

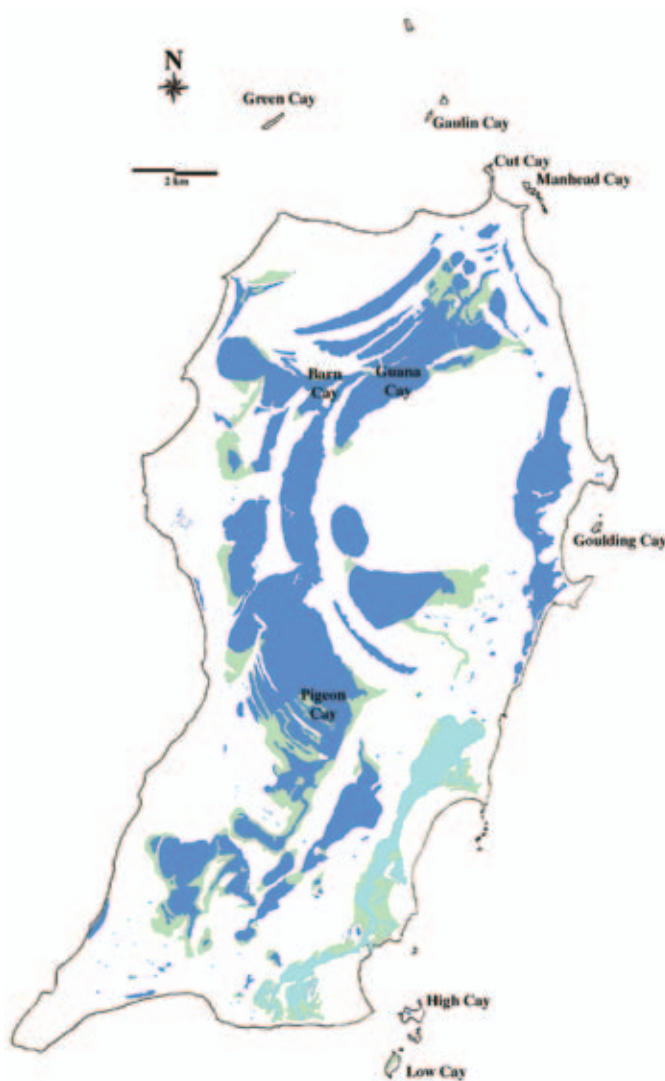
# The Terrestrial Reptiles of San Salvador Island, Bahamas

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Originally named “Guanahani” by the Lucayan Indians, who were the first humans to settle the island, San Salvador is one of 700 islands that make up the Bahamian Archipelago (Gerace et al. 1998). Located at 24°3’N latitude and 74°30’W longitude, it is 640 km ESE of Miami, Florida. Temperatures range from 17–27 °C in the winter and 22–32 °C



San Salvador, Bahamas, showing the inland system of lakes (dark blue), some associated wetlands (green), and a tidal creek (Pigeon Creek; light blue). Some sediment deposits are shown as wetlands. Labeled cays have supported San Salvador Rock Iguana (*Cyclura rileyi rileyi*) populations in recent years, although those on Barn Cay (1970s) and High and Gaulin cays (1990s) have been extirpated, and small populations have been introduced to the Club Med Resort on the main island and onto Cut Cay. Adapted from Robinson and Davis (1999).



The Dixon Hill lighthouse is situated on one of the higher elevations on San Salvador. The top of the lighthouse provides a view of the entire island.

in the summer. Most of the island’s mean annual rainfall of 100 cm falls during the May–November rainy season, with about one-fourth of the total associated with the annual hurricane season.

One-third of the island’s total surface area of 92.9 km<sup>2</sup> is comprised of a network of brackish (often hypersaline) inland lakes. Like the other Bahamian islands, San Salvador is a low carbonate island. The highest point is 37.5 m above sea level (Shaklee 1994). Soils are generally shallow, poorly developed, and retain little water. Vegetation is mainly “scrub,” with most (~60%) plants of Caribbean origin, ~30% exotic Florida imports, and 6–8% endemics (Smith 1993).

