Conservation of the herpetofauna of the Dominican Republic

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Abstract. The herpetofauna of the Dominican Republic consists of 39 frogs (two of which are introduced), 110 squamates (one possibly extinct and three or four introduced), one crocodilian, three turtles (one introduced), plus four species of sea turtles. Reflecting the recent "Global Amphibian Assessment," 32 of 37 (86%) native species of amphibians are included on the IUCN Red List. Reptilian species given formal recognition as being in need of protection include the sea turtles (listed in CITES appendices and the IUCN Red List), the two native species of pond turtles (*Trachemys* spp.; IUCN, although one as being at "lower risk" of extinction), both species of rock iguanas (*Cyclura* spp.; CITES and IUCN), two giant galliwasps (*Celestus* spp., IUCN), three boids (*Epicrates* spp., CITES), a ground boa (*Tropidophis haetianus*, CITES), and the American crocodile (*Crocodylus acutus*; CITES and IUCN). However, at least some additional squamate species appear to meet criteria for inclusion on the IUCN Red List. Four factors largely responsible for the status of these species are: (1) small ranges, habitat specialization, and encroachment by human activities (many amphibians); (2) large size and economic value (turtles, iguanas, crocodile); (3) persecution by people who fear them (galliwasps and snakes); and (4) diurnally active, terrestrial, and vulnerable to predation by mongooses and other introduced mammalian predators (some snakes, *Mabuya*). Although protection for a few species and for national parks in critical habitats is legislated, enforcement is sporadic and threats, mostly associated with exploitation and development, remain. Specific recommendations for the conservation of the herpetofauna are listed.

Key words: Amphibians; conservation; Dominican Republic; Hispaniola; reptiles.

Introduction

The Dominican Republic covers the eastern two-thirds of the island of Hispaniola (the western third is the Republic of Haiti). Hispaniola (ca. 76 500 km^2) is characterized by a rugged topography (fig. 1), which results in a mosaic of mesic highlands and often very xeric lowlands, creating a complex of varied habitats that support a remarkably diverse herpetofauna. Albert Schwartz once described Hispaniola as

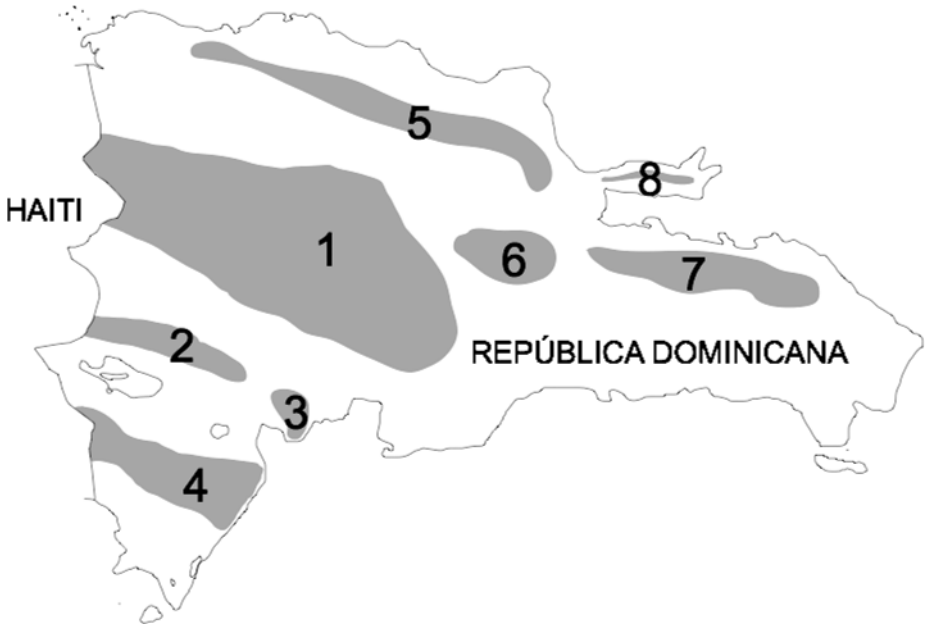

Figure 1. Physiographic features of the Dominican Republic (from Powell, 1999). Numbers correspond to major relief features: 1 = Cordillera Central, 2 = Sierra de Neiba, 3 = Sierra Martín García, 4 = Sierra de Baoruco, 5 = Cordillera Septentrional, 6 = Sierra de Yamasá, 7 = Cordillera Oriental, 8 = Sierra de Samaná.

"an island of islands," in reference to the myriad pockets of dramatically different habitats often separated by only a few kilometers (Powell et al., 1999). Because conservation issues often are addressed at the political rather than the biogeographic level, we treat the Dominican Republic as an entity independent of Haiti.

Physiography of Hispaniola

The diversity of the herpetofauna may be attributed primarily to three factors: (1) a rugged and mountainous terrain of which the dominant relief features are parallel ranges that run primarily from the northwest and west in a generally easterly direction (Weil et al., 1982; Lewis and Draper, 1990); (2) satellite islands of varying sizes and exceedingly different topographies and habitats; and (3) the peculiar geological history of the island.

The island's major mountain ranges isolate often extensive intervening valleys, and satellite ranges create narrow and often broken coastal lowlands. A lowland plain covers much of the eastern end of the island. Such structural complexity, composed of high elevations and resultant rainshadows, results in a juxtapositioning of harsh deserts, dry scrub forests, rainforests, cloud forests, and high-elevation pine savannas.

Satellite islands, many of which support endemic taxa, range in size from approximately 650 km^2 and a maximum elevation > 600 m (Île de la Gonâve;

Schwartz, 1980) to less than 0.02 km^2 and only a few meters above sea level (Cayo Muertos in the Cayos Siete Hermanos; Burns et al., 1992). Other satellites of significance on the Dominican side of the island are islas Saona, Catalina, Beata and Alto Velo.

Although "Considerable controversy exists over the interpretation of the early tectonic evolution of Hispaniola" (Lewis and Draper, 1990), the peculiar history of the island lies largely in its origin as two paleoislands (Schwartz, 1978, 1980), although as many as four elements may have combined to form the present island. The two major entities joined when the South Paleoisland "caught" the North Paleoisland after the latter collided with the Bahama Platform (Lewis and Draper, 1990), mostly likely during the Miocene (Huebeck and Mann, 1991) and maybe as early as the Eocene (Khudoley and Meyerhoff, 1971); however, as a consequence of rising and falling sea levels, partial or complete separation may have occurred intermittently throughout the Pleistocene. Reef limestones deposited during the Pleistocene are currently exposed in coastal areas and in the former marine channel that separated the paleoislands (Lewis and Draper, 1990). In the herpetological literature (e.g., Williams, 1961), the paleoislands are known as the North and South islands, respectively. The former marine strait is now a barren valley known as the Plaine de Cul-de-Sac in Haiti and the Valle de Neiba in the Dominican Republic. Much of this valley still lies below sea level and it is characterized by four remaining large lakes, two of which are saline.

The South Island is the smaller (9500 km^2) and much less complex of the two paleoislands. The principal relief features are three major mountain ranges that run from the western tip of the Tiburon Peninsula in Haiti east across the Barahona Peninsula in the Dominican Republic. The easternmost range (the Sierra de Baoruco) has a maximum elevation of over 2300 m and lies entirely within the Dominican Republic. The Barahona Peninsula south of the mountains is effectively divided by the Loma Gran Sabana, a limestone ridge with a maximum elevation of about 1100 m and vegetated by dry forest, into an extremely xeric western region and a somewhat less xeric eastern plain. Islas Beata and Alto Velo lie off the southern tip of the peninsula.

