

ARTICLES

STATUS OF THE EASTERN INDIGO SNAKE (*DRYMARCHON COUPERI*) ON ST. VINCENT NATIONAL WILDLIFE REFUGE, FRANKLIN COUNTY, FLORIDA

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Introduction

The Eastern Indigo Snake (*Drymarchon couperi*) was federally listed as a Threatened Species in 1978, under the Endangered Species Act of 1973 (Speake 1993). Eastern Indigo Snake population declines have been attributed primarily to habitat loss (Speake 1993). Additional losses have been attributed to commercial exploitation and incidental death from "gassing" of Gopher Tortoise (*Gopherus polyphemus*) burrows by rattlesnake hunters (Speake 1993). Eastern Indigo Snakes formerly ranged across the southern portions of Alabama, Georgia, Mississippi, and South Carolina and throughout Florida (Speake 1993). Stable populations of this snake require large tracts of undisturbed land. With continuing land development and intensive pine monoculture throughout the southeastern United States, available lands to harbor viable populations of this reptile continue to diminish.

In 1976, researchers with the U.S. Fish and Wildlife Service, Alabama Cooperative Research Unit (ACRU), Auburn, Alabama initiated efforts to reestablish populations of the Eastern Indigo Snake within its historic range. These efforts were continued as part of the Endangered Species Recovery Plan after the snake was federally listed in 1978. St. Vincent Island, a unit of St. Vincent National Wildlife Refuge (SVNWR) located in the Gulf of Mexico near the town of Apalachicola, Franklin County, Florida (Figure 1), was selected as a site for establishing a population of these reptiles. This selection was based on its relative isolation, extent of protected habitat, (4,990 hectares = 12,360 acres) (see Speake et al. 1978), existence

of a resident *Gopherus polyphemus* colony, a prescribed fire program, and the presence of a documented, diverse herpetofauna (see Appendix 1). Although St. Vincent Island is within the historic range of the Eastern Indigo Snake, no specimens had been recorded from the island previously.

Beginning in December 1998, a collaborative relationship was forged between USFWS personnel of SVNWR and The Center for North American Herpetology to initiate winter herpetofaunal surveys on the refuge. Two preliminary visits to the island were made in December 1998. General field collecting and observations were conducted in December 1999 and January 2000 and again in December 2000 and January 2001. In April 2001, field work was undertaken to search specifically for Eastern Indigo Snakes on St. Vincent Island, employing a variety of techniques (see Methods).

Synopsis of Eastern Indigo Snake Ecology and Natural History

As the longest snake species in North America, the Eastern Indigo Snake averages 1.5–2.1 meters (5–7 ft.) in total length, with a record length of 2.63 meters (8.6 ft.) (Conant and Collins 1998). This large, smooth scaled, diurnal snake is shiny bluish to purplish-black in color; the throat, chin, and sides of head may be white, red, coral, or pinkish in color. This snake is a commensal in *Gopherus* burrows and uses them as a retreat during periods of cold winter weather and extreme summer heat. Northern populations are specifically associated with *Gopherus* burrows on

xeric sand ridges in the winter months (Moler 1992). In the warmer months, Eastern Indigo Snakes forage along the margins of wetlands. These snakes are opportunistic feeders and will consume a variety of prey, from small mammals, frogs, fish, hatchling turtles, birds, to snakes, including Cottonmouths (*Agkistrodon piscivorus*) and Eastern Diamondback Rattlesnakes (*Crotalus adamanteus*). Eastern Indigo Snakes are not constrictors, hence prey is captured, subdued, and consumed while still alive. During peak activity periods, home range size has been estimated at 50–100 ha (125–250 ac) (Moler 1992). In winter months, home ranges are restricted to less than 10 ha (25 ac) (Moler 1992) and snakes remain in close proximity to shelter (*Gopherus* burrows, stump holes, etc.). Mating takes place from November to April and 5–10 eggs are laid during May or June. After an incubation of approximately 70–80 days, the eggs hatch. Hatchlings range from 432–609 mm (17–24 in.) in length (Conant and Collins 1998).

