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This male Green Iguana (Iguana iguana) from Fort Lauderdale (Broward Co.) is among the many species of exotic amphibians, reptiles, turtles and crocodilians that are established in Florida. (Photograph by Gary Busch).

A RUNAWAY TRAIN IN THE MAKING: THE EXOTIC AMPHIBIANS, REPTILES, TURTLES, AND CROCODILIANS OF FLORIDA

MONOGRAPH 1.

WALTER E. MESHAKA, JR.

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DEDICATION

To the memory of Henry “Hank” T. Smith, a dear friend and co-investigator on many enjoyable projects, and a person who made a positive difference in my life and in those of many others.

TABLE OF CONTENTS

FIGURE 79. Geographic distribution of the Giant Whiptail (*Aspidoscelis motaguae*) in Florida.

Diet.—In Kendall, the Giant Whiptail fed on invertebrates, especially adult and larval beetles, ants, and roaches (Meshaka et al. 2004a).

Reproduction.—In June, testes dimensions were enlarged (mean = 7.6 X 5.8 mm), and females contained three sets of previtellogenic follicles (Meshaka et al. 2004a). Bartlett and Bartlett (1999) reported a four-egg clutch laid by a captive female Giant Whiptail.

Growth and survivorship.—Meshaka et al. (2004a) collected a 37 mm SVL juvenile in September.

Activity.—The Giant Whiptail actively foraged on sunny days and was rarely active on overcast days (Meshaka et al. 2004a). Sexual pairs would forage together, and peak activity was midmorning (Meshaka et al. 2004a). Foraging generally occurred not far from cover or burrows (Meshaka et al. 2004a). In this connection, individuals typically moved back and forth from sunny sidewalks to the shade and cover of adjoining hedges all the while having maintained high body temperatures.

Threats.—There has been some speculation as to the ability of the Giant Whiptail to persist in Florida (Bartlett and Bartlett 1999). Eradication of this species might be feasible. This lizard was ecologically similar to the Six-lined Racerunner with which it was a potential competitor (Meshaka 2008a). Among other exotic species of herpetofauna, its ecological relationships with the Giant Ameiva and Rainbow Whiptail also warrant attention.

CNEMIDOPHORUS LEMNISCATUS (LINNAEUS 1758) — RAINBOW WHIPTAIL

Description.—As described by Conant and Collins (1998) and Meshaka et al. 2004a), males are brighter in color than females or immature males. The sides of the head, throat, and anterior surfaces of the limbs of adult males are bright blue or turquoise in color. Males have a brown middorsal stripe, and the sides of the body are green, greenish yellow, or bright yellow with lighter spots. The tail is blue or bluish green. In females, the sides of the head tend toward orange, seven to nine

FIGURE 80. Rainbow Whiptail (*Cnemidophorus lemniscatus*) from Miami-Dade Co., Florida. (Photographed by Suzanne Collins).

FIGURE 81. Geographic distribution of the Rainbow Whiptail (*Cnemidophorus lemniscatus*) in Florida.

light longitudinal body stripes are present, and the hind legs and tail are green (Fig. 80). Smith and Krysko (2007) provided a key to most of the whiptails in Florida.

Distribution.—The Rainbow Whiptail is a New World species whose first documentation in Florida is from Hialeah, Miami-Dade County (King and Krakauer 1966). Wilson and Porras (1983) noted that the Hialeah colony no longer existed, but that the species still occurred in isolated colonies in northern Miami-Dade County (see also Bartlett 1995; Meshaka et al. 2004a). In southern Florida, past records are only from Miami-Dade County, and reports are also only from Miami-Dade County (Meshaka et al. 2004a; Fig. 81). More recent records of the Rainbow Whiptail are from several sites in Miami-Dade County that were considered to be one continuous population (Butterfield et al. 2009). Comparisons of color pattern and meristic characters indicated that the derivation of Florida individuals was likely Columbia, Venezuela, or certain Caribbean Islands (Butterfield et al. 2009).

Body size.—In south Florida, males (mean = 65.3 mm SVL) were larger than females (mean = 62.2 mm SVL) of this species (Meshaka et al. 2004a). In Miami-Dade County, Butterfield et al. (2009) likewise noted sexual dimorphism in body size, whereby males (mean = 71.0 mm SVL) were larger than females (mean = 61.2 mm SVL).

Habitat and abundance.—The Rainbow Whiptail inhabited the sandy soil of railroad rights-of-way and adjacent vegetation (Meshaka et al. 2004a). Bartlett and Bartlett (1999) noted the species in heavily pebbled sandy habitat with sparse cover of low vegetation, an observation corroborated by Butterfield et al. (2009). Punzo (2001d) collected this species in a sparsely vegetated well-drained open sandy area adjacent to an asphalt parking lot that was overgrown with weeds. A large area with clumped vegetation and woodlot bordered the sandy area on two sides. The Rainbow Whiptail dug its own burrows in the ground and under objects (Meshaka et al. 2004a) and was extremely abundant (Butterfield et al. 2009).

Diet.—Punzo (2001d) examined the diet of adult males and females from a site in Miami from March to August. Dominant prey taxa in that study were orthopterans of at least four families, beetles, lepidopteran larvae, and spiders. Diet was similar between sexes and among months. Punzo (2001d) noted that individuals were capable of detecting beetle larvae and termites below the ground surface. Punzo (2001d) further noted an avoidance of chemically protected species, like Blister Beetles (Meloidae) and Velvet Ants (Mutillidae) that were common at the study site. Little evidence of herbivory occurred at this site (Punzo 2001d), although elsewhere the Rainbow Whiptail would eat the leaves and flowers of the European Puncture Weed (*Tribulus cistoides*) (Bartlett and Bartlett 1999). Individuals from a Miami-Dade County population fed on a wide range of invertebrates, especially beetles and ants (Meshaka et al. 2004a).

Reproduction.—In south Florida, bisexual populations of this species complex were known but it was unknown if unisexual populations also existed in Florida (Meshaka et al. 2004a). Careful examination of Florida specimens by Butterfield et al. (2009) found only bisexual individuals, thereby resolving the question of reproductive mode in the Florida populations. The mean testes dimensions of males collected in May measured 4.8 X 3.8 mm (Meshaka et al. 2004a). All females collected in May and in July contained either vitellogenic follicles or oviductal eggs (Meshaka et al. 2004a) with embryonic development having commenced in March (Butterfield et al. 2009). Clutch size, as estimated by number of vitellogenic follicles or oviductal eggs, was small (mean = 2.3 eggs) in size (Meshaka et al. 2004a). Captive females laid up to four eggs per clutch (Bartlett and Bartlett 1999) or between two and five eggs per clutch (Punzo 2001d). At least two clutches were possible annually (Meshaka et al. 2004a). Among captives, two clutches were laid in each season (Bartlett and Bartlett 1999; Punzo 2001d). Shelled eggs were longer (mean = 17.8 mm) than they were wide (mean = 8.8 mm; Meshaka et al. 2004a). Butterfield et al. (2009) detected no association between

FIGURE 82. An Argentine Giant Tegu (*Tupinambis merrianae*) from Polk Co., Florida. (Photographed by Richard D. Bartlett).

clutch size and female body size.

Growth and survivorship.—Hatchlings (mean = 29.9 mm SVL) were captured in May by Meshaka et al. (2004a). Individuals reached sexual maturity within their first year of life, although some individuals would not mature until after the breeding season at the end of the year (Butterfield et al. 2009). The smallest sexually mature female examined by Butterfield et al. (2009) measured 54 mm SVL. A female captured in early May laid two eggs on 19 May, which in turn hatched on 17 July. The two captive hatchlings of this clutch measured 27 and 29 mm SVL (Meshaka et al. 2004a).

Activity.—The Giant Whiptail was diurnal and heliothermic, actively foraging on the ground or on vegetation mats (Meshaka et al. 2004a). It was strictly terrestrial in habits and able to make full use of many human-made structures for foraging and cover (Butterfield et al. 2009). Individuals could move quickly when foraging (Bartlett and Bartlett 1999; Punzo 2001d).

Predators.—The Eastern Corn Snake was a predator of the Rainbow Whiptail (Meshaka et al. 2004a).

Threats.—The Rainbow Whiptail was a potential competitor of the native Six-lined Racerunner in light of its ecological similarity with that species (Meshaka 2008a). Among the exotic species of herpetofauna, its ecological relationships with the Giant Ameiva and Giant Whiptail also warrant attention.