The larger (67 700 km^2) and much more complex North Island is dominated by the Cordillera Central, the highest peak of which (Pico Duarte at $>$ 3000 m) is also the highest point in the entire West Indies. Another major range essentially parallels the southern "shore" of the North Island; the portion in the Dominican Republic is the Sierra de Neiba, with a maximum elevation of nearly 2300 m. Paralleling the northern coast is the Cordillera Septentrional, the highest elevation of which is Pico Diego de Campo (1250 m). Smaller, somewhat isolated ranges to the east include the Sierra de Samaná (highest point $\sim$600 m) on the Samaná Peninsula and the Sierra de Yamasá ($>$850 m), essentially an eastern isolate of the Cordillera Central that blends into the Cordillera Oriental, which lies south of Samaná Bay and extends into the karst landscape of the Los Haitises region. The Sierra Martín García ($>$1300 m) is an eastern isolate of the Sierra de Neiba and forms a relatively

mesic enclave surrounded by desert. Important lowlands of the North Island include the Valle de San Juan between the Cordillera Central and the Sierra de Neiba, the fertile Valle de Cibao north of the Cordillera Central, the northern coastal plain north of the Cordillera Septentrional, the arid Llanos de Azua in the rainshadow of the Cordillera Central, and the moderately mesic Llanura del Este. The Cayos Siete Hermanos is an archipelago of small cays off the northwestern Dominican coast, Isla Saona and the tiny Isla Catalinita lie off the southeastern tip of the island, and Isla Catalina is situated off the southern coast a few kilometers to the west.

Vegetation

Vegetative communities are as diverse as the topography. Hedges (1999) provided an overview (paraphrased herein). Characterization of forest types follows SEA/DVS (1990), Hager and Zanoni (1993) and Hedges (1999). Prevailing northeasterly winds carry moisture that typically precipitates on northern and eastern regions, whereas southern areas are usually dry. Vegetation patterns correspond closely to precipitation. Moist forests occur on northern and eastern slopes and dry xerophytic vegetation is found in southern regions and in rainshadows. Pre-Columbian Hispaniola was largely forested (Hedges, 1999). Lowland forests with high canopies graded into montane rainforests on lower slopes. Cloud forests develop at elevations over 1000 m, and pine forests and elfin woodlands occur at even higher elevations (to 2400 m). Pine forests are relatively dry, whereas elfin woodlands are characterized by windblown tangles of moss-covered trees and shrubs. Karst regions were covered by wet limestone forests with thin soils and relatively low canopies (to 25 m). Dry scrub forests, mostly in coastal areas, have low canopies ($\sim$10 m), thorny shrubs, and many cacti.

Essentially all of the lowland forests have been destroyed and were the first to disappear after colonization (Powell and Henderson, 1996a, 1996b; Hedges, 2006). Most other forests are disappearing rapidly, but may still be found in increasingly smaller fragments throughout the island. Wet limestone and dry scrub forests are being destroyed less rapidly than those of other types, mainly because of the difficulty of access and effective exploitation. Even so, many such areas, such as those in the vicinity of Monte Cristi in the northwestern part of the country, have been sufficiently altered, primarily by charcoal burners, that the resulting secondary growth constitutes an impenetrable tangle of cacti and thorny scrub. Montane rainforest remain mainly on steep slopes but, even in areas that appear superficially natural, invasions by cultivated species are rampant (e.g., Lenart et al., 1997). The only remaining extensive upland forests are in the Cordillera Central, but smaller patches persist in other areas. However, “no ‘pristine’ forests [exist anywhere] in the West Indies” (Hedges, 2006).

The Herpetofauna

The herpetofauna (table 1) of the Dominican Republic consists of 39 frogs (two of which are introduced), 110 squamates (one possibly extinct and three or four introduced), one crocodilian, three turtles (one introduced), plus four species of sea turtles. The critically endangered and potentially extinct squamate is *Alsophis melanichnus*, which may never have been common and has probably become the victim of introduced mongooses (*Herpestes javanicus*).

Endemism of terrestrial species is high (Powell et al., 1999; Hedges, 2007). All but one native frog (97%) are Hispaniolan endemics. The exception is *Leptodactylus albilabris*, which also occurs on Puerto Rico (the Dominican population had been considered distinct at the species level until recently; Hedges and Heinicke, 2007). Of 110 currently recognized squamate species recorded from the Dominican Republic, 101 or 102 (92 or 93%, depending on whether nor not *Typhlops sulcatus* occurs on Navassa Island; Powell, 1999; Powell et al., 1999) are Hispaniolan endemics and four others (*Anolis distichus*, *Mabuya sloanii*, *Sphaerodactylus elegans*, *Epicrates striatus*) are West Indian endemics. The one crocodilian (*Crocodylus acutus*) is endemic to the Western Hemisphere. One of the two native pond turtles (*Trachemys decorata*) is a Hispaniolan endemic and the other (*T. stejnegeri*) is endemic to the West Indies.

Of the introduced species, *Bufo marinus* has become widely distributed, invading even very xeric areas that provide breeding sites only intermittently. *Rana catesbeiana* is widely established in both natural and artificial freshwater systems. Two introduced lizards, *Anolis cristatellus* from Puerto Rico (Fitch et al., 1989) and *A. porcatus* from Cuba (Powell et al., 1990), are largely restricted to dramatically altered urban habitats in La Romana and Santo Domingo, respectively. Two other lizards are human commensal "house geckos." *Hemidactylus angulatus* (formerly *H. haitianus*; Weiss and Hedges, 2007), which also occurs on Cuba and Puerto Rico, is a west African species that may have arrived in the western Hemisphere as an unintended consequence of the colonial-era slave trade. The other, possibly introduced, is *H. mabouia*, which is widely distributed throughout the Neotropics (Powell et al., 1998) and may have arrived on Hispaniola by natural means, but probably was introduced with inadvertent human assistance. The introduced turtle is *Trachemys scripta elegans*, native to the eastern United States. All but the lizards were presumably imported intentionally, *B. marinus* for insect control in sugar cane fields, *R. catesbeiana* for food, and *T. scripta* via the pet trade. All probably exert a negative influence on native species, although that of the anoles is restricted to highly localized displacement of endemic ecological counterparts in urban areas. *Bufo marinus* competes with endemic toads in all but the harshest (most xeric) environments and has undoubtedly contributed to their declines. *Rana catesbeiana* probably preys on hylids and *Leptodactylus* and their tadpoles and even on *Eleutherodactylus* that venture too close to water inhabited by these voracious predators that eat anything that will fit in their mouths. *Trachemys scripta* competes and hybridizes with native turtles (Powell et al., 2000), possibly diluting unique gene pools.

Table 1. Currently recognized amphibians and reptiles known to occur in the Dominican Republic (adapted from Hedges, 2008). Only those species that have a formally recognized conservation status are listed: CITES appendices are indicated by "I" or "II," and IUCN Redlist status (IUCN, 2008) by CR (critically endangered), EN (endangered), VU (vulnerable), NT (near-threatened) and LR (lower risk).

Species	Status
AMPHIBIA, ANURA (frogs and toads)	
Family Bufonidae (true toads; one genus, four species, one introduced)	
Bufo fluviaticus	CR
Bufo fractus	EN
Bufo guentheri	VU
Family Hylidae (treefrogs; two genera, four species)	
Hypsiboas heilprini	VU
Osteopilus pulchrilineata	EN
Osteopilus vastus	EN
Family Leptodactylidae (Neotropical frogs; two genera, 30 species)	
Eleutherodactylus alcoae	EN
Eleutherodactylus armstrongi	EN
Eleutherodactylus audanti	VU
Eleutherodactylus auriculatoides	EN
Eleutherodactylus flavescens	NT
Eleutherodactylus fowleri	CR
Eleutherodactylus furcyensis	CR
Eleutherodactylus haitianus	EN
Eleutherodactylus heminota	EN
Eleutherodactylus hypostenor	EN
Eleutherodactylus jugans	CR
Eleutherodactylus leoncei	CR
Eleutherodactylus minutus	EN
Eleutherodactylus montanus	EN
Eleutherodactylus nortoni	CR
Eleutherodactylus oxyrhynchus	CR
Eleutherodactylus parabates	CR
Eleutherodactylus patriciae	EN
Eleutherodactylus pictissimus	VU
Eleutherodactylus pituinus	EN
Eleutherodactylus probolaeus	EN
Eleutherodactylus rufifemoralis	CR
Eleutherodactylus ruthae	EN
Eleutherodactylus schmidti	CR
Eleutherodactylus wetmorei	VU
Leptodactylus albilabris	LC*
Family Ranidae (true frogs, one genus, one species, introduced)	
REPTILIA, CROCODYLIA (crocodilians)	
Family Crocodylidae (crocodiles, one genus, one species)	
Crocodylus acutus	I, VU

Table 1. (Continued).

