets were in subtropical dry forest areas, but each year 2–3 nets were in human-altered areas along the ridge, all at approximately 70 m elevation. Duration of mist-netting operations and number of nets operated were subject to local meteorological conditions, an adequate number of individuals to assist with net monitoring, and the time we were allowed access to the island. Our nets were 12 m long with a mesh size of 32 mm; we typically monitored 12 nets, although the number was variable in earlier years of the banding station. Nets were opened at 0630 hrs and closed at 1100 hrs. However, nets were opened and operated during all daylight hours during migrant fallouts. We identified all birds captured to species and, when possible, gender and age (Raffaele 1989, Pyle 1997, Raffaele et al. 2003). We recorded wing chord and mass, estimated fat reserves, physiological condition, and banded each bird with an aluminum leg band provided by the U.S. Geological Survey, Bird Banding Laboratory. We measured mass with an electronic scale accurate to 0.1 g. Our fat estimates were based on the five categories presented by the North American Banding Council (2001). We used four categories to assess physiological condition of the breast muscle: emaciated, poor, fair, and good. Fat amounts and physiological condition were assessed by the same person for all but one thrush.

RESULTS

A Swainson's Thrush was first captured on Guana Island on 9 October 2000; we captured another and observed a second, unbanded individual on 16 October 2003. A fallout of Swainson's Thrushes occurred on Guana Island on 13 October 2005 and we captured 26 individuals between 13 and 15 October. Twenty-two (79%) of the 28 thrushes captured between 9 October 2000 and 15 October 2005 were AHY and 6 (21%) were HY birds. The average (±SD) mass of AHY birds (24.6 ± 2.2 g) was slightly lower than that of HY birds (26.4 ± 1.8 g). The difference approached statistical significance ($t_{26} = -1.85$, $P = 0.07$), but we suspect any difference may be related to a small sample of HY individuals. Seventeen (71%) of 24 thrushes examined had no fat reserves at time of capture, 4 (17%) had a trace of fat, 2 (8%) had a little fat built up, and 1 (4%) had a moderate amount of fat visible. We classified 1 (5%) thrush as emaciated, 12 (57%) as poor, 6 as fair (29%), and 2 (10%) of the 21 individuals as in good condition.

One AHY thrush captured at 1000 hrs on 13 October was recaptured at 0830 hrs on 14 October, 1400 hrs on 16 October, and 0650 hrs on 17 October. When originally captured, the thrush weighed 24.9 g, had no fat reserves, and was considered in poor condition. On 14 October the thrush weighed 26.0 g; it weighed 29.9 g on 16 October, and was evaluated as in fair condition with a moderate amount of fat visible. Thus it had gained 5.0 g in 3 days. It weighed 28.5 g on 17 October, possibly due to being captured before sunrise and, hence, after a nocturnal fast.

We did not conduct systematic surveys during the Swainson's Thrush fallout in October 2005 and estimates of the number arriving on Guana are subjective. We are confident that we captured only a small proportion of the Swainson's Thrushes in our immediate netting area during the fallout. We believe an estimate of 300 to 500 individuals in the area of our banding station is reasonable and probably conservative. A far greater number of Swainson's Thrushes likely made landfall on the island during the fallout.

DISCUSSION

Few studies of neotropical migrants have been undertaken in the eastern Caribbean (Wiley 2000). Ours is the only current and consistently operated autumn-migrant banding station east of Puerto Rico. This may explain our detection of previously unreported neotropical migrant species in the BVI, including Swainson's Thrush (Boal et al. 2006). The species is fairly cryptic and our observations may be evidence of a regular, if previously undocumented, migration route. However, during the fallout on Guana Island in 2005, we easily observed numerous individuals and groups moving about our study area; we doubt such a fallout would go unnoticed by ornithologists or experienced bird-watchers in the region.

If Swainson's Thrushes recently arrived in the east Caribbean, it may be due to anomalous weather events. The normal wind flow over the extreme southeastern United States and Gulf of Mexico in October is from northeast to southwest (Gauthreaux et al. 2005), resulting in crosswind displacement for which Swainson's Thrushes exhibit little or no compensation (Cochran and Kjos 1985). The storm track of most hurricanes and storms in the Caribbean would likely increase such a crossing wind. An east-to-west crossing wind would result in displacement to the west, and does not explain an approximate 1,300-km displacement east of the more commonly (yet still infrequently) used route over Jamaica (Raffaele et al. 2003).

Our data suggest at least some Swainson's Thrushes may use, or be shifting to use, the Atlantic Coast Migration Route identified by Lincoln (1935). Birds using this route "island-hop" through the Bahama Islands to the Dominican Republic, across the Greater Antilles, and south along the Lesser Antilles to South America (Lincoln 1935). Habitat loss has been identified as a possible force resulting in changes in some migration routes (Arendt 1992, Askins et al. 1992), and we may be witnessing early indications of a change in migration behavior of some Swainson's Thrushes. Alternatively, the poor condition and greater proportion of AHY thrushes arriving on Guana could be indicative of a longer open-water migration. Woodrey and Moore (1997) reported AHY Swainson's Thrushes had sufficient energy stores to complete a trans-gulf crossing, whereas HY birds likely could not under still-air conditions. Whether intentional or forced by weather conditions, fewer HY thrushes may have been able to survive if an extensive open-water crossing was undertaken. Additional data are needed on migration routes, specific stop-over site conditions, and habitats used by this species during migration before we can further speculate on associations between stop-over habitats and potential shifts in migratory routes.

Our observations have supplanted DeGraaf and Rappole's (1995) assertion that Swainson's Thrushes are absent from the Caribbean and expanded the ranges reported in Raffaele (1989), Arendt (1992), and Raffaele et al. (2003). Continued and increased monitoring effort for neotropical migrant bird presence and habitat use in the eastern Greater Antilles and the Lesser Antilles will be necessary to verify migration route use, changes in migration patterns, and development of an understanding of why such changes may be occurring.

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Report on Research Visit to British Virgin Islands
1 – 5 October 2007

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INTRODUCTION

The main purpose of this trip was to obtain blood samples of Magnificent Frigatebirds (Fregata magnificens) and Brown Boobies (Sula leucogaster) on Great Tobago and to survey the nesting Brown Pelicans (Pelecanus occidentalis) on Guana Island.

The blood samples are being analyzed to examine the genetic relationships of 4 species of tropical seabirds in the Caribbean and Pacific in order to determine the breeding population units of the species. We also made morphological measurements of adults to compare sizes among populations. Knowledge of the population genetic structure and differences in morphology of these species will contribute substantially toward identifying appropriate conservation units and strategies; however, this information is currently unavailable for most seabird species.

We hope to determine 1) the worldwide relationships of the populations, 2) if species and subspecies are properly described, 3) how natural history interacts with movement patterns, and 4) what are the barriers to gene flow.

RESULTS

We met with Esther Georges and Nancy Woodfield of National Parks Trust on 1 October in their offices and discussed this research and also some of the bird conservation issues of concern to the NPT.

We also met with Bert Lettsome and his staff at the Department of Environment and Fisheries, again, discussing this project as well as their bird conservation concerns. Both the NPT and the DEF approved our permit to collect the blood samples.

Twenty blood samples of Magnificent Frigatebirds were collected and 2 blood samples of Brown Boobies were collected. Samples were transported to the Smithsonian Institution for analyses in the genetics lab.

Great Tobago Island

The first thing that struck us as we landed on the island was the presence of a large number of goats. All during our visit we continued to see large numbers of goats (8 – 12 in a group). This is, by far, the most goats I have seen on the island over the past 10 years. This presents a severe problem for the nesting birds. Goats trample nests of Brown Boobies on the ground, as well as eat the eggs. They also keep any new trees from growing so that once the trees the frigatebirds use for nesting die, there will be no more nesting habitat for them. Unless the goats can be eradicated permanently from the island, nesting birds will eventually disappear as their habitat is destroyed and lost. This loss would represent a significant decline in the numbers of these species in the Caribbean. Great Tobago is home to 11% of the Caribbean Magnificent Frigatebird population.

Damage done by the goats to the vegetation on the island also causes tremendous erosion of soil into the surrounding water. This kills marine life ultimately reducing fish populations.

Brown Boobies (Sula leucogaster) were not nesting at the time of our visit to the island. This is very unusual as in the past during October there were nests in all stages from eggs to having large chicks. We expected to see about 100 active nests on the island. There were 5-7 fledgling boobies hanging around but they were very skittish and only two could be caught. There was evidence of several old nests which looked as though they had been destroyed. They did not look typical of a nest from which a chick had fledged. I believe the large number of goats has either destroyed the nests by trampling them as they walk around or they have eaten the eggs. Goats eating the eggs is the most likely scenario.

On the boat ride from Guana Island to Great Tobago I counted over 30 adult brown boobies roosting on rocks and flying by. Normally these birds would have been in the colony nesting.

I estimated about 600 Magnificent Frigatebird (Fregata magnificens) nests were present. Most birds were on eggs, and about 20% were still courting. Forty white-headed fledglings (chicks from last year) were still hanging around the nesting colony and possibly still getting fed by an adult. The nesting season appears to be progressing successfully at this point. Great Tobago has approximately 11% of the nesting frigates in the Caribbean.

We found 8 adults and 10 fledglings that had recently been entangled in fishing line and died (starved to death). Frigates often dive on baited hooks and get their bill caught. Most people are afraid of such a large bird and simply cut the fishing line to get rid of the bird. This leaves the line trailing behind the bird and when the bird gets back to the colony the line gets entangled in bushes, tying the bird down.

Frigates can easily be reeled in by a fisherman and the line and hook removed so that this does not happen. It would save the lives of many frigatebirds if a campaign could be mounted to educate fishermen about how to remove the line from the bird. A potential way to accomplish this would be to make a brochure/poster that could be posted at fish piers and docks explaining what to do when a frigate takes your bait.

There are few suitable trees on the island in which the birds can build a nest, and the existing nesting trees are very crowded. There are many fights as the frigatebirds claim nesting territories and try to build a nest. With the lack of regeneration of new trees owing to the goats eating all new growth, there is little nesting habitat for the frigatebirds. It may well be that the nesting population would be much larger, if there were more trees.

There were many skeletons of full-sized birds present. In this state it is impossible to determine if they were fledglings or adults, and why they died. Since there was an El Niño occurring in 2006-2007, it may be that these are birds which were affected by that and died owing to lack of food. Some may also have been caught up in fishing line.

A total of about 20 White-tailed Tropicbirds (Phaethon lepturus) were courting in the late afternoon. They are expected to initiate nests in crevices in the cliffs around the edge of the island.

Guana Island

I surveyed the nesting sites of Brown Pelicans and did not find any nesting at this time. Normally there would be 30-40 nests on Guana Island at this time of year with adults on eggs or small chicks. 2007 was a strange year for many nesting seabird species in the Caribbean area. For instance, Sooty Terns (Sterna fuscata) completely failed on the Dry Tortugas Islands off Florida this year. There was an El Niño ongoing in 2006 though mid-2007 and this could have affected food availability for pelicans. Different species are affected differently by El Niño events and the response of the various species has not been studied in the Caribbean.

Guana Island birds have essentially no human disturbance. I believe something was unusual in the food availability at the time which prevented the birds from nesting. They could have come in later in the season and began nesting in November or December as food availability changed.

Observations were made over two days on success rates of Brown Pelicans diving at Guana Island. Additionally observations were made on kleptoparisitism on Brown Pelicans by Brown Boobies and Laughing Gulls (Larus atricilla). These data will be combined with observations collected on previous visits to the British Virgin Islands to publish a paper on kleptoparisitism on Brown Pelicans.

RECOMMENDATIONS

1) Remove goats from Great Tobago Island as soon as possible. Repeated trips over a couple years will be necessary to accomplish this, as well as radio transmittering a couple goats that can be used to lead the shooters to groups of goats. There are many hiding places that goats can use on the island and it cannot be assumed that the goats are gone if they are not found on one or two trips to the island. If National Parks Trust desired, they could contact some experts in island predator removal like Dr. Brain Bell of New Zealand (http://www.wmil.co.nz, wmil@clear.net.nz).

2) Develop a campaign to educate fishermen about how to remove fishing line from birds that are caught on their hooks. Print a brochure or poster that could be posted at marinas and boat docks which illustrates how seabirds caught by a fishing hook can captured and the hook and line removed.

3) Seabirds tend to be highly philopatric, meaning that they return to the same nest site year after year. When commercial or private development of an area is being considered it should be taken into account that, if seabirds are nesting in the area, once they lose their nesting area to development, they may never nest again. Many seabird species will not move to a new nesting area when they lose their historic nesting site. A few species can be worked with to encourage them to move, but it takes some planning and field work to accomplish this.

The best policy would be to consult an experienced seabird scientist to evaluate the situation before a development is approved if seabird nesting areas are involved.

4) In addition to nesting habitat, seabirds need roosting habitat. When they are not actively involved in raising and feeding chicks, they still need areas where they can roost safely and preen (keep their feathers in good shape for flight, weatherproofing and warmth). When birds are constantly disturbed while roosting, they will eventually leave and area and go elsewhere to nest. Some safe roosting sites need to be set aside and protected for seabird use.

5) Seabirds are an excellent tourist attractant in many areas. They can bring in tourist dollars. On Barbuda fishermen use their boats to take tourists to see the Magnificent Frigate colony. This has given the fishermen a real desire to see the colony preserved. Eco-tours might prove to be a viable money-maker for fishermen in the BVI.

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Alsophis portoricensis anegadae (Squamata: Colubridae): Morphometric Characteristics, Activity Patterns, and Habitat Use

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From 2001–2005, we collected and individually marked 219 *Alsophis portoricensis anegadae* from Guana Island, British Virgin Islands, during the months September–October to determine morphometric characters, evaluate incidence of scarring and tail damage, and assess habitat use and activity. Males were longer than females and significantly heavier and heavier per unit length. Sex ratio was almost exactly 1:1 (102 M:104 F). Undamaged tails of males were significantly longer than those of females, but rates of tail damage did not differ by sex. Scarring and tail damage were more abundant posteriorly on the body and tail, and were cumulative, occurring with significantly greater frequency in larger individuals. Most damage was probably attributable to unsuccessful predation attempts by Soldier Crabs (*Coenobita clypeatus*). We found snakes in all habitats except an open grassy plain. Activity appeared to be bimodal, with a depression during the heat of the day. Although usually diurnal, three snakes were observed active at night. Most snakes were on the ground, but a small number were in water or climbing on vegetation or human-made structures. Most were in full shade and very few in full sun when first observed. Snakes most frequently were sprawled, rarely coiled, and many were first seen while moving.

SNAKES of the genus *Alsophis* (frequently referred to as "racers") are mostly terrestrial and range from the Bahamas to Dominica (Schwartz and Henderson, 1991; Powell et al., 1996). They were historically common on many islands, but introduced invasive species such as the Indian Mongoose (*Herpestes javanicus*) and Black Rat (*Rattus rattus*) prey on snakes and other native species (Sajdak and Henderson, 1991; Daltry et al., 2001; Henderson, 2004; Powell and Henderson, 2005). Consequently, they have suffered more extirpations and extinctions than any other reptilian or amphibian genus in the region. Other important factors include habitat degradation and human persecution, both common throughout the region (Daltry et al., 2001; Powell and Henderson, 2005). Despite the wide distribution, conservation concern, and large populations on mongoose-free islands, we know surprisingly little about the ecology of most members of the genus beyond basic habitat associations (Schwartz and Henderson, 1991) and diets (Henderson and Sajdak, 1996; for exceptions see Daltry et al., 2001; Heinz et al., 2004, 2005; Savit et al., 2005). The lack of even basic biological information often hampers our ability to protect remaining populations by identifying locations that are of particular biological importance.

Alsophis portoricensis inhabits the Puerto Rican Bank, including Puerto Rico proper and the Virgin Islands. MacLean (1982) reported the species to be rare or extirpated on the larger islands but still moderately common on Puerto Rico and many smaller islands. Especially in light of these declines, studies on the biology of the species are both desirable (Perry and Gerber, 2006) and difficult to implement on most remaining populations. Our goal was to document the basic biology of the species in a relatively intact system in order to provide crucial information for attempts to protect and restore populations elsewhere. We focused on two broad questions: What are the morphometric characteristics of the species and what do they tell us about its biology? Where and when are these animals active, and what ambient conditions affect activity levels?

MATERIALS AND METHODS

Study site.—Guana Island (18°38′N, 65°25′W) is situated in the West Indies and is part of the British Virgin Islands (BVI). Like most islands in the region, it is largely igneous in origin and is characterized by many steep slopes. Human activity on Guana, a private wildlife sanctuary, has been largely restricted to small portions of the island associated with an upscale resort hotel. Guana is primarily covered in dry tropical forest, with smaller contributions from forested ravines (ghuts), sun-baked rock faces, mangrove stands, and sand flats (Lazell, 2005). Biological research on the island has been ongoing for over 20 years, leading to an exceptional understanding of its biology (Lazell, 2005). The island is mongoose-free and has few, if any, feral cats because of frequent bait trapping. Previous observations (Lazell, 2005) have shown that *Alsophis* is abundant on Guana and included some anecdotal observations (e.g., Perry and Lazell, 2000; Powell et al., unpubl. data), but no detailed study has been conducted.

Morphometrics.—From 2001–2005, as part of an ongoing mark-recapture study, we collected and individually marked snakes from throughout the island during September–October. Snakes were visually located, manually captured, measured, uniquely marked with PIT tags, and released at the site of capture. For each animal, we recorded date, time of day, location, sex, snout–vent length (SVL), tail length, weight, tail damage, scarring, habitat, activity of the snake (moving, sprawled, coiled), and degree of insolation (full sun, sun-shade mosaic, or full shade). We determined weight to the nearest gram using Pesola spring scales, and SVL and tail length to the nearest mm using a metric measuring tape.

Habitat and activity.—We conducted systematic surveys during October 2001, using a 1-km trail through dry forest as our main transect. Dry weather resulted in a paucity of low vegetation and unusually good visibility. A single researcher (AB) walked the transect at 2-h increments, starting at 0600 and ending at 2130 h. During each survey, which lasted 1.5 h and encompassed the entire transect, she visually scanned a 2-m belt on each side of the trail for presence of snakes. To avoid disturbing the snakes and ensure that normal behavior was observed, the transect was visited once per day on all but two occasions, on which one visit occurred in the morning and the other during late afternoon or at night. To reduce systematic biases and ensure replication, each survey began at a different end of the transect and each sampling time was repeated twice. She avoided sampling on days when ambient conditions were not conducive to snake activity (cool, rainy days). Whenever a snake was encountered, she recorded time of day, activity (moving, sprawled, coiled), degree of insolation (full sun, sun-shade mosaic, or shade), and body, air, and substrate temperatures, measured using a Miller & Weber quick-reading cloacal thermometer. Transect data were augmented by additional observations conducted by us from 2001–2005 and by the activities of multiple researchers studying a variety of organisms on Guana at different times of day and night, revealing no snake activity at other times of day.

Statistical methods.—Statistical analyses were carried out using SPSS for Windows (SPSS Inc., Chicago, Illinois). Whenever possible, we used non-parametric tests to assure that our data met the assumptions of each test. When non-parametric tests were inappropriate, we used parametric tests after transforming the data. All *P*-values reported are two-tailed.

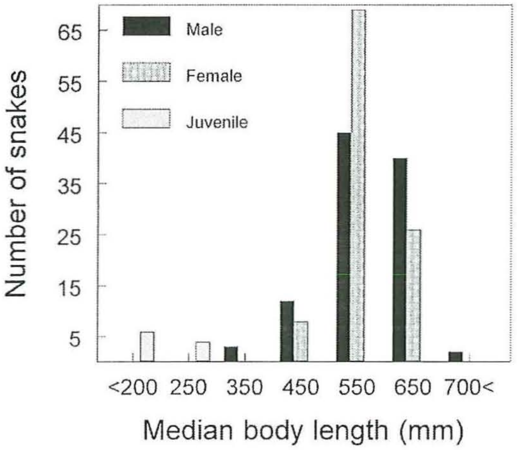

Fig. 1. Sizes (SVL) of *Alsophis portoricensis anegadae* on Guana Island ($n = 219$).

RESULTS

Morphometrics.—Snake SVL ranged from 185–855 mm ($n = 219$, $\bar{x} \pm SD = 555.4 \pm 93.7$ mm) and mass ranged from 2–308 g ($n = 219$, $\bar{x} = 62.4 \pm 31.7$ g). Nearly all of our adult animals were of moderate size (450–650 mm SVL; Fig. 1). Only two males (SVL = 767 and 855 mm) exceeded that range.

Sex ratio was almost exactly 1:1, with 102 males and 104 females in our sample. Despite the two large individuals, males were not significantly longer than females (male SVL: $\bar{x} = 574.6 \pm 75.0$ mm, $n = 102$; female SVL: $\bar{x} = 564.0 \pm 57.1$ mm, $n = 104$; Mann-Whitney *U*-test: $n = 206$, $U = 4563.5$, $Z = -1.73$, $P = 0.08$). Males were, however, significantly heavier than females (male mass, $\bar{x} = 71.2 \pm 35.5$ g, $n = 101$; female mass, $\bar{x} = 56.8 \pm 17.0$ g, $n = 104$; $n = 205$, $U = 3450.5$, $Z = -4.24$, $P < 0.001$). We used an ANCOVA of log-transformed values to ask whether the relationship between body size and mass (Fig. 2) was significantly different between the sexes. Not surprisingly, mass and body length were significantly associated ($F_{1,202} = 513$, $P < 0.001$). We also found a highly significant sexual difference, whereby males of a given length were heavier than similarly-sized females ($F_{1,202} = 23.3$, $P < 0.001$).

Tail length ranged from 25–354 mm ($\bar{x} = 232.8 \pm 58.5$ mm, $n = 219$). However, most tails (71% of measured tails) were stubbed to some degree (Fig. 3A). Undamaged tails ranged in length from 72–330 mm ($\bar{x} = 228.1 \pm 61.3$ mm, $n = 56$). Undamaged male tails ($\bar{x} = 258.6 \pm$

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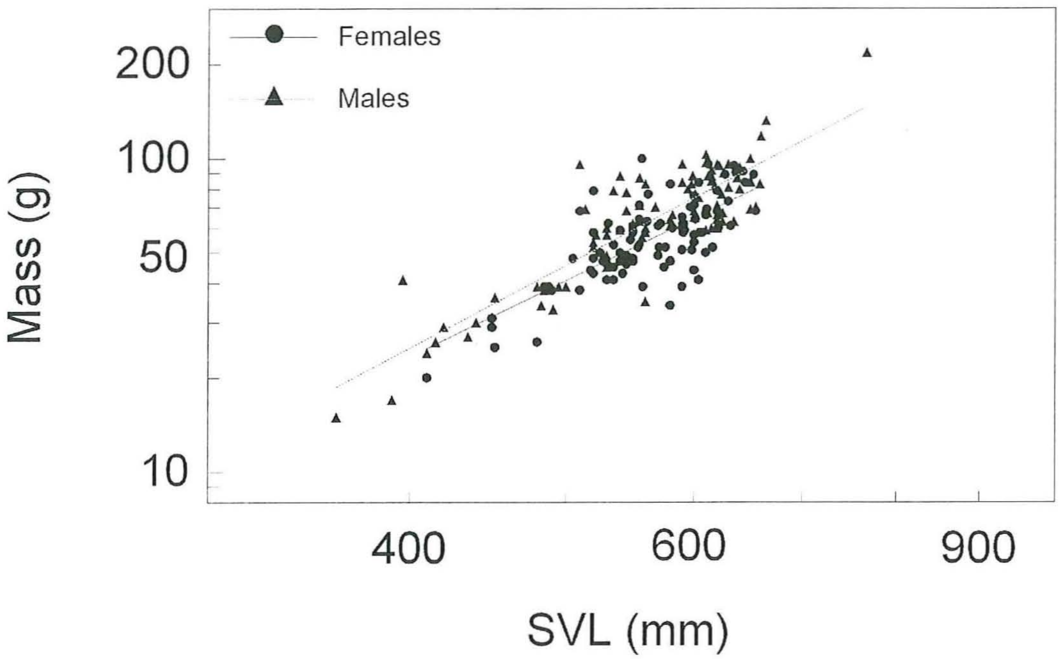

Fig. 2. The relationship between body length and mass in females (dots, full line) and males (triangles, dotted line) is significantly different.

37.2 mm, $\bar{x}$ = 50 ± 5.5% of SVL, n = 25) were longer than those of females ($\bar{x}$ = 236.6 ± 45.5 mm, $\bar{x}$ = 44 ± 8% of SVL, n = 31). The difference between the sexes in undamaged tail length was statistically significant (ANCOVA using SVL as covariate; $F_{1,59} = 2.96$, $P < 0.027$).

Frequency of tail damage was essentially the same for the two sexes (males 69%, females 74%; df = 1, $\chi^2 = 0.18$, $P = 0.68$). We did not observe tail damage in the smallest animals, but the incidence of damage rapidly and significantly increased once SVL exceeded 450 mm (Fig. 4A; n = 9 size categories, $\rho = 0.94$, $P < 0.001$). The relationship between SVL and tail length in undamaged animals was positive and statistically significant (log tail length = −0.009 + 0.909 * log SVL; linear regression, $r^2 = -0.73$, $P < 0.001$). Using this equation, we calculated the predicted tail length for animals that had sustained tail damage and correlation analysis to ask whether larger animals had more extensive damage than did smaller ones. Indeed, the percentage of the tail damage, compared to predicted values, increased significantly with body size (n = 143, $\rho = 0.19$, $P = 0.02$), suggesting that additional damage occurs over time.

Scarring of the body showed a pattern similar to that for tail damage (Fig. 3B, C). Scarring was more likely to be seen posteriorly than near the head (Table 1) and increased in frequency as snakes grew larger (Fig. 4B; n = 9 size categories, $\rho = 0.96$, $P < 0.001$). Frequency of scarring was almost identical for the two sexes (percent scarred: males 52.7% of 93 animals; females 53.3% of 90 animals, df = 1, $\chi^2 = 0.003$, $P = 0.95$). Animals with damaged tails were also more likely to have scarring than those with no tail damage ($\chi^2 = 7.21$, df = 1, $P = 0.007$).

Habitat and activity.—Snakes were abundant (n = 105) in and around the substantially altered areas associated with the hotel, donkey corrals (mostly decrepit and unoccupied), the "orchard" (a cultivated area with numerous fruit trees), and the section of beach devoted to tourism (n = 7). Snakes were similarly abundant in dry forest (n = 72), ghut forest (n = 31), and beach strand (n = 9). Only in the open grassy flat did we fail to encounter animals, although we found individuals in "islands" of vegetation or debris within the plain.