TUPINAMBIS MERRIANAE (DUMÉRIL & BIBRON 1839) — ARGENTINE GIANT TEGU

Description.—Adults are banded in black and white. Males have larger heads and jowls than do females. Juveniles are browner than adults and have a greenish cast in the anterior part of their bodies (Enge 2007; Fig. 82). Smith and Krysko (2007) provided a key to most of the whiptails in Florida.

Distribution.—The Argentine Giant Tegu is a New World species whose first documentation in Florida is from a reclaimed phosphate site in eastern Hillsborough and western Polk counties (Enge et al. unpubl. data; Enge 2007). This population was probably derived from a release of Paraguayan specimens by a commercial animal dealer 2000−2002 (Enge 2007). An isolated roadkill from Okeechobee County in 2002 may have been a waif (Enge 2007; Fig. 83). On 20 January 1993, Bert Crawford brought to the ABS a large tegu lizard caught the day before in Avon Park by a resident. The lizard was crawling on a road off Farmer Road near Albritton Road south of US-98 and west of the Atlantic Coast Railroad track. The lizard measured about 61 cm TL and was blackish in color with yellow spots.

Body size.—The Argentine Giant Tegu is a large tegu species and the largest of the Florida's teiid lizards. Males could reach 500 mm SVL and were larger than females (Duarte Varela and Cabrera 2000).

Habitat and abundance.—Individuals occurred in xeric uplands of the Balm-Boyette Scrub Nature

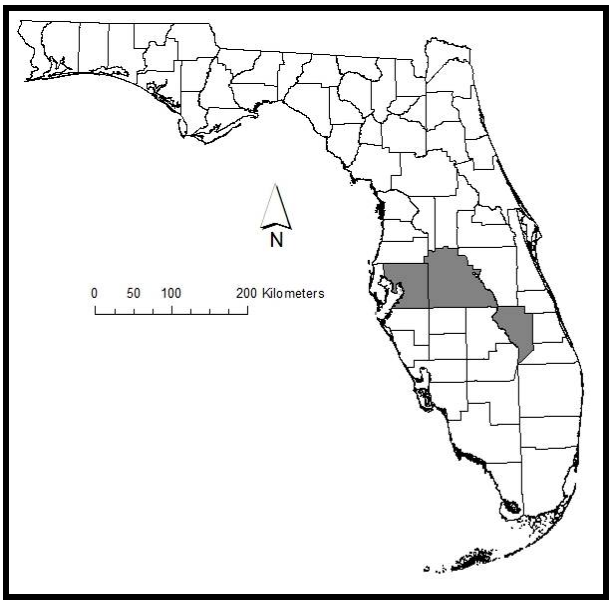

FIGURE 83. Geographic distribution of the Argentine Giant Tegu (*Tupinambis merrianae*) in Florida.

Preserve and the Mosaic Phosphate lands (Kevin M. Enge, pers. comm.; Enge 2007). Individuals used Gopher Tortoise burrows (Enge 2007).

Diet.—Enge (2007) noted omnivory in the Argentine Giant Tegu across its native geographic range and in captivity. In Florida, an individual unearthed Eastern Moles (*Scalopus aquaticus*; Enge 2007).

Reproduction.—Individuals maintained in outdoor pens in Palm Beach County usually bred in March and laid eggs in June (Enge 2007).

Growth and survivorship.—A captive female from southern Florida was sexually mature at 10 months of age and approximately 61 cm TL (Enge 2007).

Activity.—Among captives in maintained outside in southern Florida, individuals became dormant from September to February and emerged in March even if the temperatures were cool (Enge 2007). This observation suggested that day length played a role in its seasonal activity. Individuals subsequently ate a lot of food in preparation for breeding (Enge 2007). The species was diurnal and were most likely seen 1100−1400 on sunny days (Enge 2007).

Threats.—Enge (2007) noted that the Argentine Giant Tegu, a predator of eggs, could have posed a potential a hazard to a wide range of ground nesting vertebrates, including species listed as sensitive in Florida. In turn, Enge (2007) thought that this lizard, particularly during its juvenile state, was potentially at risk to the depredations of a wide range of mammals and birds.

LEIOCEPHALUS CARINATUS GRAY 1827 — NORTHERN CURLYTAIL LIZARD

Description.—The dorsum is brown or gray in color and covered with large keeled scales (Conant and Collins1998; Meshaka et al. 2004a). Scattered iridescent green flecks extend from the dorsal crest to below the lateral fold (Callahan 1982). The dorsal color of the tail is the same color as the body in males and is banded in females and juveniles (Callahan 1982; Fig. 84). Individuals from a Florida City colony are very dark in color.

Distribution.—The Northern Curlytail Lizard is a West Indian species whose first documentation in Florida is from Palm Beach County (Duellman and Schwartz 1958), thought to have initially been introduced on the island of Palm Beach during the 1940s (Weigl et al. 1969). In southern Florida, past records are from Broward (Meshaka et al. 2004a), Highlands (Meshaka et al. 2004a), Martin (Meshaka et al. 2004a), Miami-Dade (mainland, Virginia Key; Meshaka et al. 2004a), Palm Beach (Meshaka et al. 2004a), and St. Lucie (Dean et al. 2004) counties. Reports of the Northern Curlytail Lizard are from Collier, Miami-Dade, Monroe (Key Largo), and Palm Beach counties (Meshaka et al. 2004a). The Highlands County record probably represented a waif (Meshaka et al. 2004a). After Meshaka et al. (2004a) went to press, subsequent records appeared for southern Florida: Collier (Chokoloskee Island; McCoid 2002c) and Lee (Campbell and Klowden 2003) counties. Smith and Engeman (2002) captured an individual 0.3 km south of Hauge and Butterfield's (2000) Martin County record and noted that individuals had been seen there since 1994. More recent records of the Northern Curlytail Lizard are from Martin (Meshaka et al. 2005b), Monroe (Key Largo; Krysko et al. 2005), Monroe (Key West; Krysko et al. 2007c), Monroe (Little Torch Key; Krysko and Borgia 2007b), Monroe (Lower Matecumbe Key; Meshaka et al. 2006d), Monroe (Ramrod Key; Krysko and Borgia 2007b), Palm Beach (Krysko et al. 2005), and St. Lucie (Meshaka et al. 2005b; Moore et al. 2009) counties.

Elsewhere in Florida, records of the Northern Curlytail Lizard exist from Brevard County, and reports are from Indian River County (Meshaka et al. 2004a). The Indian River County report probably represented a waif

