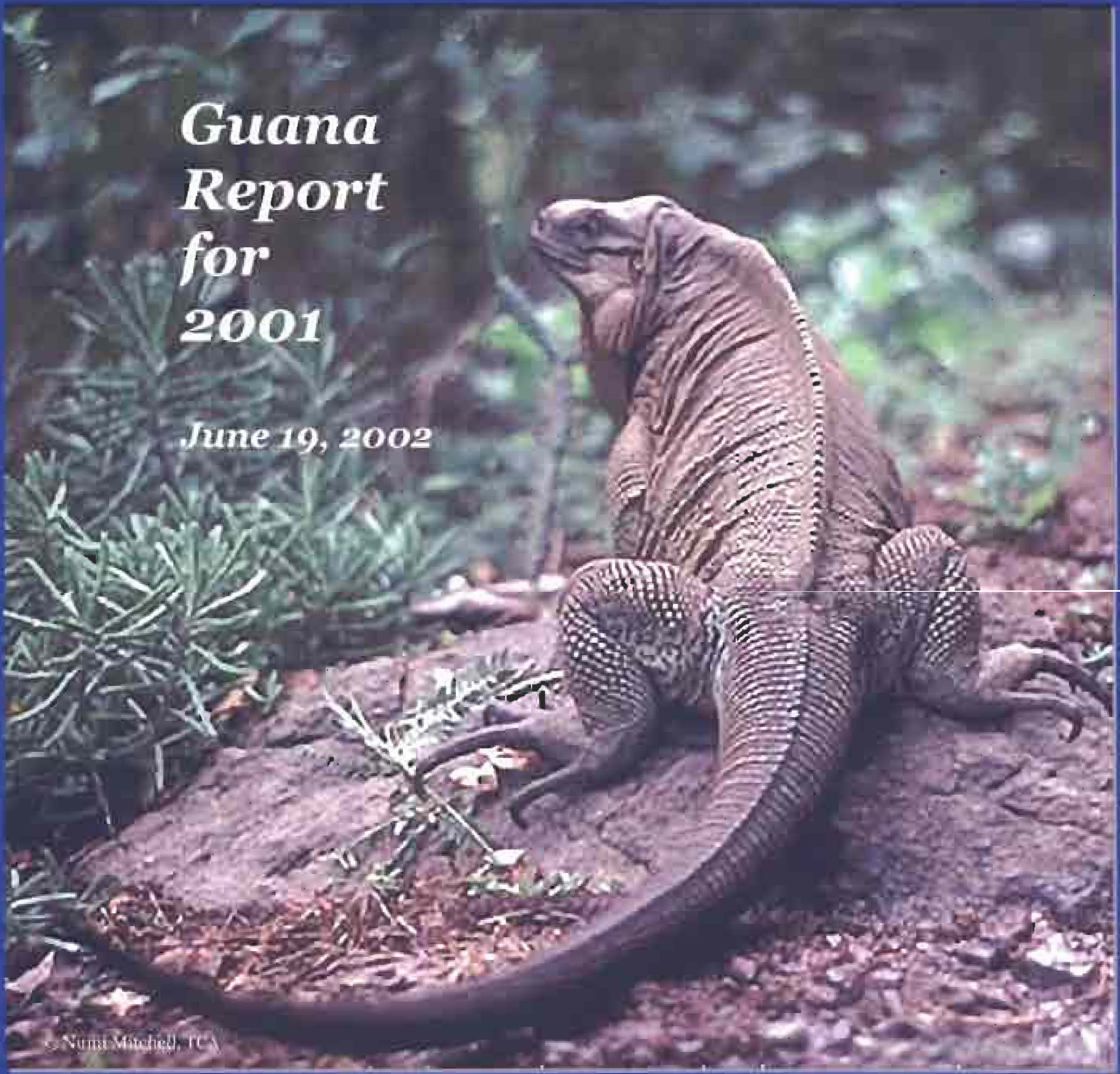
Guana Report for 2001

June 19, 2002



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The Conservation Agency

Exploration, Education, and Research

President
James D. Lazell, Ph.D.
401-423-2652

6 Swinburne Street
Conanicut Island
R.I. 02835 U.S.A.

19 June 2002

Dear Henry,

The report for 2001 is late and a little informal. A lot of material that usually goes into my annual report has gone straight into the book. For example, Kris Ovaska wrote a dozen-page summary of her five seasons of frog data -- all but a brief summary in the book. And, if I sent this ff to be typed you would get it in 2003! I have three people typing for me and they are buried. Here is what is included:

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Insects (con't):

Reptiles:

Reptiles (con't):

Birds:

Miscellaneous correspondence:

All the best,

Skip

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Basidiomycetes of the Greater Antilles Project

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During the four-year project on the Basidiomycetes of the Greater Antilles, approximately 20% of the taxa were found to be undescribed species or varieties, and some may represent new genera, families or orders.

KEYWORDS: Agaricales, polypores, Aphyllophorales, West Indies

The investigation of the basidiomycetes of the Greater Antilles was a four-year project initiated in 1996 with a grant from the USA National Science Foundation's (NSF) Biotic Surveys and Inventories Programme to the State University of New York at Cortland (grant DEB-95-25902). Many other institutions and non-governmental organisations provided matching funds and support which greatly facilitated the research, including the USDA Forest Service, the Royal Botanic Gardens at Kew, Geobotanical Institute ETH, University of Oslo, University of Goteborg, and Duke University. The objective of the project was to survey and inventory all basidiomycetes (except rust fungi) on the Greater Antillean islands of the Caribbean. In addition to the authors, our primary research group included Drs. Julieta Carranza, Karen Nakasone, Karl-Henrik Larsson, Roy Halling, Egon Horak, Orson K. Miller, Jr., Peter Roberts, Leif Ryvarden, and Rytas Vilgalys.

The habitats sampled included coastal sand dune communities, low elevation seasonally dry and moist forests, middle elevation non-seasonal wet forests (200-550 m above sea level), and rain and cloud forests at around 700 to 2,000 m a.s.l. In addition, repeated visits were made to the Dominican Republic to collect basidiomycetes in the native pine savannahs, which range from 550 to 3,000 m a.s.l. Most of the collecting was concentrated in Puerto Rico, the Dominican Republic, Guana and Tortola islands in the British Virgin Islands, and St. John in the US Virgin Islands. There was one expedition to Jamaica.

Basidiomycetes, except for durable *Lentinus* species and polypore fungi, were not well known in the Greater Antilles before this project began. Many botanists have collected hard polypores throughout the history of the Caribbean since it was colonised five centuries ago. The basidiomes of polypores have retained their characteristics sufficiently for later identification. Relatively few of the agarics and other ephemeral fungi had previously been recorded for the region. For example, Stevenson (1975) had summarised all of the previous records of fungi from Puerto Rico and the nearby Virgin Islands, but only listed 55 species of ephemeral basidiomycetes. Jamaica and Cuba were still poorly known despite receiving somewhat more attention than Puerto Rico from R. W. G. Dennis, W. A. Murrill and O. P. Swartz.

Numbers of new species and varieties

We have identified at least 75 new species and varieties so far, and this number will undoubtedly increase when all of the collections have been identified. In our research proposal, we predicted that the percentage of new species in each group would remain the same as the rate of discovery in the previous 5-15 years. Our expected percentages of new species for Agaricales (21%), polypores (6%), corticioid fungi (10%) and gasteromycetes (12%) are very close to our observed values so far (21%, 4%, 12%, and 12%, respectively; Lodge *et al.*, in press). Many of the new corticioid species are cryptic species that belong to a complex of similar taxa (Nakasone, 1999). All but one of the new polypore species are ephemeral, and were therefore easily missed by previous collectors (Ryvarden 2000a,b,c, 2001). For example, we recently found an ephemeral, orange, widely effused polypore on pine logs in the Dominican Republic that is a previously unknown species of *Antrodia* (Fig 1). The deep orange pores of this species are 1-4 mm wide and sinuous, differing from those of *A. radiculosa* (Peck) Gilbn. & Ryvarden which are subround and 3-4 per mm (Lodge & Ryvarden, unpublished manuscript).

The highest diversity and percentages of undescribed species are among the agaric fungi, especially in the families Amanitaceae (Miller *et al.*, 2000; Miller & Lodge, in press), Tricholomataceae, Entolomataceae (Baroni & Lodge, 1998) and Hygrophoraceae (Cantrell & Lodge, 2000, 2001). One of the more intriguing finds is a new species of *Callistodermatium* Fig 2, a previously monotypic genus described from South America. This new species has been collected in the mountain ranges of Puerto Rico

Fig 1. A new resupinate species of *Antrodia* on pine logs from the Central Mountain Range of the Dominican Republic. It has deep orange, sinuous pores that are larger and more irregular than those of *A. radiculosa*. (Photo by D. J. Lodge).

Fig 2. A previously undescribed species of *Callistodermatium* which was found in the mountains of Puerto Rico and the Dominican Republic. One of the diagnostic characteristics of this genus is that the pigments of the pileus surface turn violet to purple when alkaline solutions are applied, as seen in this illustration. (Photo by T. J. Baroni).

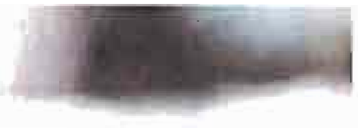

Fig 3. An unusual new species in Sect. *Firmae*, *Hygrocybe brunneosquamosa* Lodge & S.A. Cantrell, from the Luquillo Mountains of Puerto Rico. (Photo by D. J. Lodge).

Fig 4. This undescribed green species of *Hygrocybe* in Sect. *Coccineae* was collected in the Central Mountain Range of Puerto Rico. (Photo by T. J. Baroni).

Fig 5. This striking new rose-wine coloured *Humidicutis* has been found several times in the Luquillo Mountains of Puerto Rico, and is the first reported species of *Humidicutis* in the Caribbean. (Photo by S. A. Cantrell).

Fig 6. Dr. Orson K. Miller, Jr. was clearly delighted with his discovery of this blue species, *Clitocybula azurae*, in the Blue Mountains of Jamaica, shown in the inset. Dr. Karen Nakasone is standing behind him. (Photo in field by D. J. Lodge, inset by E. Horak).

and the Dominican Republic. The genus is characterised by having pileus pigments that turn purple to violet in alkaline solutions, and is thought to be related to *Cyptotrama asprata* (Berk.) Redhead & Ginns.

We expected to find about 48 species of Hygrophoraceae in the Greater Antilles, based on the number of species that were previously known and a rate of recent discoveries of 23% (Lodge & Pegler, 1990). The number of Hygrophoraceae has already exceeded our expectations by 130% (63 species). Seventeen of the additions to the mycota were previously undescribed taxa, exceeding our prediction of ten new species. Seven of the 17 new species are in Section *Firmae*, a tropical group characterised by two sizes of spores and basidia on the same basidiome. One of our new species in this group, *H. brunneosquamosa* Lodge & S. A. Cantrell (Fig 3), is very unusual in this section for having dull brown rather than bright colours and a squamulose pileus (Cantrell & Lodge, 2001). Most species in Section *Firmae* are brightly coloured (yellow, orange, red, purple or green), and have a silky-fibrillose, subviscid or viscid surface (Cantrell & Lodge, 2001). Two additional new

Fig 7. This previously undescribed species, *Amanita cruzii* O. K. Miller & Lodge, is associated with native pine in the mountains of the Dominican Republic. The orange, powdery material is the inner universal veil. (Photo by T. J. Baroni).

Fig 8. Leanne Barley, project data manager, is holding a large basidiome of *Macrocybe praegrandis* from Puerto Rico. (Photo by S. A. Cantrell).

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species of Hygrophoraceae with unusual colours are shown in Figs 4 and 5. Species with green basidiomes are rare, such as the undescribed species of *Hygrocybe* in Section *Coccineae* (Fig 4). A new species with a conic rose-wine coloured pileus shown in Fig 5 (see front cover) was initially mistaken for *H. calyptriformis* (Berk.) Fayod in subgenus *Hygrocybe*, but the broadly attached lamellae and short lamellar trama hyphae indicated it did not belong in subgenus *Hygrocybe*. There are several similar species described from South America (e.g., *H. rhodoleuca* Singer and *H. mutabilis* Singer), New Zealand (*H. rosella* Horak), and Africa (*H. vinosa* (Beeli) Heinem.). Horak (1990) transferred *Hygrocybe rosella* to *Humidicutis* based on the absence of clamp connections throughout the basidiome except for the presence of medallion-type connections at the bases of the basidia. These characteristics are shared by *H. mutabilis*, *H. vinosa*, and the undescribed species in Figure 5. This is the first report of *Humidicutis* from the Caribbean.

In terms of biogeographical patterns, most of the species in the Hygrophoraceae are restricted to the Greater Antilles or the Caribbean Basin (36% and 22%, respectively). Only one species has a pantropical distribution, *Hygrocybe hypohaemacta* (Corner) Pegler. Some of the Greater Antillean species of *Hygrocybe* in subgenus *Hygrocybe* are also found in the North Temperate zone, i.e. *H. acutoconica* (Clem.) Singer [=*H. persistens* (Britzelm.) Singer], while others are represented by new Caribbean varieties, such as *H. konradii* var. *antillana* Lodge & S. A. Cantrell and *H. calyptriformis* var. *domingensis* Lodge & S. A. Cantrell (Cantrell & Lodge, 2000).

Species with unknown affiliations

Some of the new species of agarics found in the Greater Antilles are easily placed in a genus, but they do not appear to have any close relatives. For example, Miller and Lodge (in press) described a striking new species, *Amanita cruzii* O.K. Miller & Lodge, that is associated with native pine in the Dominican Republic (Fig 7) for which we have been unable to locate any close relatives within Subgenus *Amanita*. This species is unusual in having a duplex universal veil in which the outer layer is fibrous and forms white pyramidal warts, while the inner veil is rusty in colour and powdery in texture. The inner universal veil covers the lower side of the annulus, making it appear duplex (Fig 7). Another unusual find is a strikingly beautiful blue species, *Clitocybula azurae* Singer (Fig 6). In addition to the unusual colour, this species differs from typical members of *Clitocybula* in having a dextrinoid stipe context, and veil remnants on the pileus margin and basal disc.

Some of the species we have found were previously known, but they were clearly assigned to the wrong genus. In these cases, DNA analyses have been very helpful in placing them. Legon (1999) showed illustrations of two of these i.e. *Collybia aurea* (Beeli) Pegler and *Marasmius rhyssophyllus* Mont. These two brilliant yellow species are closely related, and according to DNA analyses by Drs. Jean-Marc Moncalvo and Rytas Vilgalys (pers. comm.), they belong in the genus *Tricholomopsis*, rather than the genera in which they are currently placed. Another example is *Macrocybe praegrandis* (Berk.) Pegler & Lodge (Fig. 8), which was previously placed in the ectomycorrhizal genus, *Tricholoma* (Pegler *et al.*, 1998).

The X-files

Some of the basidiomycetes we have found have defied or challenged classification. We refer to one of these species as the nail-head fungus because of its shape and hard texture (Fig 11). The outer surface becomes brown and powdery (from spores) as it ages. This undescribed species resembles members of the genus *Tephrocybe*, but it lacks siderophilous granulation in the basidia and therefore appears to belong in the Tribe *Tricholomatae* rather than *Lyophyllae*. Two species described by Corner (1994) from Malesia (*Tricholoma furcatifolium* and *T. umbricatum*) resemble the nail-head fungus. Although Corner (1994) placed his species in the genus *Tricholoma*, he indicated that they did not exactly fit into any genus yet described. We suspect our fungus may belong with one or both of Corner's species in the monotypic genus, *Arthrosporella* Singer.

We recently made two collections of an astipitate fungus in Puerto Rico that has a completely gelatinised context in the pileus and tube trama, and tubes up to a centimetre in length (Fig 9). Although the highly ornamented cheilocystidia suggest a possible relationship with *Favolaschia*, the spores are inamyloid whereas *Favolaschia* spores are amyloid. With a combination of r-DNA sequencing by Dr. María

P. Martin, advice and reference sequences from Drs. Jean-Marc Moncalvo and Rytas Vilgalys, and morphological and molecular expertise in the *Tricholomataceae* of Drs. Greg Thorn and Scott Redhead, we have determined that the poroid fungus in Figure 9 represents and undescribed species of *Resupinatus*. A meruliod species, *R. merulioides* Redhead & Nagasawa, has previously been described from Japan.

Another unusual fungus (Fig 10) resembles *Dichopleuropus*, except that it lacks the dextrinoid dichophyses that help to characterise that genus. *Dichopleuropus* is thought to belong to the Lachnocladiaceae, and the undescribed species we found in Puerto Rico appears, according to DNA analyses by Karl-Henrik and Ellen Larsson (pers. comm.), to be related to species traditionally assigned to that family. The other group of *Dichopleuropus*-like fungi we found (Fig 12), however, does not belong to any of the major groups of basidiomycete fungi according to the Larsson's DNA analyses. Although they resemble species of *Thelephora* macroscopically, they have spores that are smooth, hyaline, and faintly amyloid rather than ornamented, warty, and inamyloid. We have found several species belonging to this group in the Caribbean, including Puerto Rico, the Dominican Republic, Tortola Island in the British Virgin Islands, and Venezuela. We believe they may represent a new family, and possibly a new order.

It is clear from the results of the Basidiomycetes of the Greater Antilles project so far that the Caribbean has a great diversity of basidiomycete fungi. Furthermore, many of these fungi appear to be restricted to the region, and some are only known from a single island or group of islands. Some of the recently discovered fungi are stretching the limits of known genera, a few are contributing to Vilgalys & Moncalvo's project to restructure the Agaricales using molecular analyses, while others apparently represent new genera, families, and possibly a new order.

For more information about the project and additional colour images, visit our web site at www.cortland.edu/nsf/ga/html.

Acknowledgements

In addition to the individuals acknowledged above, we thank our cooperators in the Dominican Republic: A. Ferrer of the Fundación Moscoso Puello; C. Cassanova of Fundación Plan Sierra; Fundación Progressio; M. Mejía and D. Rodríguez of the Jardín Botánico; Dr. Raphael M. Moscoso, and the National Park Service. We thank T. Commock and the Institute of Jamaica for assistance in Jamaica; and the Conservation Agency and the Falconwood Foundation for support while working on Guana and Tortola Islands, BVI. We are grateful to P. Catterfeld of the Research Foundation of SUNY-Cortland and L.A. Barley for taking care of a myriad of details in support of our research.

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Fig 9. This unknown species has a completely gelatinized trama in the pileus and tubes, and has tubes up to 1 cm in length (photograph by D. J. Lodge). Analyses of molecular sequences and micromorphology indicate this should be placed in the genus *Resupinatus*, which typically has lamellate basidiomes.

Fig 10. This undescribed *Dichopleuropus*-like fungus lacks dichophyses which help characterize the genus *Dichopleuropus*. (Photo by D. J. Lodge).

The Forest Products Laboratory in Madison is maintained in cooperation with the University of Wisconsin, while the lab in Puerto Rico is maintained in cooperation with the USDA-Forest Service International Institute of Tropical Forestry. This article was written and prepared by a U.S. Government employee on official time, and the information is therefore in the public domain and not subject to copyright.

Fig 11. This fungus, referred to as the 'nail-head fungus' for lack of another name, apparently belongs to the genus *Arthrosporella* in the Tricholomataceae. (Photographs by T. J. Baroni).

Fig 12. This species represents a group which, although resembling the *Dichopleuropus*-like fungus in Fig 11, does not appear to be closely related to any known basidiomycetes, according to DNA analyses. (Collected in the Dominican Republic; photo by D. J. Lodge).

SYSTEMATICS

A Redescription of the Caribbean Treehopper Genus *Antillotolania* Ramos (Hemiptera: Membracidae), with Two New Species

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Ann. Entomol. Soc. Am. 95(3): 302–308 (2002)

ABSTRACT The Caribbean treehopper genus *Antillotolania* Ramos, classified in the subfamily Stegaspidinae, is redescribed based on adult morphology. *Antillotolania doramariae* Ramos, the type species, is redescribed and illustrated; descriptions and illustrations are also given for *A. microcentroides*, new species from Guadeloupe and the British Virgin Islands, and *A. extrema*, new species from Puerto Rico. A key for the identification of adults is provided for the genus.

KEY WORDS Hemiptera, Membracidae, *Antillotolania*, treehopper, Caribbean, taxonomy

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THE CARIBBEAN TREEHOPPER genus *Antillotolania* was originally described by Ramos (1957) as a member of the membracid subfamily Centrotinae based on the exposed scutellum of *A. doramariae* Ramos, the only species known at that time. Ramos indicated that *Antillotolania* is related to *Tolania* Stål, which is currently classified in the subfamily Nicomiinae (Dietrich and Deitz 1993). Dietrich and Deitz (1993) noted a potential synapomorphy of *Antillotolania*, the genus *Deiroderes* Ramos, and the subfamily Stegaspidinae: the forewing crossvein m-cu2 connects to vein M basad of its fork. Nevertheless, this clade was not supported on all most parsimonious trees resulting from their morphology-based phylogenetic analyses; consequently, *Antillotolania* was removed from Centrotinae (Deitz and Dietrich 1993) and was considered unplaced within Membracidae.

Dietrich et al. (2001) found that *Antillotolania* grouped with the subfamily Nicomiinae and related taxa in some of the most parsimonious topologies resulting from their expanded morphology-based analysis. In contrast, results of molecular (Cryan et al. 2000) and combined molecular and morphological (J.R.C., unpublished data) phylogenetic investigations indicated that *A. microcentroides* (a new species described below) grouped with *Deiroderes* and the genus *Microcentrus* Stål (Stegaspidinae: Microcentrini). The molecular-based analyses did not include representatives of Nicomiinae, and therefore the hypothesis suggesting that *Antillotolania* may be allied with Nicomiinae (Dietrich et al. 2001) remains untested by molecular data. Still, following those investigations, *Antillotolania* remained unplaced within Membracidae.

In a morphological phylogenetic analysis of the basal lineages of Membracidae (J.R.C., unpublished data), *Antillotolania* and *Deiroderes* formed the sister group to (fossil taxa + (Microcentrini + Stegaspidini)), and was not found to be associated with Nicomiinae. Those results suggest the need for an expanded definition of Stegaspidinae to include *Antillotolania*, *Deiroderes*, and two undescribed fossil taxa. Like *Antillotolania*, species of *Deiroderes* are known only from Caribbean islands and lack the posterior pronotal process; no other extant members of Stegaspidinae are known to occur in the Caribbean, although the undescribed fossil taxa, most of which also lack a posterior pronotal process, are from Dominican amber (McKamey 1998).

Materials and Methods

Protocols used in this work follow the description of materials and methods detailed in Cryan and Deitz (1999a, 1999b, and 2000). Four-letter codens cited in the text denote insect collections where specimens are deposited. Arnett et al. (1993) listed the full postal addresses for most of the institutions; those not found in that publication are indicated by a dagger (†) following the coden. CIRAD†, Labo Entotrop (Faunistique-Taxonomie), Montpellier, France. JARC†, J.A. Ramos Collection, University of Puerto Rico, Mayaguez, Puerto Rico. MNHN, National Collection of Insects, Museum National D'Histoire Naturelle, Paris, France. NCSU, North Carolina State University Insect Collection, Department of Entomology, North Carolina State University, Raleigh, NC. UGCA, The University of Georgia Insect Collection, Department of Entomology, University of Georgia, Athens, GA. USNM, United States National Entomological Collection, Department of Entomology, United States National Museum of Natural History (Smithsonian Institution), Washington, DC.

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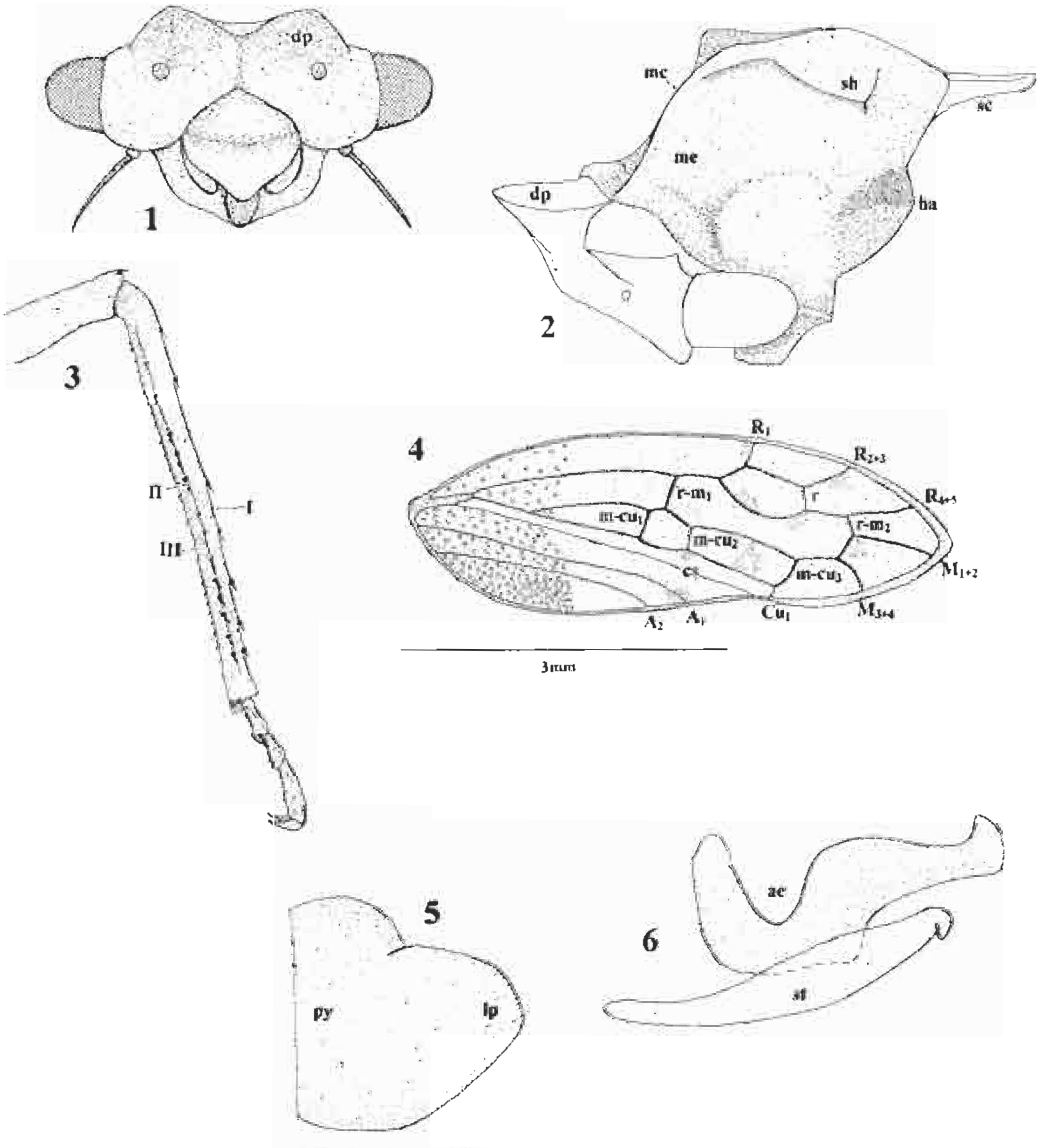

Figs. 1–6. *Antillotolania doramariae* Ramos. Structures of the holotype. (1) Head, anterior aspect (face). (2) Head, pronotum, and scutellum, anterolateral aspect. (3) Left metathoracic femur, tibia, and tarsus, ablateral aspect. (4) Right forewing. (5) Male left lateral plate and pygofer, lateral aspect. (6) Male aedeagus and left style, lateral aspect. Abbreviations: A#, anal vein(s); ae, aedeagus; Cu#, cubital vein(s); cs, claval suture; dp, dorsal projections; ha, humeral angles; lp, lateral plate; m-cu#, medial-cubital crossvein(s); M#, medial vein(s); mc, median carina; me, metopidium; sc, scutellum; sh, suprahumeral horns; st, style; py, pygofer; r, radial crossvein; r-m#, radial-medial crossvein(s); R#, radial vein(s); I, II, III, enlarged setal rows.

Genus *Antillotolania* Ramos, 1957

Antillotolania Ramos, 1957: 98. Type species: *Antillotolania doramariae* Ramos, 1957: 99, by original designation.

Diagnosis. The genus *Antillotolania* has forewings with 3–4 m-cu crossveins and the cranial vertex with extremely large, pyramiform dorsal projections; the posterior pronotal process is absent.

Adult. *Dimensions* (mm). Total length (from head to apex of forewings at rest) 4.8–5.2. *Head* (Figs. 1, 2, 7–9). Head (including eyes) wider than distance across pronotal humeri; face with fine pubescence, strongly bicornute; ocelli above centro-ocular line;

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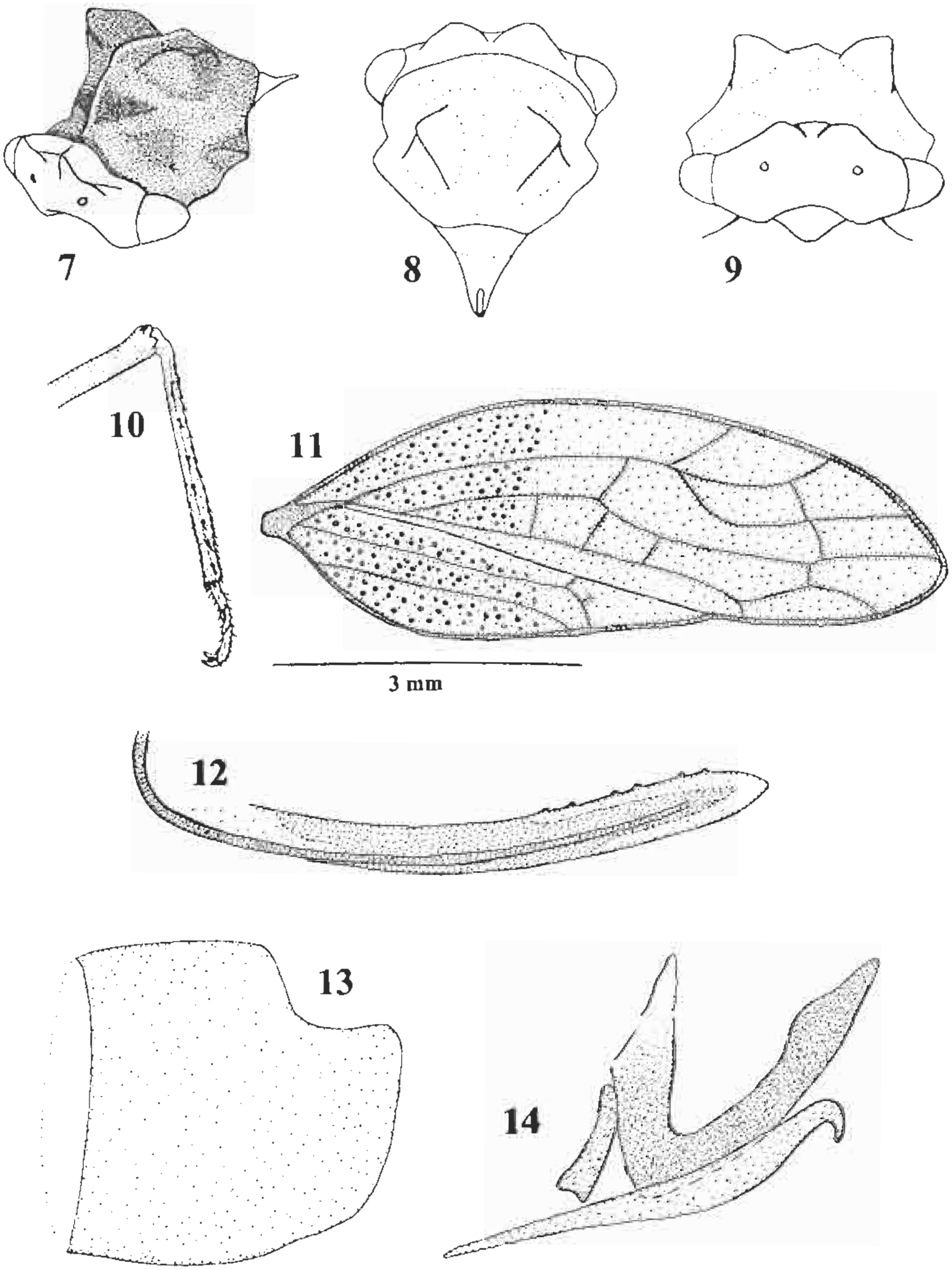
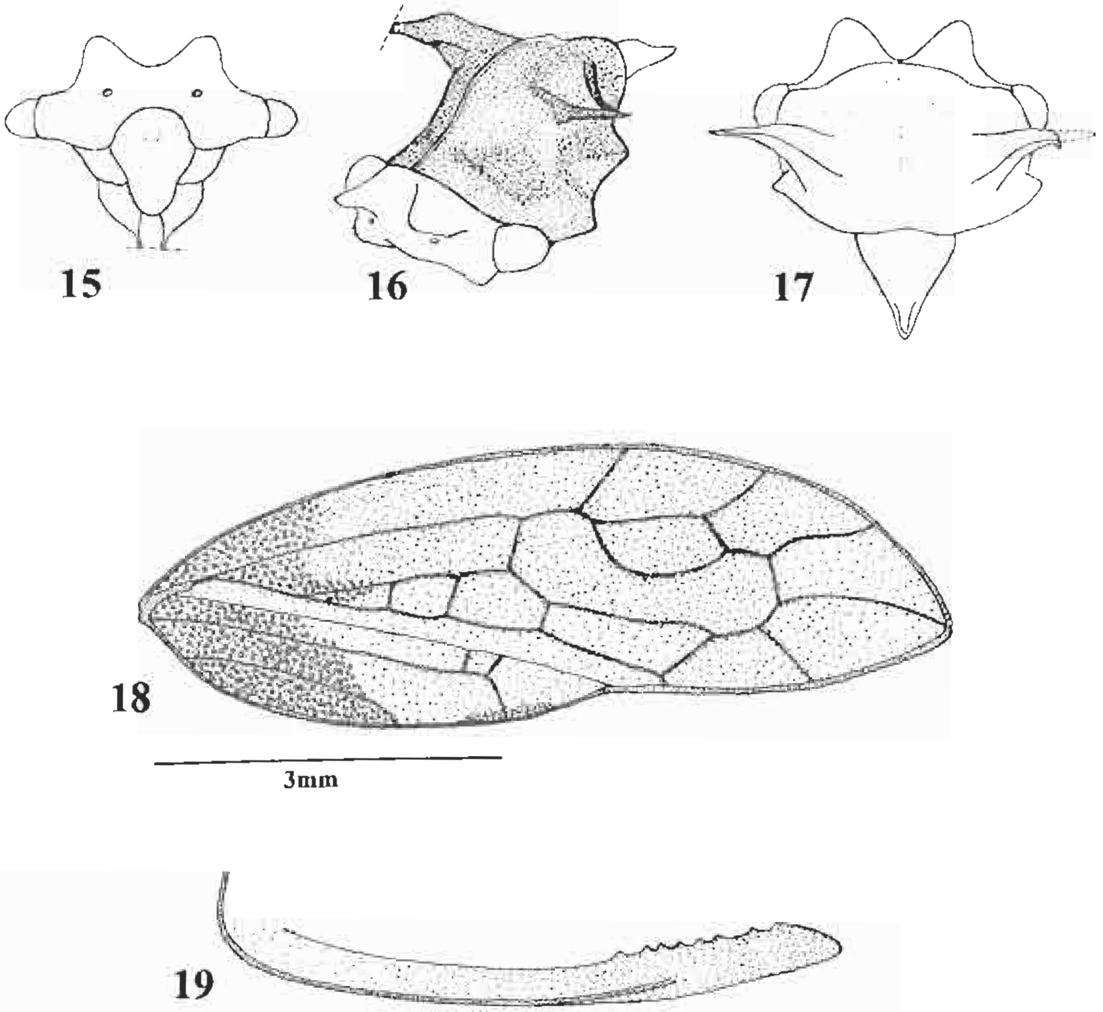


Figs. 7–14. *Antillotolania microcentroides* Cryan & Bartlett, New Species. (7) Head, pronotum, and scutellum, anterolateral aspect. (8) Head, pronotum, and scutellum, dorsal aspect. (9) Head and pronotum, anterior aspect. (10) Left metathoracic femor, tibia, and tarsus, ablateral aspect. (11) Right forewing. (12) Second valvulae, lateral aspect. (13) Male left lateral plate and pygofer, lateral aspect. (14) Male aedeagus and left style, lateral aspect.