Christopher Columbus probably first made landfall on San Salvador in Long Bay on 12 October 1492 (Gerace et al. 1998). The island, like most of the Bahamas, was completely depopulated by 1513 when Ponce de Leon passed through on his way to Florida. The British declared the

Bahamas a crown possession in 1629, but San Salvador was largely unaffected by Europeans until American colonists loyal to Britain were forced to immigrate to the Bahamas in 1783. They built impressive estates, using

African slaves as labor. The “Loyalist Period” ended in 1834, when Great Britain abolished slavery. Descendants of slaves led a subsistence existence until the U.S. established military bases on the island in 1951, leaving a functional infrastructure when they departed in the 1960s. Today, tourism and the Gerace Research Centre employ the majority of the approximately 1,000 residents.

The six native terrestrial reptiles of San Salvador have evolved to cope with the harsh xeric habitats and the onslaught of tropical storms. Most are small (the San Salvador Rock Iguana is a notable exception) and divide much of their time between seeking shelter from the inhospitable conditions and foraging for food. A few, including one introduced lizard, have taken advantage of alterations to the natural habitats by exploiting



TIFFANY SCHULTHEIS

In 1680, a pirate named John Watling supposedly chose San Salvador as his retreat. Ruins known as Watling’s Castle provided views of both eastern and western sides of the southern end of the island. As romantic as these tales are, local historian, Kathy Gerace, clearly demonstrated that the ruins are actually a late 18th-century Loyalist plantation house.



ABBY TATE

San Salvador Rock Iguanas (*Cyclura rileyi rileyi*) remain abundant on Green Cay, despite the introduction of *Cactoblastis* moths that destroy Prickly-pear Cacti (*Opuntia stricta*), a major food source. However, the population on the main island is almost extirpated as a consequence of exploitation, roadkills, the loss of habitat, and accidentally or intentionally introduced invasive species, notably Black Rats (*Rattus rattus*), feral cats (*Felis silvestris*), and dogs (*Canis familiaris*), all of which prey on adults, juveniles, or eggs.



PAULA A. HILLBRAND

Some individual iguanas on Green Cay emerge from shelters when tourists land.



PAULA A. HILLBRAND

This healthy female appears to be thriving far from the landing site.



human habitations and debris, but all have suffered to some degree from exploitation (iguanas), the loss of habitat, and accidentally or intentionally introduced invasive species, notably *Cactoblastis* moths, Fire Ants (*Solenopsis invicta*), Black Rats (*Rattus rattus*), and feral cats (*Felis silvestris*) and dogs (*Canis familiaris*) (Hayes et al. 2004).

The following annotated checklist covers only the terrestrial reptiles. In addition to these, at least one sea turtle, the Hawksbill (*Eretmochelys imbricata*), frequents the reefs and regularly nests in small numbers. Two native amphibians also occur (see the sidebar on p. 164), the Cuban Treefrog (*Osteopilus septentrionalis*) and the Bahamian Flathead Frog (*Eleutherodactylus rogersi*), and one non-native Squirrel Treefrog (*Hyla squirella*) has been observed (WKH and S. Buckner, sight record only). One incomplete snakeskin of a larger, non-native, non-booid species was also found in an outbuilding (WKH), but remains unidentified.

#### San Salvador Rock Iguana (*Cyclura rileyi rileyi*)

The best-known reptile of San Salvador, the Rock Iguana, is aptly named for its proclivity for rocky limestone terrain. It is endemic to San Salvador, but numbers have declined drastically since humans arrived. At present, fewer than 600 individuals remain, many are adults (suggestive of limited recruitment), and they are largely restricted to four tiny offshore cays and two small islets in a hypersaline lake (Hayes et al. 2004). These areas total about 31.5 ha, about 0.2% of the historical range. Together, Green and Goulding cays support more than two-thirds of the entire taxon. Only occasionally are iguanas encountered on the main island; some of these may be individuals purposefully relocated by island residents or lizards that swam ashore from the nearby cays when droughts exacerbated the already food-limited situation on the cays. Populations on Barn (in the 1970s) and High and Gaulin cays (in the 1990s) were extirpated. The Club Med resort on the mainland illegally procured individuals from Green Cay in the 1990s, but the population, protected by perimeter fencing, remains small (Hayes et al. 2004). A small population was also introduced from Green Cay to Cut Cay (five males, five females) in 2005, but it has not grown appreciably (unpubl. data).

San Salvador's iguanas are smaller than most congeners; males reach a SVL of 306 mm and females 254 mm (Schwartz and Henderson 1991; c.f., Hayes et al. 2004). However, iguanas translocated to Club Med on the mainland, with lush vegetation, have attained substantially larger body sizes (unpubl. data). Color and pattern are variable. Ground color can range from greenish gray to tanish, with varying splotches of lighter green, red, orange, or yellow of increasing intensity toward the dorsal spine ridge. The pattern of ground and splotch colors is reversed in some animals. Males are generally more vivid than females. Juveniles range from solid brown to gray and have faint longitudinal stripes but lack the vivid splotches and chevrons seen on adults.