Most snakes we encountered were on the ground, but we observed four animals in water (Powell et al., 2006) and at least 11 animals (three juveniles) that had climbed on trees or human-made structures. As indicated by our transect study, snakes (n = 20) were active throughout the day, with activity peaks in the morning and afternoon and lower activity during the heat of the day (Fig. 5A). Activity was significantly negatively correlated with ambient

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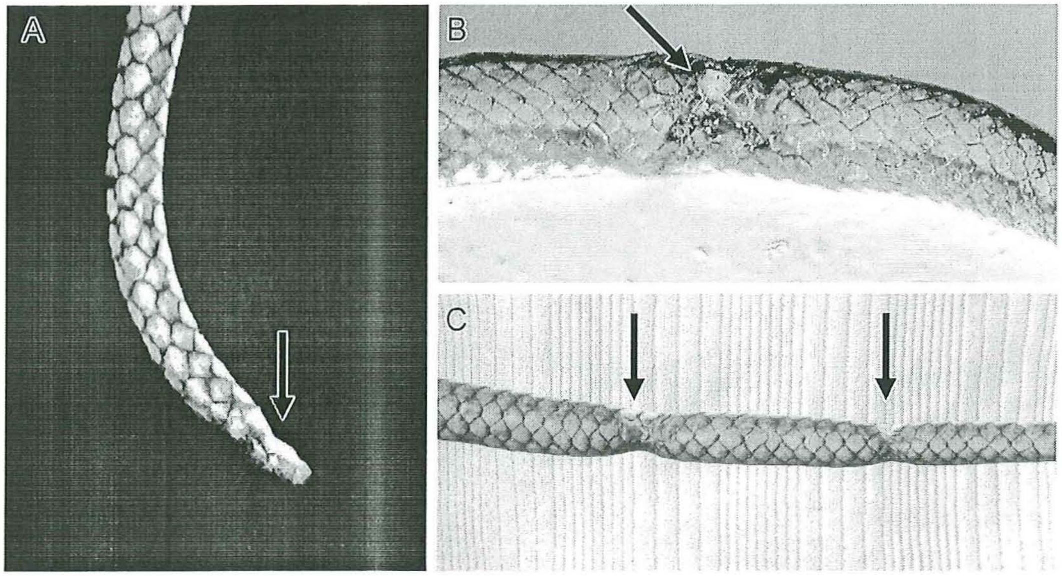

Fig. 3. Damage presumably inflicted by Soldier Crabs (*Coenobita clypeatus*) on *Alsophis portoricensis* from Guana Island, British Virgin Islands. (A) Damaged tail tip. The arrow indicates scarring just above the stump. (B) Recent damage to the posterior part of the body. The arrow indicates exposed bone. (C) Healed damage to tail. The arrows indicate two of three such scars on this individual.

temperature (Spearman correlation; $\rho = -0.71$, $n = 8$, $P = 0.05$). Snake body temperature was significantly correlated with both air ($\rho = 0.86$, $n = 41$, $P < 0.001$) and substrate temperatures ($\rho = 0.88$, $n = 37$, $P < 0.001$). However, multiple regression showed that substrate temperature had no immediate effect on body temperature ($t = 0.88$, $P = 0.39$) once the statistically significant effects of air temperature ($t = 3.50$, $P = 0.001$) were removed. Total snake encounters over the five-year study period ($n = 205$ for which time of day was recorded) show a similar pattern (Fig. 5B), although encounter rates were not corrected for search effort. We did observe three snakes active at night, one of them at a night-light (Perry and Lazell, 2000).

Of 154 snakes for which insolation data were collected, seven (4.5%) were found in full sun, 89 (57.8%) were in full shade, and 58 (37.7%) were first seen in a sun-shade mosaic. Snakes were seen in the full sun only early and late in the day (Fig. 6), although shade and sun are available in nearly all habitats on most days. Of 188 snakes for which posture data are available, 76 (40.4%) were moving when first seen, 90 (47.9%) were sprawled, and 22 (11.7%) were coiled.

DISCUSSION

Size and tail damage.—Individuals of *A. portoricensis* on Puerto Rico, St. Thomas, and Buck Island (off St. Thomas) routinely reach large size (Schwartz, 1966; Schwartz and Henderson, 1991), but those on Guana Island rarely exceed 650 mm SVL. This is consistent with the characterization of *A. p. anegadae* by Schwartz (1966) as a subspecies of "moderate size." We lack the data to determine whether the paucity of large individuals on Guana is genetically or energetically constrained. However, these snakes presumably subsist almost entirely on the ubiquitous anoles (*Anolis* spp.), the largest of which (*A. cristatellus*) attain SVLs of only about 75 mm. Larger prey (e.g., *Ameiva, Cyclura,* or rodents) appear to be taken only rarely. Furthermore, *Ameiva,* although abundant, are not nearly as ubiquitous as anoles (Nicholson et al., 2005), and, at least during our September–October sampling periods, most individuals were small (juveniles or subadults with SVL ≤ 55–60 mm; pers. obs.). Rock Iguanas (*C. pinguis*) have only recently been introduced to the island (Lazell, 2002). Their consumption by snakes (LeVering and Perry, 2003) is probably adventitious and limited to larger snakes, as hatchling iguanas are stocky and have an average SVL of about 108 mm and mass of 60 g (Perry et al., in press). We have no records of snakes on the island consuming rodents (*Mus* or *Rattus*).

Many snake studies report SVL (e.g., Fitch, 1981), but fewer report mass or the relationship between SVL and mass. In contrast, many studies of lizards report such data (e.g., Pough, 1973; Perry, 1989), and such relationships provide important

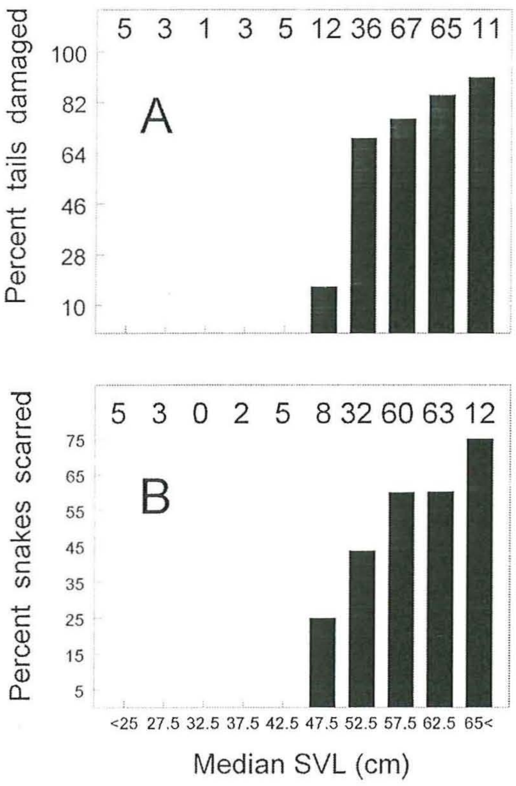

Fig. 4. Frequency of injuries as a function of size in *Alsophis portoricensis*. The number above each column represents sample size. (A) Tails are significantly more likely to be damaged as snakes grow larger. (B) The frequency of overall scarring increases with body size.

information on the biology of a species (Guyer and Donnelly, 1990). For example, we know that the Guana population is flourishing, suggesting our snakes are not unduly stressed. Consequently, demonstrations that animals in other populations have lower mass for a given body length could indicate compromised condition that might be attributable to pressures imposed by introduced predators or poor habitat quality.

Reptiles typically show female-biased sexual size dimorphism (SSD; Fitch, 1981), and this also is true for snakes (Shine, 1994). Our data indicated that *A. portoricensis* is an exception to that rule, as males were longer and significantly heavier and heavier per unit length than were females. The opposite pattern was found in *A. antiguae* (Daltry et al., 2001), but we have not been able to locate additional studies reporting such information for *Alsophis*. The relatively low mass of females compared to males of similar size may indicate a difference in the cost of reproduction between the sexes (e.g., Shine, 1980), and the longer tails of males likely reflect the need to hold the reproductive organs, as in other species (Shine et al., 1999).

The tail is important to at least juvenile *A. portoricensis*, which exhibit caudal luring as a foraging strategy (Leal and Thomas, 1994). The level of damage we found—nearly 70%—is high compared to other records we have been able to locate: about 10% in *Thamnophis sirtalis* (Jayne and Bennett, 1989), 26% in *Aipysurus laevis* (Burns and Heatwole, 2000) and *Psammophis phillipsii* (Akani et al., 2002), 42% in *A. antiguae* (Daltry et al., 2001), and 55% in *Scaphiodontophis annulatus* (Henderson, 1984). However, our findings are consistent with other reports for *A. portoricensis* (Schwartz, 1966). What might be causing damage at these levels? Potential avian and mammalian predators, with the exception of the Pearly-eyed Thrasher (*Margarops fuscatus*), are uncommon on Guana (Lazell, 2005). Given that damage appears in large snakes rather than small ones, thrashers are probably not responsible. Avian and mammalian species also are likely to be fairly effective as predators and thus unlikely to leave many scarred survivors (Jaksic and Greene, 1984). In contrast, crabs, and especially Soldier Crabs (*Coenobita clypeatus*), are common on the island (Haralson et al., unpubl. data) and are unlikely to frequently kill snakes. This species is known to prey on eggs of ducks (Meier et al., 1989) and doves (Rivera-Milán and Schaffner, 2002) in Puerto Rico and

TABLE 1. THE FREQUENCY OF SCARS IN *Alsophis portoricensis*. Numbers represent the number of individuals with at least one scar on the head, body (divided into three equal parts), or tail. Note that the frequency of scars increases from the head toward the tail.

	Scar location					
		Body	Body	Body		
	Head	Anterior 1/3	Middle 1/3	Posterior 1/3	Tail	Combined
Scarred	3	18	30	56	79	99
Unscarred	188	174	162	136	112	93
Percent unscarred	98.4	90.6	84.4	70.1	58.6	48.4
n	191	192	192	192	191	192

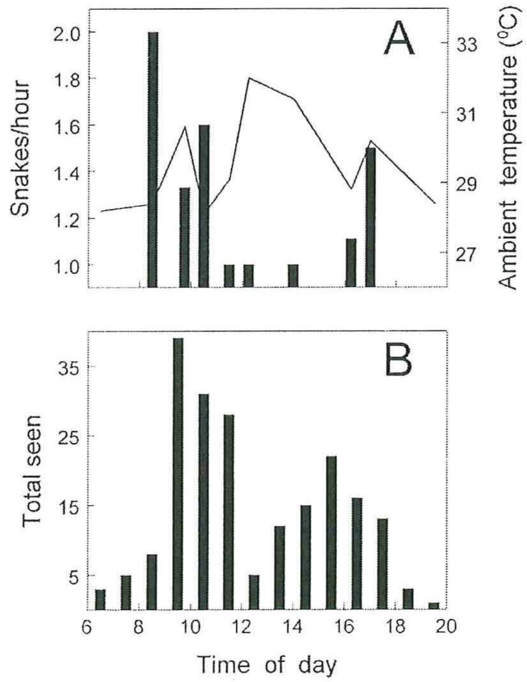

Fig. 5. Activity time of *Alsophis portoricensis* on Guana Island, British Virgin Islands. Snakes are significantly more active during the morning and afternoon hours, when ambient temperatures are slightly cooler. (A) Effort controlled transect study ($n = 20$). The line shows ambient temperatures measured during the study. (B) Total observations over the five-year study period ($n = 205$).

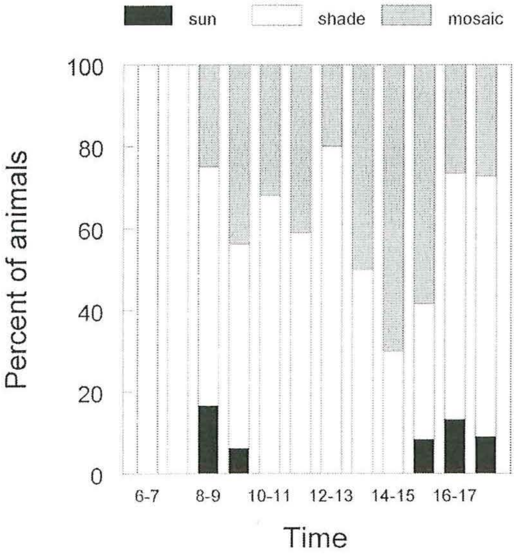

Fig. 6. Insolation conditions at locations where *Alsophis portoricensis* were observed on Guana Island, British Virgin Islands, as a function of activity time. Despite ongoing availability, snakes avoid direct sunlight during the warmest parts of the day.

parrots in the Cayman Islands (Wiley et al., 2004). Other species of crabs also are known to prey on terrestrial snakes (Hecht et al., 1955; Maitland, 2003), marine snakes (Voris and Jeffries, 1995), sea turtles (Wood, 1986), frogs (Ryan et al., 1981), and other species (Greene, 1988; Schwartz and Henderson, 1991:560). Crabs, and especially Soldier Crabs, appear to be a plausible culprit for the tail loss and scarring we observed (Fig. 3C).

Habitat and activity.—Although not corrected for effort, our data emphasize the fact that these snakes occur virtually everywhere on the island and that proximity to humans does not deter their presence. Because Guana is a "snake-friendly" island, we believe that our results indicate that, under the right conditions, snakes and humans can peacefully co-exist.

Our data indicate a bimodal activity period, with a relative lull during the warmer times of the day (approximately 1200–1400 h). A bimodal pattern of activity in snakes is not unusual (Gibbons and Semlitsch, 1987) and has been seen in the closely related *A. rufiventris* on St. Eustatius (Savit et al., 2005) and ecologically similar *Liophis poecilogyrus* in Brazil (Maciel et al., 2003). Bimodal activity often is related to avoidance of high daytime temperatures (Gibbons and Semlitsch, 1987; Peterson et al., 1993; Maciel et al., 2003; Savit et al., 2005). Our data show that the body temperatures of *A. portoricensis* tracked those of an animal's immediate environment, and especially air temperature, which changes more rapidly than ground temperature. In the absence of data on availability of thermal resources in the environment, we do not know whether this represents thermoconformism, active thermoregulation, or some intermediate degree of thermal control. However, the apparent avoidance of full sun during the warmer parts of the day suggests that at least some degree of active choice is involved.

Members of the genus *Alsophis* are generally considered to be diurnally active (e.g., Schwartz and Henderson, 1991). *Alsophis portoricensis* was not known to be active at night until a recent observation of an individual exploiting the "night-light" niche (Perry and Lazell, 2000), something few snakes are known to do (Perry and Fisher, 2006). With extensive sampling effort by multiple searchers extending throughout the day, we observed a few more instances of snakes active at night away from lights. These indicated two things. First, *A. portoricensis* is active, albeit rarely, after dark, and this doubtlessly facilitated the exploration of the night-light niche. Second, with similar effort, additional species may be found occasionally active at atypical times. Similarly, although species of *Alsophis* are usually terrestrial, previous reports indicated that some individuals swim (Powell et al., 2006) and climb (Pérez-Rivera and Laboy-Rivera, 1996), even as high as 18–20 m in rainforest habitat (Thomas and Kessler, 1996).

Racers such as *A. portoricensis* are important predators in intact Caribbean ecosystems. However, accelerated rates of development and invasive species dispersal in the Caribbean mean that few intact communities remain, and snakes in the genus *Alsophis* are among the species disappearing most rapidly. Despite this, our knowledge of their biology, a prerequisite for any conservation work, remains limited. The present study begins to address this knowledge gap for *A. portoricensis* and reiterates the need for similar work on related species.

Acknowledgments

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ALSOPHIS PORTORICENSIS ANEGADAE (Puerto Rican Racer). **SCAVENGING.** Evidence for scavenging by pit vipers and aquatic species continues to accumulate (DeVault and Krochmal 2002. Herpetologica 58:429–436), but cases of terrestrial colubrids feeding on carrion are much less common. On 23 September 2005 at 1150 h we captured a male *Alsophis portoricensis angadae* (560 mm SVL, 82.5 g) within a hotel complex (18.4793ºN, 64.5781ºW) on Guana Island, British Virgin Islands. It had recently ingested a relatively large food item of unusually angular shape, which we obtained by forced regurgitation (Fig. 1). The ejected food items consisted of two chicken bones (a humerus weighing about 5 g and about half of an ulna, weighing about 1 g) which we deposited in the Yale Peabody Museum (YPM F-4171-2). The snake was released at the site of capture. Chicken wings are provided to workers at a construction site located about 70 m from the capture site and leftovers are often discarded in the nearby brush. Based on the state of digestion, which had left few traces of meat on the bones, the snake had likely encountered the bones very recently. *Anolis cristatellus*, a major component of the diet of the racer, is abundant at the site, thus lack of food is unlikely to have been a factor. Although scavenging is not a large part of the diet of *A. portoricensis*, this observation suggests that some snake species have greater dietary flexibility than often believed.

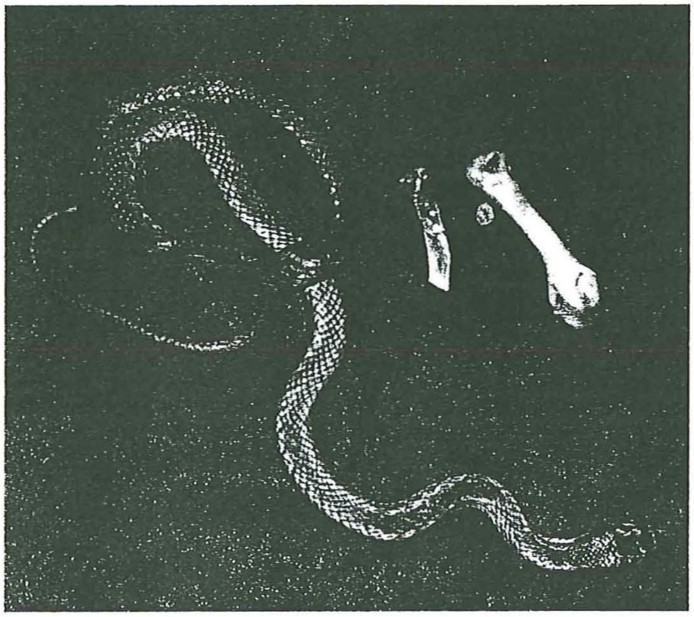

FIG. 1. *Alsophis portoricensis* and chicken bones it regurgitated.

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Body Size and Timing of Reproduction in the Highly Endangered Stout Iguana, *Cyclura pinguis*, in the British Virgin Islands

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ABSTRACT.—**The stout iguana, *Cyclura pinguis* (also known as the Anegada iguana), survives only in the British Virgin Islands and the total population is believed to be about 250 individuals. The sole remaining natural population, on Anegada, is declining in both numbers and area inhabited. Several extra-limital populations have been established, and here we report on body size and timing of egg-laying in the Guana Island population, which is thriving. Egg laying occurs in June and July, and hatchlings emerge in September and October. For hatchlings, mean snout-vent length was 108 mm, mean undamaged tail length was 197 mm, and mean mass was 60 g. Growth of hatchlings is rapid. Overall, the relationship between log mass and log body length is statistically significant. Comparisons to data published for Anegada animals show that iguanas of similar length weigh more on Guana, suggesting possible food limitation in the Anegada population. Until progress is made towards establishing a national park on Anegada, reintroduced populations, such as the one on Guana, constitute a critically important precautionary measure for *Cyclura pinguis*. Moreover, we strongly recommend enhancing the Guana gene pool.**

KEYWORDS.—**Conservation, British Virgin Islands, lizard, Iguanidae, Guana Island**

All iguanas of the genus *Cyclura* are considered threatened or endangered under the World Conservation Union (IUCN) Red List criteria. Still, most remain poorly studied (Alberts, 2000). The stout iguana, *C. pinguis* (also known as the Anegada iguana), is thought to have originally inhabited the entire Greater Puerto-Rico Bank (Pregill, 1981; Lazell, 2002, 2005). Today, however, the species survives only in the British Virgin Islands (BVI; Binns, 2003). Until recently, the only surviving population existed on the island of Anegada (approximately 38 km^2), where introduced herbivores, feral predators, and increasing development greatly degraded conditions for the species and caused a major population decline (Carey, 1975; Mitchell, 1999; Lazell, 2002). Because the species is so rare, our data are considerably less extensive than we would like. Unfortunately, similar problems plague many species of Caribbean iguanas (e.g., Mitchell et al., 2002, for *C. carinata* in the Turks and Caicos).

After reviewing the current situation in the wild, Lemm et al. (2005) concluded that conditions "justify an ex-situ conservation program as a safeguard against extinction" for this species. Over the last twenty years, *C. pinguis* has been translocated to a number of islands in the BVI (Lazell, 2002; J. Lazell, unpubl. data). Of the translocated populations, the one on Guana Island has been best studied (e.g., Goodyear and Lazell, 1994; Mitchell, 1999; Perry et al., 2003) and appears to be flourishing (Mitchell, 2000; Perry and Mitchell, 2003). The population on Necker Island is also expanding (Lazell, 2000; Binns, 2003). However, the other reintroductions are too recent for proper evaluation. Conservation efforts also include a headstarting facility on Anegada, which has lately released 24 individuals back into the wild (Binns, 2003; Bradley, 2004).

With only about 250 individuals thought to remain in all extant wild populations, *C. pinguis* is considered critically endangered (Alberts, 2000, 2004; Hudson and Alberts, 2004). The Anegada population appears to be shrinking both in numbers and in geographic scope on the island (Gerber, 2004). This severe threat to the species' survival

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demands that detailed information about its biology be obtained to implement successful conservation and restoration efforts. However, the small number of remaining animals makes obtaining such information difficult, especially on Anegada where only a few free-ranging individuals remain. The densest extant population, numbering about 100 individuals (Perry and Mitchell, 2003) and common enough such that it is both frequently observed and reintegrated into the food chain, is the one restored to Guana Island (LeVering and Perry, 2003; Perry et al., 2003). However, little is known about the life history of this critically endangered species anywhere, including Guana Island. We begin addressing this lack of data by reporting on timing of reproduction and body size, two important aspects of the biology of *C. pinguis* on Guana Island.

Data on timing of breeding activities were taken from a survey of the literature (see below) and interviews with BVI residents. Body size measurements were obtained from systematic collection efforts conducted in October of 2003 and 2004. We surveyed the island on foot and with a vehicle and, using nooses, attempted to capture every iguana sighted. Capture success was high for hatchlings (>75% of sighted animals) but much lower for adults (<25%). Captured animals were measured (snout vent length [SVL] and tail length [TL] to the nearest mm), weighed (for hatchlings, ±1 g, using a Pesola scale; for adults, ±100 g, using a Pesola scale or the change in weight reported by a bathroom scale when an individual picked up the animal), PIT tagged (AVID Identification Systems Inc., Norco, CA, USA), and released at the site of capture. Not all measurements were obtained for all individuals. Animal-related procedures were carried out under Texas Tech University ACUC permit 05006-01. Statistical analyses were conducted in SPSS using two-tailed probabilities. Whenever comparisons were conducted between measures representing different dimensionality (i.e., mass vs. length), a log transformation was used to linearize the data.

Published data on timing of reproduction in *C. pinguis* are sparse but consistent in two respects: oviposition occurs in June and July and eggs are deposited in sandy areas. On Guana, Lazell (2005: 185) documents some nesting in late June and a gravid female in late July while Binns (2003) reported that some females were heavily gravid in late July of 2002. As part of the headstarting efforts on Anegada, nests are located every year in June and July (Gerber, 2004). Incubation on Guana Island appears to take about three months, with hatchlings appearing in late September or October and rapidly dispersing into the higher elevations in the center of the island. L. Jarecki and F. Kraus (pers. com.) found iguana eggs that had been accidentally dug up on the Guana Island beach in late September or October 1991. These hatched three days later. Roger Miller also reports a large number of hatchlings being seen in late September of 2004. Our own observations indicate that the prevalence of recently-hatched hatchlings on Guana occurs in late September and October of most years. Hatching on Anegada also occurs at that time (Gerber, 2004) and there have been no sightings of hatchling on Guana at any other time of the year.

In 2003 we obtained body size data for 29 hatchlings and four adults. Data collected in 2004 included 18 hatchlings and two adults, one of which was previously captured in 2003. In 2005 we captured 13 new hatchlings on Guana and recaptured an adult previously measured in 2003 and 2004. Mean hatchling SVL was 108 mm (SD = 10.8 mm, N = 59), mean undamaged tail length was 197 mm (SD = 12.9 mm, N = 21), and mean mass was 60 g (SD = 28.3 g, N = 52). For animals with complete tail, SVL and tail length were directly related (linear regression: tail length = 133.6 + 0.604*(SVL), $R^2 = 0.32$, N = 20, p = 0.008). Of the animals for which tail measurements exist, tail damage consisting of missing tips (Figure 1) was noted in three, a rate comparable to that seen on Anegada (Gerber 2000 in Iverson et al., 2004, Table 13.8).

The relationship between SVL and mass was positive and significant for Guana animals (Figure 2, squares and regression line; linear regression: log(mass) = −3.213 + 2.440*log(SVL), $R^2 = 0.65$, N = 51, p < 0.001).

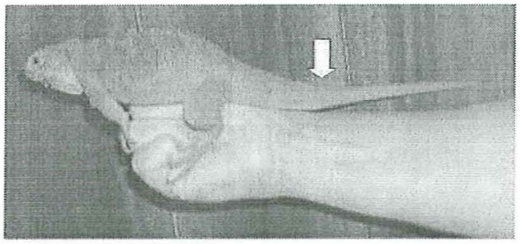

FIG. 1. A young *Cyclura pinguis* showing tail regeneration after unusually extensive damage of unknown origin. The arrow indicates where the original tail ends and the regenerated tail begins.

Comparing current Guana size data to those collected by Carey (1975) and Mitchell (1999) on Anegada (Figure 2) shows that the difference between the three studies in the size-mass relationship was statistically significant (ANCOVA of log-transformed adult mass as a function of sampling effort [present study for Guana; Carey, 1975 and Mitchell, 1999 from Anegada], with log[SVL] as the covariate; $F_{2,22} = 4.343$, $p = 0.026$). Guana animals reach similar masses at shorter SVLs, and Anegada animals fared less favorably in the late 1980s than they did two decades earlier. This supports the view of Carey (1975) and Mitchell (1999) that Anegada iguanas suffered from food limitation for a long period and that the condition of Anegada animals deteriorated between the 1960s (Carey, 1975) and the late 1980s (Mitchell, 1999).

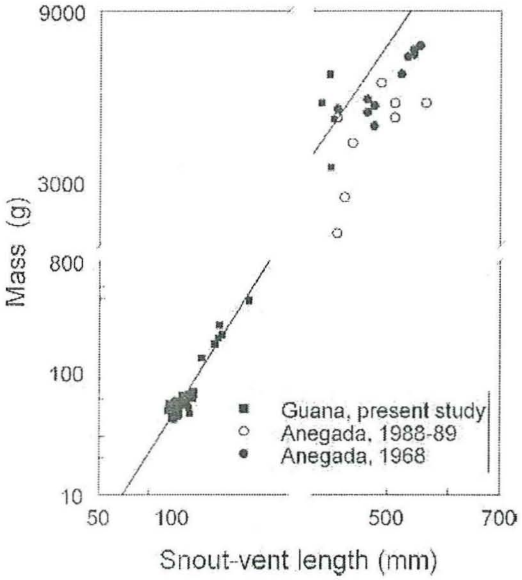

FIG. 2. The relationship between snout-vent length and mass in *Cyclura pinguis*. Guana data are from the present study, those for Anegada are from Carey (1975) for the 1968 values (full circles) and Mitchell (1999) for 1988-89 values (empty circles). The line represents the relationship for Guana animals. Previously measured Anegada animals had a lower mass at a given body size than seen on Guana today.

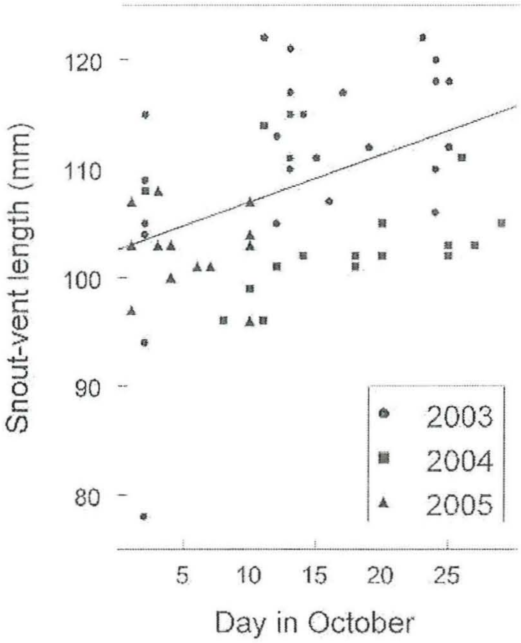

FIG. 3. Snout-vent length of juvenile *Cyclura pinguis* upon first capture. The increase over time is statistically significant, whereas the difference between years is not. The line represents the linear regression of the combined data.