Figs. 15–19. *Antillotolania extrema* Cryan & Bartlett, New Species. (15) Head, anterior aspect (face; portions below dashed line are obscured by specimen's point-mount). (16) Head, pronotum, and scutellum, anterolateral aspect (dashed line indicates broken portion). (17) Head, pronotum, and scutellum, dorsal aspect; apex of right suprahumeral horn is broken (missing portion approximated by dashed line). (18) Right forewing. (19) Second valvulae, lateral aspect.

frontoclypeus flattened. *Thorax: Pronotum* (Figs. 2, 7–9). Scabrous; metopidium depressed; supraocular callosities distinct; median carina well developed, with a small median tubercle caudad of suprahumeral horns (not visible in Fig. 2); posterior process absent; suprahumeral horns either produced or represented by low carinae. Pronotal surface sculpturing: punctate, one associated seta beside each pit. *Scutellum* (Figs. 2, 7–8). Short, ecarinate; basal two-thirds swollen, flattening to acute apex. *Legs* (Figs. 3 and 10). Metathoracic femur lacking cucullate setae; tibia with enlarged setal rows I, II, and III, some with cucullate setae; tarsomere I with one apical cucullate seta. *Forewing* (Figs. 4, 11, 18). 3–4 branches of R extending to wing margin; vein R4+5 fused basally with either R1 (Fig. 4) or R2+3 (Figs. 11 and 18); 2 r-m and 3–4 m-cu crossveins present. *Hindwing*. Venation essentially identical to Microcentrus hindwing venation as illustrated by Deitz (1975, figure 37c) and Dietrich et al. (2001, figure 2B); apex with arcuate chaetoids (Dietrich and Deitz 1993, Dietrich et al. 2001). *Genitalia*. ♀ Second valvulae (Figs. 12 and 19) uniformly narrow; dorsal ridge of distal one-third with small serrations. ♂ Lateral plates (Figs. 5 and 13) fused basally with pygofer; aedeagus (Figs. 6 and 14) with posterior arm sinuate; styles (Figs. 6 and 14) stout, with small apical hook.

Range. Puerto Rico; Guadeloupe; British Virgin Islands.

Remarks. Species of *Antillotolania* have a shallow, median groove on the dorsum of the scutellum, suggesting that a posterior pronotal process was present in the ancestors of this group, but has been secondarily lost. The life history, biology, and identity of host plants are entirely unknown for all species of this rarely collected genus.

Key to the Species of Adult *Antillotolania*

1\. Suprahumeral horns small, little more than raised carinae (Fig. 2); forewing vein R4+5 fused basally with R1 (Fig. 4); forewing vein A1 curved smoothly to wing margin *A. doramariae* Ramos

1′. Suprahumeral horns large, well developed (Figs. 7–9, 16, 17); forewing vein R4+5 fused basally with R2+3 (Figs. 11 and 18); forewing vein A1 abruptly bent toward trailing edge of wing 2

2\. Suprahumeral horns (Figs. 7–9) not extending beyond humeri in dorsal view; forewing (Fig. 11) with distal m-cu crossvein distad of fork of vein M; metathoracic tibiae (Fig. 10) with cucullate setae in rows I–III . . . . *A. microcentroides*, New Species

2′. Suprahumeral horns (Figs. 16–17) extending beyond humeri in dorsal view; forewing (Fig. 18) with distal m-cu crossvein basad of fork of vein M; metathoracic tibiae with cucullate setae in row II only . . . . *A. extrema*, New Species

Antillotolania doramariae Ramos (Figs. 1–6)

Antillotolania doramariae Ramos, 1957: 99.

Type Locality. Maricao State Forest, Puerto Rico.

Adult ♂. *Dimensions* (mm). Total length 4.8–5.3; width between humeral angles 1.3–1.5; pronotal length 1.0–1.2; wing length 3.8–4.0; width of head including eyes 1.5–1.7. *Coloration.* Body fuscous; pronotum ferrugineous; forewings brown basally, hyaline distally with irregular spots; legs brown. *Head.* Face (Figs. 1–2) weakly sulcate between large, pyramiform dorsal projections; postclypeus not trilobed; foliate lobes weakly developed. *Thorax: Pronotum* (Fig. 2). Humeral angles stout; suprahumeral horns reduced to low carinae. *Scutellum* (Fig. 2). Distal one-third flat, acuminate, with shallow, medial groove dorsally. *Legs* (Fig. 3). metathoracic tibia with cucullate setae in rows I, II, and III (row I may have reduced number of setae). *Forewing* (Fig. 4). Holotype forewings with four branches of R extending to wing margin (nontype specimen examined with three branches of R); 2 r-m crossveins present (distal r-m crossvein distad of fork of vein M); 3 m-cu crossveins present (holotype left forewing with only 2 m-cu crossveins), all basad of fork of vein M. *Genitalia.* Lateral plates (Fig. 5) fused to pygofer, represented by posterior lobe; aedeagus and styles (Fig. 6) stout; aedeagus with posterior arm sinuate, anterior face not denticulate, lobed apically. ♀ Not examined.

Nymph. Unknown.

Distribution. Puerto Rico (Maricao and Carite State Forests) [USNM].

Material Examined. HOLOTYPE [♂] [NCSU, deposited on indefinite loan at USNM] with labels. "Insular Forest,/Maricao, P.R./27 November 1952," "J.A. Ramos/Collector," "Holotype," "*Antillotolania/doramariae* Ramos/MS," and "ON INDEFINITE LOAN/FROM N. CAROLINA/ST. UNIV. RALEIGH." Other specimens: 1 ♂ from JARC (Deitz Research #83-138a ♂).

Remarks. *Antillotolania doramariae* has an unusual combination of forewing features: the presence of 2 r-m and 3 m-cu crossveins is generally regarded as a plesiomorphic condition within the family Membracidae, whereas the branching of vein R seems to be either ancestral or derived. The male holotype has both forewings with apparently four branches of vein R extending to the wing margin, and the JARC specimen (also male) has three branches of R. Ramos (1957) described the female allotype (unavailable for study) as having five apical forewing cells, suggesting three branches of R. Ramos differentiated *A. doramariae* from the related species *Deiroderes inermis* Ramos (also described as new in that work) based on characters of the head and pronotum.

Antillotolania microcentroides, New Species
(Figs. 7–14)

Type Locality. Crètes, Guadeloupe.

Adult. *Dimensions* (mm). Total length ♀ 8.8, ♂ 8.5; width between humeral angles ♀ 2.2–2.4; ♂ 2.5; pronotal length ♀ 1.6–1.9, ♂ 2.0; forewing length ♀ 6.5–7.0, ♂ 7.0; width of head including eyes ♀ 2.5, ♂ 2.6. *Coloration.* Body with pale pubescence; pronotum generally brown with darker suprahumeral horns and lighter metopidium; metopidium with dark brown 'diamond' (Fig. 7); forewings tan (membranous areas lightly pigmented); legs tan to brown. *Head.* Face (Figs. 7–9) with dorsal projections distinctly large, with apices separated by a distance just shorter than the distance between ocelli. *Thorax: Pronotum* (Figs. 7–9). Middorsal ridge slightly produced, extending over full length of pronotum; supraocular callosities distinct; suprahumeral horns simple, pyramiform, not extending beyond humeri in dorsal view; humeral angles moderately produced. *Scutellum* (Figs. 7–8). Relatively short and flat (just slightly produced anteriorly; Fig. 7); apex acuminate, but with middorsal groove on apical 1/4 (Fig. 8). *Legs* (Fig. 10). Metathoracic tibiae with three enlarged setal rows, each bearing cucullate setae (row I with 19–21 cucullate setae, row II with 6–7, and row III with 11–15); cucullate setae in row III only on distal half of produced ridge. *Forewing* (Fig. 11). Basal one-third slightly thickened, punctate except for area between vein Cu and claval suture; 2 r-m crossveins; 3–5 m-cu crossveins (all specimens examined differ in the number of crossveins on left and right forewings); 1–2 crossveins extending from claval suture to vein A1. *Genitalia.* ♀ Second valvulae (Fig. 12) uniformly narrow and slightly curved dorsally; dorsal ridge of distal one-third with six small teeth. ♂ Lateral plates (Fig. 13) fused to pygofer (line of fusion not evident); styles (Fig. 14) elongate, slender, hooked apically; aedeagus (Fig. 14) strongly U-shaped, tapering apically, anterior face of posterior arm slightly swollen, not denticulate.

Nymph. Unknown.

Distribution. Guadeloupe [MNHN]; British Virgin Islands: Tortola (Sage Mt.) [USNM].

Material Examined. HOLOTYPE [♂, dissected] [CIRAD, deposited at MNHN] with labels "Guadeloupe, Crètes/de Bouillante 23-V-1965/battage en forêt/J. Bonfils," "4," "CIRAD," and "Holotype ♂/*Antillotolania/microcentroides*/Cryan & Bartlett." PARATYPE [♀] [CIRAD, deposited at MNHN] with labels "Guadeloupe, Crètes/de Bouillante VIII-1966/battage en forêt/J. Bonfils," "4," "CIRAD," and "Paratype ♀/*Antillotolania/microcentroides*/J.R. Cryan & C.R. Bartlett." PARATYPE [♀, dissected, with forewings point mounted below thorax and head] [NCSU, deposited on indefinite loan at USNM] with labels "BRITISH VIRGIN/ISLANDS: Tortola/Sage Mtn., 1700+ ft./28-X-1997/C.R. Bartlett/Beating," and "Paratype ♀/*Antillotolania/microcentroides*/Cryan & Bartlett."

Remarks. This new species is placed in the genus *Antillotolania* based on the following features: presence of >2 m-cu crossveins in the forewing, the lack of the posterior pronotal process, the large projections on the vertex of the head, and fusion of the male lateral plates to the pygofer.

The genitalia of the female paratype were dissected for illustration and the remainder of the abdomen was removed for nucleic acid extraction and DNA sequence analysis. As noted above, *A. microcentroides* was included in a molecular phylogenetic investigation of higher membracid relationships as "*Antillotolania* n. sp." (Cryan et al. 2000). In those analyses (with data from two nuclear genes), it grouped with *D. inermis*, *Microcentrus caryae* (Fitch), and *M. perditus* (Amyot & Serville) with relatively strong support (bootstrap = 77% and Bremer = 4). An expanded analysis incorporating evidence from additional genes and morphology (J.R.C., unpublished data) resulted in a similarly robust clade of (*D. inermis* + (*A. microcentroides* [as *A.* n.sp.] + *M. caryae*)).

The female paratype of *A. microcentroides* was collected during an ongoing biotic survey of the British Virgin Islands (particularly Guana Island; Bartlett 2000), sponsored by the Conservation Agency to investigate questions of island biogeography. This specimen from Tortola (British Virgin Islands) was swept from woody vegetation at the edge of a southwesterly facing clearing on Sage Mountain.

The specific name translates as "*Microcentrus*-like;" morphologically, the pronotal structure of *A. microcentroides* is strikingly similar to that of certain *Microcentrus* species (J.R.C., unpublished data).

Antillotolania extrema, New Species (Figs. 15–19)

Type Locality. Caribbean National Forest, Puerto Rico.

Adult ♀. *Dimensions* (mm). Total length 7.5; width between humeral angles 2.0; pronotal length 1.2; forewing length 6.5; width of head including eyes 2.2. *Coloration.* Body, including pronotum and legs, generally light brown; forewings tan basally, hyaline distally with irregular spots of brown pigmentation. *Head.* Face (Fig. 15) with dorsal projections extremely long, pyramiform, with apices separated by a distance longer than the distance between ocelli; ocelli located at base of dorsal projection; postclypeus unilobed; foliate lobes rounded, weakly developed. *Thorax. Pronotum* (Figs. 16–17). Suprahumeral horns well developed and attenuated apically, extending beyond humeri in dorsal view; metopidium depressed. *Scutellum* (Figs. 16 and 17). Relatively short, slightly produced anteriorly; apex acuminate with middorsal groove on apical 1/4 (Fig. 17). *Legs.* Metathoracic tibiae with two enlarged setal rows (row III not enlarged); only setal row II bears cucullate setae (row II of right and left legs each has seven cucullate setae). *Forewing* (Fig. 18). Vein A1 abruptly bent toward claval suture distally; basal one-third slightly thickened, punctate except for area between vein Cu and claval suture; 2 r-m crossveins; 4 m-cu crossveins (left and right forewings agree in number); distal m-cu crossvein basad of fork of vein M; two crossveins extending from claval suture to vein A1. *Genitalia.* Second valvulae (Fig. 19) uniformly narrow and slightly curved dorsally; dorsal ridge of distal one-third with eight small teeth. ♂ Unknown.

Nymph. Unknown.

Distribution. Puerto Rico.

Material Examined. HOLOTYPE [♀, dissected; apex of right suprahumeral horn broken] [UGCA] with labels "PUERTO RICO: Caribbean/N.F., MT, Britton/Trail, 28-V-1994/R. Turnbow," "JLA Research/359 ♀," "UGA," and "Holotype ♀/*Antillotolania/extrema*/Cryan & Bartlett"

Remarks. This new species, described from a single female specimen, is placed in the genus *Antillotolania* based on the following features: the large projections on the vertex of the head (15–17), the posterior pronotal process lacking (Figs. 16 and 17), and the presence of >2 m-cu crossveins in the forewing (Fig. 18). Like *A. doramariae*, *A. extrema* is known only from the Caribbean Island of Puerto Rico. Ramos (1957) described the suprahumeral horns of *A. doramariae* as "very variable in prominence and sharpness;" thus, while we acknowledge the possibility that *A. extrema* is actually an radical variation of *A. doramariae*, we consider that possibility unlikely based on differences in wing venation and metathoracic leg chaetotaxy.

The Latin specific name "*extrema* refers to the suprahumeral horns and cranial dorsal projections of *A. extrema*, which are extremely long with respect to the other *Antillotolania* species.

Acknowledgments

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Jarecki family and the staff of Guana Island for their hospitality. A portion of this work appeared in the 1995 thesis submitted by J.R.C. in partial fulfillment of his M.S. degree in entomology (North Carolina State University). Funding was provided, in part, by the North Carolina Agricultural Research Service (NCSU, Raleigh, NC) and by the University of Delaware Agricultural Experiment Station.

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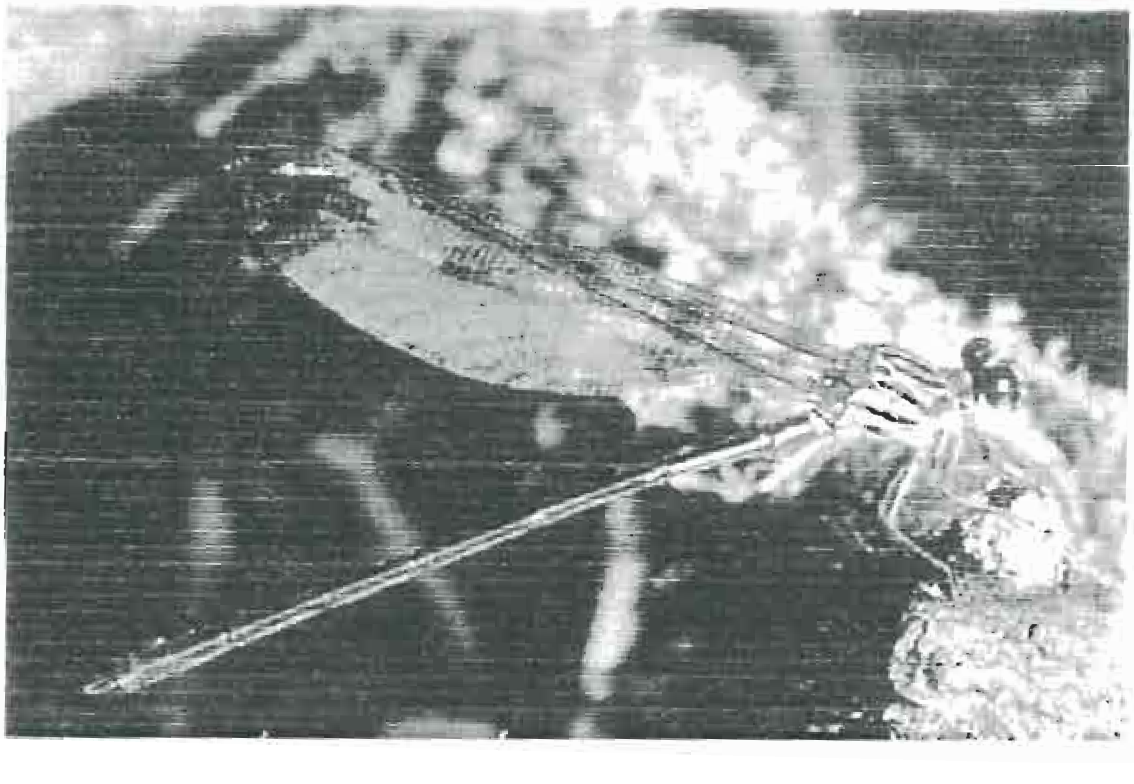

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A FISTFUL OF BOLIVIANOS!

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Back to Bolivia! That was the rebel yell by Ken Tennessen and Steve Valley. Jim Johnson and I quickly joined them for a November trip. This time we brought lots of dollars and Bolivianos with us. (See **ARGIA** 12:1, April 2000).

We arrived in Santa Cruz on time despite several attempts by US airport security to delay us. We met Lic. Julieta Ledezma at the Museum and one of our favorite odonatology students, Ingrid Vaca Gonzalez, who would accompany us on this expedition. The next day, we headed out for Villa Tunari where we stayed most of the trip.

Our favorite B & B hotel (some advice: don't go to any motels in Bolivia, as we found that the term "motel" has quite a different, actually risqué, meaning here) was the Hotel Araras with its macaws, parrots, toucans, and spider monkeys at our doorsteps! Despite almost constantly cloudy and rainy weather, plus a few blockades on the side roads by the campesinos who grow the coca and an extensive military presence, we had a fantastically fun time! The food was great, especially the surubi catfish cooked in coconut milk! We sipped Paceña beer (of course for medicinal purposes) as we made the scene in our terrific commemorative Bolivia T-shirts, courtesy of Steve Valley. Thanks, Steve!

We collected many exciting species of Odonates! Just east of Tunari, at a small stream next to the main highway, we got such gomphids as ***Archaegomphus*** nr. ***furcatus, Progomphus boliviensis, Phyllocycla anduzei,*** and ***Phyllogomphoides lieftincki***. We collected over 35 species at this one small stream. This is Jim Johnson's favorite place.... ask Jim about the local water pipes and their structural soundness!

Here and nearby, we got libellulids like ***Dasythemis esmeralda, Micrathyria artemis***, and ***Misagria parana.*** Some aeshnids collected were ***Coryphaeschna perrensi*** and a gigantic ***Staurophlebia***. Among the more notable damselflies, we got ***Acanthagrion abunae, A. jessei, Argia hamulata, Epipleoneura*** spps., ***Heteragrion inca, Lestes dichrostigma, L. falcifer, Mnesarete devillei, Palaemnema clementia, Protoneura amatoria***, and ***Telebasis sanguinalis***.

At a nearby lake, we got a new species of shade-loving ***Metaleptobasis*** under memorable but difficult collecting conditions. This green and red-eyed yellow damselfly hid in the dense tangled shrubbery at the west end of the lake. Almost every small tree or vine I brushed against or touched with my net was home to vicious, stinging arboreal orange ants. Yea, they enjoyed tormenting me to the breaking point but I persevered, all for the sake of science and nature. As the song goes, "She blinded me with science!"

West of Villa Tunari in the montane rainforest, we found interesting odonates such as ***Progomphus occidentalis***, the pruinose white ***Macrothemis mortoni***, the giant ***Libellula herculea, Gomphomacromia*** spps., ***Acanthagrion vidua, Argia nigrior, Cora irene, Philogenia buenavista, Polythore boliviana***, and ***"Teinopodagrion" setigerum***. Ken and Steve took us to their favorite site and we saw the unbelievable ***Cora terminalis*** with its metallic blue wings. The color was only visible from certain angles, otherwise the wings looked transparent. They shimmered like strobe lights during its territorial clashes and courtship displays over the seepage stream. It was well worth the price of admission to Bolivia!

We did take a day off to drive west to the dry, potato growing country around Cochabamba. We didn't do much collecting and nothing much happened except four dogs chased me during a pit stop and one of them nipped me in the right calf. Fortunately, the MASH unit was on hand and Hawkeye (Steve Valley) and the others fixed me up. Thanks, Compadres!

Most days we experienced lots of rain, and we didn't get to see many odonates except a few things if we were willing to get wet. We did add some new species to the list that we didn't get before on previous trips. We found a new species of ***Lestes*** nr. ***apollinaris, Acanthagrion*** sp., that lake ***Metaleptobasis***, and ***Micrathyria*** sp. Undoubtedly many more discoveries await travelers to Bolivia. One good thing I noticed was the unbroken expanse of montane rainforest west of Villa Tunari, unlike the patchwork of the eastern Andes in Ecuador caused by landslides and clear-cutting. Hopefully, Bolivia will continue to protect its virgin rainforests.

All in all, it was a great trip! We even had bolivianos left over! Yes, we are ready to go back! Doborochi!

* * *

MISCELLANEOUS NOTES ON BRITISH VIRGIN ISLAND DRAGONFLIES

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This is the third note on the October odonate fauna of the British Virgin Islands (BVI): (**ARGIA** 1999, 11:(1)16-16-19; 2000, 12 (1):18-19). The changes from 1997 to present are difficult to interpret because there are no earlier studies. This note adds three species to the BVI.

My five visits to the BVI have all been in October, 1997-2001, so reference to these years in the text means October.

Species and site notes

Lestes forficula - New species for BVI. First collected in September 1990 by David Smith at The Slob on Anegada Island (specimen in IORI collection). It was found to be quite common in a stock pond on Ridge Road, Tortola in 2000 and 2001 but was not found in either year on Anegada despite serious searching.

Brachymesia furcata - First seen at Botanical Garden, Tortola in 1999, absent in 2000 but a few present in 2001.

Brachymesia herbida - At Botanical Garden, Tortola since 1999 and in 2001 also collected on Guana Island and at stock pond on Ridge Road, Tortola in 2001 (single individuals). In addition a large population was present in the ditch ponds around the Beef Island Airport.

Erythemis simplicicollis - CORRECTION - 2000 **ARGIA** article should read ***Erythemis vesiculosa***.

Erythrodiplax berenice - New species for BVI. Collected in September 1990 on Anegada by David Smith (IORI collection). Refound there in 2000 and 2001 as well as on Tortola and Beef Island. The most abundant odonate in the islands with incredible densities around the salt pond and mangroves on Anegada Island and lesser numbers in similar habitat on Tortola and Beef Island.

Erythrodiplax umbrata - A common species on Tortola, Guana and Beef Islands but very rare on Anegada. One individual seen there in 2000.

Micrathyria dissocians - New species for BVI. Common in stock pond on Ridge Road in 2000 and 2001.

Anegada island is the only flat coral island in the country. It has a large central salt pond and three freshwater slobs. Two are mostly filled with trees and the third, The Slob, has been bulldozed out to leave a pond in the middle of bare coral. In 2000 all three had ***Orthemis ferruginea***, ***Ischnura ramburii*** and ***Tramea abdominalis*** with the more open pond having larger numbers. Only two ***Pantala flavescens*** and one ***Erythrodiplax umbrata*** were found in a day and a half on the island. 2001 was much drier and all three ponds had shrunk in size and depth. ***Erythrodiplax umbrata*** was not present and ***Ischnura ramburii*** was scarce.

Tortola: Three ponds were checked on Ridge Road in 2000. Two had the standard species while the last, about 60x30 feet, also contained ***Lestes forficula***, ***Micrathyria dissocians***, ***Perithemis domitia***, and in 2001 ***Brachymesia herbida***. This third pond differs in having dense aquatic growth including water hyacinth.

Rate of immigration

Most if not all the odonates on Guana Island are from other islands. The major freshwater pool is unsuitable for larval growth. The other pools hold only a few larvae, frequently dry up, and the only emerging larvae we have seen was killed by one of the abundant anolis lizards. The island is thus a good site to study immigration. ***Erythrodiplax umbrata***, ***Orthemis ferruginea*** and ***Tramea abdominalis*** are all common on Beef and Tortola Islands, only a mile or so from Guana.

In 2000 and 2001 we tried to estimate populations and immigration rates of these three species on Guana Island. Using a modified mist net held horizontally over the pond it was possible to capture most of the individuals in a relatively short time.

In 2000 we captured dragonflies on only a few days, marked individuals and either returned them to pond or removed them to another island. A few marked ***Orthemis*** and ***Tramea*** were still present 10 days later but most (20 plus marked) were not found again. Marked ***Erythrodiplax*** individuals (12) taken to Beef Island did not return. Maximum populations were about the same on the first and last days of trapping: ***Erythrodiplax*** 12; ***Orthemis*** 20; ***Tramea*** 2.

In 2001 we tried to capture every individual present each day and remove them to another island. The maximum numbers were vastly different from 2000 (***Erythrodiplax*** 3; ***Orthemis*** 3; and ***Tramea*** 3). In 5 days we caught 10 Tramea, 7 Orthemis and 7 ***Erythrodiplax*** with numbers declining so there was only 1 ***Tramea*** found the last day, an immigration rate of about 1 individual per species per day. After a 4 day break numbers had recovered to first day levels. After another 4 day break, due to bad weather, we made a visual estimate (floating debris in a pond 300 times as large as the original 5x2 foot pool precluded using mist net) of at least 10 ***Tramea***, 10 ***Orthemis*** and 5 ***Erythrodiplax***.

In both years, when we removed the adult male ***Erythrodiplax*** they were replaced by subadult males. In 2000 removal of ***Orthemis***, almost all "purple", resulted in a replacement population of mainly "red" individuals. Populations in both years were approximately 2-3 times the number of occupied territories (except see ***Tramea*** under establishment of new species).

Conclusions: Individuals of all three species wander randomly from other islands searching for new habitat and land on Guana. These are primarily subadult individuals who move on if habitat is not available, or stay and mature if habitat is available. A larger pond size, as in 2000 and the last day of our stay in 2001, attracts and hold more individuals. Immigration rates also must be dependent on size of source populations. Drier conditions in September of 2001 presumably produced a lower immigration rate than in 2000.

Establishment of New Species

In 1997 huge numbers of ***Tramea calverti*** invaded Guana Island and Anegada Island. This species has not been recorded since.

In 1997 huge numbers of ***Pantala hymenaea*** invaded Guana Island but not Anegada. This species has not been seen since.

The failure of these two species to establish populations is difficult to explain. Certainly Tortola and Anegada presented suitable breeding pools although Guana did not.

In 1997 huge numbers of ***Tramea abdominalis*** invaded Guana Island but not Anegada. It was not seen on Guana Island in 1998 but has been increasingly common since. On Tortola, not checked until 1999, it has also increased in abundance and on Anegada was common in 2000 and 2001. This species was probably already established on Tortola, but its absence from Anegada in 1997 and subsequent abundance in 2000 and 2001 leaves the question open It was definitely absent from Guana in 1998 but has increased its population each year since. Is this due to new populations on Tortola and Beef Island or an explosion of those populations following a series of wet years?

Brachymesia herbida was first recorded from Tortola in 1999 and since it was at a permanent water source of long standing was assumed to have always been present there. The appearance of the species in 2001 on Guana Island and at a pond on Tortola where it was absent in 2000 plus the establishment of a large population on Beef Island again presents the choice of explosion with series of wet years or recent invasion.

The absence of ***Lestes forficula*** on Anegada although present in 1990 would suggest that there is regular extinction and reestablishment of populations in the BVI.

Acknowledgements

Thanks to the Jarecki family, the Falconwood Foundation and James Lazell of The Conservation Agency for making this study possible. Thanks also to my wife and several bird banders who helped in mist netting dragonflies.

Fred C. Sibley Home phone 607-594-4179 or 594-3584 2325 County Road 6, Alpine, NY 14805 fcsibley@empacc.net

* * *

ODONATA OF ST. THOMAS AND ST. JOHN, VIRGIN ISLANDS

Nick Donnelly

I had not envisioned writing an account of the relatively meager Odonata fauna of the northern US Virgin Islands, but Fred Sibley's excellent articles on the nearby British islands have made me realize that there is interest in this area. I spent about six months on these islands in 1956 and 1957 while carrying out a geological mapping project. The islands are thorn scrub and semi-arid in most part, with only small remnants of original forest. They have very few attractive fresh-water habitats, mainly streams ("guts") with low flow and stockponds, which generally had unvegetated shorelines. On most days I went into the field without a net. This can be a big mistake, as I found several times.

St. Thomas is one of the original localities listed by Hagen (1861) for two of his newly described species: ***Agrion*** (=***Enallagma***) ***coecum*** and ***Diplax*** (=***Erythemis***) ***credula***. There are some problems with both of these, and they are discussed below.

I also list some Odonata found in the vicinity of Cruz Bay, St. John, by Whitehouse (1939). These were from small streams whose names had disappeared by the time of my visit 18 years later. I include also some species reported by Klots (1932) from both the US and British Virgin Islands.

In my several return visits (up to 2000). I have seen the few aquatic habitats degraded further with sprawling development, as the rich have purchased and fenced off tracts containing access to the few "guts" that have fresh water most of the year. Stockponds have largely disappeared, as the economy has become almost entirely tourist development in the subsequent decades. Turpentine Run, between Donoe and Mt. Zion in the east central part of St Thomas, is a low-gradient

From: "Scott Miller" <miller.scott@nmnh.si.edu>
To: "Vitor Osmar Becker" <vbecker@rudah.com.br>
Cc: <hq@theconservationagency.org>; "Lianna Jarecki" <ljarecki@hlscc.edu.vg>; "Wenhua Lu" <wenhua@etal.uri.edu>
Sent: Monday, May 06, 2002 8:03 PM
Subject: Guana Island moth paper

The following paper is out, although I have not seen the paper version yet.

Becker, V. O., and S. E. Miller. 2002. Large moths of Guana Island, British Virgin Islands: a survey of efficient colonizers (Lepidoptera: Sphingidae, Notodontidae, Noctuidae, Arctiidae, Geometridae, Hyblaeidae, Cossidae). Journal of the Lepidopterists' Society 56(1):9-44.

I will send reprints when I get them, but if you want it now, you can get the pdf file at the Allen Press ftp site. Use "anonymous" as the user name. It is too big to email (10 Megabytes).

Enjoy.

From: "Scott Miller" <miller.scott@nmnh.si.edu>
To: "Wenhua Lu" <wenhua@ETAL.URI.EDU>; <hq@theconservationagency.org>; "Lianna Jarecki" <ljarecki@hlscc.edu.vg>
Sent: Tuesday, May 07, 2002 3:27 PM
Subject: Fwd: Correction for Guana moth paper again

Oops, we screwed up some of the figure legends on the otherwise elegant color plates. Therefore, I will not release the reprints until we have the corrected plate, assuming that's the way the editor goes. Scott

>To: Carla Penz <flea@mpm.edu>
>From: Scott Miller <miller.scott@nmnh.si.edu>
>Subject: Correction for Guana moth paper again
>Cc: "Vitor Osmar Becker"<vbecker@rudah.com.br>, Karolyn Darrow
><darrow.karolyn@nmnh.si.edu>, miller.scott@nmnh.si.edu
>
>Carla: I just received the pdf version of the Guana moth paper, although I
>have not seen the printed version yet. The paper looks great, but a
>serious lapse occurred in checking the proof for the figures. The figure
>captions for 112-150 refer to the reverse of the image, which means the
>ones in the middle are correct, but the left and right sides are
>reversed. The image is correctly printed, so we must have constructed the
>captions from a reversed image. Karie and I spent a lot of time checking
>the figure calls, captions and figures, but somehow this escaped us. I
>think I was duped by the figures in the middle being correct.
>
>Anyway, we should insert a correct captions in the earliest possible
>issue. I will send a corrected version shortly.
>
>Sorry. Scott

From: "Scott Miller" <miller.scott@nmnh.si.edu>
To: "Wenhua Lu" <wenhua@etal.uri.edu>;
Sent: Saturday, May 25, 2002 9:36 PM
Subject: Guana Island refs

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Skip: I assume you've seen these?

Martin, J. W. 2002. Microprosthema jareckii, a new species of stenopodidean shrimp (Crustacea: Decapoda: Stenopodidea: Spongicolidae) from Guana Island, British Virgin Islands. Proceedings of the Entomological Society of Washington 115(1):108-117.

Miller, O. K., Jr., D. J. Lodge, and T. J. Baroni. 2000. New and interesting ectomycorrhizal fungi from Puerto Rico, Mona, and Guana Islands. Mycologia 92(3):558-570.

The large moth paper is out, but I don't want to release the reprints until we have issued a correction to the plate that was mirror-imaged.

Vitor and I will be working soon on finishing the pyralid moth paper, and I'm working with David Adamski on a paper on the few species of the microleps of the obscure family Blastobasidae.

Scott

From: "Roy Snelling"
To: <hq@theconservationagency.org>
Sent: Saturday, May 18, 2002 4:16 PM
Attach: Guana.dat

Skip:

Good chatting with you the other day. I will try to put together a chapter for your book on the aculeate Hymenoptera (those with stingers) of Guana. In the meantime, and recognizing that I might not be able to complete it in time, I am sending a list of the critters involved. Note that things such as Braconidae, Ichneumonidae, and other parasitics are not included. Partly this is because I know little about them and partly because I never made any special effort to collect them. Possibly Paul Marsh could come up with some info on the Braconidae.

Are you guys going back to Hong Kong this summer? I do remember my one trip with some fondness. I am still trying to find time to get back to southeast Asia, but so far the Kenya gig has taken up most of my available field time. As is, I have almost no time to sit down and write papers.

Best wishes,

Roy

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From: "Daniel Perez"
To: <hq@theconservationagency.org>
Cc: "Scott Miller" <Miller.Scott@NMNH.SI.EDU>
Sent: Friday, March 01, 2002 9:35 AM
Subject: Orthopteroids of Guana Island

Hello Skip:

Sorry, that this has taken long again. I just found your letter today at home. Looks like it was misplaced for a few days. I came back from Santo Domingo Feb. 12, after a month of good collecting.

I had actually received from Scott that list of acridids that I identified in 1995 and had put it aside with the note to correct the misidentification. Apparently I was not very familiar with the species at that time. I have no doubt that all BVI Schistocerca have to be only one species, Schistocerca nitens. I did not see anything else while I was there and S. serialis is not uncommon when it is around. So this has to be corrected somehow at the Bishop Museum. This is why I'm copying this message to Scott.

We can look for the mantis in Scott's material. I have already rounded up the crickets and one phasmid that were there. I'll write to Barry Valentine to borrow his orthopteroids. He was convinced he had some unreported roaches but that needs confirmation. I did send him some reprints shortly after the Guana trip.

The weird and wonderful cricketoid you mention must be a Gryllacrididae. I seem to remember seeing at least one of those near the hotel area but could not catch it. Undoubtedly there are still cricket species to be collected there.

These days I'm busier than ever though enjoying it. A paper on the Guana Orthopteroids is in my list.

Thanks for the follow up,

DANIEL

Hello Skip:

Wanted to write again just in case you are planning to put the list of orthopteroid species in your book on Guana fauna. I have further found that Dave Nickle had identified the leaf-shaped katydid common in the hotel area as Turpilia sp. instead of the name I gave you Microcentrum. These two genera are very similar and easily confused with each other.

Hope this helps,

DANIEL

Daniel E. Perez-Gelabert, PhD
Research Associate
Dept. of Systematic Biology
U.S. National Museum of Natural History
Smithsonian Institution
Washington, DC 20560-0169. USA.

From: "p. j. devries" <pjd@mpm.edu>
To: <wenhua@etal.URI.EDU>
Sent: Tuesday, May 21, 2002 10:47
Subject: new guana bug

Skip, below is an email that will bring tears to your eyes. Likely the first record of Atrichopogon on guana, ever. The fly makes a pin-head seem large.... At any rate, I'll advise him to keep the specimen, if thats alright with you. Let me know.

Haven't forgot the b'fly section, and I scribble on it upon occasion. Just been busy.
Phil

Subject: ceratopogonid
Date: Mon, 20 May 2002 16:57:11 -0700
X-Priority: 3
To: "Phil de Vries" <pjd@mpm.edu>
From: "Art Borkent" <aborkent@jetstream.net>

Phil, I finally got around to looking at the ceratopogonid you reported flying around a pinned scarab. Brian Brown sent it to me a while back but I've been up to my eyeballs with other demands.