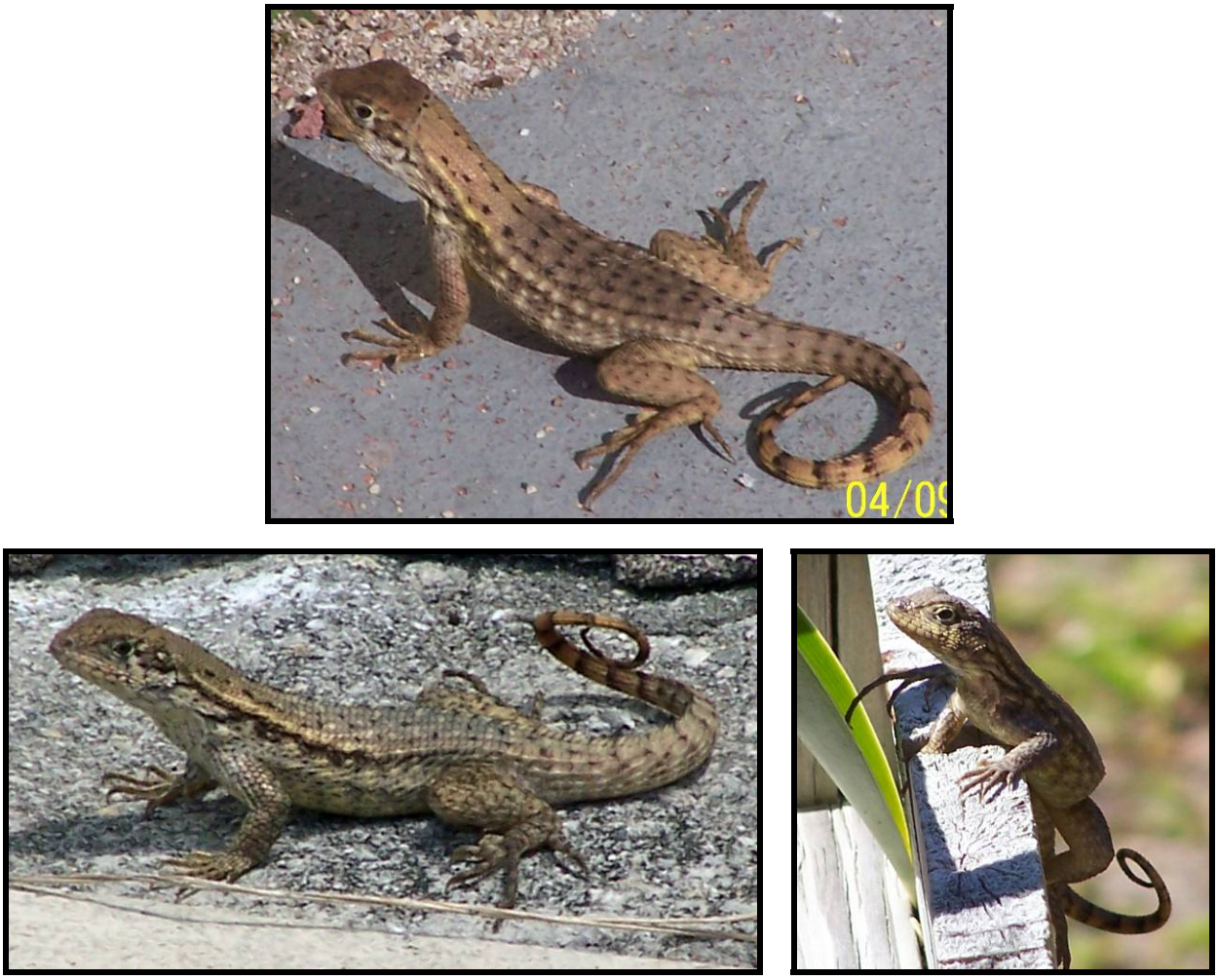

FIGURE 84. Northern Curlytail Lizards (*Leiocephalus carinatus*) from Fort Lauderdale, Broward Co., Florida. (Photographed by Gary Busch).

(Meshaka et al. 2004a), and a subsequent search revealed no individuals (Meshaka et al. 2005b). After Meshaka et al. (2004a) went to press, subsequent records appeared for northern Florida: Brevard County (Krysko and King 2002b). More recent records of this species are from Alachua County (Krysko et al. 2008b). The rate of dispersal along the Florida East Coast by the Northern Curlytail Lizard has been phenomenal (Smith and Engeman 2004a; Smith et al. 2004), with what appeared to be a continuous distribution from northern Broward County to the Martin County line (Meshaka et al. 2005b). Notwithstanding the mediating effects of urban heat islands, frost isotherms predicted unstable populations north of Fort Pierce on the East Coast and just south of Sarasota on the West Coast (Meshaka et al. 2005b). It remains to be seen to what extent the spotty distribution south of Palm Beach County (Fig. 85) was real or an artifact of collecting effort (Meshaka et al. 2005b). Meshaka et al. (2006d) thought that rocky habitat, warm climate, and proximity to roads all but assured this species of extensive colonization on the Florida Keys.

Body size.—In southern Florida, adult males were larger in body size than adult females. For example, In Palm Beach, adult males (mean = 92 mm SVL) were larger than females (mean = 87 mm SVL) that were measured by Callahan (1982) and for males (mean = 94.7 mm SVL) and females (mean = 82.9 mm SVL) measured by Meshaka et al. (2004a). In Martin and Palm Beach counties, males (mean = 96.9 mm SVL) were likewise larger than females (mean = 84.6 mm SVL) that were measured by Meshaka et al. (2006e).

Habitat and abundance.—In Florida, the Northern Curlytail Lizard excelled around open rocky habitat, both natural and in artificial analogs, such as sidewalks, walls, rubble piles, etc. (e.g., Callahan 1982; Layne 1987; Hauge and Butterfield 2000; Krysko and King 2002b; McCoid 2002c). For this reason, the Northern

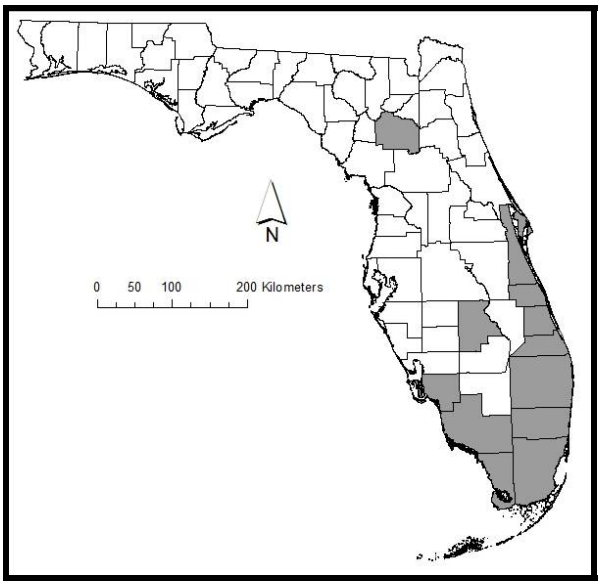

FIGURE 85. Geographic distribution of the Northern Curlytail Lizard (*Leiocephalus carinatus*) in Florida.

Curlytail Lizard is very well-suited to living along sidewalks and parking lots, which provide superabundant habitat in its expanding geographic range in Florida. Burrows were typically excavated under a hard surface, such as large stones, sidewalks, or asphalt (Smith and Engeman 2004a; Meshaka et al. 2004a).

Diet.—Crickets and grasshoppers comprised much of the curlytail's diet in Palm Beach; however, isopods and anoles were also eaten (Callahan 1982). Another diet sample from Palm Beach was comprised of invertebrates, especially beetles, roaches, and ants (Meshaka et al. 2004a).

Reproduction.—In Martin and Palm Beach counties, testes dimensions were at their maximum during spring and summer and peaked from April to August (Meshaka et al. 2006e). Seasonal change in testis length was positively associated with day length, and fat development was lowest fall and winter (Meshaka et al. 2006e). In Palm Beach County, oviposition occurred in June and July (Callahan 1982), and oviductal eggs were present in May and July samples (Meshaka et al. 2004a). In Martin and Palm Beach counties, shelled eggs were present in females during May-August, and September clutches were possible (Meshaka et al. 2006e). Callahan (1982) reported clutches of four to five eggs, and Meshaka et al. (2006e) estimated clutch sizes of four eggs using the number of enlarged follicles (mean = 4.3 eggs) and number of shelled eggs (mean = 4.0 eggs). Clutch size was positively associated with body size using either measure of clutch size estimation (Meshaka et al. 2006e). In southern Florida, single clutch production by the Northern Curlytail Lizard was the rule (Callahan 1982; Meshaka et al. 2004a; Meshaka et al. 2006e); however, multiple clutch production was nonetheless possible, even if rare (Meshaka et al. 2006e). The shelled eggs of the Northern Curlytail Lizard were longer (mean = 18.9 mm) than they were wide (10.8 mm; Meshaka et al. 2006e). Fat development in females was highest preceding shelled egg deposition (Meshaka et al. 2006e).

Growth and survivorship.—In Martin and Palm Beach counties, hatchlings (38.9 and 41.1 mm SVL) were found in August and September, although hatching was possible as early as June (Meshaka et al. 2006e). Minimum body size at sexual maturity was larger in males: 80.0 mm SVL (Callahan 1982), 81.2 mm SVL (Meshaka et al. 2004a), and 78.6 mm SVL (Meshaka et al. 2006e). Minimum body size at sexual maturity was smaller in females: 73.0 mm SVL (Callahan 1982), 70.2 mm SVL (Meshaka et al. 2004a), and 71.3 mm SVL (Meshaka et al. 2006e). Age at sexual maturity was six months in males and five months in females (Meshaka et al. 2006e).

Activity.—The Northern Curlytail Lizard was active throughout the year (Callahan 1982; pers. obser.). In warm weather individuals emerged from retreats 1−2 hr after sunrise (Callahan 1982; Smith and Engeman 2004a). Diel activity was bimodal, whereby lizards were active until early afternoon and then again later in the afternoon (Callahan 1982). On cooler days in November and December, diel activity was unimodal whereby individuals emerged later in the morning and were active continuously until they retreated for the day earlier in the afternoon (Callahan 1982). The Northern Curlytail Lizard was generally terrestrial; however, juveniles could ascend trees to heights in excess of 3 m above ground (Meshaka et al. 2004a). Moore (2008) observed the use of roofs by this lizard, which individuals accessed by climbing adjacent trees. Behavior by those individuals observed by Moore (2008) suggested that the roof served as a defended resource. Bartlett and Bartlett (1999) noted that individuals often allowed a close approach by humans. Both males and females curled their tails as a territorial signal (Callahan 1982).

