REPTILE DIVERSITY IN AN AMAZING TROPICAL ENVIRONMENT: THE WEST INDIES

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To the memory of Ernest E. Williams and Austin Stanley Rand

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Summary

The main features that differentiate “reptiles” from amphibians are their dry scaled tegument and their shelled amniotic eggs. In modern studies, birds are classified under the higher category named “Reptilia”, but the term “reptiles” used here does not include birds. One can externally identify at least, three groups of reptiles: turtles, crocodiles, and lizards and snakes. However, all of these three groups are made up by many species that are different in some morphological characters like number of scales, color, size, presence or absence of limbs. Also, the habitat use is quite variable; there are reptiles living in almost all the habitats of the Earth, but the majority of the species are only found in the tropical regions of the world. The West Indies is a region of special interest because of its tropical climate, the high number of species living on the islands, the high level of endemism, the high population densities of many species, and the recognized adaptive radiation that has occurred there in some genera, such as *Anolis*, *Sphaerodactylus,* and *Tropidophis*. Another amazing feature is the convergent evolution of the lizards of the genus *Anolis* in the Greater Antilles into ecomorphological types called “ecomorphs”. Each of the four islands (Cuba, Hispaniola, Puerto Rico, and

Jamaica) has its own set of ecomorphs, very morphologically similar to each other, although phylogenetically different. Unfortunately, such special West Indian species richness and endemism is under severe threat of extinction. The modification of habitats by Humans and the introduction of some very invasive exotic species have had a negative effect on native reptiles. Only humans can reverse this problem, using nature while keeping its conservation in mind.

1. Introduction

Modern classification of vertebrates includes birds as a subgroup of the class Reptilia, and this is generally accepted by taxonomists. However, herpetologists have been, for a long time, engaged in the study of amphibians and reptiles (but no birds). That is why, in this chapter on "reptiles" will focus on reptiles, excluding birds. Amphibians are different from reptiles in their tegument which lack scales, in having four fingers in their hands (when they have hands), and several other internal characters like skeletal, cardiovascular, urinary, and reproductive systems, the non amniotic eggs, and the presence of many glands with external secretions. Reptiles have evolved to be reproductively independent of water because they lay amniotic shelled eggs in humid, but not water environments. Also, their scaled skin helps them to live outside the water, even in sunny places.

One can externally identify, at least, three groups of reptiles: turtles, crocodiles, and lizards and snakes. Turtles are quite different from other reptiles, with their body embedded in a dorsal carapace and a ventral plastron, and their jaws without teeth. Crocodiles have their dorsum protected with many bony plates roofed by skin, very strong jaws with teeth, and a vigorous tail. Lizards and snakes make up a very morphologically diverse group called "scaly" because their entire bodies are covered by scales. All of the species have elongated bodies with large tails; more than a half of them have four limbs with five fingers and five toes (most of the lizards) and the other ones have evolutionarily reduced or lost their limbs (some lizards an snakes).

Reptiles occupy almost all the habitats of the world. The majority of them are terrestrial (live on land): on or under the ground, on trees, and inside caves. Some of them inhabit water, mainly inland waters, but also in estuaries and marine water. There are reptiles in the entire world, except in the Arctic and the Antarctic regions. However, in the warmest and wettest tropical and subtropical regions the greatest diversity of reptiles is found, not only in number of species, but also in body shapes, sizes, colors, and habitats.

Tropical reptiles are especially adapted to hot and humid habitats. They are mainly found in the tropical regions of the world, between the Tropics of Cancer and Capricorn, but also in some of the subtropical regions. In other terms, tropical reptiles live in four of the six Biogeographic Realms of the World: Neotropical, Ethiopian, Oriental, and Australian. Within the Neotropical Realm is the Antillean subregion, also called the West Indies.