The specimen is a male Atrichopogon and it cannot be identified to species because the genus is a taxonomic hell-hole. Buckets of species out there, most with very similiar males, and very few described (and those very inadequately). The fact that it is a male means that it could not be using the scarab as a food source because the males do not have the equipment to penetrate cuticle. Perhaps the male was attracted to the scarab because it may be the food source for the females and that means increased odds of sex.

Do you want the specimen back? let me know. Saludos. Art

Dr. Art Borkent,
1171 Mallory Road,
Enderby, British Columbia,
V0E 1V3, Canada.

Telephone: (250) 833-0931
FAX: (250) 832-2146
Email: aborkent@jetstream.net
Research Associate: Royal British Columbia Museum and
the American Museum of Natural History.

"Vocatus atque non vocatus deus aderit"

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THE OHIO STATE UNIVERSITY

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Phone 614-292-7773
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3 December 2001

Drs. Wenhua Lu and Skip Lazell
Wes Watkins Ag. Research and Extension Center
Division of Agricultural Sciences and Natural Resources
P O Box 128
Lane OK 74555

Dear Skip and Wenhua,

Here are some miscellaneous updates:

I won't be at the ESA meetings in December. I'd planned to go, but there is too much to do here. Can you mail the specimens?

Thanks for the information about Bartlett's material; I've checked with Mike and he still has some of it.

Pascoe's types are in London, BMNH at least the anthribids are there. I assume your stuff is there too.

The mordellid counts from the two Malaise traps are included. All the Liao collections covered more than one month, and the largest (several months) was so decayed, it was discarded. Dr Liao was not clear about the dates. When I asked him, he was not able to remember all the details, so the dates I've provided are approximate dates when the samples were picked up. It is not very satisfactory.

Buena and I picked up two specimens that I though were teneral *Mordellistena lineata* –they have vague longitudinal patterns like *lineata*, but the entire ground color is dirty yellow. I'm going through the unmounted u/v light and general beating collections looking for more. There are a lot of specimens, so it will take time.

The roaches are a problem. We apparently now have 15 species from Guana, plus your #6, which I don't recognize. The three most common species (2 *Symploce*, and *Cariblatta* –your #3) were discarded because they obscured the view of the small fry and interfered with the sorting. Since these three included almost all the roaches in the Malaise traps, I can provide counts of only a few others. I've saved the bulk samples and will check for fulgoroids as time permits.

Your two unknown beetles sound interesting. The round one may be in Leiodidae, and the possible anthribid could be very worthwhile.

Buena has found information about the Malaise trap, a solar computer, and u/v light—all included here.

As you know by now, the agave weevil is *Scyphophorus acupunctatus* Gyllenhal. I've photocopied some information for you; it is included. While on Guana, we took the opportunity to look at the dead agaves more closely, and we Berlese funneled the sites of weevil damage. We found everything from nematodes to pseudoscorpions, mites, beetles, flies, and parasitic wasps, etc. etc. The mites and wasps are being studied here; I hope to have some preliminary data soon. So far the tiny parasitic wasps are in families which attack larval flies, not beetles. The two families of larger wasps which parasitize beetle larvae (Tiphiidae and Scoliidae) occur on Guana. The tiphiid is *Myzinum haemorrhoidale* (Fabricius); the black and yellow scoliids both are *Campsomerus dorsata* (Fabricius) and *Campsomeris trifasciata* (Fabricius). Their biology is unknown, but related species are known to prefer scarab (june bug) larvae. A local histerid beetle is a possible predator, but there is a larger histerid which has been introduced into the West Indies to control related weevils in bananas, sugar cane, and pineapple. It is *Plaesius javanus* Erichson (from Java). We collected it in Jamaica in 1956. I do not know if it has been effective; however, our collection manager works on histerids so I'll check with him when he returns from Mexico. Two terrestrial species of Hydrophilidae occur with the agave weevils and the larger may be a biological control candidate. I don't have the literature to identify it except it is close to *Dactylosternum* in the United States.

A preliminary report on the mites from the dead agave just came in. One rotten, weevil infested stem had over 700 specimens distributed in an estimated 14+ families and 16+ species. I have names for six of the families and two genera. At present, there is nothing to suggest that this assemblage will be useful in biological control. Some of the mites are phoretic on beetles, others inhabit sites with high organic content and/or high moisture. I'll keep checking.

(Best wishes from us both.

Barry & Buena

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14 December 2001

Dr. Skip Lazelle
870 South Pebble Creek Road
Lane OK 74555

Dear Skip:

The October 2001 session on Guana was by far our most successful. When Buena and I arrived, collecting was routine, with most of the collections duplicating those made previously, and with many species missing. Then the rains came and we started to pick up species new to the survey, plus short series of species previously represented by single specimens. As you know, the latter are critically important because they clarify problems of sexual dimorphism and individual variation. The checklist now has 55 families of beetles, 235 genera, and 333 species; the last up from our previous estimate of 237, and the first estimate of 148. About half of this year's increase is due to the unusually good collection success, and half is the result of my trip to Montana to study Michael Ivey's West Indies collection. Mike and I are collaborating to publish a Guana beetle checklist. At present, we are fine-tuning the manuscript . . . adding a formal classification to replace the alphabetical sequence, breaking the larger families into subfamilies, and adding comments on classification, identity, collecting, etc. To our knowledge, no island as small as Guana has so rich a beetle fauna. We expect our paper to provide a new and surprising base line for other island studies. St. Croix, much larger than Guana, has been the subject of two beetle surveys that total only 309 species (including many fresh-water species absent on Guana). Guana will change many scientists' perceptions of small island diversity.

As time and opportunity permit, we have searched for other invertebrates. Of specisl interest we now have all four "myriapod" classes . . . this year we finally found members of the obscure class Pauropoda in Berlese funnel samples. The arachnid order Solpugida is now known from Guana, as are the very rare primitive mites called Opilioacarida. We also have free-living and insect parasitic nematodes, and a healthy population of small amblypygids from the old stone fencerow by the sand pit. An unexpected bonus was a diverse arthropod fauna in beach sand at or just above high tide level. This yielded a variety of minute new beetles, pill bugs, centipedes, mites, spiders, etc. This miniature ecosystem deserves (and will receive) more work next year. So far, we have looked at only a few samples from North Bay beach. Each sample takes hours of microscopic examination, so the process is exceptionally tedious.

Discovery of the agave weevil, *Scyphophorus acupunctatus* Gyllenhal, on Guana has created a wave of interest. E-mails and requests for more information continue as people see dead agaves on other islands. We suspect the weevil is widespread in the northern Antilles, but have few actual records. Buena has established that the weevils fly, and we are investigating the other insects associated with the killed plants. Summaries of this were mailed to you (Oklahoma address) this past week. Histerid beetles, earwigs, and scoliid and tiphiid wasps are potential biological control candidates. The small parasitic wasps we found probably attack associated fly larvae, not the weevils. Work continues on this. It would be useful to look for and at the weevils on other islands. A long-established population should provide data on biological control. Checking at other times of the year could also be heuristic.

Thanks for all the help, and best wishes to you both.

Sincerely yours,

Barry

Barry D. Valentine
Professor of Zoology, Emeritus

British Virgin Islands: Guana Island. X-2001

Taxa in rotten Agave associated with *Scyphophorus acupunctatus* Gyll.

NEMATODA: several, not identified.

ARACHNIDA:
O Pseudoscorpionida. Two specimens of an unidentified bright pink species were found.
O. Acari. A diverse fauna of mites was extracted with a Berlese funnel. At least 14 families and 16 species are represented by over 700 specimens. At present, 6 families and 2 genera have been named. The identifications continue.

INSECTA:
O. Collembola. At least 3 families of springtails occur; they have not been identified further.
O. Coleoptera. Adults of 4 families of beetles and a variety of very small larvae were present.
F. Hydrophilidae. Two species of terrestrial hydrophilids were present. The larger appears close to *Dactylosternum* and may be a potential biological control agent; the smaller is too small to attack larger larvae and adults, but may eat eggs.
F. Staphylinidae. A single specimen was found.
F. Histeridae. A dozen specimens of *Omalodes laevigatus* Quensel were associated with the weevils. Although they are predators, we did not find evidence of injury to weevil larvae. NOTE: An exotic, larger species, *Plaesius javanus* Erichson, has been used in biological control of closely related weevils in bananas, sugar cane, and pineapples in the West Indies. We saw it in Jamaica. It may be a useful predator.
F. Ptiliidae. Two minute species were present.
O. Blattaria. Black cockroach nymphs were common in the samples, but we do not yet have adults.
O. Diptera. Several families of fly larvae were present and abundant. All appear to be scavengers on the rotting plant tissue.
O. Hymenoptera. Three families of minute parasitic wasps were found.
F Figitidae. Two species of these minute wasps were present. Their hosts are not known, but some other species in the family are known to prefer Diptera larvae.
F. Diapriidae. Winged and wingless specimens occurred, probably the same species. Related species are parasites of Diptera larvae.
F. Unknown. One damaged specimen.

Barry and Buena Valentine
Columbus, Ohio. xii-2001.

To: <bvalentine@core.com>
Subject: weevil
Date: Monday, November 19, 2001 9:33 AM

Thought you might be interested. Eva

From: "Michael A. Ivie" <mivie@montana.edu>
To: caribbean-biodiversity@yahoogroups.com
Subject: [carib-biodiversity] Alien Beetle Invasion on VI Christmas Cactuses
Date: Sat, Nov 10, 2001, 4:41 PM

In fact, this weevil is not a new plague, having been known in the Virgin Islands for several years now. Scyphophorus acupunctatus Gyllenhal is the name of this weevil. I identified the first Virgin Islands specimens, which were discovered by Carlos Robles of the UVI Cooperative Extension Service, in 1994. A native of the US southwest and Mexico, it was introduced into Florida, from where it has spread to the West Indies apparently via uninspected nursery stock. By 1982 it had made it to Cuba, Hispaniola and Jamaica.

Dr. Keularts of the UVI Extension Service, who sent the specimens for identification, alerted authorities of this species' danger shortly after it was first detected on Water Island and St. Thomas in 1984. It seems that no one did anything, and continuing reports of uninspected nursery stock being imported to resorts such as the one on Guana Is. are well known. The West Indian species of Century Plants seem very susceptible to this pest, but particularly in times of drought. In its natural habitat, the weevil hits the plant when it senesces, after flowering. Under that circumstance, this is not a problem for the host because they die then anyway, but in the VI the weevil has been seen to attack plants that have not yet flowered.

Michael A. Ivie, Ph.D.
Department of Entomology
Montana State University
Bozeman, MT 59717

(406) 9.94-4610 Voice
(406) 994-6029 FAX
mivie@montana.edu

Nomenclatural changes for selected Mordellidae (Coleoptera) in North America

John A. Jackman
Department of Entomology
Texas A&M University
College Station, Texas, 77843-2475, USA

and

Wenhua Lu
The Conservation Agency
6 Swinburne Street
Jamestown, RI 02835, USA

Abstract. New nomenclatural changes are presented for selected North American mordellid beetles (Coleoptera: Mordellidae). The following five genera are newly recorded from the United States: *Mordellaria* Ermisch 1950, *Falsomordellistena* Ermisch 1941, *Mordellina* Schilsky 1908, *Mordellochroa* Emery 1876, and *Pseudotolida* Ermisch 1950. The following species are transferred from *Tomoxia* and represent new combinations: *Mordellaria borealis* (LeConte 1862), *Mordellaria fascifera* (LeConte 1878), *Mordellaria latipalpis* (Ray 1946), *Mordellaria serval* (Say 1835), and *Mordellaria undulata* (Melsheimer 1845). The following species are transferred from *Mordellistena* and represent new combinations: *Falsomordellistena hebraica* (LeConte 1862) and *Falsomordellistena pubescens* (Fabricius 1798); *Mordellina blatchleyi* (Liljeblad 1945), *Mordellina pilosella* (Ray 1947), *Mordellina pustulata* (Melsheimer 1845), *Mordellina ustulata* (LeConte 1862), and *Mordellina wickhami* (Liljeblad 1945); *Mordellochroa scapularis* (Say 1824); *Pseudotolida arida* (LeConte 1862), *Pseudotolida knausi* (Liljeblad 1945), and *Pseudotolida lutea* (Melsheimer 1845). *Mordellina ustulata* (LeConte 1862) represents a return to species rank after being treated as a subspecies of *Mordellistena andreae* LeConte 1862. There are a total of 17 genera of Mordellidae in America north of Mexico.

Introduction

The latest revision of the Mordellidae in North America was published by Liljeblad (1945). The latest catalog of North American mordellids was completed by Bright (1986) and was subsequently updated by Jackman (1991) resulting in 12 genera recognized in North America north of Mexico. Jackman (1991) suggested that some of the North American species have not been correctly assigned to genera as European and Oriental authorities understand them. Consequently, we continue to investigate the generic placement of North American mordellids.

Although various authors have added to the work, Franciscolo (1957) prepared the most comprehensive study for the world genera. In this paper we propose nomenclatural changes that are justified based on our current understanding of the genera. The characters used in the key by Franciscolo (1957, 1965, 1967) provide the basis for the nomenclatural changes. We transfer five species from *Tomoxia* to *Mordellaria*. From *Mordellistena*, we transfer two species to *Falsomordellistena*, five species to *Mordellina*, one species to *Mordellochroa*, and three to *Pseudotolida*. Our work increases the number of genera in America north of Mexico from 12 to 17 total. Further study will likely justify additional nomenclatural reassignments.

Mordellaria Ermisch 1950

Mordellaria contains about 14 species in Africa, Japan, Chile, Taiwan, and now North America. No worldwide key to species is available. Takakuwa (1985) provided a key to species in Japan and Taiwan. The keys to species by Liljeblad (1945) and Ray (1946) will separate species in North America even though these species are treated in *Tomoxia*.

Mordellaria has the scutellum triangular or more or less rounded at the apex. Male genitalia of the genus (e.g., Lu et al. 1997) are very different from those of *Tomoxia* redefined by Franciscolo (1982). These characters separate it from *Tomoxia*, which has the scutellum quadrilateral or trapezoidal. Based on these characters, five North American species are here transferred from *Tomoxia*: *Mordellaria borealis* (LeConte 1862); *Mordellaria fascifera* (LeConte 1878); *Mordellaria latipalpis* (Ray 1946); *Mordellaria serval* (Say 1835); and *Mordellaria undulata* (Melsheimer 1845), [NEW COMBINATIONS].

Falsomordellistena Ermisch 1941

Falsomordellistena contains about 25 species and is found primarily in Japan, Taiwan, China, and now North America. Hatayama (1985) provided a key to species in Japan and Taiwan.

Falsomordellistena has the penultimate tarsomeres of the fore and middle legs emarginate, more or less bilobed, and usually dilated; the apical palpomere of the maxilla is securiform or scalene in both sexes; the eyes are small, oval shaped, and sometimes slightly emarginate behind the antenna; eye facets are fine. Based on these characters, two North American species are here transferred from *Mordellistena*: *Falsomordellistena hebraica* (LeConte 1862); and *Falsomordellistena pubescens* (Fabricius 1798), [NEW COMBINATIONS]. Both of the North American species have the elytra patterned.

Mordellina Schilsky 1908

This genus contains about 45 species found in Europe, Africa, China, Japan, Taiwan, and now North America. Ermisch (1968) and Franciscolo (1967) provided keys to African species. Hatayama (1985) provided a key to species in Japan and Taiwan. Batten (1976) provided a key to the species in the Netherlands.

Mordellina has the penultimate tarsomeres of the fore and middle legs transversely truncate at the apex, or very moderately emarginate, neither dilated nor bilobed; the apical palpomere of the maxilla is securiform, scalene, or cultriform, with sharp or sometimes rounded angles in both sexes; the eyes are large, shape unusually broad, emarginate behind the antenna; eye facets are coarse, and never smaller than 0.022 mm in diameter. Based on these characters, five North American species are here transferred from *Mordellistena*: *Mordellina blatchleyi* (Liljeblad 1945); *Mordellina pilosella* (Ray 1947); *Mordellina pustulata* (Melsheimer 1845); *Mordellina ustulata* (LeConte 1862); and *Mordellina wickhami* (Liljeblad 1945), [NEW COMBINATIONS]. This restores species rank to *M. ustulata*, which has been treated as a subspecies of *Mordellistena andreae* LeConte 1862 (Liljeblad 1945).

Mordellochroa Emery 1876

Mordellochroa has at least six species worldwide and is found in Japan, Mongolia, Poland, Hungary, and probably Russia. Batten (1977) provided a key to the Palearctic species, Kaszab (1979) and Horák (1993) provided keys for the species in Hungary, and Borowiec (1996) provided a key to species in Poland.

Mordellochroa has the penultimate tarsomeres of the fore and middle legs transversely truncate at the apex, or very moderately emarginate, neither dilated nor bilobed; the apical palpomere of the maxilla is malleiform in males and securiform or scalene in the females. Based on these characters, one species is here transferred from *Mordellistena*: *Mordellochroa scapularis* (Say 1824), [NEW COMBINATION]. This species has black elytra with humeral spots reddish to yellow and the lateral ridges on the hind tibia quite short.

Pseudotolida Ermisch 1950

Pseudotolida has fewer than 10 species in Japan, China, Taiwan, Guatemala, and Brazil. Franciscolo (1982) provided a key to some species. Shiyake (1995, 1997) compared the genus to other related genera.

Pseudotolida has the penultimate tarsomeres of the fore and middle legs deeply emarginate, more or less bilobed and usually strongly dilated; the apical palpomere of the maxilla is malleiform in males and securiform in females. Based on these characters, three North American species are here transferred from *Mordellistena*: *Pseudotolida arida* (LeConte 1862); *Pseudotolida knausi* (Liljeblad 1945); and *Pseudotolida lutea* (Melsheimer 1845), [NEW COMBINATIONS].

Acknowledgments

We thank Jan Horák for pointing out that *Mordellistena scapularis* (Say) belongs in *Mordellochroa*.

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From: "Rachel Finley"
To: "Wenhua Lu" <wenhua@etal.uri.edu>
Sent: Wednesday, May 22, 2002 2:35 PM
Attach: Guana Exp Transmission.doc
Subject: Re: October Science Month

Skip-
Sorry about the attachment, I always forget to actually add the file.
Any time in October would be good, but if possible I would like to be down for 3 or 4 weeks. This is the only way I can get a good experiment in. Could you accommodate myself and an assistant for most of October? Otherwise, let me know what dates I could come. Again, Lianna probably has room in August if someone would like to go then.
Rachel

> ----- Original Message -----
> **From:** Wenhua Lu
> **To:** Rachel Finley
> **Sent:** Thursday, May 09, 2002 11:12 AM
> **Subject:** October Science Month
>
> Hi Rachel: No attachment. But ok. Just pick any dates in October and let me know ASAP. Best, Skip
>
> Wenhua Lu, Ph.D.
> Oklahoma State University
> Wes Watkins Agriculture Research & Extension Center
> P. O. Box 128
> Lane, OK 74555
> 580-889-7343 (phone) 580-889-7347 (fax)
> 580-364-0543 (home)
>
>> ----- Original Message -----
>> **From:** Rachel Finley
>> **To:** wenhua@etal.uri.edu
>> **Sent:** Wednesday, May 08, 2002 2:58 PM
>> **Subject:** Skip - October Science Month
>>
>> Hi Skip
>>
>> I am interested in coming to Guana's Science Month in October and wanted to know if there was any room available for an assistant and myself?
>>
>> I started working at Guana with Graham Forrester the summer of 2000, and have been working on my Ph.D. dissertation since last summer (I attached the manuscript detailing some of the work from last year). Last year we rented an apartment on Tortola in August allowing me to work after the Marine Science Month ended, but we are a bit short on funds this year. I will be setting up some projects and working in August, but cannot stay on Tortola again. In order to make substantial progress on my dissertation research, it would be great if I could come down in October. Lianna has offered to host and terrestrial scientists that would like to go down in August if it may lighten the burden any.
>>
>> I've attached a copy of the research proposal I wrote for Lianna. We would probably accomplish most of the 'lab' experiments in August and focus on fieldwork in October.
>>
>> Would it be possible for two of us to come down in for the October Science Month? If so, what dates do you have available?
>>
>> I look forward to seeing you again at Guana.

A Comprehensive Experiment of Ectoparasite Transmission in Reef Fish

Infectious diseases are a dominant force impacting the fitness and survival of individuals, in regulating host populations, and structuring communities. The primary focus of infectious disease studies has been on microparasites (viruses and bacteria, *sensu* Anderson & May 1979) and their impact on human health, or on crops and livestock essential to our livelihood (Scott & Dobson 1989); but more recently the focus has broadened to include the ecological impact of macroparasites (i.e. helminthes) on wildlife populations (Grenfell & Gulland 1995; Grenfell and Dobson 1995). Despite the recent interest in studying macroparasites in natural populations, surprisingly few studies look at parasites regulating abundance and distribution of host populations compared to parasitoids and predators (Crawley 1992). Parasites may not be addressed in ecological studies of natural populations because of difficulties in identifying infected hosts in the population, tracking individual hosts spatially and temporally, and manipulating parasite presence and burden. Specifically, techniques that manipulate parasite intensity and prevalence at the population level are confined to lab, or small-scale field studies, and may be restricting the scope of investigations of populations under natural conditions.

In many ecological studies, the impact of predation or competition can be observed by altering the presence, abundance or type of predator or competitor (e.g. Hixon & Carr 1997). In field host-parasite studies, it is often difficult to manipulate the presence or abundance of the parasite. Disinfection of ectoparasites can often be accomplished by hand removal of parasites on individuals (see Arendt 1985; Grutter & Pankhurst 2000 for examples of individual treatment), or using general disinfectants for larger groups. Fumigation of nests and colonies have successfully controlled parasites in bird studies (Brown & Brown 1996; Moss & Camin 1970); and it is common practice to use insecticides in aquaculture and fish farm operations to treat and control the spread of parasites (although these techniques are not applicable to wild fish). Treating endoparasites in wild animals often involves capturing infected hosts and administering anti-helminth drugs individually. This technique has been successfully performed in wild Red grouse populations (Hudson *et al.* 1998), and in free ranging Soay sheep (Gulland *et al.* 1993); however, in both cases the treatment only depressed parasite numbers and did not completely eliminate parasite burden.

Experimental transmission of parasites to healthy individuals is more difficult and rare. Often individual hosts must be anaesthetized and individually infected to establish the infection in a population (in mice Scott 1987, in fish Scott & Anderson 1984). Larger-scale infections (of tens to possibly hundreds of individuals) may be possible in certain systems. For example, Khan (1988) was able to infect groups of cod held in raceways with an ectoparasitic copepod by exposing the cod to lumpfish harboring the larval copepods. And Tompkins *et al.* (2000) were able to control and monitor introduced nematode infections in Grey partridge individuals raised in captivity then released in the wild. An advantage of experimental transmission is that the intensity of infection may be manipulated by varying the exposure time of the host to the infective stage of the parasite. Lemly and Esch (1984) controlled the intensity of trematode infection in bluegill sunfish by varying the time the fish were exposed to snails releasing infective cercaria. The above examples from lab studies provide evidence that it is possible to establish an infection in captive individuals; however, controlled experimental transmission *in situ* has, to our knowledge, yet to be tested

Experimental transmission and disinfection in previous field studies have not tried, or been able to, maintain controlled infections in wild populations in a manner that allows complex ecological questions about host-parasites relationships. Reef fish are often locally abundant, are sedentary or site specific, and do not migrate after settlement into the adult habitat (Sale 1991). Complex and novel ecological questions have been addressed using reef fish; however, parasites are often overlooked or avoided in field studies (Sale 1991; Caley *et al.* 1996). Reef fish and their parasites may offer a system that is easier to manipulate than terrestrial wildlife studies, and questions on how parasites influence host dynamics can be posed. The results of a pilot study conducted this summer offer promise that an ectoparasitic copepod–benthic reef fish relationship is ideal to study the impact parasites have in population dynamics; however, details in of the system need to be worked out before complex interactions can be studied.

A novel system to examine host-parasite relationships

The host-parasite relationship was studied near Guana Island (64° 35'W, 18° 29'N), British Virgin Islands. The bridled goby (*Coryphopterus glaucofraenum* Gill), is a small benthic fish that occurs throughout the Caribbean. A parasitic copepod, *Pharodes tortugensis* Wilson, infects the gill cavity of bridled gobies near Guana Island (R. Finley pers. obs.) and at least 4 other fish species elsewhere (Ho 1971). Gobies infected by *P. tortugensis* have a slower growth rate, reduced fecundity, and suffer from higher mortality than their unparasitized counterparts (Table 1; Figs. 1 & 2; Finley & Forrester *in review*). These results, however, are correlative and do not isolate parasitism as the causal factor creating differences between infected and healthy fish. Some fish may be more susceptible to parasitic infection because of poor health, genetic predisposition, or compromised resistance and would naturally suffer lower fitness regardless of the parasites (Gulland *et al.* 1993; Hudson & Dobson 1995). Isolating parasitism by *P. tortugensis* as the primary factor affecting growth, mortality and fecundity in *C. glaucofraenum* requires a controlled experimental infection of healthy gobies, with comparisons between the control and treatment group.

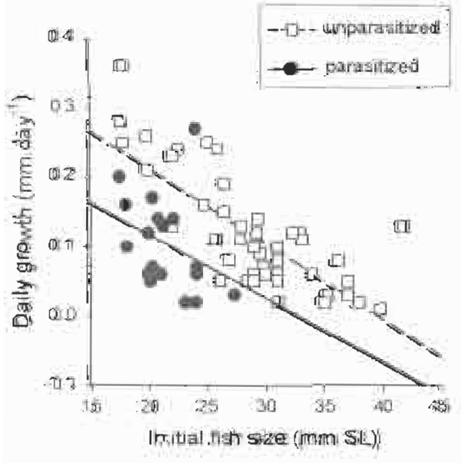

Fig. 1. Growth rates of tagged unparasitized and parasitized gobies recaptured on 24 August 2001. Growth rate was significantly faster in unparasitized than in parasitized gobies, and was dependent on the size of the fish at tagging.

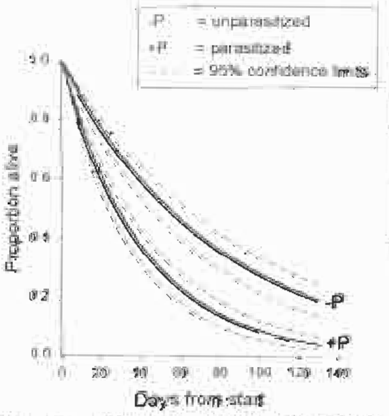

Fig. 2. Survival curves for gobies parasitized some or all of the time (y = $^{-0.024x}$), and for gobies never parasitized $y = e^{-0.013x}$).

The goby-copepod relationship may be ideal to study host parasite interactions and answer ecological questions on the impact of parasites to host populations for several reasons. *C. glaucofraenum* are benthic, sedentary fish that have a relatively short life span, allowing individual fish to be monitored for a large portion of their lives. Gobies infected with *P. tortugensis* have a swollen operculum and are easily recognized in the field. Furthermore, the fish and can be individually tagged so that the fate of parasitized and healthy fish can be followed (Malone *et al.* 1999). These fish have been used successfully in many other manipulative studies (e.g. {Forrester 1995,1999; Steele et al. 1998; Malone et al. 1999; Forrester & Steele 2000; Steele & Forrester in press) and are an excellent model organism to address questions that are of interest to ecologists.

Although the complete lifecycle of *P. tortugensis* is unknown, there is a general trend in parasitic copepods for a reduction in the number of naupliar stages, and to infect a fish host in the first copepodid stage {Kabata 1981}. No naupliar stages of *P. tortugensis* have been observed on the gills of infected fish (pers. obs.), and there is a range of sizes in the copepods found on the fish gills. The size of copepods (not including transformed females) ranged from 0.29 mm wide (cephalathorax width) by 0.34 mm long (cephalathorax and genital segment), to 0.91 mm wide by 1.04 mm long. It is very likely that *P. tortugensis* becomes infective after metamorphosis from the naupliar to the copepodid stage, then progresses through the rest of the copepodid molts and into adulthood as a resident on the fish (see Kabata 1981 for examples of other parasitic copepods). Parasitized *C. glaucofraenum* are aggregated in distribution within the population (R = 0.90; z = 2.65; Clark and Evans 1954 nearest neighbor method (Krebs 1999)). Therefore, there is a strong possibility that parasites are transmitted directly from parasitized gobies to uninfected gobies by a brief, dispersive, naupliar stage.

P. tortugensis, negatively affects the fitness of *C. glaucofraenum* and is found at a relatively high prevalence in the population (ranging from 2-19%): density and prevalence of *P. tortugensis* in the population of *C. glaucofraenum* around Guana may be correlated ($r = 0.62$, $p = 0.06$). Most infected fish were large juveniles and females (16-30 mm SL) with mean infection intensity of 7.02 copepods (range = 1-19). The frequency of infection intensity with host size was negative binomial distributed ($\chi^2 = 15.69$, df = 16, $n = 118$). Similar to other parasitic manipulation studies, we can remove parasites from infected fish by applying a general disinfectant to fish held in aquaria; but more interestingly, we may be able to infect healthy fish.

Table 1. Behavior and fecundity of parasitized and unparasitized gobies. Presented are means (± SD) and results of *t*-tests comparing the two groups.

	Parasitized	Unparasitized	*t*-test
Feeding (bites 30 s^{-1})	2.8 ± 2.7	4.5 ± 3.6	$df = 67$, $t = 2.208$, $p = 0.031$
Respiration (gill ventilations 30 s^{-1})	48.7 ± 14.1	29.4 ± 8.2	$df = 67$, $t = 6.938$, $p < 0.001$
Fecundity (gonad dry weight mg)	0.2 ± 0.1	0.63 ± 0.5	$df = 28$, $t = 4.065$, $p < 0.001$

Experimental transmission of **P. tortugensis** *to* **C. glaucofraenum**

Identifying the transmission dynamics of the parasite, and how hosts become infected, is central to understanding the epidemiology of the parasite and the first step discovering how the parasite may be able to regulate host population dynamics. Aside from the well known Red grouse - nematode system studied by Hudson and colleagues (Hudson *et al.* 1992; Dobson & Hudson 1992; Hudson *et al.* 1998), field studies investigating the population level impacts of parasites to their hosts are rare: leading to a lacuna in the field of epidemiology for macroparasites in natural populations. A possible reason for the paucity of manipulative experiments in host-parasite studies may be due to the difficulty in establishing and maintaining infections in controlled conditions. The goals of this proposal are to:

Goal 1: Determine if a parasitic infection can be experimentally established in healthy fish.

Goal 2: Determine if experimental populations of healthy and parasitized *C. glaucofraenum* can be established and maintained in the field.

Goal 3: Compare experimentally and naturally parasitized fish.

Parasite Transmission Experiment

Experimental transmission of *P. tortugensis* to *C. glaucofraenum* will initially be tested in the laboratory. By performing the experiment under controlled conditions, we can monitor the individuals and look for changes in infection status on a finer time scale (observations made multiple times a day) than can be achieved in a field experiment alone (at best, observations made daily).

Parasitized and healthy fish 16-30 mm SL (the size range of fish commonly infected -- Finley & Forrester *in review*) will be collected from reefs near Guana Island using hand nets and SCUBA, and housed in running seawater tanks on the island. Fish that appear to be healthy will be treated with CopperSafe® aquarium disinfectant for 5 days prior to the experiment to ensure that they are not harboring a low parasite burden or small, undetected copepods. Disinfection of *C. glaucofraenum* parasitized by *P. tortugensis* was successful with CopperSafe® in a pilot study. Only parasitized fish carrying gravid female copepod will be used in the treatment; parasitized fish carrying gravid copepods can easily be identified without harming the host. All fish will be tagged individually (using a visual implant tag, or a unique combination of paint injections -- see Malone *et al.* 1999 for techniques) to track parasite acquisition in the healthy fish, and the status of copepod eggs on the parasitized fish (i.e. whether the copepods have hatched or are still in ova). While the fish are held in aquaria they will be fed *ad libum* daily either a commercial fish food or, when possible, microcrustaceans collected from the field.

Experimental treatment will be randomly assigned to 20 tanks: infection tanks will pair healthy fish with infected fish to facilitate parasite transmission, while control tanks will contain only healthy fish. There will be equal numbers of fish in each treatment tank. Each tank will receive its own water source, with seawater continuously flowing through the tank. Parasitized fish will be examined daily to determine when copepods are released and potentially infective; healthy fish will be examined daily for signs of infection. If a parasitized fish dies during the experiment it will be replaced by a similarly sized parasitized fish. Alternatively, if a healthy fish dies it will immediately be examined for signs of infection and will be replaced only if it *did not* contain parasites (e.g. parasite-induced death was not apparent). The experiment will be terminated when half of the healthy fish (in the infection tanks) show signs of parasitic infection. Upon termination of the treatments, all fish will be dissected and inspected for parasites and the size and status (transformed female, or untransformed male or female) of copepods determined.

The results of the lab experiment will be interpreted as follows: If healthy fish become infected in the parasite treatment tanks, and no fish in the control treatment become infected, then direct transmission from parasitized to unparasitized fish is presumed. Alternatively, if uninfected fish in both the treatment and control tanks become infected then direct transmission and indirect transmission from a planktonic source could be possible. If healthy fish in either treatment fail to become infected, then the transmission route is unclear.

In addition to incorporating the results of the lab experimental transmission, the field experiment will assess the feasibility of establishing parasitized and control groups in the field for larger scale studies. The field experiment will have the same treatment arrangement as in the lab (treatment = healthy and parasitized fish; control = only healthy fish), but the fish will be stocked on artificial reefs constructed in sandy areas near Guana Island. Using a technique similar to Forrester (1995, 1999) we will create multiple patch reefs separated from each other and nearby reefs by at least 10 m of sand. The gobies will be stocked at densities higher than the average, but within the range normally found on the nearby reefs. As in the lab experiment, healthy fish will be disinfected with CopperSafe® and all fish will be tagged as individuals. Each patch reef will be inspected daily for mortality or disappearance of individuals, but fish will only be captured on a weekly basis to inspect for parasites. As fish can only be hand netted, and all work must be performed on SCUBA, it will be impossible to assess the infection status of individuals on a time scale shorter than weekly. The relative density of fish between treatments will be maintained: e.g. healthy fish will be added to control or treatment reefs if a substantial number disappear from a reef, and parasitized fish will be added if all disappear from a treatment reef.

The results of the field experiment will be interpreted as follows: the experiment will be ranked *successful for establishment and maintenance of parasitized and healthy goby populations* if the majority of fish on the control reefs remain parasite free and the majority of healthy fish on the treatment reefs contract parasites. The experiment will be ranked *successful for maintenance of healthy goby populations* if the majority of fish on control reefs remain parasite free even if healthy fish on treatment reefs remain uninfected. The experiment will be *ranked unsuccessful* if the majority of fish on control reefs become infected and fish on treatment reefs remain uninfected.

The final goal of this proposal is to compare "experimentally" infected fish with fish that have been "naturally" parasitized. Our previous study (Finley and Forrester in review) demonstrated that parasitized fish suffer a lower growth rate and reduced gonad mass than healthy fish; however, these results were only correlative and parasitism could not be isolated as the causal factor creating the observed differences. Groups of experimentally infected and naturally infected gobies will be tagged and followed for several weeks in the field and lab to determine if differences in the two groups are inherent characters of the fish or are explicitly a result of the parasitic infection. We may also be able to determine if some fish are more susceptible to parasitic infection or more likely to die as a consequence of the infection (e.g. test for a size/parasitic status interaction).