Little is known about growth rates in the genus *Cyclura* (Iverson et al., 2004). On Guana, hatchling SVL was significantly and positively correlated with capture date. The difference between years (Figure 3) was not statistically significant (ANCOVA of SVL with year as random factor and day since work began that year as covariate; day: $F_{1,56} = 5.396$, $p = 0.024$; year: $F_{2,56} = 2.010$, $p = 0.144$). These data suggest that growth occurred even within the relatively brief sampling period available to us. However, the data do not make it possible to estimate growth rate for individuals as each animal was only measured once. A linear regression of SVL on day measured produced a highly significant but weakly predictive relationship ($R^2 = 0.12$, $N = 59$, $p = 0.007$). Both this and the regression equation (SVL = 102.6 + 0.438*day) suggest that hatchlings grow by almost 0.5 mm each day. Young *C. pinguis* are known to face predation from feral cats (Mitchell, 2000), snakes, and birds (LeVering and Perry, 2003) and may therefore have low survivorship (Mitchell 1999). Rapid growth thus has clear benefits and is to be expected at this early stage. Data for captive animals held in a headstarting facility on Little Thatch Island provide some additional insight. Between October 2003 and 2004, one animal grew from 122 mm SVL and 70 g to 156 mm and 240 g. By October 2005 it measured 206 mm SVL and 385 g. From 2004 to 2005, one female (hatched in 2004 on Guana) grew from 102 mm and 48 g to 150 mm and 169 g, another (hatched in 2003 on Necker) grew from 132 mm and 129 g to 154 mm and 190 g, and one male (hatched in 2004 on Guana) grew from 101 mm and 50 g to 160 mm and 201 g. The only adult for which we have repeated measurements is a free-ranging adult female, measured at 370 mm SVL in 2003 (unfortunately with no data on weight), 380 mm and 3000 g in 2004, and 422 mm and 3300 g in 2005. This suggests that females of that size range are approaching the growth asymptote (Stamps et al., 1994), perhaps as a result of most energy being invested in egg production.

Ex-situ captive husbandry of *C. pinguis* is finally enjoying modest success (R. Hudson, pers. com.; Lemm et al., 2005) and the headstarting program on Anegada has become successful in raising releasable animals (Gerber, 2004) with high survival rates (K. Bradley, pers. com.). At the same time, there has been little progress in establishing protected habitat for *C. pinguis* on Anegada (Mitchell et al., 2002) and iguana habitat appears to be shrinking from ongoing degradation by feral livestock (Gerber, 2004). Until progress is made in establishing a national park on Anegada, reintroduced populations, such as the one on Guana, function as critically important safety nets for this species. However, all Guana Island iguanas are descended from only eight individuals (Lazell, 2002) and other reintroduced populations form a subset of that already-limited genetic stock. Despite the findings of Knapp and Malone (2003), who found that a translocated population of *C. cychlura inornata* is doing well despite having originated from eight founders, we strongly recommend enhancing the gene pool.

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Genetic variation in a serially translocated population of highly endangered Caribbean iguanas (*Cyclura pinguis)*

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San Diego Zoo.

Introduction

The Anagada iguana *Cyclura pinguis* is highly endangered under World Conservation Union (ICUN) Red List criteria. Historic evidence suggests that the range of *C. pinguis* once extended across the Greater Puerto Rico Bank and numbered over 4000 animals (Carrey 1975). Modern animals inhabit the single island of Anegada and have been reduced to approximately 300 animals (Mithchell 1999). Major population declines are thought to have occurred from climatic fluctuations , leaving Anegada as the sole climatic refugium for *C. pinguis* (Pregill 1968). Further declines began in the late 60's when development on the cay lead to the proliferation of introduced species and the desertification of the island. Goats, sheep, donkeys, and cattle compete with iguanas for food resources alongside feral cats, rats and dogs that have a direct impact the survivorship of young age classes. (Goodyear and Lazell 1994; Mitchell 1999).

Conservation efforts to stem declines in the species include three principle strategies. The first is directed at controlling feral cat populations and exotic mammals on the island. The second focuses increasing recruitment on Anagada through a headstart and release program that raises juvinile iguanas away from cats until they are large enough to resist predation (Bradley 2004, Perry and Gerber 2006). Lastly, a translocation program is underway to safeguard the species against extinction.

The mammal eradication efforts and headstart program are not within the scope of this study but the slow progress in controlling exotic mammals is being temporarily held in check by successes in the headstart program. Headstarting juveniles is a temporary solution to the problems faced by this species and the long-term viability of the species is still very precarious (Bradley and Gerber 2006; Perry and Gerber 2006). Translocated populations may serve as a critical tool in managing the species.

The two islands with the most conservation impact for *C. pinguis* are Guana and Necker, each of which have stable populations of translocated animals. Within the last several years, other small islands have been seeded with little information in the success of these populations (Perry and Gerber 2006). The first translocation of *C. pinguis* took place between 1984 and 1986 and consisted of eight individuals brought from Anagada to the Guana Island Wildlife Sanctuary. This group consisted of three males and five females (224-509 mm SVL), one of which was palpably gravid at the time of release (Goodyear and Lazell 1994). The translocation led to rapid population increases on the island and was estimated at 100 individuals by 2002 (Perry and Mitchell, 2003). Today, this population is likely 150 animals (G. Gerber pers. obs). Nine years later, in 1995, four hatchlings of unreported sex were brought from the Guana Island population to Necker Island and were cage reared until their release the following year (Lazell 2002). Lazell (2002) reported the survival of all four animals and the emergence of new hatchlings by 2000. As on Guana, the population on Necker has increased expeditiously to around 20 individuals today (G. Gerber pers. obs.).

The conservation value of these islands for *C. pinguis* depends on the health and welfare of these populations. Translocation efforts involving small numbers of animals are known to decrease genetic variation of the resulting populations with negative impacts on the fitness of the populations (Nei et al. 1975; Allendorf 1986). This is especially true in sequentially translocated populations where multiple bottlenecks can amplify the loss of genetic diversity and may result in declines in population growth, physical abnormalities and increase extinction (Leberg and Firmin 2007; Gautshi et al. 2002). It is critical that translocated populations that use so few founders are managed with the genetic diversity of the animal in mind.

The limited availability of samples from for *C. pinguis* curtails a rigorous investigation into the genetic structure of these translocated populations and is a common problem faced by studies on Caribbean iguana species (e.g. Perry and Gerber 2006; Mitchell et al. 2002). Nonetheless, an investigation into the genetic diversity on these islands is critical to long-term conservation planning for this species.

Sampling and Methods

104 individuals were compared for these analyses including 73 individuals from Anegada, 29 individuals from Guana, and 5 from Necker. The Anegada specimens were gathered betweem 1999 and 2005 previously genotyped for all 23 loci. This group excludes known juvenile clutchmates in an effort to reduce sampling bias. The 29 samples from Guana and 5 from Necker were genotyped from whole blood gathered in October 2006 and represent the total available samples for these areas. Whole genomic DNA extraction was conducted with Qiagen QIAamp DNA Mini kit and accompanying handbook protocols. A total of 23 loci were amplified using primers developed for *C. pinguis* and common to the 73 previously genotyped samples (Lau in prep). Fragment length was determined using an ABI 3100 Genetic Analyzer and GeneMapper Software (Applied Biosystems, 2002). Genetic diversity measures including the number of alleles per locus, allele scores, and the observed and expected heterozygosities were calculated in Excel Microsatellite Toolkit Version 3.1 (Park, 2001). Allelic richness and other measures were calculated with FSTAT (Goudet 1995).

Population	*n*	Polymorphic loci	No. alleles/ locus	Allelic range	Mean allelic richness	H_E	H_o
Source Island							
Anegada Island	73	23	4.04	3-7	2.72	0.552	0.538
First-order translocation							
Guana Island	29	23	2.87	2-5	2.39	0.491	0.418
Second-order translocation							
Necker Island	5	23	2.43	1-4	2.35	0.489	0.461

Results and Discussion

These data provide a minimum estimate for the retention of polymorphism at 23 loci and show that substantial genetic diversity is being maintained in translocated populations. The number of alleles detected per locus declines with each translocation event but the full significance is unclear. A total of 93 alleles were detected in the Anegada subset, 66 from the Guana population, and 56 from Necker. Sample size is problematic in interpreting these results, as rare alleles are not easily detected from small numbers of individuals. Correspondingly, 32 of the 35 alleles missing from the Guana sample are rare on Anegada ((f) < 0.05). These missing alleles could exist in the 120 unsampled individuals or were lost through the translocation and genetic drift. More suggestive of a reduction in variability is the loss of alleles D140 and D9, where frequencies in the Anegada population are 0.36 and 0.12 respectively. The failure to detect D140 at either island suggests that the original founders to Guana do not represent all the common genotypes of Anegada and raises a conservation concern. Nonetheless, most common alleles are present in these populations and measures that are robust to sample size variation (mean allelic richness and the expected heterozygosity (H_E)), show minimal declines between translocations.

Without knowing the founder genotypes for either translocated population it is unknown how many of the original founders contributed to the genepool. It can be inferred that more than two founders contributed to the Guana population because two heterozygous individuals can contribute a maximum of four unique alleles at one locus (max allele # = 5). For Necker, the small sample size precludes any conclusions about the minimum number of founders contributing to the gene pool (max allele # = 4).

Translocations of endangered species to protected habitats can be a critical tool in maintaining the survival of a species. The imperative to conserve a species must also consider the long-term impacts of reducing the genetic variation on the viability of the species. *C. pinguis,* has likely undergone numerous bottlenecks in the colonization of new islands, culminating in the last extant population on Anegada. As a result, current populations of *C. pinguis* may be less sensitive to a loss of genetic variation because mostly common alleles remain and are likely to persist in randomly assorting populations (Taylor et al. 2008).

Notwithstanding this potential buffer, the founder populations for these translocations were very small (3 males and 5 females to Guana, 4 hatchlings of unknown sex to Necker). These translocations were also conducted in a sequential manner resulting in a serial bottleneck for the Necker population. The effect of a serial translocation nine years after the first one is probably of less significance than the small number of founders on Necker. More samples from Necker would be helpful in assessing the amount of diversity in these animals but it is clear that additional animals from Anegada would be very helpful to the overall genetic stocks of these populations.

Genetic diversity for Guana and Necker are consistent with previously reported genetic results for the Anegada population and captive breed animals from the San Diego Zoo, with 4.3 and 2.8 alleles per locus respectively (Reinbold, unpublished data).

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Title: Evaluation of potential methods for estimation population size of the Stout Iguana (*Cyclura pinguis*) on Guana Island, British Virgin Islands

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Budget Summary:

PI Salary – one month	$5388
Benefits – one month	$2465
Travel	$1200
Materials	$2000
Equipment	$2500
Total Requested	$13553

Beginning Date and Project Duration:

1 June 2008 to January 31 2009

Summary:

I propose to evaluate detectability of stout iguanas on Guana Island, British Virgin Islands using radio-telemetry. In addition, I propose to evaluate the effectiveness of temporary marking methods for use in developing closed-population estimates of population size based on mark-resight methods.

Brent D. Bibles, Assistant Professor of Wildlife Ecology

Johan T. du Toit, Head, Department of Wildland Resources

Nat B. Frazer, Dean, College of Natural Resources

Background

The stout iguana (*Cyclura pinguis*), also known as the Anegada iguana, is considered critically endangered by World Conservation Union (IUCN) Red List (Mitchell 1996). This species is considered the oldest and most genetically unique of the Cyclura iguanas (Malone and Davis 2004). Although originally occupying much of the Greater Puerto-Rico Bank (Pregill 1981 *as cited b*y Perry et al 2007), the stout iguana is now apparently confined to the islands of Anegada, Guana, and Necker within the British Virgin Islands, having been translocated to the latter two during the 1980's and 1990's (Lazell 2002).

The population size of stout iguanas is effectively unknown, but estimates based on expert opinion are generally around 200 to 250 individuals (Mitchell 1999a, 1999b, Perry 2007). The population on Guana Island is derived from eight individuals from Anegada Island that were released between 1984 and 1987 (Goodyear and Lazell 1994, Mitchell 1999b). Guana Island is a privately owned 300-ha island operated as a small luxury resort and nature preserve. It differs from Anegada Island in being igneous in origin, smaller, and with only one exotic grazing species (Mitchell 1999b, Lazell 2002). The Guana Island population of iguanas is believed to be the densest known population, with estimates of around 100 individuals based on expert opinion (Perry and Mitchell 2003, Perry et al 2007).

Although critically endangered, the size of the stout iguana population has primarily been estimated using a variety of ad-hoc procedures producing educated estimates. Perry and Mitchell (2003) estimated the population on Guana Island the Petersen and Schnabel methods, obtaining population estimates of 134 and 95, respectively, and 95% confidence intervals on these estimates of [44,224] and [58,185], respectively. The broad range of estimates obtained (confidence interval widths > 130% of the point estimate) make them of extremely limited use for monitoring the trend of this population. Accurate estimation of iguana populations on Guana Island is problematic for several reasons. First, detectability of iguanas is limited both due to cryptic coloration and rough, densely vegetated terrain (Perry and Mitchell 2003). Second, iguanas commonly respond to capture and handling by retreating into burrows for extended periods (James Lazell and Gad Perry, personal communication, Perry and Mitchell 2003). Third, work on Guana Island is restricted to the month of October (Perry and Mitchell 2003).

I propose to begin a pilot project designed to evaluate and compare the potential for use of newer quantitative methods based on mark/recapture or mark/resight to estimate population size of the Guana Island stout iguana population using a combination of field methods involving both capture and handling (i.e., radiotelemetry) and non-capture remote marking (i.e., squirted latex paint). Although the proposed methods do not eliminate the problems in obtaining accurate estimates mentioned above, they generally produce more precise, and hopefully more useful, estimates. In addition, I propose to evaluate the potential for using a technique that does not involve capture, handling, or marking to monitor population trend of iguanas on Guana Island. Information from this pilot work will provide a basis for development of a more rigorous population monitoring program for the stout iguana in the British Virgin Islands.

Objectives

The primary objective of the proposed research is to gather information that will be used to evaluate the potential of three methods for estimating population size or trend on Guana Island. Evaluation of the methods will be based on the feasibility of applying the method under field conditions and the precision of the estimates obtained. The three methods to be evaluated are:

1) Population size based on Bowden's Estimator using the immigration/emigration option,
2) Population size using closed-population maximum likelihood estimators based on temporary remotely-administered marks, and
3) Population trend using occupancy modeling.

Study Area

This study will take place on Guana Island, British Virgin Islands. Population estimates based on marked animals will focus on defined study areas that have been used as core areas in past work, particularly areas of the island known as "The Dump," "The Orchard," and the "RO plant." The entire island will be the study area for occupancy modeling.

Methods

Bowden's estimator (Bowden and Kufeld 1995) is a closed-population estimator that uses information from resightings of individually marked animals to estimate population size. Extensions to the model allow for some movement of animals on and off the study area, if information regarding this movement is available. In addition, extensions allow for non-discrete resighting occasions. Both of these extensions may be useful to handle the field situation on Guana Island.

An intensive effort will be made to capture iguanas within the core study areas on Guana Island during the first week of October 2008. Iguanas will be captured either by hand or noose-pole. Up to 10 captured iguanas will be marked with a painted unique number and have a radio-transmitter attached externally using silicone glue. Transmitter weights, with glue, will not exceed 10% of the average juvenile iguana body mass (around 50 g; Gad Perry, personal communication). Any additional individuals captured will be marked with a unique number but will not receive a radio-transmitter. After the first week, an observer will walk through the core study areas on a daily or near-daily basis, identifying marked animals seen and counting the number of unmarked individuals detected. Counts will only be conducted during weather conditions and time of day when iguanas are active, and presumably more detectable. At least 15 resighting occasions will be conducted within each core area. The number of resighting occasions is the maximum considered logistically feasible. Data on which to evaluate sample size is limited, but based on data presented in Perry et al (2003), 15 occasions could provide confidence intervals widths that are ≤ 25% of the population estimate. However, because of the small population of the area, this value is highly dependent on the guessed population size of the core area. One purpose of the proposed study is to gather the information necessary to determine what levels of sampling intensity are necessary to develop reasonable estimates. On at least 10 occasions, auxiliary observers will be stationed just off-plot, and will determine which radioed iguanas are on-plot and available to be detected just prior to the survey of the plot by the primary observer. Data will be analyzed using the Bowden's Estimator in Program NOREMARK (Bowden and Kufeld 1995, White 1996).

In addition to the marking described above, an attempt will be made to individually mark iguanas within the core study area without direct handling. Marking will involve squirting water-based latex paint on animals (Perry and Mitchell 2003). Individual marking will be attempted by varying paint color and part of the body targeted. This temporary marking will occur just after the near daily plot surveys conducted by the primary observer. Resighting occasions for this method are the same as described above for the Bowden's estimator (i.e., 15). Capture histories will be developed for all marked individuals. Population estimates will be developed using a closed-population maximum likelihood approach in Program MARK (Huggins 1991, White and Burnham 1999, White 2005).

The potential for use of occupancy modeling to monitor population trend of stout iguanas will be evaluated. Use of this method for monitoring population trend assumes that increase or decrease in a population's size will result in changes in the rate of occupancy. This is most likely when size of the occupancy plot results in most occupancy plots possessing only one individual. The validity of this assumption for iguanas is unknown but appears reasonable because iguanas are territorial and avoid centers of activity of conspecifics (Mitchell 1999a). Occupancy plots will consist of 20 sections of trail randomly selected from all trails on the island using a geographic information system. Due to rugged terrain and vegetation, random selection of plots not based on the trail system is not feasible. However, an extensive recreational trail network exists on the island and the assumption that this trail network is representative of the island will be necessary, although this assumption seems reasonable. Section length for selection will be 250 meters. The start and end of each section, as well as 50-m intervals within the section, will be located using a global positioning system receiver and flagged with survey flagging on the first visit. Sections will be walked weekly (i.e., four visits). Data recorded will be detection or non-detection of iguanas, by age class (adult, juvenile) within the section, as well as within the first 100, 150, and 200 m of the section. This range of lengths is based on estimates of non-overlapping home range diameters of iguanas, ranging from 140 – 210 m, calculated from published estimates of density or home range size (Goodyear and Lazell 1994, Mitchell 1999b). Section covariates (e.g., predominant vegetation, slope, aspect) covariates will also be noted. Occupancy rate and detection probabilities will be calculated using the occupancy model of Program Mark (White and Burnham 1999, MacKenzie et al 2002) using the four different plot sizes. Point estimates and variability of detection probabilities and occupancy rates will be used to conduct a power analysis to determine what plot size and sample size would be necessary to estimate occupancy with enough precision to be useful in monitoring population trend in the stout iguana. Plot size will also be evaluated based on the number of iguanas detected as a coarse test of the assumption that occupancy and population size are related.

Budget

The attached budget requests one month of faculty salary support, funds for travel to and from the British Virgin Islands from Vernal, Utah, and purchase of needed materials and equipment. Equipment purchases will consist of two telemetry receivers and hand-held antennas, two GPS receivers, and up to 10 radio-transmitters. Additional materials for capturing and marking iguanas will also be purchased with funds.

Deliverables and Timeline

A detailed study plan will be developed and available for Animal Care and Use Committee approval and review by interested parties (e.g., The Conservation Agency) by 30 June 2008. Field work will be conducted during October 2008. All data will be analyzed and available in a final report by 31 January 2009.

Additional Support

Support for the proposed research will be provided by the Guana Island Resort which will provide room and board during my work on the island as part of the October Science Month organized by James Lazell of The Conservation Agency. Field assistance will be provided by researchers on the island as part of Science Month activities. All planning and implementation of this proposal will be coordinated with Gad Perry of Texas Tech University and James Lazell of The Conservation Agency. Potential future funding of this project will be in conjunction with these collaborators and contingent on the results of this initial work.

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The red-eared slider, *Trachemys scripta elegans*, in the British Virgin Islands

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Key data. *Trachemys scripta elegans*; Emydidae; red-eared slider; population; British Virgin Islands. Tortola; Road Town; pond in J.R. O'Neal Botanic Gardens (18°25′38″N, 64°37′22″W); 21 October 2003; collected by Fred Sibley; MCZ R183688. Virgin Gorda; Spanish Town (18°26′41″N 64°26′23″W); 28 October 2004; collected by Jim Egelhoff; MCZ R184120. Both verified by Joe Martinez. Museum of Comparative Zoology, Harvard University.

These are the first records of this widely-distributed species from the British Virgin Islands (BVI). The pond at the J. R. O'Neal Botanic Gardens in Road Town, Tortola (<100 m^2, <1 m depth), was constructed in the early 1980s. It is one of the few permanent bodies of fresh water in the BVI. Adult sliders were first noted there soon after construction was completed, and excavations and nests were first observed in the vegetation surrounding the pond in the mid-1990s. Hatchlings were first sighted and captured in 1998, and the population grew to 15-20 adults by the late 1990s (Arona DeWindt, pers. com.). Seining of the pond in 2003 produced 12 adults and approximately 20 juveniles. This indicates the presence of an established, reproducing population on Tortola. Additional capture efforts produced further adults and juveniles in July and October 2004, but were not sufficient to eradicate the population. A second species of freshwater turtle, *Pseudemys nelsoni*, has also been found in the same pond (Owen et al., 2006).

Trachemys s. elegans has been introduced around the world, including the Caribbean, as a result of its prevalence in the pet trade (Lever, 2003; Emer, 2004). Staff at the O'Neal Botanic Gardens observe visitors releasing turtles into the pond several times per year (A. DeWindt, pers. com.), and the chief source of these animals is presumably the pet trade (the two pet stores on Tortola report importing

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baby sliders for at least the past 20 years). In addition to direct releases by owners, at least 10 turtles donated to the Humane Society on Tortola in recent years have been released at the Gardens (Tessa Gunter, pers. com.; it is also reported that sliders are occasionally "released" into the sea).

No additional breeding populations are known from the BVI, and few suitable habitats exist. The Virgin Gorda specimen does not appear to be part of a population, but rather an escaped pet. It might have originated on Tortola, either bought at a pet store or from the O'Neal Botanic Gardens, whose staff report that visitors occasionally capture and remove juveniles, presumably for pets. At least one of these is known to have escaped elsewhere on Tortola (A. DeWindt, pers. com.). Additional turtles originating in pet stores in the British and US Virgin Islands have been released on Jost Van Dyke, according to multiple residents interviewed in 2006. Unconfirmed reports of "pond turtles" at the concrete freshwater retention ponds near the airport at Beef Island probably reflect the presence of this species there as well. We expect further spread into agricultural ponds and other artificial water bodies to eventually take place. However, scarcity of suitable habitat will likely restrict range expansion of this species in the BVI. Ecological impacts remain unstudied, but are likely to be small because of the localized nature of the invasion and the artificial nature of the habitat.

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Invasive Species Distributions Notes

Recent additions to the herpetofauna of Little St. James, US Virgin Islands

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Key data: *Iguana iguana*; green iguana; *Osteopilus septentrionalis*; Cuban treefrog; *Eleutherodactylus* sp.; rain frogs; populations; *Elaphe guttata*; corn snake; *Alsophis portoricensis*; racer; arriving individuals; US Virgin Islands. Little St. James (18°18′N, 64°50′W); October 2006; collected by Gad Perry; MCZ R183544-183545, verified by James Lazell. TNHC 65941, verified by Travis LaDuc.

The herpetofauna of the US Virgin Islands (USVI) has been described by several authors (MacLean, 1982; Schwartz and Henderson, 1991), but some islands are privately owned and seldom surveyed. Most of the smaller cays are uninhabited, the exceptions being Little St. James (LSJ) and Lovango, and most are inhospitable to amphibians because they are characterized by scrub and absence of permanent water bodies. Of the two, LSJ is the more developed, with regular shipments of plants and building materials supporting the ongoing modifications. Two visits to LSJ, one in 2005 and one in 2006, revealed the presence of several new species on the island and allowed us to document reports of others.

The Cuban treefrog has been spreading in the Caribbean in recent decades. It is now common in the USVI (Platenberg and Boulon, 2006) and nearby British Virgin Islands (BVI; Perry and Gerber, 2006). Remarkably, the USVI Division of Fish and Wildlife previously made the following suggestion about the species (Anonymous, 1991): "Cuban tree frogs [were] introduced to the Virgin Islands in the 1970s as hitch-hikers in potted plants. The only cure for the noise is to capture the frogs and release them in some uninhabited area." This doubtlessly has exacerbated the spread of this damaging invasive. The species has not previously been collected on LSJ.

According to interviews they were first observed on LSJ in 2002 or 2003, following the arrival of a shipment of coconut trees from Florida. In 2005 they were breeding in a beach pond that was historically a salt pond, but had been hydrologically altered by human activity and was then freshwater. That pond has reportedly since been drained. In 2006 we observed several adults around the inhabited center of the island and collected one specimen. Past spread of this species has primarily been via ornamental plants and construction materials (Perry and Gerber, 2006; Platenberg and Boulon, 2006), and these are likely sources of introduction into LSJ as well. CTFs require fresh water to breed and tadpoles are not found in even slightly salty habitats (Owen, 2005). Thus, the CTF probably would not be on LSJ if the pond were still a salt pond.

Several species of rain frogs are native to the Virgin Islands (Perry and Gerber, 2006; Platenberg and Boulon, 2006), and others have become invasive around the world (Lever, 2003). However, most of the smaller USVI cays lack fresh water and only have scrubby vegetation, thus do not support native frogs (Platenberg and Boulon, 2006). According to unverified reports, "coquis" arrived on LSJ in 2003, inside a shipment of plants from St. Thomas. Since that name is locally used to describe multiple *Eleutherodactylus* species and no specimen was obtained, the specific identity remains unknown. At best, this represents transfer of genetic material among populations which have been separated by rising sea levels for thousands of years. However, the frogs were not previously reported from LSJ, and thus this would be an introduction, albeit perhaps of a species that naturally occurs in the region. Moreover, since plants shipped by local nurseries often originate in Florida or elsewhere (Perry et al., 2006), the possibility remains that a non-native species was transported.

Green iguanas are common in the pet trade and have been introduced in both the USVI and elsewhere (Lever, 2003; Platenberg and Boulon, 2006). Both adults and juveniles are now commonly seen in parts of LSJ. According to interviews conducted on the island, 25 individuals were brought over from St. Thomas in 2002 and additional animals were added later. The source was one of the hotels, and the USVI Division of Fish and Wildlife reportedly helped broker the transfer to ease what they perceived to be an overpopulated captive group. Iguanas have not been introduced to uninhabited islands, many of which support breeding seabird colonies. Interviews conducted on St. Thomas suggest that locals view these introduced animals with favor and even pride.

Common in the pet trade, the corn snake is also a frequent invader in the Caribbean (Perry et al., 2007). A young individual arrived on LSJ on September 29, 2006. It was discovered and killed by island staff in spindle palms (*Hyophorbe verschaffeltii*) shipped from Fort Lauderdale, Florida, on September 24. The plants were dug from a nursery in Homestead, Florida a few days before shipping. Most likely it originated in Florida, although it is possible that it could have entered the shipment while the container was clearing customs on St. Thomas, because the snake is now found there (Platenberg and Boulon, 2006).

