

# The Conservation Agency

Exploration, Education, and Research

President

James D. Hazell, Ph.D.

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Conanicut Island

R.I. 02886 U.S.A.

2 January 1985

Dr. Henry Jarecki  
Timber Trail  
Rye, NY 10580

"Give me for  
next skip call"  
HJ/CB

Dear Henry:

A works and progress report to 22 December, 1984, with prospects for future work.

## Field Expedition, November, 1984:

Tricia Giovannone and I were present on Guana from 6-19 November, with 15-17 November off for Anegada side trip. Dr. Arthur Weiner, botanist and marine biologist, was on Guana from 9-14 November. Tricia and I were present through tropical storm Klaus; Weiner arrived the following day. Tricia took many photos documenting damage, especially showing the contrast in erosion inside and outside sheep exclosures. Weiner documented siltation and stress on the reefs (see below). We made six tree censuses resulting in what may be the first-ever quantitative description of lowland Caribbean scrub forest in near-natural condition. We obtained a magnificent specimen of The Frog, thus filling in the last nameless blank known to exist in Guana's land vertebrate species list. We got a fine specimen of The Amphisbaena -- the twenty-first known to science. We got excellent photos of live, wild, and free slipperybacks in their habitat, probably also a "first-ever." We failed to catch more iguanas for establishment on Guana, but found tracks indicating the big female is alive and well. Details on all of these items occur in the text below. Our thanks to you and Mocatta for a generally very successful expedition.

I have described projects both in terms of what has been done to date, with reports from the relevant scientists included, and what can be done next. On each first page I note who is doing the work, how much assistance they need, and the degree of financial support I estimate would be necessary in 1985.

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## ONGOING PROJECTS

## THE BOOK

A first draft has been submitted to Yale University Press, received as per copy of card below, and has already gotten one enthusiastic review (pers. comm., Ed Tripp, editor-in-chief).

Updating revision and expansion is already required for geology and species accounts of frog, amphisbaena, Liophis exiguus snake, and mastiff bat.

Selections of 20 transparencies each have been requested from Tommy and Didi so that we can get on with negotiations for color plates. All I need are their 20 best shots so I can show Ed Tripp something and he will know what we have in mind. There is no way we will be able to actually print 40 color pictures (\$600 each), so T and D need not agonize over what to send me and what not. Just pick the 20 best. If some species or scene is conspicuously absent, I'll know it and send out a request. Right now Giovannone and Mayer are handily winning the photo competition: I have their best stuff.

"I want  
one set"  
HS/CB

The book is the most important product of all the work done to date on Guana. A copy of the typescript will be sent to you as soon as I have a chance to fix it up in accordance with reviewers' comments.

YALE UNIVERSITY PRESS  
302 Temple Street  
New Haven, Connecticut 06520

We wish to acknowledge receipt of the manuscript entitled

ISLAND: An Introduction to Population Biology

and Theoretical Ecology

which will have our careful attention.

Date 12/10/84

Very truly yours,  
Editorial Department

## BIRDS

Because of their popularity and Guana's excellent assortment, birds receive a high priority for continued work. Some target species, very rare, endangered, or little-known in the world, are:

Bridled quail dove  
Newton's barefoot screech owl  
Antillean mango hummingbird  
Puerto Rican lizard cuckoo

Roseate tern  
Bahama pintail duck  
Brown pelican

The last three seem to be nesting and reproducing well on Guana. The demise of the cats will be very good for all, no doubt, as will recovery of the mangroves for the ducks. The hummingbird and the cuckoo are known on Guana only from sight records; time will tell as to what to do about these. The first two are focal for past and immediate future work.

I am in charge of owl pellet analysis but have had no time to undertake this work since collecting the material last July. I will hope to collect more in the future and get on with this in 1985. All owl nest boxes are in place on Guana, but unoccupied as of November '84. The owls might nest in them as soon as next February. They were not in place soon enough this year for owls to even consider them.

Bridled quail doves seem to be a very big deal. A recent paper by Nellis, et al. (1984. J. Wildlife Management 48: 889-894), on "population status of... columbids in the Virgin Islands" considers various pigeons and doves (family Columbidae), but does not even mention the bridled quail dove. Chipley's report follows. I believe this work should continue.

## Staff:

1. Dr. Robert Chipley, The Nature Conservancy: fully-funded.
2. Dr. Liao Wei-ping made a fine assistant last year and could do so again. He requires full-funding if so, and is discussed at length as a potential project of his own, below.
3. If not Liao, some other assistant: Room and board only.



# The Nature Conservancy

1800 North Kent Street, Arlington, Virginia 22209  
(703) 841-5300

September 24, 1984

Dr. James D. Lazell, Jr.  
The Conservation Agency  
6 Swinburne  
Jamestown, RI 02835

Dear Skip:

Thanks again for the opportunity to take part in the Conservation Agency's expedition to Guana Island in July. For me it was an extremely valuable experience to try out in practice some of the inventory and preserve design methodology I and others have been working on in our offices for so long. I was very pleased with the results. And as a conservationist, I was glad for the chance to initiate a study the goal of which is the preservation of a rare bird. I would certainly like to continue the work. I think there are many useful things an expanded study could find out, some of which I'll outline in this letter.

First, I think it can be established that the bird is genuinely rare. Since my return, I've been looking into what I can find on its status. I even looked at the 18 specimens in the U.S. National Museum--most from the collection of Stuart Danfort, collected 1935-1937, including four specimens from St. Croix (I wonder if the bird is still there), four from Montserrat and three from Saba. Bond in his 1950 Checklist says it is rare on most of the islands. Herb Raffaele based his statement on its distribution in Puerto Rico on a couple of sight records and one specimen. He also told me that in five days on St. Kitts he saw none. I spent a week on St. Lucia's west coast in 1969 without seeing one, and I spoke with Gary Graves, a student of Fran James's now a postdoc at the Smithsonian, who had just returned from 8 days on St. Lucia on the northeast coast where he saw only one for sure and possibly another 2; additionally, Bob Jenkins spent several days on Dominica a few years ago without seeing one. Of course this is all anecdotal, but at least there's no evidence to think the bird is doing particularly well anywhere but in the limited right habitat in the park on St. John and on Guana Island. And the other thing I've found out is that there isn't much else to find out; the bird is totally unstudied, as are all but one of the other 13 species in the genus. As it turns out, Guana Island is also probably one of the few places where one can study it with good hope of success. On heavily populated islands, where it is undoubtedly hunted, the bird is apparently shy and hard to observe. On Guana they are quite unwary and can be approached within a few feet.



Dr. James D. Lazell, Jr.  
24 Sept. 1984  
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Not only is the quail dove rare in general, it is also quite restricted on Guana. I observed and listed birds in all six of the habitat types I defined on Guana Island (rocky seashore; coppice and scrub; ravine (ghut) woodland; salt pond and mangrove; flats and cultivated areas; North Bay seagrape woodland); the quail dove was the only land bird I observed which is virtually confined to a single habitat type; it is also the only litter specialist and exclusively terrestrial bird in this habitat. With such a limited habitat and limited role within that habitat, it is one of the more precariously placed birds on the island.

As I see it, a continuing project would have several important goals. First and most simply it would be good to map more accurately the habitat for the bird. I spent most of my time in Quail Dove and Harris Ghuts and suspect the other ghuts are not as favorable for it; for example, I saw only one dove in two visits to Palm Ghut and none at all in my one visit to Grand Ghut, though I know you have seen them there. It would be useful to characterize the vegetation in the latter two and in other ghuts (as I have for Quail Dove and Harris Ghuts) to detect the differences and come to some sort of conclusions as to what defines optimal habitat for the birds. Another would be to establish a more accurate census as a baseline for detecting changes and fluctuations in population size. The transect I ran last summer in Quail Dove Ghut has given me an idea of the number of birds there, but capturing and marking birds with color bands (also allowing individual recognition) would lead to far better estimates. Third would be to continue studies on the life history and conservation of the species. As you suggested, we might fit some of the birds with transmitters; I've already begun looking into the equipment involved. This would give insight into the home range, territoriality, use of marginal habitats, reproductive strategy and breeding success, stability of the pair bond, dispersal of the young birds on the island and possibly to other islands, causes of mortality, daily activity patterns (there is some indication that the only time the birds spend off the ground is when they roost in trees at night)--all the sorts of information difficult to get otherwise but necessary to write a good management plan for the bird.

My main goal in this or any other study on Guana is to find out how best to manage the island as a nature preserve. I think we both agree that right now, the main management problem is the control of sheep and cats; their presence causes a gradual and inevitable degradation of the habitats and the biota. You're aware of the problems sheep have caused us on our Santa Cruz Island Preserve. Anyone only has to look at Tortola to see the damage uncontrolled livestock can cause. In a few years sheep wandering at will over the island will do the same thing to Guana. It would be useful to establish photographic stations at several points to document change in vegetation if the sheep are removed. One likely place would be on the north side of Quail Dove Ghut where sheep damage is particularly heavy. If the sheep and cats are successfully brought under control, we can monitor not only the gradual recovery of the vegetation but also the quail dove population response to the removal of these threats.



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Of course there's much other ornithological work to be done on Guana, particularly with rare and endangered species. For one, we should be alert to any opportunities to find out more about the Bare-legged Screech Owl (periodic monitoring of caves to detect current use, analysis of any further pellets collected, listening for the bird at dusk and dawn, etc. Incidentally I also looked at the three specimens for this subspecies in the USNM, all from St. Thomas and St. Croix; there was a notice in the tray that the bird is now considered endangered, affecting collection of further specimens.) For another, we should monitor the Roseate Tern colonies to gain information on nesting success. And of course we should continue simply inventorying the bird fauna of the island; it would be good in particular to know what seasonal use of its habitats are made by migrating and wintering birds.

Anyway, this letter is to let you know that my enthusiasm for continuing studies on Guana Island has, if anything, increased since my visit there last summer.

Hope your work on the book is going well.

Best regards,

*Chip.*

Robert M. Chipley, Ph.D.  
Director, Preserve Selection  
and Design

## LIZARD PHYSIOLOGY

This project involves the tiny ground geckos of the genus Sphaerodactylus. It was the subject of my note "adaptation as a sink," appended to the August report, and the subject of a paper drafted for publication by MacLean and herein included.

The work on determination of geographic variation in water loss rates (WLR) in Sphaerodactylus macrolepis, demonstrated on Guana, needs to be further documented on Guana relative to physiography and plant ecology, and extended to other islands, as alluded to in "adaptation as a sink" -- now part of the book Island....

## Staff:

1. Dr. William MacLean, C.V.I: room and board.
2. Assistant: Ellen MacLean: room and board.
3. Other assistants, like me, need no separate funding.

Inter-island travel costs: see end of report.

WATER-LOSS RATES OF SPHAERODACTYLUS PARTHENOPION (REPTILIA:  
GEKKONIDAE), THE SMALLEST AMNIOTE

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ABSTRACT

Sphaerodactylus parthenopion, with body weights between .043 and .150 grams (mean .117), is arguably the smallest amniote; the other contenders are congeners of similar size. Exposed to dry air at 25°C, these lizards loose weight at 3.5 to 13.2 mg.g<sup>-1</sup>.hr<sup>-1</sup> (mean 6.5), a high rate in absolute terms, which is allometrically comparable to those of larger S. macrolepis from the same and similar environments. S. parthenopion is restricted to the leeward, moister slopes of semi-arid Virgin Gorda, British Virgin Islands, and is presumably periodically exposed to severe water stress, but has not evolved the low water loss rates typical of desert lizards.

INTRODUCTION

Mautz (1980, 1982) demonstrated high correlation ( $r = -0.7$ ) between log WLR (water loss rate) and log body weight



for lizards from mesic and semi-arid environments, suggesting proportionality between WLR and surface area within broad environmental categories and high evolutionary inertia of area-specific water flux. This poses an enigma: Why have not smaller lizards, exposed to greater water-loss stress, evolved lower WLR's? This has occurred in lizards from arid environments, for which Mautz reports lower slope (see figure 2) and lower correlation ( $-0.44$ ). Recent findings that some *Anolis* (Hillman et al. 1979 and Hertz et al. 1978) and *Phacrodactylus* (MacLean, unpubl.) have intra-specific variation in WLR, correlated with habitat humidity do not clarify this matter. It is possible that area-specific cutaneous, respiratory, and ocular WLR's are lower in smaller lizards, but that the difference is less than that needed to balance their large surface to volume ratio--the available data (Mautz 1982b) are inadequate to test this hypothesis. Under water stress, smaller lizards should be better able to select moist microhabitats, thus compensating for their high WLR's.

WLR's of the smallest lizards, which have a mean body weight three times lower than the smallest species heretofore examined (Snyder 1979), should either fall near the extrapolated regression of log WLR on log body weight for lizards from semi-arid environments or be significantly lower than this prediction. The lower figure would indicate water retention adaptation beyond that typical of larger lizards

from semi-arid habitat--convergence with desert lizards. WLR near the regression line, on the other hand, would suggest either constant, or constant scaling of water flux per unit surface area in lizards of all sizes from semi-arid environments.

#### MATERIALS AND METHODS

Specimens were captured and maintained in individual vials without being handled or damaged in any way. Water was supplied ad libidum from time of capture. No food was supplied and initial WLR measurements were made between 3 and 6 days after capture, at which time the specimens had acclimated to 24° C for at least 24 hours. Second measurements were made between 8 and 11 days after capture, water having been supplied and food withheld in the interim. WLR's were estimated as the difference between body weight before and after exposure to 25°C dry air for 24 hours. Measurements were rejected if excretion, shedding, or death occurred during desiccation. Each specimen was desiccated twice; when both runs were successful, the mean was used.