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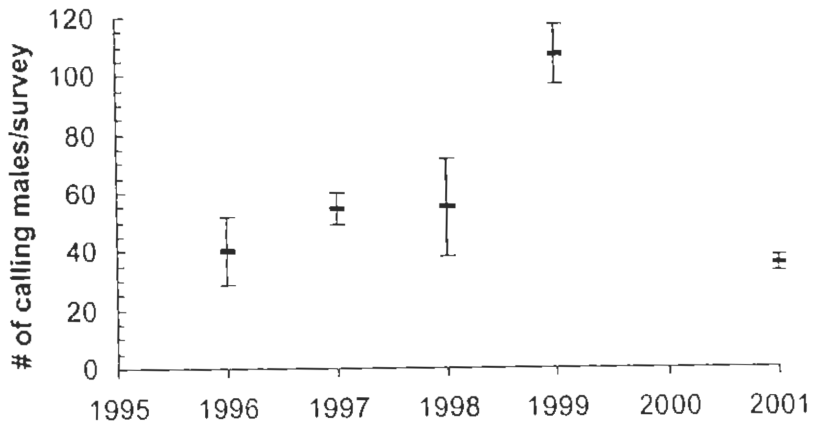
From: <kovaska@jdmicro.com>
To: "Wenhua Lu"
Sent: Tuesday, March 26, 2002 8:24 PM
Subject: Guana report 2001

Skip:
Thanks for the reprint. As to this year's Guana report, we focused on surveys of the call transects. You could include the figure of the call-counts from the book chapter. Our other focus, locating nests & females, didn't work out too well because of the dry weather (only 1 courtship & egg mass located). We did, however, get good temperature data at the nest site. So, you could say that we continued locating egg-masses as a part of study on reproductive behavior of the frogs...
Cheers,
Kristiina

Figure 1. Number of calling males detected during surveys of a transect (825 m long; 10 m wide) on Guana in October of 5 years from 1996 to 2001. Only surveys within less than 24 hours since rainfall are included. Horizontal bar – mean; whisker – 2 SE; n = 4, 2, 3, 5, 3 surveys for the 5 years, respectively.



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A Population Study of *Anolis cristatellus wileyae* from the British Virgin Islands and Their Phylogenetic Relationships to Other Selected Anole Species as Determined by Amplified Fragment Length Polymorphism (AFLP) Analysis

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I. Background Information

A. General Information

Anoles (Sauria: Iguanidae) are tropical lizards. There are approximately 140 recognized Caribbean species, with 111 of those occurring in the Greater Antilles (Cuba, Jamaica, Hispaniola, and Puerto Rico). As many as eleven species are found to occur syntopically, i.e. in the same habitat (Jackman *et.al.*, 1999).

As a genus, *Anolis* has been divided into two groups: the alpha and beta anoles. This division, which occurred early in the radiation of anoles, is based on the presence or absence of a transverse process on the anterior caudal vertebrae. Alpha anoles lack this process whereas in the beta group it is present (Williams 1969). The division of *Anolis* into several genera by Guyer and Savage (1986) has not been generally accepted (Williams, 1989; Cannatella & de Queiroz 1989).

Anoles display a suite of correlated morphological and ecological characteristics. The correspondence between morphology and niche is denoted by the term "ecomorph". Ecomorphs have been named primarily on the basis of perch site. The most important ecomorphic niches are the following: grass-bush, trunk-ground, trunk, twig, trunk-crown, and crown-giant. Among the morphological features correlated with the niche are coloration, number of toe pad lamellae, body size, body shape, and the lengths of the forelimb, hindlimb, and tail relative to body size (Beuttell & Losos, 1999).

B. Distribution Factors

There are three major modes by which anoles have occupied their current geographic distribution: vicariance, dispersal, and human introduction. In vicariance, organisms are found to occur on multiple landmasses because they occurred previously on a single, larger land mass that broke apart into two or more pieces. This occurs, for example, when ocean levels rise or fall, flooding or exposing low-lying ground. Many Caribbean islands are separated by shallow ocean. If the water level fell about 120m, as during the last glacial maximum period, multiple islands could become one island, and the converse would occur when levels rise.

Secondly, the dispersal ability of a species affects its distribution. To reach new areas, species often have to cross physical or climatic barriers. In the Caribbean, the major physical barrier is the ocean. Dispersal across the ocean could occur during hurricanes blowing between islands, or by floating on debris across the water. To colonize these new areas, the organism would need to adapt to any environmental difference present between the previous habitat and the new one. Changes can include vegetation, rainfall, competition, and food sources.

Lastly, human introduction in the last 150 years has spread anoles to many places outside their natural ranges. This can occur accidentally or intentionally.

C. Speciation and the Anole Radiation

Competition can be a strong influence in speciation. It forces adaptation or extinction. This competition can be among anoles or with other organisms occupying the same niche. Among anoles, this has resulted in differential environmental use; for example, differential perch height. Thus, the ecomorphic groups mentioned above are generated.

Geographic isolation also encourages differentiation. Gene flow is retarded; additionally selection pressures may differ between locations. For example, *A. cristatellus cristatellus* on Puerto Rico, with time and geographic isolation, gave rise to *A. cristatellus wileyae* on the small eastern islands of the Puerto Rican Bank. Further isolation within these islands resulted in *A. ernestwilliamsi* on Carrot Rock, British Virgin Islands. Through a long distance colonization event, *A. cristatellus* gave rise to *A. scriptus* of the southern Bahamas. Colonizing groups, or propagules, are typically small. Genetic changes that occur may become rooted in the population more easily during these bottleneck times.

Based on morphological and molecular data, anoles diversified early and rapidly in their history (Jackman *et.al.*, 1999). This introduces and increases difficulty in attempting to estimate the anole phylogenetic tree. The deep branching is problematic to sort out because many branchings occurred at roughly the same time. Superficial morphological features are not always helpful. Island and mainland (South/Central America) anoles have different adaptive features and mainland anoles do not exhibit the same ecomorphic specializations as island anoles. Additionally, molecular data indicates anoles of a single island are more closely than anoles of different islands that occupy the sample ecomorphic niche. For example, a trunk-ground anole on Jamaica would be more closely related to the other anoles of Jamaica than to trunk-ground anoles of other islands. This indicates that the ecomorphic specializations observed arose multiple times in anole history.

Previous work conducted using DNA:DNA hybrization (Mayer & Kirsch, 1999) and a combination of morphological and mtDNA sequence data (Jackman *et.al*, 1999) has not succeeded in resolving the deep branches. However, these methods have had success with the more recent divergences.

II. Sample Collection

Gregory Mayer collected *Anolis leachii, A. grahami,* and *A. extremus* samples on Bermuda in 1999. Arijana Barun (UW-Madison), James Lazell (Conservation Agency, Rhode Island), and Gad Perry (UW-Madison) collected *A. cristatellus wileyae* from Guana Island, Norman Island, and Necker Island, British Virgin Islands, in 2000. With help from Arijana Barun, Kate LeVering (UW-Madison), Gad Perry, and Wenhua Lu (University of Rhode Island), I collected *A. cristatellus wileyae*, *A. stratulus*, and *A. pulchellus* from Gauna Island, British Virgin Islands. Table 1 describes the species and locations collected from, as well as the height above sea level for some Guana Island locations. Figure 1 graphically depicts the locations of *A. cristatellus wileyae* collection. Other species available include *A. ernestwilliamsi*.

Samples are stored either frozen at -70°C or in 95% ethanol. For ethanol-stored samples, tissue was dissected out (heart, liver, muscle, gonads) for storage in ethanol-filled vials. Each individual collected in the British Virgin Islands has a catalog number for identification.

III. Research Goals

There are several goals; they are listed and described below in priority order. Astime has become limited, the last two goals listed will be met as time allows or passed on to someone else to accomplish.

1. To complete a population study of *A. cristatellus wileyae* on Guana Island, British Virgin Islands. Researchers at UW-Madison (Gad Perry) and Tel-Aviv University (Razi Dmi'el), with collaborators, have found differences in the evaporative water loss characteristics of *A. cristatellus wileyae* collected from parts of Guana Island, British Virgin Islands, which vary in altitude (personal communication). As in previous studies between islands (Dmi'el *et.al.* 1997; Perry *et.al.* 1999; Dmi'el 2001), data collected were not able to determine if the source of this effect was due to a genetic difference or phenotypic plasticity. *A. cristatellus wileyae* for this study have been collected from four altitudes for this study to aid in discerning the two.

2. To compare Guana Island, British Virgin Islands, *A. cristatellus wileyae* to *A. cristatellus wileyae* from other islands and *A. ernestwilliamsi* for genetic difference. *A.*

cristatellus wileyae from islands both relatively near and far were collected to determine if there was a significant genetic difference between them. The populations are geographically isolated from each other, which, combined with the differences between the islands, may be undergoing a divergence from the other populations. Previous work (Perry *et.al.* 1999; Dmi'el 2001) has shown integumentary resistance to water loss to be positively correlated to the aridity of the environment for eight *A. cristatellus wileyae* polulations and one *A. ernestwilliamsi* population; it is unclear as to whether this effect is due to genetic factors, phenotypic plasticity, or a combination of both. Samples collected for use here represent five of eight *A. cristatellus wileyae* populations and the *A. ernestwilliamsi* population sampled by Perry and Dmi'el.

3. To deduce whether beta anoles are more closely related to alpha anoles from the Caribbean islands or from mainland (South/Central America) alpha anoles. The beta anoles are represented by *A. grahami* and the island alpha anoles by *A. leachii*. The mainland alpha anoles are represented by the island anole *A. extremus*, which is closely related to some mainland alphas. With this information, the colonization pattern of the beta anoles around the Caribbean can be examined. While *A. leachii, A. grahami,* and *A. extremus* were collected on Bermuda, they were introduced to that island and are native to Antigua, Jamaica, and Barbados, respectively.

4. To contribute to the known body of information by attempting to more clearly define the deep, unresolved branches of the *Anolis* phylogenetic tree. While some recently diverged groups are well supported, the deeper branches are not. With this new method application (AFLP), maybe some of those questions can be answered, or at least addressed.

IV. Methods

A. DNA Extraction

Phenol:chloroform extraction proceeded as follows: 15-20mg of tissue were minced and digested for at least four hours at 55°C in 500μl TNE [0.01M Tris, 0.1M NaCl, 0.01M EDTA], 50μl SDS (10% w/v), and 20μl proteinase K (10mg/ml). Samples were treated with Rnase A (20mg/ml) and allowed to stand at room temperature (25°C) for two minutes. Then, an equal volume of phenol was added and mixed for five minutes, followed by centrifugation at 10,000 rpm for five minutes. The aqueous layer was transferred to a fresh microfuge tube. Next, a half volume each of phenol and chloroform was added and mixed for five minutes, followed by centrifugation at 10,000 rpm for five minutes. The aqueous layer was transferred to a fresh microfuge tube. An equal volume of chloroform was added and mixed for five minutes, followed by centrifugation at 10,000 rpm for five minutes. The aqueous layer was transferred to a fresh microfuge tube. The DNA was precipitated by the addition of two volumes of ice-cold ethanol and overnight storage at -20°C. Lastly, the sample is centrifuged for fifteen minutes at 14,000 rpm, the alcohol poured off, and the pellet drier for about fifteen minutes. The pellet was rehydrated in 100μl TE [0.01M Tris, 0.001M EDTA] and stored at -20°C.

B. Amplified Fragment Length Polymorphism (AFLP)

The AFLP method (Vos *et.al.*, 1995) was selected for several reasons. First, no information about the sequence of the organism is required. While there is some sequence information available (ie. via GenBank), the genes sequenced have not had success defining the deeper branches. Next, there are three major fingerprinting methods: AFLP, RFLP (random fragment length polymorphism), and RAPD (randomly amplified polymorphic DNA). Of those, AFLP has been shown to have the greater reproducibility when compared to RAPD, when excluding the largest and smallest 10% of bands, and bands showing less than 1% of the total lane intensity when employing a fluorescence-based DNA detection method. The band exclusion criteria resulted in nearly 100% reproducible AFLP bands, but did not significantly increase RAPD reproducibility, which showed 15% of the segregating bands non-reproducible (Bagley *et.al.*, 2001).

Additionally, AFLP has been employed successfully in reptile species. Giannasi, Thorpe, and Malhotra (2001) used the technique on the Asian snake *Trimeresurus albolabris* at the species and population levels, using fewer individuals from each location than have been collected for use here (except *A. leachii* and *A. extremus*). Additionally, Ogden and Thorpe (2002) have successfully used AFLP within the genus *Anolis* to assess divergence at four graduated taxonomic levels, some of which correspond to levels examined here.

RFLP analysis usually involves transfer of restriction cut DNA onto a membrane for Southern blotting. This requires a probe for a useful sequence and further time for development. The AFLP technique does not require such a lengthy time investment. The AFLP kit arrives with 16 primers providing 64 possible combinations.

AFLP System I was selected from Invitrogen – Life Technologies (catalog #10544013). It is for use with large genomes ($5x10^8$ - $6x10^9$ bp). Genome size was calculated based on C-values provided by T.R.Gregory (2001). The values listed for anoles were averaged with an average C value of 2.12. Using the conversion factor 1pg = 10^9bp, the average genome size of anoles is $2.12x10^9$bp.

A graphic representation of the AFLP process is depicted in Figure 2. AFLP begins with the restriction cutting of genomic DNA. Two enzymes are used, one rare cutter (*Eco*RI, 6 base recognition sequence) and a frequent cutter (*Mse*I, 4 base recognition sequence). The DNA is digested for two hours at 37°C, the enzymes inactivated by 70°C heat exposure for fifteen minutes, and then placed on ice. Three classes of fragments are generated, in order of frequency: *Mse*I-*Mse*I > *Mse*I-*Eco*RI > *Eco*RI-*Eco*RI. Next, adapters are ligated to the restriction sites with the addition of adapter/ligator sequences and T4 DNA ligase. The reaction is incubated at 20°C for two hours, then diluted 1:10 reaction:TE. The adaptors consist of an enzyme-specific sequence and a sequence serving as a primer-annealing site.

Processing continues with two PCR steps. The first is pre-selective amplification in which the *Mse*I-*Eco*RI fragments are preferentially amplified based on primer composition and PCR strategy. The *Mse*I primer has a lower annealing temperature than the *Eco*RI primer, resulting in less efficient amplification of *Mse*I-*Mse*I fragments under these PCR conditions as compared to *Mse*I-*Eco*RI fragment amplification (Vos *et.al.*, 1995). Ligated and diluted DNA serves as the template. PCR proceeds with *Taq* polymerase for 20 cycles: 30s denaturing at 94°C, 60s annealing at 56°C, and 60s elongating at 72°C. Following the confirmation of amplified DNA in the form of a smear on an agarose gel, the PCR product is diluted 1:50 in TE.

The second PCR conducted amplifies a subset of the fragments amplified in the previous PCR. This is accomplished by using primers with three selective nucleotides past the restriction site. The first PCR cycle runs 30s at 94°C, 30s at 65°C, and 60s at 72°C. Then, during the next 12 cycles, the annealing temperature is lowered by 0.7°C each cycle. The last 23 cycles run 30s at 94°C, 30s at 56°C, and 60s at 72°C.

Samples are now ready for gel analysis. For each primer pair, 50 – 100 bands are produced, with bands varying between primer pairs. More or less than this range of bands may be produced, with GC content of the selective nucleotides influencing this number; in general, higher GC content results in fewer bands amplified.

AFLP product is analyzed on a 6% denaturing polyacrylamide gel in a Bio-Rad sequencing gel rig (21 x 40 cm).

C. Visualization: Silver Staining

There are several methods available for visualizing DNA on polyacrylamide gels, including radiography, colorimetry, fluorescence, and silver staining. Silver staining has been selected for use for the following reasons. First, there are no radioactive chemicals or substances involved. Second, solutions can be produced in the lab economically. The protocol employed here was modified from Bassam *et.al.* (1991) by Pham (2001), and has demonstrated detection sensitivity down to 1pg/mm^2. The required DNA quantity for visualization with this protocol increases to 5-10pg/mm^2 for fragments smaller than 310bp (Bassam *et.al* 1991). The protocol is attached as Appendix A.

See Figure 3 for an example of a silver stained gel. The gel shows AFLP-processed DNA from and iguana (II1B3-26A, *Iguana iguana*) and two *A. cristatellus wileyae* individuals (AC1B3-26A, AC2B3-26A) from Guana Island, British Virgin Islands, where one has had slightly different restriction enzyme treatment (AC1B2-26A). Each sample was selectively amplified with the same primer pair (#26, E-AAG and M-CAT).

V. Data Collection & Storage

Data will be collected in a matrix/spreadsheet as the presence or absence of a band at each position using a binary scoring scheme where 0 represents a lack of a band and 1 represents the presence of a band. One or both of an *Iguana iguana* (common iguana) sample or a Guana Island, British Virgin Islands, *A. cristatellus wileyae* (hotel area) will be run on each gel to provide a standard for comparison, as well as an AFLP DNA ladder (Invitrogen – Life Technologies, catalog #10832012). The DNA ladder has bands at 30 bp to 330bp, with bands in between every 10bp, and at 1,668bp. Based on work by Bagley *et.al.* (2001) involving the exclusion of the largest and smallest 10% of bands and bands showing less than 1% of total intensity, we intend to include a data filter, though the criteria are not yet set. The exclusion criteria used in the work of Bagley *et.al.* (2001) were developed for use with fluorescien-labeled PCR primers, or fluorescent DNA detection. These criteria have proven to be too strict for the silver staining method of DNA detection employed here (data not shown). Gels are scanned using a flatbed scanner (Plustek, Optic Pro 9630P) to preserve them for analysis and review after the physical gel is destroyed. Adobe Photoshop may be used to adjust brightness and contrast. Gels are analysed using Gene ImagIR 4.03 (Scanalytics Inc., Fairfax, VA). Band detection proceeds using a combination of computerized and manual band calling.

VI. Data Analysis

After collection, data can be analyzed using the computer programs such as Paup, MacClade, or Phylip. Distance trees will be produced, as well as trees constructed using parsimony schemes and bootstrapping. Mean average percent difference (MAPD) between species and populations can be calculated, as were performed using RFLP data by Hendrickson (1995).

VII. Future Work

Future work in this area could proceed in many directions, in addition to any goals listed above; for example, sequencing the mitochondrial NADH dehydrogenase, subunit II, gene in *A. leachii, A. extremus,* and *A. ernestwilliamsi.* This would allow the integration of these species in to the larger phylogenetic tree built by Jackman *et.al.* (1999), as well as allow comparison with the many species for which the same sequence is deposited in the GenBank database (National Center for Biotechnology Information, http://www.ncbi.nlm.nih.gov/). Ogden and Thorpe (2002) have found that AFLP data to be "remarkably congruent" to that obtained from mitochondrial DNA, microsatellite, and morphological markers; conducting an AFLP study with species previously examined would more clearly define the degree of congruity.

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Table 1. Sample Collection Summary.

Species	Island	Locality	Number	Altitude
Anolis cristatellus wileyae	Norman Island, BVI	n/a	13	n/a
Anolis cristatellus wileyae	Necker Island, BVI	n/a	14	n/a
Anolis cristatellus wileyae	Tortola, BVI	n/a	9	n/a
Anolis cristatellus wileyae	Beef Island, BVI	n/a	19	n/a
Anolis cristatellus wileyae	Guana Island, BVI	Hotel Area	36	100m
Anolis cristatellus wileyae	Guana Island, BVI	1/2 up main road	5	40m
Anolis cristatellus wileyae	Guana Island, BVI	Whitebay Flat	10	0m
Anolis cristatellus wileyae	Guana Island, BVI	Plantation Area	7	0m
Anolis cristatellus wileyae	Guana Island, BVI	Bat Cave	10	150m
Anolis cristatellus wileyae	Guana Island, BVI	Muskmelon Bay	12	0m
Anolis cristatellus wileyae	Guana Island, BVI	Longman Point	6	??
Anolis cristatellus wileyae		**Total**	**141**	
Anolis stratulus	Guana Island, BVI	various	19	n/a
Anolis stratulus		**Total**	**19**	
Anolis pulchellus	Guana Island, BVI	various	13	n/a
Anolis pulchellus	Tortola, BVI	n/a	2	n/a
Anolis pulchellus		**Total**	**15**	
Anolis leachii	Bermuda	Barnes' Corners	2	n/a
Anolis leachii	Bermuda	Mangrove Bay	1	n/a
Anolis leachii	Bermuda	Sea Swept Farm	1	n/a
Anolis leachii		**Total**	**4**	
Anolis grahami	Bermuda	Nonsuch Island	7	n/a
Anolis grahami	Bermuda	Sea Swept Farm	1	n/a
Anolis grahami	Bermuda	Tucker's Town	2	n/a
Anolis grahami		**Total**	**10**	
Anolis extremus	Bermuda	Mangrove Bay	2	n/a
Anolis extremus	Bermuda	Naval Dockyard	2	n/a
Anolis extremus		**Total**	**4**	
Anolis ernestwilliamsi	Carrot Rock, BVI	N/a	2	n/a
Anolis ernestwilliamsi		**Total**	**2**	

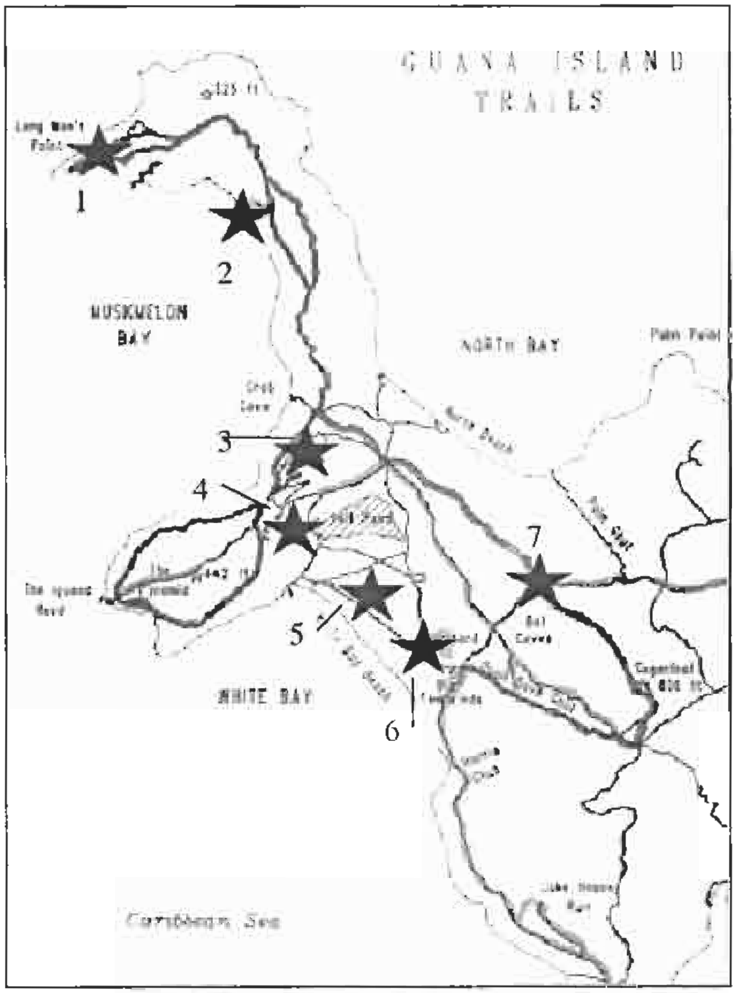

Figure 1. Graphic depiction of locations of *Anolis cristaellus wileyae* collection sites on Guana Island. 1=Longman Point, 2=Muskmelon Bay, 3=Hotel Area, 4=Halfway up the main road to the hotel, 5=Whiteflat Bay, 6=Plantation Area, 7= Bat Cave/Confluence of Red & Blue Trails. See Table 1 for site altitudes.

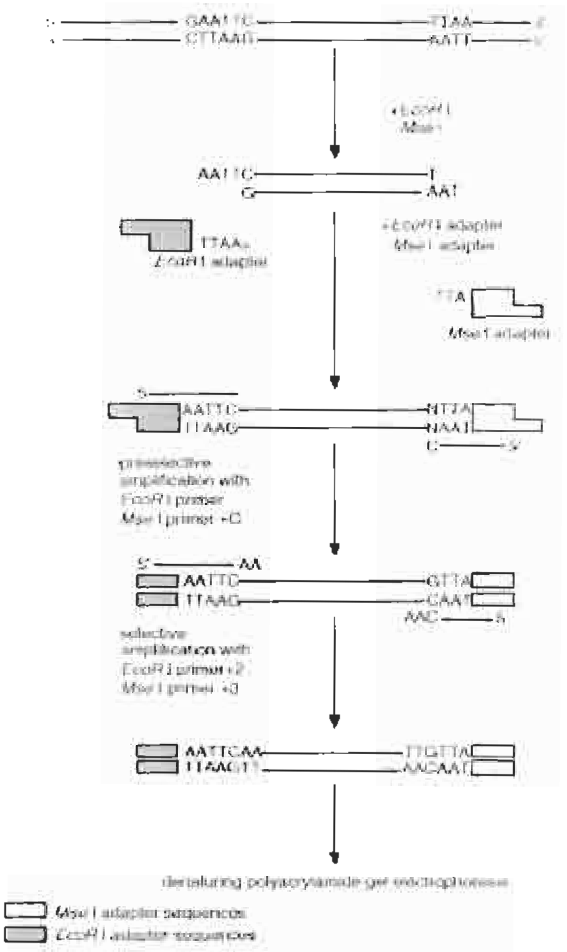

Figure 2. Graphic Representation of AFLP Technique. Taken from the AFLP System I (Invitrogen – Life Technologies) instructional literature.

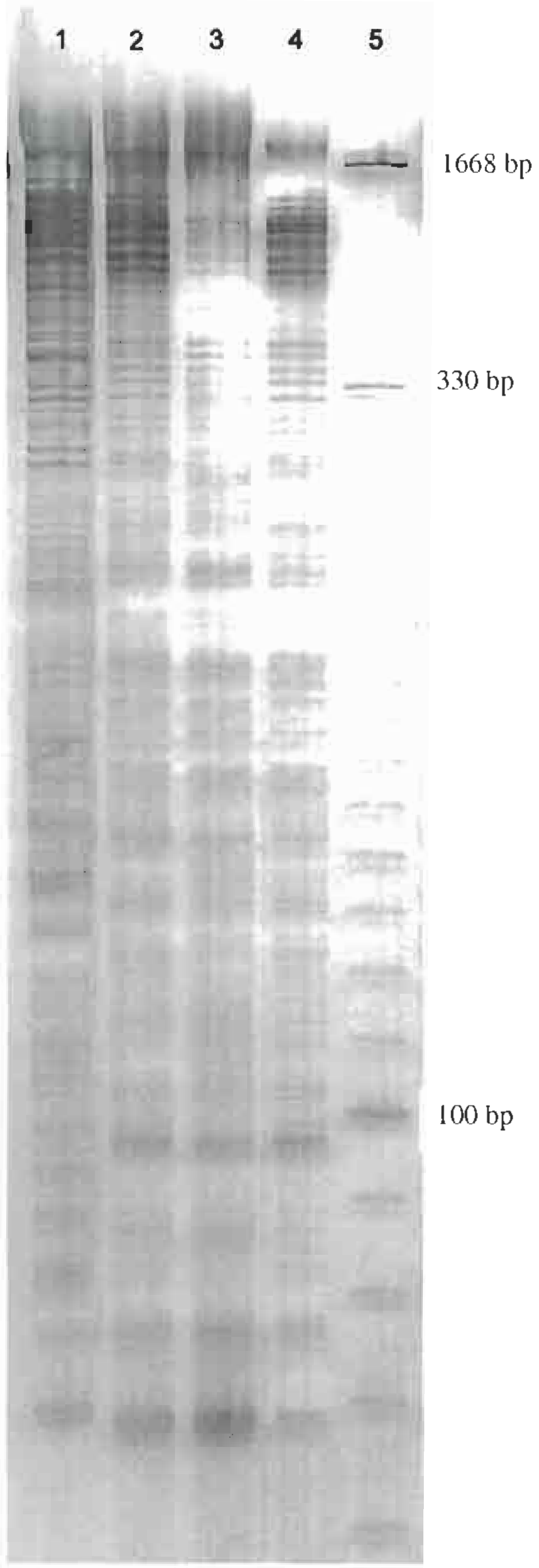

Figure 3. Silver Stained AFLP Denaturing PAGE gel. Lane 1: II1B3-26A, Lane 2: AC1B3-26A, Lane 3: AC2B3-26A, Lane 4: AC1B2-26B, Lane 5: AFLP Marker (Invitrogen Life Technologies).

Appendix A: Silver Staining Protocol

Solutions Required:

*Add any formaldehyde & sodium thiosulfate immediately before use

Solution Name	Volume
1. Fixing & Stopping Solution	**1000 ml**
a. 95% (v/v) ddH_2O	950 ml
b. 5% (v/v) Reagent Grade Acetic Acid	50 ml
2. Staining Solution	**1000 ml**
a. 99.9% (v/v) ddH_2O	999.0 ml
b. 0.1% (m/v) silver Nitrate	1.0 gm
c. 0.056% (v/v) Formaldehyde (HCOH)	1.5 ml
3. Developing Solution**	**1000 ml**
a. 97% (v/v) ddH_2O	970 ml
b. 3% (m/v) Sodium Carbonate (Na_2CO_3)	30.0 gm
c. 0.056% (v/v) Formaldehyde (HCOH)	1.5 ml
d. 0.2% (v/v) 10 mg/ml Sodium Thiosulfate ($Na_2S_2O_3*5H_2O$) [99% ddH_2O + 1% Sodium Thiosulfate]	0.2 ml (200 μl) [10ml ddH_2O + 0.1gm Sodium Thiosulfate]

**Keep in ice bath < 10°C to keep ready for use.

Directions:

1. Submerge gel in Fixing Solution at room temperature (RT) for 150 minutes, or until the tracking dye fades away. Prepare & refrigerate Developing Solution.
2. Rinse at RT in ddH_2O 2-3 times for 5 minutes each.
3. Submerge gel in Staining Solution at RT for 30 minutes.
4. Rinse both sides of plate at RT in ddH_2O for < 5 seconds.
5. Submerge gel in Developing Solution at 4-8°C.
   a. Submerge in first half of solution for ~2 minutes, shake vigorously to prevent settling of silver particles, and maintain liquid swirling.
   b. Submerge gel in second half of solution, keep swirling, and monitor for < 8 minutes. Add Stop Solution before completely developed; developing continues for a short time.
6. Submerge gel in Stop Solution at RT for < 5 minutes.
7. Rinse in ddH_2O at RT up to 1 hour (3 rinses usually sufficient).
   a. Change water every 10 minutes.

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Journal of Tropical Ecology (2001) 17:331–338. With 1 figure

SHORT COMMUNICATION

The densest terrestrial vertebrate

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KEY WORDS: absolute population density, British Virgin Islands, community ecology, geckos, leaf litter, lizards, removal sampling, *Sphaerodactylus macrolepis*

An understanding of the abundance of organisms is central to understanding ecology, but many population density estimates are unrepresentative because they were obtained from study areas chosen for the high abundance of the target species. For example, from a pool of 1072 lizard density estimates that we compiled from the literature, we sampled 303 estimates and scored each for its assessment of the degree to which the study site was representative. Less than half (45%) indicated that the study area was chosen to be representative of the population or habitat. An additional 15% reported that individual plots or transects were chosen randomly, but this often indicated only that the sample points were located randomly within a study area chosen for its high abundance of the target species. The remainder of the studies either gave no information or specified that the study area was chosen because the focal species was locally abundant.

In many environments, lizards form important elements of the food web. In many cases, they have been used as model organisms with which to examine

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questions of community assembly or species coexistence. Caribbean islands have been among the most intensely studied locales for such work. Despite this, the number of absolute population measures for lizards is low even for this region. Data for entire assemblages are rarer yet. In this paper we report sampling of entire lizard assemblages conducted on Guana Island, British Virgin Islands. We chose two habitat types: early successional (dominated by *Leucaena leucocephala* (Lam.) de Wit and *Acacia macracantha* Humb. & Bonpl. ex Willd.), and mid-successional (dominated by *Coccoloba uvifera* (L.) L.). These habitats were chosen because they are representative of many habitats in the area. Additionally they are structurally (both habitats) and compositionally (*Leucaena* habitat) similar to habitats we have examined more extensively in the western Pacific, primarily on the island of Guam, Mariana Islands (Rodda & Fritts 1996, 1998). Though non-native in the Pacific, *Leucaena leucocephala* forests are extensive in the Mariana Islands where they have been purposefully seeded for erosion control (Falanruw *et al.* 1989). This species also dominates early successional landscapes in the Virgin Islands (Little & Wadsworth 1964). If vegetative composition determines the numerical success of the resident vertebrates, we would expect the members of comparable lizard guilds to have similar abundances on the two islands.

Through human-mediated species transport there is some artificial overlap in lizard species representation between Guam and Guana. *Anolis* lizards are a conspicuous native element in the West Indies (Lazell 1991); *A. carolinensis* has been introduced throughout the Pacific, including Guam (McCoid 1999). *Hemidactylus* geckos have been widely introduced in both the Pacific and Caribbean, including Guam and Guana (MacLean 1982, Rodda *et al.* 1991; Table 1). Thus, we might expect greater similarity in the abundances of lizards between Guam and Guana than would be the case if the assemblages had complete phylogenetic and historic independence.

We chose our sample sites on the basis of vegetative representativeness of the habitat (i.e. without advance knowledge of the population density of the target vertebrate taxa). We selected plots that were qualitatively similar to a

Table 1. Comparison of forest lizard assemblages between Guam (Mariana Islands, Pacific Ocean) and Guana (British Virgin Islands, West Indies).

Activity	Stratum	Guana Island	Guam Island
Diurnal	arboreal	*Anolis cristatellus* Duméril and Bibron *A. stratulus* Cope	*A. carolinensis* Voigt *Lipinia noctua* Lesson
	large terrestrial	*Ameiva exsul* Cope	*Varanus indicus* Daudin
	small terrestrial	*Mabuya sloanei* Daudin *Sphaerodactylus macrolepis* Günther	*Carlia fusca* Duméril and Bibron *Emoia caeruleocauda* de Vis
	folivore	*Cyclura pinguis* Barbour	—
Nocturnal	arboreal	*Hemidactylus mabouia* Moreau de Jonnès	*Hemidactylus frenatus* Duméril and Bibron *Lepidodactylus lugubris* Duméril and Bibron *Gehyra mutilata* Wiegmann
	terrestrial	--	*Nactus pelagicus* Girard

typical stand in terms of tree species composition, stem diameter, stem density, canopy height and canopy coverage. In each habitat, we censused all small, non-volant, non-fossorial vertebrates. Our total forest removal technique (see below) provides unbiased density estimates for all of the species, thereby allowing us to estimate representation of all species and thus the assemblage.

We quantified the absolute population densities with 10 × 10 m forest removal plots (Rodda *et al.* in press). This technique is of value primarily for species that occur at moderately high density, and for such species is preferable to other estimates – because fewer assumptions are required. Details of this technique are reported elsewhere (Rodda *et al.* in press). Briefly, we sealed the 10 × 10 m plots to emigration or immigration of the target species by a combination of 1.5 m canopy separation (for non-volant arboreal species) and an unclimbable ground-level barrier of greased 0.5m-high aluminium flashing. The barrier is buried in the ground to preclude subterranean movements of all but specialized fossorial species. These measures were taken during the inactive period of the primary target species (thus the time-of-day varies from site to site according to species composition), to minimize disturbance and flight. In the British Virgin Islands we established the barriers at night.

Beginning on the following morning we then removed and dismantled all live and dead vegetation down to the level of mineral soil. We recorded the presence and mass of all vertebrates, as well as the fresh mass of aboveground vegetation.

During October 1998 we sampled four sites, two each in early successional (*Leucaena leucocephala*) and mid-successional (*Coccoloba uvifera*) forest on the sand flat of White Bay on Guana Island, British Virgin Islands (18.475°N, 64.578° W). For each plot we identified to species and measured all woody stems > 1 cm dbh, sampled ground-level vegetation with 20 uniformly spaced Daubenmire frame placements, measured litter depth in the centre of each of the 20 sampling points, estimated canopy height with reference to a measured rod, and judged canopy coverage on the basis of readings from a convex spherical densiometer read facing into the plot from each of the four corners. Each of our Virgin Island plots was cleared by 6–12 people in 1–2 d. We sampled two plots for each habitat type, which provided a reasonable estimate of absolute population density for species that exceed a density of about 500 ha^{-1}. We used the same technique in Pacific and Virgin Island sites, though this paper reports the results of only the Virgin Island samples.

The early-successional plots were composed almost exclusively of *Leucaena* and *Acacia* trees (Table 2), whereas the mid-successional plots had a greater diversity of woody species (the commonest, *Coccoloba uvifera*, averaged 42% of total basal area). There were a surprisingly high number of woody stems (up to 438), especially in the early successional plots, but medium and large trees (> 10 cm dbh) were generally absent (Table 2). Aside from species composition differences, the most distinct vegetation features of the two habitats were litter

Table 2. Plot characteristics for study areas on Guana Island, British Virgin Islands.