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Alsophis portoricensis have not previously been reported as invasive (Lever, 2003), nor are they common in the pet trade. However, Perry and Lazell (2000) reported that they occasionally feed at nightlights and Perry et al. (2007) identified species that do so as likely invaders. An adult animal arrived on LSJ on June 30th 2006, inside a container of coconut palms shipped on a flat rack from San Juan, Puerto Rico. It too was captured and killed by island staff. The palms were obtained from more than one location on Puerto Rico, where the species is native, therefore a more precise identification of the origination site is not possible. Racers are native to LSJ, but the Puerto Rico population is considered a different subspecies (Shcwartz and Henderson, 1991) which is reportedly more venomous than those located in the Virgin Islands (Heatwole and Banuchi, 1966), and therefore such incursions carry a potential (if small) human risk as well as ecological ones, such as predation on native species not used to this type of predator.

Acknowledgements. We thank Jeffrey Epstein for access and LSJ staff for technical assistance. Surveys on LSJ were conducted under permits STT-067-06 and STT-073-06 from the Division of Fish and Wildlife, government of the USVI. Financial support for this work was provided by The Conservation Agency through a grant from the Falconwood Foundation. This is manuscript T-9-1128 of the College of Agricultural Sciences and Natural Resources, Texas Tech University.

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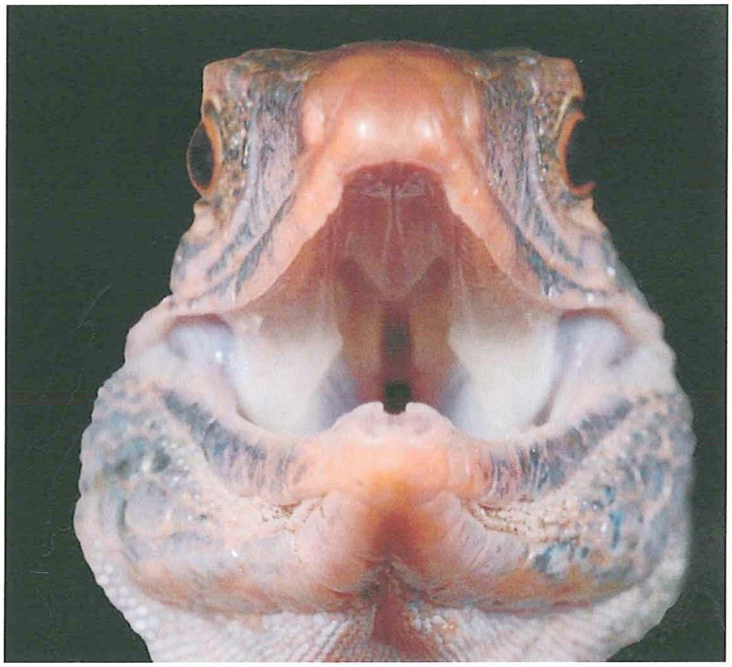
The Ground Lizards (*Ameiva exsul*) of Guana Island



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Puerto Rican Ground Lizards (*Ameiva exsul*) are widely distributed across the entire Puerto Rico Bank, but are absent or rare on islands with introduced Indian Mongooses (*Herpestes javanicus*). Primarily associated with dry habitats, smaller individuals are more vulnerable to water loss than large adults, possibly restricting them to moister microhabitats or curtailed activity periods. These diurnal lizards actively forage on insects and other small arthropods, but are facultative omnivores, eating fruits, other vegetable matter, and even small vertebrates. A large male on Guana Island was observed foraging actively in leaf litter for Puerto Rican Dwarf Geckos (*Sphaerodactylus macrolepis*) and a subadult was seen jumping into the air to catch a flying moth. Maximum known snout-vent length (SVL) for males is 201 mm and for females 103 mm. These lizards are most active at high temperatures, emerging from dens as temperatures rise in the morning and returning to shelter in late afternoon when temperatures drop. Ground Lizards are not territorial and range widely while foraging, with home ranges of males and females often overlapping. Females lay 4–7 eggs in shallow burrows, with reproduction closely associated with the rainy season in dry habitats of southwestern Puerto Rico, but less seasonal elsewhere in the species' range. Principal predators include snakes (e.g., Puerto Rican Racers, *Alsophis* *portoricensis*), predatory birds (e.g., Red-tailed Hawks, *Buteo jamaicensis*, and American Kestrels, *Falco sparvarius*), feral dogs and cats, and mongooses.

On Guana Island, Ground Lizards exploit most available habitats, including those altered by human activity, but are most abundant in Sea Grape (*Coccoloba uvifera*) leaf litter along beaches and open forests on hillsides essentially islandwide. Population densities have been estimated at 200 lizards/ha in optimal habitat, but lower estimates (34/ha in forest and 52/ha along White Bay Beach) based on encounter rates exist.

Subadults retain the juvenile stripes that may serve as protective coloration in rapidly moving animals.

2007 Activity

In October 2007, 58 lizards were captured (57 were permanently marked), 45 were adult males (mean SVL = 132.14 ± 17.15 (SD), range = 78.5–149.0 mm), three were adult females, and 10 were unsexed juveniles. Most were collected along three informal transects:

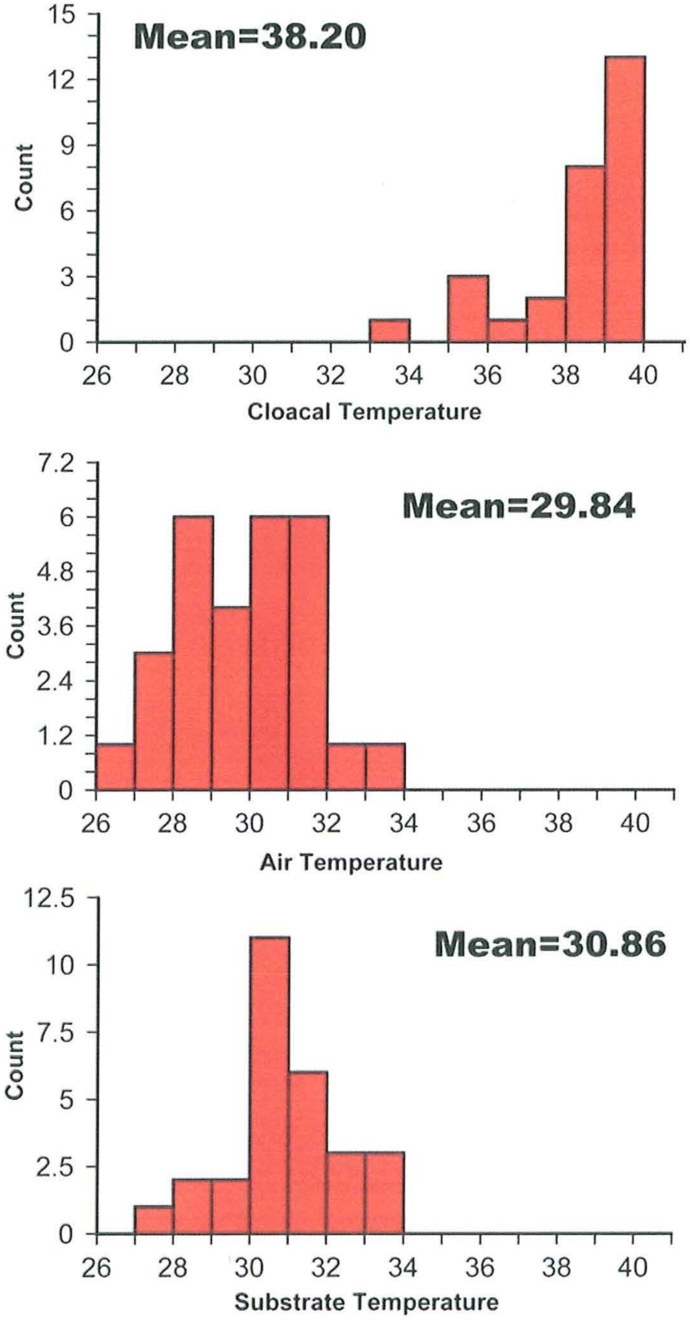
(1) Pyramid = Along the Pyramid trail, primarily along the eastern side;
(2) Iguana = Beginning near the resort, down the Iguana Trail and continuing along the Guanaberry Trail;
(3) Beach = From the end of the Guanaberry Trail, past the beach house, along the ruins, behind the dump, and continuing on to the large cistern.

Transects were not sampled with equal intensity. The Iguana and Beach transects were sampled during both weeks, Pyramid only during the second week. In 2008, all three will be sampled with equal intensity.

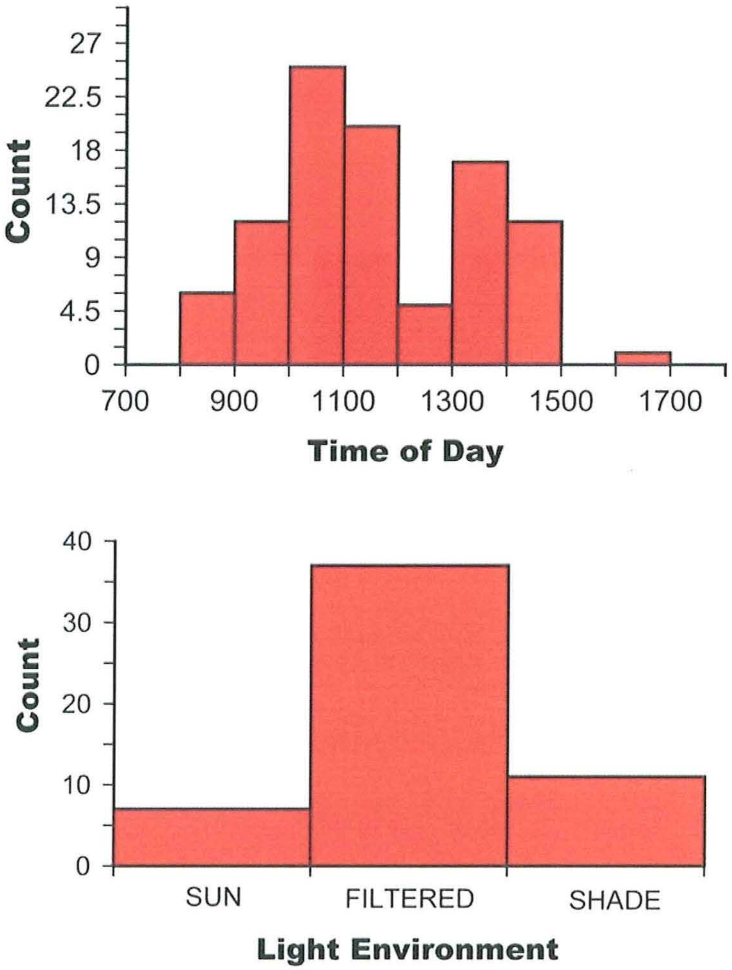
Body (cloacal) temperatures were considerably higher than either air or substrate temperatures, suggesting active thermoregulation. Mean cloacal temperatures were 38.2 °C, air = 29.8 °C, substrate = 30.9 °C.

Activity on Guana appears to be unimodal, but an accurate assessment was affected by non-continuous sampling effort throughout the day (see dip around lunchtime in the histograms). Animals were consistently observed in filtered light, far less frequently in full sun or deep shade.

Animals collected along the different transects do not differ morphologically; however, individuals collected from along the Pyramid Trail appear to be in poorer body condition (mass/SVL) than those collected along the other "transects." The steep slopes of the Pyramid (especially along the more intensely insolated eastern side) are characterized by very dry substrates and may support fewer trophic resources.



Body (cloacal), air, and substrate temperatures of Ground Lizards on Guana Island.

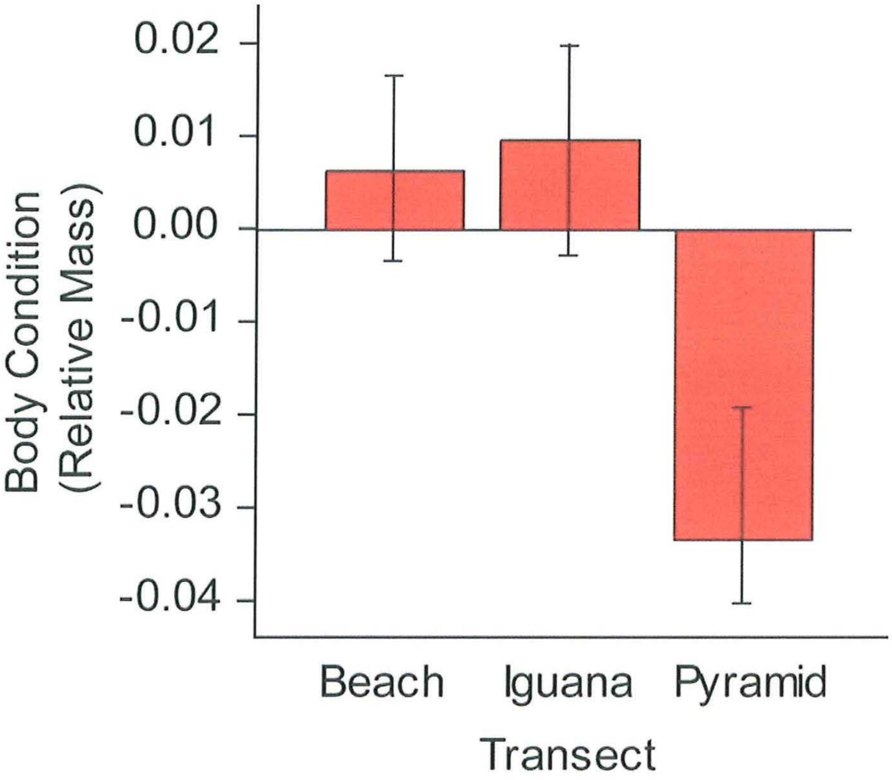


Number of lizards observed at various times of day (top) and extent of insolation where lizards were observed.

Plans for 2008

Sampling from 2007 suggests a 15:1 (male:female) sex ratio, which appears to be excessively skewed in favor of males. Although this may reflect differences in activity (and, consequently, differences in encounter rates between males and females, we cannot rule out mistakes in sexing procedures. We will sacrifice 10–20 animals to confirm the accuracy of our sexing procedures. These specimens also will yield stomach contents, providing insights into food habits, and will be a source of genetic material used to compare populations on Guana Island with each other and with populations elsewhere on the Puerto Rico Bank.

We will continue to sample all three "transects" to gather demographic data, permanently marking newly captured animals, and keeping toe-clips for genetic analysis. We will make a concerted effort to capture juvenile lizards in order to estimate annual growth rates and survival. We will continue taking morphometric measurements to examine the morphological correlates of survival and to further explore the apparent differences in body condition of animals at different sites.



Body condition of Ground Lizards collected along different "transects."

Acknowledgments

We thank the Jarecki family and the Falconwood Foundation for providing the opportunity to conduct research on Guana Island. By maintaining Guana Island as a nature preserve and permitting and actively supporting research, they have rendered a tremendous service to science and to scientists with an interest in the dynamics of West Indian island biotic communities. James (Skip) Lazell and Gad Perry have encouraged and facilitated our efforts

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Predation on a Tarantula (*Cyrtopholis bartholomaei*) by a Puerto Rican Ground Lizard (*Ameiva exsul*)

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Photographs by the author except where noted.

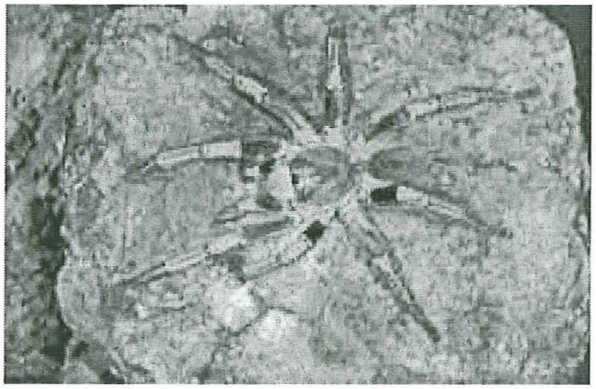
The Puerto Rican Ground Lizard, *Ameiva exsul* (Teiidae) is the most widely distributed ground lizard on the Puerto Rican Bank, which includes Puerto Rico, many satellite islands, and the Virgin Islands (but excluding Saint Croix, Desecheo, and islas Mona and Monito, which are on their own island banks). Although mainly coastal in their distribution, these lizards can be found at elevations >360 m above sea level in Puerto Rico and have been observed at ~525 m on Sage Mountain, Tortola, British Virgin Islands.

Male Puerto Rican Ground Lizards can exceed 20 cm in snout-vent length; females are smaller. These lizards are strictly diurnal and are most frequently observed in relatively open areas actively rooting in leaf litter and soil, using their tongues to probe for food. Puerto Rican Ground Lizards have a rather catholic diet, and are known to eat many arthropods, snails, frogs, other lizards and lizard eggs, as well as fungi, fruits, and even carrion.

The largest and most visible of the Virgin Island tarantulas is the Ground Tarantula (*Cyrthopholis bartholomaei*). These spiders build their nests in dry soil. With legs spread, they can span 10–13 cm.

Predation by a Puerto Rican Ground Lizard on a Ground Tarantula occurred at exactly 1029 h on 14 October 2007 in leaf litter associated with a rocky area along the road to the pier at White Bay on Guana Island, British Virgin Islands. An adult *Ameiva exsul* (SVL ~11 cm) was observed tongue-flicking what I later identified as a tarantula burrow. Initially, the lizard jumped back from the burrow, but it quickly reentered and emerged with the tarantula grasped by its abdomen. The lizard then proceeded to dismember and eat the spider. The entire episode lasted about two minutes. Subsequently, the *Ameiva* recommenced foraging.

A Puerto Rican Ground Lizard (*Ameiva exsul*) devours a Ground Tarantula (*Cyrtopholis bartholomei*).



The Ground Tarantula (*Cyrtopholis bartholomei*) can grow quite large, spanning as much as 10–13 cm.

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I thank James Lazell of the Conservation Agency for providing the opportunity to visit Guana Island and the Guana Island staff for their support. Enrique Hernández and Neftalí Ríos, Department of Biology, University of Puerto Rico at Humacao, and Alejandro Sánchez provided valuable comments on an earlier draft of this manuscript.

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The Puerto Rican Ground Lizard (*Ameiva exsul*) is most frequently observed in relatively open areas actively rooting in leaf litter and soil.

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Down but not out: marine turtles of the British Virgin Islands

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Abstract

We present the result of a multi-annual assessment of the spatio-temporal patterns of marine turtle nesting, and foraging in the Eastern Caribbean archipelago state of the British Virgin Islands. Despite exploitation over several centuries, three species (leatherback *Dermochelys coriacea*, green *Chelonia mydas* and hawksbill *Eretmochelys imbricata* turtles) are still nesting and green and hawksbill turtles are found foraging. Leatherback turtles are showing signs of a recovery co-incident with the implementation of an effective moratorium on adult take. When compared with historical data we demonstrate an apparent reduction in nesting levels in green and hawksbill turtles and a nesting range contraction in green turtles. Despite current conservation steps, it will be a decade or more before evidence of recovery can be expected in the two hard-shelled species. Coupled with wider biological knowledge, our findings offer insights into the relative resilience of the different species to exploitation pressure. Additionally, the intra-annual temporal and spatial spread of nesting demonstrated underlines the difficulties of monitoring such a multi-species assemblage in such a diffuse archipelago.

Introduction

Marine turtles in the Caribbean have been subject to exploitation for many centuries, which has resulted in large-scale reductions in population numbers (Parsons, 1962; Eckert, 1995; Jackson, 1997; Meylan, 1999; Bell *et al.*, 2006). The loss of nesting populations are believed to have wide-ranging ecological consequences (Jackson *et al.*, 2001) and recently there have been pleas for conservation programs in the Caribbean to alter their remit by focusing on the many small, widespread nesting populations still remaining (McClenachan, Jackson & Newman, 2006) and the international scope of conservation needed (Blumenthal *et al.*, 2006).

Effective management of sea turtle stocks, in the form of active conservation measures in conjunction with a reduction in exploitation pressure, has recently seen some Caribbean sea turtle populations showing signs of recovery over relatively short time frames (Garduno-Andrade *et al.*, 1999; Dutton *et al.*, 2005; Troëng & Rankin, 2005). The British Virgin Islands (BVI, 18°30′N, 64°30′W) has a history of sea turtle exploitation followed by steadily increasing conservation measures and management (Fiedler & Jarvis, 1932; Eckert, Overing & Lettsome, 1992; Hastings, 1992). However, current published information on the status and trends of nesting and foraging sea turtle populations in the archipelago is lacking.

Sea turtles have always been part of the commercial fishery in the BVI with early records showing large quantities of meat and shell being exported during the 1920s (Fiedler & Jarvis, 1932). More recently, 1825 hard-shelled turtles (green and hawksbill) were landed as part of the legal fishery from 1981 to 1985, while several hundred individuals of both species were estimated to have been killed incidentally over the same time frame (Hastings, 1992). Additionally, leatherback turtles have been, and still are, highly prized in the BVI for their meat and oil (Hastings, 2003; M. Hastings, pers. obs.). Records from the 1920s show that as many as six nesting females were taken each night (Eckert *et al.*, 1992). By the 1960s, it was still common for two nesting females to be harvested each night, although by the mid 1980s this population was at critically low numbers with only one or two females nesting each season. The protective legislation, The Turtles Ordinance 1959, was amended in 1986 to limit sea turtle harvest and protect eggs and nesting females, which greatly reduced the local commercial turtle fishery and effectively imposed a moratorium on leatherback turtle harvest (Hastings, 1992). Green and hawksbill turtles are still legally harvested in the BVI for subsistence purposes, with the current harvest being restricted to an open season from 1 December to 31 March in any year, and permits the take of green (carapace length >61 cm) and hawksbill turtles (carapace length >38.1 cm) at sea (Richardson, P.B. *et al.*, 2006). The total annual harvest in

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recent years has been estimated at 150–200 green and hawksbill turtles (Godley *et al.*, 2004). There are no quota limits and no study has been undertaken to estimate the sustainability of the current fishery. Coupled with legislative change, ever-increasing public sensitization and active research have been growing in the BVI and direct exploitation continues to decline (Hastings, 2003; Godley *et al.*, 2004).

Other than leatherback turtle nesting data, which have been collected annually since 1986, nesting information is scant for the other turtle species. Over a 12-day period in July 1981, Fletemeyer (1984), using a combination of 6.8 h of aerial surveying, an unspecified number of beach walks and interviews with local fisherman and government officials, estimated that 75 ± 25 (range = 50–100) green and 50 ± 25 (range = 25–75) hawksbill turtles were nesting annually in the BVI. Hastings (1992) reported one green and four hawksbill turtle nests and one nest of unknown species, in 1990. In 1991, one green and 16 hawksbill turtle nests were found in addition to two nests of unknown species. However, the island of Anegada, thought to be the main nesting location for both species in the territory, was not included in any of the surveys in 1990 or in 1991 (Hastings, 1992). Twenty years have elapsed since the introduction of protective legislation in the BVI and with the current trend of some Caribbean turtle populations showing signs of increasing (Garduno-Andrade *et al.*, 1999; Dutton *et al.*, 2005; Troëng & Rankin, 2005; Richardson, J.I. *et al.*, 2006), it is timely to revisit the status of marine turtles in the archipelago.

In this paper we present detailed monitoring data to provide an assessment of the nesting populations of leatherback, green and hawksbill turtles in terms of magnitude, range and seasonality in the BVI; a first in the case of the latter two species. We also present the long-term trend of leatherback turtle nesting in the BVI since the introduction of protective legislation. Furthermore, we provide information on the spatial distribution and size classes of the foraging population of green and hawksbill turtles in the BVI. The overall aims of this study are (1) to present data that can be used as a reference point for future surveys; (2) to elucidate the current spatio-temporal trends of nesting; (3) to gain insight into the current size ranges and an indication of relative abundance of local foraging aggregations.

Materials and methods

Study site

Biogeographically, the BVI forms part of the Puerto Rican Bank along with Puerto Rico and the US Virgin islands (excluding St Croix) and consists of *c.* 43 islands and cays, of which 16 are inhabited (Fig. 1a). Effectively monitoring such a large and diffuse archipelago presents many challenges to local government agencies and conservationists with limited resources. Exhaustive surveying of the entire BVI archipelago was not possible and therefore we used an approach consisting of synthesis of past monitoring data, seasonally targeted aerial surveying, and nesting beach surveys to gain an insight into the spatio-temporal patterns of nesting sea turtle populations of the BVI. In addition to the nesting surveys, we initiated an in-water capture program to establish the magnitude and size classes of the foraging populations of green and hawksbill turtles. The details of each specific methodology are given below.

Aerial surveys

Location of current turtle nesting sites across the archipelago was gathered using focused aerial surveying, which covered all the potential nesting beaches in the BVI archipelago and effectively repeated those areas surveyed by Fletemeyer (1984). The peak months of hard-shelled nesting in the region occur between May and August (US Virgin Islands, Hillis & Mackay, 1989; Antigua, Richardson, Bell & Richardson, 1999; Cayman Islands, Aiken *et al.*, 2001). Financial restrictions meant that we conducted three aerial surveys in 2004 and three surveys in 2005 (six aerial surveys in total) between 25th May and 31st August. The mean number of days between surveys in each year was 17.7 ± 4.7 days ($n = 4$ inter-survey periods) and was dictated by plane availability. All surveys were conducted in a Cessna Blackhawk and commenced at 08.00 h and lasted on average 73.6 ± 3.3 min. The variance in flight times depended on the weather and on the number of activities encountered. Flights started and finished from the island of Anegada, and followed a set route throughout the archipelago (Fig. 1a) covering all the potential turtle nesting beaches. During each survey the aircraft maintained a steady airspeed of 180 km h^{-1} at a height of 170 m above sea level and two observers surveyed beaches for fresh turtle tracks. Once tracks were encountered, the aircraft circled overhead until the species was identified and where possible nesting confirmed following Schroeder & Murphy (1999). Nesting activity was recorded on Anegada, Tortola and Sandy Cay during aerial surveying. All three nesting species (leatherback, green and hawksbill turtles) were represented and 23/25 turtle tracks (five leatherback, seven green and 11 hawksbill turtle tracks) were ground truthed during beach patrols, with species identification being confirmed correct in all cases. The two remaining hawksbill activities (Sandy Cay) were not ground truthed.