Like most iguanian lizards, San Salvador Rock Iguanas (*Cyclura rileyi rileyi*) are quite territorial. Here a larger lizard evicts a smaller individual from a prime basking site.

These San Salvador Rock Iguanas (*Cyclura rileyi rileyi*), both from Green Cay, show striking differences in condition. The individual in the upper photograph is healthy (at least partially the result of supplemental feeding by tourists), whereas the individual in the lower photograph is emaciated, testament to the food-limited realities of small cays, which are exacerbated during droughts.





In an effort to reduce unnecessary interactions and promote conservation, the IRCF has provided signs in English and French (for patrons of Club Med).

Iguanas bask on rock outcroppings and seek shelter in rock crevices and patches of Sea Grape (*Coccoloba uvifera*) and other vegetation, but require sandy areas for nest construction (Hayes 2000, Hayes et al. 2004). They also exploit sand strand with Sea Oats (*Uniola paniculata*), Buttonwood (*Conocarpus erectus*), and other mangroves, as well as other coastal coppice plant species. Iguanas are sometimes found in trees (Paulson 1966); however, most foraging and other activities occur on the ground. Although they occasionally consume or scavenge birds, land crabs, and insects (Hayes et al. 2004), iguanas are almost entirely herbivorous, often distributing seeds in their feces, which also facilitates germination and enhances the viability of the seeds and seedlings. One principal source of food is the Prickly-pear Cactus (*Opuntia stricta*), which has been severely degraded by the invasive Cactus Moth (*Cactoblastis cactorum*) (Hayes et al. 2004). On Green Cay, iguanas have become accustomed to human visitors and will flock to meet them, expecting to be fed.

Adult males are territorial throughout the year and perform displays that include head-bobs and push-ups when approached by an intruder or to attract a female (Hayes 2000). Courtship and mating occur in late May and June followed by nesting and egg laying in July. Most females actively defend nest sites, which can be used repeatedly in subsequent nesting seasons. Clutch size is related to female size, and while one clutch of 10 eggs has been recorded, most clutches contain 3–6 eggs (Hayes 2000, Hayes et al. 2004).

In addition to feral mammals and vehicles on San Salvador proper, rising sea levels threaten to inundate the low-lying cays, and diseases

could be catastrophic because of small population sizes and lack of genetic diversity. Despite strict protection by international (CITES Appendix I) and Bahamian laws, humans illegally remove iguanas for food or to supply the trade in live animals. *Cyclura rileyi* (all three subspecies) is listed as Endangered on the IUCN Red List.

#### Brown Anole (*Anolis sagrei ordinatus*)

*Anolis sagrei ordinatus* is widely distributed throughout the Bahamas, and *A. s. sagrei* is found across Cuba. Introduced populations are known from Jamaica, the Cayman Islands, several of the Lesser Antilles, the Atlantic coast of Mexico and Belize, and Florida (Powell et al. 2011).

Considered a “trunk-ground” ecomorph (Rand and Williams 1969), these anoles tend to perch low on tree trunks and other vertical structures, often assuming a “watch” position with head down and elevated to scan the area below the perch for prey (Schoener 1979). They occur in a variety of sunny habitats, including savannas, open forests, and coastal habitats, but rarely in dense forests, where they are largely restricted to openings (Henderson and Powell 2009). Populations often are densest in areas of intermediate insolation. Ecologically versatile (e.g., Oliver 1948), they readily inhabit altered habitats, where they can be quite abundant in edificarian situations such as yards and patios, where individuals can be encountered on the ground, in brush, and on fallen logs and boards, fences, and piles of debris and rocks. On San Salvador, *A. sagrei* is most likely to be encountered in open areas, where it is essentially ubiquitous and tends to perch lower than sympatric *A. distichus* (unpubl. data). It also occurs on some of the offshore cays.



Brown Anoles (*Anolis sagrei ordinatus*), especially adult males, often assume a “watch” position with head down and elevated to scan the area below the perch for prey.





ROBERT POWELL

Male Brown Anoles are intensely territorial. This individual is displaying to “protect” his territory on a discarded washing machine.