	Leucaena plots		*Coccoloba* plots	
	1	2	1	2
Dominant tree	*Acacia*	*Leucaena*	*Coccoloba*	*Coccoloba*
(% of total basal area)	(74)	(75)	(37)	(47)
Secondary tree	*Leucaena*	*Acacia*	*Acacia*	*Acacia*
(% of total basal area)	(26)	(25)	(31)	(10)
Total basal area (cm^2)	990	1617	1560	2675
Stems > 1 cm dbh	292	438	235	137
Stems > 10 cm dbh	0	0	0	3
Canopy height (m)	5	5.5	6.5	6
Canopy cover (%)	76	68	81	71
Litter > 1 cm (% of 20 point samples)	5	70	95	75
mean litter depth (cm)	0.31	1.75	3.33	4.89
Herb coverage (mean of 20 Daubenmire samples)	21	31	10	7
Vegetation wet mass (kg)	997	1231	2074	2366
Sphaerodactylus collected	6	262	676	380

amount (coverage and depth) and total wet mass of vegetation (range 997–2366 kg). In the earliest successional plot (*Leucaena*-1) litter was barely present (*c.* 5% of surface), whereas deep litter (mean = 4.9 cm) covered almost the entire forest floor in *Coccoloba* plot 1 (Table 2).

Faunal abundances were apparently related to these plot differences (Tables 2, 3). We obtained a total of seven snakes, 1401 lizards, and no amphibians, birds or mammals. The vast majority of individuals (94.5%) were of a single lizard species, *Sphaerodactylus macrolepis*, found in leaf litter. Statistical power is limited with four samples, but there was an obvious positive association (r^2 = 0.84) between the abundance of this diminutive diurnal gecko and the coverage of leaf litter. In the plots with extensive leaf litter this species was extraordinarily common (Table 3), reaching a higher density than has been reported for non-aggregated lizards (Figure 1). We project that this gecko attains densities of around 67 600 ha^{-1} in areas having continuous *Coccoloba* litter. Our average density in the *Coccoloba* plots was 52 800 ha^{-1}.

The high density we observed was unprecedented among all non-aggregated vertebrates. No mammals or birds are known to approach the high densities attained by reptiles and amphibians (Welty & Baptista 1988, Fa & Purvis 1997). A landmark study (Burton & Likens 1975) of leaf litter salamanders (*Plethodon cinereus* Green) in New Hampshire documented densities of around 2950 ha^{-1}. This value is near the upper reported limit of densities for salamanders that are not aggregated along water courses or in tiny rock refugia. The highest published density of non-aggregated frogs (20 570 ha^{-1}) is for the coqui frog, *Eleutherodactylus coqui* Thomas, in Puerto Rico (Stewart & Rand 1991). Although our density estimates for *Sphaerodactylus macrolepis* are near the cloud of densities reported for other lizard species in the logarithmic scale shown in Figure 1, the next highest value (23 600 ha^{-1}, for *Anolis stratulus* (Reagan 1992) is less

Table 3. Mean densities of species obtained from Guana Island removal plots (see also Table 2). Although six *Typhlops richardi* were obtained during sampling, the sampling technique is considered inappropriate for this fossorial species. The ground level barrier has not been tested on snakes such as *Liophis portoricensis*; if the barrier is not completely effective, the obtained results may be underestimates for that species.

		Leucaena plots	*Coccoloba* plots
Numbers ha^{-1} Snakes	*Liophis portoricensis*	50	0
	Typhlops richardi	0	300
Lizards	*Ameiva exsul*	200	0
	Anolis cristatellus	1000	1100
	Anolis pulchellus	50	0
	Anolis stratulus	600	900
	Sphaerodactylus macrolepis	13400	52800
Biomass (kg ha^{-1}) Snakes	*Liophis portoricensis*	3.05	0
	Typhlops richardi	0	0.71
Lizards	*Ameiva exsul*	1.22	0
	Anolis cristatellus	0.69	1.68
	Anolis pulchellus	0.09	0
	Anolis stratulus	0.63	1.00
	Sphaerodactylus macrolepis	3.60	15.26

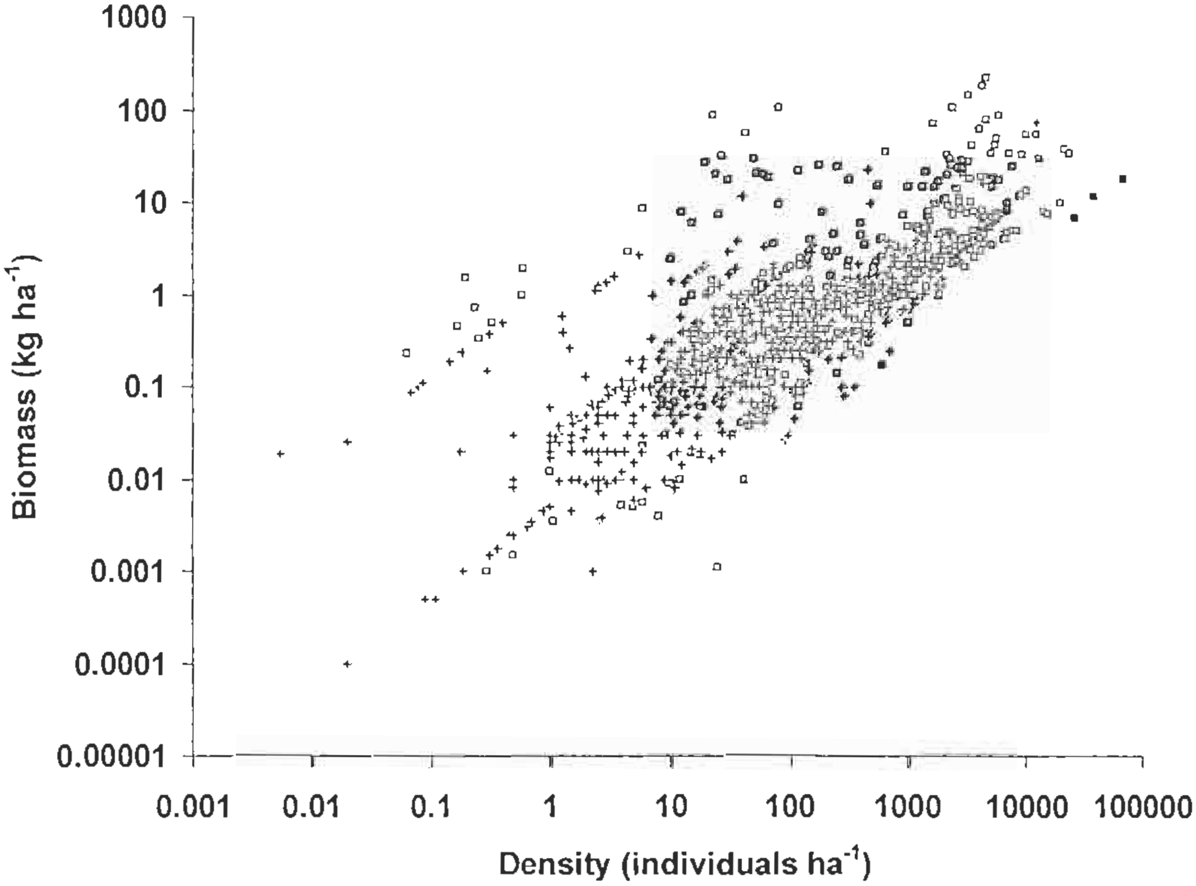

Figure 1. Density estimates of 1072 non-aggregated lizard species/venue combinations taken from our work and 228 literature sources (available upon request). Values marked with a + are from mainland sites; the others are from islands. The four filled symbols represent the *Sphaerodactylus macrolepis* samples reported here, three of which exceed prior records for numerical density, but none is exceptional in terms of biomass.

than half the average value we recorded in mid-successional forest (we also found *A. stratulus* in our plots, but at a much lower density: 600–900 ha^{-1}). Thus, our censuses of *S. macrolepis* constitute a new record, despite the choice of site without regard to focal species abundance.

What is responsible for the high densities we found? Our impression is that many of the 73 *Sphaerodactylus* species recorded from the West Indies (Schwartz & Henderson 1991) are likely to occur at high densities. The previously published density values for *S. macrolepis* on Guana Island (Lazell 1991) include a conversion error, which when corrected (to 16 000 and 26 000 ha^{-1}) indicates a higher density than had been previously recorded. Despite these high densities, *Sphaerodactylus* have apparently not engendered much interest from ecologists, probably because of their secretive habits and small size (*S. macrolepis* mean mass = 0.285 g in our samples). One commonality among the species that exhibit the highest absolute densities (Figure 1) is their presence on islands. Presumably predation is reduced on islands, though other factors may also play a role (Andrews 1976). Fauth *et al.* (1989) found a strong association between leaf litter depth and the diversity and abundance of herpetofauna in tropical leaf litter. Several of the high density species mentioned above (temperate salamanders, tropical frogs) have also been associated with leaf litter, though a proximate cause for high density in leaf litter is not obvious.

Most dense terrestrial vertebrates are small. A more equitable basis for comparison among species might be biomass density (Table 3). *S. macrolepis* has the highest biomass density of the species recorded in our Guana Island plots, but its biomass is unremarkable. A variety of lizards exhibit values near 100 kg ha^{-1} (Figure 1). The two lizard species with the highest documented biomass densities are *Gallotia stehlini* Schenkel, for which the four highest values are 109–228 kg ha^{-1}, all in the Canary Islands (Vernet *et al.* 1997) and *Iguana iguana* L., which was documented at 107 kg ha^{-1} on an island in Colombia (Müller 1972). These are roughly an order of magnitude higher than that of *S. macrolepis* or *Loxodonta africanus* Blumenbach, the African elephant, two species at opposite ends of the size spectrum which both exhibit biomass densities of around 10 kg ha^{-1} (Fa & Purvis 1997, Prins & Reitsma 1989; present study). Due to their great mass, a few mammals attain biomass densities higher than that of *Sphaerodactylus*, but none approaches that of some island lizards (Figure 1).

Does the high density of *Sphaerodactylus* have an analogue in the lizard assemblages of Pacific islands? Litter insectivores are also the densest species in our Pacific samples. In *Leucaena* habitat in northern Guam, for example, litter dwelling insectivores outnumbered those from all other guilds, averaging 10 275 ha^{-1} (23.9 kg ha^{-1}) in our eight samples (unpubl. data). Aside from the importance of litter insectivores, there was little overall functional similarity between Guam and Guana lizard assemblages. Though arboreal diurnal lizard species occur in both places, they were absent from 11 of 12 samples on Guam, but numerous in all Guana samples. This was unexpected given that *Anolis* occur in both places. While the Brown Tree Snake (*Boiga irregularis* Merrem in Bechstein) could be responsible for the low density of arboreal diurnal lizards, especially anoles, on Guam (Rodda & Fritts 1992), it does not explain the similar results obtained on nearby, snakeless islands (unpubl. data). No reptilian folivore has emerged in the Marianas.

The most striking difference between the two islands was in the nocturnal niches, however. We detected no individuals of nocturnal species on Guana Island, whereas about half of all terrestrial vertebrate individuals on Guam are from nocturnal species (Rodda & Fritts 1996, 1998). This is especially surprising in light of the presence of introduced *Hemidactylus* sp. in both places. Apparently the failure of *Hemidactylus mabouia* to proliferate away from human habitation on Guana Island is unrelated to the presence of native lizard competitors, since none is known from the island. This example suggests caution in invoking competition to explain the abundance or distribution of *Hemidactylus frenatus* in the Pacific (Case & Bolger 1991a, b; Case *et al.* 1994).

The pattern of gross dissimilarity between guild abundances that emerges from this comparison of assemblages in Pacific and West Indian islands differs from the relatively high overlap in assemblage structure detected on the basis of species composition (Table 1). The addition of information about species abundances strengthens the impression that historical factors or some process other than community adaptation severely constrains ecological roles and potential abundances. Although population densities are often difficult to quantify, they appear to provide considerable insight into the functioning of ecosystems.

ACKNOWLEDGEMENTS

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Lizard Abundance in Guana

Despite the importance of accurate population density estimates in ecology, many studies of lizard abundance are biased because selection of study sites is commonly based on the high density of the species studied. The authors quantified absolute population densities of lizards with four 10 x 10 m forest removal plots in Guana Island, British Virgin Islands. Early successional and mid-successional forests were surveyed, and the results were compared with data of a previous study made in the island of Guam, Mariana Islands. Of the 1401 lizards obtained, 94.5% corresponded to the diurnal gecko *Sphaerodactylus macrolepis*, which was found primarily in leaf litter. With a density of 67,600 ha^{-1}, *S. macrolepis* was found to be the densest terrestrial species among non-aggregated vertebrates. Therefore, this lizard represents an excellent model organism for ecological studies in spite of its secretive habits and small size. Lizard assemblages in Guana are similar to those in Guam only in that litter insectivores are the densest species. The main difference between Guam and Guana is that Guana lacks nocturnal species, whereas in Guam nearly half of all terrestrial vertebrate individuals correspond to nocturnal species. This dissimilarity between guild abundances in Guana and Guam contrasts with the significant overlap in assemblage structure between both islands. The authors concluded that some process other than community adaptation significantly influences ecological roles and potential abundances.

Rodda, G. H., G. Perry, R. J. Rondeau, and J. Lazell. 2001. The densest terrestrial vertebrate. Journal of Tropical Ecology 17:331–338.

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***LIOPHIS PORTORICENCIS ANEGADAE* (NCN). NIGHT-LIGHT NICHE.** Geckos have for years been known to associate with human dwellings, foraging around lights at night. More recently, diurnal lizard species have developed this behavior, termed "night-light niche" by Schwartz and Henderson (1991. Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History. University of Florida Press, Gainesville, Florida. 720 pp.). McCoid and Hensley (1993. Herpetol. Rev. 23:87–88) listed seven species of *Anolis* and a skink (*Cryptoplepharus poeciliopleurus*), and Perry and Buden (1999. Micronesica 31:263–273) added another skink, *Lamprolepsis smaragdina*, to the list of reptiles that employ this behavior. On Guana Island, British Virgin Islands, the crested anole *Anolis cristatellus* has for years been known to occupy this niche (Lazell, unpubl.). In October 1999, the diurnal gecko *Sphaerodactylus macrolepis* was first seen in the night-light niche, with individuals seen foraging on path lights between 2030 and 2100 h (Perry, unpubl.). In the last three years, however, a diurnal colubrid snake has also joined the growing list of species foraging at lights in the night. Starting in 1997, we have observed several individuals of *Liophis portoricensis anegadae* apparently ambushing lizards at these lights. On 2 October 1999, one was observed consuming an *Anolis*, itself using the light to ambush prey. To our knowledge, this is the first record of a snake occupying the night-light niche. With this development, a chain that started with insects being attracted to lights, and then extended to insect predators, now has its first secondary predator.

We are indebted to Barry and Buena Valentine for recording the *Anolis* consumption.

Submitted by **GAD PERRY**, Department of Zoology, University of Wisconsin, 430 Lincoln Drive, Madison, Wisconsin 53706-1381, USA (e-mail: GPerry@facstaff.wisc.edu), and **JAMES LAZELL**, The Conservation Agency, 6 Swinburne St., Jamestown, Rhode Island 02835, USA.

From: "Arijana Barun"
To: <wenhua@ETAL.URI.EDU>
Sent: Thursday, May 09, 2002 10:27 AM
Subject: amphisbaenians

Hi Skip and Wenhua,

About two months ago I accepted the graduate position with Dr. Dan Simberloff at University of Tennessee, Knoxville. Most of Dr. Simberloff's graduate students work with invasive species and I was offered the opportunity to work with the mongoose in Croatia. The basic question I will be looking into is the autecology of the mongoose, its possible interaction with the stone marten, and the autecology of the stone marten in the same region. There are many ways to take such a project and it is up to me now to find the best way. I wanted to work with herps but I could not refuse the offer to work with Dr. Simberloff and in Croatia. When I visited UT-Knoxville we talked about you Skip and he asked me all about Guana and ongoing projects. I told him that I would be interested in continuing the Alsophis project but that will have to wait until next year. The reason is that in the same week that I was accepted at UT, I found out that I was pregnant. It was a huge shock for me and for Vlado. After talking to Graduate committee it all looks a lot more promising. I will officially start in Fall 2003 but my first field season will be in Summer 2003. Next month I am moving to Knoxville, so that during the pregnancy I can prepare the proposal and get ready for a first field season (Summer 2003). My family is going to look after the baby while I am in the field and Vlado is going to change the job so that he does not travel as much as he does now.

I am currently working at Smithsonian National History Museum in DC on two projects. First is in GIS department where I mostly analyze and map data for researchers at the museum. The other is at the Amphibian and Reptile Department trying to figure out if there is any correlation between ecology and morphology of Toad-headed lizards, Phrynocephalus.

Gadi and I started to write the diet paper and the activity for Alsophis. At least one of the amphisbaenians, and perhaps both, have been tagged for deposition by you Skip. Gadi and I would like to include the museum accession numbers. Can you please e-mail it to either me or Gadi. I will be in Madiso WI for few days next week.

I am very sorry for not being able to continue the Alsophis project this year. I will keep in touch wit Gadi and see how it goes in the future.

Hope everything is going great with you.
Arijana

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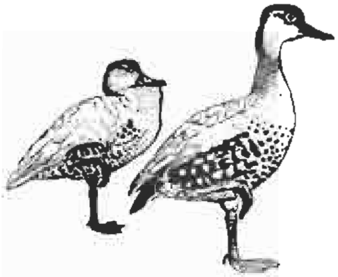

THE STATUS OF THE WEST INDIAN WHISTLING-DUCK (*DENDROCYGNA ARBOREA*) IN ST. KITTS–NEVIS, JANUARY–FEBRUARY 2000

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Abstract—A survey of the status of the globally threatened West Indian Whistling-Duck (*Dendrocygna arborea*) was conducted on St. Kitts-Nevis (17°15'N, 62°40'W) during January–February 2000. Historically, these Lesser Antilles have been considered the southern edge of the species' range, but the only known record of its existence is an undated museum specimen from St. Kitts (St. Christopher). There are no known records from Nevis and, currently, there is no suitable habitat. During this survey, the West Indian Whistling-Duck was neither sighted nor heard on either island. A well-known former hunter on St. Kitts reported having seen the whistling-duck in small numbers on several mangrove-fringed ponds 15–20 years ago, but they were only occasional visitors, not residents. Today, only one pond provides suitable habitat and the future prospects are bleak. The government supports development of tourism for both islands, and reportedly has already approved the best remaining mangrove-fringed pond on St. Kitts as a development site for two new hotels, with a boardwalk extending across the pond as a nature walk.

Resumen– EL ESTADO DE LA CHIRIRÍA ANTILLANA (*DENDROCYGNA ARBOREA*) EN SAN CRISTÓBAL-NEVIS, ENERO-FEBRERO DE 2000. Un levantamiento para determinar el estado de la globalmente amenazada Chiriría Antillana (*Dendrocygna arborea*) se realizó en San Cristóbal-Nevis durante enero-febrero del 2000. Históricamente, estas Antillas Menores han sido consideradas como los territorios más meridionales de la distribución de la especie, pero el único registro de su existencia en el lugar es un espécimen de museo proveniente de San Cristóbal. No se conocen registros de Nevis y en la actualidad no existe hábitat apropiado. Durante este levantamiento no se avistó ni escuchó a la chiriria en ninguna de las dos islas. Un cazador de renombre en San Cristóbal reporta haber visto la chiriría en números pequeños en varias lagunas orladas de mangle hace 15–20 años, pero tan sólo eran visitantes ocasionales, no residentes. Hoy en día, sólo una laguna provee hábitat adecuado y las perspectivas para el futuro no son prometedoras. El gobierno apoya el desarrollo del turismo en ambas islas y supuestamente ha aprobado que la mejor laguna orlada por manglares que queda sea el lugar de dos nuevos hoteles, con un paseo tablado cruzando la laguna como sendero natural.

Key words: Caribbean wetlands, Dendrocygna arborea, *St. Christopher, St. Kitts-Nevis, West Indian Whistling-Duck*

INTRODUCTION

THE WEST INDIAN WHISTLING-DUCK (*Dendrocygna arborea*; WIWD) is a globally threatened member of the *Dendrocygnini* tribe (del Hoyo *et al.* 1992). This tribe is comprised of eight species within the *Anserinae* subfamily, which are intermediate in morphology between ducks and geese (Bond 1936). The whistling-duck is confined to the Bahamas and the Greater and Lesser Antilles (Collar *et al.* 1994). Once common, its population has declined substantially throughout its range (Raffaele *et al.* 1998) and is now believed to consist of only 15–20,000 individuals spread out in many small, fragmented groups (BirdLife International 2000). The species is considered vulnerable to extinction, the primary threats being destruction of their wetland habitat for tourism development and agriculture, under-regulated hunting, and natural catastrophes such as hurricanes (BirdLife International 2000), as well as poaching and predation by introduced mongooses and rats (Kear and Williams 1978; J. Daltry, pers. comm.). Although the species is legally protected throughout most of its range, enforcement of hunting laws is inadequate or non-existent and poaching is widespread (Staus 1998a).

A West Indian Whistling-Duck and Wetlands Conservation Project has been launched by the WIWD Working Group of the Society of Caribbean Ornithology to raise awareness about the plight of the duck and promote actions that will reverse its further decline (Sorenson and Carey 1998; Sorenson and Bradley 1999, 2000). These include (1) the development of educational materials (e.g., slide show, coloring book, puppet show, duck identification cards for hunters, and wetlands education workbook), (2) teacher education workshops to demonstrate the use of these materials and the promotion and funding of Watchable Wildlife Ponds, and (3) funding of surveys in several Caribbean countries (Sorenson and Bradley 1999, 2000). Additional surveys of the status, distribution, and habitat use of the WIWD in each of the islands it is believed to inhabit are needed before a comprehensive Caribbean-wide conservation plan can be formulated (Sorenson and Carey 1998).

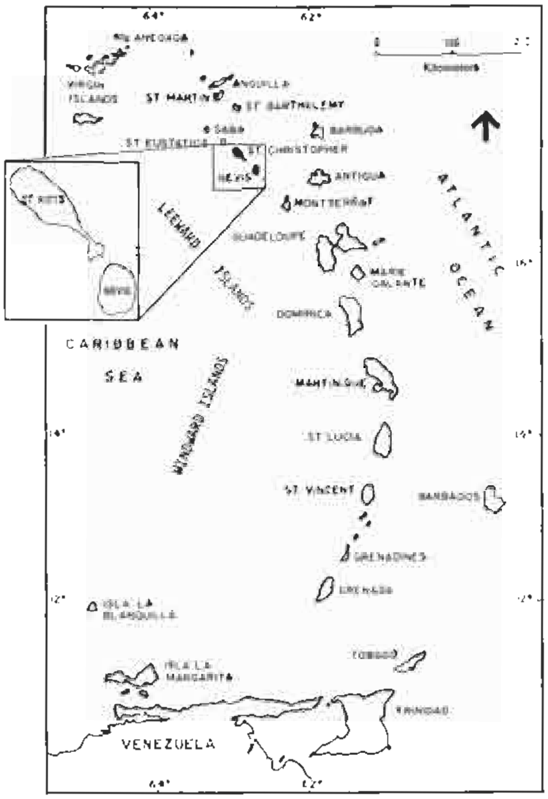

Fig. 1. The Lesser Antilles, with inset of St. Kitts–Nevis (Country Environmental Profile 1991).

St. Kitts-Nevis (17°15'N, 62°40'W) and Antigua and Barbuda (17°06'-40'N, 61°45'W) have historically been considered the southern edge of this species' range (Collar *et al.* 1992). However, although it is a year-round resident on Antigua and Barbuda (Raffaele *et al.* 1998), the only record of its existence on St. Kitts-Nevis is an undated museum specimen from St. Kitts in the Museum of Comparative Zoology, Cambridge, Massachusetts, USA (Collar *et al.* 1992). There have been no recent sightings or data from either island (L. Sorenson, pers. comm.). The purpose of this survey was to determine the status of the species in St. Kitts-Nevis. The survey was conducted in consultation with the WIWD Working Group of the Society of Caribbean Ornithology (SCO) and conservation groups on both St. Kitts (St. Christopher Heritage Society) and Nevis (Nevis Historical and Conservation Society).

GENERAL BIOLOGY AND ECOLOGY

The West Indian Whistling-Duck is the largest and bulkiest of the whistling-ducks, weighing about 1150 g (Madge and Burn 1988). Males and females are alike in size and appearance in the field, being rather dark overall with pale faces and forenecks, and extensive black and white spotting along the flanks. In flight, they appear dark above and below, with head drooped and feet extending beyond the tail; in good light it may be possible to see the spotted underparts

(Raffaele *et al.* 1998). It is less vocal than other whistling-ducks, the call being a shrill, but rather harsh, whistled "visisee." It is normally a resident, non-migratory species (Madge and Burn 1988), but also has been known to fly up to 40 km to visit other islands (Staus 1998b). It is not known to be particularly shy or wary.

The WIWD feeds nocturnally and is crepuscular, becoming active at dusk when it flies to its feeding areas from coastal mangroves and marshy areas where it has spent much of the day hidden, loafing in small groups on waterside banks or perched amongst partially-submerged trees and branches (Madge and Burn 1988). It feeds primarily on grasses, berries, and fruits, especially the fruits of the Cuban royal palm (*Roystonia regia*), as well as cultivated seeds and grain on agricultural land (del Hoyo *et al.* 1992). In previous studies in the Bahamas (Staus 1998a,b), this species exhibited strong site fidelity, consistently using the same roosting and feeding sites. The birds in that study preferred to roost in mangroves and pond-edge vegetation during the day, and feed on fresh or brackish ponds and tidal flats during the night. Non-breeding birds spend little time on the water and are not known to dive (del Hoyo *et al.* 1992, Staus 1998a). On the other hand, birds with broods spend much time swimming while their ducklings feed (Staus 1998a). The WIWD breeds during the rainy season, primarily from June to October, but the timing varies by location.

STUDY SITES

St. Kitts-Nevis is in the northern part of the Leeward Islands in the Lesser Antilles (Fig. 1). Once British colonies, the two islands today are the independent nation of St. Kitts–Nevis, which remains part of the British Commonwealth. Separated by a 3.2-km channel, both islands are mountainous with rainforest-covered volcanic peaks, the highest on St. Kitts being Mount Liamuiga (1156 m) and on Nevis being Nevis Peak (985 m). St. Kitts, approximately 30 km long and 9 km wide (176 km^2) with a population of about 35,000 (200/km^2), is the larger and more densely populated of the two islands. Almost all of its arable land, from the lower edge of the central rainforest (250—450 m asl) to the coastal highway ringing the island, some 4250 ha (10,500 acres; 24% of the island's land mass), is cultivated with sugarcane (Mager 1997). Small plots of vegetable and root crops are scattered between and above the sugar plantations (Country Environmental Profile: St. Kitts and Nevis 1991). There are 10 substantial salt ponds, totaling approximately 200 ha (Honebrink 1993), spread along its low-lying southeastern shore and the Southeast Peninsula (Table 1 and Fig. 2), all of which were once ringed with living mangroves, and all of which might have provided suitable habitat for the whistling-duck at some time.

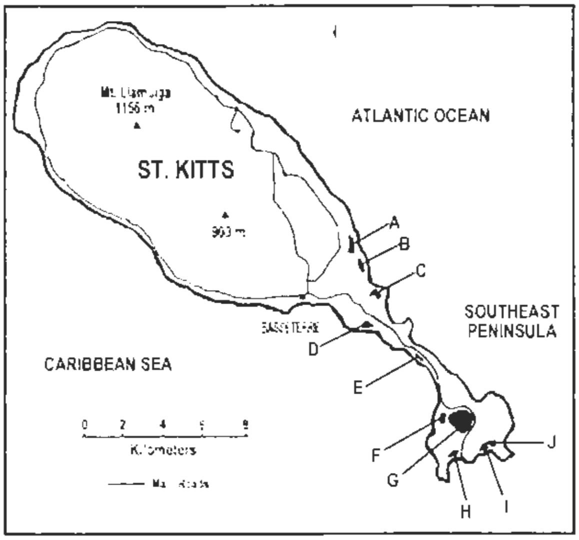

Fig. 2. Salt ponds (A through J) on St. Kitts, Lesser Antilles. See Table 1 for data on ponds.

Nevis (93 km^2) is not only smaller than St. Kitts, with fewer people (about 9,000; 97/km^2); it is also steeper without the extensive coastal plains or large-scale agriculture. Coastal features include long sandy beaches and a system of small freshwater lagoons along the western (leeward) side of the island, and smaller rocky beaches and massive sea-facing cliffs along the eastern side. The freshwater lagoons are of two types, depending on their primary sources: mountain ravine run-off or underwater springs. Some of these lagoons appear to "flush" themselves into the sea occasionally, whereas others appear to remain in a relatively stagnant condition until the rainy season arrives (Country Environmental Profile 1991). Several are fringed by mangroves and might have provided suitable day roosting habitat for the whistling-duck.

SURVEY METHODS

The objectives of the survey were to determine whether the WIWD is extant on St. Kitts-Nevis and, if so, to develop a population estimate and a description of its habitat usage. The survey plan consisted of three parts, a physical count of any birds present, interviews with ornithologists and former hunters, and local library research. The "look-see" counting

Table 1. Salt ponds of St. Kitts (See Fig. 2 for map locations). Source: Honebrink (1993).

Map location	Name	Approximate size (ha)
A	Greatheeds Pond	14
B	Half Moon Pond	11
C	Muddy Pond	6
D	Frigate Bay Pond	7
E	Friars Bay Pond	4
F	Little Salt Pond	30
G	Great Salt Pond	109
H	Majors Bay Pond	9
I	Cockleshell Pond	6
J	Mosquito Bay Pond	7

method (Bibby *et al.* 1992) was believed to be the most appropriate, because the amount of suitable habitat on St. Kitts and Nevis is limited, the species' site fidelity has been shown to be strong, and it has not been known to be particularly shy or wary. The potential bias of double counting, caused by the movement of birds from already surveyed areas to areas that have not yet been surveyed (Bibby *et al.* 1992), was considered to be less of a problem with WIWD due to its strong site fidelity and lack of wariness.

A pilot survey was conducted to determine the appropriateness of the "look-see" counting method in various locations and at various times of day, following consultations with local experts. From 11 to 25 January, each wetland area was visited once initially during the daytime to assess its potential as a daytime roosting and loafing area (e.g., isolation from human activity, presence of healthy mangroves, and presence of other wildfowl species). Based on the findings of a similar survey conducted in 1999 in the Turks and Caicos Islands by the Royal Society for the Protection of Birds (UK), The Wildfowl and Wetlands Trust (UK), and the National Trust of the Turks and Caicos, taped call playback at dusk in likely habitats appeared to be the method that would give the best results (Hilton *et al.* 2000). Therefore, once the likely habitat areas on both islands were identified, each was visited again between 27 January and 1 March from dusk into early evening (18:00–20:00). Taped sets of four repeated calls were played back at 5-min intervals throughout this period and the sites were repeatedly scanned with 10x binoculars and a 20–60x telescope.

A cursory survey and interviews of local naturalists were also conducted on both islands to determine the abundance of royal palm and cultivated grain crops, the favorite foods of the whistling-duck (Johnsgard 1978).

RESULTS

No West Indian Whistling-Ducks were seen or heard on either island. Discussions with a prominent ornithologist (D. Robinson) and naturalist (J. Johnson) on Nevis, as well as research at the library of the Nevis Historical and Conservation Society failed to uncover any record or recollection of the whistling-duck on Nevis. The library contained reports of several avifauna surveys on Nevis dating back to 1982 (Morris and Lemon 1982, Robinson 1988, Esser 1990), none of which included any records of Anatidae occurring on the island. The small freshwater lagoons, all of which were visited, had been variously incorporated into a golf course, damaged extensively by a recent hurricane, or heavily littered with paper and plastic items. The waterbirds found on these lagoons were almost exclusively herons and egrets: Little Blue Heron (*Egretta caerulea*), Tricolored Heron (*E. tricolor*), Snowy Egret (*E. thula*), Cattle Egret (*Bubulcus ibis*), Great Blue Heron (*Ardea herodias*), Great Egret (*A. alba*), Yellow-crowned Night-Heron (*Nycticorax nycticorax*), and Green Heron (*Butorides virescens*). There was only one small grove of royal palms on the island and no grain crops were found.

St. Kitts, with 10 substantial salt ponds at its southeastern end, initially appeared to have more potentially suitable habitat for the whistling-duck (Table 1). All of these ponds, however, are located in either heavily developed areas or within the zones designated by the government as the main tourist development areas on the island. A prominent former hunter and conservationist remembered seeing the WIWD occasionally on one or two of these ponds 15–20 years ago, but they were infrequent visitors, staying only a few days (C. Evelyn, pers. comm.). He assumed they had flown in from Barbuda or Antigua , both approximately 100 km from St. Kitts. At the time of our surveys, these ponds were generally in poor condition. Perhaps the worst example was Greatheeds Pond, once a freshwater pond of approximately 14 ha, surrounded by thick mangrove forest (Honebrink 1993; C. Evelyn, pers. comm.) and considered St. Kitts' best example of a mangrove swamp (Country Environmental Profile 1991). This pond is now a fraction of its former size, more saline than the sea (Honebrink 1993), and surrounded by the parking area of a concrete block factory, a firing range, and a refuse disposal area. The few mangrove trees around its shores were dead (K. Orchard, pers. comm.) and the only sign of wildlife observed on or near this pond during our surveys was a Common Moorhen (*Gallinula chloropus*) that was calling.

Muddy Pond, which has been reshaped and used for wastewater treatment (Honebrink 1993), is now shallow (<1m), polluted with bits of paper and plastic debris, and surrounded by a golf course fairway, an industrial building and residential units. Its narrow (<5 m) mangrove fringe is still alive, but consists of unusually small, thin trees (<5 m in height) that are totally ineffective in shielding the pond from surrounding activity. Although this pond is reported (K. Orchard, *in litt.*) to regularly hold herons and Black-necked Stilts (*Himantopus mexicanus*), no birds were observed during this survey. Half Moon Pond, once the site of an aquaculture venture, is also reported to regularly hold herons and stilts, and hundreds of waders during their fall and spring migration (K. Orchard, *in litt.*), but we observed no birds there during our surveys.

Frigate Bay Pond has been incorporated into a golf course. At the time of our surveys, this pond was dry, having been intentionally drained. Normally, there are a few mangrove trees growing around its edges and ducks and moorhens are regularly seen there (K. Orchard, *in litt.*). Great and Little Salt Ponds, once the site of salt production, as well as the other Southeast Peninsula ponds (Majors Bay, Cockleshell, and Mosquito Bay) are all open and afford little cover for waterfowl. The mangrove fringes of these ponds all appear to be either dead or dying. The only two waterbirds seen on these ponds were small waders: Ruddy Turnstone (*Arenaria interpres*) and Black-bellied Plover (*Pluvialis squatarola*). The Southeast Peninsula, which has been designated as the primary area for tourism development, has recently been opened up with a new highway close to the ponds and several of its ponds have been considered for onshore marina development (Honebrink 1993).

Friars Bay Pond is currently the best remaining example of what the mangrove-fringed ponds of St. Kitts once must have been like. This small pond is still fringed on three sides with healthy mangrove trees and provides cover for waterfowl. During our surveys, Friars Bay Pond held seven Blue-winged Teal (*Anas discors*), one Belted Kingfisher (*Ceryle alcyon*), one Common Moorhen, a pair of Black-necked Stilts, and a pair of American Coots (*Fulica americana*). However, this pond is also threatened with development, because it apparently has been approved as the site of two new hotels with an elevated boardwalk across the pond and mangroves (K. Orchard, pers. comm.).

Government-owned sugarcane plantations dominate the agriculture in St. Kitts. There appeared to be no large fields of grain crops and a naturalist on St. Kitts who has been leading walking and four-wheel drive expeditions into the island's forests for 10 years reported that there were very few royal palms on the island (G. Pereira, pers. comm.).