The West Indian region is a cluster of islands, geographically located between the Gulf of Mexico and the Caribbean Sea. The islands differ greatly in size and origin. The

Greater Antilles include the largest islands, Cuba being the largest (110 922 km$^{2)}$, followed by Hispaniola (Haití and República Dominicana, 76 000 km^2), Jamaica (10 9991 km^2), and Puerto Rico (9 085 km^2). In Bahamas are situated 700 islets and more than 2 000 cays, with Andros (4 144 km^2) as the largest one. The Lesser Antilles (235 700 km^2) are composed of more or less 40 small islands, islets, and cays, ranging between 0.2 to 750 km^2 (Figure 1). All of the West Indies, except for the northern portion of the Bahamas, are in the tropical zone, below the Tropic of Cancer. The entire Antillean subregion has a benign tropical climate, with two main seasons: rainy season, from May to October, and dry season, from November to April. The geological origin of the West Indies is still debated, but what is most widely accepted is that the Greater Antilles originated from an ancient proto archipelago that moved eastward from what is now the Isthmus of Panama, whereas the Lesser Antilles is a volcanic arc lifted up "in situ", and the Bahamas was formed by the collision of the Caribbean plate and the North American plate.

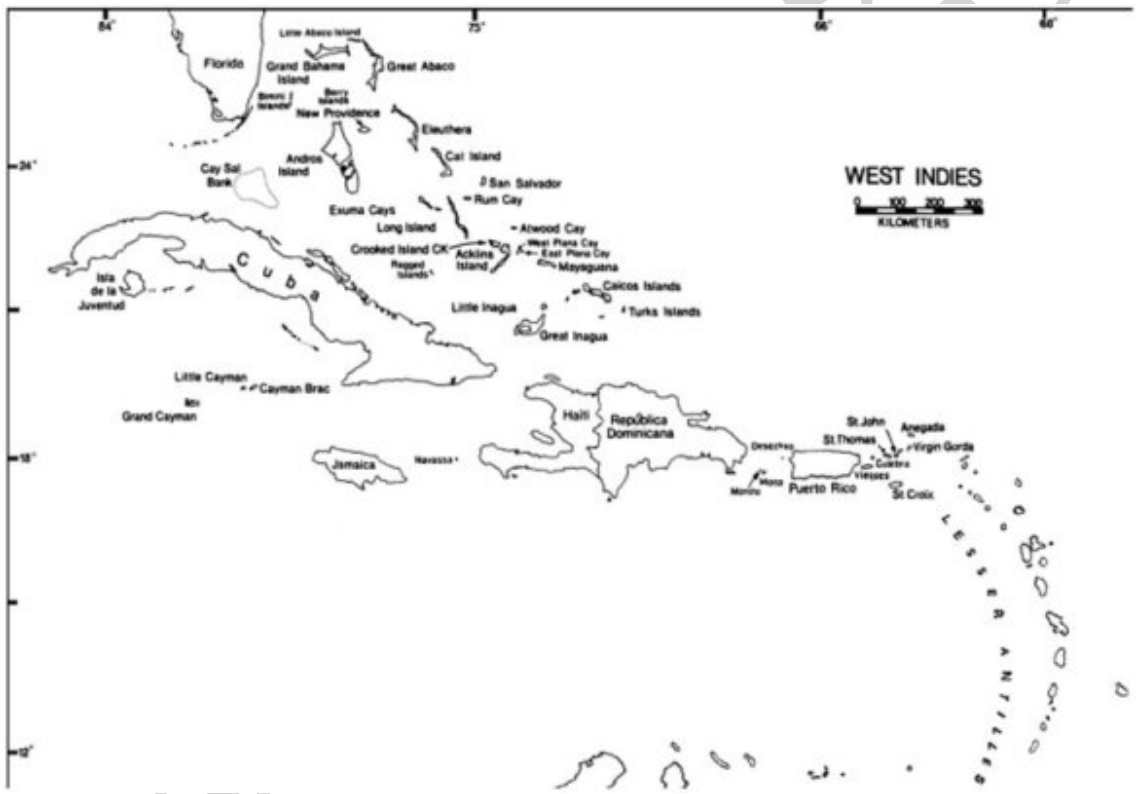

Figure 1. Geographic location of the West Indies.

The geographic location, the climate, the huge number of islands, islets, and cays, with different origin, sizes, and physical geography, have allowed that in the West Indies have established a big number of species, with a high level of endemism. This chapter deals with the reptile diversity in such an amazing neotropical subregion, focusing on the largest archipelago, Cuba, as a study case.