Beach surveys of Tortola and nearby islands

Monitoring Tortola's leatherback turtle nesting beaches is conducted by BVI Conservation and Fisheries Department (BVICFD) personnel and has been ongoing since 1986 (see Hastings, 2003 for an overview). Before 1994, leatherback turtle nesting activity was assessed retrospectively with beach surveys being conducted bi-weekly from mid-March to mid-June although the total number of surveys and personnel involved in each year is unknown. Since 1994, nightly beach patrols have been conducted between March and August on the main leatherback turtle nesting beaches and beach wardens cover the remaining Tortola beaches every 4–5 days. Beach wardens cover all beaches on Tortola

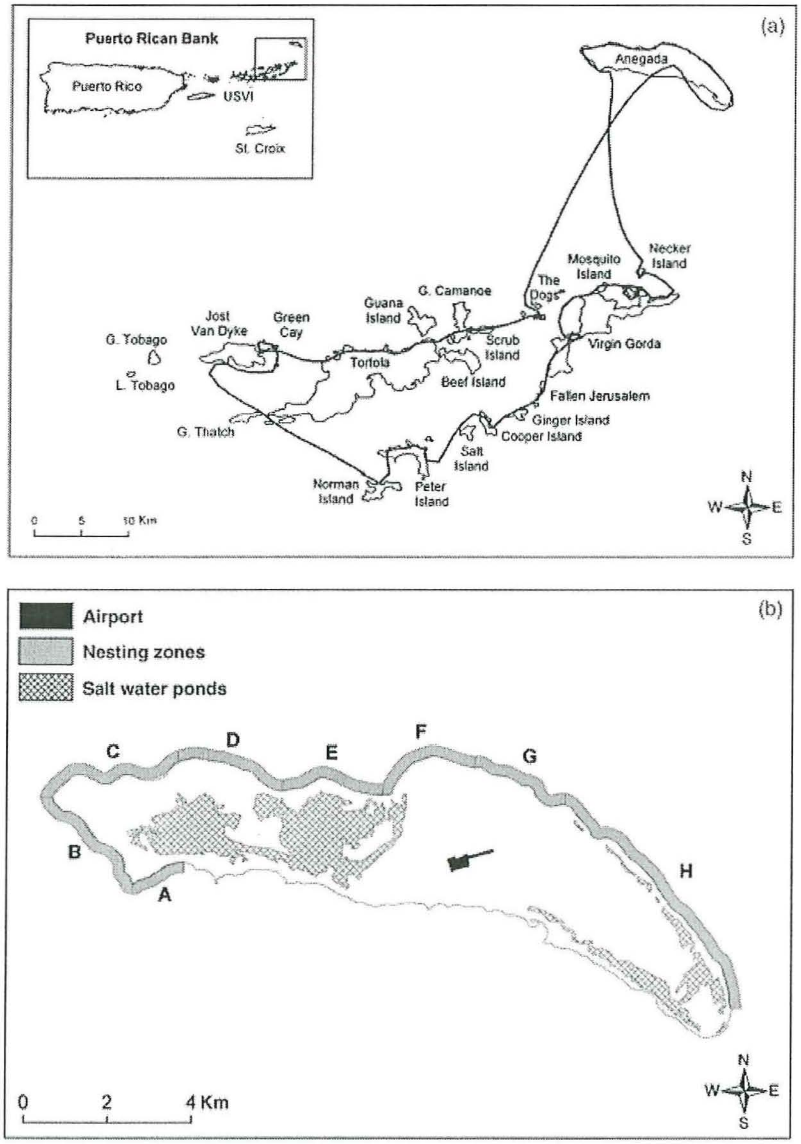

Figure 1 Map of the British Virgin Islands (BVI) and the monitoring locations for sea turtle nesting in the BVI by (a) aerial surveying and (b) foot patrols on the beach sections of Anegada. Inset in (a) shows location of the Archipelago in relation to the Puerto Rican Bank.

at least once every 7 days as part of their daily duties throughout the year, which is more than adequate to ensure that all turtle nesting activities are detected (Bjorndal *et al.*, 1999). Occasional female hawksbill turtles and or tracks are encountered during leatherback turtle surveys by the BVICFD staff. However, the majority of nesting green and hawksbill turtle nesting attempts on islands other than Tortola and Anegada are recorded in an opportunistic manner and are primarily reported to BVICFD by a network of local interested residents and tourists.

Beach surveys of Anegada

Foot patrols for sea turtle nesting activity were conducted between 17 November 2003 and 22 September 2005. The northern and western coastline of Anegada, containing sea turtle nesting habitat, was arbitrarily divided into manageable portions (Fig. 1b). The remainder of the southern coastline of Anegada is rocky or mangrove-fringed shoreline and therefore has no suitable habitat for nesting sea turtles. The frequency of surveying was irregular and designed to elucidate general spatio-temporal patterns of nesting and offer an approximate indication of the magnitude of nesting for the different species. In total, 181 foot surveys of the nesting beach sections of Anegada were conducted, and there was some variation in the number of surveys that each section received (Table 1). The mean number of foot surveys per section was $= 22.6 \pm 1.53$, $n = 8$ sections. For most beach sections the majority of surveys were concentrated during the peak months of the nesting season (Table 1), with the rest of the surveys spread evenly through the rest of the calendar year. Our surveys effectively covered two complete

Table 1 The number and seasonal breakdown of nesting beach surveys that took place on Anegada between November 2003 and September 2005

		Number of surveys								
		November 2003 to October 2004				November 2004 to October 2005				
Beach	Length of beach (km)	January–March	April–June	July–September	October–December	January–March	April–June	July–September	October–December	Total number of surveys
A	1.47	0	3	5	2	2	1	6	2	21
B	2.97	0	3	5	2	2	1	6	2	21
C	3.27	0	3	5	2	2	1	5	2	20
D	2.74	0	3	5	2	2	1	3	2	18
E	2.78	0	3	5	2	2	1	4	2	19
F	1.81	0	3	7	2	2	1	7	2	24
G	2.75	1	3	8	2	2	1	9	2	28
H	7.00	1	3	10	2	2	1	9	2	30

turtle nesting seasons. All beach surveys took place during daylight hours and subsequently any sea turtle tracks that were encountered were assessed retrospectively. Each track was identified to species and nesting was confirmed following Schroeder & Murphy (1999).

Foraging

To sample foraging populations of green and hawksbill turtles we carried out an extensive in-water capture programme that consisted of a territory wide effort based from Tortola and a concentrated effort in Anegada. All sampling took place in shallow (<15 m) coastal waters. A total of 294.75 h were spent in-water sampling from Tortola, with the mean number of hours per day sampling being 3.13 ± 0.02 h, $n = 95$ days. In contrast, 542.75 h were spent sampling at Anegada with the mean number of hours per day sampling being 4.98 ± 0.14 h, $n = 109$ days. Turtles were captured by hand via a combination of free diving or the rodeo-style method (Ehrhart & Ogren, 1999) with all subsequent measurements being conducted in the same way. Each turtle that was caught was given a unique numbered set of inconel flipper tags attached to the trailing edge of each fore flipper proximal of and adjacent to the first large scute (Balazs, 1999) and a series of biometric data were taken. Local fisherman on Anegada, using set nets targeting turtles, provided a small number of turtles (10 green, two hawksbill turtles) for measuring before consumption. Using a flexible measuring tape, we measured the curved carapace length notch to tip (CCLn-t) and the curved carapace width (CCW) (Bolten, 1999). We also measured the straight carapace length notch to tip (SCLn-t) and the straight carapace width (SCW) using large vernier callipers (Bolten, 1999).

Statistical analyses

All statistical analyses were carried out using GenStat Release 7.1 (GenStat, 2003). All tests were parametric and two-tailed unless the data violated the assumptions of normality in which case non-parametric equivalents were used. To assess the foraging size class distributions of turtles caught at Anegada and Tortola, we used the Kolmogorov–Smirnov two-sample test. This test compares the two empirical cumulative distribution functions in order to try and detect differences in the shape of the underlying distributions with the test statistic being the absolute difference between the cumulative distribution functions and converted to a χ^2 equivalent for ease of interpretation (GenStat, 2003). Means ± one standard error are presented throughout, unless otherwise stated.

Results

Nesting

The total number of leatherback turtle nests recorded in the BVI ranged between 0 and 65 nests between 1986 and 2006 (Fig. 2). Despite the number of leatherback turtle nests dropping to zero in 1989, the long-term trend, since this minima, has generally been a steady increase since the early 1990s with year accounting for 63% of the variance in the total number of nests (linear regression: $F_{1,20} = 34.8$, $P<0.001$, Fig. 2). The survey regime before 1994 was different and could potentially cause bias but there is still a significant effect of year on the number of leatherback nests if the data before 1994 are excluded (linear regression: $F_{1,12} = 8.1$, $P<0.02$, $r^2 = 0.37$). It should be noted that the inclusion of a quadratic and/or a polynomial term did not improve the r^2 value of the model and hence we present the basic linear regression for simplicity. Therefore, we are confident that the general trend of increasing nest numbers is real and not an artefact of variable monitoring effort. Furthermore, analysis of the same data utilizing an Autoregressive Integrated Moving Average (ARIMA) approach to account for the same females re-nesting every 2–3 years returns the same positive significant effect of year, with all the autoregressive parameters being non-significant. However, following a peak of nesting in 2003, the total number of nests has been slightly lower in the most recent seasons (Fig. 2).

A total of 26 green and 24 hawksbill turtle nests were recorded on Anegada between November 2003 and September 2005. During the same time period members of the public

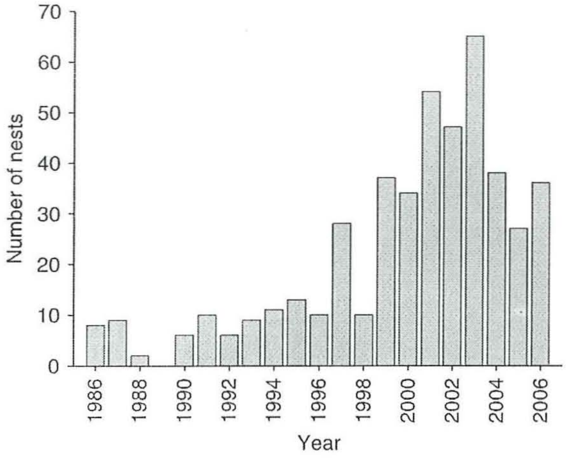

Figure 2 The number of leatherback turtle *Dermochelys coriacea* nests recorded in the British Virgin Islands from 1986 to 2006. Linear regression: $y = -4.67 + 2.42x$, $r^2 = 0.63$.

reported an additional 18 turtle nests from several different islands (Tortola: one green and 11 hawksbill turtle nests; Beef Island: two hawksbill nests; and single hawksbill nests from each of Cooper Island, Saba Rock, Sandy Cay and Virgin Gorda).

Spatially, leatherback turtle nesting is confined to the north shore of Tortola, with occasional nests on the west coast of Anegada and a rare nest on Virgin Gorda (Fig. 3a). In contrast, green turtle nesting is almost entirely confined to the north shore beaches of Anegada with a rare nest occurring on the south-west coast of Tortola (Fig. 3b). It should be noted that the entire south coast of Anegada is completely unsuitable for any nesting turtle species. Hawksbill nesting was much more widely distributed throughout the BVI (Fig. 3c) with nesting occurring on seven different islands during the time frame of this study although the vast majority of hawksbill nesting occurs on the west and north shores of Anegada (Fig. 3c). Comparison with the combined historical nesting records (Fletemeyer, 1984; Hastings, 1992) shows that there has been a significant decrease in the number of islands with green turtle nesting (Fisher's exact test: $P = 0.03$), with only two islands hosting green turtle nesting now, compared with 10 islands historically. The hawksbill turtle nesting range shows no significant change (Fisher's exact test: $P = 0.59$), with seven islands hosting nesting today compared with 10 previously (Fig. 3b and c, respectively). It should be noted that the islands found to have nesting in the 1990/1991 study were recorded as having nesting in 1981 and therefore combining the historical records makes no difference to the overall result.

The main nesting season for leatherback turtles in the BVI is from March to June with a peak in nesting numbers occurring in May (Fig. 4a). Very few leatherback turtle nests have been recorded outside this time period and there is very little overlap in nesting with the other two nesting species. The green turtle nesting season is likely to be from June to September with the main peak of nesting activity occurring in August (Fig. 4b). Similar to the green turtle nesting season, the hawksbill turtle demonstrates a main peak of nesting activity in August although nesting is more protracted occurring throughout September and October, with

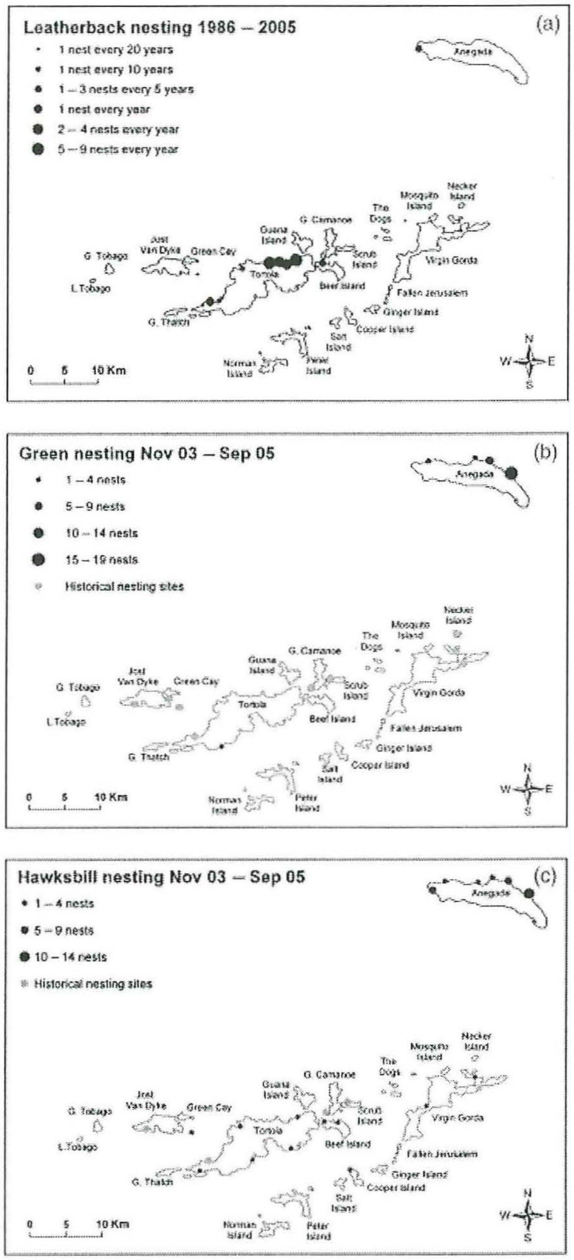

Figure 3 The locations and number of nests for (a) leatherback sea turtles *Dermochelys coriacea* based on 20-year data; (b) green sea turtles *Chelonia mydas* from November 2003 to September 2005 and (c) hawksbill sea turtles *Eretmochelys imbricata* from November 2003 to September 2005 in the British Virgin Islands archipelago. Historical records of nesting locations from Fletemeyer (1984) and Hastings (1992).

a small number of nests recorded throughout most months of the year (Fig. 4c).

Foraging

Foraging aggregations of sea turtles are widespread and abundant in the shallow coastal waters of the BVI. In total, 172 green turtles and 328 hawksbill turtles were caught in the waters of the BVI and the distribution of captures for each species in the archipelago from Tortola and Anegada are shown in Fig. 5a–d, respectively. There was no significant difference in the shapes of the size class distributions of foraging green turtles that were caught from Tortola or from Anegada (Kolmogorov–Smirnov two sample test: $\chi^2 = 1.5$; $P = 0.47$; Fig. 6a and c). Nor was there a difference in the shapes of the size class distributions of foraging hawksbill turtles (Kolmogorov–Smirnov two-sample test: $\chi^2 = 1.5$; $P = 0.47$; Fig. 6b and d).

Overall, 1.65 ± 0.13 and 5.71 ± 0.41 turtles were caught per day from Tortola and Anegada, respectively. These values equate to a catch per unit effort of 0.53 and 1.1 turtles h^{-1} for Tortola and Anegada, respectively. It should be noted that these values include processing time estimated at approximately 15 min per turtle.

Discussion

Three species of sea turtle are still nesting in the BVI but these populations no doubt represent depleted populations when compared with historical records and ranges (Fletemeyer, 1984; Eckert *et al.*, 1992; Hastings, 1992; Jackson, 1997), with the numbers of all three nesting species still appearing to be critically low. It would appear that the number of nesting female leatherback turtles are showing signs of recovery as the number of annual nests has risen over the past 10 years and in all likelihood the implementation of a moratorium on harvest in 1986 is a contributory factor. Since 1994, the monitoring effort of Tortola's leatherback beaches has been consistent and we believe these increases to be genuine and not an artefact of variable monitoring effort, although the same cannot be said for nesting numbers before 1994. The rise in the number of leatherback nests in the BVI is also mirrored in the nearby nesting beaches of St Croix, US Virgin Islands (Dutton *et al.*, 2005), although elsewhere in the Caribbean, leatherback nesting numbers appear to be either stable or slightly declining (Troëng, Chacón & Dick, 2004). Furthermore, a similar pattern of slightly reduced nesting numbers following peaks in 2001 and 2003 has been demonstrated at the nearby leatherback rookery at St Croix (Garner, Garner & Coles, 2006; P. H. Dutton, pers. comm.).The observed variation in the total number of nests over the last few years is most likely to be a result of the inter-annual variability in nesting numbers, coupled with the female condition, which will affect the total number of nests a female lays in a given season (Miller, 1997; Broderick, Godley & Hays, 2001). It could be argued that because the leatherback turtles are long-lived and take a decade or more to reach sexual maturity, the observed sharp

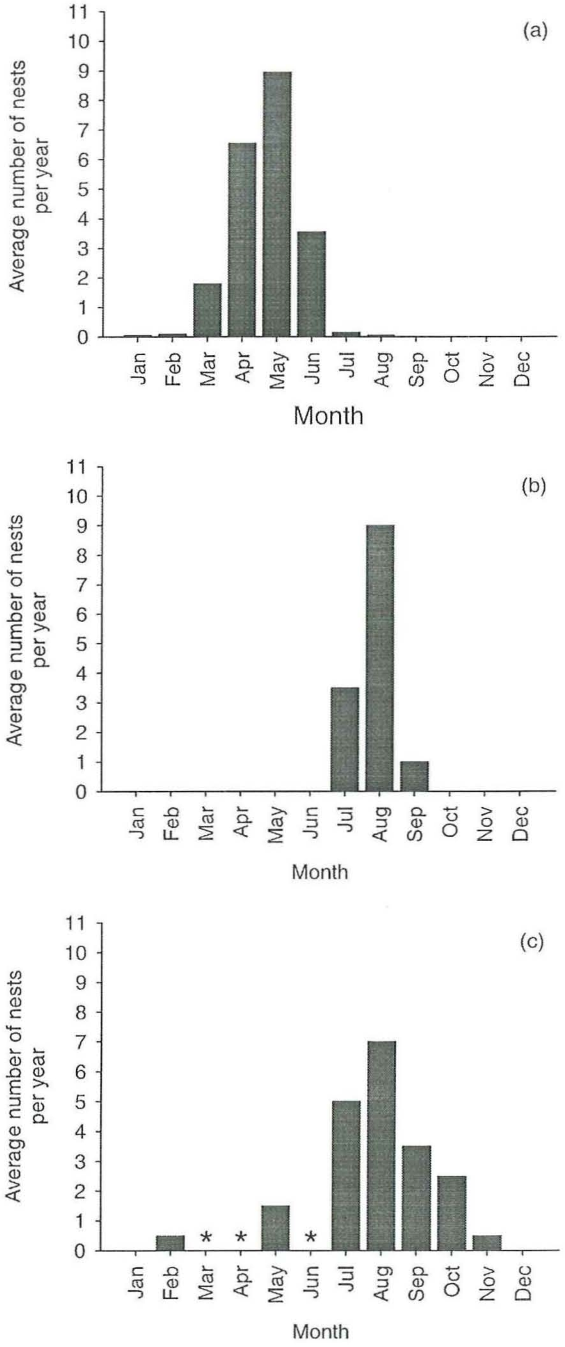

Figure 4 The seasonality of nesting in the British Virgin Islands for (a) leatherback turtles *Dermochelys coriacea* based nesting data from 1986 to 2006; (b) green turtles *Chelonia mydas* based on two years of nesting data (November 2003 to October 2005) and (c) hawksbill turtles *Eretmochelys imbricata* based on two years of nesting data (November 2003 to October 2005). *No systematic surveys were conducted during these months on Anegada.

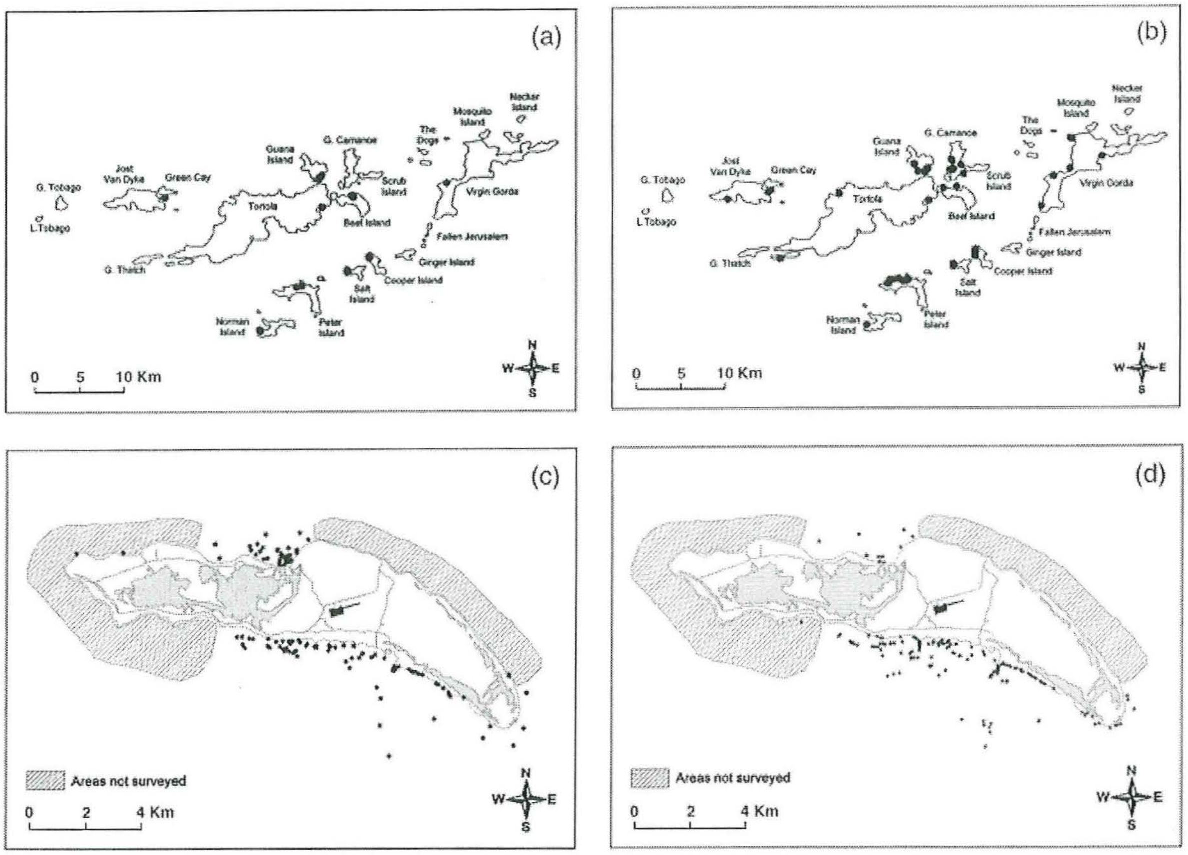

Figure 5 The capture locations of foraging (a) green turtles *Chelonia mydas* and (b) hawskbill turtles *Eretmochelys imbricata* captured by Tortola based efforts and those for foraging (c) green and (d) hawskbill turtles captured in Anegada. Shaded areas in (c, d) indicate areas not systematically surveyed due to turbidity or difficult boat access.

increases in nesting numbers are due to variable survey effort. However, we believe that this is not the case here for several reasons. Firstly, we are dealing with a meta-population that includes highly protected populations in the US Virgin Islands and Puerto Rico (Dutton *et al.*, 1999, 2005) and leatherback turtles are known to be less site faithful, in terms of nesting, than was originally thought (Rivalan *et al.*, 2006; Georges *et al.*, 2007). Secondly, results elsewhere suggest that colonization can sometimes involve a large number of animals over a short time scale, for example over one or a few decades (Rivalan *et al.*, 2006). Thirdly, leatherback sea turtles have one of the shortest generation times, *c.* 10 years, of all sea turtle species (Zug & Parham, 1996), which would fit with our observed increases, and finally, leatherback turtles are no longer being butchered on the BVI nesting beaches.

Tortola certainly appears to be the heart of leatherback turtle nesting in the BVI with only sporadic nests occurring on two other islands. Leatherback turtles have specific nesting requirements and are known to prefer to nest on 'high energy' beaches with steep slopes, deep-water approaches and absence of any fringing reef (Mrosovsky, 1983; Eckert, 1987; Eckert *et al.*, 1989), which are in abundance on the north shore of Tortola. However, it is surprising that green turtles do not nest on these same beaches because the two species are known to nest on the same beaches at other sites (Whitmore & Dutton, 1985; Bjorndal & Bolten, 1992). Green turtles are thought to show a higher degree of site fidelity than the other turtle species (Miller, 1997; Bjorndal, Bolten & Troëng, 2005; Richardson J.I. *et al.*, 2006; Rivalan *et al.*, 2006; Formia *et al.*, 2007; Georges *et al.*, 2007) and in all likelihood the green turtle nesting population on Tortola, the most populated island in the BVI, was effectively lost, possibly due to human exploitation, before surveys began in the early 1980s. Fletemeyer (1984) recorded 19 green turtle nests on eight different islands and 20 hawksbill turtle nests on five islands during 6.8 h of aerial surveying over a 12-day period in July 1981 and suggested that 75 green and 50 hawksbill turtles were nesting each year. These estimates of nesting female numbers multiplied by the mean number of clutches per season would equate to approximately 220 green and 137 hawksbill clutches per nesting season in the early 1980s (Green turtles: mean number of clutches per season = 2.93; hawksbill turtles: mean number of clutches per season = 2.74, Miller, 1997). Furthermore, 70 foot surveys of 18 beaches in July

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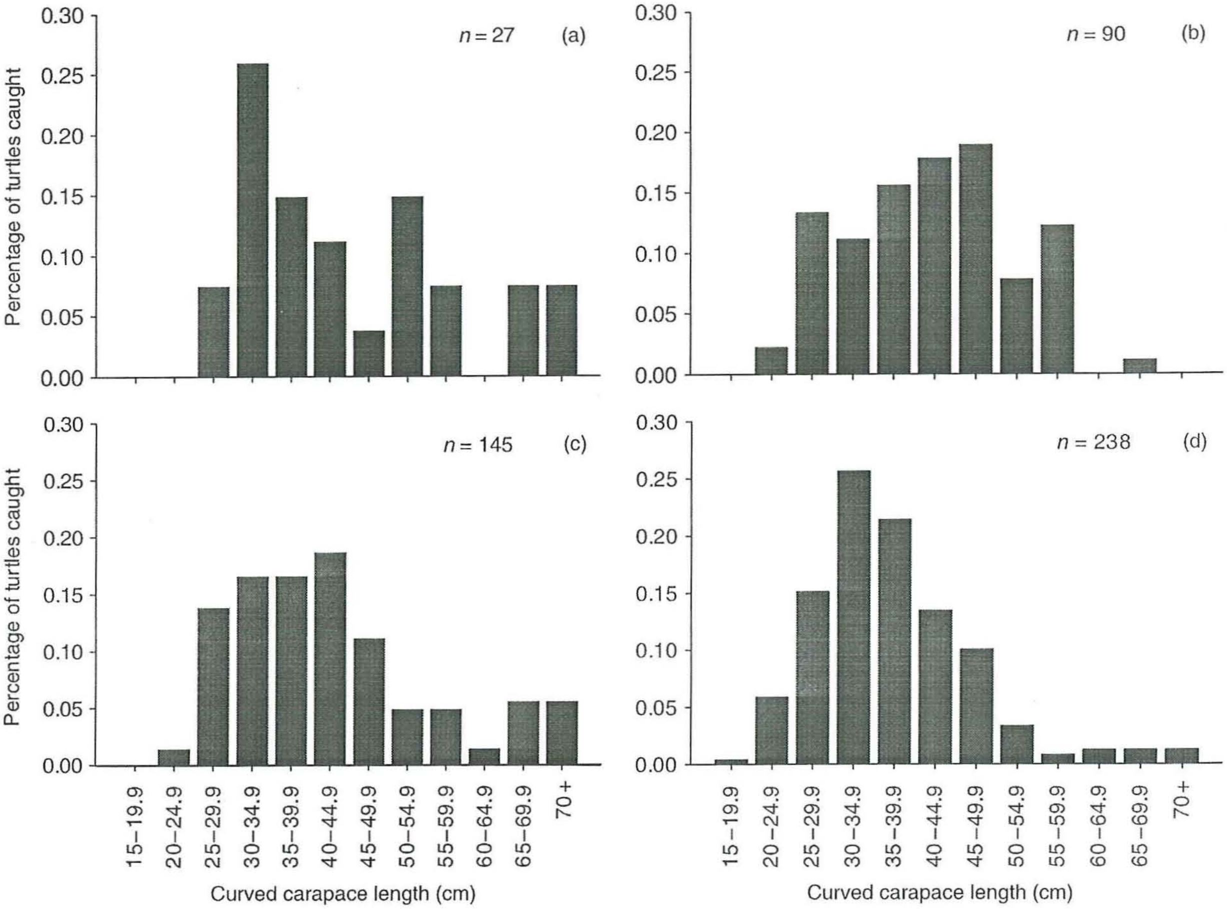

Figure 6 Size class distribution of captured (a) green turtles *Chelonia mydas* from Tortolan-based efforts; (b) hawksbill turtles *Eretmochelys imbricata* from Tortolan-based efforts; (c) green turtles from Anegada and (d) hawksbill turtles from Anegada.