DISCUSSION

No West Indian Whistling-Ducks were seen or heard during this survey of wetland habitats on St. Kitts and Nevis. Although all potential wetland habitats on both islands were visited, the survey was conducted in only one season (mid-winter dry season) and only in one year. West Indian Whistling-Ducks are known to be nomadic occasionally (Staus 1998b) and it is therefore possible that they could occur on St. Kitts during other times of the year, or when conditions are particularly good (e.g., wet) on St. Kitts–Nevis or particularly bad (e.g., drought) on nearby islands. However, interviews with local hunters, naturalists, and residents, and our observations of the condition of the wetland habitat suggest that it is unlikely that the whistling-duck has been a resident or regular visitor on either island for many years. Whereas some of the wetlands on St. Kitts might have once supported small populations or occasional WIWD visitors, it seems unlikely that the species could be reintroduced here because of past and continued wetland degradation. This suggests that St. Kitts-Nevis should no longer be considered part of this species' normal range.

Although not home to the West Indian Whistling-Duck, the salt pond wetland system on St. Kitts, which is unique in the Lesser Antilles (Country Environmental Profile 1991), attracts large numbers of waterbirds during the spring and fall migration periods (K. Orchard, *in litt.*). With renovation, it could again become an important habitat for wintering waterbirds such as herons, egrets, and small waders, and a substantial attraction for tourists. In addition to their importance for waterbirds, these ponds and their mangrove swamps also protect the marine habitat around St. Kitts by collecting and filtering rainwater runoff that otherwise could severely damage inshore marine ecosystems such as coral reefs and sea grass meadows (Honebrink 1993).

The legal infrastructure for protecting and renovating these wetlands seems to be in place, in the form of the 1987 National Conservation and Environmental Protection Act. This act, combined with the

1913 Wild Birds Protection Ordinance Act, the 1973 Pesticides Act, the 1986 Southeast Peninsula Land Development and Conservation Act, and the 1989 Litter Act, would seem to provide the bases for protecting these wetlands from further degradation, cleaning them up, and renovating many of them to their former condition. What seems to be needed is a comprehensive conservation action plan for this valuable national asset.

Acknowledgments

We are most grateful to Kate Orchard of the St. Christopher Heritage Society, and to David and Joan Robinson of the Nevis Historical and Conservation Society for their helpful guidance and assistance in the planning and execution of this study; also to Dr. Lisa Sorenson, co-Chair of the WIWD Working Group of the Society of Caribbean Ornithology for providing a tape of the whistling-duck's call for playback, WIWD conservation educational materials, and much helpful advice and support. Geoff Hilton provided helpful comments on an earlier version of this manuscript.

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RESTORATION OF THE GREATER FLAMINGO (*PHOENICOPTERUS RUBER*) TO ANEGADA, BRITISH VIRGIN ISLANDS

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Abstract.—Following a trial establishment of seven Greater Flamingos (*Phoenicopterus ruber*) on Guana Island, British Virgin Islands, in 1987, the Bermuda Aquarium, Museum, and Zoo provided 18 flamingos to The Conservation Agency, funded by the Falconwood Foundation, for reintroduction to Anegada in 1992, where a large nineteenth century population had been eventually extirpated in the twentieth century. These birds nested successfully in 1995. The flock has increased to 63 birds, including 11 fledglings, in 2001, and a population seems firmly established.

Resumen.—RESTAURACIÓN DEL FLAMENCO (*PHOENICOPTERUS RUBER*) EN ANEGADA, ISLAS VÍRGENES BRITÁNICAS. Después del establecimiento experimental en 1987 de siete flamencos (*Phoenicopterus ruber*) en la isla de Guana, Islas Vírgenes Británicas, el Bermuda Aquarium, Museum, and Zoo donó 18 flamencos a The Conservation Agency, fundada por la Fundación de Falconwood, para una reintroducción en 1992 en Anegada, lugar donde hubo una gran población nidificante en el siglo XIX que fue exterminada en el siglo XX. Estas aves se reprodujeron exitosamente en 1995. La bandada ha aumentado a 63 aves en 2001, incluyendo 11 pichones que han alzado vuelo, y la población parece estar firmemente establecida.

Key words: Anegada, British Virgin Islands, conservation, Greater Flamingo, Phoenicopterus ruber, *restoration*

SIR ROBERT HERMANN SCHOMBURGK (1804–1865), a British subject born at Freiburg, Prussian Saxony, traveled to America in 1829 and to the island of Anegada in the British Virgin Islands (BVI) in 1830 (Anonymous 1957). Schomburgk (1832) chronicled the vast numbers of Greater Flamingos (*Phoenicopterus ruber*) on Anegada, but noted they were even then declining and no longer nesting. By mid-twentieth century no resident birds remained, although small groups of flamingos occasionally visited the island (Mirecki 1977).

Reintroduction of flamingos to the BVI, in combination with the restoration of Anegada rock iguanas (*Cyclura pinguis*) to islands within the lizard's former range – the Greater Puerto Rico Bank – was a plan first conceived and promulgated by me in 1980 when I was employed by what was then the Department of Natural Resources and the Environment, Government of the British Virgin Islands, under the direction of Robert Creque. My plan was initially vetted by Creque and proposed to several prominent leaders on Anegada: if I could find a suitable home for some Anegada rock iguanas, and capture and move them, I promised to obtain Greater Flamingos for re-establishment on Anegada. I did not know how difficult and expensive this would be, or that it would take over a decade to accomplish.

Over the next several years I worked with the owners of Guana Island to establish it as a wildlife sanctuary; remove or control exotics like sheep, burros, and cats; restore vegetation; and build a program of scientific research. During this period the National Parks Trust (NPT) developed into a major quasi-governmental entity under the direction of Dr. Nicholas Clarke. The iguana transfer and flamingo importation – part and parcel of the same restoration program – were constant topics of conversation with Clarke, Mr. Louis Potter of Town and Country Planning, BVI Government (who was drawing up the excellent – if still unfulfilled – plans for a National Park on Anegada), and numerous other government officials. In 1987 we got the first flamingos from the Bermuda Aquarium, Museum, and Zoo, through the good offices of then-Director Richard Winchell. These birds came with the stipulation that they had to survive on Guana without being poached prior to placing any on Anegada. I published my plans in a local newspaper (Lazell 1987).

Guana Island and my organization, The Conservation Agency (TCA), continued to work hand-in-glove with Mr. Potter, the Deputy Governor Mr. Elton Georges, National Parks Trust then-Director Rob Norton, and government officials in general until finally, on 7 March 1992, we were able to bring 18 flamingos from Bermuda to Anegada. There was a great ceremony on that occasion, involving the BVI's then-governor Peter Penfold, then-Deputy Chief Minister Ralph O'Neal, then-Education Minister Louis Walters, Guana's owners Dr. Henry and Gloria Jarecki, the prominent citizens of Anegada, then-Director of NPT Rosmond DeRavariere, TCA's Vice-President Dr. Numi Goodyear (Mitchell), and many government officials. The proceedings were accurately described by Goodyear (1992) for NPT

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and in the local newspapers by Johnson (1992) and Pickering (1992), the latter explicitly detailing the long-standing – and at last fulfilled – flamingos for iguanas trade I had envisioned and promised years before. I describe these details and cite the contemporaneous media coverage because of the erroneous assertion that iguanas "were moved without the permission and involvement of the BVI government" (Garcia 2001). Left uncorrected, and without the context of the flamingos-for-iguanas restoration project, this false statement could have seriously deleterious ramifications adversely affecting NGO projects in the BVI and ever farther afield.

Internationally, Barnes (1992) provided a good account of the initial restoration and Conyers (1996) and Colli (1996) documented the growth of the population. Unfortunately, Raffaele *et al.* (1998) made no mention of the Anegada (or other BVI) population. Over the years the original Guana flock dwindled as older birds died. By 1992, the remaining four individuals left Guana frequently and visited other BVI salt ponds. Far from being poached, they were extremely popular and welcome wherever they appeared. Conyers (1996) reported that four birds joined the original 18 on Anegada, making 22 before successful nesting 1995. These may have been the four Guana survivors, but Conyers saw no bands on them and believed all the birds from Bermuda carried bands.

There are still seven non-breeding birds on Guana Island, all replacements for the original seven of 1987. Attempts led by Dr. Caitlin O'Connell-Rodwell, of Stanford University, to induce breeding with artificial stimuli in this flock are scheduled for 2002. The Anegada population has grown regularly. BVI NPT's Rondel Smith, long an active collaborator with TCA on the flamingo and iguana project, monitors the Anegada population. Christina Leahy, a TCA volunteer, and Lianna Jarecki, Stoutt Community College, Tortola, checked the Anegada population and reported to me on 20 July 2001 that it totals 63 flamingos, including 11 young of the year.

I am indebted to so many people for the success of this project that I can herein note only a few: Richard Winchell and James Conyers from Bermuda, Governors David Barwick and Peter Penfold, Deputy Governor Elton Georges, Chief Minister Ralph O'Neal, Town and Country Planner Louis Potter, National Parks Trust Chairperson Janice George-Creque, NPT Directors Nicholas Clarke, Rob Norton, Rosmond DeRavriere, and Joseph Smith-Abbot of the BVI, Henry and Gloria Jarecki of Guana Island, Tony Smith, Rondel Smith, Lowell and Sue Wheatley, Herman Groezinger, and the late Clement Faulkner of Anegada, and Numi (Goodyear) Mitchell of The Conservation Agency. I am especially grateful to National Parks Trust staff who monitor the flock and have been successfully responsible for resolving human-flamingo conflicts.

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From: "Caitlin O'Connell-Rodwell" <ceoconnell@stanford.edu>
To: "Lianna Jarecki" <ljarecki@hlscc.edu.vg>;
Sent: Saturday, February 16, 2002 9:07 PM
Attach: Flamingo final draft.doc; Figure 1.ppt
Subject: flamingo manuscript

Dear Lianna and Skip,

Attached is our manuscript that I will submit to *Biological Conservation*. I would appreciate any feedback you might have. I am still waiting to hear back from the Bermuda Zoo about the ages of the 6 individuals and I need a better estimate of the size of the salt pond (if you have one).

I look forward to your input.

Thanks a lot. Hope to arrange to be able to spend the month of March or April of next year on Guana/Anegada. It is tough to be bound to an academic schedule and I wasn't able to organize it for this coming March/April.

Take care,

Caitlin

ABSTRACT:

We used artificial social stimulation (decoys, vocalization playbacks, and artificial nests) to encourage breeding in a population of six Greater ~~Caribbean~~ flamingos *(Phoenicopterus ruber ruber)* that had not successfully bred since their introduction to Guana Island in 1992. During a control period prior to the introduction of stimuli, flamingos exhibited no social displays or nest building activities. All flamingos were observed approaching the decoy area as a flock within a few hours after introduction of stimuli, and social displays were exhibited at a low rate by a few birds within the first 24 hours. In a twelve-hour watch conducted two-weeks post introduction of artificial stimuli there was a significantly greater number of group display behaviors, as well as nest-building behaviors, as compared with the control period and immediately after the introduction. The majority of group displays were performed by two individuals (although at least one social display posture was observed for each bird) and three birds exhibited nest-building behaviors. Overall, individuals spent most of their time feeding and resting/sleeping during all observation period. We suggest that social attraction techniques may be a useful tool to stimulate breeding in captive and wild small populations of flamingos.

Artificially induced group display and nesting behaviors in the reintroduced population of Caribbean flamingos *(Phoenicopterus ruber ruber)* on Guana Island, BVI

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Key words: Caribbean flamingo, group displays, *Phoenicopterus ruber ruber*, reintroduction, reproductive success, social attraction

Running title: Artificially induced group displays in Caribbean flamingos

INTRODUCTION:

While their pre-Columbian distribution is not well known, Carribean flamingos *(Phoenicopterus ruber ruber)* historically occurred widely on islands and mainland shores in the Carribean (Sprunt 1975). Flamingos were known to breed in the British Virgin Islands, particularly on Anegada Island where large numbers were recorded by European travelers in the 1800s (Lazell, In press). But the population quickly declined as the birds were hunted for food and by the 1950s no resident flamingos were observed (Colli 1996). Although flamingos are not historically documented at Guana Island, a salt pond does exist that could have provided foraging and nesting habitat.

In an attempt to reestablish Caribbean flamingos in the British Virgin Islands, eight birds from the Bermuda Zoo were brought to Guana Island, a wildlife sanctuary, in 1987 (Lazell, In press). By 1992, four of these birds (all pinioned) had died and the remaining four free-flying birds had flown off the island. In 1992, eight more birds were released on Guana Island and 18 birds were reintroduced to Anegada Island (Lazell, In press). Courtship behavior and nest building was observed in the Anegada population, but no chicks were observed until 1995 after four wild birds (possibly the four from original Guana Island introduction) had joined the Anegada flock. Although both populations appear to not be limited by food supply or excessive predation (Colli, 1996), only the Anegada population has successfully bred and has grown from 18 to 63 individuals (Lazell, In press).

The Guana population currently consists of six individuals, four males and two females ranging from 9 to 21 years old. In the year following the 1992 release of birds, nest building activity was observed in the center of the salt pond, where an artificial island had been created. No egg laying occurred and no social displays or breeding activity has been observed in subsequent years. The island was subsequently removed.

Successful reproduction in flamingos may require a minimum flock size (Stevens & Pickett, 1994). The lack of breeding activity in the Guana population may be due to an inadequate colony size to stimulate breeding behavior. In captivity, a relationship has been found between behavioral stimulation from group displays and breeding success. Increasing the flock size at Zoo Atlanta from 17 birds to 21 birds played a role in increasing the frequency of display activity by 48% and synchronous group displays by 100%, which resulted in a doubling in the frequency of mounts and copulation events (Stevens, 1991). In colonial waterbirds, vocalizations are also important for attracting individuals to a breeding site (Kress, 1997). In captive flamingos, it has been shown that increases in group displays (which includes a vocalization component) stimulates breeding behavior and increases reproductive success (Stevens 1991).

The success of restoration programs for colonially breeding birds depends on several factors, including food abundance, predation pressure, and reproductive success that in some species is dependent on social stimulation and a threshold population size. Methods to reestablish colonial waterbird colonies and artificially stimulate breeding and nesting activities using "social attraction techniques" were developed in the 1970's by Stephen Kress of the National Aubudon Society of the United States. Social attraction techniques involve the use of decoys and vocalization playbacks to artificially simulate a large breeding colony. This technique is becoming an effective management tool for encouraging the recolonization of extirpated breeding colonies. The combination of decoys, mirrors, tape recordings of vocalizations, and in some cases, predator control, has led to led to restoration of Arctic (*Sterna paradisaea*), Common (*S. hirundo*) and Roseate (*S. dougallii*), Sandwich (S. sandvicensis), and Least Terns (*S. albifrons*); Black Skimmers (*Rynchops niger*); Atlantic Puffins (*Fratercula arctica*); Leach's Storm-Petrels (*Oceanodroma leucorhoa*); Dark-rumped Petrels (*Pterodroma phaeopygia*); Laysan Albatross (*Diomedea immutabilis*); and Common Murre (*Uria aalge*) (Parker et al. 2000; Kress, 1997; Watanuki and Terasawa 1995; Schubel 1993; Podolsky and Kress 1991; Podolsky and Kress 1989; Podolsky k 1985).

In the case of the terns, sightings doubled within the first year following introduction of stimuli and nest building behaviors were exhibited in the first and second years following the stimuli introduction. It wasn't until the third year that breeding occurred, but by the fifth year breeding occurred without the assistance of social attraction tools with a total of 424 nests from three species of terns (Kress, 1983). The common murre project had dramatic results with birds observed amongst the decoys a day after the introduction of stimuli and successful breeding occurred in the months that followed at a colony that had been inactive for 10 years (Parker et al. 2000). These active seabird restoration techniques are new tools that have the potential of supplementing traditional management techniques such as site acquisition and the protection of existing colonies (Kress and Strilich, 1993).

Some indication that artificial stimuli may enhance flamingo breeding comes from studies of both captive and wild flamingos. Large mirrors placed in the enclosure of captive L lesser F flamingos (*Pheniconais minor*) resulted in an elevated rate of "marching displays" (a social group display) (Pickering and Duverge 1992). In France, the construction of an island and artificial nest mounds attracted wild flamingos which had lost their nesting habitat nearby (Johnson 1976). Four years after construction of the island, successful mating occurred and was initiated in the area with the artificial mounds.

In this study, we tested whether the introduction of artificial stimuli would induce group displays or any other reproductive behavior in the Guana Island population of Caribbean flamingos *(Phoenicopterus ruber ruber).* The stimuli included the addition of decoys to simulate a larger population, broadcasting group display calls (Head-Flagging calls), and the addition of artificial nests and eggs. Behaviors of each bird were monitored prior to and after the introduction of the stimuli and analyzed to determine whether there was a measurable change in overall activities towards social displays and/or reproductive behavior.

METHODS:

This study was conducted at the salt pond (approximately 300 m by 150 m) on Guana Island, in the British Virgin Islands, over a three-week period during the month of July, 2001 when the island is primarily turned over to scientists to conduct various conservation related marine projects during Marine Science Month. The six flamingos were monitored for a 12-hour period over three days, so that all dawn to dusk hours were covered (from 7 a.m. to 7 p.m.), prior to the introduction of the artificial stimuli. All birds had numbered plastic leg bands allowing recognition of individuals. The behavior of each individual bird was documented, and assigned a behavioral code, every five minutes over the 12 hours by visual observations, using binoculars and a 15-45x spotting scope, and by video recording, using a Sony Digital 8. Observations were conducted from the west end of the pond, the furthest distance from the north-east end of the pond, where the birds were known to spend the majority of their time.

Normal, everyday or "comfort movement" behaviors were categorized as feeding, preening, wing-flapping, wing-stretching, walking, resting, or sleeping (Kahl 1975). Group or "ritualized" displays associated with breeding were categorized using terms and descriptions by Kahl (1975) and Studer-Thiersch (1975), as Marching, Head-Flagging, Wing-Salute, Twist-Preen, Wing-Leg Stretch and Inverted Wing-Salute, False-Feeding, and Broken-Neck. Vocalizations associated with behaviors were also documented. Courtship and nest building behaviors were categorized as outlined in Shannon, 2000. Courtship behavior is not as discrete as group display behaviors and involves a pairing off of a male and female, a female initiating copulation by stepping away from the group, the male following, and the female lowering her head into the water (False-Feeding) and spreading her wings. Nest building behaviors were noted when a bird either stood on a nest, used it's beak to fix a nest, or made contact with an artificial egg.

data are plural. Also at least p. 9 too

After the 12-hour baseline behavioral data ~~was~~ were collected, 10 wooden flamingo decoys were placed near the shoreline of the south-east ~~end of~~ the pond to artificially increase the perceived population size, including seven decoys in Head-Flagging postures. Head-Flagging is the first in a series of group display postures that initiates subsequent group display postures (Kahl 1975, Studer-Thiersch 1975). A cluster of 8 artificially-constructed mud nests was build at the edge of the salt pond and 3 decoys in incubating postures and 5 artificial eggs were placed on various nests, an egg in each nest with the incubating decoys and 2 eggs in empty nests.

Head-Flagging calls were obtained from the Dallas Zoo and spliced together into a 30-minute recording that was burned onto a CD. The CD was broadcast in a loop for 12 hours a day after the introduction of the decoys using a Sony water resistant CD player, charged by a 12 V marine battery that was recharged once a week as needed.

Two additional observation periods were conducted: within 24 hours after the introduction of the artificial stimuli and two weeks later. For each observation period we calculated the percentage of scans devoted to social/ reproductive behaviors (groups display or "ritualized" movements as listed above, plus courtship and nesting) for each individual bird. A univariate repeated measures ANOVA and Tukey's multiple comparison procedure were applied to compare the rate of social/reproductive behaviors displayed by the birds between the three observation periods. This test was calculated in SAS, version 8.02 with observation period as a fixed factor and individual bird as a random factor and $\mu = 0.05$.

RESULTS:

The occurrence of social/ reproductive behaviors increased significantly following the introduction of artificial stimuli ($F_{2,10} = 5.80$, $P = 0.0212$). Tukey multiple comparisons indicated no difference between the observation periods before and immediately following the introduction of stimuli but a significant difference between both of these observation periods and the observation period two weeks later (Figure 1).

No social displays or reproductive behaviors were exhibited during the observation period prior to the introduction of artificial stimuli. During the observation period immediately after stimuli introduction, three Head-flagging social displays were recorded for two birds. Two weeks after the stimuli introduction, a total of 31 social/reproductive behaviors were observed. During this last observation period, all but one individual exhibited social displays (including Head-Flagging, Wing-Salute, Twist-Preen, Wing-Leg Stretch and Inverted Wing-Salute) and three individuals engaged in nest-building activities. Two individuals (one male and one female) displayed more and investigated the nests more than the others (13 and 10 recorded social/ reproductive behaviors for these two birds, respectively).

During all observation periods, the birds spent the majority of their time feeding (between 55-68% of time), followed by sleeping or resting (between 15-27% of time), and preening (between 8-11% of time). Two weeks after stimuli introduction, 3.6% of time was spent in social/reproductive behaviors and were observed between the hours of 0700-1000 and 1600-1900.

DISCUSSION:

Sampling Rates and Relative Observations:

Although we chose a sampling regime of 5 minute blocks over 12 hour periods and the data were significant two weeks after the introduction of artificial stimuli, there were many more behaviors observed outside of the 5 minute blocks, particularly in the 12 hour period just after the introduction of the artificial stimuli. There were 17 group display behaviors observed overall in this period, 3 of which fell within the 5 minute blocks. In addition, upon analysis of video data, more group displays were observed in the dusk period just after our 12 hour watch ended, indicating that there was a larger change in behavior in this period then represented by the way in which the data was prepared for analysis.

The Adaptive Role of Group Displays and Associated Vocalizations:

Key studies have demonstrated the importance of male vocalizations in priming female hormones for reproduction. Lehrman and Freidman (1969) demonstrated that vocal stimulation done without visual cues caused a doubling in size of ovarian follicles in ring doves. This phenomenon is also thought to be the case for parakeets (Ficken et al., 1960) and canaries (Warren & Hinde, 1961). In the little blue penguin (Waas, 1988) it was further demonstrated that crested penguin calls had no effect on their reproductive status, while male calls from their own species did.

Flamingos perform mass, mixed-sex group displays thought to play a role in ensuring synchronous nesting and/or facilitating pair formation (Pickering & Duverge, 1992). The frequency of displays varies widely between individuals, unrelated to sex (Pickering & Duverge, 1992), a phenomenon we also observed in our population, which may imply that certain members of the flock play a key role in instigating group displays.

In flamingos, both sexes call during particular group displays, the Caribbean flamingo having two vocalizations associated with group displays, Head-Flagging and Wind-Salute calls (Kahl, 1975). These vocalizations are most likely important to prime both sexes for reproduction. It is unclear what the relative role of the group display vocalizations and visual stimuli play in priming hormones in flamingos. It is interesting to note that the flamingos in this experiment orientated towards the decoys when preparing to display. The decoys were investigated on many occasions, and outside of display periods, at least three of the flamingos spent time amongst the decoys during nest building, resting and sleeping. The source of the vocalizations, on the other hand, was never investigated. It would be interesting to have a site devoted to vocalization playbacks, a site devoted to decoys and a third site containing both sources of stimulation to determine which behavior was more important, if not both.

Field experimentation with social attraction techniques demonstrate the probable importance of the presence of decoys as a visual cue to land from a distance and in creating the appearance of a larger flock or colony. The relative importance of decoys versus vocalization playbacks is not completely understood yet.

Timing of Artificial Stimuli:

Although the Anegada population has bred between April and June (Jarecki, pers. comm., 2000), Zoo New England reports that the breeding season for Carribean flamingos occurs between May-August (Reo and O'Gara, 2001), and apparently, breeding can occur at any time throughout the year, and flamingos may breed twice in a year (Sedenko, 2001). It was reasonable to expect, then, that the flamingo population on Guana Island may respond to breeding queues during the month of July. Even though flamingos may not breed every year and breeding and nest building may depend on rainfall and its effect on food supply, we still expected that at least breeding behaviors may be induced artificially at that time, regardless of whether an actual mating event occurred.

Having demonstrated that artificial stimuli induce group displays and subsequent reproductive behavior (nest building) in Caribbean flamingos and cause a significant increase in these behaviors over time, in the future, we plan to conduct these experiments prior to the breeding period (March/April) in order to maximize the potential of breeding. Follow up studies will then be conducted to determine nesting success, clutch size, and population growth.

CONCLUSIONS:

Social attraction techniques have played an important role in the reestablishment of colonial nesting birds in the wild. Current population estimates of wild Carribean flamingos is in order of a few 100,000 but no simultaneous censuses have been conducted throughout its range and we do know that their distribution and numbers were historically larger (Johnson 2000). While flamingos are no longer hunted in huge numbers as they were in the last century, loss of habitat and pollution is a major concern for a species that relies on the unique environment of pristine salt ponds for foraging and breeding. Worldwide there are probably ~~less~~ fewer than 30 major breeding sites for all 6 flamingo species (Conway 2000). A recent conference on ~~the~~ conservation biology of flamingos indicated the importance of salt ponds: "flamingos are individually numerous, but colonially and reproductively, endangered in a world of changing landscapes and vanishing feeding and breeding sites." (Conway 2000).

Our study demonstrates that the use of artificial stimuli could play an important role in flamingo reintroduction programs, and perhaps even stimulate reproduction in wild populations of flamingos whose numbers have been drastically reduced. This technique could also be useful in captive breeding programs where other measures have failed to help stimulate breeding.

ACKNOWLEDGEMENTS:

We would like to thank Steve Kress of the National Audubon Society for his support of the project and Jeanette Boylan of the Dallas Zoo for providing the headflagging calls, and Byron Bodt of Bodt Decoys for making the decoys. We would also like to thank Lianna Jarecki, the director of the Marine Science Program on Guana Island for her enthusiastic support of this project, as well as Guana Island staff for assistance on the island. We thank ~~Skip~~ James Lazell of The

Conservation Agency for his input and the BVI National Parks Trust for providing data on the Anegada population. We also thank Dean Kildaw for his helpful comments on this manuscript. Funding for this project was provided by the Falconwood Corporation and Guana Island Marine Science Month.

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Figure legend:

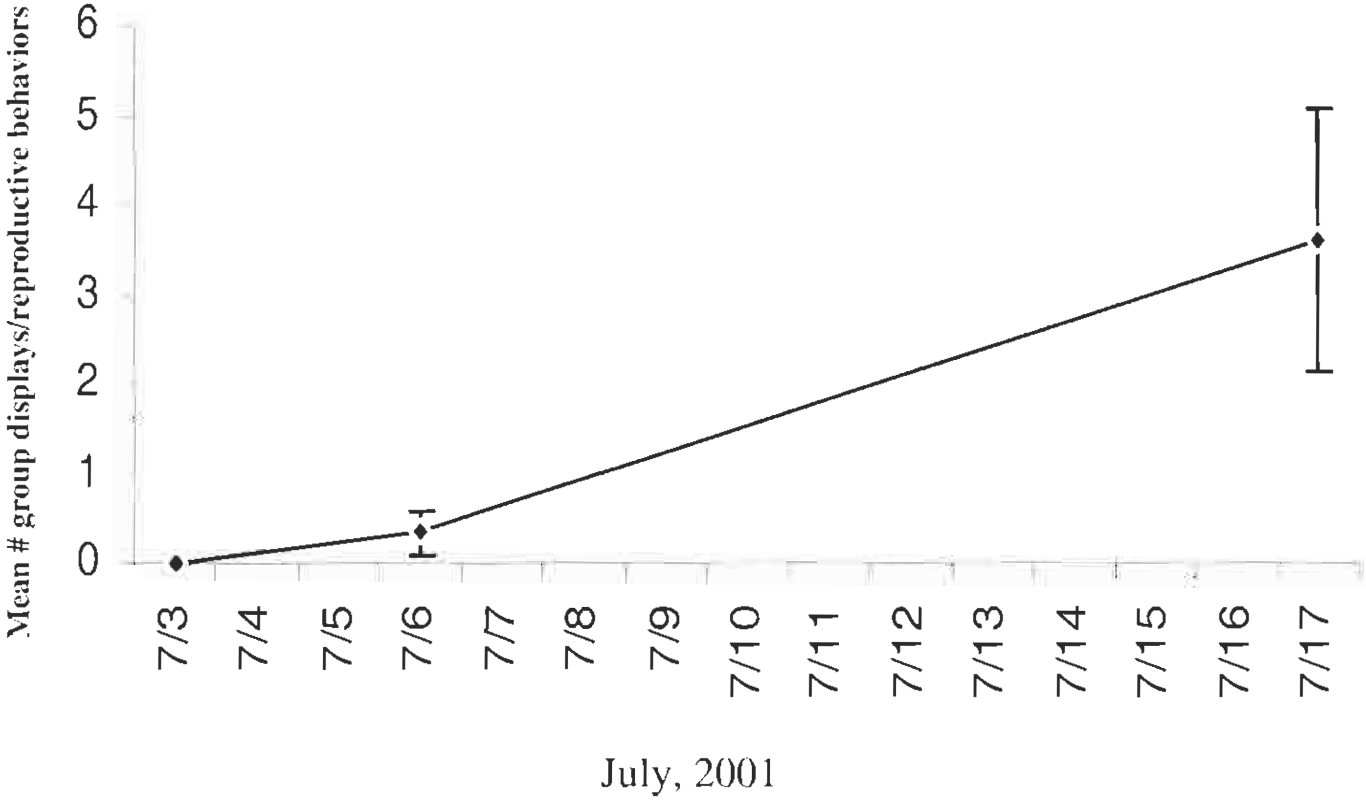
Figure 1.) Occurrence of group displays/reproductive behavior 12 hrs prior to, 12 hrs after, and two weeks after introduction of artificial stimuli. Tukey multiple comparisons test indicates a significant change in behavior two weeks after the introduction of artificial stimulation.

Despite lawyers and journalists, A, B + C is logically very different from A, B, + C. For example, there brown, black, and white bears. The notion of brown, black and white bears is ridiculous. Well, of course, there are brown, black, white, and black and white bears. Check your handy Strunk & White....

Sure do hope it works!

Best,
Skip

Email if you get this -- I'm never sure faxes go through.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July, 2001

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20 November 2001

Dr. James Lazell
The Conservation Agency
6 Swinburne St.
Conanicut Island, RI 02835

Dear Dr. Lazell,

Enclosed is a copy of my final report entitled "Avian Surveys On Guana Island, BVI (4-10 October 2001)" resulting from my recent visit to Guana Island funded by The Conservation Agency. Hopefully the results from this work will be useful to you and the island's owner for future monitoring and conservation efforts. I have also enclosed some additional information which you may find useful.

As discussed, I am very much interested in conducting future studies on Guana and associated islands. I am particularly interested in studying the effects of goat removal on the avifauna of Normal Island (my memory is bad, but I believe this was the island you mentioned). Unfortunately, I would not be available until late April or May, although these may be prime times for censuses in the breeding season. Such a study would involve establishment of point count survey points, conducting baseline point count censuses, some minor vegetation measurements at each point and possibly some mist netting. I believe the work could be conducted in a one week period, with future follow-up surveys to monitor the response of the island to goat removal. I think this could be an important study, given the effects of goats and sheep on islands worldwide. Let me know if this work might be possible there.

I will work with Wayne Arendt to see that our bird surveys are finally published and will provide the resulting reprint once this has occurred.

I greatly appreciated the opportunity to conduct research on Guana Island and it was a pleasure to finally meet and discuss various West Indian natural history issues of common interest. Again thank you for allowing me the opportunity to work on Guana Island and I hope that I might be able to again conduct research on Guana and other islands relevant to the Conservation Agency's interests there.

Regards,

Joe Wunderle

Joseph M. Wunderle, Ph.D.
Wildlife Team Leader &
Research Wildlife Biologist

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AVIAN SURVEYS ON GUANA ISLAND, B.V.I.
(4-10 OCTOBER 2001)

By

Joseph M. Wunderle, Jr.

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A final report submitted to the Conservation Agency,
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20 November 2001

Abstract. – Point count censuses of birds as well as general observations were conducted on Guana Island, BVI from 4-10 October 2001 and compared with similar censuses conducted in October 1994 by Wayne Arendt (1995). Median number of individuals and median number of species per fix-radius point were significantly lower in the 2001 counts than in 1994. Six species including: Antillean Crested Hummingbird, Bananaquit, Common Ground Dove, Mangrove Cuckoo, Pearly-eyed Thrasher and Zenaida Dove showed significant declines from 1994 to 2001 in median number of individuals per fixed-radius point. Four of the declining species (Bananaquit, Mangrove Cuckoo, Common Ground-Dove and Zenaida Dove) had lower detection ratios in 2001 than in 1994, indicating that they were more difficult to detect in the recent counts. It is likely that most of the declines are related to differences in detectability related to differences in breeding behavior and perhaps changes in vegetation both related to seasonal and annual rainfall differences between 1994 and 2001. Bridled Quail-Dove counts did not change from 1994 to 2001 and a total of 26 quail-doves were observed, suggesting that Guana may harbor one of the highest densities known for this regional endemic. One and possibly two additional White-crowned Pigeons were observed in Harris Gut, indicating that original captive-release birds from 1999 or their offspring still occur on or visit Guana. The island of Anegada was visited on 9 October and the results of avian observations are provided. Continued monitoring of Guana's avifuana is recommended and phenology studies of trees and shrubs are encouraged to document seasonal and year-to-year variation in food supplies to identify potential bottleneck periods for the islands nectarivores, frugivores, and seedeaters.

INTRODUCTION

Guana Island is a protected nature reserve of approximately 340 ha with a maximum elevation of 245 m, located in the British Virgin Islands. Guana Island is recognized for having one of the richest faunas known for an island of its size (Lazell 1996). For example, at least 50 bird species may be seen regularly, although more than twice that number are possible (Norton et al. 1989, Mayer and Chipley 1992, Lazell 1996).

Although there are no permanent human residents on the island, it is home to the Guana Island Club. Visitors to Guana have little impact on the island's environment and rarely venture far on the island's trails. The island's owner is a committed conservationist, which accounts for the island's protected status. Not only has the island been protected, but in addition, efforts have been made to lessen or eliminate human impacts (e.g., removal of sheep from the island) as well as to re-establish populations of species which have been lost from the island (e.g., iguana, *Iguana pings*; red-legged tortoise, *Geochelone carbonaria*; Greater Flamingo, *Phoenicopterus ruber*; White-crowned Pigeon, *Columba leucocephala*).

Numerous studies of Guana Island's biota have been sponsored by the Conservation Agency of Jamestown Rhode Island, especially during science month held each October. These studies have proven useful for documenting the occurrence and status of species on the island as well as providing basic information on the natural history, ecology, and biology of the island's flora and fauna. This information provides the basis for monitoring and managing the island's diverse flora and fauna.

This study was conducted to survey the island's terrestrial avifauna especially the Bridled Quail-Dove (*Geotrygon mystacea*) and the White-crowned Pigeon. The quail-dove, a regional endemic, is a species of conservation concern given its limited geographic range and the White-crowned Pigeon's status has remained uncertain following a reintroduction of 14 birds in the spring of 1999

(J. D. Lazell, pers. comm.). In addition, this study documented changes in terrestrial bird populations on Guana by replicating the thorough point count surveys conducted in October 1994 by Arendt (1995). Arendt's study provides a valuable baseline for comparison of potential population changes over a seven-year period.

METHODS

All birds observed on Guana Island from 4-9 October 2001 were noted (Appendix 1) as were birds observed on nearby Anegada on 8 October 2001 (Appendix 2). Birds were censused using the methods of Arendt (1995) with only minor modifications. As in Arendt's original 1994 study, fixed radius points of Hutto et al. (1986) were used to census birds. During each point count the observer tallied all birds detected by sight and sound during a 10 min. period within a 25-m radius as well as those detected beyond 25 m. Although noted, birds flying over the point count circles were not included in the analysis. Aquatic species were also excluded from the analysis. Sixty-five point counts were conducted from 0600 to 0940 on 4, 5, 6, 7, 9, and 10 October 2001. Each point was located at 100 m (paced) intervals along trails (Figure 1). Efforts were made to locate points along the same trails used by Arendt as shown in his summary report. However, Arendt's points 1 through 25 were located along transects which were not replicated in this study. In place of transects, point counts were conducted along established trails that approximately covered the same area and habitat as sampled by Arendt in his points 1 – 25.