Species	Status
REPTILIA, SQUAMATA (scaled reptiles)	
Family Amphisbaenidae (amphisbaenians; one genus, three species)	
Family Anguidae (galliwasps; one genus, ten species)	
Celestus anelpistus	CR
Celestus warreni	CR
Family Boidae (boas; one genus, three species)	
Epicrates fordii	II
Epicrates gracilis	II
Epicrates striatus	II
Family Colubridae (common snakes, six genera, 10 species)	
Family Gekkonidae (geckos, four genera, 28 species, one or two introduced)	
Family Iguanidae (iguanas; one genus, two species)	
Cyclura cornuta	I, VU
Cyclura ricordii	I, CR
Family Leiocephalidae (curlytails; one genus, six species)	
Family Leptotyphlopidae (thread snakes; one genus, three species)	
Family Polychrotidae (anoles; one genus, 31 species, two introduced)	
Family Scincidae (skinks; one genus, two species, one possibly introduced)	
Family Teiidae (ground lizards/whiptails; one genus, three species)	
Family Tropidophiidae (ground boas; one genus, one species)	
Tropidophis haetianus	II
Family Typhlopidae (blind snakes; one genus, eight species)	
REPTILIA, TESTUDINES (turtles)	
Family Cheloniidae (sea turtles, three genera, three species)	
Caretta caretta	I, EN
Chelonia mydas	I, EN
Eretmochelys imbricata	I, CR
Family Dermochelidae (leatherback sea turtles, one genus, one species)	
Dermochelys coriacea	I, CR
Family Emydidae (pond turtles, one genus, three species, one introduced)	
Trachemys decorata	VU
Trachemys stejnegeri	LR

* Hedges and Heinicke (2007) placed the Hispaniolan ditch frog (*Leptodactylus dominicensis*) into the synonymy of *L. albilabris*. The Hispaniolan population had been designated in the IUCN Red List as EN (Hedges et al., 2004).

Conservation Status

Insular populations of terrestrial animals often suffer as a consequence of alterations to their habitats by humans (e.g., Wilson et al., 2006 and references therein). Habitat specialists and endemic species that have evolved in the absence of efficient mainland predators and competitors are particularly vulnerable (e.g., Powell and Henderson, 2005 and references therein). Although a few species (sea turtles; e.g., Dutton et al., 2005) and even some genera (e.g., West Indian rock iguanas in the genus *Cyclura*; e.g., Alberts, 2000; Alberts et al., 2004) have been the focus of

intensive conservation efforts, populations of many more species are in various stages of decline, and some are in imminent danger of extinction, often with little recognition by the public or even professional conservation biologists (Hedges, 2006).

Schubert (1993) noted that data available at that time were inadequate for estimating accurately the number of species lost to human activities. Particularly vulnerable are species with population sizes already reduced dramatically, those that are especially sensitive to human disturbance, those that are naturally "rare" or have very restricted ranges, and those that are actively exploited for economic purposes (Powell et al., 2000). Sadly, we know so little about many other species that we simply cannot draw definitive conclusions about their status, and the lack of timely and accurate data may be the most critical element responsible for our inability to provide more than "educated guesses" regarding the status of many species. Consequently, the species listed in the following paragraphs are not intended to comprise a comprehensive list, but are merely our most recent estimates of those in immediate danger of extirpation or extinction.

Formal criteria exist for evaluating the conservation status of species in nature (IUCN, 2001). Application of these critera lead to categories of increasing risk of extinction: CR (critically endangered), EN (endangered), VU (vulnerable), NT (near-threatened) and LR (lower risk). Species for which no reasonable doubt exists that the last individual has died are designated EX (extinct) and those known to survive only in cultivation, captivity, or as naturalized populations outside the historical range of the species are EW (extinct in the wild). Species that have not been evaluated against the criteria are annotated NE (not evaluated) and those for which evaluations have been attempted but for which inadequate information is available are designated DD (data deficient). Evaluations must be based on credible data and include consideration of abundance, areas of occupancy or suitable habitat, actual or potential levels of exploitation, and effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.

An intense effort to assess the conservation status of amphibians worldwide (IUCN et al., 2006; Hedges, 2006) resulted in many species that had previously received little or no attention (e.g., Powell et al., 2000) afforded at least an acknowledgement of their precarious state through inclusion on the IUCN Red List (IUCN, 2008), which assesses specific threats to the ongoing existence of species. Although a comparable effort is being initiated for reptiles (S.B. Hedges, pers. comm.), an obvious inequity currently exists, and we anticipate that many reptilian species will receive a formal acknowledgement of their precarious conservation status once attention is focused on the issue. At this time, when considering only the amphibians and reptiles of the Dominican Republic, 32 of 37 (86%) native species of amphibians known to occur in the country are red-listed (table 1). In stark contrast, only 15 of 108 (14%) native reptilian species are included in the IUCN list (and four of the listed species are sea turtles that are endangered throughout the region and the world).

Among species that are excluded is one snake that may already be extinct (*Alsophis melanichnus*) and several others that are known to be very rare (*A. anomalus* and two species in the genus *Ialtris*). All are diurnally active and terrestrial. The principal threat is undoubtedly predation by introduced mongooses (*Herpestes javanicus*; Henderson and Sajdak, 1986; Powell and Henderson, 2005). Although red-listing may come too late for some of these snakes (Powell, 2005), we hope that efforts to assess the conservation status of the world's reptiles succeeds in shedding light on the plight of species for which hope may still exist.

A large percentage of Dominican amphibians are habitat specialists that rely on relatively undisturbed forests and often have very small distributions. Almost all of the species afforded formal protective status (table 1) fall into the first category (IUCN et al., 2006; IUCN, 2008), but even those associated with lowland areas have small ranges (e.g., *Bufo fractus*) or ranges that are becoming increasingly confined by development for social infrastructure, tourism, or agriculture (e.g., *B. guentheri*). The high percentage of native frogs now known to be threatened with extinction stands in stark contrast to previous lists of endangered Dominican species that listed no amphibians (Aquino, 1983) or only a single species (*Osteopilus vastus*: IUCN, 1996; *Bufo fluviaticus*: Powell et al., 2000).

Reptiles frequently are the most abundant and obvious naturally occurring vertebrates in the Dominican Republic (Henderson and Powell, 1999, 2001), but overviews of conservation needs have been rare. Although many species are ecological generalists (Henderson and Powell, 1999; Powell and Henderson, 2006) and some thrive in altered habitats, populations of many others are declining at alarming rates.

Addressing these concerns for native Dominican reptiles, all sea turtles are listed in CITES Appendix I. *Chelonia mydas* and *Caretta caretta* are red-listed as endangered, whereas *Eretmochelys imbricata* and *Dermochelys coriacea* are critically endangered. In addition, sea turtles are protected by national and local legislation. Although all turtles are affected by habitat alteration, the sea turtles especially by the development of nesting beaches, the principal threats are due to ongoing exploitation of eggs and adults by humans for food (e.g., Stam and Stam, 1992; Fleming, 2001).

Two species of rock iguanas (*Cyclura ricordii* and *C. cornuta*), two species of pond turtles (*Trachemys decorata* and *T. stejnegeri vicina*), and the one crocodilian (*Crocodylus acutus*) have been recognized as threatened or endangered for some time (Aquino, 1983; IUCN, 1996; Powell et al., 2000) and additional, recently published information regarding their status is readily available (*Cyclura ricordii*: Ottenwalder, 2000b; ZOODOM et al., 2002; Bendon and Binns, 2003; Arias et al., 2004; Ramer, 2004a, 2004b: Ramer and Hudson, 2005; Rupp et al., 2005, 2007; *C. cornuta*: Ottenwalder, 2000a; Ottenwalder and Powell, 2002; *Trachemys decorata*: Ottenwalder, 1994a, 1994b; Seidel, 1996; *T. stejnegeri vicina*: Seidel, 1996; *Crocodylus acutus*: SEA/DVS, 1993; Schubert and Santana, 1996).