Predators.—In Palm Beach County, the Northern Curlytail Lizard was preyed upon by the Great Barracuda (*Sphraena barracuda*; Smith and Engeman 2003), Green Heron (Hubbard et al. 2008), Loggerhead Shrike (*Lanius ludovicianus*; Smith et al. 2006b), Northern Mockingbird (Smith et al. 2006c), and feral dog (Smith and Moore 2009a). In one instance, however, a large Northern Curlytail attacked a juvenal Northern Mockingbird in Boynton Beach (Smith and Engeman 2007). A road-killed individual was

scavenged by a Gray Squirrel (Smith et al. 2006d). A Little Blue Heron captured a Northern Curlytail Lizard along a seawall in Martin County (Smith and Engeman 2004b). In southern Florida, the Yellow-Crowned Night Heron (*Nycticorax violaceus*), Great Egret (*Casmerodius albus*), and Cattle Egret (*Bubulcus ibis*) would stalk this lizard (Meshaka et al. 2006e). The Northern Curlytail Lizard was preyed upon by the Madagascar Giant Day Gecko, a diurnally active lizard (May and Krysko 2009). Potential predators include the domestic cat (Callahan 1982; Meshaka et al. 2004a), Red-shouldered Hawk, American Kestrel (*Falco sparverius*), Loggerhead Shrike (Callahan 1982), and the Eastern Racer (Meshaka et al. 2004a). Dean et al. (2006) noted cannibalism in this species.

Threats.—Native lizards such as the Green Anole, Six-lined Racerunner, Southeastern Five-lined Skink (*Plestiodon inexpectatus*), and the Florida Scrub Lizards (*Sceloporus woodi*) were considered to be likely at risk from this geographically rapidly expanding species, especially in the least human-modified habitats (Smith and Engeman 2004a; Meshaka et al. 2005b). Population densities of the Brown Anole were negatively affected by the depredations of the Northern Curlytail Lizard (Callahan 1982). Diet of the Northern Curlytail Lizard overlapped that of the Brown Anole, and the species might also have been a superior competitor of the Brown Anole for food (Callahan 1982). This species is in turn negatively impacted by a wide range of predators, including the exotic Madagascar Giant Day Gecko. An individual from Juno Beach, Palm Beach County, was entangled in a metal ring, which encircled its body just above its waist (Dean et al. 2005). Many lizards were killed in a Boynton Beach colony when resurfacing the parking lot filled in the many refugia (Smith and Engeman 2004a), such that on three sides of the study area 86%, 88%, and 91% of the once active burrows were entombed within a few days (Smith and Moore 2009b). Feasibility of its eradication in Florida was discussed by Engeman et al. (2009c).

LEIOCEPHALUS SCHREIBERSII (GRAVENHORST 1837) — RED-SIDED CURLYTAIL LIZARD

Description.—The dorsum is brownish gray in color, and the sides are marked with dark red and lightly colored spots (Conant and Collins 1998; Meshaka et al. 2004a). As described by Bartlett and Bartlett (1999), males are more brightly colored than females and juveniles. Red bars are present on the flanks with pale blue patches between them. Turquoise may be present on the front and rear limbs. Females and juveniles are paler in color than males and have about eight dark transverse bars crossing the dorsum (Fig. 86).

Distribution.—The Red-sided Curlytail Lizard is a West Indian species whose first documentation in Florida is from Miami-Dade County (Wilson and Porras 1983). The colony had been in existence since 1978 but appeared to no longer exist after habitat modification in 1981 (Wilson and Porras 1983). The first colony gave rise to another colony in Miami Lakes (Wilson and Porras 1983). In southern Florida, past records are from

FIGURE 86. Red-sided Curlytail Lizard (*Leiocephalus schreibersii*) from Haiti. (Photographed by Suzanne Collins).

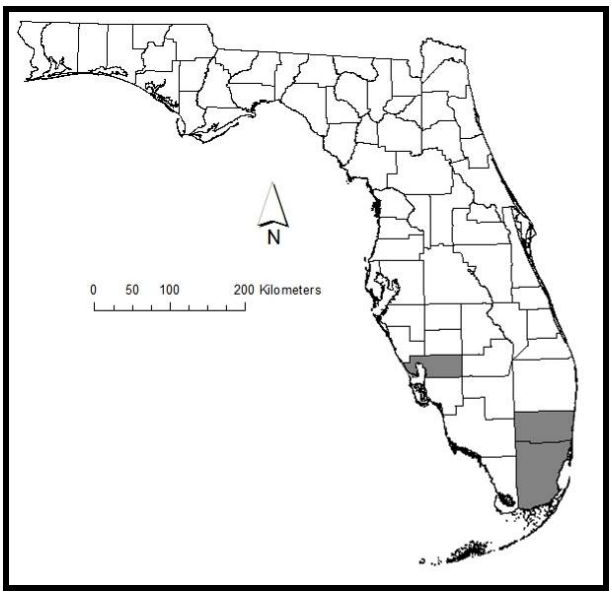

FIGURE 87. Geographic distribution of the Red-sided Curlytail Lizard (*Leiocephalus schreibersii*) in Florida.

Broward (Bartlett and Bartlett 1999) and Miami-Dade counties (Bartlett 1994; Meshaka et al. 2004a), and reports are from Miami-Dade County (Meshaka et al. 2004a). After Meshaka et al. (2004a) went to press, a subsequent record appeared for Broward County in southern Florida (Townsend et al. 2002). More recent records of the Red-sided Curlytail Lizard are from Charlotte (Krysko et al. 2005) and Miami-Dade (Krysko and Burgess 2008) counties (Fig. 87).

Body size.—The smaller of the two Curlytail Lizards in Florida, males of this species occasionally reached 254 mm TL, and females have reached 216 mm TL (Bartlett and Bartlett 1999).

Habitat and abundance.—The North Miami population inhabited a railroad track in a residential area (Meshaka et al. 2004a). In Punta Gorda, individuals were seen on sandy areas along a fence line (Krysko et al. 2005). The Homestead, Miami-Dade County, colony is well-established and appeared to be expanding in range (Krysko and Burgess 2008).

Diet.—The Red-sided Curlytail Lizard described as primarily insectivorous (Meshaka et al. 2004a). Its diet in Florida remains in need of study.

Growth and survivorship.—In Punta Gorda, numerous hatchlings were observed in June (Krysko et al. 2005).

Predators.—The Red-sided Curlytail Lizard might be susceptible to the many of the same predators as the Northern Curlytail Lizard and perhaps more so in light of its smaller adult body size.

Threats.—The Red-sided Curlytail Lizard has long been restricted in its Florida geographic distribution. Disparate recently discovered colonies warrant concern regarding the potential for subsequent geographic dispersal of this species.

VARANUS NILOTICUS (LINNAEUS 1758) — NILE MONITOR

Description.—Adults are dark in color with lighter bands and stippling. Juveniles are boldly patterned in black and gold to yellow (Fig. 88).

Distribution.—The Nile Monitor is an Old World species that whose first documentation in Florida was from isolated reports in central Florida (Meshaka et al. 2004a); however, specimens necessary to make the claim of establishment were not available to Meshaka et al. (2004a), and so the authors listed the status of this species as uncertain. That same year, Enge et al. (2004c) confirmed establishment of the Nile Monitor in Cape Coral, Lee County. This colony dated back to about 1990 (Enge et al. 2004c). The species is common in the pet trade (Meshaka 2006). In southern Florida, the Nile Monitor has been recorded in Lee County, and reports are from Broward and Miami-Dade counties, the latter two counties of which the species was probably not reproducing (Enge et al. 2004c).

Elsewhere in Florida, records of the Nile Monitor exist from Orange County (Enge et al. 2004c; Fig. 89). At the time of this writing, the Nile Monitor appeared to have been limited toa single large area of Lee County where it is very well established. Its popularity in the pet trade, often ending at adult size, its penchant for canals, and a large trophic breadth lead me to suggest that this species will soon follow the colonization path of the Green Iguana.

Body size.—Enge et al. (2004c) noted a 1500 mm TL male and 520 mm SVL female Nile Monitor from Cape Coral.

Habitat and abundance.—In Cape Coral, the Nile Monitor was most closely associated with residential areas but individuals were also seen along canals (Enge et al. 2004c). Individuals have also been seen swimming to shore from mangrove islands (Enge et al. 2004c).