Materials and Methods

To survey for these large, diurnally active snakes, the use of drift fence/funnel trap arrays were employed (Fitch 1987). This technique has proven effective for sampling the Texas Indigo Snake (*Drymarchon corais*) (Irwin 1993). From 26–31 December 2000, a series of eleven drift fence/funnel trap arrays were installed in favorable habitats near an original stocking site (see History of Stocking Efforts), along the ecotone of cabbage palm-live oak forest and dune ridges with active *Gopherus* burrows, along the margins of fresh water marshes and ponds, and in mesic cabbage palm-live oak hammocks. Drift fences consisted of 61 cm high by 9.1 m sections of commercially available silt fencing. Single-ended funnel traps were fashioned from ca. 4 mm x 4 mm mesh hardware cloth and placed at each end of the drift fences. Traps were checked at least once every 24 hours, and in many instances twice a day. Drift fences were activated from 2–29 April 2001.

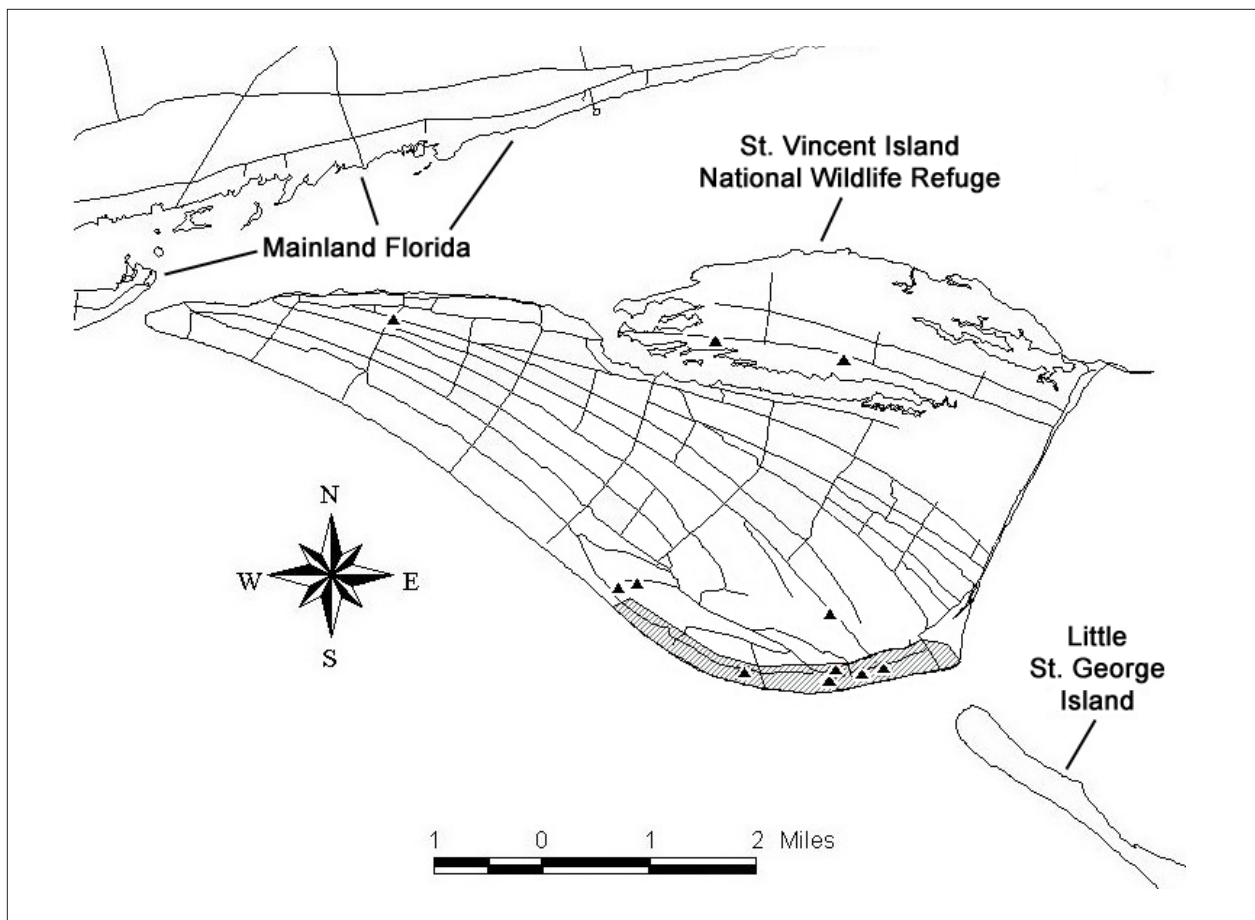


Figure 1. A map of St. Vincent Island National Wildlife Refuge, Franklin County, Florida. Lines on the island are sand or shell roads. Shaded area along the southeastern coast delineates an active colony of Gopher Tortoises (*Gopherus polyphemus*). Dark triangles indicate where fence lines and funnel traps were set during this study.

On 15 January and 31 December 2000, *Gopherus* burrows, $n = 12$ and $n = 15$ respectively, were examined using a Sony WatchCam model FDM-402A burrow video camera, with a flat black and white monitor. The video camera was inserted into *Gopherus* burrows until it reached maximum equipment range (~6 m) or the camera was obstructed and could not be moved deeper.

As part of the ongoing winter herpetofaunal survey of the refuge, artificial shelters ($n = 53$), consisting of corrugated tin or plywood sheets, were scattered throughout the island in December 1999 and January 2000. These shelters were monitored throughout the survey period. Additional survey techniques were also employed, consisting of general field collecting (i.e., turning of logs, palm fronds, etc.), observation of surface active herpetofauna, and road-cruising of refuge.

History of Stocking Efforts