Three species of boids (*Epicrates fordii*, *E. gracilis*, *E. striatus*) and one tropidophiid (*Tropidophis haetianus*) are afforded some protection by inclusion of the

entire families in CITES Appendix II. These snakes remain abundant in some areas, and the CITES listing reflects presumed threats emanating from international trade for the pet industry, which currently are not applicable to these species. Also, spurred in part by recent re-evaluations of taxonomic status (Hallermann and Böhme, 2002; Powell and Henderson, 2003), the conservation status of the giant galliwasps (*Celestus anelpistus*, *C. warreni*) has been updated (Powell et al., 2000; Powell and Henderson, 2003; IUCN, 2008).

Powell et al. (2000) also addressed the status of four diurnally active terrestrial snakes (*Alsophis anomalus*, *A. melanichnus*, *Ialtris agyrtes*, *I. dorsalis*) that appear to be particularly vulnerable to predation by introduced mongooses and a single species of dwarf gecko (*Sphaerodactylus cochranae*) that apparently has been rare for some time and suffers currently from habitat alteration and destruction. The possible extinction of *A. melanichnus* was mentioned by Schwartz and Henderson (1991) and the status of *S. cochranae* was addressed in Glor (1999) and Glor et al. (2001).

Additional reptilian species (Powell et al., 2000) may be locally abundant, but with very restricted ranges that render them exceedingly vulnerable to stochastic events. Others exhibit highly specialized habitat requirements, often tied to intact forests that are disappearing rapidly. Still others have fragmented ranges, portions of which are sparsely populated. At least some of these taxa undoubtedly meet IUCN Red List criteria (IUCN, 2001).

Species in the first category (at times locally abundant, but with restricted ranges) include *Anolis altavelensis*, *A. sheplani*, *A. strahmi*, *Celestus marcanoi*, *Leiocephalus altavelensis*, *Sphaerodactylus ladae*, *S. ocoae*, *S. perissodactylius*, *S. samanensis*, *Leptotyphlops asbolepis* and *L. calypso*. Those with specialized habitat requirements tied to mature or structurally intact forests include *Anolis bahorucoensis*, *A. barbouri*, giant anoles (*A. baleatus*, *A. barahonae*, *A. ricordii*), and *Darlingtonia haetianus*. Species with fragmented ranges in at least portions of which population densities are presumably very low include *Anolis whitemani*, *Mabuya lineolata*, *Phyllodactylus hispaniolae*, and *Leptotyphlops pyrites*. The problem with determining whether or not these species are of concern is that current data regarding abundance and extent of populational distributions are largely lacking, in some instances the situation is aggravated by the small size and secretive habitats of some forms (e.g., some geckos in the genus *Sphaerodactylus* and the threadsnakes in the genus *Leptotyphlops*). The intent of including them here is merely to draw attention to conditions that might warrant some acknowledgment of their status or even some form of formal protection.

Complicating matters further is the possibility that some populations currently considered to be subspecies (Powell, 1993; Williams, 1999) or others not even recognized at the subspecific level may represent unique gene pools within widely distributed species complexes. Whether these populations warrant recognition as distinct taxa depends largely on the definition of species being applied (see discussion in Powell and Henderson, 2003 and references cited therein). Neverthe-

less, without efforts to survey and analyze especially the isolated populations, they may disappear without any awareness of their unique qualities. Examples include *Sphaerodactylus darlingtoni noblei* and a subspecifically unassigned population of *S. savagei* in San Cristóbal Province.

Also, ground-dwelling, diurnally active lizards in the genera *Ameiva* and *Leiocephalus* are vulnerable to predation by mongooses (e.g., Powell and Henderson, 2005). Although Dominican species in both genera are locally abundant and widespread, isolated populations in areas with relatively little human activity (which presumably reduces mongoose activity) may be vulnerable to extirpation (or extinction, if any such populations warrant recognition as full species; e.g., Gifford, 2005). Examples include an unnamed population of *A. lineolata* in the extreme eastern Dominican Republic (M.E. Gifford, pers. comm.) or *A. taeniura meyerabichi* and other isolated populations of *A. taeniura* that are unassigned to any subspecies in montane areas or the dry lowlands south of Baní.

Threats

Like many other island nations in the Caribbean Basin (Harcourt et al., 1996), the Dominican Republic faces multiple threats to biodiversity posed by a growing population, with attendant urban sprawl and the need for increased agricultural productivity, and economic development, much of which is related to the growing tourist industry. The human population of the nation stood at 7.8 million in mid-1994 (Harcourt and Ottenwalder, 1996), and population density increased from 48/km^2 in 1950 to a projected 177/km^2 in 2000 and 203/km^2 in 2010 (MacDonald, 1992). Although annual growth rates appear to be slowing from an estimated 2.2% in mid-1994 and 1.9% from 1990-2000 to a projected 1.4% from 2000-2010, the pressure on land use and productivity continues to rise, as do opportunities for additional introductions of exotic species and exploitation of amphibians and reptiles for food or as pets (e.g., Henderson, 1992; Lever, 2003; Powell, 2003). Another substantive threat potentially of greater and more immediate impact on the conservation of amphibians and reptiles results from the increasingly frequent confrontations between tourism or mining development and protected areas. The prevailing model of rampant and unsustainable development, which relies heavily on foreign investment, has encroached already on areas currently within the protected areas system.

Conservation Action

No specific legislation addresses the conservation of amphibians and reptiles. However, at present, two laws offer some protection to the herpetofauna, as well as other components of the nation's flora and fauna. The General Law on Environment and Natural Resources (Law 64-00) was promulgated after reviews of the legal

and institutional framework for the environmental sector. One consequence was the creation of the Ministry of Environment and Natural Resources (SEMARN, 2000; SEMARN, 2007). Although no specific references are made to the herpetofauna, Chapter IV, under Title IV (Natural Resources) refers to the protection of species of both flora and fauna and the ecosystems where they live. Also, Title II, Chapter III refers to the National System of Protected Areas, which encompasses at least portions of the ranges of many amphibians and reptiles, and, in particular, a large percentage of those facing some degree of endangerment. The General Law on Protected Areas (Law 202-04) addresses and reviews the consideration of areas protected under Law 64-00.

The National System of Protected Areas (Hoppe, 1989; Valdez Sierra and Mateo Féliz, 1992; Moya Pons et al., 2004; fig. 2) in 1994 had a ratio of protected area to total surface area of 0.178, which increased in 1995 to 0.311, and in

Figure 2. The Sistema Nacional de Áreas Protegidas (National System of Protected Areas; adapted from Moya Pons, 2004; provided by the Secretaría de Estado de Medio Ambiente y Recursos Naturales). Shaded areas represent scientific reserves (including two marine mammal sanctuaries), national parks (including two submarine parks), natural monuments, wildlife refuges, forestry refuges, panoramic roadways and national recreation areas. Unfortunately, the protected status of many of these areas exists only on paper, enforcing the status of others is lax to nonexistent, and the long-term status of all relies on the often inconsistent support of a legislature with close ties to developers.

2000 to 0.326, the 16th highest ratio of any nation (the ratio of protected area to surface area refers to totally or partially protected areas of at least 1000 ha that are designated as national parks, natural monuments, nature reserves, or wildlife sanctuaries, protected landscapes and seascapes, or scientific reserves with limited public access; the data do not include sites protected under local or provincial law; based on the UN Common Database calculated from UNEP-WCMC; Globalis, 2007). The system currently includes eight scientific reserves (including two marine mammal sanctuaries), 19 national parks (including two submarine parks), 17 natural monuments, 15 wildlife refuges, 15 forestry refuges, nine panoramic roadways, and three national recreation areas (SEMARN, 2007). Of the amphibian species that have a formally recognized conservation status (table 1; 32 species), the ranges of only five (16%) are not included in the national system of protected areas, probably the best protection possible for *in situ* conservation. Of all the reptilian species listed, the ranges of only two, the galliwasps (*Celestus anelpistus*, *C. warreni*) are not in protected areas.