2. Reptile Diversity

One of the most common ways to report on reptile diversity is the number of species in

a country, region or locality. Taxonomists are the people engaged in the classification and naming of the species and, since the XVII Century, there have been many taxonomists describing reptile species and ordering them into families and orders. From the taxonomic level of family, in the tropical regions of the world all the 13 extant families of turtles are known to be present; the three families of crocodiles; 18 of the 19 families of lizards (one family includes a northern Florida limbless lizard); and all of the 18 families of snakes.

The Antillean subregion comprises 44.2% of such tropical reptile families. Three of the turtle families are autochthonous, with five species in the family Emydidae, and five marine turtles (families Chelonidae and Dermochelyidae) that surround the Antillean seawaters. In addition, two species of the family Testudinidae and one of the family Pelomedusidae were introduced to the Lesser Antilles. One family of crocodiles (Crocodylidae) with three species is present in the West Indies, aside from one species of the family Alligatoridae, introduced to Cuba, Puerto Rico, and Grenada. Regarding the lizards, 15 species belong to the family Amphisbaenidae; 27 to the family Anguidae; 104 to the family Gekkonidae, plus one more introduced to the Lesser Antilles; 3 to the family Gymnophthalmidae; 173 to the family Iguanidae *s. l.* (13 to Iguanidae, 136 to Polychrotidae, and 24 to Tropiduridae); 3 to the family Scincidae; 24 to the family Teiidae; and 1 to the family Xantusiidae. The snakes are 12 species in the family Boidae; 51 in the family Colubridae; 8 in the family Leptotyphlopidae; 25 in the family Tropidophiidae; 27 in the family Typhlopidae; and 2 in the family Viperidae.

Polychrotidae and Gekkonidae are the most diverse families, with the highest number of species, each family containing one of the most speciose reptile genera of the World: *Anolis* and *Sphaerodactylus*, respectively. Both genera are found throughout all the Antillean subregion. On the other hand, six families are poorly represented. Dermochelyidae (Leatherback seaturtle) has one worldwide species, that although it is mainly pelagic, it uses the most pristine beaches of the West Indian to lay its eggs. Of the three species of Crocodylidae, one is endemic to the West Indies, but one of the other species also is found in northern South America and one in southern North America, Central America, and southern South America. Gymnophthalmidae is a central and southern American family, but two species of the genus *Gymnophthalmus* and one of the genus *Bachia* are living on some islands of the Lesser Antilles. Scincidae is a tropical and subtropical worldwide family; however, of the three species of the genus *Mabuya* one species is found in the Bahamas, one in Hispaniola, one in Jamaica, two in Puerto Rico, and one in the Lesser Antilles. The least represented family is Xantusiidae, with only an "ancient" species living in the southernmost part of Cuba. Viperidae is a worldwide family, with more than 120 species; while in the West Indies, there are just two endemic species, one for each island of the Lesser Antillean arc.

2.1. Morphology

The remarkable diversity of families of reptiles in the West Indies has been taxonomically classified based on differences in morphology (size, shape, and color). In this sense, there is a lot of variation in size, from the diminutive geckonid species of the genus *Sphaerodactylus* (the smallest amniotes in the world) to the large marine turtles. Shape is quite variable as well. For example, there is considerable variation in limbs:

some species have four well developed limbs, others are without limbs, and others possess reduced limbs. Also, when limbs are present, several species have them modified as flippers, like in some turtles; in many species limbs have claws, in others no, or not in all the fingers and toes. The most striking characteristics of the fingers and toes are the toe pads, with subdigital lamellae, in the species of the genera *Anolis* and *Chamaeleolis* and in the geckos. The shape of the body is also diverse in this group: turtles have almost oblong bodies with carapace and plastron from which protrude the head, tail, and limbs; the other reptiles have elongated bodies with more or less long heads and tails. The variety of colors and of color patterns is also wide. There are uniformly colored species, but most of the reptiles have bright colors, arranged in countless designs and patterns. Again, the species of the genera *Anolis* and *Chamaeleolis* are distinctive in having dewlaps, with colors that contrast with the body colors and that are species specific (i.e. useful in identifying the species).