Speake (1990) summarized Eastern Indigo Snake repatriation efforts throughout the historic range of this species in Alabama, Florida, Georgia, Mississippi, and South Carolina, from 1976 to 1986. Tracts of land over 3,000 ha in size were considered to be suitable for repatriation, based on radio-telemetry work on adults by Speake et al. (1978). The stocked animals came from a variety of sources: hatchlings and juveniles from a captive breeding colony, wild caught adults, snakes confiscated by state or federal authorities, and snakes donated from various sources such as zoos. A total of 40 Eastern Indigo Snakes were released on St. Vincent Island between 1980 and 1982 (Speake 1990) (Table 1).

On 20 August 1980, personnel from ACRU and the Florida Game and Freshwater Fish Commission, Endangered Species Division, (ESD) released twenty Eastern Indigo Snakes on St. Vincent Island, consisting of two adults (one male and one female) and eighteen juveniles (sex undetermined). One year later on 26 August 1981, personnel from ACRU and ESD released one adult female and four juveniles. These snakes had been taken as evidence in an

Table 1. Number of Eastern Indigo Snakes (*Drymarchon couperi*) released from 1980–1982 on St. Vincent Island, Franklin County, Florida.

	1980	1981	1982	Total
Adults	2	1	0	3
Hatchlings	18	4	15	37
Total	20	5	15	40

illegal wildlife trade investigation. On 1 September 1982, fifteen hatchlings were released; ten came from the Santa Fe Zoo, Gainesville, Florida, and five from the ACRU. All animals were released within the *Gopherus* colony located in the sand dunes along Dune Road on the southeastern corner of the island (Figure 1). Five sightings of Eastern Indigo Snakes were reported from various locations on the island in 1982, consisting of two adults and three juveniles, one of which was captured in a drift fence array (Christman 1984).

Post-Release Monitoring and Incidental Observations

Follow-up monitoring and survey efforts were undertaken between 1983 and 1990 (Speake 1990, see Table 2). These survey efforts were concentrated during the fall, winter, and spring months when snakes were expected to be found in association with *Gopherus* burrows on sand ridges. Monitoring methods for Eastern Indigo Snakes in *Gopherus* burrows included the use of a coaxial cable video camera, listening hoses (i.e., garden hose inserted into burrow), and a bionic ear device for sound amplification

Table 2. Post-release observations of Eastern Indigo Snakes (*Drymarchon couperi*) by D. Speake, USFWS refuge personnel, and hunter reports on St. Vincent Island, Franklin County, Florida. Date refers to survey dates by D. Speake; last survey in 1990. Data taken from refuge annual narrative reports 1980–2000.