Up to 24 specimens were run simultaneously, each in a plastic tube, 61 mm in diameter. Tubes were plugged into a 10 x 50 cm plenum, ensuring uniform flow and permitting rapid assembly while weighing lizards. Air was supplied by a 4

Maclean

WLR's

p 4

stage 3500 psi compressor, with water traps at each stage and a large accumulator bank, and passed through a drying tower containing Drierite (which did not change color or gain weight during the experiments). Total flow of air was regulated at  $5 \text{ l min}^{-1}$ , giving an average flux of  $110 \text{ cm sec}^{-1}$  in the specimen tubes. Temperature regulation was achieved by passing the air through approximately 15 m of copper tubing immersed in a heated water bath, controlled by a thermostat in the air path between the water bath and the tube plenum. An important advantage of this system in a region of unreliable electric power is that the air bank continues to supply air through the end of an experiment during an outage, during which the temperature slowly rises about  $2^{\circ}\text{C}$ . No outages occurred during the experiments reported here.

## RESULTS

Sphaerodactylus parthenopion WLR's were significantly higher ( $p > 0.99$ ) than those of S. macrolepis collected sympatrically on Virgin Gorda and from three localities on nearby Guana Island; these data are summarized in table 1. Other studies (summarized in Mautz 1982) report WLR's as high or higher than those found in S. parthenopion, but the methods are so diverse as to render comparison futile. Available WLR data for



MacLean

WLR's

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Sphaerodactylus species are shown in figure 1.

Three of the dozen parthenopion used died during these experiments, while only one of the 41 macrolepis, subjected to the same procedures, died. This statistically significant difference indicates a higher sensitivity to desiccation in the former. Uric acid residue was found after 13 out of 24 parthenopion dessications (0.54), but in only 21 of 84 macrolepis runs (0.25), which suggests higher metabolism in the former during the experiments.

#### ECOLOGICAL OBSERVATIONS

S. parthenopion is known only from the west, leeward side of Virgin Gorda, which is somewhat moister than the windward side. It occurs on forested slopes near sea level and has not been found at some sites which seem to offer suitable habitat. All specimens were secreted when first located, in contrast to S. macrolepis, which were active in the area at the same time. S. parthenopion can be moderately common, but it is uncommonly difficult to collect.

## DISCUSSION

Some water loss studies of larger reptiles, reviewed in Mautz 1982, have compartmentalized respiratory, ocular, and cutaneous WLR's, a feat not yet achieved for Sphaerodactylus. Because the areas of these three components of surface are subject to different scaling factors relative to body size, pooling their WLR's into one measure can be expected to obscure the presumed allometric relationships. Geckos such as Sphaerodactylus have dry eyes covered by scales, so that water loss per unit of ocular surface is probably similar to that of skin. It is still disconcerting to pool ocular-cutaneous WLR with respiratory WLR, as the surfaces are distinct (dry vs. moist) and the presumed scaling factors are different--respiratory surface area should be proportional to mass, while external surfaces can be expected to scale on the square of linear dimensions. Data from compartmentalized water loss studies are too limited to permit allometric analysis at this time.

There is a substantial body of data relating total WLR to body weight in lizards. Mautz (1982) grouped these into species from arid, semi-arid, and mesic habitats and regressed log WLR on log weight (W) for each. In spite of variance introduced by diverse experimental methods, the

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WLR's

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correlation coefficients were high ( $-0.73$  and  $-0.77$ ) for mesic and semi-arid groups, making the relationship  $WLR = aW^b$  empirically useful. When the same log-log transform regression is performed with the five samples reported on here (figure 2), the results are similar. The correlation is very high ( $-0.89$ ) and the slope is similar to that Mautz (1982) found for mesic and semi-arid species sets; the intercept is substantially below that of Mautz's mesic set and somewhat below his semi-arid set. Mautz's arid species set has both much lower slope and much lower correlation ( $-0.44$ ) than those of the three other regressions discussed, suggesting that smaller desert species have evolved very low WLR's.

S. parthenopion has approximately the WLR that would be predicted by extending the log/log regression lines for mesic and semi-arid lizards to its minute body mass. Under controlled conditions, this species loses body weight 70% more rapidly than does its larger sympatric congener, and this difference can be attributed to allometry alone, with the caveat that surface-area specific water fluxes could vary allometrically.

These lizards certainly suffer water-stress during droughts and probably at other times as well; what is known of their behavior would indicate brief activity during the least drying parts of the day, separated by long periods



MacLean

WLR's

p 8

spent secreted in the moistest microhabitats. It is thus enigmatic that parthenopion has not evolved lower WLR's, as have desert lizards,, including many other Gekkonidae.

#### CONCLUSION

Sphaerodactylus parthenopion, one of the smallest amniote vertebrates, desiccates at the high rate predicted by an allometric equation and is very susceptible to death from water loss. This species has not compensated for its very small size by evolving resistance to water loss higher than that of congeners. It presumably survives by tracking the least desiccating microhabitats in its semi-arid environment, an inference supported by field observations.

#### ACKNOWLEDGEMENTS

I am indebted to my colleagues James D. Lazell, Gregory Meyer, and Michael Gibbons and to volunteers Fran and Dale Ford, and Ellen MacLean for assistance in the field.

This work was supported by the Conservation Agency and Dr. Henry Jarecki.

through a grant from Mocatta Metals Corporation.

Corrected  
in litt.  
N 84:

MacLean

WLR's

p 10

## ILLUSTRATIONS

table 1. weights, WLR's

	mean WLR mg. g <sup>-1</sup> .hr <sup>-1</sup>	S.E.	mean W g	S.E.	N
S. parthenopion	6.48	1.49	0.12	0.02	6
S. macrolepis					35
sympatric	3.84	0.60	0.33	0.05	7
Guana 1	3.55	0.34	0.22	0.03	9
Guana 2	4.95	0.54	0.19	0.02	11
Guana 3	3.44	0.44	0.25	0.04	8

figure 1. sphaero WLR's

figure 2. log WLR/log W regressions

## OTHER REPTILES

Work on other reptiles involves basic evolutionary biology: geographic variation, speciation, and anatomical adaptations, and population biology. There is much "alpha-level" work to be done: geographic ranges to be determined; new species and subspecies to be described and named.

I began the Anolis work in 1980 with the discovery of Anolis ernestwilliamsi on Carrot Rock and the documentation of the other three species on the other BVI's. MacLean called my attention to the 1960 record of a juvenile male "new anole" on Peter Island which was the first example seen of A. ernestwilliamsi (not named at that time, because the specimen was lost). Lianna rediscovered Anolis pulchellus on Guana in March, 1984. This led to the massive quantitative population data collected on the three-species guild on Guana reported in the book Island.... My aim is to have Greg Mayer take over the Anolis work, and function primarily as his assistant and coauthor myself. The first of the following documents is his proposal.

Two other species are immediately focal and I want to continue work on them: the slipperyback skink and the amphisbaena. The slipperyback, Mabuya m. sloanii, is the most mammal-like living reptile in reproductive anatomy and physiology. Following are a letter from Dr. Blackburn at Cornell and the summary of his recent paper on a Brazilian species. Ours is even more extreme: smaller litters, bigger babies (based on Culebra specimens Grant collected).

Amphisbaena fenestrata is simply one of the weirdest animals on Earth. Only 18 specimens were known when Gans and Alexander wrote the Bulletin excerpted below. Since then another has been collected on St. Thomas. I got one on Guana last March, and Tricia got her beauty -- alas dead and drowned -- last November. Rumor has it that another was found -- also drowned -- on St. John the same day (8 Nov.) Tricia got hers. I want to get one alive to test the notions of MacLean (see below), and just generally to see what it is like. Preliminary examination of the four available BVI specimens indicates that dividing postcloacal scale number into body annuli separates all of these from all other A. fenestrata (note highlighted parts of excerpted Bulletin, following). We may well have a new form to describe.

And we are always looking for more boas, need a specimen of the Liophis exiguus snake, expect to find new populations of Sphaerodactylus parthenopion, and maybe even rediscover the giant Anolis roosevelti, known from two specimens collected by Grant on Culebra in 1930 and reported on Tortola in 1860.

## Staff:

1. Dr. J.D. Lazell: fully-funded.
2. Greg Mayer, Harvard: fully-funded.
3. Assistant and photographer: fully-funded.
4. Two additional assistants: room and board.  
Inter-island travel costs....



## Anolis Lizards

by  
Greg Mayer, MCZ, Harvard

The aim of the studies is to understand the processes by which new species are formed, and how new species are then combined into communities of increased ecological diversity. Archipelagos have long been recognized as favorable situations for the study of such processes; Darwin was greatly influenced by his experiences in the Galapagos, and Wallace, co-founder of the theory of evolution by natural selection, chose the Malay Archipelago as the site of studies which would be most instructive to him on the problem of the origin of species. The Virgin Islands also present many favorable opportunities and prospects for research on this problem.

The formation of species requires that two or more initially conspecific populations become isolated from one another, and that the separated populations evolve so that an initially geographic isolation becomes genetic. We can thus look at species formation by studying those factors which control evolution within populations, and then consider the results of evolution among an array of isolated populations. When one or more of these isolated populations differentiates ecologically, so that newly speciated forms are able to coexist, then diversity of the local community is increased. The following list is in an order roughly corresponding to the sequence of events outlined above. It begins with factors affecting the evolutionary trajectory of individual populations, goes on to the actual trajectory of a population, then the results of different trajectories among an array of populations, and finally community studies aimed at elucidating the origin of sympatric ecological diversity. Some of the proposed studies overlap; e.g., interaction of related species is as much a factor in the evolutionary trajectory of a population as it is a property of the community, but such interactions are here listed under community studies.

The primary subject species should be the crested anole, Anolis cristatellus. It is the most widespread species of lizard in the Virgin Islands. It presents numerous advantages. Besides being widespread, it is very abundant, easily captured, marked, and observed, and has a number of differentiated geographically representative forms, including the Carrot Rock anole, Anolis ernestwilliamsi. The saddled anole, Anolis stratulus, and the grass anole, Anolis pulchellus, will also be studied to the extent that they present circumstances amenable to study.

Factors affecting evolution within populations. Population structure, population dynamics, and ecological relationships are among the factors here. We wish to determine the selective factors in the environment, and the properties of the population which determine response to such pressures (genetic factors are considered below). The studies which need to be carried out on Guana in 1985 are the following:

- 1) Diet. The food habits of the crested and saddled anoles will be determined by examination of stomach contents.

2) Predation. Species feeding upon the lizards will be determined by observation of avian predation, and stomach content analysis of snakes and Ameiva. This can be done in 1985, with some stomach content analysis of previously collected snakes supplementing fresh observations.

3) Structural habitat. The preferred perch sites and habitat occupation of the anoles will be determined by Rand-Schoener census, a technique which has proven successful in studies of anoles on other islands.

4) Thermal habitat. The preferred body temperature of the anoles, which is an important part of their distribution within the habitat, will be determined by taking body temperatures of individuals observed during the Rand-Schoener censuses.

5) Population size. Calculation of population size and density, using various methods of estimation, were carried out in 1982 and 1984. These will be continued at the three established sites of Guana, and perhaps extended to other sites on the island. At least three censuses of each site should be done each field period.

6) Sex ratio. This will be augmented with more data during the course of population size studies.

7) Home range and territory size. These will be determined by mapping observations of marked individuals. This was begun in 1984 and should be continued in 1985.

8) Daily activity cycle. This will be determined by following marked individuals. This also provides many opportunities for observations of feeding, predation, courtship, etc.

9) Reproductive cycle. This will require collection of small samples in all seasons of the year. Information available from previously collected specimens needs to be supplemented by specimens collected during times of the year when scientific personnel have not visited Guana. This is largely museum work and can be done back at Harvard.

Microevolution in action. These studies will show the actual action of selection on the phenotype, and, if the genetic studies are successful, we will be able to predict the population's evolutionary response to observed selection differentials. The 1982 (normal year) and 1984 (extreme drought) material already at Harvard will be most useful here as a departure point. These studies are long-term.

1) Heritability of meristic characters. The genetics of these characters will be studied by parent offspring regression. This will require the collection of substantial numbers of females, and the successful hatching of eggs laid in captivity. This is the technically most difficult part of the study. Preliminary observations were made in July, 1984, and during a visit to Jamaica in September, 1984. The first full scale attempt at carrying out the experiment can be made in 1985.

2) Cross-sectional selection. This is the measurement of phenotypic selection by comparison of juveniles to adults. This will require the



collection of series of juveniles and adults. This can be done in 1985, and should be repeated as often as possible, so as to become integrated with longer term perception of natural selection.

3) Within-cohort selection. This is the measurement of phenotypic selection by comparison of same aged individuals at successive points in time. This can be begun in 1985.

4) Within population evolution. This is the measurement of phenotypic evolution by comparison of recent and old samples from the same population. Grant's collection should contain Guana specimens from the 1930's, and older specimens for many other of the Virgin Islands. This requires comparison of this older museum material with recently collected specimens. It will also be possible to observe short-term changes by comparison of earlier and later samples within those recently collected.

Any selection or evolution observed will be interpreted with respect to the factors listed above and available historical data on climatic conditions.