1990 and 78 surveys of 23 beaches between August and November 1991 resulted in only one green turtle nest being recorded each year (Hastings, 1992). Hastings (1992) also reported four hawksbill turtle nests in 1990 and 16 hawksbill turtle nests in 1991 from the same surveys. However, it should be noted that Anegada was not surveyed in either of these years. We recorded only 26 green turtle nests on two islands (25 nests on Anegada, one nest on Tortola) and 24 hawksbill turtle nests over the course of two complete nesting seasons, which included 7.3 h of aerial surveying of the entire archipelago and exhaustive foot surveys of both Tortola and Anegada. Our findings would seem to indicate that there has been a reduction in the magnitude of both hard-shelled species and a reduction in the spatial distribution of nesting green turtles throughout the territory since the early 1980s (Fig. 3b), with Anegada being the last stronghold for both hard-shelled species in the BVI. However, it should be noted that the lack of systematic monitoring of hard-shell nesting means that firm conclusions regarding population trends cannot be made due to potential bias caused by sampling effort and the inter-annual variability in nesting. Indeed, other monitoring projects in the Caribbean have shown that both green and hawksbill nesting numbers are on the increase (Garduno-Andrade *et al.*, 1999; Troëng & Rankin, 2005; Richardson J.I. *et al.*, 2006; Beggs, Horrocks & Krueger, 2007; but see Bell *et al.*, 2007). Nevertheless, unlike the other two turtle species, hawksbill turtles typically have a more widespread nesting distribution in the BVI, characteristic of their less-rigid nesting requirements (Horrocks & Scott, 1991) and this attribute may make hawksbill turtles in the BVI and elsewhere more resilient to local extirpation but conversely makes active monitoring and conservation efforts aimed at this species more difficult to implement. Indeed, if one considers the slightly perverse perspective of actively making the nesting populations of all three species in the BVI extinct, then it would be easiest to accomplish for green turtles due to their high site fidelity and strict nesting beach requirements. Extirpation of Leatherbacks would be more difficult because, although they have strict nesting beach requirements, they are not very site faithful and recruitment will occur from other populations. Hawksbills would be most resilient because of their flexible nesting requirements, making nesting most diffuse.

Our monitoring data clearly show that the peak of leatherback turtle and hard-shelled turtle nesting is temporally separated in the BVI, with leatherback turtle numbers peaking in May while the hard-shelled species are centred about August, and these findings mirror the patterns shown by neighbouring nesting populations of leatherback turtles (US Virgin Islands, Garner *et al.*, 2006; Central America Caribbean coast, Troëng *et al.*, 2004), green turtles (Costa Rica, Troëng & Rankin, 2005) and hawksbill turtles (US Virgin Islands, Hillis & Mackay, 1989; Antigua, Richardson *et al.*, 1999; various locations in the Caribbean Sea, Chacón, 2004). The dichotomy in nesting peaks, coupled with the extended hawksbill turtle nesting season, effectively complicates monitoring by prolonging the turtle nesting season from March to November. To intensively monitor nesting of this multi-species assemblage, in such a diffuse archipelago, would require resources that are currently beyond local government capacity. However, our survey regime has shown that targeted bouts of focused fieldwork can still provide valuable and reliable insights into sea turtle nesting ecology in terms of magnitude and seasonality and that such temporally targeted bouts of fieldwork at index sites offers the potential for future trend detection.

We spent a large number of hours sampling the foraging turtle assemblage in the waters of the BVI, and in terms of capture frequency (CPUE) our figures (0.57 turtles h^{-1} Tortola and 1.1 turtles h^{-1} Anegada) are comparable with those reported from various sites at Mona Island, Puerto Rico (range 0.48–2.38 turtles h^{-1}; León & Diez, 1999) and Jaragua National Park and Cabo Rojo, Domincan Republic using similar methodology (range 0.86–3.43 turtles h^{-1}; León & Diez, 1999). Our CPUE estimates are minimum estimates as they incorporate processing time, and therefore the relatively high relative abundance of turtles inhabiting the waters of the BVI indicates that it is an important foraging ground for both species in the region. Our results from the in-water capture programme showed that green and hawksbill sea turtles constitute the vast majority of the foraging sea turtle population in the BVI, although loggerhead turtles are occasionally reported (S. Gore, pers. obs.). Foraging green and hawksbill turtles can be found throughout the archipelago, highlighting the difficulty of setting conservation priorities, although there are pockets of higher relative abundance. Anegada is without question a highly important area for both species, especially for small (<40 cm SCL), turtles and foraging turtle stocks appear to be healthy. It is most likely that foraging stocks are mainly from the major rookeries elsewhere in the Caribbean and a full genetic assessment of the foraging populations is currently being undertaken.

It is interesting to note that there were few large (>60 cm SCL) individuals of both species captured during the in-water study, particularly as there are active breeding populations of both green and hawksbill turtles. Hawksbills >60 cm SCL accounted for only 3% (10/328) of those caught at Anegada and Tortola combined, whereas 7% (14/197) of hawksbill turtles at Mona and Monito islands, Puerto Rico (Diez & van Dam, 2002) and 44% (47/106) at the southern Great Barrier Reef feeding ground (Limpus, 1992) caught during similar in-water studies were >60 cm SCL and CCL, respectively. A similar pattern exists for green turtles with 13% (22/172) of those individuals caught at Anegada and Tortola combined being >60 cm SCL whereas 18% (24/135) of green turtles at Culebra (Collazo, Boulon & Tallevast, 1992) and 22% (31/141) at Great Inagua, Bahamas (Bjorndal & Bolten, 1988) were >60 cm SCL.

Human consumption could be responsible for the apparent lack of large turtles although the depth of the water where search efforts were focused, is in all likelihood the major influence on these results. Shallow inshore areas were the focus of our in-water work; indeed, 73% of all captures at Anegada were in water < 1 m in depth and the maximum depth of a capture at Anegada was 4.8 m. Models of optimal diving behaviour suggest that smaller individuals should seek prey items in shallower water and larger individuals in deeper water, even though small individuals are capable of diving to greater depths (Mori, 2002). Large adult and near-adult hard-shelled turtles may not use the same foraging grounds as smaller turtles and a concept of sequential developmental habitats, typically of increasing depth with increasing body size (Ehrhart & Redfoot, 1995; Musick & Limpus, 1997), has been used to explain the size class differences found at different foraging grounds. There may be a dichotomous shift from developmental foraging habitat to adult foraging habitat and this has been used to explain the size class distributions of immature hawksbills on the southern Great Barrier Reef (Limpus, 1992) and green turtles in the Gulf of California, Mexico (Seminoff *et al.*, 2003). This may be especially true for hawksbill turtles at Anegada, with small turtles inhabiting the shallow warm waters and associated patch reefs and sea grass beds, growing until they reach a threshold limit, *c.* 50–55 cm SCL. Once the size threshold is reached, individuals may then relocate to the deeper waters of the outer reef wall habitat when they are large enough to avoid predation by the majority of large predatory fish species. Although logistically challenging, an assessment of the size classes of turtles inhabiting the deeper waters of the outer reef wall coupled with tagging would be useful in evaluating whether a size-related shift in foraging habitat is actually occurring at these sites.

Nesting leatherback turtles in the BVI have shown a steady increase since the early 1990s and it is highly likely the moratorium on leatherback turtle harvesting has been a factor in the rise in nesting females. However, nesting populations from the BVI, US Virgin Islands, Puerto Rico and possibly other islands in the Antilles are all thought to contribute to a larger regional metapopulation (Dutton *et al.*, 2005). Therefore, the rise in nesting numbers in the BVI may, in part, be attributable to supplementation of individuals from other nearby rookeries that are also on the increase (Dutton *et al.*, 2005). Irrespective of the true source of the increase in nesting leatherback turtles in the BVI, it is clear that conservation measures aimed at reducing the pressure on nesting female turtles can aid the recovery of nesting populations in a relatively short time frame (Bjorndal *et al.*, 1999; Balazs & Chaloupka, 2004; Dutton *et al.*, 2005; Troëng & Rankin, 2005). In contrast to the leatherback turtle situation, the number of nesting hard-shelled turtles in the BVI appears to have decreased markedly from the numbers reported in the early 1980s by Fletemeyer (1984). It is not possible to generate any current trend for the number of nesting hard-shelled turtles because data will need to be gathered over extended time periods as a result of inter-annual variability in nesting numbers, which is especially prolific in green turtles (Broderick *et al.*, 2001). We have, however, highlighted the current spatio-temporal patterns of nesting and have provided a baseline to direct future monitoring. Any recovery of hard-shelled nesting numbers would be expected to take longer than the leatherback turtles due to inter-specific differences in time to maturity and site fidelity. Leatherback turtles are thought to reach maturity between 9 and 14 years old (Zug & Parham, 1996), while hard-shelled turtle maturity estimates range between 20 and 40 years for some populations (Boulon, 1994; Chaloupka & Limpus, 1997; Bjorndal, Bolten & Chaloupka, 2000; Diez & van Dam, 2002; Balazs & Chaloupka, 2004). Furthermore, tagging and genetics studies have shown that leatherback turtles are not particularly site faithful (Rivalan *et al.*, 2006; Georges *et al.*, 2007), unlike green turtles (Bjorndal *et al.*, 2005; Formia *et al.*, 2007) and hawksbill turtles (Richardson J.I. *et al.*, 2006).

Despite being constrained by resources, we have gained significant insights into the spatial distribution and seasonality of nesting sea turtles of the BVI as well as highlighting the widespread stocks of foraging juveniles in BVI waters. These are relevant to the conservation of nesting and foraging sea turtle stocks in the BVI and the wider Caribbean. This loss of sea turtle numbers is thought to be one of the first steps in the dismantling of Caribbean marine ecosystems and it has been suggested that protection of small nesting populations needs to be more strongly advocated (McClenachan *et al.*, 2006). When given complete protection, nesting populations of sea turtles in the Caribbean seem to have the capacity to recover relatively rapidly (Garduno-Andrade *et al.*, 1999; Dutton *et al.*, 2005; Troëng & Rankin, 2005; but see Bell *et al.*, 2006) and the leatherback turtle population of the BVI appears to be demonstrating this effect. We have shown evidence strongly suggestive of a reduction in nesting levels for green and hawksbill turtles, as well as a reduction in the nesting range for green turtles, and despite current conservation steps being undertaken (Hastings, 2003), it might be a decade or more before positive signs of recovery could be evidenced in these hard-shelled species. The intra-annual temporal and spatial spread of nesting of the three turtle species also highlight the difficulties faced by, generally under-resourced, local government agencies in monitoring such a multi-species assemblage in a widespread archipelago like the BVI.

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Insects and Other Invertebrates

B & B Valentine

March 30, 2008

29 March, 2008
Skip:

Here is an outline of this years more interesting developments:

CRUSTACEA: Isopoda. We were working on pill-bugs when an e-mail arrived from Cokendolpher asking about our material! The timing was uncanny unless you mentioned it.
Two women from the Milwaukee Public Museum have just published a checklist of West Indies species. They list 12 species from Puerto Rico and 13 from the entire Virgin Islands, 8 shared; so Virgin Islands have 5 not on P.R., and P.R. has 4 not on Virgin Islands. For comparison, we have at least 12 species from Guana, plus one more from Tortola, and the sorting and identification process is still incomplete. The fact that we have not made any special effort to collect these beasts adds to the surprising diversity. We will, of course, change that. Also, if I remember correctly, we gave an early batch to one of the Ivy Leagers - I forget which one - with no dets in response.

INSECTA: Roaches. Our manuscript on V.I. species is nearing completion, and will be an important summary (22 species) of a poorly known fauna. Wenhua (and Daniel) did much of the work, and I am pleased with the quantity and quality of our efforts. I E-mailed Dr. Gutierrez in Cuba (specialist in W.I. roaches) but after 10 days, have no response.

Walking sticks. I have been editing the mss. on the six Virgin Island species, but have declined to be an author. This is an order about which I know very little beyond the universal principles and rules of systematic proceedure.

Grasshoppers and crickets. Still infuriating delays and silence from the authorities who have our material. Have about 200 more specimens which will not be

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sent out until
the first lots are reported.

Earwigs. We still have only three V.I. species: one from Guana and St
John, two from Tortola. These are very different from our five species from other West Indian Islands.
None are identified.

True bugs. We have a new family for Guana - Notonectidae (back swimmers) - predaceous aquatic beasts that swim upside down: one came to our u/v light at Upper Camanoe.
Also, a third species of corixid (water boatman), also at u/v light, and a new stink bug (Pentatomidae) which has not yet been identified. Several stink bugs which were common in the early 1990's have
not been seen in the past few years; perhaps they do better in dryer weather.

Plant hoppers. The fulgoroid collection continues to diversify. Our
major difference with Bartlett's paper involves the family Derbidae. He had one species from Guana, we now have
seven. Of these, 3 are single specimens, each caught in a different year...a good example of the
importance of repeated visits.
We still disagree about some unrelated identifications (of Flatidae), and
two more new faces have surfaced.
The large family of leaf hoppers (Cicadellidae) is still not identified.
We get new ones every year, and I keep hopeing the diversity will slow down before I send them out.

Book and bark lice. Not identified (the major authority died a few years
ago). Whereas your book has my estimate of 10 species, we now have about 16 - this without a serious effort
to find these tiny, difficult to identify (have to be dissected), beasts.

Lacewings, etc. (Neuroptera). I have asked Dr. Flint at the Smithsonian
(who identified our material) to coauthor a summary of our fauna. He is emeritus and has not yet answered.
When he did our stuff, we had only three tiny coniopterygids, which require relaxation, dissection,
and remounting...we now have over a hundred and he may well be put off by the prospect. I'll see what
we can work out.

Flies. Robber flies (Asilidae): Dr. Aubrey Scarbrough has identified the
first lot of 100+ specimens. Guana has 5 genera, each with one common species...including Beameromyia
virginensis described (1997) from Guana. We have a taxonomic problem: the genus Efferia (the big common
black beast) is one species: E. stylata (F.), vide Scarbrough, while to me it looks like a sibling

2

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complex. We'll see.
Bee flies (Bombylidae): Evenhuis & Miller, 1994, listed the B.V.I.
fauna (9 islands represented) with 6 species present, 5 on Guana. We now have 10 species on Guana plus one more
on Tortola. I e-mailed Evenhuis, whom I know, but he is so overwhelmd by specimens, he begged off.
I haven't tried Scott, but I suspect he has the same problem. Will keep you posted.
Hover flies (Syrphidae): still no progress. We have 4 species of
these neat beasts on Guana, in 4 different genera. Sorting of other families continues.
Ants, bees, and wasps (Hymenoptera): Evaniidae: these are very odd ancient
predators on cockroach eggs, with fossils from Jurassic times similar to present species. They are
essentially unchanged for 150 million years. Guana has three species which are going to Andy Dean at North
Carol. State Univ., who is the major authority. Fine-grained sorting for the rest of the order is progressing,
but the process is time-consuming.

Beetles and weevils (Coleoptera): We have 16 new records for Guana,
including 3 nitidulids, 2 carabids, 2 lady
bugs, 3 chrysomelids, a third species of the hydrophilid water beetle genus
Berosus, another diving beetle, a scarab, a click beetle, an ant-like beetle, a pselaphid, and a weevil. The
scarab subfamily Aphodiinae has been reworked, based on several recent studies in which early
"dumping-ground" genera have been brought up to date. Our original list of five species has a new look:
Ataenius beattyi Chapin Guana
" gracilis (Melsheimer) Guana also
in lit. from: Puerto Rico, St Croix
" michelli Chalumeau Guana, Little Thatch
" scabrellus Schoenherr Guana, Anegada
" scutellaris Harold Guana, Tortola also
in lit. from: Puerto Rico, St Thomas, St Croix
Martineziana deutertrei (Chalumeau) Guana
Platyomus parvulus (Chevrolat) Guana
Nialaphodius nigrita (Fabricius) Guana, Anegada
Labarrus pseudolividus (Balthasar) Guana, Anegada
The family Nitidulidae is under review...our original four species are now:
Carpophilus sp. Guana, Tortola
" sp. Guana
" sp. Guana
Conotelus sp. Guana, Tortola (?)
Lobiopa sp. Tortola
" sp. Tortola
Epuraea (Haptoncus) sp. Guana
Stelidota ruderata Erichson Guana, Tortola
" sp. Guana
" sp. Tortola

The related, odd, rare, virtually unknown family Smicripidae has two (possibly three) Guana species, and none from any other island. Our nitidulids and smicripids are under study by a world specialist, so we hope to have more details soon. Several other families are also out for study, but this is often an agonizingly slow process. Will keep you posted.

My manuscript on the anthribid weevils of the Virgin Islands (95% complete) has just had a major boost. The special folks at the Florida State Collection of Arthropods have offered me use of their auto-montage equipment, which produces extraordinary, sharp, three-dimensional photos of even tiny, convex insects, in color. There is nothing that equals it. We did a trial run and the results far exceeded my expectations. Our neighbor, Dave Dennis, whom you met, helped with the final processing. When he returns, I'll ask him to e-mail a sample to you. Will keep you posted. We send our very best.

Barry, and Buena & Susan
bv@nwcs.com

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Research Proposal for Scientists' Month on Guana Island, October 2008

Dr. Barbara L. Thorne, Professor
Department of Entomology, University of Maryland, College Park, MD 20742

Research Partner: **Dr. Edward J. Weiler**
Director, NASA Goddard Space Flight Center, Greenbelt, MD 20771

During Scientists' Month '08 on Guana Island I would like to continue three studies on termites, building on work originally initiated in collaboration with Dr. Margaret Collins in the late 1980s, and later expanded with co-authors Drs. Michael Haverty, Robert Denno, and David Hawthorne. The first two projects center on basic biology (although with applied implications because termites are structural pests); the third project has an exclusively applied focus.

Research Projects:

1] Long-term monitoring of *Nasutitermes* nest growth, activity, and recruitment

Long-term studies of termites in the field are extremely rare, and Guana Island now hosts one of the longest continuously monitored termite populations worldwide. With initial sampling in 1989, a group of *N. acajutlae* colonies has been monitored in 1992, 1993, 1994, 1996, 1998, 1999, and 2003. The 1989 – 1999 data resulted in the publication *Thorne, B.L. and M.I. Haverty. 2000. Nest growth and survivorship in three species of Neotropical Nasutitermes (Isoptera: Termitidae). Environmental Entomology, 29: 256-264.* Continued monitoring in 2008 will extend this study to nearly two decades, and will result in another publication with the longest series of field demographics ever completed for termites.

2] Colony Population Genetics

Following up on the work of Denno, Hawthorne, and Thorne (2001), I would like to sample for expanded intra-colony genetic analysis of Nasutitermes and Heterotermes. With ever more sophisticated genetic techniques (now available in my own lab) and a broader foundation of comparative knowledge about termite population genetics, I would like to sample colonies of *Nasutitermes acajutlae, N. costalis*, and *Heterotermes* on Guana Island (and other BVI islands if convenient). Microsatellite genetic markers will be analyzed to determine colony structure (e.g. infer number of reproductives and degree of inbreeding) and the possibility of polydomous nesting (do single families occupy more than one nest?). These are fundamental questions for understanding how termite colonies form, grow, and persist. There is a small amount of data on these topics for *Nasutitermes*; none yet for the pest genus *Heterotermes*.

3] Applied Project: Will BVI *Heterotermes* feed on termite bait matrices?

Subterranean termites of the genus *Heterotermes* are a destructive structural pest in the BVI and many areas of the Caribbean and beyond. Traditional liquid termiticides can be an effective control technique in some circumstances, but they are expensive, not environmentally friendly, and they cannot be used in many situations

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because of proximity to cisterns or bodies of water. Termite baits offer a promising alternative, but *Heterotermes* are notoriously difficult to direct toward baits. I have been working with novel bait matrices on North American termites, and would like to test them on Caribbean species. I will use only the 'blank' bait matrices, not laced with any pesticide, for these trials.

Thorne's publications resulting from work on Guana Island:

- Haverty, M.I., M.S. Collins, L.J. Nelson, and B.L. Thorne. 1997. Cuticular hydrocarbons of the termites of the British Virgin Islands (Isoptera: Kalotermitidae, Rhinotermitidae, Termitidae). *Journal of Chemical Ecology* 23 (4): 927-964.

- Collins, M.S., M.I. Haverty, and B.L. Thorne. 1997. The termites (Isoptera: Kalotermitidae, Rhinotermitidae, Termitidae) of the British Virgin Islands: distribution, moisture relations, and cuticular hydrocarbons. *Sociobiology* 30(1): 63-76.

- Thorne, B.L. and M.I. Haverty. 2000. Nest growth and survivorship in three species of Neotropical *Nasutitermes* (Isoptera: Termitidae). *Environmental Entomology*, 29: 256-264.

- Denno, R.F., D.J. Hawthorne, and B.L. Thorne. 2001. Reduced flight capability in British Virgin Island populations of a wing-dimorphic insect: role of habitat isolation, persistence, and structure. *Ecological Entomology* 26: 25-36.

Dr. Ed Weiler's proposed contributions while on Guana:

- assist with termite research
- produce a star map guide for future use by Guana tourists
- offer scientists an evening workshop on identifying stars, planets, and other objects in the BVI sky
- give a talk in the Symposium or at the Junior College on highlights from the Hubble Telescope's discoveries (Ed served for many years as the Chief Scientist for the Hubble Space Telescope) or on Global Climate Change and the prognosis for ocean / sea level rise in the Caribbean and BVI

Bed Night Request and Preferred Dates:

We proposed to stay 7 nights and would strongly prefer a time block during the final third of October

Preferred Room Unit:

If available, we would like to be in Fallen Jerusalem 1; as second choice either of the other FJ rooms; third choice would be Camanoe.

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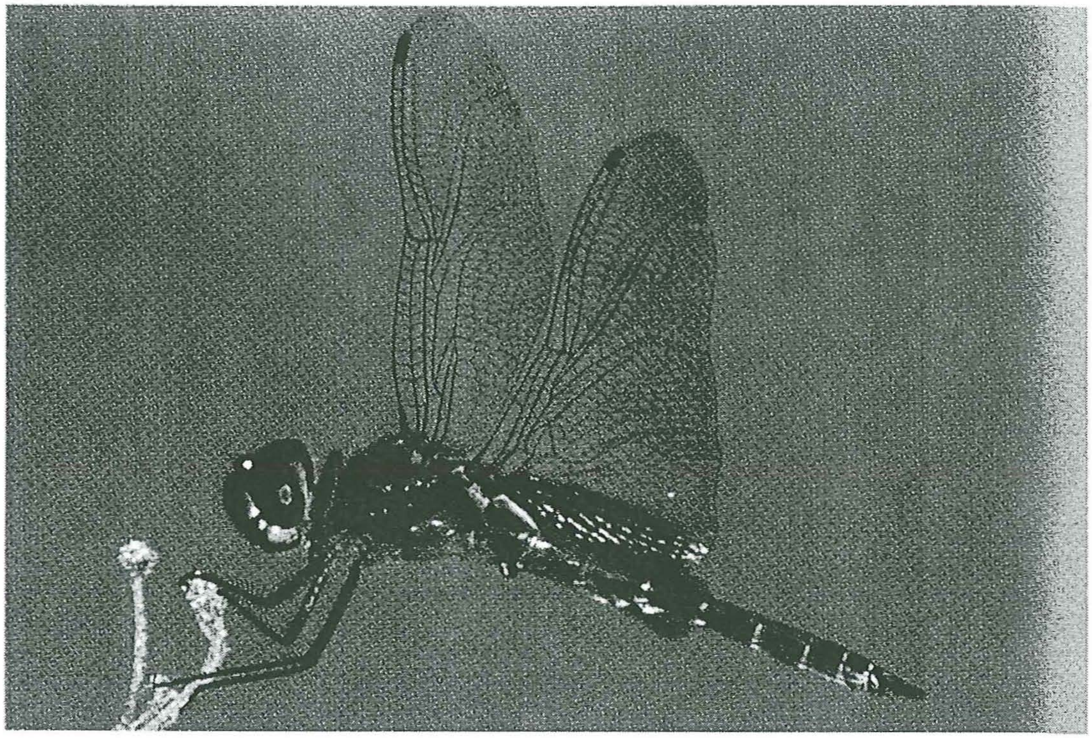

Tramea calverti (Striped Saddlebags)

British Virgin Islands (BVI) Revisited: Colonization of an Island

Fred C. Sibley, The Conservation Agency, 6 Swinburne St., Jamestown, RI 02835; home address, 2325 Co. Rd. 6, Alpine, NY 14805, <fcsibley@empacc.net>

In October of 1997 I collected my first odonate in the BVI, and wrote about the spectacular odonate invasion of the island (ARGIA 11[1]: 16–19). Since then Peggy and I have returned each October, with the exception of 2005. Most of the time has been spent on Guana Island with sporadic visits to the larger islands—Anegada, Tortola and Virgin Gorda. When I asked Nick Donnelly in 1997 if he knew of anyone who had collected in the region, he replied, "Why would anyone go there for odonates?" My list for the islands was ten species with only *Tramea calverti* [English names in appendix] and *Pantala hymenaea* being slightly unexpected. Thus, his comments seemed appropriate, but in hindsight we both failed to appreciate (1) the value of repeat visits to the same area and (2) the opportunity to study colonization on an island with essentially no resident odonates.

In October 2006 we returned to Guana for another "Science Month" and found an island greener than we had ever seen it. The previous year had been as wet as 1997 with flooding of the Flat and, unlike normal years, there had been rain in every month. Although the small study pond of previous visits had been filled in, the higher water table created several tiny ponds in natural depressions. The salt pond, where discharge water from the desalinization plant is stored, had been restructured to drain more effectively to the ocean. That plus the increased rain fall resulted in greatly reduced salinity and a fresh water lens at the far end of the pond. The mangroves edging the pond were now flourishing and expanding after years of barely surviving. But most exciting, this pond, ignored when it more saline, was being exploited by a great number of species and individuals.