*Anolis sagrei* has long toes and reduced toe pads, which facilitate running and jumping rather than climbing (e.g., Losos 2009). Males on Cuba reach a SVL of 70 mm (Schwartz and Henderson 1991) and females 47.8 mm (Rodríguez Schettino 1999), but most individuals on San Salvador are smaller. Ground color varies from light gray to brown to almost black with patches, spots, and chevrons on females and young males, but lacking in adult males.



GUILLERMO G. ZUNIGA



PAUL A. HILBRAND

We found multiple females, two intact eggs, shells of at least seven hatched eggs, and a recent hatchling in a pile of debris near the edge of a large concrete catch basin near the Gerace Research Centre, suggestive of communal nesting in Brown Anoles.



ROBERT POWELL



WILLIAM K. HAYES

Female Brown Anoles (*Anolis sagrei ordinatus*) retain a juvenile pattern that might be comprised of a middorsal stripe or a series of spots or rhomboid shapes.

Like most anoles, Brown Anoles tend to feed on insects and other small arthropods, although they are known to eat smaller lizards, including juvenile conspecifics (Henderson and Powell 2009). Generally diurnal, lizards on San Salvador are known to exploit the “night-light niche,” feeding on nocturnal insects attracted to artificial lights at night (R. Powell, unpubl. data).

In typical anoline fashion, *A. sagrei* engages in social behaviors that include head-bobs, push-ups, vertical tail wags, and dewlap extensions. Males are aggressively territorial and often become very dark (even black) when facing off or fighting an intruder (Schwartz and Henderson 1991).





ROBERT POWELL



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Proud sponsor of the IRCF and this centerfold

Together, Green (where this photograph was taken) and Goulding cays support more than two-thirds of the entire world's population of San Salvador Rock Iguanas (*Cyclura rileyi rileyi*).



## San Salvador's Amphibians

Two native frogs occur on San Salvador, but are limited by the harsh xeric conditions and near absence of fresh surface water, which are not conducive to an amphibian lifestyle. Although the Bahamian Flathead Frog (*Eleutherodactylus rogersi*) has no free tadpole stage (tadpoles develop in the egg and hatch as tiny froglets), moist conditions are essential for the survival of the eggs. The Cuban Treefrog (*Osteopilus septentrionalis*) does require fresh surface water for breeding, and has undoubtedly benefited from artificial "ponds" such as cisterns and catch basins.



WILLIAM K. HAYES

Bahamian Flathead Frogs (*Eleutherodactylus rogersi*) are rarely encountered outside the rainy season.



WILLIAM K. HAYES

Cuban Treefrogs (*Osteopilus septentrionalis*) begin calling with the first showers of the rainy season. They spend the dry season deep in moisture-retaining crevices under the bark of trees, buildings, or piles of debris.



HAY'S CUMMINS, MIAMI UNIVERSITY

Green Herons (*Butorides virescens*) have quickly adapted to prey made available by humans. This heron is eating a Cuban Treefrog tadpole in the waters of the catch basin near the Gerace Research Centre. We also observed a Green Heron stalking and eating Brown Anoles.



Reproduction in most populations appears to coincide with the rainy season (June–October; Henderson and Powell 2009), but little is known about populations on San Salvador, where we discovered evidence of communal nesting in June 2011.

#### Bark Anole (*Anolis distichus ocior*)

*Anolis distichus*, with 17 currently recognized subspecies, occurs on Hispaniola and the Bahamas (Powell and Henderson 2009), and at least two subspecies have been introduced in southeastern Florida. *Anolis d. ocior* is endemic to San Salvador and Rum Cay in the Bahamas.

Bark Anoles live primarily in forested areas, but also occur along coastal zones, in scrub savannas, and in human-modified habitats, including on and in houses (Schwartz and Henderson 1991). On San Salvador, they are locally abundant, but missing from many areas that lack large trees and deep shade. They also occur on several offshore cays. Bark Anoles are “trunk” ecomorphs (Rand and Williams 1969), and generally perch on tree trunks or analogues such as fence posts or telephone poles, on which they feed primarily on ants. They also will consume other insects and small arthropods. They “restlessly” search and then passively wait in front of an ant trail to “gobble” up unsuspecting prey with a quick flick of the tongue (Schoener 1968, 1979; Schoener and Schoener 1980).