Evolution in action: geographic variation and speciation. These studies will examine the results of microevolution and isolation among populations. The purpose will be to attempt to relate this larger scale evolution to what we know to be going on within populations.

1) Geographic variation: how do isolated and semi-isolated populations differ from one another? At a micro-scale, we want to know if phenotypic differences can occur within an island (e.g., Guana or Tortola), while more broadly we want to know in what way populations on different islands vary. All three anoles are candidates, but Anolis stratulus is the place to start because it is abundant, has not been systematically studied, and shows preliminary indications of interesting geographic variability. In 1985 we wish to begin collecting this species from as many islands as possible, to demonstrate geographic variation, and possibly lead to the naming of new forms.

3) Speciation: how do closely related species differ, and what are their geographic distributions? In the BVI, the species to look at is ernestwilliamsi, because it can be compared to the detailed data on cristatellus we will be gathering on Guana. Specifically, we want to make morphological comparisons, especially of those characters of selective and ecological significance; we want to know its karyotype (which we also need to know for Guana cristatellus for comparison); and we want to determine its distribution.

Community patterns. We are here concerned with how species fit together into communities; that is, how newly formed species acquire the ecological differences that allow them to coexist in the same habitat.

1) Other species' diets, structural and thermal habitats. These will be used to determine what ecological factors separate the species, allowing them to coexist. Studies have been begun and can continue in 1985.

2) Interspecific interaction. Direct confrontations between individuals are sometimes important in structuring communities, and we need to determine this for the anoles of Guana. This can be begun as part of the study of daily activity cycle in 1985, and can be continued experimentally if called for by observational work.



3) Careful determination of what anoles occur on The Monkey. As an essentially isolated patch of habitat detached from the main part of Guana, The Monkey provides the best opportunity for studying a different, very small, arid community, and can help in determining what factors limit the distribution and abundance of the other Guana anoles. Camping at The Monkey for a few days may be the best way of doing this.

Much interpretation of community evolution depends on the extent to which competition is a structuring force. The three studies mentioned above will begin to give us some ideas, and might eventually lead to better, and perhaps experimental, tests of the extent of competition.

The program outlined above is a multiyear project. Much of it can be accomplished in a single field season, but the truly important and unique approaches to microevolution in action will require more than one season for practical reasons. These studies are designed to be longer, and can only yield useful results if they are. The promise of Guana as a unique biological and scientific asset lies in its potential for long-term work on important ecological and evolutionary questions (which can only be addressed by long-term studies) in a stable and biotically rich environment, and the numerous opportunities for comparative study provided by the surrounding archipelago.

Reference:

- Boag, P.T., and P. R. Grant. 1981. Intense natural selection in a population of Darwin's finches (Geospizinae) in the Galapagos. *Science* 214(4516): 82-85.

## NEW YORK STATE COLLEGE OF VETERINARY MEDICINE

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CORNELL UNIVERSITY

ITHACA, NEW YORK 14853

## DEPARTMENT OF ANATOMY

607/256-5454 Ext. 2553

Dr. James D. Lazell  
The Conservation Agency  
6 Swinburne St.  
Conanicut Island  
R.I. 02835

7 November 1984

Dear Dr. Lazell:

Thanks for your recent letter of 22 October. I was interested to hear that you are working on Mabuya m. sloanii, and that it also exhibits eutherian-like reproduction. I suspect that the same reproductive specializations are shared by all New World Mabuya, based on the scattered evidence available from the various species. Whether reproductive specialization preceded invasion of the genus into the New World remains uncertain. The few viviparous Old World Mabuya for which we have evidence seem to be fairly generalized as live-bearing lizards go. However, this is not surprising given that viviparity has evolved on multiple occasions ( $\geq 4$  times) within the genus.

I have enclosed the reprints we now have available on M. heathi. I am currently involved in an extensive study of the placenta via the use of histology and scanning EM. One ongoing problem is that the tissue with which I am working is not optimally fixed, and tissue damage is evident microscopically. I've also been unable to obtain fresh material or to find anyone who currently has access to live specimens to fix material for TEM study. I am most willing to collaborate with anyone who can provide appropriate quantities of fresh or fixed material on any papers deriving from my study of that material. This is just what I've done with Laurie Vitt and Carol Beuchat.

I would greatly appreciate learning of the nature of your work on M. m. sloanii. Do you have any particular plans for the anatomy of the placenta? If not, can you suggest any possible sources for reproductive tracts of this or other species of Mabuya? I am looking forward to hearing from you.

Sincere regards,



Daniel G. Blackburn



## Eutherian-like reproductive specializations in a viviparous reptile

(placenta/embryology/convergent evolution/reproductive strategy/lizard)

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**ABSTRACT** The viviparous Brazilian scincid lizard *Mabuya heathi* exhibits a suite of reproductive specializations widely believed to be confined to the eutherian mammals. This skink ovulates the smallest known reptilian egg ( $\approx 1.0$  mm in diameter). Placental transport accounts for  $>99\%$  of the dry mass of the periparturient fetus, representing a degree of placentotrophy proportionately greater than that reported in any other non-mammalian vertebrate. Placental morphology and the timing of fetal growth implicate the chorioallantoic placenta in maternal-fetal nutrient transfer. The yolk sac placenta regresses prior to any major increase in embryonic dry mass. Precocial gonadal maturation and postponement of reproductive investment until well after ovulation enables females to become pregnant at 3-4 months of age, long before attainment of full adult body size.

Reptile viviparity typically is regarded as a simple phenomenon in which eggs are retained in the maternal oviducts and hatch *in utero* before birth, a pattern sometimes termed "ovoviviparity" (1-3). Although morphologically specialized placentas have been described for a few squamate reptiles (4-6), quantitative data on placental transport are limited to water and small amounts of inorganic ions, amino acids, and nitrogenous wastes (7-10). Eutherian mammals, in which nutrients are supplied by means of a placenta ("placentotrophy"), contrast markedly with reptiles, in which the large yolk-rich egg usually is assumed to contain sufficient energy for embryonic development ("lecithotrophy") (6, 11).

We present evidence that *Mabuya heathi*, a Brazilian scincid lizard, exhibits a suite of reproductive characteristics virtually unknown outside of the eutherian mammals, representing an extreme among known reptilian adaptations for viviparity. Specializations of *M. heathi* include the following: (i) ovulation of an egg smaller than that known for any other reptile; (ii) a prolonged (8-12 months) gestation; (iii) formation of a chorioallantoic placenta with a close association between fetal and maternal tissues; (iv) development of a transitory yolk sac placenta; (v) a postovulatory supply of virtually all of the nutrients for development; and (vi) a degree of placentotrophy greater (relative to ovum size) than has been demonstrated in any other non-mammalian vertebrate. This species also possesses other unique adaptations, including the ability of females to become pregnant while at a "juvenile-like" body size and subsequently to grow large enough to accommodate the developing fetuses prior to major embryonic growth.

### MATERIALS AND METHODS

Specimens of *M. heathi* were collected (by L.J.V.) near Exu, Pernambuco, Brazil, from March 1977 through February 1978. Upon sacrifice of each specimen, relevant morpho-

metric and meristic data were collected (12) and reproductive tracts were excised and placed in 10% formalin. Individual ovum-embryo samples were removed, rolled dry on paper towels, and weighed. Further studies of the preserved material were conducted in 1981-1983. Representative samples were oven dried at 60°C to a constant mass and weighed to determine preserved dry mass. Morphology was examined through microdissection with a Wild M8 binocular dissection microscope with a photographic attachment. Extraembryonic membranes were carefully peeled from adjacent tissues and conventionally processed for scanning electron microscopy by counterfixing in  $\text{OsO}_4$ , washing in sodium cacodylate buffer, dehydrating in acetone, critical point drying, and coating with gold in a Balzer sputter coater. Specimens were viewed by means of an AMR 1000 A scanning electron microscope.

### RESULTS

*M. heathi* breeds seasonally and produces one litter per year. In our sample, litter size ranged from 2 to 9 ( $\bar{x} = 5.03 \pm 0.12$ ;  $n = 131$ ) and was positively correlated with female snout-vent length (SVL) ( $r = 0.52$ ;  $F_{1, 129} = 47.7$ ;  $P < 0.0001$ ; brood size =  $-1.339 + 0.088 \times \text{SVL}$ ). Gestation lasted 8-12 months, with ovulation and fertilization occurring from October to January and parturition occurring the following fall (September to October) (Table 1). Our sample suggests that all females in the population become pregnant during each reproductive season, including those born only 3-4 months previously. These females are born at about 31 mm SVL, reach sexual maturity while still at a small body size (45-52 mm SVL), and only subsequently grow large enough (68-92 mm SVL) to accommodate the developing fetuses.

*M. heathi* ovulates eggs with an average diameter of 1.0 mm (range = 0.9-1.2 mm) (Fig. 1A) and an average dry mass of 0.40 mg (range = 0.22-0.68 mg). Near-term fetuses (Fig. 1B) average 31 mm SVL and 154 mg of dry mass, representing a developmental dry mass increase of 38,400%.

More than 99% of the increase in embryonic dry mass occurs during the 6 months following formation of the chorioallantois (Table 1). The most rapid mass increase occurs in the last 3 months of pregnancy, during which the chorioallantoic placenta is morphologically specialized. During this period, the allantois contacts the entire inner surface of the chorion, vascularizing it by means of the accompanying umbilical vessels. Although a shell membrane separates embryonic and maternal tissues very early in development, this shell membrane is no longer visible by mid-gestation. Thus, the chorion and uterus appear to be in direct contact, with the result that uterine vessels leave their impression on the outer surface of the chorion (Fig. 1C). At the embryonic pole of the egg, an ovoid placentome develops. This is a highly vascularized and thickened area of the chorion that attaches

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Abbreviation: SVL, snout-vent length.



STUDIES ON AMPHISBAENIDS (AMPHISBAENIA,  
REPTILIA). 2. ON THE AMPHISBAENIDS  
OF THE ANTILLES

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WITH TWELVE PLATES

AT HARVARD COLLEGE  
CAMBRIDGE, MASS., U.S.A.

DECEMBER, 1962

INTRODUCTION

In his third Antillean checklist, Barbour (1937) recognized two genera and nine species of amphisbaenids on islands of the northern Caribbean. The names of these species and their approximate ranges (see Figs. 1-4 for all localities) were:

<i>Amphisbaena cubana</i> Peters	Cuba
<i>Amphisbaena innocens</i> Weinland	Southwestern Hispaniola
<i>Amphisbaena caudalis</i> Cochran	Grande Cayemite Id., Haiti
<i>Amphisbaena munnii</i> Barbour	Hispaniola, except the Southwest
<i>Amphisbaena bakeri</i> Stejneger	Northwestern Puerto Rico
<i>Amphisbaena caeca</i> Cuvier	Puerto Rico
<i>Amphisbaena fenestrata</i> (Cope)	Virgin Islands
<i>Cadea blanfordi</i> Stejneger	Western Cuba
<i>Cadea palmarum</i> Dickerson	Isla de Pinos

In 1951 Vanzolini (1951a) resurrected Cope's genus *Diphalus*, originally based on the species *fenestratus*. Consideration of the status of this supposedly monotypic genus, endemic to a small group of islands midway in the Caribbean, led to our becoming interested in the relations of the other Antillean species of *Amphisbaena*. Besides forming one of a continuing series of studies and notes on the Amphisbaenia, this paper was designed to supply the West Indies discussion group with a summary of yet another group of Caribbean animals. We have included the two species of *Cadea* in keys, maps, and summaries, though the information presented rests in part on the work of Zug and Schwartz (1958), and on some unpublished data kindly made available by the latter.

While two studies of the variation within single species of amphisbaenids have recently been published (Vanzolini, 1951, 1955), there exists no comparison of the range of variation within and between several closely related forms of amphisbaenids. An attempt at such analysis might offer a test of the occasionally stated and often implicit hypothesis that the variation of one common species may serve as a guide to the variability of rarer forms.

No attempt has been made to deal with the broader relationships of the forms discussed, as it is intended to treat this matter jointly for the entire family at a future time. Zoogeographic discussion has also been kept to a minimum, derived primarily from internal evidence. Extended discussion of this topic is best handled for the fauna as a whole, and the zoogeographic scheme then synthesized from a maximum of independent analyses of individual groups.

Camp (1923) and other authors.

The chin shield pattern shows variation in relative length of infralabials and postmentals-malars. This is best indicated by the number of postgenial (between the malars) and postmalar (between the third infralabials) scale rows. Four patterns (coded in appendix under the heading CHIN) exist: (a) two rows of postgenials—no postmalars, (b) two postgenials—one postmalar, (c) two postgenials—two postmalars, and (d) three postgenials—no postmalars. The number of segments in each postgenial and postmalar row have also been listed. The postmalar row often shows considerable asymmetry, with one side appearing to have been separated from the malar by a suture (item 22, Fig. 5) while the other is subdivided into a regular series of segments. The medial edges of the malars often show a similar cutting off of segments, which explains some of the variation in postgenial segment counts.

**Cloacal region:** The cloaca is surrounded by a ring of segments that project some distance into the proctodeum, and are prolapsed during defecation. Their number and relative shape is subject to considerable variation and asymmetry. A deep transverse fold subdivides the cloacal rim into anterior and posterior portions. The anterior group (precloacal segments) is generally larger and more closely jointed, thus forming a shield for most of the cloacal opening. The shield is slightly scalloped in the center of its posterior margin. The precloacal pores lie on the midventral segments of the last body annulus rather than on the precloacal segments. The pores show some, possibly ontogenetic and sexual, variation in size and pigmentation. Every kind or size of pore was counted and the count has been recorded, followed by the numbers of pre- and postcloacal segments. Counts included all segments regardless of size, though segments lying in line radially from the cloaca were counted as one.