FIGURE 88. A Nile Monitor (*Varanus niloticus*). (Photographed by Richard D. Bartlett).

Diet.—In Cape Coral, the Nile Monitor chased ducklings and Brown Anoles, and ate Goldfish (*Carassius auratus*), a rabbit (*Sylvilagus* sp.), grubs, and eggs of the Brown Anole (Enge et al. 2004c).

Reproduction.—In August, a female contained eight well-developed eggs (Enge et al. 2004c). In captivity, eggs incubated for six to 10 months (Meshaka 2006).

Growth and survivorship.—Enge et al. (2004c) collected a 131 mm SVL hatchling in October (Enge et al. 2004c). In captivity, individuals were sexually mature in about three years (Meshaka 2006).

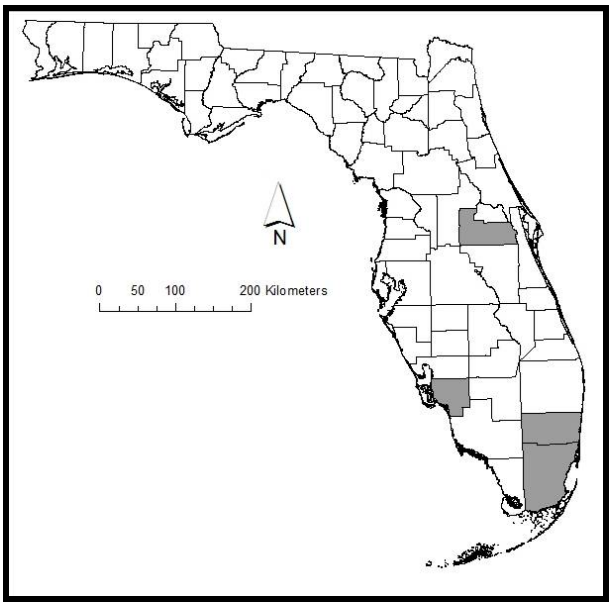

FIGURE 89. Geographic distribution of the Nile Monitor (*Varanus niloticus*) in Florida.

Predators.—The American Alligator was a potential predator of the Nile Monitor (Meshaka 2006).

Threats.—The degree to which the Nile Monitor can colonize natural habitat arguably warranted immediate investigation in light of its trophic position (Meshaka 2006). Likewise, its potential for negatively impacting legally considered at-risk species was a concern (Enge et al. 2004c; Meshaka 2006). The extent to which the Nile Monitor could invade natural systems could have depended in large part on the degree to which it would be threatened by the American Alligator (Meshaka 2006). Because of its large body size and carnivory, Enge et al. (2004c) raised the concern that the Nile Monitor could negatively impact sensitive species and native wildlife. Feasibility of its eradication in Florida was discussed by Engeman et al. (2009c).

RAMPHOTYPHLOPS BRAMINUS (DAUDIN 1803) — BRAHMINY BLIND SNAKE

Description.—As described by Conant and Collins (1998) and Meshaka et al. (2004a), the body is grayish black. The head and neck are similarly thick, and the tail is pointed (Fig. 90).

Distribution.—The Brahminy Blind Snake is an Old World species whose first documentation in Florida is from three separate localities in Miami-Dade County, the earliest record of which was from South Miami (Wilson and Porras 1983). In southern Florida, past records are from Broward (Meshaka et al. 2004a), Highlands (Meshaka et al. 2004a), Lee (Meshaka et al. 2004a), Miami-Dade (Enge et al. 2004b; Meshaka et al. 2004a), Monroe (Big Pine Key, Key Vaca, Key West; Meshaka et al. 2004a), Palm Beach (Meshaka et al. 2004a), and Sarasota (Meshaka et al. 2004a) counties, and reports are from Miami-Dade (Meshaka et al. 2004a), Monroe (Key West; Lazell 1989), and Palm Beach (Meshaka et al. 2004a). After Meshaka et al. (2004a) went to press, a subsequent record appeared for Monroe (Stock Island) County in southern Florida (Collins and Collins 2002). More recent records of the Brahminy Blind Snake are from Charlotte (Klowden and Olson 2007) and Collier (Marco Island; Krysko et al. 2005) counties.

Elsewhere in Florida, records of the Brahminy Blind Snake exist from Alachua (Meshaka et al. 2004a), Brevard (Grace and Van Dyke 2004), Hillsborough (Hennessy and Michalak 2004), Orange (Meshaka et al.

FIGURE 90. A Brahminy Blind Snake (*Ramphotyphlops braminus*) from Palm Beach Co., Florida. (Photographed by Suzanne Collins).

2004a), Pinellas (Meshaka et al. 2004a), and Seminole (Meshaka et al. 2004a) counties, and reports are from Leon County (Meshaka et al. 2004a). After Meshaka et al. (2004a) went to press, a subsequent record appeared for Alachua County in central and northern Florida (Townsend et al. 2002). More recent records of the Brahminy Blind Snake are from Alachua (Somma 2007), Brevard (Krysko et al. 2005), Citrus (Krysko et al. 2005), Hernando (Godley et al. 2009), Lake (Fairchild and Enge 2008), Leon (Krysko et al. 2005), Pasco (Wallach 2008), and Volusia (Somma and Skelley 2007) counties (Fig. 91). The Brahminy Blind Snake also occurs as an established exotic species elsewhere in the United States (Meshaka 2008a).

Body size.—The Brahminy Blind Snake is the smallest of the exotic snakes established in Florida. Two adults (113.3 and 137.9 mm TL) were measured from south Miami, Miami Dade County (Meshaka et al. 2004a).

Habitat and abundance.—In ENP, the Brahminy Blind Snake was occurred in the Hole-in-the-Donut area and Royal Palm Hammock (Meshaka et al. 2000). In Miami Dade County, the Brahminy Blind Snake occurred in pine rockland habitat of county parks (Enge et al. 2004b). Meshaka et al. (2004a) found this species in Brazilian Pepper stands, Australian Pine stands, disturbed tropical hardwood hammock, pinelands, and residential areas. Meshaka et al. (2004a) found individuals under logs, rocks, and trash and in nests of Florida Carpenter Ants (*Camponotus abdominalis floridanus*). In Miramar, Broward County, an individual inhabited the palm boot or sheath of a Washington Palm nearly 2 m above the ground (Meshaka et al. 2008a). Hennessy and Michalak (2004) collected an individual from leaf litter in Tampa, Hillsborough County. Grace and Van Dyke (2004) found an individual under decaying pine needles in a garden in West Melbourne, Brevard County. The species used termite mounds in Gainesville (Somma 2007).

Diet.—The pupae of ants and termites comprised the diet of the Brahminy Blind Snake in Florida (Meshaka et al. 2004a).

Reproduction.—Two adults from south Miami of this all-female species were collected in May, one with two

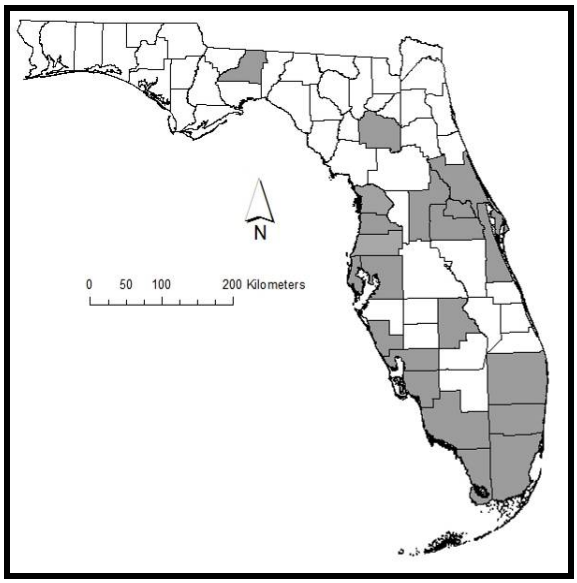

FIGURE 91. Geographic distribution of the Brahminy Blind Snake (*Ramphotyphlops braminus*) in Florida.

yolked follicles and another with six very small ovarian follicles (Meshaka et al. 2004a).

Activity.—A fossorial species in Florida (Meshaka et al. 2004a), individuals were seldom seen in the open. However, heavy rain can force individuals to the surface of the ground.