*Anolis distichus* is comparable in size to the Brown Anole, with males attaining a maximum SVL of 58.4 mm and females 50.2 mm on Bimini and the Andros Islands (Schoener 1988). These anoles have a smooth, even coloration ranging from gray to brown to light green to yellow, and lack the



GUILLERMO G. ZAVIGA

Bark Anoles (*Anolis distichus*) occur on Hispaniola as well as in the Bahamas. Almost certainly a complex of species, dewlap and ground colors vary considerably. The dewlap of this displaying male *A. d. ocior* is typical of individuals on San Salvador.



ABBY TATE

San Salvador Curlytails (*Leiocephalus loxogrammus parnelli*) are most abundant in open scrub or rocky habitats.

distinct chevrons or blotches of *A. sagrei*. The venter is usually dull white. Males tend to be more richly colored than females.

Bark Anoles are very restless in nature, rarely remaining in one spot for more than a few minutes. When approached, these anoles “squirrel” to the opposite side of the perch before moving up or down to avoid a threat. Often most active in early morning and late evening, these lizards seek shade during the heat of the day. Like other anoles, territorial and mating displays include head-bobs, push-ups, and dewlap extensions.

#### San Salvador Curlytail (*Leiocephalus loxogrammus parnelli*)

*Leiocephalus loxogrammus parnelli* is endemic to San Salvador, and the only other subspecies occurs on Rum Cay, although a population not assigned to either subspecies apparently occurs on Conception Island (Schwartz and Henderson 1991). These lizards are found along edges of large open areas, particularly rocky sites, but also on sandy beaches and more densely vegetated coastal habitats and in human settlements. They are less abundant in scrub and shrub habitats (Schwartz and Henderson 1991). They are frequently encountered around some of the ruins dating back to the loyalist era. Small populations exist on Catto and High cays.

Albeit far more terrestrial (lizards in the genus *Leiocephalus* rarely climb into trees), they are, like anoles, primarily ambush predators, feeding largely on insects and other small arthropods, although they will take smaller lizards (Schoener et al. 1982). Facultatively and seasonally omnivorous, they also eat buds, flowers, seeds, and small fruits.

San Salvador Curlytails are of moderate size, with males reaching a SVL of 90 mm and females 70 mm. They can be identified by black and white longitudinal stripes down the back and by their body shape. Ground





ROBERT POWELL

Despite the common name, not all “curlytails” curl their tails. This juvenile is curling its tail about as much as has been observed in lizards on San Salvador.

colors range from brown to gray. Males are often streaked with black diagonal lines, whereas females typically possess two cream-colored longitudinal stripes. The venter is gray, occasionally with a yellow-orange cast (sometimes bright).

Social behaviors involve head-bobs and push-ups, and threat displays might include gular inflation and elevation on all four limbs. As implied by the common name, Curlytail lizards are known for the ability to curl their



TIFFANY SCHULTHEIS

Although curlytails rarely climb, they will occasionally forage into low vegetation or climb onto elevated perches to escape predators.

tails and, in some species, the coiled tail rides over their backs like the tail of a scorpion — but the San Salvador Curlytail does not curl its tail. Mating is thought to coincide with the rainy season, when females lay eggs that need two months to hatch (Schwartz and Henderson 1991).

### Tropical House Gecko (*Hemidactylus mabouia*)

This non-native species was first seen in San Salvador in 1998. Native to Africa, now widely distributed in South America and the greater Caribbean, the species has been introduced in southern Florida (Powell et al. 1998). The adhesive and water resistant eggs of *H. mabouia* can stick to cargo of various types, which facilitates this species' expansion to new parts of the world (Gibbons 1985), but most West Indian introductions are almost certainly attributable to “hitch-hiking” with goods (especially ornamental plants) and containers (Kraus 2009, Powell et al. 2011).

Ground color usually is pale gray or tan, although this can vary considerably based on the location and condition of an individual. Similarly, a pattern of dark chevrons ranges from quite distinct to virtually absent. Males reach a SVL of 68 mm (Schwartz and Henderson 1991), females 61 mm (Howard et al. 2001).

In the Western Hemisphere, these nocturnal geckos are almost exclusively synanthropic commensals (Henderson and Powell 2009), and are typically found around buildings and on walls, where they are frequently observed foraging for insects attracted to artificial lights (Perry et al. 2008,



ROBERT POWELL

Introduced Tropical House Geckos (*Hemidactylus mabouia*) are closely associated with human habitations and frequently forage around artificial lights at night.



WILLIAM K. HAYES

Although almost exclusively synanthropic commensals, Tropical House Geckos occasionally exploit natural habitats such as trees and limestone outcroppings near the shore.