**Body proportions:** Snout-vent and tail measurements were read by adpressing the specimen to a meter stick. Readings of snout-vent length were recorded to the nearest mm, those of tail length to .5 mm.

**Appearance of eye:** All amphisbaenids have eyes. As with other cephalic structures there is a decrease in their relative size during life. Observations also suggest a thickening and gradual pigmentation of the overlying skin with age. This, plus the depigmentation of the retina and reduced translucency of the skin due to the vagaries of preservation, is responsible for the comments on "invisible" eyes and "blind" (= *cacca*) forms (cf. Gundlach, 1881).

## GENERIC STATUS

Five generic names have been used for one or another of the species discussed here. These are:

*Amphisbaena* Linné, 1758. Type species: *A. fuliginosa* Linné by first reviser (Fitzinger, 1843).

*Typhloblanus* Fitzinger, 1843. Type species: *A. coeca* (sic) Cuvier 1829 by original designation.

*Sarea* Gray, 1844. Type species: "*A. coeca*" (= *A. ridleyi* Boulenger, 1890) by original designation.

*Cadea* Gray, 1844. Type species: *Amphisbaena punctata* Bell, 1827 (names preoccupied, replaced by *Cadea blanoides* Stejneger, 1916) by monotypy.

*Diphalus* Cope, 1861. Type species: *D. fenestratus* Cope by monotypy.

*Amphisbaena* is the oldest generic name for limbless amphisbaenians. The Antillean forms *cacca* Cuvier, 1829, *innocens* Weinland, 1862, *cubana* Peters, 1878, *bakeri* Stejneger, 1904, *manni* Barbour, 1914, and *caudalis* Cochran, 1928, are customarily referred here.

*Typhloblanus* belongs in the synonymy of *Amphisbaena*, even though it would be available if it became desirable to distinguish the Antillean species by generic or subgeneric status.

The generic name *Sarea* does not belong in the present assemblage as Boulenger (1890, p. 481; see also Boulenger, 1890a, p. 79; Stejneger, 1904, p. 676) has shown that Gray based it upon a misidentified specimen of *Amphisbaena ridleyi* Boulenger, 1890, from "Porto Bello" (read Fernando Noronha, Brazil). The latter form thus becomes the type species and the generic name belongs in the synonymy of *Amphisbaena*.

Little comment need be made on the genus *Cadea*, clearly distinct from *Amphisbaena* by the unpaired prefrontal scale, by a number of skull characteristics (Vanzolini, 1951a), and by the retention of the hypocentrum of the atlas. It includes the Caribbean species *blanoides* Stejneger, 1916 and *palirostrata* Dickerson, 1916.

The resurrection of *Diphalus* by Vanzolini (1951a, p. 114) made without examining a specimen, stimulated the present study. He listed three distinguishing characters: (1) a pointed rather than a rounded, or flattened snout, (2) the separation of the nasal shields by a narrow process of the rostral, and (3) a dental formula (premaxilla, maxilla, dentary) of 5, 4, 7 rather than 7, 4-5, 7-9.



The first of these characteristics is worthless as the actual difference is minor, and there is considerable evidence of ontogenetic changes in the head shape. The head of *fenestrata* is no more pointed than is that of *innocens*. It might also be argued that this difference is far less striking than that between the Antillean species as a group and such blunt-headed yet congeneric (?) forms as *alba* and *fuliginosa*.

The separation of the nasal shields is clear and constant, but hardly more significant than the fusion of ocular and second labial in *cubana* or of rostral and nasal in *manni*.

Of the characters listed, we should have most confidence in the low number of premaxillary teeth, as this number is usually remarkably constant in amphisbaenids and equals 7 in all species of *Amphisbaena* checked thus far. Vanzolini apparently obtained the counts from Boulenger (1885, p. 449), who must have been misled by an aberrant or poorly prepared specimen. The skulls of the type and of MCZ 36306 both have 7 teeth on the premaxilla.

These two skulls were compared with skulls of each of the Antillean species of *Amphisbaena* (*A. c. cubana*, MCZ 10802; *A. c. barbouri*, MCZ 12135; *A. i. innocens*, MCZ 27596; *A. i. caudalis*, MCZ 25551; *A. manni*, MCZ 44389, plus 5 cleared AMNH specimens; *A. bakeri*, UPR 11; *A. caeca*, CM 36377, 37636, MCZ 36317). The comparison furnished no grounds for generic separation. Plates 1-3 show views of skulls of *A. fenestrata* and *A. caeca*. Differences similar to those shown may be seen between skulls of any pair of the other species. *A. fenestrata* also agrees with the other species of *Amphisbaena*, all of which differ from the two forms of *Caeca*, in lacking the hypocentrum of the atlas. This is a matter to be discussed in a subsequent paper.

#### KEY TO THE ANTILLEAN AMPHISBAENIDS

1. All median cephalic shields paired, prefrontals in contact with supra-labial, preloacal pores in continuous row, sharply defined lateral grooves, color uniform, possibly with uniform markings on (dorsal) segments ..... (*Amphisbaena*) 2.
- First median post-rostral shield azygous, prefrontals kept from labial contact by elongate preocular shield, row of preloacal pores with central gap, poorly marked lateral grooves, segments with irregular spots ..... (*Caeca*) 9.

9. Body annuli 175-218 (counted on ventral surface), caudal annuli 10-14, segments in a midbody annulus 25-33, snout rounded, blunt ..... *C. blanoides*
- Body annuli 274-320 (counted on ventral surface), caudal annuli 12-17, segments in a midbody annulus 32-39, snout domed, laterally compressed ..... *C. palirostrata*

#### TAXONOMIC DISCUSSIONS

##### Genus AMPHISBAENA Linné, 1758<sup>1</sup>

*Amphisbaena* Linné, 1758. Type species: *Amphisbaena fuliginosa* Linné, 1758, by first reviser (Fitzinger, 1843).

*Typhloblennius* Fitzinger, 1843. Type species: *A. caeca* (sic) Cuvier, 1829, by original designation.

*Sarco* Gray, 1844. Type species: "*A. caeca*" (= *A. vidleyi* Boulenger, 1890), by monotypy.

*Diphalus* Cope, 1861. Type species: *D. fenestratus* Cope, 1861, by monotypy.

**Discrimination of the species:** The application of the biological species concept (Mayr, 1942) encounters its greatest difficulty when one is dealing with populations on adjacent islands, populations that may represent either distinct species or races of a single polytypic form. Remnants of a morphological concept inevitably remain, since it is usually necessary to use the degree of phenotypic difference of the allopatric populations as the indicator of some sort of "inter-population fertility potential." The degree of phenotypic difference may furnish but a poor inference of the actual difference between the genotypes (e.g. Zahavi and Wahrmann, 1957, p. 354), yet it remains the only indicator available for museum material.

The present analysis has made use of the fact that two of the forms here recognized as species were polytypic, one of these (*A. cubana*) on a single land mass. Our species differences involve characteristics that remain constant in each of these cases and generally a greater number of differences as well. We also checked for increased similarity of populations from adjacent parts of adjacent islands.

Analysis demonstrated that each of the large islands of the Antilles (Cuba, Hispaniola and Puerto Rico), and the group of small islands known as the Virgin Islands, has a distinct, endemic species of *Amphisbaena*. Hispaniola and Puerto Rico each have a second species of more limited distribution, but sympatric with the first at least over part of its range.

<sup>1</sup> The generic synonymy is complete only for names based on forms from the Antilles.



seen, indicating geographical (though possibly not ecological) sympatry; (b) *A. bakeri* has clearly higher counts of body annuli (range of 239-255, against 217-237 for *A. caeca*); (c) *A. bakeri* has a distinctly shorter tail than have specimens of *A. caeca* from the jointly occupied range (Fig. 9), though the range of measurements of eastern *A. caeca* overlaps them; (This suggests that the relatively shorter tail length is not directly correlated to the increased number of body annuli.) (d) the relatively longer internasal contact length (compared either to snout-vent or to interprefrontal contact length—Fig. 10) of *A. bakeri*, which again is clearer when comparison is made to specimens from sympatric populations of *A. caeca*; and (e) the relatively larger maximum size of *A. bakeri* (Fig. 8).

The presence of such diverse specimens might also be explained in other ways, less probable on the basis of present evidence. Thus no reason exists to suspect ontogenetic change (or ontogenetic selection) for the characters in question. Both sexes are present in each sample, eliminating the idea of sexual dimorphism. Decision for geographical (= ecological?) polymorphism would require detailed collecting data, and for non-geographic polymorphism would require data on broods, both of which are lacking. Reference should here be made to the peculiar low-count specimens from Aguadilla and Salinas which have been discussed in more detail below.

The increased difference in relative tail length in the jointly occupied range might be explained as "character displacement" (Brown and Wilson, 1956), but the data are not as clear for relative length of internasals, while the data on presence of a postmalar row suggest an increased similarity between sympatric rather than allopatric populations. Thus, *A. bakeri* lacks both postmalar and a third row of postgenials; more than 210 specimens of *A. caeca* have postmalar, but 5 of the 7 specimens lacking this row of segments come from western Puerto Rico where the frequency of postmalar drops from 99 to 65 per cent.

(6) The characters differentiating *A. bakeri* from *A. caeca* make it more, rather than less, different than the latter is from both *A. innocens* and *A. manni*.

(7) Only *A. caeca* is found in eastern Puerto Rico. It differs from the allopatric *A. fenestrata* of the Virgin Islands (St. John, St. Thomas, Tortola) by contact between the nasal segments (except for one anomalous specimen from Lares, fig. 131 in Stejneger, 1904), by lower counts of body and higher counts of caudal

annuli, by somewhat greater numbers of dorsal and ventral, and distinctly higher total numbers of segments to a midbody annulus, and by a relatively shorter tail (Fig. 11).

In two of these characteristics (higher number of body annuli and relatively shorter tail) *A. fenestrata* approaches *A. bakeri*. Comparison of Figures 9 and 11 shows different slopes for the growth curves of these two species so that the similarity seems fortuitous.

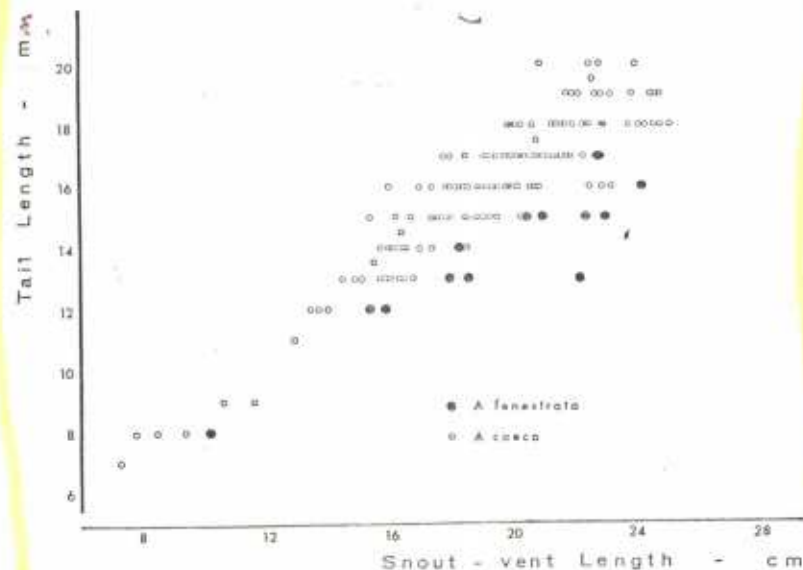


FIG. 11. Scatter diagram of tail length versus snout-vent length of *A. fenestrata* and *A. caeca*.

*Interrelationships of the species:* The forms under discussion show considerable similarity in general scale arrangement, habitus, and superficial appearance. Preliminary review of a number of internal characteristics did not provide any evidence that would modify this statement.

Granting this similarity, it becomes more difficult to establish any simple pattern or sequence of relationships, particularly since we are ignorant regarding the genetic basis of the observed variation. There is thus no reason for the often implicit assumption that a difference of X units between the ranges of a character in two species implies a greater similarity of genotypes than



*AMPHISBAENA FENESTRATA* (Cope), 1861

*Diphalus fenestratus* Cope, 1861, p. 76. Type locality: St. Thomas, Virgin Islands (by present restriction). HOLOTYPE: USNM 11715. *Amphisbaena antillensis* Reinhardt and Lütken, 1862, p. 224. Type locality: St. John, Virgin Islands (by present restriction). LECTOTYPE: KM R-449. PARATYPES: KM R-4411 (Virgin Islands), ZMU 4346 (St. Thomas).

*Notes on the types:* Cope (1861, p. 76) described *D. fenestratus* from material discovered by A. H. Riise "in the West Indian Islands of St. Thomas and Santa Cruz," but neglected to name a type. Stejneger (1904, p. 678) believed the type to be USNM 11715. This specimen had initially been catalogued as collected on St. Thomas by A. H. Riise. Stejneger crossed off St. Thomas in the USNM catalog and wrote "St. John" above this. He cited the specimen as from St. John without giving reasons for his action. St. Thomas was the home of the collector and is one of the islands on which this species occurs. Since the inter-island variation of the species is insufficient to allow us to allocate specimens to islands, it seems best to retain the original locality.