Year	Date	Speake Observ	USFWS Observ	Hunter Observ	Total
1983	April	1	0	0	1
1984	Aug/Sep	0	2	0	2
1985	January	1	1	1	3
1986	February	2	0	0	2
1987	March	0	0	0	0
1988	February	1	1	0	2
1989	—	0	0	2	2
1990	March	0	0	0	0
1991	—	—	0	1	1
1992	—	—	0	0	0
1993	—	—	0	0	0
1994	—	—	1	1	2
1995	—	—	0	0	0
1996	—	—	0	2	2
1997	—	—	0	0	0
1998	—	—	0	0	0
1999	—	—	0	1	1
2000	—	—	0	1	1
Total	—	5	5	9	19

in burrows (Speake 1990). Active searching included traversing sand ridges on foot or in ATVs in search of active snakes or signs that might lead to a snake. Monitoring efforts from 1983 to September 1986 resulted in a total of 9.1 person days of search effort and a capture rate of 2.3 person days per capture. Between October 1986 and September 1989, 3.5 person days of search effort yielded a rate of 0.9 person days per capture (Speake 1990). No data were collected on movements, growth rates, and population dynamics, as originally envisioned, due to a lack of recaptures and limited amount of time spent on population monitoring (Speake 1990).

The following survey information was gleaned from SVNWR annual narrative reports. Survey efforts in 1983 produced one capture; a gravid adult female that was released in 1980. This individual had grown 102 mm, was 2032 mm in total length, and had gained 455 g in mass. Survey efforts in August and September of 1984 produced no Eastern Indigo Snakes. However, in January of 1985, 28 Gopher Tortoise burrows were surveyed using the burrow video camera and produced several observations. One Eastern Indigo Snake was captured and measured 1829 mm TL with a mass of 2.95 kg (sex not given). This individual was reportedly released in 1980 as a 457 mm TL hatchling. In addition, thirteen Gopher Tortoises, four Eastern Diamondback Rattlesnakes and one Pigmy Rattlesnake (*Sistrurus miliarius*) were observed. A *Gopherus* burrow survey in February 1986 located two adult Eastern Indigo Snakes, both weighing 3.4 kg and with total lengths of 2337 mm and 2108 mm. Survey efforts in March 1987 produced two shed skins of adult Eastern Indigo Snakes. Survey work on 3 February 1988, produced the last verifiable observation of an adult Eastern Indigo Snake on St. Vincent Island. The snake was released as a hatchling in 1980, and was 1829 mm in total length at the time of capture (sex not given). No burrow survey work was performed in 1989. The last video camera burrow survey was conducted by Speake in March 1990; no Eastern Indigo Snakes were found. It was suggested that, due to a warm winter, the snakes may have already dispersed from winter burrow refugia.

A total of five observations of Eastern Indigo Snakes by refuge personnel were reported between 1983–2000, the last occurring in 1994. However, none of these sightings were verified with either live animals or photographs. From 1985–2000, deer hunters reported nine sightings of Eastern Indigo Snakes in the months of November through January. Several of these reports were made by hunters who claimed to be familiar with this species. One of the most recent sightings, in 1999, was reported to have been 9 feet

(2743 mm) in length. None of the observations by hunters were verified with either live animals or photographs. In the absence of a live specimen or good photograph to verify these reports, we consider these observations suspect, given the possibility that some of these observations could be misidentified Eastern Racers (*Coluber constrictor*) or Coachwhips (*Masticophis flagellum*). Despite maximum size differences, these black, diurnally active snakes are often mistaken for the similarly colored Eastern Indigo Snake (Speake 1993). It is interesting to note that no recent observations or evidence of the presence of *Drymarchon couperi* have been reported by professional biologists on the refuge staff.

Summary of Field Work 1999–2001

Surveys were conducted for thirteen days during the period 24 December 1999–15 January 2000; no Eastern Indigo Snakes were observed during this time. On 15 January 2000, twelve *Gopherus* burrows were surveyed using a burrow video camera; five adult Gopher Tortoises were observed, but no Eastern Indigo Snakes were encountered. Between 19 December 2000 and 15 January 2001, surveys were conducted for a total of twelve days. On 31 December 2000, fifteen Gopher Tortoise burrows were surveyed using a burrow video camera; three adult Gopher Tortoises and two adult Eastern Diamondback Rattlesnakes were observed in burrows, but again no Eastern Indigo Snakes were located.