2.2. Habitat

Another of the way that the West Indian reptiles have diverged is in their use of habitat. They live in all the different types of ecosystems present in the Antillean subregion: mangroves, coastal vegetation, spiny shrubwoods, semi-deciduous, evergreen, pine, pluvial, and cloudy forests, secondary vegetation, pastures and cultures. Water is also inhabited by reptiles: there are species in sea water and in fresh water as well. Houses and other human made sites are used too. All the strata of the ecosystems are occupied by reptiles: some of them are excellent burrowers and spend almost all their time under the ground; some live under the leaf litter, some on the ground, and others above ground on trees or rocks.

Food is one of the main resources that a reptile needs to obtain. According to their type of food, West Indian reptiles occupy all the food levels. There are a few primary consumers, which feed on vegetable material. Many of the species are secondary consumers that feed on invertebrates, mainly insects. Some can be classified as tertiary consumers that eat other vertebrates and their eggs, as well as reptiles. A few species are omnivorous, eating both vegetable and animal materials. On the other hand, they are preys of other tertiary consumers like birds and mammals, and some are considered a good source of food for humans.

The time of activity is also variable. A lot of species are diurnal, sleeping at night; there are some that have two peaks of activity, at dawn and at dusk; and others are nocturnal.

3. West Indian Reptiles

The first written references of the West Indian herpetofauna are found in the voyage diary and letters of Christopher Columbus, in which he mentioned turtles and iguanas seen during his first voyage in 1492. Also, the so called “chroniclers of Indies” by Father Bartolmé de Las Casas (1526-1552: “Historia de las Indias”), Father Ramón Pané (1494-1498: “Relación acerca de las antigüedades de los indios”), and Gonzalo Fernández de Oviedo (1535: “Historia general y natural de las Indias, islas y tierra firme del Mar Océano”) referred to the presence and importance of marine and terrestrial chelonians, large serpents, and iguanas for the West Indian people that they encountered

during the first years of the European colonization.

Moreover, archeological evidence demonstrates that "aruacos", the people who lived in the West Indies at least six or even 10 centuries before the arrival of Columbus, used several species as food or handicraft and included them in their mythological view of the world. For example, burned bones of iguana (genus *Cyclura*) in remains of Cuban aborigines indicate its use as food; other archeological findings reveal the utilization of iguanas, chelonians and boids in the feeding habits of the West Indian aborigines. In the exhibitions of the Cuban Museum of Anthropology there is a "dujo" that is a wooden iguana used as a chair, in which you sit down on its dorsum. Also, at that museum exists a turtle carved in stone that corresponds to a marine turtle, probably a representation of: "Caguama" (*Caretta caretta*): for West Indian pre-Columbian peoples "Caguama" was the mother of all the Humankind, the source of water and food, a very important icon in their mythology. Another symbolic entity is "Iguanaboina", the union of iguana and boa, a representation of the god of the contraries: day and night, Sun and Moon, light and darkness, rain and dryness.

Carolus von Linnaeus, a Swedish man who in 1758 introduced a natural system to classify plants and animals, was the first who classified some West Indian reptiles. His work was the starting point for the classification of the living world. During the XIX Century, the number of reptile species described increased to 163 species by means of the conscientious work of naturalists such as Edward D. Cope, Gabriel Bibron, André M. C. Duméril, Samuel Garman, John E. Gray, and Wilhelm Peters. The XX Century represents an explosion in West Indian taxonomy, starting with Leonard Stejneger at the beginnings of the 20th Century, to the late Albert Schwartz and Ernest E. Williams in the 1990s, continuing with Richard Thomas, Orlando H. Garrido, and S. Blair Hedges, who are still describing new species. As of August 2006, 524 species have been described for the West Indies, including the five sea turtles that spend the majority of their time in the Antillean seas but come to the beaches to lay their eggs.

Antillean reptiles are characterized by a high level of endemism. Of the 60 genera represented in the West Indies, 12 are endemic to this subregion (Table 1). Hispaniola and Cuba have the highest numbers of genera; also, eight of the 12 endemic genera are found in Hispaniola and seven in Cuba. On the other hand, seven genera have been introduced to the subregion.

Cuba and Hispaniola are the largest islands and they have the more complex geography, with mountain ranges and flatlands, preserved and disturbed areas, and intricate forests with several vegetation types, all of which allows the presence of many genera in relatively small areas.