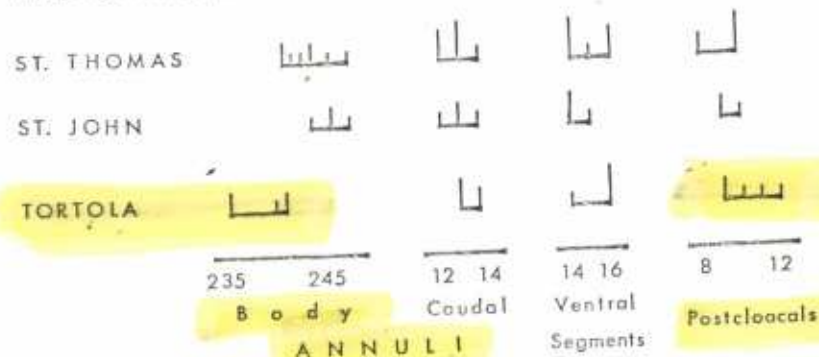


FIG. 32. *A. fenestrata*. Diagram of body annuli, caudal annuli, ventral segments per midbody annulus, and postcloacal segments for specimens from the three Virgin Islands.

Grant, to whom we owe much of the material here discussed, has presented reasons (1937a, p. 512; 1946, p. 60) for the probable absence of this species from "Santa Cruz" (=St. Croix). We here restrict the type locality to "St. Thomas."

*Amphisbaena antillensis* was described by Reinhardt and Lütken (1862, p. 224) from "St. Thomas og St. Jan." The

Universitetets Zoologiske Museum in København retains two specimens (KM R-449 and R-4411) marked "Original exemplar" (=Types) in Reinhardt's handwriting. These are the remnants of a type series, part of which was exchanged to other museums (Braestrup, *in litt.*). Neither is in perfect agreement with the original description, which appears to have been composite. We select KM R-449 from "St. Jan" as lectotype, because it is closest to the original description and bears a definite locality label. The restricted type locality is then St. John.

*Diagnosis:* A form of *Amphisbaena* with the nasal scales kept from contact by the ascending process of the rostral which contacts the frontals. Specimens have 236 to 249 body annuli; 12 to 14 caudal annuli; 13 to 14 dorsal and 14 to 16 ventral segments per midbody annulus; 2 postgenial and 1 postmalar rows of chin shields; and 4 precloacal pores. Caudal autotomy not present.

*Geographic variation:* The sample is too small to justify a long discussion, but Figure 32 suggests that the Tortola sample differs from those collected on St. Thomas and St. John. It is perhaps suggestive that there is a tendency for values approaching those shown by *A. caeca* with increasing distance from Puerto Rico.

The possible occurrence of this species on Virgin Gorda, Culbra and Viques has never been confirmed.

*Description:* Meristic characters are summarized in Table 1, and Figures 8, 11 and 32, individual data in the appendix. Figure 33 shows the head scalation, Figure 34 the ventral surface of the tail and cloacal zone.

Preserved specimens are various shades of brown, solidly so on the dorsal surface of the head and tail. On the rest of the body the rectangular center of each segment is much darker than its margin, giving the impression of dark spots. The color is darker dorsally than ventrally. Most of the specimens have most of the midventral region white, due to a dropping out of the pigment on a number of the ventral segments.

The head scalation is characterized by the posterior elongation of the rostral which keeps the nasals from contact and inserts for some slight distance between the prefrontals. The first body annulus continues dorsad and includes the slightly enlarged parietals. Only the postocular and temporal lie anterior to it, but occasional specimens show various fusions and complications between segments of the first two body annuli. The first annulus lies in a plane normal to the long axis of the animal's trunk.

The shape of the head and segmentation of the head joint

reminds one of *A. caeca*, as does the segmentation pattern of the trunk. The tail shows no autotomy plane.

*General observations:* The skull of this form is illustrated in Plates 1 and 3.

*Range:* Virgin Islands, from St. Thomas to Tortola.

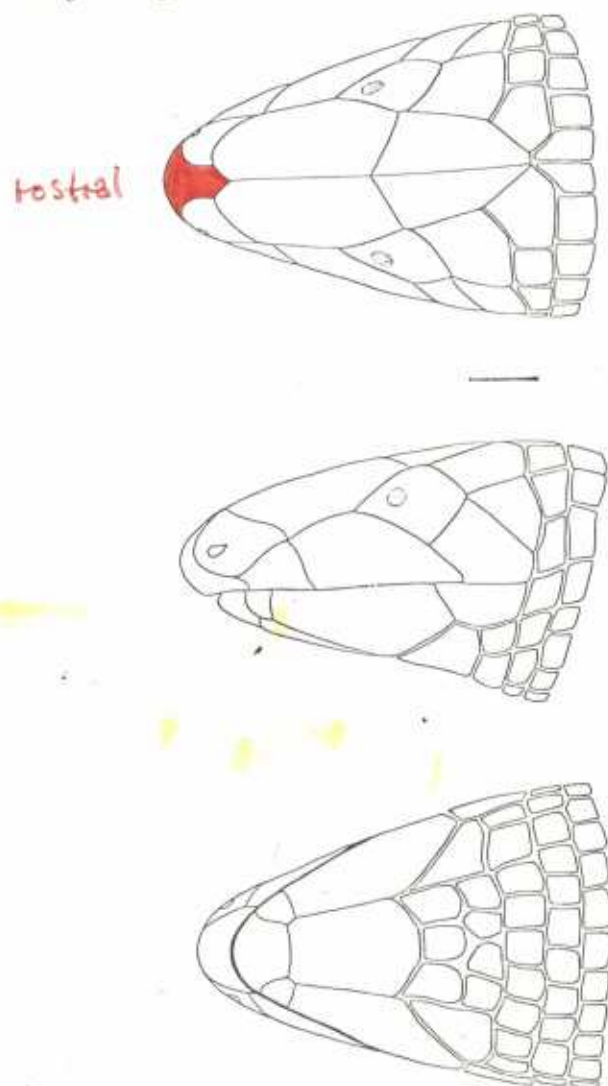


FIG. 33. *A. fenestrata*. Dorsal, lateral and ventral views of MCZ 36305 from Tortola, Virgin Islands. The line equals 1 mm to scale. (V. Cummings, del.)

*Locality records* (see Fig. 1 for map): VIRGIN ISLANDS: — (Barbour, 1914, 1930, 1935, 1937; Cope, 1869; Gray, 1872, 1873; Günther, 1865; Stejneger, 1904); KM R-448, R-4411 (PARATYPE *antillensis*). **ST. THOMAS:** — (Boulenger, 1885, 1890; Cope, 1861; Grant, 1937a, 1946; Gray, 1865, 1872, 1873; Meerwarth, 1901; Reinhardt and Lütken, 1862; Stejneger, 1904 see NOTES ON THE TYPES; Strauch, 1881); BM 60-4-18-71-72; CNHM 51586 (800' altitude, on shady hillside); HM 308; KM R-4410; MHNP 1071; USNM 11715 (HOLOTYPE *fenestrata*); ZMU 4346 (PARATYPE *antillensis*). **ST. JOHN:** — (Boulenger, 1885; Reinhardt and Lütken, 1862; Stejneger, 1904 see above; Strauch, 1881); BM 65-10-2-11; KM R-449 (LECTOTYPE *antillensis*); VM 12345<sup>1</sup>; KUMNH 45630 (West end Great St. James). Dorothea (Grant, 1946); UMMZ 91436. **TORTOLA:** — (Grant, 1932a); MCZ 36305-06; SU 14633; UMMZ 73847 A-B (+C); 80649.

*Habitat:* "It lives like *Typhlops* and is usually found in St. Jan under dry leaves of sugar cane which are cut off the cane

during the harvest. These leaves are left covering the fields for some time. . . . On St. Thomas, where sugar cane is no longer grown, it is found under stones in small holes on moist ground; here it is very rare." (Rüse, in Reinhardt and Lütken, 1862, translation courtesy of F. W. Braestrup.)

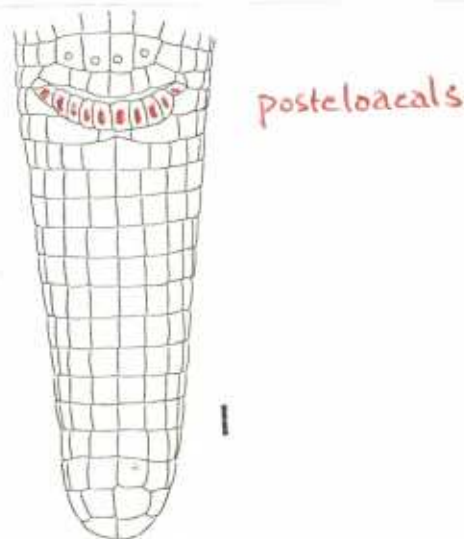
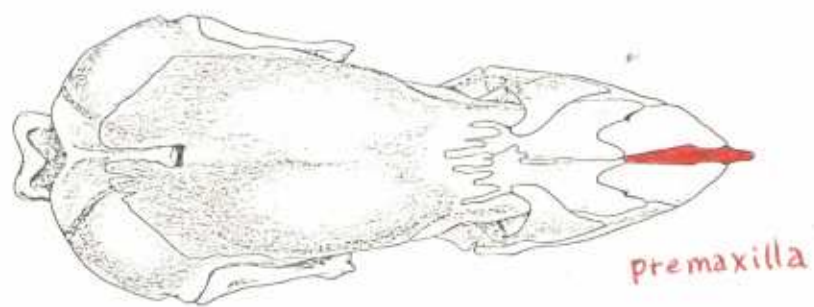
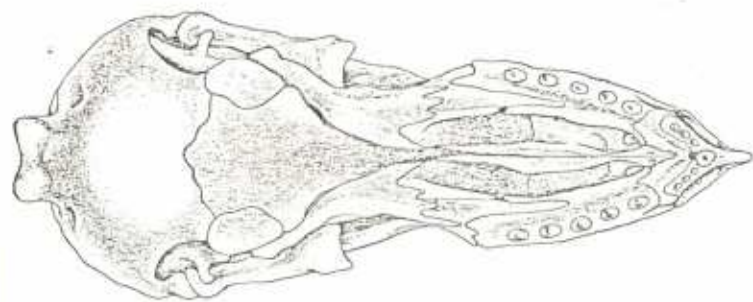
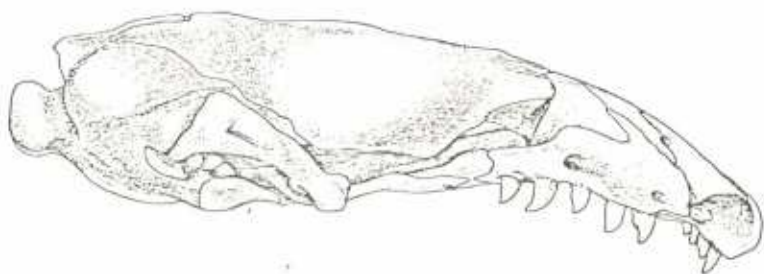


FIG. 34. *A. fenestrata*. Ventral view of cloaca and tail of MCZ 36305 from Tortola, Virgin Islands. The line equals 1 mm to scale. (E. Coogle, del.)



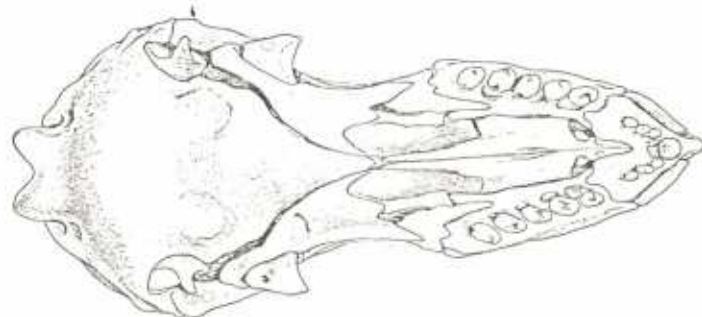
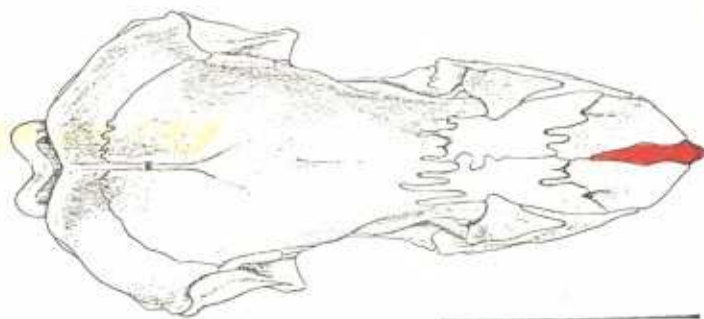


premaxilla



#### PLATE 1

*Amphisbaena fenestrata*. Dorsal, lateral and ventral views of the skull of MCZ 36306. The line equals .2 cm to scale. (M. Franson, del.)



#### PLATE 2

*Amphisbaena caeca*. Dorsal, lateral and ventral views of the skull of MCZ 36317. The line equals .5 cm to scale. (M. Franson, del.)

# Reptiles and Amphibians of the Virgin Islands

William P. MacLean, Ph.D.