During April 2001, survey work specifically targeting Eastern Indigo Snakes was conducted on St. Vincent Island, employing drift fence arrays, artificial shelters, burrow camera surveys, and general diurnal and nocturnal collecting (see Methods). All four techniques proved successful in capturing amphibians, turtles, reptiles, and crocodylians (see Appendices 2 and 3). However, this survey effort failed to produce any Eastern Indigo Snakes, despite 4,546 trap-hours and 938 person-hours. It should be noted that seventeen Eastern Racers (*Coluber constrictor*) were captured in drift fence arrays (Appendix 2). This snake was quite common throughout the island, and might account for many (if not all) of the hunter observations made from 1989 to 2000.

Discussion

Previous attempts to establish a population of *Drymarchon couperi* on St. Vincent Island may have been influenced by variables such as the presence of feral livestock, climatic extremes, or an as yet unquantified limiting factor precluding natural occur-

rence on the island. Feral hogs (*Sus scrofa*) have been established on St. Vincent Island for decades. These animals originated from free ranging livestock of European settlers, and from intentional releases for the purpose of providing hunting opportunities. This exotic species can and does have serious impacts on native flora and fauna. During the survey period 1999–2001, we observed evidence of feral hog impact on ephemeral wetlands and forest floor understory plant communities. Areas as large as 50 x 50 m or greater were found where hogs had rooted up the vegetation and soil to the extent that the area had the appearance of being mechanically plowed. Hogs are omnivores, and their diet includes a wide range of plants and animals. All manner of small vertebrates are consumed—amphibians, turtles, reptiles, young crocodylians, birds, and mammals, including other hogs, armadillo (*Dasypus novemcinctus*), and fawns of white-tailed deer (*Odocoileus virginianus*) (Hellgren 1993). Therefore, the impact of this species on terrestrial and ephemeral wetland herpetofauna deserves serious consideration. During our survey work, we did not observe significant numbers of Water Snakes (*Nerodia*) or Cottonmouths (*Agkistrodon piscivorus*), taxa that inhabit the margins of freshwater habitats where feral hogs are known to forage. These snake species could potentially be a significant part of the diet of Eastern Indigo Snakes (Moler 1992) on St. Vincent Island, and may have been seriously depleted by feral hogs prior to the introduction attempt. In addition, the potential exists that hogs prey on eggs and juveniles of Eastern Indigo Snakes. Furthermore, feral hogs are predators of the eggs and young of Gopher Tortoises and marine turtles, taxa that are known to nest on the island. Thus, feral hogs negatively impact the herpetofauna of St. Vincent Island, either directly as predators and/or indirectly through habitat destruction and competition for food.

Eastern Indigo Snake releases from 1980–1982 occurred during and just after severe drought conditions on St. Vincent Island. A rainfall deficit of 163 cm (64 in.) was recorded from 1976 through 1981. The average annual precipitation on St. Vincent Island for the past 25 years (1976–2000) is just over 140 cm (55 in.). Drought conditions may have reduced potential prey species such as Water Snakes (*Nerodia*) and Cottonmouths (*Agkistrodon piscivorus*). The habit of feral hogs feeding at wetland ecotones may have suppressed already low prey densities even further. Thus, the extreme environmental conditions during 1980–1982 may have played a role in preventing the establishment of Eastern Indigo Snakes on St. Vincent Island.

Although the Eastern Indigo Snake has never

been reported as occurring on St. Vincent Island, the island is only 400 meters from the mainland at Indian Pass. It is possible that the Eastern Indigo Snake has an aversion to brackish or hyper-saline waters, thus preventing immigration from mainland populations.

Recommendations

On 30–31 May 2001, a meeting was attended by representatives from over 15 state and federal agencies, non-governmental organizations, and the timber industry in Yulee, Florida, to discuss means of protecting the Eastern Indigo Snake. This meeting reflected the need for continued efforts at restoring Eastern Indigo Snake populations in the southeastern United States.

St. Vincent Island appears to contain suitable habitat for the Eastern Indigo Snake. We think that if any extant population of this species persisted on St. Vincent Island, our survey effort should have produced evidence of its presence. Therefore, our results suggest that the stocking effort failed.