The Dominican Republic is party to multilateral environmental agreements that include CITES (www.cites.org), the Convention on Biodiversity (www.biodiv.org/convention/convention.shtml), and the Cartagena Convention with the SPAW (Specially Protected Areas and Wildlife in the Wider Caribbean Region; www.cep.unep.org/pubs/legislation/spaw.html) Protocol. Within the resultant legal framework, all species of amphibians and reptiles are legally protected.

At present, the Secretaría de Estado de Medio Ambiente y Recursos Naturales (SEMARN) is working with international partners to develop a biodiversity law, which will add legal protection at the species level. At the national zoo (ZOODOM), a breeding program of critically endangered *Cyclura ricordii* has been implemented with support from IUCN's Iguana Specialist Group as part of the species' recovery plan (Ramer and Hudson, 2005).

Although a number of Dominican NGOs promote environmental conservation, at present, only Grupo Jaragua (www.grupojaragua.org.do) is focusing on the conservation of amphibians and reptiles (Ramer, 2005; Rupp et al., 2005). National and local outreach activities reach thousands of primary and secondary school students and teachers. Synergistic collaborations exist with the Dominican Ministry of Education, one of the main national newspapers, elements in the private sector, and domestic and international NGOs, testament to which is the ongoing research on *Cyclura ricordii* in the southwestern Dominican Republic (e.g., Arias et al., 2004; Rupp et al., 2005, 2007). This research has been complemented by environmental education initiatives and creation of local governmental protected areas. In addition to ZOODOM, these initiatives are supported by the IUCN Iguana Specialist Group, MacArthur Foundation, Spanish Cooperation Agency, and the Indianapolis Zoo. Concurrent research and educational activities address the conservation of sympatric *C. cornuta*. Also, in collaboration with the Secretaría de Estado de Agricultura/Departamento de Vida Silvestre (SEA/DVS) and ZOODOM, Grupo

Jaragua has actively promoted conservation of *Crocodylus acutus*, although that program is not currently active.

Working on baseline data (Ottenwalder, 1982; Ross and Ottenwalder, 1983), since 1996, with staff (C.E. Diez and R. van Dam) from Proyecto Carey in Puerto Rico (Isla Mona) and the Dominican Republic (http://members.seaturtle.org/proyectocarey/index/htm) and additional support from international agencies, Y.A. León of Grupo Jaragua has conducted population studies of marine turtles, with an emphasis on *Eretmochelys imbricata* (e.g., León and Diez, 1999; León and Bjorndal, 2002; Diez et al., 2003). Integration of local fishermen and, in particular, the youth of local fishing communities is critical to the success of this effort. Nearly 900 turtles have been captured, tagged, and released in Jaragua National Park. The long-term studies have been supplemented since 2006 by nesting surveys and assessments of incidental take by fishermen. Since 2005, foraging ground surveys have been conducted in Monte Cristi and del Este national parks. An educational campaign focusing on the illegality of the "tortoiseshell" trade was initiated in 2007.

The Future

The best and most feasible approach for the conservation of Dominican amphibians and reptiles is the inclusion of at least some of threatened species' critical habitats and ranges within the protected areas system. Thus, conservation of most amphibians and reptiles in the country depends on the existence and enforcement of a well-established and managed protected areas system. However, Hedges (2006) cautioned that "*the existence of protected areas should effectively be ignored in assessing the conservation status of native species, unless there is unambiguous evidence that such a designated area is truly affording protection*" (italics in original).

The Dominican system of protected areas, although in general having good coverage of main ecosystems, habitats, and species composition, still needs to be revised in order to include the endangered species of amphibians and reptiles with ranges not currently encompassed in protected areas. In particular, special attention should be given to the endemic toads (*Bufo fluviaticus* and *B. fractus*) and the giant galliwasps (*Celestus warreni* and *C. anelpistus*). Other species, although with ranges included at least in part within protected areas, should be addressed by specific conservation programs. These include the freshwater turtles (*Trachemys decorata* and *T. stejnegeri*). The main threats to toads and galliwasps is habitat destruction, and to freshwater turtles, habitat destruction, overfishing, and more recently, hybridization with invasive *T. scripta* (Powell et al., 2000). A well-established breeding population of the latter is now known to exist in the National Botanical Garden in Santo Domingo. Another group of special concern includes the diurnally active terrestrial snakes (*Alsophis* spp. and *Ialtris* spp.). Although inoffensive, snakes are routinely killed by local people who fear them. Special educational efforts should be implemented to address this issue. Regarding marine turtles, greater efforts should be given to abiding by CITES regulations,

including steps to eliminate the sale of marine products at airports and other tourist destinations.

In brief, for amphibians and reptiles to be adequately conserved in the Dominican Republic, we recommend the following: (1) The national system of protected areas should be expanded, revised to include ranges of species presently not included, and integrated into current and future plans for local and national development. Assuming adequate levels of enforcement, the conservation needs of a majority of species of special concern would be addressed most effectively in this fashion. (2) A nationwide educational program on amphibians and reptilian conservation must be implemented. This year, for the first time, a private-sector company provided a 2007 calendar with photographs and educational information about amphibians and reptiles. The same company also produced a short video, constituting an excellent resource for environmental education. (3) Support for research must be obtained and used to learn more about the status of endangered species about which we know little (e.g., *Eleutherodactylus* spp., *Celestus* spp.). (4) At present, the endangered species receiving too little attention is *Crocodylus acutus*. The Dominican population is almost exclusively restricted to Lago Enriquillo. Because of the species' size, potential commercial value, and a reproductive strategy that depends on a peculiar set of local environmental conditions, the threat of adverse effects on the remaining population is great. A program should be reestablished to monitor this species.

Summary

Like many other insular nations (and islands throughout the world), the Dominican Republic supports a herpetofauna with a large proportion of endemic species. Portions remain relatively intact; however, the herpetofaunal communities in many areas have suffered immensely from habitat destruction or alteration, much associated with the growing human population and the burgeoning tourist industry, from the introduction of invasive species that compete with or prey on native amphibians and reptiles, from exploitation of some species for economic gain or food, and persecution of others resulting from fear or disgust.

Conservation priorities in less damaged regions should focus on preserving relatively natural areas through protection, education, limitations on development, and control of invasive species (those that have already been introduced and those that might be), preferably by inclusion in the national system of protected areas. Priorities in extensively altered areas, already overrun with exotics, must seek to minimize the damage already inflicted and prevent further degradation.

Standing in the way of implementing these recommendations are under-funded conservation organizations that rely on the work of too few people, a largely apathetic resident population often resistant to educational programs, lax enforcement of existing legislative measures, and governmental entities with firm commitments to development — a litany of hurdles faced by essentially every conservation organization (governmental, not-for-profit, or private) throughout the region.

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References

Alberts, A., Ed. (2000): West Indian Iguanas. Status Survey and Conservation Action Plan. Gland, Switzerland and Cambridge, United Kingdom, IUCN.

Alberts, A.C., Carter, R.L., Hayes, W.K., Martins, E.P., Eds (2004): Iguanas: Biology and Conservation. Berkeley, University of California Press.

Aquino, A.T. (1983): Anfibios y reptiles de la Hispaniola en peligro de extinción. Conf. Rev. Cien. Divul., Mus. Nac. Hist. Nat. **1**: 26-30.

Arias, Y., Incháustegui, S., Rupp, E. (2004): *Cyclura ricordii* on the Barahona Peninsula: A preliminary report. Iguana **11**: 8-13.

Bendon, J., Binns, J. (2003): 2002 Iguana Specialist Group conference. Iguana **10**: 3-9.

Burns, J.K., Cunningham, C.A., Dupuis, R.A., Trask, M.N., Tulloch, J.S., Powell, R., Parmerlee, J.S., Jr., Kopecky, K.L., Jolley, M.L. (1992): Lizards of the Cayos Siete Hermanos, Dominican Republic, Hispaniola. Bull. Chicago Herpetol. Soc. **27**: 225-232.