College of the Virgin Islands  
St. Thomas, U.S. Virgin Islands

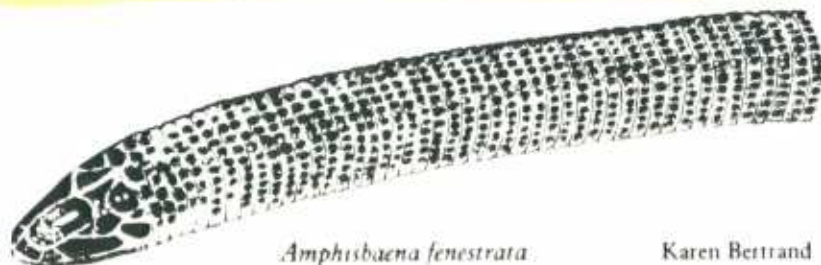
MACMILLAN  
CARIBBEAN

## 34 *Amphisbaena fenestrata*

St. Thomas, St. John, St. Croix

This legless lizard is a burrower and is only seen when one is digging or turning stones or litter. It is easily distinguished from *Typhlops*, the blind snake, by its beige or pink color, and the rings of scales around the body.

Amphisbaenids, unlike typhlopids, are voracious predators. When handled they are prone to bite and although the animal is less than 10 inches long and ¼ inch in diameter, the bite can be painful, sometimes drawing blood or removing a piece of skin. I have seen scars on blind snakes which are probably from amphisbaenids. Although I know of no direct observations on the feeding habits of *A. fenestrata*, from these indirect observations and data on other species, I surmise that our species will attack almost anything that moves, either eating the whole thing or a chunk, if the prey is large.



*Amphisbaena fenestrata*

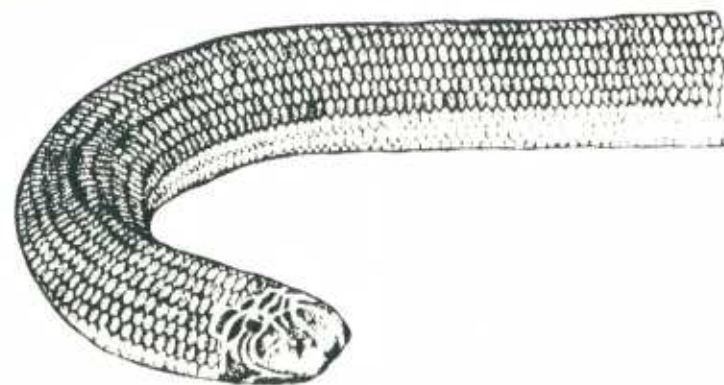
Karen Bertrand

## 35 *Typhlops richardii*

Virgin Islands and Puerto Rico

*Typhlops* are generally known as worm snakes or blind snakes. They are small snakes (5 to 10 inches overall), with reduced eyes, and spend their lives underground. The body and tail is nearly cylindrical, and the tail ends in a sharp point. When threatened above ground, worm snakes will coil up with their heads protected by coils and wave their tails about, so as to attract the attacker to the part where least harm can be done.

Worm snakes are grey or brown above and cream below. Their teeth are greatly reduced, and they feed on soft-bodied insects such as termites, which they crush, releasing the juices into their mouth and discarding the solid part. In moist areas of St. Thomas they are fairly common. Many worm snakes have V-shaped scars on their bodies, which, I suspect, are wounds inflicted by the worm lizard, *Amphisbaena fenestrata*. I attempted to demonstrate this experimentally, by putting a number of *Typhlops* and a worm lizard in a terrarium together. Unfortunately, the worm lizard died within a few days, and I have been unable to obtain another.



*Typhlops richardii* (the worm snake or blind snake)

Karen Bertrand

## 36 *Epicrates monensis*

Tortola, St. Thomas

The Virgin Islands ground boa is an exceedingly rare snake. Only eleven VI specimens are known to be in biological collections. Ten of



## INSECTS

The bulk of the work since collecting in July has been in labelling, sorting, packaging, and sending the thousands of specimens to the authorities who will identify them and describe any new forms. The Millers have sent about 30 references to biogeography of insects and other things, including plate tectonics, to me for inclusion in the book Island.... They have identified most of the large, colorful species for Ann Payne's illustrations. Most of these data are on 3 x 5 cards and not reproduced here. A couple of letters follow. You should now have in hand a letter from the Smithsonian indicating the value of the insect specimens you donated, for IRS purposes.

This work will take a long time to show dramatic results. We need massive collections during a normally wet year -- I hope 1985. As the material reaches the specialists and their comparative examinations proceed, nifty things will emerge. The returns on large-scale entomological collecting, as done by the Millers, come in over decades. This is, however, where the major contribution to knowledge will be in terms of finding new species. I believe this work should be continued and expanded to include some inter-island comparisons.

## Staff:

1. Scott Miller, Harvard: fully-funded.
2. Pam Miller, Tufts: fully funded.  
Inter-island travel costs.



*National Museum of Natural History • Smithsonian Institution*

WASHINGTON, D.C. 20560 • TEL. 202-357-2107

Entomology, NHB 127

16 August 1984

Skip:

After various travels, we have landed here for awhile. I will be in and out of the MCZ, but basically here until the end of October.

Thanks again for the Guana Island trip. The Gulf of California trip went well, but I would have rather been on Guana!

The Guana insect material is currently half labelled and we are now waiting for more labels. There are many interesting beasts included and more details will follow.

You should have received the info that I left at the MCZ for you: references on Caribbean tectonics and the name of the "Jack Spaniard". I just saw a new book on Caribbean tectonics -- Bonini, W.E. et al. (ed.), 1984, Geol. Soc. Amer. Mem. 162.

Some "bad news": *Dryas iulia iulia* was described by Fabricius in 1775, apparently from St. Croix. It is found on Puerto Rico and the Virgin Islands. The most recent review listed 13 subspecies for this species, but the validity of at least some of them is certainly questionable. (Ref: Clench, H.K. 1975. Systematic notes on ~~HYXXEYX~~ *Dryas iulia* (Heliconiidae). J. Lepid. Soc. 29: 230-235). One more item; Any reasonable family classification of butterflies considers Heliconiidae a synonym of Nymphalidae.

The good news: For reports on the 1956 and 1958 "Smithsonian-Bredin Caribbean Expeditions", which visited Guana Island, see Smithsonian Report for 1956, pp. 443-460 (publ. 1957), and for ~~1958~~ 1958, pp. 419-430 (publ. 1959). They worked off of a boat and visited lots of islands, but only for short periods on any island.

More news later. Just wanted to get these notes off before they get buried on my desk!

Best Regards,

Scott (&amp;Pam) Miller



## MUSEUM OF COMPARATIVE ZOOLOGY

*The Agassiz Museum*

HARVARD UNIVERSITY . CAMBRIDGE, MASSACHUSETTS 02138 . TEL. 617 495-2466

13 December 1984

Dr. J.D. Lazell  
c/o 1140 Munroe St.  
Jackson, MS 39202

Dear Skip:

Here is the letter I promised. The tawny-winged Guana Island wasp mimic is Horama pretus (Cramer), known from the Greater and Lesser Antilles (only), including Puerto Rico, St. Thomas (type locality), St. John, Tortola, Virgin Gorda and St. Kitts. Taxonomic reference is Dietz & Duckworth, 1976, Smith. Cont. Zool. 215 (revision of genus).

The most recent mimicry reference for Ctenuchidae that I can locate without a massive search is: Beebe, C.W. & R. Kenedy. 1957. Habits, palatability and mimicry in thirteen ctenuchid moth species from Trinidad, B.W.I. Zoologica 42: 147-158.

There are also a few older refs in German: Sietz, A. 1890. Stettiner Ent. Zeit. 51: 258-266; Schrottky, C. 1909. Deuts. Ent. Zeit., Iris [usually filed under Iris] 22: 122-132, and 1911. Zeit. Wissensch. Insekten. 11: 125-129.

"get"  
HJ/rB

Also, I just saw the following in the MCZ library:  
Baker et al., 1984, Field key to Antillean bats, Occ. Pap. Mus. Texas Tech. Univ. 94.

Best wishes for happy holidays and a good "New York"  
[as a foreign colleague just wrote me!]. Please keep  
in touch on Guana and China.

Best Regards,

Scott Miller

## PLANTS AND MARINE BIOLOGY

I have received nothing more to date from Dr. Ellmore at Tufts; he promises a report and list soon.

I suggest we switch to Dr. Arthur Weiner, the only person known to me who can expertly deal with these three topics:

1. Inventory and ecological description of the terrestrial vegetation of Guana. +
2. Development of a "Garden of Eden."
3. Inventory and development of the inshore reefs at White, Muskmelon, and North Bays, featuring scientific and recreational values.

Weiner's report on his November trip follows. He cannot come to Guana in July, but could spend a good portion of June on the Island. If other (e.g. flamingo) plans gel, I will be there the second half of June too, so that would work out well.

I think you, Art, and I should get together sometime before I head across the Pacific in March to discuss his joining the team. Specifically, the Garden of Eden is a bit of a mystery to me (what you want, where, at what cost, why you think you don't already have it, etc.), and what level of marine "development" and recreational use is envisioned. I do know just what I want in terms of terrestrial plant inventory. It will be a tall order for one biologist to handle all of this, but if anyone can, it's Art.

"when?"  
LS/CB

Staff:

1. Dr. Arthur H. Weiner: fully-funded.
  2. Carol Fries, assistant: room and board.
- "why?" LS
- "whose?"  
LS





*Arthur H. Weiner, Ph. D.*

*Rt. 2 - Box 310*

*Summerland Key, Florida 33042*

December 7, 1984

Dear Skip:

I would like to take this opportunity to thank you and the owners of Guana Island for the chance to visit and study the island and nearshore reefs. As you know, I have spent considerable time working on Vieques, Culebra and the American Virgin Islands, on land and in the water. I therefore have a pretty fair basis for comparing Guana to other nearby islands. Any comparative assessment, based on my brief visit, would certainly be premature, but I would venture the following general observations:

1. The upland plant communities are in good to excellent shape in terms of health condition and woody plant diversity.
2. Areas which had been disturbed by early settlements appear to be recovering to their historic condition.
3. Exotic plants, although established around the resort, have not made substantial encroachments into the natural systems. Care should be taken to insure that these plants do not "escape" into natural areas where they would displace native plant and wildlife populations.
4. Ground covers, i.e. graminoids, have been eliminated from much of the area which I visited. Surface soils, which would otherwise be stabilized by these plant communities, are now de-stabilized and subject to erosion.
5. The neashore reefs are subject to severe adverse impacts from terrigenous sediments and appear to be stressed.
6. The island has tremendous potential for active environmental recreation programs, both on land and in the water.

It was certainly serendipitous to have arrived on Guana on the heels of tropical storm Klaus. Because of the poor visibility which resulted from the storm, I was unable to see much of the nearshore reef system, but, on the other hand I was able to observe, first hand, the impacts of a storm event on these reefs, and those adjacent to Tortola. The White Bay reefs, on the south side of Guana, were observed to receive runoff from the tidal creek which communicates with the large salt pond below the Club. This runoff is carried by the nearshore currents on to the reefs where it inflicts significant stress upon the filter feeders, including corals, of this shallow water marine community. From my limited observations, it appears that the corals of these reefs are in poor condition as a result of sediment stress.

"Visit!"  
AST/60

From observations made from the top of Guana and from Sage Mountain on Tortola, it appeared that turbidity plumes were impacting nearshore reefs. These plumes were undoubtedly composed, to a great extent, of terrigenous sediments washed off the uplands by Klaus. I would guess that the reefs which are impacted by this type of storm event are also subject to long term, chronic turbidity stress. This type of stress results from excessive upland runoff which occurs even after normal rains. Excessive runoff, in the B.V.I. is, in my opinion, caused by poor land use practices on steep upland areas. Poorly planned land development and agricultural practices, especially over-grazing by sheep and goats, is resulting in destabilization of soils which end up on the nearshore reefs. Thus, the combination of long term sediment stress and that of acute stress generated by storms events, places the reefs in jeopardy.

I am familiar with a similar situation which occurred in Kanehoe Bay in Hawaii, where excessive upland runoff, resulting from land development, destroyed a beautiful and diverse reef system. I would assume that the reefs of the B.V.I. support a significant proportion of the tourist economy and that it would be in everyone's best interest to preserve and protect them. To this end, I would make the following suggestions to the owners of Guana Island:

1. Eliminate or enclose all livestock.
2. Continue to carry out all agricultural endeavors only on flat areas of bottomland.
3. Eliminate sewage outfalls or re-direct them away from the reefs. Any sewage released into nearshore waters should be adequately treated in order to eliminate pathogenic fungal, bacterial or viral populations. This is especially important in areas where "water-contact" activities are conducted.
4. A method to conserve cistern water would be to irrigate gardens and landscape plants with "gray water" from showers and sinks. Gray water can be segregated from "black water" at the source and safely re-cycled for the above-mentioned uses. This is a common practice in the Florida Keys.

Some time in the future, I would very much like to inventory and map the reefs adjacent to Guana and to also assess the health of these reefs. I believe these data would be valuable for management purposes and as part of the natural history data base for Guana. If the owners would like to educate guests about the natural history of the local marine environment, information derived during this survey could be used by guests of the Club who choose to snorkel these reefs or dive on other reefs in the area. In this context, it would be helpful to establish a marine aquarium, containing local marine organisms, in one of the common



rooms of the Club. Fish and invertebrates could be collected from the local reefs, by guests or staff, and returned to the reef at regular intervals in order to guarantee the health of both the reef and aquarium systems. A slide show of local reefs and marine organisms could be developed by the staff and utilized as an evening program for guests.