Predators.—In southern Florida the Brahminy Blind Snake was eaten by the Cane Toad and Puerto Rican Crested Anole (Meshaka et al. 2004a). In Hernando County, and individual had been eaten by a Short-tailed Kingsnake (*Lampropeltis extenuata*; Godley et al. 2009).

Threats.—The Brahminy Blind Snake is at risk to the depredations of the Cane Toad and Puerto Rican Crested Anole, presumably after rains.

BOA CONSTRICTOR LINNAEUS 1758 — BOA CONSTRICTOR

Description.—This is a thick-bodied snake, whose body is heavily patterned in shades of brown and vertebrally marked in brown saddles (Fig. 92).

Distribution.—The Boa Constrictor is a New World species whose first documentation in Florida is from Miami-Dade County, where it thought by Dalrymple (1994) to have been breeding. Butterfield et al. (1997) noted the species from the same site. Meshaka et al. (2004a) noted the existence of a specimen from Miami-Dade County in the FLMNH but did not feel that the aforementioned data were sufficient for them to confirm its establishment in Florida. Consequently, the species was listed by the authors in a section of uncertain status. Providing evidence of mixed-size-classes and corroborating the extensive observations of the species at the Deering Estate, Snow et al. (2007a) provided the evidence necessary to for me to include the species as established in Florida. In southern Florida, past records are from Miami-Dade County (Snow et al. 2007a), where it has occurred in extreme southeastern mainland Florida, apparently since the 1970s (Fig. 93). Its establishment was associated with the pet trade.

Body size.—The largest individual measured by Snow et al. (2007a) was approximately 2510 mm TL.

Habitat and abundance.—In south Florida, the Boa Constrictor inhabited the tropical hardwood hammock, pine rockland, and the nearby human-disturbed areas of a park (Snow et al. 2007a).

Diet.—Snow et al. (2007a) reported a Boa Constrictor captured in August that had eaten a Virginia Opossum (*Didelphis virginiana*).

Reproduction.—In southern Florida, live birth occurred in May and June, and young of the year appear in August and September such that 86% of all captures during those months were young of the year (Snow et al. 2007a).

Activity.—Most captures of Boa Constrictors at the Deering Estate took place during the day, but Snow et al.

FIGURE 92. A juvenile Boa Constrictor (*Boa constrictor*) from Miami, Miami-Dade Co., Florida. (Photographed by Richard D. Bartlett).

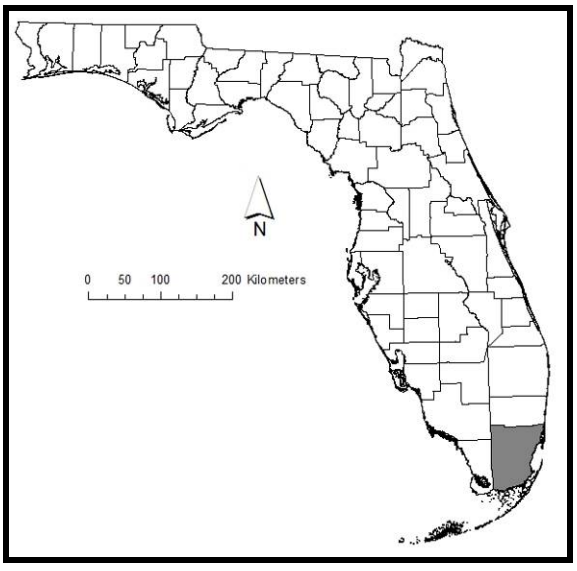

FIGURE 93. Geographic distribution of the Boa Constrictor (*Boa constrictor*) in Florida.

FIGURE 94. Burmese Pythons (*Python bivittatus*) from Everglades National Park, Monroe Co., Florida including an adult female brooding her eggs (lower left). (Photographed by Richard D. Bartlett [upper left] and Mike Rochford [right and lower left]).

(2007a) noted the limited access to the park for research at night.

Predators.—The Eastern Indigo Snake is the likeliest predator of the Boa Constrictor at the Deering property.

Threats.—This large constrictor was a potential threat to a wide range of vertebrates but was also subject to fire, presumably from prescribed burns in the pine rockland of the Deering Estate (Snow et al. 2007a).

PYTHON BIVITTATUS KUHL 1820 — BURMESE PYTHON

Description.—This is a thick-bodied snake, whose body is patterned heavily in tan, brown, and white (Meshaka et al. 2004a; Fig. 94).

Distribution.—The Burmese Python is an Old World species whose first documentation in Florida is from ENP, Miami-Dade and Monroe counties, where most records came from the saline glades of ENP (Meshaka et al. 2000). A steady stream of observations during the 1990s, especially at the southern end of the park, mixed size classes, and vouchers, all from a region of the park that to the present day continues to support this species made the case for Meshaka et al. (2000). In November 1997, I received an individual from the shooting range in East Everglades. In southern Florida, past records are from Miami-Dade (Meshaka et al. 2004a) and Monroe (Meshaka et al. 2000, 2004a) counties and past reports are from Miami-Dade County (Meshaka et al. 2004a). More recent records are from Collier (Snow et al. 2007a), and Monroe (mainland; Snow et al. 2007a, and Key Largo; Greene et al. 2007) counties, and reports are from Broward County (Snow et al. 2007a). Key Largo has been the site of more collections of this species. Since the early 2000s, numbers of individuals found and locations rapidly increased (Snow et al. 2007a)

suggestive of aggressive geographic expansion in southern Florida (Fig. 95). It has become more commonly encountered along Loop Road and on SR-92 near Collier Seminole State Park (Tad Bartareau, pers. comm.). Two models were used to predict the potential geographic distribution of this constrictor outside of its native range. With respect to the United States, the model by Rodda et al. (2008) predicted suitable conditions beyond Florida that included the southeastern United States. A subsequent model that used 19 climatic variables predicted a Florida range that did not extend beyond its current distribution and separate suitable habitat in extreme southern Texas (Pyron et al. 2008).

FIGURE 95. Geographic distribution of the Burmese Python (*Python bivittatus*) in Florida.

Body size.—The Burmese Python is Florida's largest snake. In southern Florida, individuals measured up to 4570 mm TL (mean = 2180 mm TL), and most individuals ranged from 3000−3240 mm TL (Snow et al. 2007a). The largest female thus far reported from southern Florida measured 4870 mm TL (Krysko et al. 2008c).

Habitat and abundance.—Through 2001, mixed size-classes of this species were seen primarily but not exclusively, in the saline glade region of ENP, especially in the vicinity of West Lake (Meshaka et al. 2000, 2004a). Outside of the park, individuals were also seen in the mangrove fringe of Miami-Dade County (Meshaka et al. 2004a). Since that time, individuals have appeared in abundance farther inland and to northern reaches of ENP (Meshaka et al. 2004a; Snow et al. 2007a; Wil Hyde, pers. comm.; William Loftus, pers. comm.; Ken Rice, pers. comm.; Ray Snow, pers. comm.), many of the habitats were freshwater glades (Snow et al. 2007a), which underscored a meteoric increase in abundance and expansion of the Burmese Python in its southern Florida distribution from a colony that most certainly had established by the 1990s.

Diet.—A male from West Lake, ENP, contained the remains of a Gray Squirrel (Meshaka et al. 2004a). Popularized in the media, a large Burmese Python died with a large American Alligator in its stomach and remains from other stomachs included those of a Bobcat and wading birds. From southern Florida specimens, Snow et al. (2007a) listed rabbits (*Sylvilagus* sp.), Hispid Cotton Rats (*Sigmodon hispidus*), Gray Squirrels, Raccoons, Virginia Opossums, Round-tailed Muskrats (*Neofiber alleni*), Rice Rats (*Oryzomys palustris*), Domestic Cats, unidentified mammals, Pied-billed Grebes (*Podilymbus podiceps*), House Wrens (*Troglodytes aedon*), Limpkins (*Aramus guarauna*), White ibis (*Eudocimus albus*), and unidentified birds as prey of the Burmese Python. Other items in its diet from ENP include the Cotton Mouse (*Peromyscus gossypinus*), Fox Squirrel (*Sciurus niger*), Old World rats (*Rattus sp.*), Virginia Opossum, White-tailed Deer (*Odocoileus virginianus*), Key Largo Woodrat (*Neotoma floridana smalli*), and Domestic Goose (*Anser sp.*) (Snow et al. 2007b). In light of its attack on American Alligators, the Burmese Python is a potential predator of the Spectacled Caiman (Meshaka 2008a).