Several genera have many species represented in the West Indies. Also, many of them are very abundant, with high population densities that despite the small sizes of such species, adds a large amount of biomass to the terrestrial ecosystems. The large number of species can be attributed to the adaptive radiation that has occurred in at least three genera, *Anolis*, *Sphaerodactylus*, and *Tropidophis*. A little more than 42% of the species of the genus *Anolis* live in the West Indies, principally on Cuba, while the other species inhabit the American mainland, from southern North America to northern South

America, and on some of the Pacific islands like Malpelo and Coco. Most of the species of the genus *Sphaerodactylus* inhabit the islands of the Antillean subregion, mainly on Hispaniola: of the 99 of these small lizards known up to date, only 11 live outside the West Indies, in Central and northern South America. With less species (29) than the two former genera, *Tropidophis* is almost completely restricted to the West Indies, with the majority of the species being found in Cuba (16 species), 10 species distributed on three other islands (Hispanola, Jamaica, and Cayman Islands), and only three species living in South American.

Taxons	Cuba	Hispaniola	Jamaica	Puerto Rico	Cayman Islands	Lesser Antilles	Bahamas
Order Testudines							
Family Cheloniidae							
Chelonia	1	1	1	1	1	1	1
Caretta	1	1	1	1	1	1	1
Eretmochelys	1	1	1	1	1	1	1
Lepidochelys	1	1	1	1	1	1	1
Family Dermochelyidae							
Dermochelys	1	1	1	1	1	1	1
Family Emydidae							
Trachemys	1	2	1	1	1	2	2
Family Pelomedusidae							
Pelusios (I)						1	
Family Testudinidae							
Geochelone (I)				1		2	
Order Crocodylia							
Family Crocodylidae							
Crocodylus	2	1	1		1	1	
Family Alligatoridae							
Caiman (I)	1			1		1	
Order Squamata							
Family Xantusiidae							
*Cricosaura**	1						
Family Teiidae							
Ameiva	1	3	1	5		10	2
Cnemidophorus						1	
Kentropyx						1	
Family Anguidae							
Celestus		12	8		1		
Diploglossus	3			1		1	
Ophisaurus (I)					1		
Family Gekkonidae							
Aristelliger		3	1		1		2
Gekko (I)						1	
Gonatodes	1	1	1		1		
Hemidactylus	3	2	1	2	1	2	2
Phylodactylus		1		1		1	
Sphaerodactylus	21	35	8	11	1	8	9
Tarentola	1		1				1
Thecadactylus						1	
Family Gymnophthalmidae							

Bachia						1	
Gymnophthalmus						2	
Family Iguanidae							
*Cyclura**	1	3	1	3	2		3
Iguana				1	1	2	
Family Tropiduridae							
*Leiocephalus**	6	12			1	1	5
Family Polychrotidae							
Anolis	58	43	7	16	5	26	7
*Chamaeleolis**	5						
*Chamaelinorops**		1					
Family Scincidae							
Mabuya		1	1	2		1	1
Family Amphisbaenidae							
Amphisbaena	3	5		5			
*Cadea**	2						
Family Colubridae							
Alsophis	1	2	1	3	1	5	1
*Antillophis**	1	1					1
*Arrhyton**	8		3	1			
Chironius						1	
Clelia						2	
*Darlingtonia**		1					
Diadophis					1		
Elaphe (I)				1	1	1	1
*Hypsirhyncus**		2					
*Ialtris**		3					
Liophis						5	
Mastigodryas						1	
Nerodia	1						
Pseudoboa						1	
Tretanorhinus	1				1		
*Uromacer**		3					
Family Boidae							
Boa						1	
Corallus						2	
Epicrates	1	3	1	2			3
Family Tropidophiidae							
Tropidophis	16	2	3		3		3
Family Leptotyphlopidae							
Leptotyphlops		4				2	1
Family Typhlopidae							
Ramphotyphlops (I)				1	1	1	
Typhlops	2	9	1	7	2	6	3
Family Viperidae							
Bothrops						2	
TOTAL OF GENERA	29	30	22	24	24	38	22

Table 1. Taxonomic composition of the West Indies. The endemic genera to the West Indies are marked with an asterisk (*) and the introduced genera, with an (I.). Encased

are the numbers of species in each island.