Guana Island (named for a rock formation that resembles an iguana head) is a small (ca 800 acres) dry island with minimal (sometimes zero) freshwater sites for odonates. In good years, the suitable sites (1–3) are tiny with late larvae being cannibalized by earlier larvae. Production of adults is close to zero and even the most optimistic projection would only involve four taxa (*Ischnura ramburii*, *Erythrodiplax umbrata*, *Orthemis*, and *Tramea abdominalis*). Periods of very intense rain (10–15 inches) produce large temporary pools on the island, but these usually dry up before even fast developing larvae like *Pantala* can emerge. Thus, all odonates on Guana can be considered immigrants from off island. One removal study (ARGIA 14[1]: 5–7) initially indicated a rather steady rate of immigration, but when a heavy rain storm produced a many fold increase in pond size, the number of immigrants increased dramatically as well. This seemed to indicate the potential for colonization was huge and supported the idea of large numbers of individuals constantly looking for new habitat to invade. Many of the ten species present in 1997 were thought to be from quite distant locations but the subsequent finding of breeding populations on Tortola and Beef Islands (only a few miles away) reduced that subset to *Pantala hymenaea* and *Tramea calverti*. From 1997 through 2004 five species new to BVI list were found on the main island of Tortola, (ARGIA 12[1]: 18–19), but these were probably previously present and not new arrivals. Only one individual of one of these species made it to Guana.

Since 1997 the area has started to receive more rain and 2005 and 2006 were exceptionally wet, not only in amount of rainfall but in 2006, the distribution through the year. The author did not visit the islands in 2005 but other scientist reported large numbers of dragonflies following a storm similar to the 1997 storm. On arrival in 2006, the island was obviously greener than on any previous visit and a quick survey found small freshwater ponds where none had been before. In addition a change in the outflow from the desalinization plant had made the pond attractive to many BVI species to lay eggs.

Of the ten species recorded in 1997 only seven were found in the following years with October species lists ranging from four to six species. One new species was added to the Guana Island list, *Brachymesia herbida*, but *Pantala hymenaea*, *Perithemis domitia,* and *Tramea calverti* were not seen after 1997. *Perithemis* is resident on Tortola but *P. hymenaea* and *T. calverti* were still vagrants to the BVI with one individual each recorded on other islands during that period.

Now 2006: The seven "regular" Guana species listed above were not just present they were all more abundant than on any previous visit and all were paired or egg laying. *Perithemis domitia*, not seen since 1997, was defending territory on two tiny shaded pools. *Tramea onusta*, new to the BVI, was common and egg laying in the salt pond. *T. calverti*, not seen since 1997, was only slightly less common than *T. abdominalis*. *Erythrodiplax berenice*, new to Guana, was holding territories at the salty end of the salt pond and common. *Hemianax ephippiger*, new for the BVI, was an interesting accidental from either Africa or, more likely, from a newly established population in the Caribbean. By the end of 2006, we had two new species for the BVI, three for Guana Island, and more species recorded (14 vs. 11) on Guana Island in one day than in the previous ten visits.

It would not be inconsistent with the findings of our previous removal studies or general knowledge of odonates to find nearby species arriving as soon as new habitat opens up, but the arrival of *Pantala hymenaea*, *Tramea calverti,* and *T. onusta* were unexpected. There has been habitat available on the larger islands but never any previous indication of breeding populations of these three species. In 2006 there were no exceptional storms to push migrating individuals off course and into the BVI, but these species arrived and arrived in numbers. Perhaps the wetter aspect of all the islands in the area caused them to explore further than they might have in drier years.

After the BVI visit a week was spent on Montserrat in the Lesser Antilles with minimal time on odonates, but *Lestes forficula*, *Ischnura capreolus*, *Anax junius*, *Brachymesia herbida*, *Miathyria marcella*, and *Tramea abdominalis* were added to that island list (see Donnelly, ARGIA 18[4]: 13–14). This brought up the question of why the difference in species lists between BVI and Lesser Antilles.

The difference between the American Virgin Islands and BVI lists (see Donnelly, ARGIA 14[1]: 7–9) is somewhat easier to explain. Three species are stream species and we have not found permanent streams in the BVI. Two species, *Anax junius* and *Erythrodiplax justiniana*, are not recorded from the BVI but there are sight records of an *Anax* and an unknown *Erythrodiplax*/*Erythemis*. *Enallagma civile* is then the only missing species that would find suitable habitat in the BVI. Maybe we haven't looked hard enough.

On Montserrat and other Lesser Antillian islands there is suitable habitat for *Pantala hymenaea*, *Tramea calverti* and *T. onusta*, but no records. Are the water gap and/or the uninviting dry islands between BVI and the Lesser Antilles sufficient to stop or seriously impede immigration? This is not a great distance, 100 miles, and it is surprising to find that strong fliers like those mentioned above have not been recorded in the Lesser Antilles. Is this just lack of collecting combined with the sporadic eruption of these three species or a real barrier?

Orthemis, strong fliers and common, are represented by different species in the BVI and Lesser Antilles. There is some barrier preventing the *Orthemis macrostigma* of the Lesser Antilles from establishing in the BVI and the *Orthemis* "Antillean Red" and "Antillean Purple" from establishing in the Lesser Antilles. One can assume the species cross the gap in both directions, but in numbers too small to overcome competition from existing populations. Is a 100 mile water gap the limiting factor in the dispersal of this genus?

Appendix

The appendix lists all BVI species recorded to date and updates information from the earlier notes.

Lestes forficula (Rainpool Spreadwing): Regular although uncommon—community college pond on Tortola and airport ponds on Beef Island. Now absent from the initial discovery site on Tortola due to invasion of water hyacinth. There is a historical record from Anegada but not recorded in any recent visits.

Ischnura ramburii (Rambur's Forktail): Always widespread in BVI but sporadic on Guana. Abundant on Guana in 2006, with many pairs.

Hemianax ephippiger (Vagrant Emperor): (ARGIA, 18[4]: 17) third record for New World—one female. The subsequent report of several individuals on Dominica by François Meurgey and Gaeille Weber (ARGIA 18[4]: 14–16) strengthens the idea the species has recently established in the New World. By that reasoning this would be a colonizer from the Lesser Antilles and not from Africa.

Brachymesia furcata (Red-tailed Pennant): Common on several ponds on Tortola—particularly the Josiah Bay Pond, a new and very large freshwater site produced by damming the ocean end of bay.

Brachymesia herbida (Tawny Pennant): Only once recorded for Guana. Common on Tortola (see *B. furcata*). Recorded from Anegada island starting in 2002.

Erythemis vesiculosa (Great Pondhawk): An uncommon but widespread species on Tortola and sporadically recorded on Guana and Anegada. Several pairs and numerous individuals on freshwater end of Guanasalt pond in 2006.

Erythrodiplax berenice (Seaside Dragonlet): Probably the most abundant species in the BVI and found in all mangrove areas, but not previously present on Guana. In 2005, the salt pond on Guana became less saline and mangroves, formerly barely surviving, have flourished. In 2006 numerous *E. berenice* inhabited the saltier portion of the pond, but were absent from the freshwater end. It seems surprising that all the species coming to Guana detect small amounts of salinity and avoid, or invade, such waters, but are unable to respond appropriately to lethal dump ponds with oily surfaces.

Erythrodiplax umbrata (Band-winged Dragonlet): Always a regular species in BVI and on Guana but present in much greater numbers in 2006 at the freshwater end of the Guana salt pond.

Micrathyria dissocians ("Antillean Dasher"): Not recorded since 2002 when its one pond site on Tortola filled in with water hyacinth.

***Orthemis* "Antillean Red"**: There are red and purple form *Orthemis* in the BVI and they are now thought to be separate species. The red form is found on all the islands and is the only form found on Anegada. It is the dominant (95%) form on Beef Island and mildly brackish areas of Virgin Gorda but absent from high elevation ponds (over 500 feet) on Tortola and Virgin Gorda. Somewhat surprising to find both forms on Guana (ratio of 6 purple to 9 reds) where habitats are all sea level. On Guana there is a decided preference by reds for the freshwater end of salt pond and purples for road puddles.

***Orthemis* "Antillean Purple"**: See above.

Pantala flavescens (Wandering Glider): Fairly common and seen most years on Guana with the expected increases everywhere after heavy rain. More common than the following species in 2006.

Pantala hymenaea (Spot-winged Glider): A few recorded in 2004 on Beef Island for the first BVI record since 1997—perhaps established by then at Josiah Bay Pond. On Guana, in 2006, they were mixed in with feeding groups of *P. flavescens* and *Tramea*.

Perithemis domitia (Slough Amberwing): Fairly common at a number of spots on Tortola. The two individuals recorded on Guana in 1997 were floating half dead in an oily pool and obviously storm waifs. This year the species was found again on Guana, but represented by territorial males at two small, heavily shaded "depression" ponds. Found in ponds that in drier years would not have been present.

Tramea abdominalis (Vermilion Saddlebags): Present on Guana in most years and common on the larger islands. Only slightly more common than *T. calverti* in 2006 and less common than *T. onusta*.

Tramea calverti (Striped Saddlebags): One very worn individual was found on Virgin Gorda in 2004 but otherwise not seen in BVI since 1997. Slightly less common in 2006 than the other species of *Tramea* but all three using the salt pond and feeding in swarms over the grassy field.

Tramea onusta (Red Saddlebags): A new species for the BVI. Nick Donnelly (ARGIA 14[1]: 7–9) recounts the only other record for the Virgin Islands. A 1960s machete kill—don't get Nick mad. The random collecting of *Tramea* on this trip produced six males and a female of this species compared to eight males and a female combined for the other two species. The specimens collected represented a tiny fraction of the Tramea present.

Acknowledgements

Thanks to the Jarecki family, The Falconwood Foundation, and Skip Lazell of The Conservation Agency who in different ways made this trip to the British Virgin Islands possible.

Bugs: Order Hemiptera

Thomas J. Henry

Dear Skip,

I have gone over the material another time and updated our list. So far, we have 89 species, representing 22 families of Heteroptera, or true bugs. This is a combination of what Barry had accumulated (28 spp.) and what Al and I collected last October (61 spp.). Most of the species represent new island records; at least one species of Miridae is new to science. I think this is pretty amazing for such a small island. No doubt, there are still quite a number of bugs to be discovered. I would expect the attached list to go over 100 with additional fieldwork. Al and I plan to give it another try this coming October.

Best wishes,

Tom

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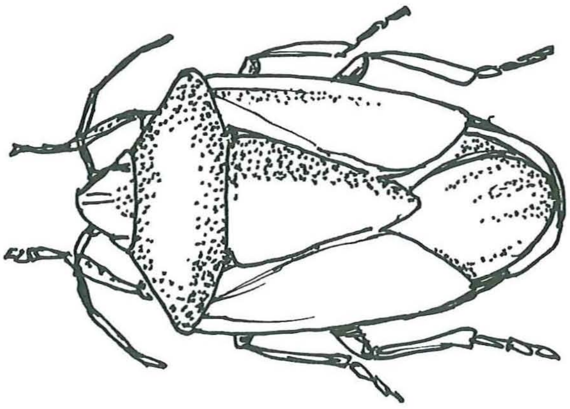

Preliminary List of the Heteroptera Collected on Guana Island 6-13 Oct. 2007
Based on Henry, Wheeler, and [illegible] collections

ENICOCEPHALIDAE:

1. Species 1

ALYDIDAE:

1. *Burtinus luteomarginatus* Maldonado
2. *Esperanza texana* Barber*
3. *Megalonotus pallescens* (Stal)*

ANTHOCORIDAE:

1. Species 1
2. Species 2
3. Species 3
4. Species 4

BLISSIDAE:

1. *Blissus* sp., prob. *antillus* Leonard

COREIDAE:

1. Catorhintha sp.
2. *Chariesterus* sp.
3. *Cebrinis* sp., nr *cauta* Brailovsky
4. *Leptoglossus zonatus* (Dallas)

CORIXIDAE:

1. Species 1

CYDNIDAE:

1. *Amnestus pusio* (Stal)
2. *Corimelaena cognata* (Van Duzee)
3. *Rhytidoporus identatus* Uhler
4. *Tominotus communis* (Uhler)

HEBRIDAE:

LYGAEIDAE:

1. *Kleidocerys virescens* (Champion)
2. *Nysius scutellatus* Dallas
3. *Oncopeltis* (nymphs only)
4. *Xyonysius californicus* (Stal)

MIRIDAE:

1. *Dagbertus* olivaceus (Reuter)
2. *Diphleps* sp., prob. *maldonadoi* Henry
3. *Eustictus brunnipunctatus* Maldonado.
4. *Cyrtocapsus* new species
5. *Engytatus modestus* (Distant)
6. *Macrolophus* sp. 1
7. *Macrolophus* sp. 2
8. *Nesidiocoris tenuis* (Reuter)
9. *Paracarniella puertoricensis* Henry and Ferreira
10. *Phytocoris brunneus* Maldonado
11. *Pseudatomoscelis seriatus* (Reuter)
12. *Pycnoderes* heidemanni
13. *Reuteroscopus hamatus* Kelton
14. *Rhinacloa pallipes* Maldonado
15. Rhinacloa *forticornis* Reuter
16. *Trigonotylus tenuis* Kirkaldy

PENTATOMIDAE:

1. *Edessa* sp.
2. *Euschistus* sp. (shiny brown)
3. *Euschistus* sp. (dull brown)
4. *Mecidea longula*
5. *Mormidea* sp.
6. *Oebalus pugnax* (Fabricius)
7. "*Tepa*" sp.
8. *Banasa herbacea* (Stal)
9. *Bericynthes hastator* (Fabricius)

10. *Brepholoxa barberi* Rider
11. *Caribo fasciatus* Rolston
12. *Chinavia wygodzinskyi* Rolston
13. *Cyptocephala antiguensis* (Westwood)
14. *Euschistus crenator* (Fabricius)
15. *Loxa viridis* (Palisot de Beauvois)
16. *Proxys victor* (Fabricius)
17. *Thyanta testacea* (Dallas)
18. *Vrelsirea violacea* (Fabricius)

NABIDAE:

1. *Nabis capsiformis* (Germar)

NINIDAE:

1. *Cymoninus notabilis* (Distant)

OXYCARENIDAE:

1. *Oxycarenus hyalinipennis* (Costa)

PYRHOCORIDAE:

1. *Dysdercus andreae* (Linnaeus)
2. *Dysdercus* sp. 2

REDUVIIDAE:

1. Emesinae sp. 1 (small)
2. Emesinae sp. 2 (large)
3. phymatid nymph
4. *Zelus longipes* (Linnaeus)

RHOPALIDAE:

1. *Jadera antica* (Walker)
2. *Liorhyssus hyalinus* (Fabricius)
3. *Niesthrea sidae* (Fabricius)
4. *Niesthrea* sp.

RHYPAROCHROMIDAE:

1. *Bubaces uhleri* (Distant)
2. *Paromius dohrni* (Guerin)
3. *Pseudopachybrachius vinctus* (Say)
4. *Neopamera albocincta* (Barber)
5. *Neopamera neotropicalis* (Kirkaldy)
6. *Neopamera* sp.
7. *Ozophora* sp. 1
8. *Ozophora* sp. 2

SALIDAE:

1. Species 1

SCHIZOPTERIDAE:

1. Species 1

SCUTELLERIDAE:

1. *Diolcus* sp. 1
2. *Tetyra antillarum* Kirkaldy

TINGIDAE:

1. *Corythaica carinata* Uhler (slender sp. on *Desmodium* vine)
2. *Corythucha gossypii* (Fabricius)
3. *Leptopharsa* sp. 5 (slender sp. on tree)
4. *Pseudocysta perseae* (Heidemann)
5. *Teleonemia* sp. 1
6. *Teleonemia* sp. 2
7. *Vatiga manihotae* (Drake) (cassava)

Preliminary totals for 2007

Henry and Wheeler collections: 61 spp.
Valentine collections: 28 spp.

Grand total: 89 species, representing 22 families:

SYSTEMATICS

A Revision of *Burtinus* (Hemiptera: Alydidae)

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ABSTRACT The genus *Burtinus* is revised. Its two species, *Burtinus notatipennis* (Stål) and *Burtinus luteomarginatus* Maldonado, may be distinguished by differences in features of the antenna, degree of hind-coxal separation, ovipositor, and genital capsule. *B. notatipennis* is widespread in Central and northern South America (and Trinidad), and it also occurs in the Bahamas, Arizona, Texas, and Florida. *B. luteomarginatus,* hitherto known only from the type locality (Puerto Rico), is found throughout elsewhere in the Greater Antilles (Cuba, Dominican Republic) and in Guana (British Virgin Islands). We give several new country records.

KEY WORDS Hemiptera, Heteroptera, Alydidae, Neotropical, Caribbean

Burtinus Stål is a small Neotropical and neosubtropical genus of the alydid subfamily Alydinae. The genus is related to *Alydus* F., *Tollius* Stål, and *Megalotomus* Fieber; the genital capsules of the males of all four genera bear surcapsular spines, and all four, together with the paleotropical *Euthetus* Dallas, have a stridulitrum on the edge of the forewing's corium, and a hind-femoral plectrum (Schaefer et al. 1989). *Burtinus* was described by Stål 1860 as a genus; Stål (1870) then reduced *Burtinus* to subgeneric rank within *Alydus;* and finally, Stål (1873) restored *Burtinus* to generic rank. Although Distant in 1893 apparently still regarded *Burtinus* as an *Alydus* subgenus, others have treated it as a genus since Stål (1873). The genus can be separated from others in the New World by the key in Schaefer (2004), and see generic discussion below.

The two species in *Burtinus* are *Burtinus notatipennis* (Stål) and *Burtinus luteomarginatus* Maldonado. *Burtinus femoralis,* originally described by Distant (1881) in the *Alydus* subgenus *Megalotomus,* was later removed by him to the *Alydus* subgenus *Burtinus* (Distant 1893); in 1914, *B. femoralis* (Distant) was synonymized with *B. notatipennis* (Barber 1914). Later, Fracker (1918) suggested that *B. femoralis,* "larger and paler than the form which Stal [sic] described," might be considered a variety of *B. notatipennis.*

B. luteomarginatus, as its name suggests, was separated by its describer (Maldonado 1953) from *B. notatipennis* by a narrow pale line along the lateral margins of the thorax and corium, among other characters. Recently, in a collection of alydids from Nicaragua, C.W.S. found some specimens with and some without the pale marginal line, and other specimens with a partial line or one so dark as not to be easily distinguished. We have since discovered that all these specimens are *B. notatipennis,* a discovery that casts doubt on the reliability of the pale marginal line to separate these species. And so, we looked closely at more specimens, from more places.

We now know that *B. luteomarginatus,* originally described from Puerto Rico (Maldonado 1953) and until now known only from there, occurs elsewhere in the Greater Antilles, as well as eastward in Guana (British Virgin Islands) and St. Kitts. *B. notatipennis* is mostly a mainland species, occurring along the southern United States border, throughout Mexico, as far south as Colombia (note Froeschner 1981 does not list this species from Ecuador); and east again into Venezuela and Trinidad. We have two female specimens from Trinidad (both from Curepe, Santa Margarita, Circular Rd., one female collected November 1971; the other female collected July 1971; both in the C. J. Drake Collection, U.S. Natural History Museum, Washington, DC). Both are unequivocally *B. notatipennis.* However, this is not surprising, because Trinidad, a scant 25 km away, is essentially part of the South American mainland.

Herein, the genus *Burtinus* is revised This revision is based on ≈450 specimens.

Descriptions

Genus *Burtinus*

Burtinus Stål 1860 (?1859: although the date "1859" occurs in the journal's title, "1860" appears below with the publisher's name and address. We assume, though others do not, that the date of publication is 1860.): 458-459 (key, orig. descr.).

Burtinus Stål 1870: 214 (redescr., as subgenus of *Alydus*).

Burtinus Stål 1873: 90 (genus, key).

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Table 1. Measurements (millimeters) of *B. notatipennis* (*n* = 1)

	Texas		Florida		Trinidad		Panama		Bahamas	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Body length	12.35	12.22	11.05	11.96	10.21	12.16	11.83	10.79	10.92	11.57
Head width (widest point)	2.36	2.31	2.14	2.36	2.31	2.34	2.26	2.11	2.06	2.28
Head width (before eyes)	1.45	1.44	1.34	1.57	1.45	1.45	1.37	1.32	1.29	1.42
Head length (from ocelli)	1.76	1.73	1.62	1.62	1.62	1.65	1.59	1.52	1.49	1.75
Eye to ocellus	0.30	0.28	0.28	0.28	0.26	0.26	0.23	0.23	0.25	0.30
Interocular width	1.27	1.29	1.19	1.39	1.25	1.32	1.19	1.17	1.16	1.35
Interocellar width	0.38	0.4	0.43	0.50	0.43	0.42	0.28	0.26	0.36	0.33
Pronotum width	3.12	2.85	2.67	3.04	2.78	2.81	Not measured		2.64	2.84
Pronotum length	2.24	2.21	2.54	2.11	1.98	2.22	2.03	1.91	1.94	2.08
Scutellum width	1.19		0.79	1.17	0.99	0.99	Not measured		196	1.06
Scutellum length	1.10	1.37	1.16	1.35	1.2	1.43	1.37	1.16	1.16	1.21
Antennal I	1.58	1.44[a]	1.32	1.32	1.45	1.45	1.57	1.32	1.29	1.27
Antennal II	1.65	1.55	1.37	1.49	1.55	1.49	1.72	1.32	1.32	1.32
Antennal III	1.82	1.65[a]	1.49	1.53	1.52	1.56	1.82	1.55	1.4	1.48
Antennal IV	3.37	2.81[a]	3.04	2.76	2.87	2.81	3.04	2.84	2.9	2.8
Rostral I	1.21	1.12	1.09	1.19	1.19	1.25	1.29	1.25	1.16	1.32
Rostral II	1.45	1.25	1.29	1.39	1.52	1.49	1.42	1.42	1.29	1.45
Rostral III	0.45	0.46	0.48	0.59	0.59	0.56	0.50	0.56	0.50	0.46
Rostral IV	0.99	0.94	0.94	0.99	1.02	0.96	0.99	0.99	0.89	1.09

[a] Another female specimen.

Burtinus Lethierry and Severin 1894: 107 (cat.).
Burtinus Van Duzee 1917: 112 (cat.).
Burtinus Fracker 1918: 265 (systematic and distrib. note).
Burtinus Blatchley 1926: 263 (brief redescript.).
Burtinus Torre Bueno 1941: 82, 84 (key, brief redescript.).
Maldonado Capriles 1953: 40–42 (redescript., relationships).
Burtinus Brailovsky and Flores 1979: 266 (redescript.).
Burtinus Grillo Ravelo 1989: 91 (key to Cuban genera).
Burtinus Schaefer et al. 1989: 506 (genit. capsule, relationships).

Redescription. Based partly on Maldonado 1953 and Schaffner 1964.

Total Length. 9.1–13 mm (Tables 1 and 2). Overall color varying from golden to moderately dark brown.

Head. Slightly declivent, slightly rounded between eyes, wider (including eyes) than long; clypeus slightly longer than paraclypei; margins of head with a few long pale setae. Distance between ocelli greater than distance between an ocellus and the ipsilateral eye; ocellar tubercle angled outwardly. Antennal tubercle small, pale. Antennae paler than head; base of IV even paler, and apical half of IV dark; I and IV slightly clavate and slightly curved (IV more so); IV with more abundant, more slender, and more recumbent setae than I-III; I longer than head; IV>III>II>I. Color of head: brown to dark brown, with pale stripe from tip of clypeus to between eyes or to base of head, this continuing in some specimens onto pronotum; on either side of midline, between eye and antennifer, narrowly oval pale spot, this obscure in pale specimens; another, round, just lateral to each ocellus, this spot too absent in paler specimens; clypeus with a few very small red spots. In darker specimens, a dark band extending from eye to eye and incorporating bases of ocellar tubercles; in paler specimens only lateroposterior part of tubercle dark. Dark line extending from eye, below antennal tubercle, to side of paraclypeus (this line vague in paler specimens). Buccula just reaching level of antenna, broadly oval, tapering posteriorly. Rostrum extending to or just beyond mid coxae; II>I>IV>III; tip dark.

Thorax. Pronotum wider than long, declivent anteriorly, broadening posteriorly; color varying from pale to dark brown, collar region usually darker; sides narrowly carinate, carinae paler than body of pronotum; pronotum punctate, except collar region; punctations small and each with a very small golden supine seta; medial third of lateral margins slightly sinuate; medial third of posterior margin slightly infolded subterminally, often pale; humeral angles rounded (*B. luteomarginatus*) or subacute (*B. notatipennis*), never acute

Table 2. Measurements (millimeters) of *B. luteomarginatus* (*n* = 1) (Puerto Rican specimens are holotype and paratype)

	Puerto Rico		Dominican Republic	
	Male	Female	Male	Female
Body length	9.82	11.05	10.08	10.92
Head width (widest point)	1.95	2.06	2.06	2.1
Head width (before eyes)	1.19	1.25	1.27	1.25
Head length (from ocelli)	1.50	1.45	1.35	1.45
Eye to ocellus	0.43	0.63	0.23	0.26
Interocular width	1.12	1.2	1.16	1.16
Interocellar width	0.30	0.30	0.33	0.31
Pronotum width	2.31	2.48	2.36	2.43
Pronotum length	1.65	1.88	1.91	1.77
Scutellum width	1.12[a]	1.12[a]	0.87	1.07
Scutellum length	1.28[a]	1.29[a]	1.09	1.2
Antennal I	1.16	1.17	1.35	1.22
Antennal II	1.37	1.39	1.60[b]	1.40
Antennal III	1.45	1.49	1.49	1.53
Antennal IV	2.36	2.28	2.71	2.34
Rostral I	1.09	1.25	1.02	1.19
Rostral II	1.24	1.29	1.22	1.29
Rostral III	0.50	0.50	0.40	0.48
Rostral IV	0.83	0.86	0.89	0.94

[a] Estimated; partly destroyed by pin.
[b] Antennal II on other side, 1.52 mm.

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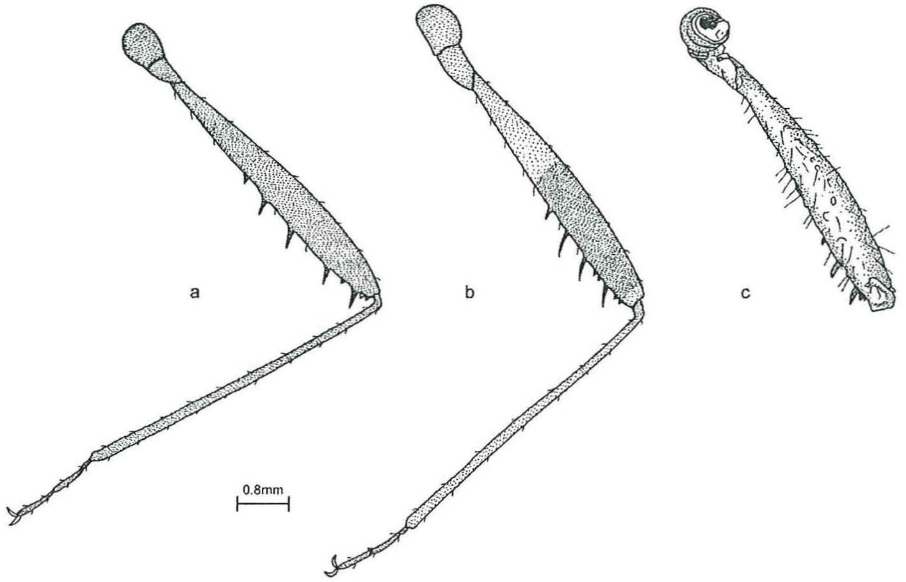

Fig. 1. (a and b) Hind femora, *B. notatipennis.* (c) Hind femur, *B. luteomarginatus* (holotype).

or pointed; collar narrow, sharply defined; anterior calli not prominent, about one-fourth length of pronotum, elevated for middle two-thirds of width, rough, impunctate, often darker than remainder of pronotum. Scutellum longer than wide, usually with larger punctations than on pronotum and with very long posteriorly directed setae (fewer punctations and setae in some specimens); tip rounded, pale, slightly raised. Wings extending slightly beyond tip of abdomen. Corium same color as pronotum, with small, irregular, pale or reddish spot at base of posteriormost cell; punctate, with lines of punctations outlining veins; corium curving slightly inward one-half distance along length; tip of corium prolonged about three-fourths of wing's length; stridulitrum extending about two-thirds length of corium; membrane dusky to fuscous (dark against darker abdomen). Hind wings dark to fuscous. Thoracic pleura and sterna lighter than dorsum, metapleuron sometimes darker dorsally; pleura and sterna with small darker pits, each with a small recumbent seta; sometimes with some small reddish spots; mesosternum of darker specimens sometimes dark brown. Metathoracic scent gland auricle raised, broadly S-shaped; evaporative area anterior to opening, small, raised. Legs pale, except femora (especially hind femora) dark or mottled with dark. Tibiae and femora straight, tibiae terete and without terminal spine. Hind femur somewhat incrassate (both sexes), with three (*B. luteomarginatus*—except two in holotype) or four (*B. notatipennis*) stout, dark subterminal spines, and sometimes with several smaller spines, these (if present) usually between the last (apicalmost) two large spines; with (darker specimens) or without pale spots or band subterminally (Fig. 1a–c). Fore coxae close together, mid coxae wider apart, hind coxae wide apart (*B. luteomarginatus*) or close together (*B. notatipennis*). Tip of tibia, third tarsal segment, and claws dark in darker specimens. Tarsal segments I>II+III, III>II.