Reproduction.—The left testis of a 2880 mm SVL male in November from ENP measured 310 X 30 mm (Meshaka et al. 2004a). In southern Florida, the species was gravid during January-April (Krysko et al. 2008c). During 5 March-26 April 2004, four females from in or near ENP contained 35−46 large but unshelled oviductal eggs (Snow et al. 2007a). Clutch size estimates based on oviductal egg counts ranged from 21−85 eggs in five gravid females (2980−4870 mm TL) collected during January- March 2005 and in March 2007 (Krysko et al. 2008c). The mean egg length was 52 mm (range = 49−58 mm) from one clutch of 79 eggs (Krysko et al. 2008c). Snow et al. (2007c) found a female guarding her nest in a vegetated debris pile in ENP in May 2006. The clutch size of the nest was 46 eggs and diameters of the eggs averaged 91.8 X 62.7 mm (Snow et al. 2007c). In ENP, clutch size ranged from 19−46 eggs (average = 35.8 eggs), and relative clutch mass of a subsample was 17.6% (Snow et al. 2007c). Hatchlings were present in June (Snow et al. 2007a).

Activity.—Meshaka et al. (2004a) noted observations of this species in mangrove forest and on roads following cold fronts. In southern Florida, activity occurred continuously though the year. Snakes were

FIGURE 96. Spectacled Caiman (*Caiman crocodiles*). (Photographed by Suzanne Collins).

primarily diurnal during October-April and primarily nocturnal during June-August (Snow et al. 2007a). This large species, not surprisingly, has made long-distance movements. In one instance, a radio-tracked male had moved 69.8 km (43 mi) in the Everglades (Harvey et al. 2008).

Predators.—In ENP, the American Alligator was a predator of the Burmese Python (Snow et al. 2006). The same was possible by the Spectacled Caiman (Meshaka 2008a).

Threats.—Meshaka (2008a) suggested that this large constrictor had the potential to become the top predator of the southern Everglades system and poses a threat to a wide range of vertebrates, including humans. Harvey et al. (2008) listed a number of sensitive species that could be at risk from the depredations of this species, not the least of which is the Key Largo Woodrat. The Burmese Python may likewise be predator and prey of the Spectacled Caiman.

Advertisements have appeared on the web that offered for sale Burmese Pythons captured from the Everglades and even illegally in ENP. Theft of federal property notwithstanding, illegal removal of these animals diminishes the accuracy of population size and structure estimates being conducted in the park that is necessary to make good management decisions and strategies. This activity also aids in future dispersal events of the Burmese Python as harvested and illegally poached animals and/or progeny escape or are released elsewhere in Florida, thereby undercutting recent efforts at their eradication. Feasibility of its eradication in Florida was discussed by Engeman et al. (2009c) and a very useful update on the methods used to study the species and results within the context of exotic species management was provided by Harvey et al. (2008).

CAIMAN CROCODILUS (LINNAEUS 1758) — SPECTACLED CAIMAN

Description.—As described by Conant and Collins (1998) and Meshaka et al. (2004a), the body is brownish gray in color and patterned in darker blotches. A distinct U-shaped ridge is present between the eyes (Fig. 96).

Distribution.—The Spectacled Caiman is a New World species whose first documentation in Florida is from Miami-Dade County (Wilson and Porras 1983). It had been known to occur in southern Florida since the 1950s (Wilson and Porras 1983) and was breeding since 1960 (Ellis 1980). In southern Florida, past records are from Broward, Miami-Dade, and Palm Beach counties (Meshaka et al. 2004a). The Homestead-Florida City population appears to be the stronghold of its presence in Florida.

Elsewhere in Florida, records of the Spectacled Caiman exist from Brevard and Seminole counties (Meshaka et al. 2004a; Fig. 97). I do not know its present status in these two northern counties. Evaluation of these northerly sites could provide critical information regarding the future of the Spectacled Caiman in Florida.

Body size.—Florida specimens rarely exceeded 2000 mm TL (Meshaka et al. 2004a).

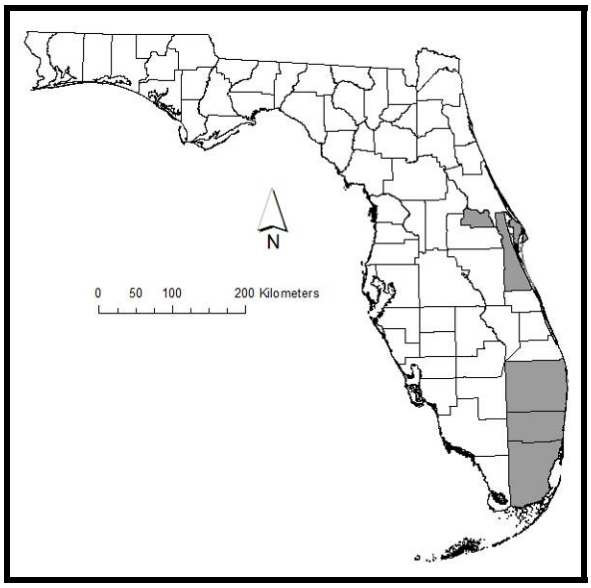

FIGURE 97. Geographic distribution of the Spectacled Caiman (*Caiman crocodilus*) in Florida.

Habitat and abundance.—The Spectacled Caiman was well-established in urban and agricultural areas on southern Miami-Dade County, where it could often be found in small weedy canals and lurking in the culverts of larger canals (Meshaka et al. 2004a). Population sizes in southern Florida had been on the rise in recent years in southern Florida (Meshaka et al. 2004a). The Spectacled Caiman had been seen in, but was not established in, ENP (Meshaka et al. 2004a).

Diet.—In Florida, Ellis (1980) reported fish, amphibians, and mammals in the diet of this species. The Spectacled Caiman was a potential predator of the Burmese Python (Meshaka 2008a). I add aquatic turtles to the list of potential prey items of this crocodilian in Florida.

Reproduction.—The Spectacled Caiman guards its nests; however, the reproductive cycle of this species in southern Florida does not seem to be known.

Activity.—In Homestead-Florida City, I have seen the species throughout the year. Meshaka et al. (2004a) noted wariness of this species. A good time to see this species is at night during the summer, and in the winter individuals can be seen basking on pond edges.

Predators.—The Burmese Python was a potential predator of the Spectacled Caiman (Meshaka 2008a).

Threats.—As a potential competitor of the American Alligator, the Spectacled Caiman presented a potential problem even while restricted in introduced habitat and geographic range (Meshaka 2008a). This crocodilian could be a predatory threat to native aquatic turtles. The Spectacled Caiman was considered to be a potential predator and prey of the Burmese Python (Meshaka 2008a) and predator of the Slider.

FLORIDA'S EXOTIC RUNAWAY TRAIN

As 2003 came to an end, 276 amphibian, reptilian, chelonian, and crocodilian species were documented as exotic introductions on a global level (Lever 2003), 64 taxa of which are introduced and established in the United States (Meshaka 2008a; Snow et al. 2007a; Collins and Taggart 1998−2008 et seq.). The 47 exotic amphibian, reptilian, chelonian, and crocodilian species in Florida as reported here are comprised of four frogs and toads, 38 lizards, one turtle, three snakes, and one crocodilian (Table 1). This exotic herpetofauna represents 24.6% of the total number of herpetofaunal species found in Florida (Meshaka and Ashton 2005). As noted previously (Butterfield et al. 1997; Meshaka et al. 2004a; Meshaka 2006), the accumulation of exotic species updated here has been rapid and has yet to be controlled, thereby representing a continuing runaway train symptomatic of Florida's exotic species problem generally. Using this herpetofaunal subset, I ask the following: Why does this phenomenon exist, where is this train going, and how can it be controlled, if at all?

GENERAL PROFILE

The typical exotic herpetofaunal species in Florida is a lizard, most likely an anole or gecko. It is also likely to be small-bodied, early maturing, and insectivorous. Typically, it is a species strongly associated with people and disturbed habitat, human-mediated or otherwise. Southern Florida is apt to be the center of its introduced distribution and its dispersal rate shows no sign of a plateau. It was most likely introduced through the pet trade. A few exceptions to this general profile exist and are glaring in their differences. For example, some of the species are large in body size, slow to mature, and are not insectivorous, such as the Burmese Python and Boa Constrictor. In some cases association with the pet

trade occurred after an initial and incidental human-mediated introduction, as in the case of the Cuban Treefrog and the Mediterranean Gecko. For some species, dispersal events within Florida can be human-mediated, accidental (e.g., Godley et al. 1981; Campbell 1996; Meshaka 1996a), or otherwise (Meshaka et al. 2004a,b).