When at the end of the 1950s Bruce B. Collette visited the Bosque de La Habana, a secondary forest along the west side of the Almendares river which flows from south to north dividing the city of Havana, Cuba, into the older and the newer zones, he noticed a relationship between morphology and ecology of the lizards of the genus *Anolis*. For that reason, his 1961 paper inspired Austin Stanley Rand to document that morphologically similar lizards of Puerto Rico were using similar structural microhabitats (that is, perch height and diameter, and places for basking), and he was the first to introduce, in 1964, the term ecomorph for these groups of species. He, and Ernest E. Williams, continued defining the concept until, in 1983, E. E. Williams provided the general characteristics, in term of morphology and ecology, of the ecomorphs of the Greater Antilles. Studies on ecomorphology are abundant in the literature about West Indian herpetology, beginning with papers by these two great researchers of Antillean reptiles. In that sense, six ecomorphs are now recognized: crown (large lizards living mostly in the canopy of trees); trunk-crown (medium large lizards living on the trunks, near the canopy); trunk (medium large or small lizards living on trunks, but without reaching the canopy nor the ground); trunk-ground (small lizards living on the trunks near to the ground and often descending to the ground); twig (large or small lizards living on branches and twigs); and grass-bush (small lizards living on trunks of shrubs or on stems of grasses). However, there is a tendency to subdivide the grass-bush ecomorph in two (grass and bush) and to include one more, the rock ecomorph.

Antillean reptiles represent some of the largest and smallest amniotes. The Leatherback turtle (*Dermochelys coriacea*) has a mean carapace length of 2 m and is the largest extant turtle of the world. Among lizards, the Cuban iguana (*Cyclura nubila nubila*) has a total length of 1.5 m which is only exceeded by the largest known lizard of the world, *Varanus komodoensis*, with a total length of 3.1 m. Snakes are generally large reptiles; however, the largest reported sizes are of boas, like the huge “anaconda” from South America, that is the largest extant snake in the world with a total length of 8 m or more. The boid genus *Epicrates* has 10 species, 9 of which are endemic to the West Indies, and the Cuban boa (*Epicrates angulifer*) reaches a total length of 6 m, a little less than the “anaconda”. The gekkonid species of the genus *Sphaerodactylus* are very small lizards, the smallest in the world, and two of the smallest species live in the West Indies: *S. parthenopion* from the Virgin Islands, with a mean snout-vent length of 16 mm for males and of 18 mm for females, and *S. ariasae* from Dominican Republic, with a mean snout-vent length of 18 mm for both sexes. Within the genus *Anolis*, a widespread genus in the Western Hemisphere, there are some Antillean species that are the smallest in the genus: the Cuban members of grass anoles, including *Anolis cupeyalensis* with a mean snout-vent length of 30.6 mm for males and of 28.5 mm for females and *A. alfaroi* with a mean snout-vent length of 33.9 mm for males and of 30.1 mm for females.

Antillean reptiles are under the same negative worldwide impacts, as many other organisms, which include the human activities and other natural catastrophic events. However, these impacts are intensified by the island geography of this subregion, where many of the islands are small to very small, threatened not only by their initial small population sizes, but also by the impending increase of the sea level. Nonetheless,

fragmentations, or loss of the suitable habitats for the lives of reptiles, as well as contamination, are the main factors that threaten the extinction of reptiles, or have even lead to the extinction of some West Indian species. In addition, the introduction of predatory animals, such as rats, mongooses, wild boars, cats, and dogs, continues to have a very negative impact on reptiles, as they feed on adult reptiles and their eggs. Human beings affect the survival of reptiles, not only by modifying their habitats, but by what is worst, killing them because of fear and aversion to them, or for false beliefs about the injuries that some species could cause to humans. In addition, for some species, the uncontrolled use of adults or eggs for food has had major impacts. Knowledge of the reptile fauna of the West Indies, and the factors that threaten them, is very important so that all possible actions to prevent the loss of these animals, that are so important to the ecological webs of the subregion, can be implemented.

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Biographical Sketch

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