Abdomen. Dorsum and venter same color as pronotum, or paler; dorsum and venter often with small reddish spots (as on thorax). Connexival segments 3–6 usually dark posteriorly, in darker specimens this dark coloration extending slightly medially, on to edge of terga 3–6; on paler specimens connexival dark coloration restricted to posterolateral corners. Sterna 3–4 with a sublateral, and sterna 5–7 with a submedial, dark spot; on sterna 5–6 this spot sometimes bears a trichobothrium, but not always. Trichobothrial bases sometimes dark. Venter impunctate, but setose (more setose laterally). Genital segments same color as venter. Male genitalia: Figs. 2 and 3; and discussion below. Measurements: Tables 1, 2, and 4.

Discussion. *Burtinus* possession of a corial stridulitrum and a hind-femoral plectrum groups the genus with *Alydus, Tollius, Megalotomus,* and *Euthetus* (Schaefer and Pupedis 1981). Of these genera, the last is an Old World (Ethiopian, Oriental) genus; the others are New World. However, only *Burtinus* is tropical (*Tollius* is southern Nearctic, and the other two are Holarctic). The possession by the four New World genera of surcapsular spines on the genital capsule (which *Euthetus* lacks), groups them further as a monophyletic clade (the *Alydus*-group), as do a similar shape of the paramere and some features of the aedeagus (Schaefer et al. 1989). Within the *Alydus*-group, *Burtinus* seems close to *Megalotomus* and perhaps *Tollius,* in their possession of possibly homologous extensions of the genital capsule's cuplike sclerite (Schaefer et al. 1989). *Burtinus* also is linked to these genera (and to *Tollius*) by the extensions or protrusions on the paramere (Figs. 2c and d, and 3b), although these are small (and extension a may be absent) in *B. luteomarginatus*). The *Alydus*-group itself is largely a temperate group, its southernmost member, *Burtinus,* venturing no further south than northern South America.

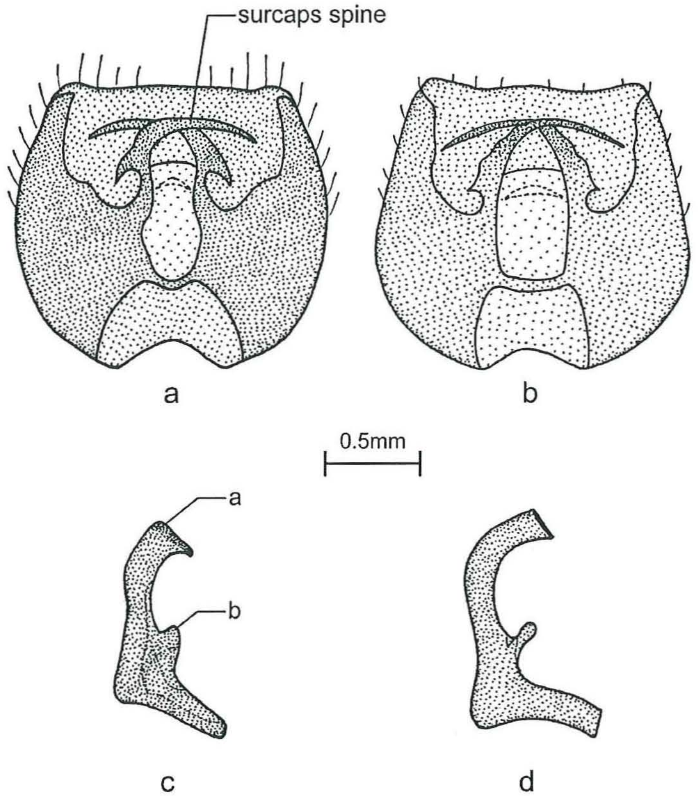

Fig. 2. *B. notatipennis.* (a and b) Genital capsules, dorsal views, cuplike sclerite extension (c.s. ext.), cuplike sclerite fused with median projection (c.s.+m.p.), surcapsular spine (surcaps spine). (c and d) Left parameres, subapical protrusion (a), inner medial protrusion (b). (a and c) Specimen from Tamaulipas, México. (b and d) Specimen from Colima, México.

Burtinus differs from *Tollius* in having a well-developed metathoracic scent gland apparatus (a plesiomorphy), and from *Alydus* and *Megalotomus* in the distance between the ocellar tubercles relative to that from a tubercle to an eye; in *Burtinus*, the intertubercular distance is greater than or equal to that from eye

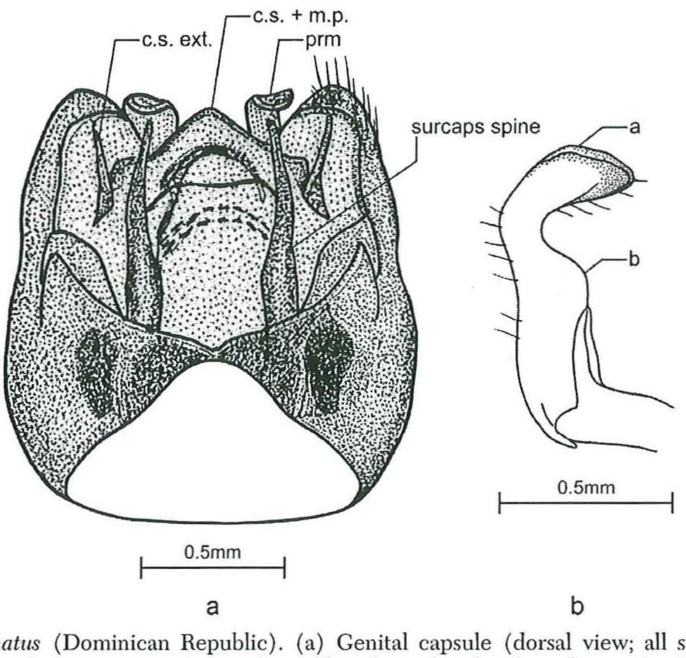

Fig. 3. *B. luteomarginatus* (Dominican Republic). (a) Genital capsule (dorsal view; all structures removed except surcapsular spine), cuplike sclerite extension (c.s. ext.), cuplike sclerite fused with median projection (c.s.+m.p.), surcapsular spine (surcaps spine). (b) Left paramere, subapical protrusion (a), inner medial protrusion (b).

to tubercle; and in *Alydus* and *Megalotomus*, the intertubercular distance is less.

The tip of the *Burtinus* scutellum is pale, slightly raised, and rounded not pointed. These conditions occur almost universally in the other alydine genera, to a greater (e.g., *Neomegalotomus*) or lesser (e.g., *Apidaurus*) degree (C.W.S., unpublished).

In overall color, shape, and size, *Burtinus* resembles *Neomegalotomus*, another Neotropical alydine, whose range encompasses that of *Burtinus* (C.W.S. and I.A., unpublished). However, the humeral angles of *Burtinus* are rounded or subacute (the usual condition in Alydinae; C.W.S., unpublished), whereas those of *Neomegalotomus* bear a short spine; also, *Burtinus* has, and *Neomegalotomus* lacks, the surcapsular spines of the genital capsule and the corial stridulitrum and hind femoral plectrum (Schaefer 2004).

Nothing is known of the biology of these insects, except that Maes and Göllner-Scheiding (1993) list *B. notatipennis* as feeding on *Cajanus* (Leguminosae) and *Citrus* and *Coffea* (Rubiaceae). Other members of the subfamily Alydinae prefer Leguminosae (Schaefer 1980, Schaefer and Mitchell 1983), and it is probable that so do both *Burtinus* species.

B. notatipennis exists as a mainland ring (southern border United States, Central America, and northern South America) around the Greater Antillean *B. luteomarginatus.* We have examined several thousand specimens of Alydinae from the New World, and we have found no *Burtinus* from the Lesser Antilles, except for a single specimen (*B. luteomarginatus*) from St. Kitts, and a series from Guana (although Guana, British Virgin Islands, is close enough to Puerto Rico to be considered Greater Antillean.). We also have series of *B. notatipennis* from the Bahamas and Trinidad; the former is very close to Florida, and the latter is essentially part of Venezuela. We suggest that *B. luteomarginatus* may be found on Jamaica, and it should be sought between Guana and St. Kitts. We also wonder if *B. notatipennis* might be collected between Florida and Texas; if not, perhaps these populations originated from the Bahamas and Mexico, respectively.

Burtinus notatipennis (Stål)

Alydus notatipennis Stål 1860 (?1859: see note on date in References): 459 (orig. descr.).

Alydus (*Burtinus*) *notatipennis* Stål 1870: 214 (cat.).

Alydus notatipennis Distant 1893: 373 (notes resemblance to *A. femoralis*; Mexico, Colombia).

Alydus (*Burtinus*) *notatipennis* Barber 1914: 521 (reaffirms syn. of *A.* (*B.*) *femoralis* Distant with *A.* (*B.*) *notatipennis* Stål; Florida).

Alydus (*Megalotomus*) *femoralis* Distant 1881: 158, plate 15, fig. 9 (orig. descr.).

Alydus femoralis Distant 1893: 373 (transferred to subgenus *Burtinus*).

Burtinus femoralis Lethierry and Severin 1894: 107 (cat.).

Alydus (*Burtinus*) *femoralis* Barber 1910: 37 (syn.; Arizona).

Burtinus femoralis Fracker 1918: 265 (perhaps variety of *B. notatipennis*).

Burtinus femoralis Maes and Göllner-Scheiding 1993: 13 (distrib. México, Guatemala, Nicaragua, Panama); *Burtinus notatipennis* Lethierry and Severin 1894: 107 (cat.).

Burtinus notatipennis Van Duzee 1916: 14 (checklist).

Burtinus notatipennis Van Duzee 1917: 112 (cat.).

Burtinus notatipennis Fracker 1918: 265 (redescr., distrib.).

Burtinus notatipennis Torre Bueno 1941: 84–85 (redescr.).

Burtinus notatipennis Maldonado Capriles 1953: 41, 43 (male genitalia).

Burtinus notatipennis Barber 1954: two (distrib.: collected on S. Bimini Isl., Bahamas)

Burtinus notatipennis Brailovsky and Flores 1979: 266–268 (redescript.; illustr. dorsal view whole bug, and metathoracic scent gland; occurrence in United States, México, Guatemala, Colombia; note: Froeschner 1999 cites Brailovsky and Flores as recording this species from Panama, but they do not).

Burtinus notatipennis Froeschner 1988: seven (distrib. Texas); *Burtinus notatipennis* Schaefer et al. 1989: 502, 504, 505 (fig. and descr. paramere, genital capsule).

Burtinus notatipennis Grillo Ravelo 1989: 90 (misident. =*B. luteomarginatus.*

Burtinus notatipennis Maes and Göllner-Scheiding 1993: 13 (distrib. México, Honduras, Nicaragua, Costa Rica, Colombia; food plants).

Redescription. *Total length* 9.45–13.37 mm (Table 1). *Head:* as genus; antennal segment I as slender as II and III, becoming clavate about two-thirds along segment; segments II and II sometimes darkened apically. *Thorax:* concolorous with head, lateral and posterior margins of pronotum not pale; callar region and corium concolorous with rest of pronotum, with small, irregular, pale or reddish spot at base of posteriormost cell. Scutellum slightly darker. Humeral angles subacute. Margin of corium sometimes narrowly pale. Propleura same color as pronotum; prosternum darker; mesopleuron, mesosternum, metapleuron concolorous, metasternum darker; posterior margin of metasternum pale. Hind femur with four large spines, the three apicalmost evenly spaced, distal one a little further removed (Fig. 1a); a few specimens with additional smaller femoral spines (Fig. 1b). Mid coxae further apart than hind coxae; hind coxae separated by a distance less than the width of a coxa. *Abdomen:* sterna dark, heavily spotted. Male genitalia: Fig. 2. Measurements: Table 1.

Distribution. *B. notatipennis* occurs from the southern border of the United States throughout México and into northern South America (Colombia, Venezuela, and Trinidad), as well as the Bahamas (including Grand Bahama Island). The United States localities are all far south (Florida: Dade and Monroe counties; Texas: Cameron and Brewster counties; Arizona: Cochise County; Barber 1910).

Distant (1881) described *Alydus* (*Megalotomus*) *femoralis* from Guatemala, and, in 1893, he transferred it to the then subgenus *Burtinus,* as *Alydus* (*Burtinus*) *femoralis.* In his original description (Distant 1881), he suggested the species is related to *Megalotomus pallescens* Stål, a species that he later (Distant 1901) synonymized with *Megalotomus rufipes* (Westwood). These species of *Megalotomus* are now in *Neomegalotomus* (Schaffner and Schaefer 1998), a genus not closely related to *Burtinus* (see above).

In 1910, Barber suggested strongly that *Alydus* (*Burtinus*) *femoralis* Distant is the same as *Burtinus notatipennis* (Stål) (Barber 1910); and, in 1914, Barber formally synonymized *Alydus* (*Burtinus*) *femoralis* Distant with *Alydus* (*Burtinus*) *notatipennis* Stål (Barber 1914). Distant (1893) had already noted that Stål's description of *Alydus notatipennis* "resembles that of my *A. femoralis.*"

Burtinus luteomarginatus Maldonado Capriles

Burtinus luteomarginatus Maldonado Capriles 1953: 40–41 (orig. descr., male genitalia, dorsal view).
Burtinus notatipennis Grillo Ravelo 1989: 90–91 [misidentified] (Cuba).

Redescription. Based in part on male holotype and female allotype; note: parts of the original description of Maldonado (1953) of this species apply also to *B. notatipennis.*

Total Length. 9.1–11.5 mm (Table 2). *Head:* as genus; antennal segment I slightly thicker than I and III, becoming clavate at about midsegment; segments II and III rarely darkened apically. *Thorax:* brown to dark brown, lateral and posterior margins of pronotum narrowly pale; callar region dark. Scutellum and corium about same color as pronotum (sometimes slightly darker or paler), with small, irregular, pale spot at base of posteriormost cell. Humeral angles rounded. Margin of corium narrowly pale. Prosternum and propleuron concolorous brown; meso- and metasterna darker brown, and darker than their pleura; posterior margin of metasternum pale. Hind femur with three large spines (two in holotype [Fig. 1c] and a few other specimens). Mid coxae closer together than hind coxae; hind coxae separated by a distance at least equal to width of a coxa. *Abdomen:* Sterna dark, heavily spotted. Male genitalia: Fig. 3. Measurements: Table 2.

Distribution. *B. luteomarginatus* occurs in the Greater Antilles, St. Kitts, and Guana (British Virgin Islands). Although we have other alydines from Jamaica and Haiti, we have no specimens of *Burtinus* from these places.

We have a single immature, a pinned second instar of *B. luteomarginatus* (from Guana Island, British Virgin Islands). The specimen is too shriveled for a good description, but a few features can be noted: Body appearing dark, but actually mottled yellow and dark brown; some irregular red spotting on head and pronotum. Pronotal margin with narrow pale line. Cuticle overlying dorsal abdominal scent glands (at tergal borders 3–4, 4–5, and 5–6) very large, conspicuous, smooth, dorsal half ivory white, ventral half chestnut brown. Antennae flattened; IV>III=II>I; I and basal two-thirds of II-IV pale, apical third dark brown. Rostrum reaching midabdomen; II>I>IV>III; I pale, II-IV dark brown. Legs: hind femur flattened; all femora brown, hind femur with pale band; all tibiae pale,

Table 3. Development of pale marginal line of pronotum and corium in *Burtinus*

	Development of marginal line		
	With both lines	With one or the other line	With none
B. notatipennis			
Texas	45	1	0
Arizona	1	0	0
Florida	4	6	12
Mxico: Baja California	0	6	0
Sonora	0	2	0
Sinaloa	11	0	0
Nayarit	9	0	0
Jalisco	4	8	0
San Luis Potosi	5	0	0
Tamaulipas	2	0	0
Vera Cruz	0	11	0
Moráles	1	0	8
Tabasco	0	2	0
Chiápas	0	16	0
Yucatan	0	0	2
Guatemala	0	8	0
Honduras	1	0	0
Nicaragua	15	16	0
Salvador	0	0	2
Panama	3	0	7
Colombia	4	0	1
Venezuela	1	0	0
Bahamas	13	0	0
Trinidad	2	0	0
B. luteomarginatus			
St. Kitts	1	0	0
Puerto Rico (types)	2	0	0
Dominican Republic	10	0	0
British Virgin Islands	(Guana)	33	0
Cuba	32	0	0

Table 4. Range of body lengths (millimeters), by locality, of *B. notatipennis* and *B. luteomarginatus* (number in parentheses is number of specimens available)

Locality	Body length
B. notatipennis	
Arizona (1)	11.15
Texas (7)	10.92–13.37
Florida (27)	9.88–12.29
Mexico (103)	9.49–12.61
Guatemala (8)	10.79–11.70
Honduras (1)	11.31
Salvador (2)	10.05–11.70
Nicaragua (32)	10.92–12.61
Costa Rica (8)	10.01–12.22
Panama (8)	10.79–11.73
Colombia (4)	10.08–11.31
Venezuela (1)	10.79
Trinidad (2)	10.21–11.7
B. luteomarginatus	
Cuba (34)	10.01–12.09
Dominican Republic (10)	9.56–11.05
Puerto Rico (types)	9.1–11.5
British Virgin Islands (34)	9.10–11.31

Table 5. Differences between *B. notatipennis* and *B. luteomarginatus* (other differences in text)

	B. notatipennis	*B. luteomarginatus*
Antennal segments I and II	I=II, uniformly colored	I<II, dark apically
Antennal segment I	Slightly stocky, gradually clavate	Slender, less gradually clavate
Hind-femoral spines	3–4 (see text)	4–5 (see text)
Surcapsular spines	Crossed	Straight

darkened apically; first tarsal segment pale, second dark. Note: The alternation of dark and light on the appendages is conspicuous, and perhaps distracts predators. In addition, of course, this instar resembles an ant (like the instars of all alydines, as far as is known).

The Two Species may be Separated with the Following Key.

1. Antennal segment I equal in length to II, both unicolorous; distance between hind coxae less than width of a coxa. . . . . *B. notatipennis*
   Antennal segment I shorter than II, both dark apically; distance between hind coxae as great as or greater than width of a coxa . . . . *B. luteomarginatus*

Discussion. The two species, *B. notatipennis* and *B. luteomarginatus,* resemble each other closely in shape, color, patterning and markings, and surface texture; and in these features they also resemble many species in other genera of Alydinae, particularly the many light to dark brown moderate-sized alydines. Both species have a pale midcephalic (ecdysial) line and several pale cephalic spots; the first continues onto the pronotum in all *B. notatipennis,* but the latter occurs only on pale specimens. Antennal segments II and III in *B. notatipennis* are uniformly brown or light brown (rarely, luteous), and only rarely are they darkened apically (and then only slightly). These antennal segments in *B. luteomarginatus* are luteous or light brown (dark brown in Dominican Republic), and darkened apically. Each species has a small irregularly shaped spot at the base of the posteriormost corial cell; this spot is pale in *B. luteomarginatus* and either pale or reddish in *B. notatipennis.*

The feature thought best (Maldonado 1953) to separate the two species, and for which *B. luteomarginatus* is named, is constant in that species, but it varies in *B. notatipennis.* The pronotal margin and the edge of the corium of *B. luteomarginatus* are pale, as a narrow off-white line that extends about three-fourths of the length of the corium. This line on pronotum and corium occurs also in many *B. notatipennis,* but in some only the pronotal line is present, in others only the corial line, and in still others there are no lines at all (Table 3). All our Cuban specimens are clearly *B. luteomarginatus,* both morphologically and with the pale line (Table 3); yet, Grillo (1989) identified his Cuban specimens as *B. notatipennis.* We do not know why.

On average, *B. luteomarginatus* is smaller than *B. notatipennis* (Tables 1 and 2), but far more specimens overlap in size than lie at the extremes. *B. luteomarginatus* ranges in length from 9.1 to 11.57 mm, and *B. notatipennis* from 9.49 to 13.37 mm (Table 4). The largest specimen (perhaps not surprisingly) is from Texas: 13.7 mm. long; and the smallest (9.1 mm.) is from Guana (British Virgin Islands) (Table 4). Of more importance than these ranges, is the large amount of overlap within and between the two species.

Morphological differences are less ambiguous (Table 5). The first antennal segment of *B. notatipennis* is as slender as segments II and III, and it becomes slightly clavate beginning about two-thirds from the apex. Antennal segment I is slightly more stocky than II and III in *B. luteomarginatus,* and it becomes slightly clavate from midsegment (the clavate condition is therefore more noticeable, because less gradual).

Table 6. Some characteristics of surcapsular spines of *B. notatipennis* (spine curved inward at a right angle) (more details in text). Note: one specimen from each location, except Florida and Grand Bahama Island (2 specimens)

Location	Flange	Lateral spine	Tip	Distal portion
USA: Florida	Small, serrate	Narrow, sharp	Sharp, not bifid	Gently curved
USA: Texas	Small, pointed (incorporating lateral spine?), serrate	0 (see Flange)	Sharp, not bifid	Gently curved
Mexico: Morelos	Moderate-sized, not serrate	Low, blunt	Sharp, not bifid	Gently curved
Mexico: Yucatan	Low, elongate, extending near lateral spine, serrate	Small	Sharp, not bifid	Gently curved
Costa Rica	Small, distal	Moderate, sharp	Sharp, not bifid	Gently curved
Panama	Small, pointed (incorporating lateral spine)?, few serrations	0 (see Flange)	Rounded, very slightly bifid	Gently curved
Colombia	Very small, a few small blunt teeth, no serrations	Short, toothlike	Rounded, bifid	Gently curved
Grand Bahama Islands	Small, toothed	Narrow, sharp (like Florida)	Sharp, not bifid	Gently curved
Bahamas (San Salvador, Andros Island)	Small, broad, no serrations	Narrow, sharp (like Florida)	Rounded, bifid	Double-curved (broadly S-shape)
Venezuela	Small (incorporating lateral spine?)	0	Rounded, not bifid	Gently sinuate

Table 7. Some characteristics of surcapsular spines of *B. luteomarginatus* (spine straight) (more details in text)

Location	Tip reaching	Shape	Serrate? Toothed?	Tip bifid?
Cuba	Posterior edge genital capsule	Slender, tapering evenly	No	No
Dominican Republic	Slightly beyond posterior edge genital capsule	Slender, tapering evenly	No	No
British Virgin Islands (Guana)	Posterior edge genital capsule	Slender, tapering evenly	No	No

The metathoracic scent gland auricles of both species are S-shaped (as they are in several other alydines). However, that of *B. luteomarginatus* is broadly smooth, whereas in that of *B. notatipennis* the anterior and posterior parts are raised and knoblike (Brailovsky and Flores 1979: fig. 23).

The hind femora of *B. luteomarginatus* have either two or three large spines and a single small spine (and several small blunt teeth) near the apex (Fig. 1c). Those of *B. notatipennis* have three or four large spines and one or two small spines (and several small blunt teeth) (Fig. 1a and b). The small (fourth) spine in *B notatipennis* is near midfemur; there is no comparable spine in *B. luteomarginatus*. These arrays are the same in both sexes of each species.

The distance between the hind coxae in *B. luteomarginatus* is at least equal to the width of a coxa, whereas in *B. notatipennis* the hind coxae are closer together. Also, the hind coxae of *B. luteomarginatus* are wider apart than are the mid coxae; in *B. notatipennis*, the mid coxae are farther apart than are the hind coxae. It should be noted that this is often a genus-level character in Alydinae (Schaffner 1964).

The number of stridulatory teeth (per 0.11 mm of stridulitrum) does not differ between the two species, as it does between species, and genera, in other alydines (Schaefer and Pupedis 1981). Mexican *B. notatipennis* have 5 or 5.5 teeth/0.11 mm (n = 5); Nicaraguan *B. notatipennis* have 5 or 5.5 (n = 2); Florida *B. notatipennis* are more variable: 4.5, 5.5, and 6 teeth (n = 3); Bahamas *B. notatipennis* have 5.5 or 6 teeth/0.11 mm (n = 2). The *B. luteomarginatus* holotype (male) and paratype (female) have 6 and 6.5 teeth/0.11 mm, respectively; and a female from St. Kitts has 5.5. In neither species did we find a difference in the sexes.

The parameres of the two species differ (Figs. 2c and d, and 3b). The projections ("a" and "b") that are fairly prominent on the *B. notatipennis* paramere (Fig. 2c and d) are much less so in *B. luteomarginatus* (Fig. 3b).

Finally, an important difference between the two species is in the surcapsular spines (Tables 6 and 7) of the male's genital capsule. *Burtinus* is one of four genera, all New World, with these spines (see above) (Schaefer et al. 1989), which arise from the dorsal rim of the genital capsule, near where this rim joins the lateral rim (Schaefer et al. 1989). In *B. notatipennis*, the two surcapsular spines curve medially, and spine one crosses over the other (Fig. 2a and b; Schaefer et al. 1989: fig. 3c); in *B. luteomarginatus* each extends directly posteriorly, usually to the posterior edge of the capsule (Fig. 3a; Table 7). This difference between the two species is striking and easily seen even on dried pinned specimens. Unfortunately, the function of these spines is unknown.

Variation in Surcapsular Spines of *Burtinus*. The spine in *B. notatipennis* itself may be more or less serrate, usually on the spine's outer (lateral) edge just posterior to the lateral spine (see below), but sometimes only near the tip (Panama) and sometimes on the medial surface as well (Venezuela, well serrated; Yucatan, very lightly serrated; Table 6). The outer edge of the surcapsular spine is usually expanded along its middle as a flange, which is often further extended laterally as a lateral spine; in a few specimens there is no spine (Table 6). The distal part of the spine is nearly always gently curved, but in one specimen (Venezuela) it is slightly sinuate, and S-shaped in two specimens from the Bahamas (Table 6). In a few specimens, the tip of the spine is bifid (Table 6). The variations in this spine do not seem to be correlated with distribution.

The surcapsular spines of our *B. luteomarginatus* specimens did not vary (we had only three male specimens, one each from three localities). Those of a specimen from the Dominican Republic extend somewhat farther posteriorly than do those of the other specimens (Table 7).

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Light-edged Big Head Bug, *Burtinus luteomarginatus*
Photo by Dr. Thomas Henry