On a more ambitious scale, artificial reefs, composed of waste concrete and/or steel, e.g. 55 gallon drums, could be placed on barren bottoms near the island. I have been involved, for a number of years, with a highly successful artificial reef construction program in the Florida Keys. These reefs, which have been placed in depths from 40 to 200 feet, are quite productive. They attract a diverse association of shellfish and finfish and have become exceptional recreational resources for divers and sport fishermen. There is no reason to believe that artificial reefs properly constructed and emplaced adjacent to Guana Island would not do likewise.

Environmental education initiatives involving upland systems could include a self-guided natural trail with significant environmental and archeological features marked and coded to a guide book. A herbarium containing a collection of Guana Island plants could be a significant part of a natural history museum of the island which could also contain a collection of corals from nearshore reefs. A natural history library would either enhance the museum or stand alone for reference. Establishing a natural history museum and library would not involve great expense in time or money but would certainly be a valuable amenity for the Club.

I would be most willing to discuss my findings and recommendations with you and the owners. I expect to be in the northeast sometime this winter or spring and could arrange my schedule for a meeting.

Again, thank you for the opportunity of visiting Guana.

Sincerely,



Arthur H. Weiner, Ph.D

## POTENTIAL PROJECTS

Bats. -- This study has reached a fine, but I hope temporary, stopping point. The paper Lianna and I wrote has been officially accepted for American Museum Novitates and is scheduled for publication in early 1985. It is a nifty little paper: a suite of new records for Guana; the first use of rarefaction as a diversity index on oceanic islands or with mammals; the first primary correlation of species diversity to elevation. Lianna's point that species:spatial correlations can only exist when species' populations are arranged in a lognormal or rarefaction sequence is a major one. This paper will surely be a landmark for her if her career in biology develops.

I have gone into batflies; an excerpt on them from the text of Island... is appended, illustrated by Ann Payne. The bat and batfly work done on Guana to date is an important part of the whole documented in my book.

However, a signal part of our paper was to predict bat species diversity on other islands in the Virgins. The batfly census poses new and nifty questions. I want someone to take this project over and do the following: 1. Determine the population biology and feeding ecology of Guana's bats; 2. Follow up on the predictions of Lazell and Jarecki; and, 3. Get involved in parasitology as exemplified by our streblid batflies.

I believe we have a wonderful potential here for great discoveries -- even of "extinct" bats -- and excellent publications. I have invited applicants (Lianna, my first choice of course, does not feel up to it). I am willing to serve as assistant on this.



# The American Museum of Natural History

Central Park West at 79th Street New York, New York 10024 (212) 873-1300



January 8, 1985

Dr. James D. Lazell, Jr.  
536 Navesink River Rd.  
Red Bank, N.J. 07701

Dear Dr. Lazell:

I received your letter of December 29, unfortunately after I edited your paper and mailed it to your Rhode Island address for review. Can you ask someone to forward it to you at Red Bank?

As to your question about acceptance for publication, I assure you that the paper is now in production. (The aforementioned review is the first step.) Galley proofs will arrive for proofreading approximately eight weeks after you return the copyedited manuscript to me and the paper will be printed approximately eight weeks after you return galleys.

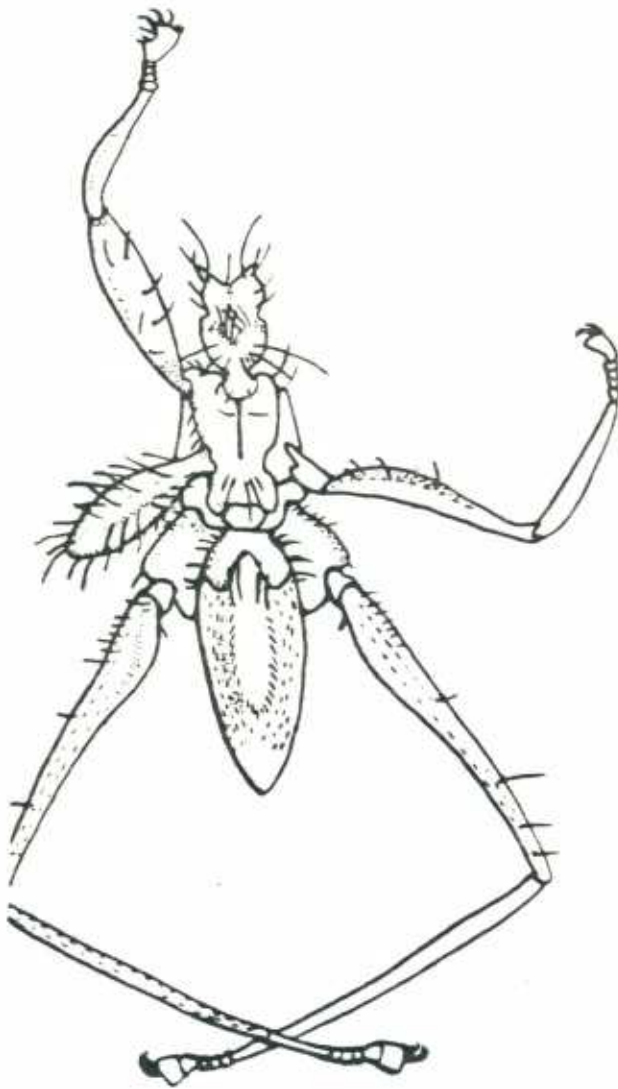
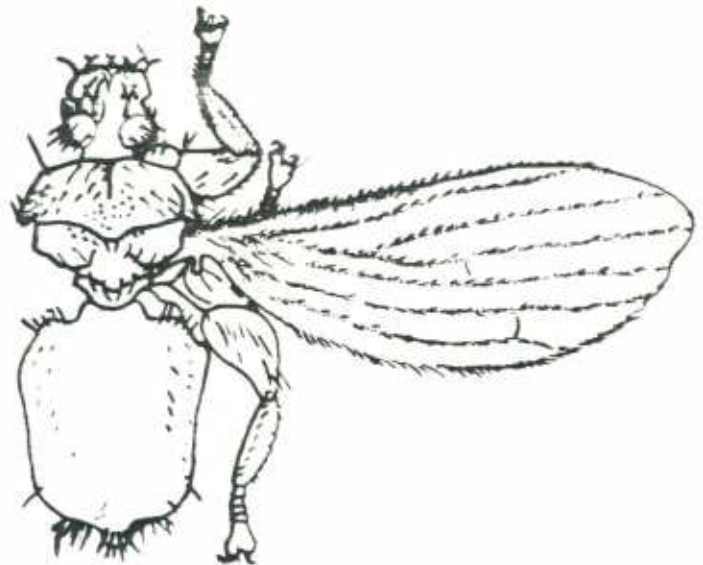
Please don't hesitate to phone me at the above number if you have any further questions.

Sincerely yours,

*Brenda Jones*

Brenda Jones  
Editor, Scientific Publications

## BATFLIES

*Megistopoda aranea**Trichobius intermedius*

An exemplary little guild of parasites occurs in the colony of fruit bats (Artibeus j. jamaicensis) on Guana: at least two species of the family Streblidae, of the order Diptera, class Insecta: Megistopoda aranea and Trichobius intermedius. I am indebted to Dr. Rupert Wenzel of the Field Museum for virtually everything I know about them, except my own field data which were collected largely with the help of Lianna Jarecki.

There are two families of dipteran insects called batflies because their species are parasitic largely or exclusively on bats.



Nycteribiidae is a small family of 13 genera, all but two of which are confined to the Old World. One of these two genera, Herskovitzia, is endemic and found only on the highly specialized bats of the genus Thyroptera in South America. The second genus, Basilia, occurs mostly on the abundant and widespread bats of the genus Myotis; like them, it occurs in both Old and New Worlds. The nycteribiids seem, therefore, to show a pattern consistent with fairly recent invasion of the New World and just the beginnings of adaptive radiation here (Wenzel and Tipton, 1966).

The Streblidae are far more complex. There are 23 New World genera; endemism is high: not even subfamilies are shared between New and Old Worlds. The picture is of an older, long-established set of radiations (Wenzel and Tipton, 1966). Advani and Vazirani (1981) note streblid parasites of parrots, doves, and an opossum. Most streblids are true ectoparasites -- blood suckers. One Old World genus, Ascodipteron, however, has become so modified as to be essentially endoparasitic. The females lose their wings and invade the host's tissues. All streblids are said to give birth to fully developed larvae, one at a time; that is about as K-selected as an insect can get (Advani and Vazirani, 1981). In a magnificent monograph, Wenzel, Tipton, and Kiewlicz (1966) document the streblids of Panama. They note a major problem with the group: some species, like our Trichobius intermedius, fly well and "not only leave the host at the slightest disturbance but will often land on another nearby bat, frequently of another species." They go on to note:

"Such 'disturbance transfers' are not uncommon, among Streblidae of bats caught in nets. These flies often return to the original host, if time and opportunity permits... . While the need for the most rigorous precautions in collecting ectoparasites is well known, in the past they have rarely been observed in the case of batflies."

Webb and Loomis (1977) list 19 species of streblids known from Artibeus jamaicensis, our fruit bat. Most are Central American. Only Megistopoda aranea and some species of Trichobius are recorded for the West Indies -- both from Puerto Rico; both streblids also occur in Central America (Wenzel, pers. comm.). These authors list three species of the nycteribiid batflies Basilia on Central American Artibeus jamaicensis, so it is probable nycteribiids may be found someday in the Antilles or even on Guana. Advani and Vazirani (1981) describe the differences between nycteribiids and streblids, just in case we do ever need to know. Nycteribiids have their heads set back, apparently arising behind the front coxae, and capable of being folded back on the dorsum; the thorax is flat and broadly expanded; the palpi are longer than broad; and there are never wings at any stage in life. Streblidae have their heads in the normal fly position; they do not fold back; the thorax is never more than slightly flattened; the palpi are broader than long and usually project leaf-like in front of the head; and they all have wings, though females of Ascodipteron do lose theirs.

Our second species of phyllostomid (leaf-nosed) bat is Brachyphylla cavernarum, called the cave bat. It seems to be rare on Guana, although



abundant in caves quite like ours on other, nearby islands. Brachyphylla occur only in the West Indies. Webb and Loomis (1977) list just two species of batflies, both streblids, from them: Nycterophilina coxata ("British West Indies") and Trichobius truncatus (Puerto Rico). We have found neither on the Island.

Our third known bat species is Molossus molossus (family Molossidae). Wenzel, Tipton, and Fowler (1966) list few parasites of any sort for this genus. The only batfly noted, a streblid, is Trichobius dunni from the South American mastiff bat Molossus bondae. If this lack of batflies on widespread (islands plus mainland), abundant Molossus molossus is real, it eliminates a discernable pattern in batfly biogeography. I suspect it reflects instead a great need for additional work. Are mastiff bats, genus Molossus, too small to harbor large ectoparasites like batflies? Put another way, are the habitat patches -- individual mastiff bats -- so small that they can support too few individual streblids to comprise viable populations? This is the sort of species: area problem that prevents big predators like bears or lions from living on little islands.

Both Artibeus jamaicensis and Brachyphylla cavernarum occur in the same cave on Guana (Lazell and Jarecki, 1984). This presents us with an opportunity to test the notion of Advani and Vazirani (1981) that streblids are "roost specific," rather than host specific, parasites. Do streblids of the widespread bat A. jamaicensis, which supports a rich diversity of species, colonize B. cavernarum in the same roost, known only from the Antilles and

supporting only a small known streblid fauna? Lawton and Price (1979) consider comparative species richness of parasites on hosts. Mahon (1976) looks at parasite dispersal mechanisms.

Wenzel, Tipton, and Klewlicz (1966) and Wenzel (1976) provide side views of Megistopoda proxima from Central and South America. Wenzel (1970) cites sources for illustrations of bits and pieces of our species, M. aranea. Trichobius intermedius was described and named by Peterson and Hurka (1974) from Artibeus j. jamaicensis from Hispaniola; they did not, however, illustrate it. Ann Payne spent July, 1984, on Guana Island and illustrated both of these species from fresh specimens subsequently sent to Dr. Wenzel.

On 19 July, 1984, we collected some ecological data on the streblid batflies of Guana, and we added one Megistopoda aranea from a Tortola Artibeus on 20 July. A very interesting picture emerges:

"Why?"  
Jg/CB

Artibeus j. jamaicensis:

Sex and condition	<u>Megistopoda aranea</u>	<u>Trichobius intermedius</u>
Female with nursing young, crown-rump 54	---	11
Female with nursing young, crown-rump 47	---	8
Pregnant female (Guana)	---	---
Female, non-reproductive	1	1
Pregnant female (Tortola)	1	---
Male, old and scarred	1	---
Male, adult	1	---
Male, adult	---	---



Females are more heavily parasitized by Trichobius intermedius in our small sample, and females carrying nursing young are by far the most heavily parasitized. Male fruit bats are more likely to have only Megistopoda aranea, and that species is no more abundant (absent, in fact, in our sample) on females carrying young than on non-reproductive or pregnant females.

If Trichobius intermedius fits the reproductive strategy outlined for all streblids by Advani and Vazirani (1981), the females bear live larvae which pupate on the cave walls. These would naturally infest baby bats left hanging on the walls when their mothers went out foraging (Lazell and Jarecki, 1984, show that female Artibeus can and do sometimes carry their young in flight; we do not insist that they always or must do so). A baby bat, with its returning mother, might be a superbly rich habitat for Trichobius and generate a small population boom. But what of Megistopoda? Is it simply out-competed on female-plus-young fruit bats by the burgeoning Trichobius? It is far more specialized for parasitic life and cannot fly. It usually remains still and attached to the bat with its hooked feet; it may not be as capable a disperser as Trichobius.