Although there is a risk that differences in observer abilities may confound comparisons of census results obtained by different observers, I believe that such differences are minimal in the comparisons made in this study. Dr. Arendt and I have worked together in the field and have similar observation and hearing abilities as evident in similar point count results obtained during our work in Puerto Rico. In addition, both of us have over 20 years field experience with vocalizations and appearance of the common Caribbean bird species typical of Guana's avifauna. Thus it is unlikely that any differences found in this study are a result of observer differences in abilities to detect and identify the birds on Guana.

Analyses of point count data involved calculation of mean number of detections within the 25 m radius point counts, proportion of 25 m radius point counts with one or more detections, and proportion of unlimited radius point counts with one or more detections. Mann-Whitney U tests were used to compare the median number of detections per 25 m radius point counts from this study with the previous studies of Arendt (1995). Alpha levels of 0.05 or less are accepted as significant. To determine the likelihood that a species would be detected within the 25 m fixed-radius, I calculated a detectability index or ratio using the methods of Hutto et al. (1986). This ratio is equivalent to the number of point counts at which a given species was recorded only beyond the 25-m radius, divided by the total number of counts in which the species was recorded.

Tape playback of vocalizations of White-crowned Pigeons and Bridled Quail-dove (see Appendix 1 for scientific names) were used to locate the two species. Tape playback was used at the end of alternating point counts (spaced at 200 m intervals) and involved 2.5 min of White-crowned Pigeon calls and 3.5 min of quail-dove calls. Pigeon vocalizations were taken from Reynard (1969) and quail-dove vocalizations taken from the CD provided with the text of Oberle (1999). Tape playback was conducted with a Sony TCM 5000 cassette tape recorder set at 75% full volume. At the end of each playback session an additional 2 min of silence was used to detect responses. A total of 19 different playback sessions were conducted at points 1, 3, 5, 7, 9, 11, 13, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, and 36 (Figure 1).

An effort was made to note White-crowned Pigeons and Bridled Quail-doves between point counts and while walking slowly along trails at the completion of each morning sample of point counts. In addition, three late afternoon/dusk surveys were made to detect White-crowned Pigeons on the hillside above the orchard (4 Oct. 1630 – 1745; 5 Oct. 1630 –1745) and Harris Gut (6 Oct. 1630 – 1745).

RESULTS

Point Counts – A total of 14 terrestrial bird species were detected during 65 point counts (Figure 1), of which 13 species were tallied in the 25-m fixed radius point counts (Table 1). Within the fixed radius point counts an average of 2.6 species and 3.6 individuals were detected per point. Of the 14 species detected during the point counts, 11 species were resident on Guana and three species were Neartic migrants (Prairie Warbler, Blackpoll Warbler, Black-and-white Warbler). The five most abundant species in the point counts in order of decreasing abundance were the: Pearly-eyed Thrasher, Bananaquit, Green-throated Carib, Zenaida Dove, and Caribbean Elaenia. The average number of thrashers detected per fixed radius point was almost twice the number of Bananaquits, the next most abundant species (1.5 vs. 0.8 individuals per point).

The results from my fixed radius point counts of October 2001 differed from the earlier counts of Arendt in October 1994 in several ways (Figure 2). Overall, the average number of species per point was significantly (Mann-Whitney U = 2520, P = 0.007) lower in the recent counts (2.6 vs. 3.5) as was the average number of individuals per point (3.6 vs. 5.8; Mann-Whitney U = 2764, P = 0.001). Contributing to these declines were six species that had significantly fewer mean detections per point in October 2001 than previously, and include Pearly-eyed Thrashers, Bananaquits, Antillean Crested Hummingbirds, Mangrove Cuckoos, Common Ground-Doves, and Zenaida Doves (Figure 2). Four of the declining species (Bananaquit, Mangrove Cuckoo, Common Ground-Dove and Zenaida Dove) had lower detection ratios in 2001 than in 1994 (Figure 3), indicating that they were more difficult to detect in the recent counts. Differences in the incidence of singing behavior likely contributed to increased detectability of doves in 1994, as 78% of Common Ground-Dove detections and 82% of Zenaida Dove detections were of singing individuals (Arendt 1995), in contrast to the October 2001 counts in which neither species was heard singing.

Response To Playback – No response of White-crowned Pigeons or Bridled Quail-Doves was detected to tape playback of vocalizations. One Bridled Quail-Dove calling before the playback session continued to call at the same rate during the playback and in the 2-min silent period afterwards as it had before playback began. Had these species been breeding it is likely that the playback technique would have been more effective. Two Scaly-naped Pigeons arrived during a playback session of White-crowned Pigeon vocalizations and landed in a tree canopy within 20 m of the observer, although it is unknown if this was a response or just coincidental.

Observations of White-crowned Pigeons & Bridled Quail-Doves - A total of 14 Bridled Quail-doves were detected during the point counts, 8 individuals within 25 m and 6 individuals beyond 25 m. In addition, another 12 quail-doves were found while walking between point count locations. Thus a total of 26 individual quail-doves were found during the October 2001 count period. Quail doves were detected at points 26, 28, 29, 31, 37, 38, 41, 43, 44, 51, and 65 and between points 37–38, 43-44, and 56-57 (Figure 1). All quail-dove observations occurred within the distribution range known for the species on Guana Island (Chipley 1991, Figure 1). Six individual quail-doves were heard calling during the point counts.

One White-crowned Pigeon and possibly two others were observed as they flushed from a tree canopy along the Monkey Point Trail at Harris Gut on the morning (0920) of 9 October. One individual with a distinct white crown was observed as it flew from a tree with two other dark pigeons. The three pigeons flew off together, but the crowns of two birds were not seen. Thus it is possible that as many as three White-crown Pigeons were present.

DISCUSSION

The declines in bird abundance observed in the 2001 counts may mostly be attributable to changes in detectability. Although Arendt's counts were run at the same time of year as my own (1 – 11 October 1994 vs. 4-9 October 2001), differences in seasonal rainfall prior to the counts probably affected detectability. Arendt's counts were conducted at the end of a wet period that had been preceded by an extensive drought (F. Sibley, pers. comm.). As a result the vegetation was more open and birds were still breeding (e.g., pigeons and doves) as noted by Arendt (1995). In contrast, my counts were conducted during an extended dry period (J. D. Lazell, pers. comm.) and no evidence of breeding was detected. Singing or calling associated with breeding undoubtedly contributed to the greater detectabiliy of Zeniada Doves and Common Ground Doves in Arendt's point counts, although both species were occasionally encountered in different parts of the island outside of the 2001 counts. Mangrove Cuckoos had high detectibility ratios (0.59) in the 1994 counts, mostly as a result of active calling associated with breeding, in contrast to 2001 in which Mangrove Cuckoos were not detected in point counts (2 cuckoos were observed between counts). Declines in Bananaquit counts may also be attributable to absence of breeding in 2001, as well as possible differences in flower abundance (flowers were mostly absent), which may have also contributed to declines in Antillean Crested Hummingbird detections.

It is not apparent that the 2001 decline in Pearly-eyed Thrasher detections are related to differences in breeding activities between 1994 and 2001. Only about 5% of the thrashers were singing in the 1994 counts (Arendt 1995) compared with 7% in 2001 and detection ratios were actually higher in 2001 (0.59 vs. 0.47). Thus it is unlikely that the significant thrasher decline from 1994 (2.1 thrashers/25m radius point) to 2001 (1.5 thrashers/25m radius point) can be attributed to differences in detectability, but may reflect an actual population decline of thrashers on Guana. It seems unlikely that control efforts related with the removal of nuisance thrashers around the hotel has substantially contributed to this decline.

Guana island is especially notable for its high Pearly-eyed Thrasher abundance as observed by Arendt (1995). Even with recent declines in counts, thrasher abundance on Guana is still higher than the next highest known counts on St. John, USVI (1.2 thrashers/25 m radius point, pre-hurricane; Askins and Ewert 1991). This high thrasher abundance is of concern given the threat that thrashers pose as predators of eggs and nestlings (Arendt 1995).

Bridled Quail-Dove detections in the fixed-radius point counts remained constant from 1994 to 2001 despite an increase in the detection ratio from 0 to 0.29. Although actual estimates of total numbers or density estimates of quail-doves have not been made, it appears that reasonable numbers of Bridled Quail-Doves survive on Guana. It is likely that Bridled Quail-Doves have some of their highest densities on Guana Island of anywhere in their limited range (Puerto Rico and associated islands through some of the Virgin Islands south to St. Lucia, Raffaele et al. 1998). Bridled Quail-Doves were absent from the pre-hurricane fixed-radius point counts of Askins and Ewert (1991) on St. John USVI and in similar counts by Wunderle and Waide (1993, unpublished results) in a variety of habitats on Puerto Rico, despite the known presence of the species at the sampled sites on both islands.

Quail-doves appear to be especially sensitive to the effects of hurricanes as observed after recent hurricanes struck nearby islands. For example, Bridled Quail-Doves confined to a few forest fragments on St. Croix, USVI showed significant declines in counts conducted in the aftermath of Hurricane Hugo and searches in traditional sites failed to detect the species (Wauer and Wunderle 1992). Bridled Quail-doves appear to be sensitive to openings in the forest canopy, as observed in the related Ruddy Quail-Dove (*Geotrygon montana*), which disappeared from traditional areas with extensive canopy damage following a recent hurricane which struck the Luquillo Experimental Forest (LEF) in Puerto Rico (Waide 1991, Wunderle 1995). However, Ruddy Quail-Doves did persist in undamaged forest patches scattered throughout the continuous LEF (11,330 ha), and in other undamaged forest reserves on Puerto Rico. In contrast, the Bridled Quail-Doves were confined to a few remnant forest fragments before Hurricane Hugo struck St. Croix. However, once these fragments were extensively damaged, quail-doves had few, if any potential refugia, thereby increasing the likelihood of their loss from St. Croix. This may not be the case for Guana Island, which may have adequate forest area with diverse exposures to provide potential post-hurricane refugia for quail-doves preventing their local extinction following a hurricane. Moreover, close proximity to Tortola may facilitate post-hurricane re-colonization of Guana Island by quail-doves from protected refugia on the larger island.

The presence of at least one White-crowned Pigeon on Guana Island found during my October surveys indicates that individuals or their offspring may still survive from the releases of birds on Guana Island in 1999. The observations and evidence for breeding of White-crowned Pigeons on Beef Island (J. D. Lazell, pers. comm.) further suggests that the re-introduction may be potentially successful, at least for returning the species to the British Virgin Islands. It is not obvious why the released white-crowns did not remain and nest on Guana Island, although it is possible that breeding has gone undetected on Guana. It is also possible that appropriate food resources are lacking for White-crowned Pigeons to now breed on Guana., however studies of the food resources available on Guana (or any other small Caribbean island for that matter) have not be made.

In the future it would be valuable to continue periodic monitoring of Guana Island's terrestrial bird populations using the methods initiated by Arendt (1995). This is especially important for monitoring the effects of droughts and hurricanes, both of which can have substantial effects on Caribbean bird populations (Wiley and Wunderle 1994, Dugger et al. 2000). Such long-term monitoring is especially important in protected areas to track the status of sensitive species and to identify potential problems requiring management intervention. In addition, it would be valuable to conduct flowering and fruiting phenology studies of some of the more common trees, shrubs, and vines on Guana to document the seasonal variation in flower and fruit availability. Flowers, fruits, and seeds are important food resources for a number of animal species on Guana and an understanding of their seasonal and year-to-year variation would be helpful in identifying potential bottleneck periods for organisms relying on these resources (e.g., Wunderle 1999).

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Table 1. Abundance of terrestrial bird species in 65 point counts conducted on Guana Island, BVI in October 2001. Shown are the mean detections per point within 25-m radius fixed-radius point counts; proportion of 25-m radius fixed-radius point counts in which the species was represented by at least one individual; proportion of unlimited radius point counts in which the species was represented by at least one individual; and the species detection ratio which is equivalent to the number of point counts at which a given species was recorded only beyond the 25-m radius, divided by the total number of counts in which the species was recorded.

Species	MEAN	f(≤25m)	f (u)	Detection Ratio
Pearly-eyed Thrasher	1.54	0.85	0.86	0.59
Bananaquit	0.82	0.57	0.58	0.05
Green-throated Carib	0.25	0.23	0.28	0.00
Zenaida Dove	0.23	0.17	0.18	0.00
Caribbean Elaenia	0.23	0.18	0.26	0.18
Black-faced Grassquit	0.17	0.15	0.15	0.00
Scaley-naped Pigeon	0.12	0.11	0.15	0.20
Bridled Quail-Dove	0.12	0.11	0.11	0.29
Gray Kingbird	0.09	0.08	0.18	0.67
Antillean Crested Hummingbird	0.05	0.05	0.05	0.00
Prairie Warbler	0.03	0.03	0.05	0.00
Blackpoll Warbler	0.03	0.03	0.03	0.00
Black-and -White Warbler	0.02	0.02	0.02	0.00
Smooth-billed Ani	0.00	0.00	0.02	1.00

FIGURE LEGENDS

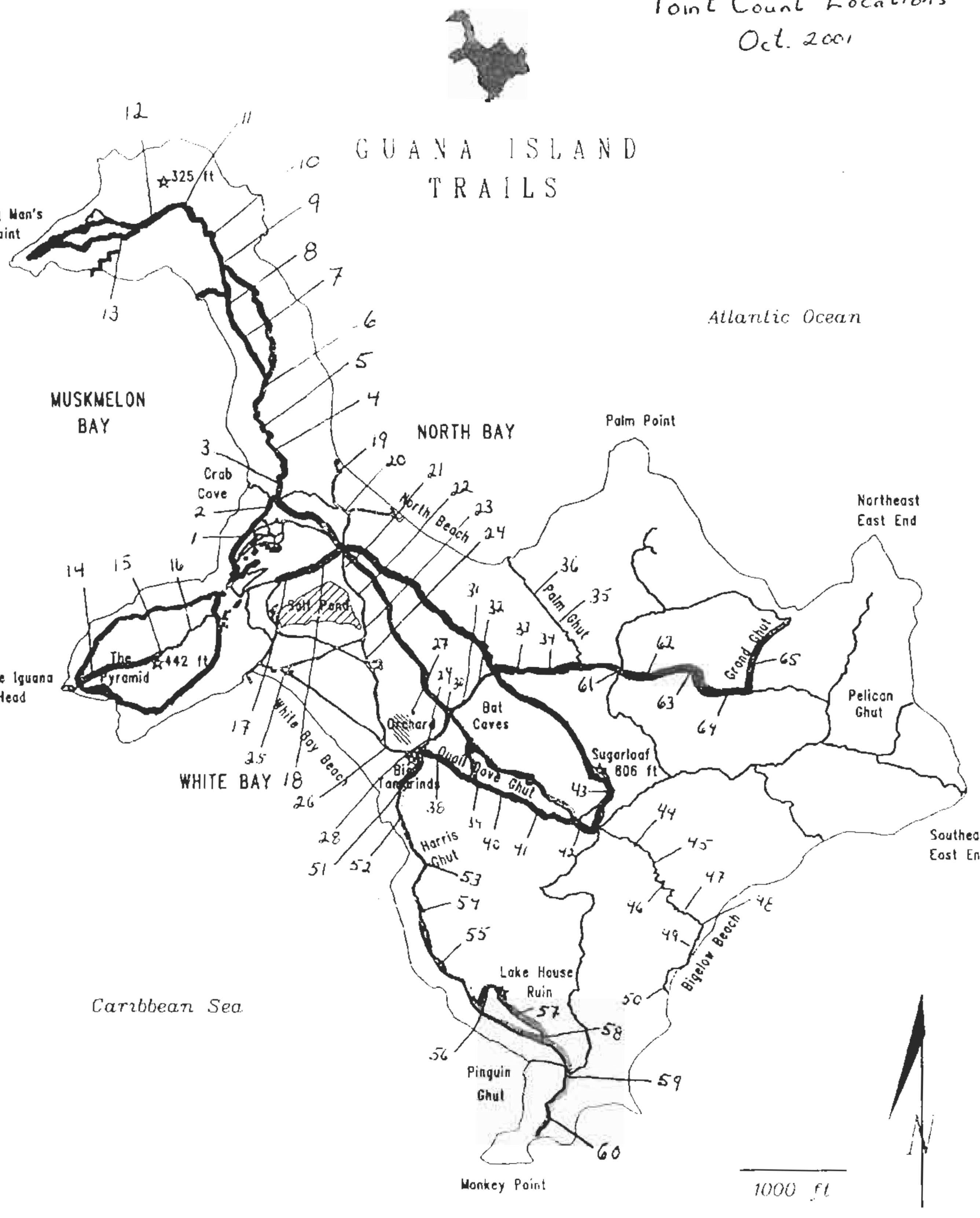
Figure 1. Location of 65 point count sites where point counts were conducted on Guana Island, BVI in October 2001. Counts were spaced at 100 m intervals paced along established trails

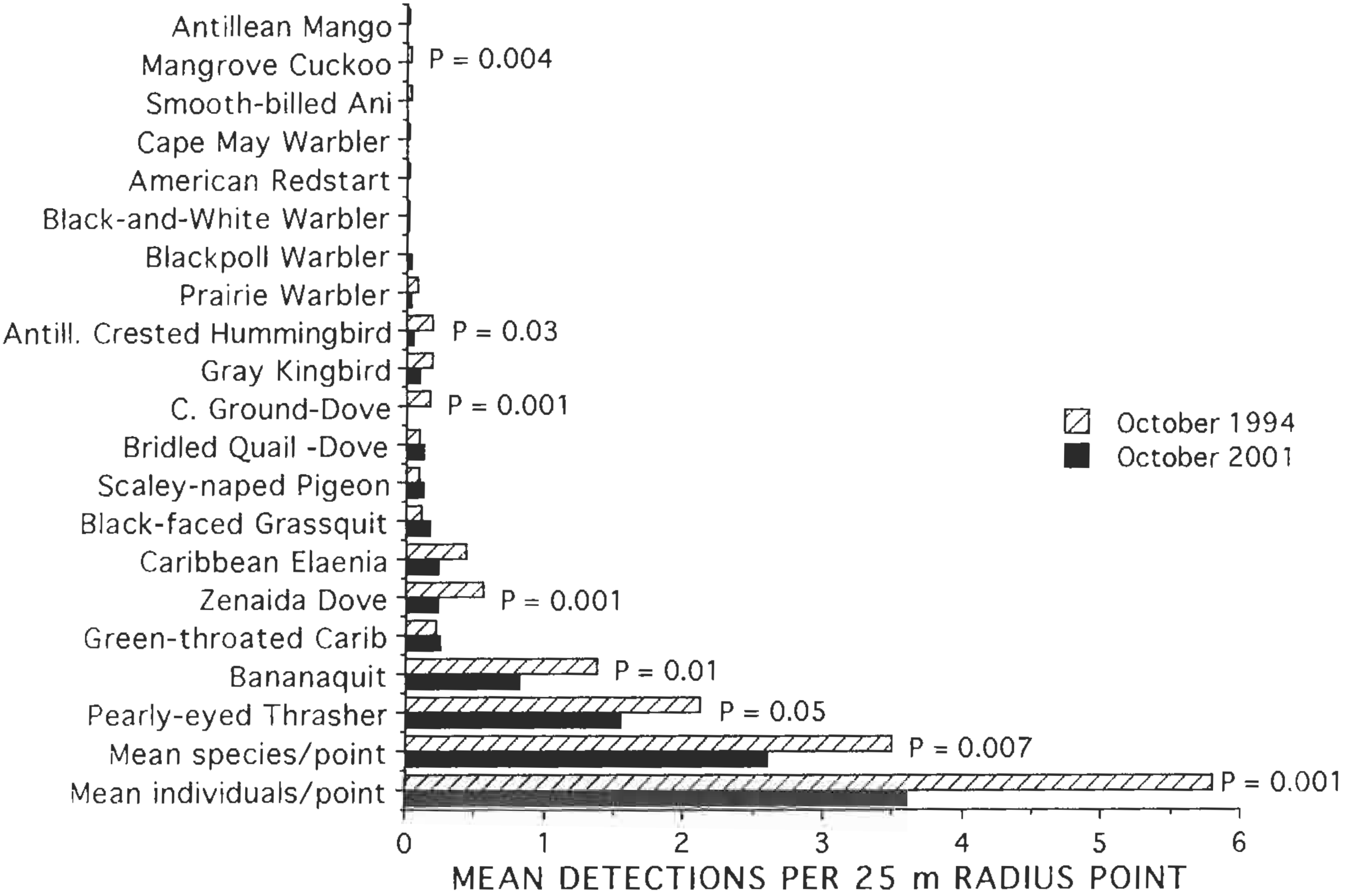
Figure 2. Mean detections of birds per point in fixed-radius point counts of 25 m radius on Guana Island, BVI in October 1994 and October 2001. Counts in 1994 were conducted at 60 points by Arendt (1995). Counts in 2001 were conducted at 65 points. P values indicate significance level based on a comparison of medians for the two years with a Mann-Whitney U Test.

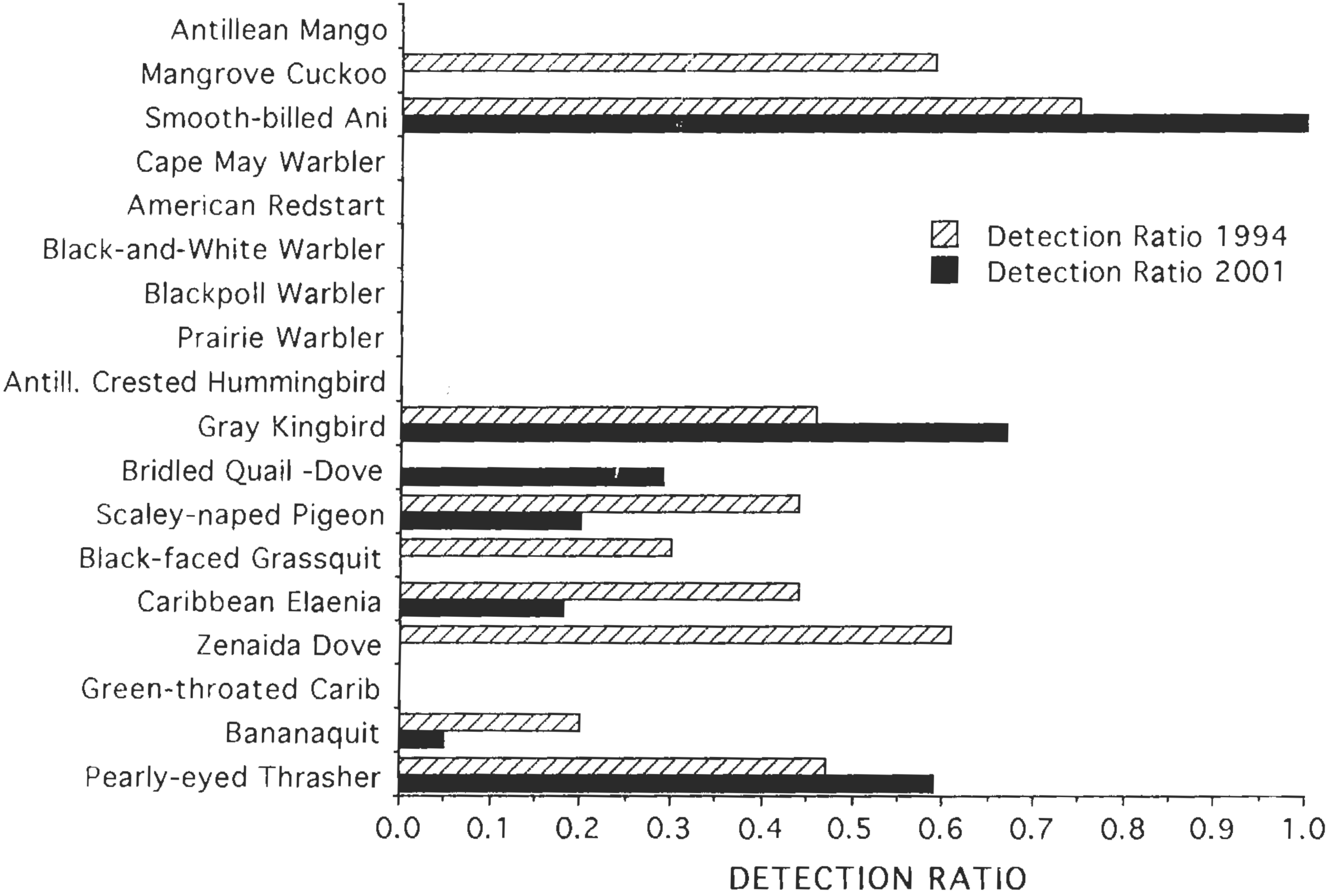
Figure 3. Detection ratios of birds detected in point counts on Guana Island, BVI in October 1994 and October 2001. Detection ratios based on 60 point counts of Arendt (1995) and 65 point counts in October 2001. Detection ratio is equivalent to the number of point counts at which a given species was recorded only beyond the 25-m radius, divided by the total number of counts in which the species was recorded (Hutto et al. 1986).

Figure 1.

Point Count Locations
Oct. 2001




Antillean Mango
Mangrove Cuckoo
P = 0.004
Smooth-billed Ani
Cape May Warbler
American Redstart
Black-and-White Warbler
Blackpoll Warbler
Prairie Warbler
Antill. Crested Hummingbird
P = 0.03
Gray Kingbird
C. Ground-Dove
P = 0.001
Bridled Quail -Dove
Scaley-naped Pigeon
Black-faced Grassquit
Caribbean Elaenia
Zenaida Dove
P = 0.001
Green-throated Carib
Bananaquit
P = 0.01
Pearly-eyed Thrasher
P = 0.05
Mean species/point
P = 0.007
Mean individuals/point
P = 0.001
▨ October 1994
■ October 2001
0
1
2
3
4
5
6
MEAN DETECTIONS PER 25 m RADIUS POINT



Antillean Mango
Mangrove Cuckoo
Smooth-billed Ani
Cape May Warbler
American Redstart
Black-and-White Warbler
Blackpoll Warbler
Prairie Warbler
Antill. Crested Hummingbird
Gray Kingbird
Bridled Quail -Dove
Scaley-naped Pigeon
Black-faced Grassquit
Caribbean Elaenia
Zenaida Dove
Green-throated Carib
Bananaquit
Pearly-eyed Thrasher
▨ Detection Ratio 1994
■ Detection Ratio 2001
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
DETECTION RATIO

APPENDIX 1. Birds observed on Guana Island, BVI during 4-8 amd 9-10 October 2001. The following designations of abundance are used: Abundant = observed during virtually all outings, most habitats; Common = observed during most outings, most habitats; Uncommon = observed less frequently, fewer habitats.

Brown Booby (*Sula leucogaster*) – Common offshore.
Brown Pelican (*Pelecanus occidentalis*) – Common offshore.
Magnificent Frigatebird (*Fregata magnificens*) – Common offshore.
Little Blue Heron (*Egretta caerulea*) – 1 adult, North Beach.
Cattle Egret (*Bubulcus ibis*) – 1White Bay Flats
Green-backed Heron (*Butorides striatus*) – 1 White Bay.
Yellow-crowned Night-Heron (*Nycticorax violaceus*) – 1 heard at Salt Pond.
Greater Flamingo (*Phoenicopterus ruber*) – 6 Salt Pond.
White-cheeked Pintail (*Anas bahamensis*) – 5 Salt Pond.
Red-tailed Hawk (*Buteo jamaicensis*) – 1 on trail to Long Man's Point; 1 over White Bay Beach.
American Kestrel (*Falco sparverius*) – 2 White Bay Flats.
Black-necked Stilt (*Himantopus mexicanus*) – 5 Salt Pond.
Lesser Yellowlegs (*Tringa flavipes*) – 2 Salt Pond.
Spotted Sandpiper (*Actitis hypoleucos*) – 2 Salt Pond.
Ruddy Turnstone (*Arenaria interpres*) – 6 Salt Pond.
Laughing Gull (*Larus atricilla*) – Uncommon offshore.
Royal Tern (*Sterna maxima*) – Uncommon offshore.
Scaly-naped Pigeon (*Columba squamosa*) – Common, widespread.
Zenaida Dove (*Zenaida aurita*) – Common, widespread.
Common Ground-Dove (*Columbina passerina*) – Common widespread.
Bridled Quail-Dove (*Geotrygon mystacea*) – Common in moist guts.
White-crowned Pigeon (*Columba leucocephala*) – 1 maybe 3 total along Monkey Trail at Harris Gut.
Mangrove Cuckoo (*Coccyzus minor*) – Uncommon widespread.
Smooth-billed Ani (*Crotophaga ani*) – 4 White Bay Flats.
Green-throated Carib (*Eulampis holosericeus*) – Common widespread.
Antillean Crested Hummingbird (*Orthorhynchus cristatus*) – Uncommon widespread.

APPENDIX 1, Continued

Belted Kingfisher (*Ceryle alcyon*) – 1 White Bay; 1 Bigelow Beach.
Caribbean Elaenia (*Elaenia martinica*) – Common in xeric sites – widespread.
Gray Kingbird (*Tyrannus dominicensis*) – Uncommon widespread.
Caribbean Martin (*Progne dominicensis*) – 7 cliffs, Long Man's Point
Barn Swallow (*Hirundo rustica*) – 2 White Bay Beach.
Pearly-eyed Thrasher (*Margarops fuscatus*) – Abundant widespread.
Prairie Warbler (*Dendroica discolor*) – 1 point 6.
Blackpoll Warbler (*Dendroica striata*) – 1point 25 & 31; 1 White Bay Flats.
Black-and-White Warbler (*Mniotilta varia*) – 1 point 45.
Ovenbird (*Seiurus aurocapillus*) – 1 by laundry house.
Northern Waterthrush (*Seiurus noveboracensis*) – 1 heard Salt Pond.
Bananaquit (*Coereba flaveola*) – Abundant, widespread.
Black-faced Grassquit (*Tiaris bicolor*) – Uncommon, widespread.

APPENDIX 2. Birds observed on Andegada, BVI on 8 October 2001 from 0830-1600.

Brown Booby (*Sula leucogaster*) – 1.
Brown Pelican (*Pelecanus occidentalis*) – 5 +.
Magnificent Frigatebird (*Fregata magnificens*) – 2.
Little Blue Heron (*Egretta caerulea*) – 2.
Snowy Egret (*Egretta thula*) – 1.
Cattle Egret (*Bubulcus ibis*) – 4.
Great Egret (*Ardea alba*) – 1.
Great Blue Heron (*Ardea herodias*) – 1.
Greater Flamingo (*Phoenicopterus ruber*) – 45.
White-cheeked Pintail (*Anas bahamensis*) – 6.
Blue-winged Teal (*Anas discors*) – 40+.
American Kestrel (*Falco sparverius*) – 1.
Osprey (*Pandion haliaetus*) – 1.
Sora (*Porzanz carolina*) – 3.
Greater Yellowlegs (*Tringa melanoleuca*) – 1.
Lesser Yellowlegs (*Tringa flavipes*) – 5.
Pectoral Sandpiper (*Calidris melanotos*) – 6.
Red Knot (*Calidris canutus*) – 2.
Least Sandpier (*Calidris minutilla*) – 3.
Semipalmated Sandpiper (*Calidris pusilla*) – 4.
White-rumped Sandpiper (*Calidris fuscicollis*) – 5.
Sanderling (*Calidris alba*) – 3.
Spotted Sandpiper (*Actitis hypoleucos*) – 3.
Ruddy Turnstone (*Arenaria interpres*) – 15+.
Black-bellied Plover (*Pluvialis squatarola*) – 1.
Laughing Gull (*Larus atricilla*) – 5.
Royal Tern (*Sterna maxima*) – 10+.
Gull-billed Tern (*Sterna nilotica*) – 1.
Sandwich Tern (*Sterna sandvicensis*) – 10+.
Common Ground-Dove (*Columbina passerina*) – 15+.
Belted Kingfisher (*Ceryle alcyon*) – 1.
Smooth-billed Ani (*Crotophaga ani*) – 2.
Caribbean Elaenia (*Elaenia martinica*) – 10+.
Gray Kingbird (*Tyrannus dominicensis*) – 6.

APPENDIX 2, continued

Barn Swallow (*Hirundo rustica*) – 1.
Northern Mockingbird (*Mimus polyglottos*) – 5.
Prairie Warbler (*Dendroica discolor*) – 2.
Yellow Warbler (*Dendroica petechia*) – 10+.
Northern Waterthrush (*Seiurus noveboracensis*) – 1.
Bananaquit (*Coereba flaveola*) – 8.
Black-faced Grassquit (*Tiaris bicolor*) – 1.

From: <SchreiberE@aol.com>
To: <hq@theconservationagency.org>
Sent: Wednesday, May 08, 2002 10:42
Subject: Skip

Dear Skip,
I'm just checking in. Had emailed you a few months ago and it came back - old email. I understand you had one o Bob Rickelfs students on Guana last year for some blood sucking!

I've sent some advice along to the Natl. Parks Trust on creating more frigate habitat on Great Tobago. It sounds like they are really trying to get rid of the goats finally.

I keep thinking about the report of Brown Boobies nesting on Guana. During May and Oct. I never saw any sign o nesting. Is there a time of year when you have seen them on nests? Given that incubation is 6 weeks, chick rearing 12 weeks, and post-fledging feeding 4-10 weeks - they should be present over a 5 month period

I think it would be great to take one of the remote beaches and try to get trerns nesting - plant the dummy birds and play calls. There is such a need for them to have a protected, predator free area to nest.

Hope all is going well. Know you are keeping busy!! We leave for a month on JOhnston Atoll next week. Putting satellite transmitters on great frigates. At last learning something about where these birds go to feed.

Best regards,
Betty Anne

* *

E. A. Schreiber, Ph.D.
National Museum of Natural History
Smithsonian Institution
4109 Komes Court
Alexandria, VA 22306
Phone 703 768-6726
Fax 703 768-9010

Dear Dr. Lazell,

Thank you for your letters in response to our recent paper, as well as the information on the banding station. Unfortunately, I am not actually doing this isotope work anymore. I've moved onto a PhD program at Cornell. Its too bad we didn't know about your work a few years ago, because as you know, its difficult to get samples from that area.

However, I would definitely suggest holding onto your feathers. There is no real protocol for preserving feathers. You just need to keep them dry in envelopes or something similar. We actually use plastic slide pages. Currently, I also believe you need large sample sizes to do this work accurately (15-20+ per species per site). However, if more warblers seem to fit this pattern, then your multi-samples would probably be very useful to someone in the future.

Thanks again.

Dustin

Dustin R. Rubenstein
Cornell University Department of Neurobiology and Behavior
Seeley G. Mudd Hall
Ithaca, NY 14853-2702

The Conservation Agency

The Conservation Agency
Temporary Field Office
870 Pebble Creek Rd.
Lane, OK. 74555
hq@theconservationagency.org

27 November 2001

Mr. Louis Potter
Town and Country Planning
Government of the B.V.I.
British Virgin Islands

Dear Louis:

I am sorry we did not have a chance to get together this October: lots to talk about. The demands on my time on Guana seem ever-increasing.

I understand Great Dog Island is up for sale. When I last visited it in 1998, it was in excellent ecological condition. There were no goats or other feral ungulates and no mongooses or cats in evidence. Maybe not even rats. We have not done a proper faunal survey but we have seen most of the regular members of the reptile fauna there. Pending a floral survey, Great Dog could be an excellent restoration site for stout iguana, *Cyclura pinguis*, and red-legged tortoise.

At present, Great Dog is notable for it's population of the BVI endemic bo-peep, *Eleutherodactylus schwartzi*. The population is very small -- probably not more than a couple dozen individuals. The frogs on Great Dog are larger than in any other known population; this implies a genetic difference is likely. They are mostly confined to one area on the ridge top dominated by the large, terrestrial bromeliad *Hohenbergia antillana* -- itself an uncommon plant in the wild. This unique symbiosis on Great Dog should be preserved.

I know there is little in a legal sense any of us can do about private property, but I have found most land owners eager to conserve nature -- if they just know about it. I would suggest that all of us try to be aware of who owns/buys Great Dog and write to the new owner(s), emphasising not just the frog-bromeliad suite but a general philosophy of "design with nature" and "plant natives".

In the latter connection, Rudy O'Reilly, USDA St. Croix, has pointed out to me the great inferiority of the commercially available Cuban Royal Palm in contrast to the VI native species, *Roystonea borinquensis*. The Cuban species grows more slowly in the VI, never grows large, and often fails to fruit. We should encourage cultivation of the native Royal Palm and discourage planting of the exotic. This is just one example of many that an active native plant nursery could provide at a potentially great economic benefit to enterprising individuals and the community. I am sending this letter to everyone I believe can help. In advance, thanks to you all.