Diez, C.E., Vélez-Zuazo, X., van Dam, R.P. (2003): Hawksbill turtles in seagrass beds. Marine Turtle Newsl. **102**: 8-10.

Dutton, D.L., Dutton, P.H., Chaloupka, M., Boulon, R.H. (2005): Increase of a Caribbean leatherback turtle *Dermochelys coriacea* nesting population linked to long-term nest protection. Biol. Cons. **126**: 186-194.

Fitch, H.S., Henderson, R.W., Guarisco, H. (1989): Aspects of the ecology of an introduced anole: *Anolis cristatellus* in the Dominican Republic. Amphibia-Reptilia **10**: 307-320.

Fleming, E.H. (2001): Swimming Against the Tide: Recent Surveys of Exploitation, Trade, and Management of Marine Turtles in the Northern Caribbean. Washington, DC, TRAFFIC North America.

Gifford, M.E. (2005): Ecotones and hybrid zones: Implications for conservation illustrated by ground-dwelling lizards from Hispaniola. Iguana **12**: 234-239.

Globalis (2007): Globalis — Dominican Republic (http://globalis.gvu.unu.edu/indicator_detail.cfm?IndicatorID=80&Country=DO).

Glor, R.E. (1999): Biodiversity assessment for different land uses: Rare dwarf gecko rediscovered. In: CIFAD (Cornell International Institute for Food, Agriculture and Development) Annual Report 1997-98, p. 14-15. Ithaca, New York, Cornell Univ.

Glor, R.E., Flecker, A.S., Benard, M.F., Power, A.G. (2001): Lizard diversity and agricultural disturbance in a Caribbean forest landscape. Biodiversity and Conservation **10**: 711-723.

Hager, J., Zanoni, T.A. (1993): La vegetación natural de la República Dominicana: Una nueva clasificación. Moscosoa **7**: 39-81.

Hallermann, J., Böhme, W. (2002): On giant anguids from the West Indies, with special reference to *Celestus warreni* (Schwartz, 1970) and its relatives from Hispaniola (Reptilia: Squamata: Anguidae). Mitt. Hamb. Zool. Mus. Inst. **99**: 169-178.

Harcourt, C., Billington, C., Sayer, J. (1996): Introduction. In: The Conservation Atlas of Tropical Forests, The Americas, p. 9-16. Harcourt, C.S., Sayer, J.A., Eds, Gland, Switzerland, IUCN.

Harcourt, C., Ottenwalder, J.A. (1996): Hispaniola. In: The Conservation Atlas of Tropical Forests, The Americas, p. 102-111. Harcourt, C.S., Sayer, J.A., Eds, Gland, Switzerland, IUCN.

Hedges, S.B. (1999): Distribution patterns of amphibians in the West Indies. In: Patterns of Distribution of Amphibians: A Global Perspective, p. 211-254. Duellman, W.E., Ed., Baltimore, MD, Johns Hopkins Univ. Press.

Hedges, S.B. (2008): Caribherp: West Indian amphibians and reptiles. Island lists: Hispaniola (http://evo.bio.psu.edu/caribherp/lists/hsp-list.htm).

Hedges, S.B. (2006): An overview of the evolution and conservation of West Indian amphibians and reptiles. Appl. Herpetol. **3**: 281-292.

Hedges, S.B. (2008): Caribherp: West Indian amphibians and reptiles. Island lists: Hispaniola (http://evo.bio.psu.edu/caribherp/lists/hsp-list.htm).

Hedges, S.B., Heinicke, M.P. (2007): Molecular phylogeny and biogeography of West Indian frogs of the genus *Leptodactylus* (Anura, Leptodactylidae). Mol. Phylogen. Evol. **44**: 308-314.

Hedges, S.B., Incháustegui, S., Thomas, R., Powell, R. (2004): *Leptodactylus dominicensis*. In: IUCN 2006. 2006 IUCN Red List of Threatened Species (www.iucnredlist.org).

Henderson, R.W. (1992): Consequences of predator introductions and habitat destruction on amphibians and reptiles in the post-Columbus West Indies. Carib. J. Sci. **28**: 1-10.

Henderson, R.W., Powell, R. (1999): West Indian herpetoecology. In: Caribbean Amphibians and Reptiles, p. 223-268. Crother, B.I., Ed., San Diego, CA, Academic Press.

Henderson, R.W., Powell, R. (2001): Responses by the West Indian herpetofauna to human-influenced resources. Carib. J. Sci. **37**: 41-54.

Henderson, R.W., Sajdak, R.A. (1986): West Indian racers: A disappearing act or a second chance? Lore **36**: 13-18.

Hoppe, J. (1989): Los Parques Nacionales de la República Dominicana. The National Parks of the Dominican Republic. Santo Domingo, República Dominicana, privately published.

Huebeck, C., Mann, P. (1991): Structural geology and Cenozoic tectonic history of the southeastern termination of the Cordillera Central, Dominican Republic. Geol. Soc. Amer. Spec. Pap. **262**: 315-336.

IUCN (International Union for the Conservation of Nature and Natural Resources). (1996): 1996 IUCN Red List of Threatened Animals. Gland, Switzerland, IUCN.

IUCN (International Union for Conservation of Nature and Natural Resources). (2001): 2001 Categories and Criteria (version 3.1) (www.redlist.org/info/categories_criteria2001).

IUCN (International Union for the Conservation of Nature and Natural Resources). (2008): 2008 IUCN Red List of Threatened Species (http://www.iucnredlist.org).

IUCN (International Union for the Conservation of Nature and Natural Resources), Conservation International, and NatureServe. (2006): Global Amphibian Assessment (http://www.globalamphibians.org).

Khudoley, K.M., Meyerhoff, A.A. (1971): Paleogeography and geological history of the Greater Antilles. Geol. Soc. Amer. Memoirs **129**: 1-199.

Lenart, L.A., Powell, R., Parmerlee, J.S., Jr., Lathrop, A., Smith, D.D. (1997): Anoline diversity in three differentially altered habitats in the Sierra de Baoruco, República Dominicana, Hispaniola. Biotropica **29**: 117-123.

León, Y.M., Diez, C.E. (1999): Population structure of hawksbill turtles on a foraging ground in the Dominican Republic. Chelon. Conserv. Biol. **3**: 230-236.

León, Y.M., Bjorndal, K.A. (2002): Selective feeding in the hawksbill turtle, an important predator in coral reef ecosystems. Mar. Ecol. Progr. Ser. **245**: 249-258.

Lever, C. (2003): Naturalized Reptiles and Amphibians of the World. Oxford, Oxford Univ. Press.

Lewis, J.F., Draper, G. (1990): Geology and tectonic evolution of the northern Caribbean margin. In: The Geology of North America. Vol. H. The Caribbean Region, p. 77-140. Dengo, G., Case, J.E., Eds, Boulder, Colorado, Geological Society of America.

MacDonald, J.S. (1992): Contemporary size and distribution of population. In: The Cambridge Encyclopedia of Latin America and the Caribbean, 2nd edition, p. 151-157. Collier, S., Skidmore, T.E., Blakemore, H., Eds, New York, Cambridge Univ. Press.

Moya Pons, F., Ed. (2004): Atlas de los Recursos Naturales de la República Dominicana. Santo Domingo, República Dominicana, Secretaría de Estado de Medio Ambiente y Recursos Naturales.

Moya Pons, F., Reynoso, F., Sánchez, R. (2004): Programa Nacional de Valorización de Areas Protegidas. Santo Domingo, República Dominicana, Editora Buho, Secretaría de Estado de Medio Ambiente y Recursos Naturales.

Ottenwalder, J.A. (1981): Estudio preliminar sobre el status, distribución y biología reproductiva de las tortugas marinas en la República Dominicana. Santo Domingo, Departamento de Biología, Universidad Autónoma de Santo Domingo.

Ottenwalder, J.A. (1994a): Conservation program for the South Hispaniolan Slider Turtle (*Trachemys decorata*) in the Dominican Republic, 1994. Summary progress report prepared for the 1994 AZA/Chelonian Advisory Group Meeting. New Orleans: International Herpetological Symposium.