I have come this far without stating just what defines a parasite; that is now important. Price (1980) states: "a parasite is an organism living in or on another living organism, obtaining from it part or all of its organic nutriment, commonly exhibiting some degree of adaptive structural modification, and causing some degree of real damage to its host." That is a pretty tight

and restrictive definition. It rules out vampire bats, blood sucking flies like tabanids and mosquitoes, and lets us humans off the hook: we do not actually live on the species we drain and enslave. The last clause interests me the most, because real damage seems to me to be an analog of competition in guilds or communities. If host and parasite coevolved long enough, I would expect natural selection to eliminate real damage. This is exactly what has happened in the case of commensalism. The ultimate adaptive nirvana is mutualism, where both species benefit.

With the fruit bats and their streblids on the Island I do not see real damage. Nevertheless, I believe it must be there. The streblids live on the bats' blood, and flies must be a detriment to the bats. But they certainly look healthy enough, despite their streblids. There is a further problem with the streblid<sup>us</sup> ecosystem, stated by Advani and Vazirani (1981): "The larva after being discharged from the vagina... forms a puparium thus the only food taken by the species throughout its life history is blood of the vertebrate host. It is interesting that the food factors which can not be supplied by vertebrate blood are compensated by the activity of the micro-organisms like mycetomes present in the pupipara." Ah yes, and "big fleas have little fleas... ." One wonders if the streblids' mycetomes are parasites, commensals, or mutualists? Or, are the streblids to the mycetomes what humans are to cows and apples: masters owning slaves?



Frogs. -- Here's a tiger whose tail we have in hand. My summary letter to Flores, a grad student at Harvard, is now known to be simplistic. The name Eleutherodactylus antillensis is based on five carcasses stored in Copenhagen. They did not, as I supposed, all come from St. Thomas. They are claimed to have also come from St. John, St. Croix (where no member of this group is known to live), and Vieques (where the species may be the same as on Puerto Rico). Solution of this mess -- highly likely to result in the naming of a new species from somewhere -- will require work beyond the BVI. I have asked both Flores and George Drewry (Office of Endangered Species, USFW) -- specialists on these frogs -- to submit proposals. I assume Mocatta would only fund that part of this project involving Guana and the close BVI, if any part at all.

Social Insects. -- The ants and termites represent a distinct sort of entomological investigation not directly addressed by the Millers' work (as do the batflies). What we want is not just to know their names, but to know their ecology and behavior. Many other sorts of insects, called termitophiles, are associated with Nasitermes -- the fellows who make the big nests. I believe this sort of research calls for a specialist to work in cooperation with the Millers; I am looking for one.

BBC Wildlife Magazine. -- This very attractive publication pays about US\$95 for a full-length feature article and a few pounds each for color photographs. I have received a letter from R. K. Cox, their editor, dated 3 December '84, asking for an article about the BVI. My notion would be to do it, if and when I had the time, highlighting Guana as a wildlife sanctuary. It would be an excellent way for Tommy and Didi to get published as photographers, even if not lucrative. It could be great publicity for the Club. Opinion is hereby solicited.

# The Conservation Agency

Exploration, Education, and Research

President

James D. Lazell, Ph.D.

401-428-2652

6 Swinburne Street

Gonanicut Island

R.I. 02835 U.S.A.

4 December 1984

Glen Flores, Herpetology  
Museum of Comparative Zoology  
Cambridge, MA 02138

Dear Glen:

I have looked into the literature a bit re the Guana Island frog, and reach the following tentative conclusions:

1. We have on Guana the real Eleutherodactylus antillensis; it occurs also on Tortola and St. Thomas (type-locality), and elsewhere in the Virgin Islands.
2. The frog now being called "antillensis" in Puerto Rico is another, possibly unnamed, species. It is smaller, shorter-legged, has a more prominent canthus, and a two-note call.
3. Real antillensis, as on Guana, has a call like E. brittoni: a single, high note repeated rapidly. It is a bit slower: two or three notes per second instead of the five shown by Drewry and Rand (1983) for E. brittoni.
4. One could make a fascinating hypothetical reconstruction of speciation and recolonization on the Virgins and Puerto Rico in which real VI antillensis represents a derivative of the two-note PR form, which evolves its novel call as character divergence in sympatry with E. schwartzi, then reinvades PR in the Wurm glacial maximum, where it speciates to become E. brittoni. One could take this scenario back through the Quaternary and generate most of the entire PR assemblage.

I enclose a couple of Kodachrome transparencies of the Guana frog made by Tricia Giovannone, who collected the specimen. I have some better ones in hand: more suitable for publication.

Keep me posted on froggy events.

Best,

*Ship*

JDL:CES

Encs. (two slides)

cc: Tricia Giovannone  
362 Wianno Avenue  
Osterville, MA 02655

Liao. -- I am very fond of Liao and value him immensely as a colleague in my China work. He wants desperately to come back to the U.S. and to Guana. What he needs to do scientifically is work at the American Museum of Natural History (AMNH) in New York on extinct and vanishing birds of tropical China. There are dozens of species -- with locality data and often field notes -- stored there which are not now known to survive in China. TCA can get him his plane fare and money for reasonable living expenses, but not room in NYC at the going rates. Can we make a deal for your 79th Street apartment?

Liao is a good man in the field on Guana, and can certainly benefit Chipley's studies. However, the only thing I really need him there for is to get a paper done comparing the avifaunas of Guana and the Paracel Islands (Xi Sha), at the same latitude in the South China Sea. Comparing Guana to other places is of paramount importance to me; that's what biogeography and theoretical ecology are all about.

For me (and science) the best thing would be for Liao to spend two weeks in June at AMNH working on Chinese birds. Then, two weeks in early July on Guana doing field work with Chipley and writing with me. Then two more weeks at AMNH -- say, the last two weeks of July. One simply cannot work in that atmosphere of PDB and naphthalene for more than a couple of weeks without suffering severe debilitation.

I believe the Guana-Paracel comparative paper will be a very important one scientifically, and get us well into the limelight. That sort of paper, especially involving birds, will be very avant garde. A critical point is that no other scientists on Earth are in a position to make this comparison. In the larger view, Guana needs to be compared to Barro Colorado, the smaller Galapagos, Cocos, the Hawaiian Leewards, various Fijis, and several islands in the Banda Sea. Then we'll be getting somewhere. Anyway, I support Liao for full funding on Guana for two weeks, and hope I can make a deal with you for some apartment time in NYC.



Personnel Summary. -- I count seven fully-funded applicants not counting Liao, so let's say eight (he is definitely an applicant). That leaves out Michael Gibbons. Now, he is one of my best friends and was a good contributor of specimens and -- especially -- ideas last time. I needed him for various theoretical aspects of the book. He's a great fellow to have around, but I do not see him making a specific scientific contribution. My inclination is to invite him on a room-and-board basis, if he wants to handle his own transportation.

I can find only five room-and-board assistants listed above; perhaps I miscount (usually do). That is too few. Bill MacLean (like his assistant Ellen) is a sixth r-and-b: they don't need transportation. We will predictably need more assistants. One naturally thinks of Didi, Lianna, and Tommy (that order is alphabetical, not the one I think of them in). I wonder what sorts of commitments we could get from any of them?

"ages?"  
HS/CB

In any case I think we need at least two or three more full-time-equivalent, r-and-b assistants. Our results in the field are directly proportional to the number of people fielded, until that exceeds the few each scientist can usefully supervise.

Inter-island Costs. -- Continued work on lizard physiology, general herpetology, and entomology require inter-island comparisons and field work. Other studies -- like birds and plants -- will certainly benefit thereby. As those latter studies progress past the census stage on Guana, their need for broader comparisons will increase. The potential studies of bats and frogs, anchored so well on Guana (if we want to keep that advantage) are essentially comparative. So, I think we need to fund five day trips during the month to other islands in the BVI.

"Jost, GC, Tortola" HS/CB

I believe people doing comparative studies in the USVI, Puerto Rico, and such can hunt up their funds elsewhere. For example, if Flores makes a good case for our assistance on the frog project, we could fund his work on Guana, some (five days) access to other BVI's, and he can get Harvard or someone else to handle St. Thomas, St. John, Vieques, and Puerto Rico.

My next step is to send out a questionnaire to the people named above and get their dates. I'll do this if and when you OK it in principle. I would personally like to be on Guana, with at least one assistant, from about mid-June well into or through July. The additional time will be needed, I believe (and hope), if the animal introductions noted below begin to snowball into a lot of work.

#### ANIMAL INTRODUCTIONS

Iguanas. -- The endemic BVI Iguana pinguis has now been proven (by Greg Pregill at Smithsonian, looking at subfossil and recent bones) to have been widespread in Puerto Rico and the Virgin Islands. It is likely the largest native New World lizard. The last living population is on Anegada, where it is in grave danger from pot-shooters, dogs, cats, and government development schemes. This may be the species referred to as living on Guana by Major Chapman Grant in 1932. I believe establishing or re-establishing them on

"probs.  
+ risks?  
- see a picture"

Guana is a wonderful idea. To that end, a gravid female was brought over in July '84. I believe she is doing well and has laid her eggs: tracks only attributable to her were found at the south end of White Bay. Small sets of similar tracks may have been baby 'guanas (ground lizards do not show a belly drag and these tracks did).

In any case, I want to bring more over from Anegada, and have set that project in motion. There is no reason to be afraid of these herbivorous animals, and they do not smell bad. I think they will prove a greater attraction on Guana than their mundane relative, Iguana iguana, is on St. Thomas (e.g., Lime Tree Bay).

Flamingos. -- This immensely popular project should be Go for '85. We were all tooled up for '84, but the flamingos simply did not hatch because of the drought (which exacerbated the feral hog predation problem). Given a normal year, we should manage this project in June. We are tooling up again to do so.

African Animals. -- I am still searching for the right species. We need something colorful and attractive which will not denude the Island, not drink more water than the existing sheep and donkeys (preferably less), and will not attack people. Currently Cape mountain zebra and various species of gazelles seem to be front runners. I am using Guana letterhead for all relevant correspondence, so you will know before I do what is going on with this project. I'll find out when you tell me. (NB: gazelles are good to eat.)

White-crowned pigeon. -- These great, flashy game birds have been extirpated from the entire BVI. They do survive in the USVI, but damn few. They are making a comeback, thanks to game management and law enforcement (Nellis, et al., 1984. J. Wildl. Manage. 48: 889-894). They are of great biogeographical interest because they nest in mangroves; thus they are a land bird with reproductive aspects of a sea bird. As soon as Guana's cats are rendered vanishingly scarce and our mangroves have grown back big enough to hold nests, I want to re-establish white-crowns. They are larger than street pigeons, blue-black with scarlet trim, and have snow-white caps. They are excellent eating.

Tortoises. -- The morocoy, or red-legged tortoise (Geochelone carbonaria) was once widespread and common in the Virgin Islands. Populations are known from Tortola, Beef Island, Virgin Gorda, Peter Island, and St. Thomas. They have simply been eaten up most places, like other big tortoises in the world (they are good eating, too). They get to a shell length of half-a-meter, which is larger than a U.S. snapping turtle, but not as large as a Galapagos tortoise. They may weigh sixty pounds. Unlike their Galapagos relatives, they are very colorful: black, brown, yellow, and red. They are herbivorous and graze on grass mostly. They are slow and ponderous, easily tamed, and do not bite people. I think they are ideally suited to Guana. If you OK them, all I have to do is catch some. That's the sort of thing I am 'sposed to be good at, given a selected field assistant.

"They stay in same place?"  
NJ/CB



## FINANCES TO DATE

Of the \$13,000 in medical expenses to be amortized at \$500 per week, none remains. I worked full-time from Sunday, 5 August til Sunday, 25 November on the book: 15 weeks. Since then, as follows: — "on what?" HJ

26 November. . . . .	4 hours	
9 December. . . . .	2 "	} Math for Biozeg update.
10 " . . . . .	4 "	
12 " . . . . .	2 "	
20-22 " . . . . .	24 "	- Biozeg & this report
Carried over from August . . . . .	15 "	
TOTAL . . . . .	51 hours	

Or, one week, plus eleven odd hours; so 16 weeks at \$500 per week. So:

Reported in August. . . . .	\$ 7,500
Reported herein . . . . .	8,000
TOTAL . . . . .	15,500
Already advanced. . . . .	<u>13,000</u>
Balance . . . . .	\$ 2,500

"EWS +  
china +  
Africa"  
HJ

Predictably, the book will shortly emerge from the critical review process with lots of requests for changes. I already know I have to update some parts. I am perfectly willing to undertake all this on my own time: it's not Guana's or Mocatta's fault that updates and revisions are called for. Perhaps, however, my enthusiasm for doing work on this book on my own could be used as a chip in bargaining for some NYC time for Liao.

Between now and June I will have to do a fair amount on flamingos and other species for Guana of no import to the book. I will continue to log those hours unless you tell me otherwise, but will assume I am not working for Guana full-time again until next June.

"make a  
guess  
on  
#15."  
HJ

Drop me a line at Rt. 2, Box 309, Middle Torch, Summerland, FL 33042 (no phone). I'll then phone you on some Saturday or Sunday to further hone plans.

I think things are going just great!

Happy New Year,

*Ship*

James D. Lazell, Ph.D.

JDL:CES