Powell and Henderson 2008). On San Salvador, they are encountered in those and other urban situations, sometimes under loose bark, or even under rocks that by day are exposed to direct sunlight (unpubl. data).

Their adhesive feet allow them to scale walls and hang from ceilings to catch prey. These geckos are wary and easily frightened and emit squeaks when captured or fighting (e.g., Bartlett and Bartlett 1999). In Florida, Tropical House Geckos breed throughout the year. Eggs are laid singly or in pairs under rocks, leaf litter, or in various crevices, and communal nesting has been observed (Krysko et al. 2003, Henderson and Powell 2009).

#### San Salvador Dwarf Gecko (*Sphaerodactylus corticola soter*)

*Sphaerodactylus corticola* occurs only in the Bahamas; *S. c. soter* is endemic to San Salvador, where it is known from many offshore cays as well as islets in the inland lakes. Often associated with human settlements or debris (Schwartz and Henderson 1991), these geckos also are found under palm fronds, boards, logs, small rocks, and in piles of natural and human trash (Schwartz 1968) or even in iguana burrows (Gicca 1980).

These diminutive lizards (male SVL to 37 mm, females to 39 mm; Schwartz 1968) have short legs, thick tails, and pointed snouts. Ground color is pale to medium brown, and the pattern varies from almost uniform to small flecks and dots. Occasional females have vague, pale dorsolateral lines that are remnants of the juvenile pattern. The skin is soft and velvet-like.

San Salvador Dwarf Geckos are primarily nocturnal; they hide by day beneath cover and emerge at dusk to feed on small insects. On San Salvador, they often enter buildings but rarely crawl on walls, remaining on or close to the ground. They mate from June to December; clutches of single eggs, sometimes deposited communally, are laid in leaf litter or crevices under loose bark, and hatchlings have a SVL of 16–17 mm (Schwartz 1968, Schwartz and Henderson 1991).

#### San Salvador Threadsnake (*Epictia columbi*)

Threadsnakes occur in both the Eastern and Western hemispheres, but this species (formerly *Leptotyphlops columbi*; Adalsteinsson et al. 2009) is endemic to San Salvador, where it is the only snake known to occur on the island. This very secretive and seldom seen species is almost exclusively fossorial, but can be encountered when lifting surface cover (Riley 1981) or above ground shortly after heavy rains. They also are found in logs, and are known locally as “wood worms” (Schwartz and Henderson 1991).

The occurrence of threadsnakes on this one island in the Bahamas, and on several other isolated islands in the West Indies that have never been connected to continents, suggests they are capable of dispersal over ocean waters, presumably on rafts of vegetation or volcanic pumice, or within



San Salvador Threadsnakes (*Epictia columbi*) are very secretive and almost exclusively fossorial, but can be encountered when lifting surface cover or above ground shortly after heavy rains.

floating logs (Adalsteinsson et al. 2009). The San Salvador Threadsnake has been documented on Gaulin Cay (Riley 1981) and Low Cay (Dave Manary, pers. comm.), so it probably occurs on most offshore cays.

The San Salvador Threadsnake is very small and slender, superficially resembling an earthworm. The head and body are mostly very dark, almost black, and the venter is slightly lighter. Maximum SVL is 180 mm (Schwartz and Henderson 1991), with a very short tail (~13 mm).

Threadsnakes use their shovel-like mouth to scoop up ant larvae and pupae. The mouth and feeding mechanism (mandibular raking) appear to be adaptations for rapid feeding, which is needed when raiding ant nests due to vulnerability to ant attacks (Kley and Brainerd 1999). This gives the snake a chance to make a hasty exit. Fire Ants (*Solenopsis invicta*) from South America have become established on San Salvador (Davis et al. 2001), and these aggressive predators with powerful stings could threaten the San Salvador Threadsnakes as well as the other small reptiles on the island.

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San Salvador Dwarf Geckos (*Sphaerodactylus corticola soter*) often enter buildings but rarely crawl on walls, remaining on or close to the ground.



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## Call for Papers

The editors are actively soliciting articles and news items on amphibians and reptiles from throughout the world. General articles and short notes can deal with any aspect of reptilian or amphibian biology, including conservation, behavior, ecology, physiology, or systematics, but we also are interested in travelogues to exciting herpetological destinations, commentaries, records of introduced species, and articles about responsible husbandry. All submissions except travelogues and commentaries are subject to peer review. Prospective authors should consult recent issues for format; additional instructions are available on the IRCF website: (<http://www.ircf.org/uploadfile.php>).



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