Ottenwalder, J.A. (1994b): Translocation and monitoring program for the South Hispaniolan Slider Turtle (*Trachemys decorata*). A proposal for field research submitted to the Columbus Zoo's AHSSC Committee.

Ottenwalder, J.A. (2000a): Taxonomic account: Rhinoceros iguana, *Cyclura cornuta cornuta*. In: West Indian Iguanas: Status Survey and Conservation Action, p. 22-27. Alberts, A., Ed., Gland, Switzerland and Cambridge, United Kingdom, IUCN.

Ottenwalder, J.A. (2000b): Taxonomic account: Ricord's iguana, *Cyclura ricordi*. In: West Indian Iguanas: Status Survey and Conservation Action, p. 51-55. Alberts, A., Ed., Gland, Switzerland and Cambridge, United Kingdom, IUCN.

Ottenwalder, J.A., Powell, R. (2002): Brief notes on the status of Hispaniolan Rhinoceros Iguanas, *Cyclura cornuta*. Iguana Times **9**: 78.

Powell, R. (1993): Comments on the taxonomic arrangement of some Hispaniolan amphibians and reptiles. Herpetol. Rev. **24**: 135-137.

Powell, R. (1999): Herpetology of Navassa Island, West Indies. Carib. J. Sci. **35**: 1-13.

Powell, R. (2003): Exploitation of reptiles in the West Indies: A long history. Iguana **10**: 67-70.

Powell, R. (2005): Editor's remarks. Iguana **12**: 283.

Powell, R., Crombie, R.I., Boos, H.E.A. (1998): *Hemidactylus mabouia*. Cat. Amer. Amphib. Rept. **674**: 1-11.

Powell, R., Henderson, R.W. (1996a): Introduction. In: Contribution to West Indian Herpetology: A Tribute to Albert Schwartz, p. 11-14. Powell, R., Henderson, R.W., Eds, Ithaca, New York, Society for the Study of Amphibians and Reptiles Contributions to Herpetology, vol. 12.

Powell, R., Henderson, R.W. (1996b): A brief history of West Indian herpetology. In: Contribution to West Indian Herpetology: A Tribute to Albert Schwartz, p. 29-50. Powell, R., Henderson, R.W., Eds, Ithaca, New York: Society for the Study of Amphibians and Reptiles Contributions to Herpetology, vol. 12.

Powell, R., Henderson, R.W. (2003): Taxonomic and conservation status of giant Hispaniolan *Celestus* (Reptilia, Anguidae). Carib. J. Sci. **39**: 237-240.

Powell, R., Henderson, R.W. (2005): Conservation status of Lesser Antillean reptiles. Iguana **12**: 62-77.

Powell, R., Henderson, R.W. (2008): Urban herpetology in the West Indies. In: Urban Herpetology. Herpetological Conservation, vol. 3. Jung, R.E., Mitchell, J.C., Eds, New Haven, Connecticut, Soc. Study Amphib. Rept.

Powell, R., Ottenwalder, J.A., Incháustegui, S.J. (1999): The Hispaniolan herpetofauna: Diversity, endemism, and historical perspectives, with comments on Navassa Island. In: Caribbean Amphibians and Reptiles, p. 93-168. Crother, B.I., Ed., San Diego, Academic Press.

Powell, R., Ottenwalder, J.A., Incháustegui, S.J., Henderson, R.W., Glor, R.E. (2000): Amphibians and reptiles of the Dominican Republic: Species of special concern. Oryx **34**: 118-128.

Powell, R., Smith, D.D., Parmerlee, J.S., Jr., Taylor, C.V., Jolley, M.L. (1990): Range expansion by an introduced anole: *Anolis porcatus* in the Dominican Republic. Amphibia-Reptilia **11**: 421-425.

Ramer, J. (2004a): Ricord's Iguanas, *Cyclura ricordii*: Isla Cabritos population census, 2003. Iguana **11**: 34-35.

Ramer, J. (2004b): A survey of Ricord's Iguanas (*Cyclura ricordii*) and Rhinoceros Iguanas (*Cyclura cornuta cornuta*) in Isla Cabritos National Park, Dominican Republic, 2003. Iguana **11**: 88-95.

Ramer, J. (2005): The faces of Grupo Jaragua. Iguana **12**: 252-255.

Ramer, J., Hudson, R. (2005): Ricord's Iguana (*Cyclura ricordii*): Species recovery plan update. Iguana **12**: 27.

Ross, J.P., Ottenwalder, J.A. (1983): The leatherback turtle, *Dermochelys coriacea*, nesting in the Dominican Republic. In: Advances in Herpetology and Evolutionary Biology, p. 706-713. Rhodin, A.G.J., Miyata, K., Eds. Cambridge, Massachusetts: Museum of Comparative Zoology.

Rupp, E., Incháustegui, S., Arias, Y. (2005): Conservation of *Cyclura ricordii* in the southwestern Dominican Republic and a brief history of the Grupo Jaragua. Iguana **12**: 222-233.

Rupp, E., Incháustegui, S., Arias, Y. (2007): Ricord's Iguana (*Cyclura ricordii*) on the southern shore of Lago Enriquillo, Dominican Republic. Iguana **14**: 2-7.

SEMARN (Secretaría de Estado de Medio Ambiente y Recursos Naturales). (2000): Ley General sobre Medio Ambiente y Recursos Naturales. Santo Domingo, República Dominicana: Publicación Oficial.

SEMARN (Secretaría de Estado de Medio Ambiente y Recursos Naturales). (2007): Sistema Nacional de Áreas Protegidas (www.medioambiente.gov.do/cms/index.php).

Schubert, A. (1993): Conservation of biological diversity in the Dominican Republic. Oryx **27**: 115-121.

Schubert, A., Santana, G. (1996): Conservation of the American Crocodile (*Crocodylus acutus*) in the Dominican Republic. In: Contribution to West Indian Herpetology: A Tribute to Albert Schwartz, p. 425-433. Powell, R., Henderson, R.W., Eds. Ithaca, New York: Society for the Study of Amphibians and Reptiles Contributions to Herpetology, vol. 12.

Schwartz, A. (1978): Some aspects of the herpetogeography of the West Indies. In: Zoogeography in the Caribbean, The 1975 Leidy Medal Symposium, p. 31-51. Gill, F.B., Ed., Philadelphia: Acad. Nat. Sci. Philadelphia. Spec. Publ.

Schwartz, A. (1980): The herpetogeography of Hispaniola, West Indies. Stud. Fauna Curaçao Other Carib. Isl. **61**: 86-127.

Schwartz, A., Henderson, R.W. (1991): Amphibians and Reptiles of the West Indies: Descriptions, Distributions, and Natural History. Gainesville, Univ. Florida Press.

SEA/DVS (Secretaría de Estado de Agricultura/Departamento de Vida Silvestre). (1990): La Diversidad Biológica en la República Dominicana: Reporte Preparado por el Departamento de Vida Silvestre para el Servicio Alemán de Cooperación Social-Tecnica y Fondo Mundial para la Naturaleza (WWF-US). Santo Domingo, Secretaría de Estado de Agricultura, SURENA/DVS.

SEA/DVS (Secretaría de Estado de Agricultura/Departamento de Vida Silvestre). (1993): Estudio y Protección de Cocodrilo Americano (*Crocodylus acutus*) en la República Dominicana. Santo Domingo, Secretaría de Estado de Agricultura, SURENA/DVS.

Seidel, M.E. (1996): Current status of the biogeography of the West Indian turtles in the genus *Trachemys* (Emydidae). In: Contribution to West Indian Herpetology: A Tribute to Albert Schwartz, p. 169-174. Powell, R., Henderson, R.W., Eds, Ithaca, New York: Society for the Study of Amphibians and Reptiles Contributions to Herpetology, vol. 12.

Stam, S., Stam, R. (1992): Trouble for sea turtles in the Dominican Republic. Mar. Turtle Newsl. **57**: 18-19.

Valez Sierra, G., Mateo Féliz, J.M. (1992): Sistema de Áreas Protegidas de República Dominicana. Santo Domingo, República Dominicana, Fondo Pro-naturaleza.