With best wishes,
Skip Lazell Skip
hq@theconservationagency.org

cc: Bert Lettsome
Joseph Smith-Abbott
Clive Petrovic
Lianna Jarecki
Rowan Roy

We are working on our m problem....

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United States Department of Agriculture

NRCS Natural Resources Conservation Service

USDA

Virgin Islands Service Center, 5030 Anchor Way, Ste. 2 Gallows Bay, VI 00820

May 14, 2002

Dr. Skip Lazell
The Conservation Agency
6 Swinburne Street
Jamestown, RI 02835

Dear Dr. Lazell

There are many advantages to using native vegetation for reforestation. Perhaps the strongest argument is for the conservation of local botanical diversity and structure. Exotics in the same genera as native species pose a double threat. Some exotics can "escape" and out-compete native species for space and resources. But, closely related introduced species can also hybridize with native counterparts, so the integrity of the local gene pool is compromised.

This integrity is secured only by careful selection of the plant material to be established. In the U.S. Virgin Islands we are currently trying to establish protocol for collecting native seeds. This is a new venture and we hope to make headway on this topic in the coming months. Even the introduction of native species from Florida stock, for example, could affect future generations of local plants. Not only are exotic pests and diseases introduced, but foreign genes are also released into the local population.

Aside from the environmental threats posed by some exotic species, most tend not to perform as well as natives. Many lack pollinating or dispersal agents normally found in their natural habitat. Growth rate may also be affected by local soil types, or other environmental factors. Cuban Royal Palms planted at the University of the Virgin Islands, St. Croix Campus, are out grown by Puerto Rican Royal Palms planted around the same time. Even the Cuban Royals planted at the Community College in Tortola do not seem as robust as Puerto Rican Royals of the same size.

For the Royal Palm "reintroduction" project on Guana Island I would recommend using the Puerto Rican Royal Palm, *Roystonea borinquena*. This species extends from Puerto Rico into the U.S. Virgin Islands and would be the most logical choice for any reforestation project on Guana. For large sized specimens Puerto Rico would be the best source. They should start producing seed and attracting birds within a few years. As I recall these are to be planted on the flat between the woods and the garden. This may be a good site for the palms to become established if the salinity is not too high in that area. This palm is a riparian species in St. Croix, so Quail Dove Ghut, just to the east, may be a good site for additional plantings of seeds or seedlings from the U.S. Virgin Islands. Please let me know how this project progresses.

Sincerely,

Rudy G. O'Reilly, Jr.
District Conservationist

Elizabeth Righter
104 26th St NW
Bradenton, Florida 34205
March 5, 2002

Mr. Skip Lazell
The Conservation Agency
8 Swinburne St.
Jamestown, RI 02835

Dear Skip:

It was nice to talk to you the other day. I hope that the research on Guana Island will continue and I am looking forward to being a part of it next October.

Enclosed are vertebrate fauna lists that Liz Wing composed based on her analysis of samples from excavation units in midden deposits at the Tutu site in St. Thomas. I have enclosed our radiocarbon dates for the various excavation levels so that you can place the data chronologically. I have also included a list of fauna from a sort of grab sample from the Mainstreet site in downtown Charlotte Amalie. A radiocarbon date from the lowest levels of this site-which was essentially Cedrosan Saladoid--was AD. 182-uncalibrated.

If you use this material in publications, please cite:

Wing, E. S., deFrance, S., & L. Kozuch (1995). *Faunal remains from the Tutu Archaeological Village, St. Thomas, USVI.* Manuscript on file at the Division for Archeology and Historic Preservation, Charlotte Amalie, St. Thomas.

Radiocarbon dates are from:

Righter, Elizabeth (Ed), in press. The Tutu Archaeological Village Site: a Multidisciplinary Case Study in Human Adaptation. To be published by Taylor and Francis Books, London.

At Tutu, as you know, Elizabeth Righter was Principal Investigator and Director with the help of 30 professional archaeologists and more than 200 other volunteers.

I hope this information helps. Let me know how your research turns out.

Best wishes,

Elizabeth Righter

PS Let me know if you are planning to cite the dates because the publishers may have other ideas about the title of the book.

The Conservation Agency

Exploration, Education, and Research

President
James D. Lazell, Ph.D.
401-423-2652

6 Swinburne Street
Conanicut Island
R.I. 02835 U.S.A.

April 4, 2001

Mr. Bennet Smith, Chairperson
Airport Development Committee
Chief Minister's Office
Government of the British Virgin Islands
Road Town, Tortola, B.V.I.

Dear Mr. Smith:

My colleagues here and I are gravely concerned about the plan to dredge sand from the sea bottom west of Lee Bay, Great Camano, because we believe it would drain sand from the beaches along the southeast shore of Guana Island.

Guana's southeastern beaches are quite small, but are critical nesting habitat for Roseate Tern (Sterna dougallii) and Stout Iguana (Cyclura pinguis), both internationally listed endangered species. Indeed, the Stout Iguana -- which formerly occurred throughout the islands of the Greater Puerto Rico Bank including Puerto Rico, all the U.S.V.I. except St. Croix, and all the B.V.I. -- today occurs only on Anegada, Guana, and Necker Islands in all the world.

For over 20 years this Agency has sponsored conservation in the B.V.I. It was this Agency that brought flamingos back to Anegada. We believe the wildlife of the B.V.I. -- terrestrial and marine -- is key to the country's economic success and prosperity.

Anything that could disrupt important wildlife habitat or fishing grounds is an immediate threat to the economic well-being of the people of the B.V.I. Therefore, we must oppose any sea bottom dredging close to any islands or reefs - especially between Great Camano and Guana.

Most sincerely,

James Lazell, Ph.D.
President

cc: Hon. Ralph O'Neal
Hon. Julian Fraser
Governor Frank Savage
Bertrand B. Lettsome
Stuart Logan
Eva Baskin

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United States Department of Agriculture
Agricultural Research Service
Southern Plains Area
P.O. Box 159, Hwy. 3 West
Lane, Oklahoma 74555

March 25, 2002

Dr. James Lazell
870 South Pebble Creek Rd.
Lane, OK 74555

Dear Dr. Lazell,

This letter is a follow up to our recent conversation regarding my presenting a seminar on germplasm collections and their benefit to agricultural science. My presentation will be titled "Germplasm collections: a functional study of *Citrullus lanatus*".

I am also interested in the cucurbit species of Guana Island. It has come to my attention that there are two species of cucurbits found on Guana Island. One of these species is introduced while the other is believed to be a native plant species. The latter species *Cayaponia racemosa* has only one accession in the USDA Plant Germplasm Collection. It is also possible that *C. racemosa* was misidentified and is actually *C. americana*. This species has no accessions in the USDA Plant Germplasm Collection. I would like the opportunity to visit Guana Island to catalogue and collect seed for introduction into the Germplasm Collection.

Sincerely,

Angela R. Davis

Dr. Angela R. Davis
Research Geneticist

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Ecological Restoration

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13 March 2002

Dr. James Lazell
The Conservancy Agency
6 Swinburne Street
Jamestown, Rhode Island 02835

Dear Dr. Lazell,

Thank you for your patience while we reviewed your manuscript, "Restoring vertebrate animals in the British Virgin Islands." Enclosed you will find a copy of your original manuscript with suggested revisions based on my thoughts and those of a reviewer who has considerable experience with the wildlife ecology of the Caribbean. We think these suggested changes will help improve the manuscript both in terms of readability and style.

I would very much like to see your story and ideas in an upcoming issue of *Ecological Restoration*. Frankly, there has been a shortage of articles about animal restoration in our journal and elsewhere. Your account not only shows that animal restoration is possible, it raises the question of using "analogs" for certain keystone species, which I find an interesting proposition. So, I hope that you will take the time to look over our suggestions and make the necessary revisions. In addition to the revised text, I would also like to suggest that you send along some slides or photos of the species mentioned in the story–the extirpated species, the restored species, or the analog species. Please send both the revised manuscript and the art work to me by June 15, 2002.

Thank you for your time and effort in this matter. Please feel free to contact me with any questions or concerns. I look forward to helping you share your information with the readers of *Ecological Restoration*.

Sincerely,

Dave

Dave Egan, Editor
Ecological Restoration

PRACTICE AND PERSPECTIVE

Restoring Vertebrate Animals in the British Virgin Islands

by James Lazell

About 4,000 years ago, successive waves of human beings began settling the West Indies, causing many extirpations and extinctions of native animals (Olson 1989, Martin and Steadman 1999). The British Virgin Islands (BVI) did not escape this onslaught, which has continued up to the present, with the most recent faunal losses perpetrated by trans-Atlantic peoples (Mirecki 1977, for the avifauna). Losses of larger, possibly "keystone" species, are well documented and include predatory birds, major seed dispersers, mammals, and the largest native herbivores—tortoises and iguanas.

At The Conservation Agency, we have set out to repair extirpations by introducing conspecific individuals of greater flamingo (*Phoenicopterus ruber*), white-crowned pigeon (*Columba leucocephala*), whistling frog (*Eleutherodactylus schwartzi*), red-legged tortoise (*Geochelone carbonaria*), and stout iguana (*Cyclura pinguis*) from populations on other islands. Should we now begin repairing extinctions by introducing ecologically equivalent exotic species when no other alternative exists? Possibilities might include the Hawaiian monk seal (*Monachus schauinslandi*) as a replacement for the Caribbean monk seal (*M. tropicalis*), Guam rail (*Rallus owstoni*) for DeBooy's rail (*Nesotrochis debooyi*), and Puerto Rican iguaca (*Amazona vittata vittata*) for the original Virgin Islands parrot (*Amazona vittata* subsp. indet.). Could the introduction of carefully selected exotics adequately fill empty niches?

Local extirpations and species extinctions obviously leave empty ecological niches. Furthermore, if a "keystone" species is lost, there will be ripple effects throughout the entire community on a relatively small island (Brown 1995, Whittaker 1998, Lundberg and others 2000, Morgan Ernest and Brown 2001, Bond 2001)). For example, in the Antilles, local extirpation of a major seed disperser—such as the white-crowned pigeon—may impair recruitment in some plants, resulting in their decline and eventual loss. This change may result in habitat loss for migratory birds (and declines or losses of the birds themselves). Changes in the plant community may also lead to increased soil erosion and concomitant siltation, degradation, and even death of marine communities, such as coral reefs and turtle-grass flats. For example, the vast salt ponds of Anegada, BVI, supported a huge colony of flamingos in the 19th century (Schomburgk 1832). We cannot expect these ecosystems to function normally or naturally without flamingos today.

I seek to restore vertebrate faunas of BVI to the closest semblance possible of their prehuman functional condition. The following accounts provide details of efforts to restore whistling frog, red-legged tortoise, stout iguana, flamingo, and white-crowned pigeon to BVI. I also provide arguments for introducing exotic species to fill vacant ecological niches even when these cannot be filled by

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closely related species from nearby Caribbean islands.

Whistling Frog

Whistling frogs (*Eleutherodactylus* spp.) are poor dispersers across seawater. That a few occasionally do succeed at waif dispersal is demonstrable; they do occur on many oceanic island banks never connected to other lands (Schwartz and Henderson 1991). However, each bank characteristically supports an endemic species, which is presumably autochthonous. Large banks, like the Puerto Rico Bank, show internal speciation. For example, *Eleutherodactylus schwartzi* is endemic to the Virgin Islands (perhaps now surviving only in BVI) and is the sister species of the Puerto Rican whistling frog, *E. coqui* (MacLean 1982). Two other species of whistling frogs (*E. antillensis* and *E. cochranae*) also occur in BVI (Ovaska and others 2000), but these are widespread on the Puerto Rico Bank and do not show obvious inter-island differentiation. However, *E. schwartzi* does. The Great Dog Island population, occurring on the smallest island in BVI that supports any frogs, consists of notably large individuals of this species (Ovaska and others 2000).

Locals in the BVI call all whistling frogs "bo-peeps." Thus, when people report that there used to be "bo-peeps" on an island, one cannot know which species. In 1997, we chose *E. schwartzi* as the species to restore to Little Thatch Island because it has been demonstrably lost from some islands (MacLean 1982, St. John, USVI), and has the smallest range of the three species. We chose stock from Tortola, the closest island to Little Thatch with a large population of *E. schwartzi* (the only closer island is Frenchman's Cay, where *E. schwartzi* is rare). On October 27 1997, we removed seven males, six females, and four egg clutches (8-11 eggs, average 10 eggs per clutch) and the bromeliads (*Tillandsia* spp.) in which they resided. We set the bromeliads and frogs among other bromeliads growing on Little Thatch Island. The population expanded rapidly and within a year frogs were calling "all over" this island (Jon Morely, manager, *pers. comm.* October 24 1998).

Tortola may have been a poor choice for this reintroduction, however. If development plans go forward on the island, the Great Dog population may be extirpared and a unique gene pool could be lost. We are looking for another protected island to relocate some of the Great Dog Island population. **[I just want to be clear: Is your concern about the population on Tortola or Little Thatch??]**

(Neither: Great Dog)

Red-Legged Tortoise

Although the red-legged tortoise probably does not migrate easily across water, humans have transported it to such an extent that its status as a native on many islands is questionable (MacLean 1982, Schwartz and Henderson 1991, but see Lazell 1993). Indeed, many older local people in BVI remember taking these tortoises from island to island as well as eating them. They also remember populations of red-legged tortoises on various islands, where in recent years there have been no tortoise sightings.

Today, red-legged tortoises are still common on Water Island and Little St. James in USVI, but rarely seen on Virgin Gorda and Tortola. If any survive on St. Thomas, they are extremely few in number. In 1986, the late Dr. William MacLean brought one of the last known individuals, a large adult female, from St. Thomas over to Guana to join five tortoises that Walter Phillips brought from Water Island that same year. In July 1987, Dr. Nicholas Clarke, then director of the BVI National Parks Trust (NPT), brought a large male over from Tortola to Guana Island. These seven individuals comprise the founders of the present population on Guana Island, where red-legged tortoises are now common.

On October 22 1997, Clive Petrovic, Stoutt Community College, Tortola, donated an adult female red-legged tortoise, 10.5-in (27-cm) carapace (dorsal shell) length. She was set up in an enclosure with sufficient depth of loose soil to nest on Necker Island, BVI. Petrovic knew she had mated with a male housed at the Botanic Garden, Road Town, Tortola, and predicted she was gravid. She did nest, and an estimated (from eggshells) dozen hatchlings emerged on July 12, 1998. Most of the hatchlings escaped through the wire mesh of the enclosure, but two were retained in a semi-captive state. They measured 2.6 and 3.2 inches (66 and 80 mm) carapace length on October 19, 1998. The adult female was later released, although she tends to remain in close proximity to the building; she is usually easily found and regularly seen. **[who released her? What building are you referring to?]** *

On October 13, 2000, while visiting Guana Island from the Division of Forestry and Wildlife, Dominica, Stephen Durand found a young adult male tortoise—8.8-in (22.5-cm) carapace length—that I then translocated to Necker Island. This individual tortoise took to his new home and its incumbent female red-legged tortoise with passionate exuberance. In July 2001, Joanne Netherwood (manager, *pers. comm.* July 25, 2001) saw hatchling tortoises.

Stout Iguana

Paleontologists have found the bones of the stout iguana on several islands in the Puerto Rico Bank (Pregill 1981). They are seemingly poor water crossers, and we know little of their inter-island geographic variation. Grant (1932) claimed iguanas were present on Guana Island about 1930, but he identified the species as the common or green iguana (*Iguana iguana*). However, no one else has reported this species on Guana Island. If there were iguanas present in the 20th century, they were probably the last survivors of a stout iguana population.

In 1980, while officially employed by what was then the Department of Natural Resources and the Environment, Government of the British Virgin Islands, under the direction of Robert Creque, I first conceived and promulgated the plan to restore stout iguanas to islands within the Greater Puerto Rico Bank and flamingos to BVI. Creque agreed with my plan and I proposed it to several prominent leaders on Anegada. The proposal was straightforward: If I could find a suitable home for some Anegada iguanas, then capture and move them, I promised to obtain greater flamingos for re-establish-

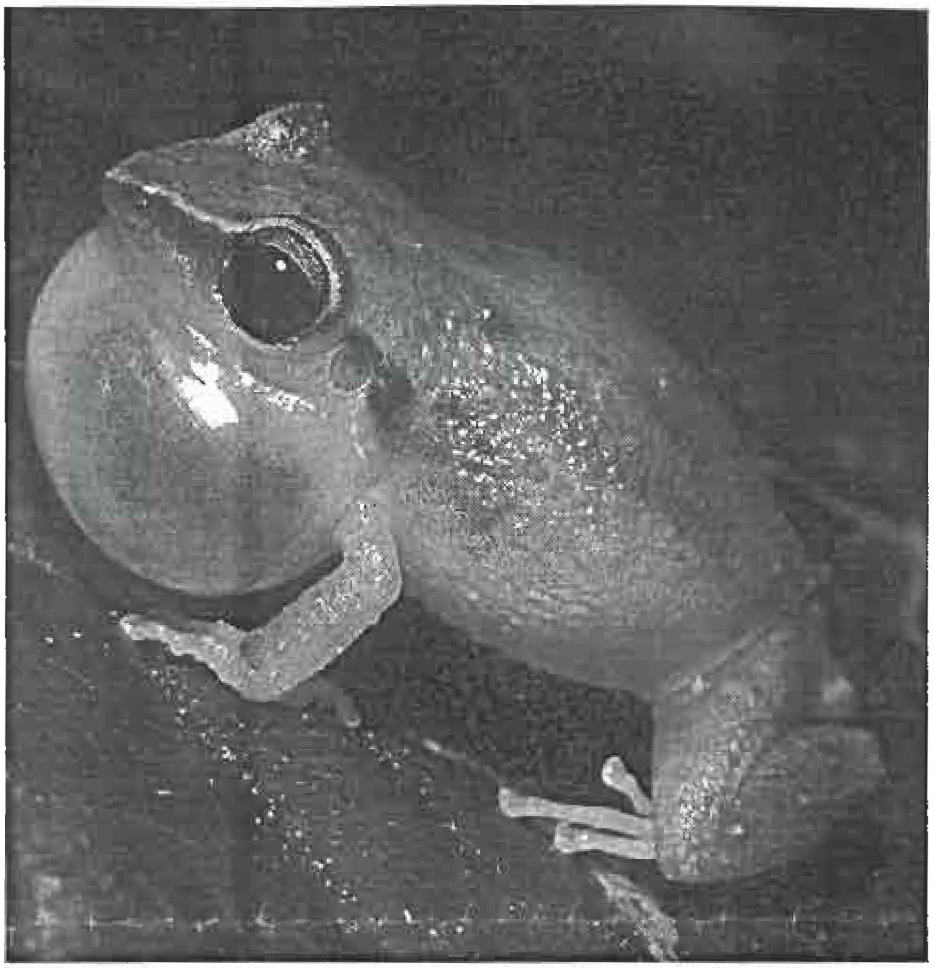
* Netherwood; only one.

ment on Anegada. I simply had no choice except to obtain stout iguanas from Anegada—it was the only island that had any at all.

During the next several years, I worked with the owners of Guana Island to establish that island as a wildlife sanctuary, remove or control exotics (such as sheep, burros, and cats), restore vegetation, and build a program of scientific research. During this period, the National Parks Trust (NPT) developed into a major quasi-governmental entity under the direction of Dr. Nicholas Clarke. The iguana transfer and flamingo importation—part and parcel of the same restoration program—were constant topics of conversation between Dr. Clarke, Louis Potter of Town and Country Planning, BVI government (which was drawing up plans for a National Park on Anegada), and numerous other government officials.

It was apparent during this period that iguanas were declining on Anegada. In 1980, when I first observed them, they had already disappeared completely from the Citron Bush area—the same area where Carey (1975) had found the highest densities in the 1960s. The best remaining concentration was at Bones Bight, where the late Clement Faulkner maintained a feeding station for them. My colleagues on Anegada feared the worst for this population because they saw no proximate hope of controlling or eliminating the ungulates (especially goats) that were out-competing iguanas for food plants. Everyone agreed that a second population needed to be re-established. In 1984, I brought the first iguana from Anegada to Guana Island. During the next two years, I brought seven more to the island. The population of stout iguanas fairly exploded on Guana Island (Kirby 1986, Goodyear and Lazell 1994).

In October 1995, I brought four hatching stout iguanas from Guana Island to Necker Island (Lazell 1995). We cage-reared the animals until October 1996, when one of the iguanas escaped. After that, we released the remaining three animals. All four survived and established recognizable territories. On May 1, 1999, I caught and released the larger of the two females, the previous escapee, and noted that she appeared heavily gravid. On October 1, 1999, I noted the first hatchling iguana on Necker Island (Lazell 2000). I revisited Necker about a year later. The first reptile I saw was a hatchling stout iguana. In all, I saw many juveniles in two age classes and all four adults. Rebecca Leigh reports that the stout iguana is now abundant on Necker Island (Rebecca Leigh, manager, *pers. comm.* April 11, 2002).



A [redacted] whistling frog (*Eleutherodactylus schwartzi*) make its presence known. Author James Lazell and his colleagues restored this species of whistling frog to Little Thatch Island in the British Virgin Islands. They have also restored other species, including red-legged tortoise, stout ignuas, flamingo and white-crown pigeon, to various islands in the BVI. *Photo courtesy of* [redacted] Kristiina Ovaska

In detailed, long-term studies, Mitchell (1999 and 2000) reported that while the same plants that form the mainstay of stout iguana diet occur on Anegada and Guana, stout iguanas on Guana actually prefer to eat different native species. We believe this is because the forage on karst bedrock, alkaline soils of Anegada is relatively low quality compared with that on igneous bedrock, acidic soils of Guana. After a decade of collaborative research, Mitchell concluded that vulnerability to predation, due to fewer shelter sites, was the reason stout iguanas had been extirpated from islands such as Guana and Necker. In the absence of artificial predation—man and exotic carnivores such as dogs, cats, and mongooses—the igneous bedrock, acid soil islands are, many believe, the optimal iguana habitat (Goodyear and Lazell 1994). Iguanas often survive on karst, but survival is often in suboptimal habitat, and I believe that is the case with stout iguanas on Anegada. The highest densities reported for Anegada are well below the density on igneous Guana and Necker Islands today.

Greater Flamingo

Flamingos are strong long-distance fliers. Decades after the BVI breeding populations were extirpated, occasional dispersers visited these islands (Mirecki 1977). They did not recolonize, however, because they are highly gregarious nesters. There seems to be a critical minimum needed for the group to initiate reproductive activities. Finding no group to join, and being too few to initiate reproduction on their own, the dispersers apparently perished or moved on.

Schomburgk (1832) chronicled the vast numbers of greater flamingos on Anegada, but he noted they were even then declining and no longer nesting. By mid-20th century no resident birds remained, although small groups of flamingos occasionally visited the island (Mirecki 1977).

In 1987 we received the first flamingos from the Bermuda Aquarium, Museum, and Zoo, through the good offices of then-director Richard Winchell. These seven birds came with the stipulation that they had to survive on Guana without being poached, prior to placing any on Anegada. I published my plans in a local newspaper (Lazell 1987). While the translocation was successful, the birds failed to reproduce, probably because of the low number in the population.

Guana Island and my organization, The Conservation Agency (TCA), continued to work closely with Louis Potter; Deputy Governor Elton Georges; Rob Norton, then-director of NPT; and various government officials. On March 7, 1992, we were able to bring 18 flamingos from Bermuda to Anegada. There was a great ceremony on that occasion, involving the BVI's then-governor Peter Penfold, then-deputy Chief Minister Ralph O'Neal, then-Education Minister Louis Walters, Guana's owners Dr. Henry and Gloria Jarecki, the prominent citizens of Anegada, then-director of NPT Rosmond DeRavariere, TCA's vice-president Dr. Numi Goodyear (Mitchell), and many government officials. The proceedings were accurately described by Goodyear (1992) for NPT and in the local newspapers by Johnson (1992) and Pickering (1992), the latter explicitly detailing the long-standing—and at last fulfilled—flamingos-for-iguanas trade I had envisioned years before.

I describe these details and cite the contemporaneous media coverage because of the erroneous assertion that iguanas "were moved without the permission and involvement of the BVI government." (Garcia 2001) Left uncorrected, and without the context of the flamingos-for-iguanas restoration project, this false statement could have serious deleterious ramifications adversely affecting NGO projects in BVI, and even farther afield.

"A useful goal for restoration is reinstating earlier selection regimes."

Internationally, Barnes (1997) provided a good account of the initial restoration, and Conyers (1996) and Colli (1996) documented the growth of the flamingo population. Unfortunately, Raffaele and his colleagues (1998) made no mention of the Anegada or Guana population in their regional bird guide. Over the years, the original Guana flock dwindled as older birds died. By 1992, the remaining four individuals left Guana frequently and visited other BVI salt ponds. Far from being poached, they were extremely popular and welcome wherever they appeared. Conyers (1996) reported that four birds joined the original 18 on Anegada, making 22 prior to successful nesting in 1995. These may have been the four Guana survivors, but Conyers saw no bands on them and believed all the birds from Bermuda carried bands.

There are still seven non-breeding greater flamingos on Guana Island, all replacements for the original seven removed in 1987. Dr. Caitlin O'Connell-Rodwell of Stanford University plans to use artificial stimuli to induce breeding in this flock sometime in 2002. Meanwhile, the Anegada population has grown. Rondel Smith of BVI NPT, an active collaborator with TCA on the flamingo and iguana project, continues to monitor their progress. Christina Leahy, a TCA volunteer, and Lianna Jarecki, Stoutt Community College, Tortola, reported to me on July 20 2001 that the population totals 63 greater flamingos, including 11 young birds.

White-Crowned Pigeon

Like flamingos, white-crowned pigeons (*Columba leucocephala*) are strong long-distance fliers. In the late 1970s, Mirecki (1977) reported them extirpated from BVI as a breeding species, although occasional individuals did appear from time to time. We arranged with the Puerto Rico Department of Natural Resources to bring young squabs from Puerto Rico to Guana Island. We failed to get nesting with 4 squabs in 1997, but added 10 more in 1998 and achieved reproductive success with those 14 in the aviary. Unfortunately, some predator, probably rats (*Rattus rattus*), killed the young squabs in their nests.

In October 1998, we released all 14 adult birds. We strongly suspect they have been joined by dispersers. In this case, there is certainly no reason to worry about genetic differentiation of stocks because, like flamingos, white-crowns in the Antilles are metapopulations with probable panmixis, and slight inter-island genetic divergence (Norton and Seaman 1985). I have not observed white-crowns nesting on Guana Island, probably because I have not been present except in October, which is past the appropriate nesting season. However, every year since 1999, several observers, including myself, have observed fledgling birds with dull gray crowns. In 1999, Tortola's renowned birder Rowan Roy (*pers. comm.* April 12, 2002) observed white-crowned pigeons nesting on Beef Island, adjacent to the east end of Tortola. He reports white-crowned pigeons are seen regularly on Beef Island and eastern Tortola. It would now be appropriate to undertake a census on all three islands.

The Next Species

An immediate candidate for restoration to BVI is the West Indian whistling-duck (*Dendrocygna arborea*), formerly a regular nester (Phillips 1922). Mirecki (1977) reports this species as "fairly common... in the 1930s, but... now extirpated." Sorenson and Bradley (1998 and 2000) provide an overview of the status of this species and current conservation efforts now underway on its behalf. Several aviculturalists in the United States are breeding these magnificent big ducks, which should make them potentially available for relocation. However, the species is listed in
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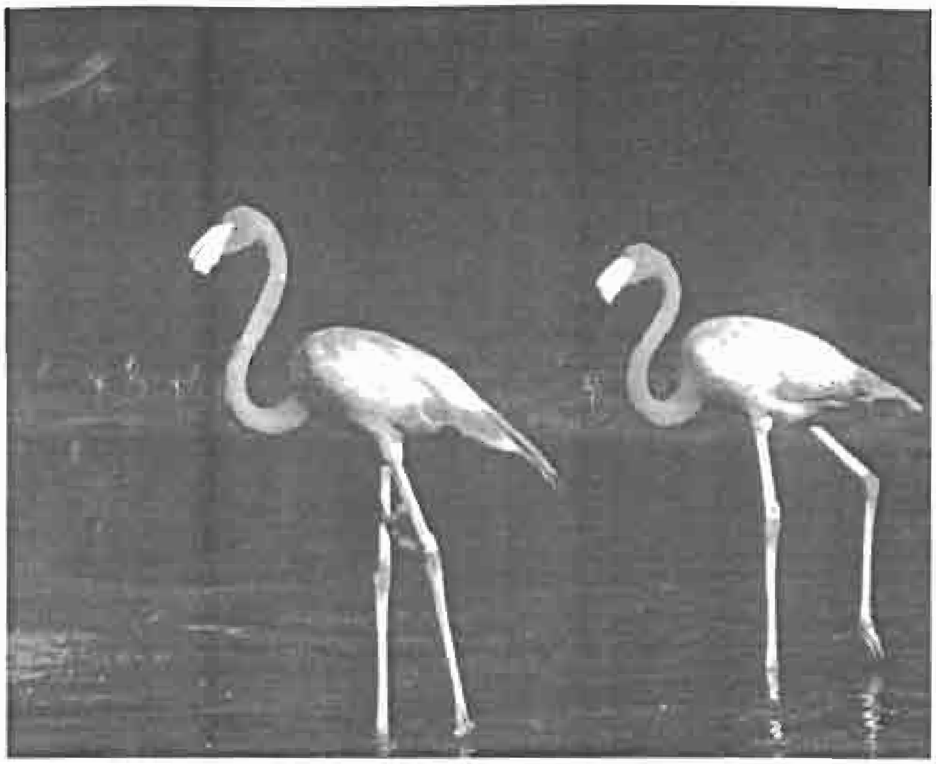
CITES Appendix ~~[illegible]~~, so anyone wishing to do so will have to obtain a CITES export permit from the United States. There may also be import complexities beyond the usual veterinary certification for BVI, depending on whether BVI falls under the UK-EU CITES regulations. I can find no information on geographic variation in this species or the origins of the captive breeders. This is a project in the preliminary research phase.



Two greater flamingos (Phoenicpterus ruber) wade in the shallows on Guana Island. Author James Lazell was successful in restoring greater flamingo and in the course of doing so learned that the population needs to reach a critical size (about 20 breeding birds) before reproduction will take place. *Photo by Kerry Sherred, The Conservation Agency*

The next series of potential BVI vertebrate species restorations brings us into the more controversial realm. The practice of reestablishing an exterminated species or subspecies with a distinctly different species or subspecies is not without precedent. Of particular note is the highly successful restoration of the peregrine falcon (*Falco peregrinus*) in mid-continent North America using birds of five different subspecies (Tordoff and Redig 2001), some from as far away as Spain. Three bird species in BVI are candidates for replacement.

The Academy of Natural Species in Philadelphia holds specimens of the Puerto Rican woodpecker (*Melanerpes portoricensis*) from St. Thomas (Cory 1889). St. Thomas and the other major Virgin Islands of the Puerto Rico Bank—St. John, Tortola, and northeast to Guana, the Camanoes, and Scrub—were a continuous land mass as recently as 6,000 years ago (Heatwole and MacKenzie 1967). I believe the woodpecker must have been a major pre-Columbian ecological influence in the forests of these islands and would be an important member of a restored fauna on a still-forested island, like Guana.

Early European accounts of the Virgin Islands often include references to parrots (Juniper and Parr 1998). *Amazona vittata gracilipes*, a subspecies of the iguaca or Puerto Rican parrot, survived on Culebra, east of Puerto Rico and just west of the Virgin Islands, into the 20th century (Wetmore 1927). Williams and Steadman (2001) indicate this parrot occurred as far east into the Lesser Antilles as Barbuda and Antigua. Today the iguaca survives on Puerto Rico in rainforest and mountain habitats, in what was probably always a poor, peripheral habitat compared to the original lowland forest (Raffaele and others 1998). In addition to the wild flock of about 50, about 100 are maintained in captivity at aviaries on Puerto Rico. I propose putting some captive breeders on Guana Island in subsidized, semi-captive conditions; young birds would be allowed to disperse, eventually—one hopes—adapting to wild conditions in the forest. These parrots might eventually disperse to nearby Tortola, where remnant forest would probably support a small, wild population. Reforestation in BVI could ensure eventual expansion of populations to hundreds of birds.

Paleontologists have found subfossil remains of DeBooy's rail from many sites on Puerto Rico and the Virgin Islands (Wiley 1985). It was apparently a flightless, terrestrial species that was plausibly reported as surviving on Virgin Gorda, BVI, in the 1940s (Ripley 1977). The Guam rail (*Gallirallus owstoni*) seems ecologically similar. While extirpated in the wild on Guam by the brown tree snake (*Boiga irregularis*), it survives and breeds prolifically in captivity (Taylor 1998).

There is an introduction program for the Guam rail on the island of Rota, which I disapprove of because there is no evidence that a rail was ever part of the natural ecosystem of that island. I have repeatedly suggested informally to numerous colleagues that an appropriate thing to do with captive Guam rails is introduce them to islands that formerly did support flightless, terrestrial rails, such as DeBooy's rail. DeBooy's rail occurred throughout what are today's Virgin Islands of the Puerto Rico Bank, and even St. Croix, just a few thousand years ago, before the species was exterminated by man (Wiley 1985). Guam rails demonstrably live well in artificial, man-dominated ecosystems, as they did on Guam prior to snake population build-up.

I propose an experimental approach to rail restoration in BVI. I would select an island, like Norman Island, that has been subjected to severe degradation through human use and overgrazing by feral ungulates, especially goats. I would remove the ungulates (a process already underway) and control some human activities and eliminates others, such as woodcutting for charcoal. After conducting a biological survey, I would introduce Guam rails and document the results. For example, the tiny terrestrial gecko, *Sphaerodactylus macrolepis*, reaches the highest densities of any known non-aggregated terrestrial vertebrate in the world on Guana in BVI (Rodda and others 2001). If this species is a major prey item for a flightless, terrestrial rail, then their densities—presently about 67,600 lizards per hectare—could be interpreted as an artificial product of rail extermination.

I also strongly advocate placement of Guam rails on several Pacific islands, notably Wake—formerly inhabited by Wake rail (*Rallus wakensis*), Laysan—formerly inhabited by Laysan rail (*Porzana palmeri*), and especially Kahoolawe, on the Greater Maui Bank of the Hawaiian Islands, which might easily have supported four or more species of flightless, terrestrial rails (Olson and James 1982). Morin and her colleagues (1999) discuss restoration prospects for Kahoolawe, which they describe as excellent, but did not consider close relatives of extinct species. I received no response to my written suggestion (Lazell *in litt.* February 22, 1999) that Guam rail be considered.

The Caribbean monk seal (*Monachus tropicalis*) was once a prominent animal throughout the Caribbean. Today, it no longer exists (Kenyon 1977). Remarkably, the Caribbean monk seal is so closely related to the surviving Hawaiian species (*M. schauinslandi*) that some people have suggested they were conspecific. The Caribbean form, for which the small islands in BVI called The Dogs and Seal Dogs are named (Lazell 1995), was strictly a carnivorous, littoral marine mammal. It was a keystone species in the Antillean ecosystem. I believe every effort should be made to establish a monk seal population from Hawaii in the Virgin Islands.

Conclusions

My purposes in providing this account have been to document our restorations in BVI, correct errors that have been unfortunately published, and suggest programs of animal reintroduction leading to restorations that are as yet unconsidered—or considered distinctly unpalatable—by many of my American colleagues. In this latter aspect, I follow my colleagues in New Zealand, where TCA officers and members visited in 2000. Mick Clout (2001) summarizes much of this wonderfully productive, increasingly successful program, quoting Ian Atkinson "that a useful goal for restoration is reinstating earlier selection regimes," and that a strong case can be made "for replacement of some extinct species with 'ecologically appropriate' and related extant species."

Finally the computer-generated picture of gloom-and-doom forecast by Lundberg and others (2000) which states that ecosystems close down after extirpations and establish new, depauperate levels resistant to reintroduction of the lost species, seems inapplicable to our work in the British Virgin Islands. All seven attempts to reestablish breeding populations of f~~our~~ive vertebrate species have been received most successfully within their ancestral ecosystems: two populations of stout iguana (Guana, Necker), two of red-legged tortoise (Guana, Necker), greater flamingo (Anegada), white-crowned pigeon (Guana), and whistling frog (Little Thatch Island).

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