Human-mediated dispersal of species (= exotic) has been going on for a long time in this world and for a variety of reasons. Specific to Florida, the opportunity for exotic species colonization began a long time ago, at least as early as the time of Florida's ancient Indians who traded in the Caribbean. The conquering Spanish empire brought with them their own exotic diseases as well as the plants and animals they favored, which themselves carried exotic parasites and diseases. Intentionally and unintentionally, this exotic species accumulation continues through today at frequencies unknown in the past through a combination of relentless habitat modification, isolation and marginalization of native species communities, and an astonishing array and volume of imported species. This entire restructuring of much of Florida's biotic communities has shifted from the days of isolated populations of new exotic species in recently cleared natural habitat surrounded by an intact biota. The scale has tipped, especially in southern Florida, to the inevitability of human development bringing with it an exotic fauna to long-disturbed land parcels with long-diminished native species communities (Meshaka et al. 2008a). These parcels already have the seeds of an exotic community, are benefited by the development, and rejuvenated by hitchhikers during development (Meshaka et al. 2008a). Thus, new exotic species or new populations of exotic species at a new human development are evermore likely to face off with other exotic herpetofauna than native species with which it might compete, depredate, or be depredated at some point.

One can expect to see more species entering extreme southern Florida, more species ranging northward in scattershot fashion, further development of a diverse, region-wide, even if unstable, new urban herpetofauna and, lastly, exotic encroachment into natural areas. This last phenomenon may reveal itself in two ways. First, colonization of natural areas might occur simply through opportunity as populations become established near suitable natural habitats into which individuals can subsequently disperse. Second, searching in natural habitats may detect populations of species previously thought be restricted to disturbed situations. A striking example demonstrating this last phenomenon was the discovery of the Burmese Python in Everglades National Park. Until 2000, an established population was concentrated in the extreme southern portion of the park in what was primarily mangrove forest and hammock. Soon thereafter, the snake began to appear regularly in the freshwater glade system farther north and in the Hole-in-the-Donut restoration area of Long Pine Key (Snow et al. 2007a).

FRAMEWORK TO CONTROL THIS RUNAWAY TRAIN

From the literature, it is apparent that taxonomic content, geographic patterns, ecological distributions, and dispersal agents are the best known elements of colonization dynamics of the Florida exotic herpetofauna. Less well known, however, are the types of impacts or severity of impacts among the exotic species themselves (e.g., Callahan 1982; Meshaka 2000) and between exotic species and native species (e.g., Campbell 2000; Meshaka 2001).

The framework proposed below is based on treating what is known and what is unknown about the colonization patterns of Florida's exotic herpetofauna. Some of these suggestions amplify earlier recommendations (e.g., Meshaka et al. 2004a; Meshaka and Babbitt 2005). Based on what is known about these exotic species, I recommend:

• A restriction in the pet trade of imported herpetological species to minimize the pool of potential introduced taxa. To start, species known to pose a threat to humans should not be imported into Florida, except for use by accredited zoos, or in university or museum research facilities. Alternatively, ownership of such animals could be subject to a registry. Candidate species for this category include venomous snakes, large varanid lizards and constrictors, and poison-dart frogs. Species with a moderate to high likelihood of colonization success should not be kept in Florida. Candidates for this category include boas and pythons and monitors. Taxonomic groups that are demonstrably capable of successfully colonizing Florida, even if harmless to humans, such as geckos and anoles, should likewise be removed from Florida's pet trade. Very simply, an exotic species must be *shown* to pose little if any risk to colonizing the target state *before* it can be legally traded in the United States. The Florida Fish and Wildlife Conservation Commission in conjunction with local wildlife organizations have come to support periodic amnesty days to collect exotic animals. This is a good step, and subsequent efforts at the local, state, and federal level to actively remove exotic species from urban and wilderness areas will provide quantifiable measures of success in restoration efforts. I do not make my aforementioned suggestions lightly. It is most understandable to me and I am empathetic to the fact that this suggestion may be viewed by some as too restrictive and by others not restrictive enough. I believe that my suggestions can even be improved upon. As someone who first and foremost treasures Florida's native herpetofauna and who also supports

herpetoculture, I hope that this approach I proffer will not stifle the herpetocultural business but rather redirect it in a fine-focused and eco-harmless way thereby balancing environmental stewardship with business and genuine interest in non-native herpetoculture.

• A restriction in the pet trade of native amphibian, turtle, reptile, and crocodilian species exports. The goal of this proposal is two-fold. First, to minimize opportunity for exotic species to establish by protecting native community integrity with a full compliment of potential competitors and predators that would otherwise be marginalized from what is an astonishing annual harvest of native species. Second, to protect prey species that would likewise be diminished by unnecessary harvest. In this regard, Enge (2005) quantified the depressing numbers of native herpetofauna removed each year from Florida.

• A greater funding effort to protect natural areas as functionally intact communities. Much of Florida's exotic herpetofauna is associated with disturbance. The few exotic species capable of colonizing natural habitats are generally limited in the number of such areas they can colonize. Further, functional systems exclude or negatively impact many of these exotic species. For example, high water years in Everglades National Park, which came closer to mimicking natural hydropatterns, negatively impacted populations of the Cuban Treefrog (Meshaka 2001). Unburned sandy uplands in south-central Florida were inhabited by more Greenhouse Frogs than nearby tracts that were subjected to a more natural burn regime (Meshaka and Layne 2005). Interestingly, winter prescribed burns reduced population densities of both Cuban Treefrogs and Pinewoods Treefrogs the following year; however, within two years population densities of both species returned to pre-burn levels (Tad Bartareau, unpubl. data). Cane Toads, plentiful enough that captures of 194 individuals took place during one year in a subdivision in south-central Florida, were absent in adjoining sandy uplands (Meshaka et al. 2006a). Likewise, the Brown Anole, established around the main buildings at the Archbold Biological Station in the town of Lake Placid, was absent in adjoining frequently burned and more natural scrub (James N. Layne and Walter E. Meshaka, unpubl. data). The same pattern has held true for this lizard, where it has been absent in managed sandhill habitat owned by the University of South Florida but was ubiquitous in the surrounding developed area even up to the fence between the research area and a main road (Mushinsky 1985; Henry R. Mushinsky, pers. comm.).

• I propose a statewide grade school curriculum on *Florida Ecology* to instill and strengthen a collective ethic among students with respect to environmental stewardship. A *Florida Ecology* program could easily and logically be partnered with adjacent state parks, many of which have interpretive and education staff. This would allow younger students to "graduate" to the *Parknership* program, which successfully links universities with state parks and has produced positive results in training young biologists in the field of ecology. *Parknership* has used state parks in a way fully compatible with state park mission statements relating to successful stewardship of the natural resource. Clearly, a gradual system of education that introduces younger students with state parks and maintains that relationship through university-level involvement holds the greatest promise of benefit to all parties involved- students, native herpetofauna, and the natural environment.

WHAT WILL THIS FRAMEWORK PROVIDE?

These four recommendations will:

• Decrease dispersal events of herpetofauna into Florida, both numbers of exotic species and numbers of attempts by those species.

• Decrease the ability of exotic herpetofauna to establish once they have dispersed to Florida.

• Instill and fortify a public will to value and protect indigenous environments and their native wildlife.

THE UNKNOWN

Life history study, through counts and collections, is necessary in a way that tests correlates of successful colonization. This includes geographic distribution and comparison with native populations.

What will that provide?—This recommendation will:

• Provide a measure of likelihood of colonization success

• Identify and quantify impacts.

• Provide answers regarding the extent to which an exotic species can be eradicated and how best such and eradication might be accomplished.

Why this approach?—

• Species studies provide the biologically sound information necessary to implement the sorts of public policies that can minimize the numbers of exotic species and individuals of those species, thereby creating an

engineer, as it were, to return some semblance of order to this runaway train we now call the Florida exotic herpetofauna.

POST SCRIPT

After this manuscript was in press, there were reports that three new species became established in Florida. Data associated with these three publications met the criteria for establishment used in this manuscript, and I consider them established in Florida.

African Five-lined Skink- *Trachylepis quinquetaeniata* (Lichtenstein 1823): St. Lucie County (Krysko et al. 2010).

Oustalet's Chameleon- *Furcifer oustaleti* (Mocquard 1894): Miami-Dade County (Guillett et al. 2010).

Northern African Python- *Python sebae* (Gmelin 1789): Miami-Dade County (Reed and Rodda 2009).

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Contents