Weil, T.E., Black, J.K., Blutstein, H.I., Johnston, K.T., McMorris, D.S., Munson, F.P. (1982): Dominican Republic: A Country Study, 2nd edition. Washington, DC: Department of the Army.

Weiss, A.J., Hedges, S.B. (2007): Molecular phylogeny and biogeography of the Antillean geckos *Phyllodactylus wirshingi*, *Tarentola americana*, and *Hemidactylus haitianus* (Reptilia, Squamata). Molecular Phylogenetics and Evolution **45**: 409-416.

Williams, E.E. (1961): Notes on Hispaniolan herpetology 3. The evolution and relationships of the *Anolis semilineatus* group. Breviora **136**: 1-8.

Williams, E.E. (1999): Over 300 years of collecting in the Caribbean. In: Caribbean Amphibians and Reptiles, p. 1-30. Crother, B.I., Ed., San Diego, California, Academic Press.

Wilson, B.S., Horrocks, J.A., Hailey, A. (2006): Conservation of insular herpetofaunas in the West Indies. Appl. Herpetol. **3**: 181-195.

ZOODOM (Parque Zoológico Nacional), Grupo Jaragua, IUCN-SSC Iguana Specialist Group, International Iguana Foundation, Durrell Wildlife Conservation Trust. (2002): Ricord's iguana, *Cyclura ricordii*: Species recovery plan, 2002-2007. Iguana Ricordi, *Cyclura ricordii*: Plan de Recuperación de la Especie, 2002-2007. Gland Switzerland, IUCN.

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Addendum

A number of taxonomic changes have been applied to species of amphibians and reptiles in the Dominican Republic (table A1). Most notable is the partitioning of several genera of snakes in the family Leptotyphlopidae (Adalsteinsson et al., 2009) and others formerly placed in the family Colubridae, but now considered members of the Dipsadidae (Hedges et al., 2009; Zaher et al., 2009). In addition, Hedges et al. (2008) placed all West Indian species of *Eleutherodactylus* in the family Eleutherodactylidae and Gamble et al. (2007, 2008) recognized the families Phyllodactylidae (genus *Phyllodactylus*) and Sphaerodactylidae (genera *Aristelliger*, *Gonatodes*, and *Sphaerodactylus*) for geckos previously placed in the family Gekkonidae, which is now restricted to Hispaniolan geckos in the genus *Hemidactylus*. Frost et al. (2006) resurrected the genus *Peltophryne* for West Indian toads, and Chapparro et al. (2007) assigned *Bufo marinus* to the genus *Rhinella*. Frost et al. (2006) also relegated *Rana catesbeiana* to the genus *Lithobates*.

Two new introduced lizards have been discovered (Scantlebury et al., 2010). *Hemidactylus frenatus* (Gekkonidae) is native to southeastern Asia and parts of Africa. It has become widely established in the Western Hemisphere, but had not been previously recorded from the West Indies. *Gymnophthalmus underwoodi* (Gymnophthalmidae) is a parthenogenetic species native to northeastern South America and presumably some of the southern Lesser Antilles. This is the first record from the Greater Antilles.

Three species of *Sphaerodactylus* are known only from the immediate vicinities of their respective type localities, all of which are in imminent danger from development. *Sphaerodactylus epiurus* occurs only in isolated karst hills, the western edge of which is an active quarry. Although the type locality of *S. perissodactylius* is within the Parque Nacional Sierra Martín Garcia, the habitat

Table A1. Taxonomic changes affecting species of amphibians and reptiles in the Dominican Republic.

AMPHIBIANS
Bufonidae
Peltophryne fluviatica (formerly *Bufo fluviaticus*)
Peltophryne fracta (formerly *Bufo fractus*)
Peltophryne guentheri (formerly *Bufo guentheri*)
Rhinella marina (formerly *Bufo marinus* or *Chaunus marinus*)
Eleutherodactylidae (formerly assigned to the family Leptodactylidae)
Eleutherodactylus spp. (all West Indian species in the genus)
Ranidae
Lithobates catesbeianus (formerly *Rana catesbeiana*)
REPTILES
Phyllodactylidae (formerly assigned to the family Gekkonidae)
Phyllodactylus spp. (*P. hispaniolae* and *P. sommeri*)
Sphaerodactylidae (formerly assigned to the family Gekkonidae)
Aristelliger spp. (*A. expectatus* and *A. lar*)
Sphaerodactylus spp. (all species in the genus)
Dipsadidae (formerly assigned to the family Colubridae)
Haitiophis anomalus (formerly *Alsophis anomalus* or *Ocyophis anomalus*)
Hypsirhynchus melanichnus (formerly *Alsophis melanichnus* or *Ocyophis melanichnus*)
Hypsirhynchus parvifrons (formerly *Antillophis parvifrons*)
Ialtris haetianus (formerly *Darlingtonia haetianus*)
Leptotyphlopidae
Mitophis asbolepis (formerly *Leptotyphlops asbolepis*)
Mitophis calypso (formerly *Leptotyphlops calypso*)
Mitophis pyrites (formerly *Leptotyphlops pyrites*)

is threatened by charcoal production. As of August 2010 (D. Scantlebury, pers. comm.), signs of active charcoal production (e.g., log piles and bags of charcoal) were abundant. *Sphaerodactylus schuberti* might be more widely distributed than the other two species, but the type locality is on private property, and the habitat is severely degraded by overgrazing by goats.

In addition, 31 new protected areas were established, expanding the total coverage of protected areas in the Dominican Republic by 13,037.24 km^2.

References

Adalsteinsson, S.A., Branch, W.R., Trape, S., Vitt, L.J., Hedges, S.B. (2009): Molecular phylogeny, classification, and biogeography of snakes of the family Leptotyphlopidae (Reptilia, Squamata). Zootaxa **2244**: 1-50.

Chapparro, J.C., Pramuk, J.B., Gluesenkamp, A.G. (2007): A new species of arboreal *Rhinella* (Anura: Bufonidae) from cloud forest of southeastern Peru. Herpetologica **63**: 203-212.

Frost, D.R., Grant, T., Faivovich, J., Bain, R.H., Haas, A., Haddad, C.F.B., de Sá, R.O., Channing, A., Wilkinson, S.C., Donnellan, M., Raxworthy, C.J., Campbell, J.A., Blotto, B.L., Moler, P., Drewes, R.C., Nussbaum, R.A., Lynch, J.D., Green, D.M., Wheeler, W.C. (2006): The amphibian tree of life. Bull. Amer. Mus. Nat. Hist. **297**: 1-370.

Gamble, T., Bauer, A.M., Greenbaum, E., Jackman, T.R. (2007): Evidence for Gondwanan vicariance in an ancient clade of gecko lizards. J. Biogeogr. **35**: 88-104.

Gamble, T., Bauer, A.M., Greenbaum, E., Jackman, T.R. (2008): Out of the blue: A novel, trans-Atlantic clade of geckos (Gekkota, Squamata). Zool. Scripta **37**: 355-366.

Hedges, S.B., Duellman, W.E., Heinicke, M.P. (2008): New World direct-developing frogs (Anura: Terrarana): Molecular phylogeny, classification, biogeography, and conservation. Zootaxa **1737**: 1-182.

Hedges, S.B., Couloux, A., Vidal, N. (2009): Molecular phylogeny, classification, and biogeography of West Indian racer snakes of the Tribe Alsophiini (Squamata, Dipsadidae, Xenodontinae). Zootaxa **2067**: 1-28.

Scantlebury, D., Ng, J., Landestoy, M., Glor, R.E. (2010): *Hemidactylus frenatus* and *Gymnophthalmus underwoodi* in the Dominican Republic. Rept. Amphib. **17**, in press.

Zaher, H., Grazziotin, F.G., Cadle, J.E., Murphy, R.W., de Moura-Leite, J.C., Bonatto, S.L. (2009): Molecular phylogeny of advanced snakes (Serpentes, Caenophidia) with an emphasis on South American xenodontines: A revised classification and descriptions of new taxa. Pap. Avul. Zool. **49**: 115-153.