Future attempts to establish a viable population of the Eastern Indigo Snake (*Drymarchon couperi*) on St. Vincent Island might be considered once again. If such efforts are considered, we suggest that the feral hog population first be substantially reduced or eliminated altogether. Reduction or elimination of feral hogs on St. Vincent Island would also eliminate predation on the state and federally protected Gopher Tortoise and marine turtles. Habitat conditions and prey densities are part of an ongoing study by us, and the data derived therefrom will be considered in future repatriation efforts. We think St. Vincent Island should serve as a refugia for Eastern Indigo Snakes, because available mainland habitat continues to decrease due to ever-increasing human population and unchecked human development and its attendant environmental destruction.

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Appendix 1. Over the past thirty years, surveys and incidental collections have clarified the herpetofaunal diversity of St. Vincent (Island) National Wildlife Refuge (Blaney 1971, Christman 1984, Means and Lewis 1997, Means and Christman 1998, Peacock and Lewis 2000, Lewis and Collins 2000, Lewis and Irwin 2001, Lewis, Irwin, and Irwin 2001). Forty-one species were recorded during our surveys from 1998 to date. Those species denoted with an asterisk (*) were not observed by us during the course of our work. Those species denoted with a double asterisk (**) were not observed by us and are considered of questionable occurrence and in need of verification.

Salamanders (1)

Two-toed Amphiuma *Amphiuma means*

Frogs (11)

Southern Cricket Frog *Acris gryllus*
 Oak Toad *Bufo quercicus*
 Southern Toad *Bufo terrestris*
 Eastern Narrowmouth Toad *Gastrophryne carolinensis*
 Green Treefrog *Hyla cinerea*
 Pine Woods Treefrog *Hyla femoralis*
 Squirrel Treefrog *Hyla squirella*
 Little Grass Frog *Pseudacris ocularis*

Bullfrog *Rana catesbeiana***
Pig Frog *Rana grylio*
Southern Leopard Frog *Rana sphenoccephala*

Turtles (15)

Florida Softshell *Apalone ferox*
Loggerhead *Caretta caretta**
Green Turtle *Chelonia mydas**
Common Snapping Turtle *Chelydra serpentina**
Chicken Turtle *Deirochelys reticularia*
Leatherback *Dermochelys coriacea**
Gopher Tortoise *Gopherus polyphemus*
Eastern Mud Turtle *Kinostemon subrubrum*
Atlantic Ridley *Lepidochelys kempi**
Alligator Snapping Turtle *Macrochelys temminckii*
Diamondback Terrapin *Malaclemys terrapin**
Eastern River Cooter *Pseudemys concinna***
Florida Cooter *Pseudemys floridana*
Florida Redbelly Turtle *Pseudemys nelsoni*
Eastern Box Turtle *Terrapene carolina*

Lizards (5)

Green Anole *Anolis carolinensis*
Six-lined Racerunner *Aspidozelis sexlineata*
Broadhead Skink *Eumeces laticeps*
Eastern Glass Lizard *Ophisaurus ventralis*
Ground Skink *Scincella lateralis*

Snakes (26)

Cottonmouth *Agkistrodon piscivorus*
Scarlet Snake *Cemophora coccinea*
Eastern Racer *Coluber constrictor*
Eastern Diamondback Rattlesnake *Crotalus adamanteus*
Eastern Indigo Snake *Drymarchon couperi***
Eastern Corn Snake *Pantherophis guttatus*
Eastern Rat Snake *Pantherophis alleghaniensis*
Mud Snake *Farancia abacura*
Rainbow Snake *Farancia erytrogramma***
Eastern Hognose Snake *Heterodon platirhinos**
Southern Hognose Snake *Heterodon simus**
Scarlet Kingsnake *Lampropeltis elapsoides**
Common Kingsnake *Lampropeltis getula**
Coachwhip *Masticophis flagellum*
Gulf Salt Marsh Snake *Nerodia clarkii**
Plainbelly Water Snake *Nerodia erythrogaster**
Southern Water Snake *Nerodia fasciata*
Florida Green Water Snake *Nerodia floridana*
Rough Green Snake *Opheodrys aestivus*
Glossy Crayfish Snake *Regina rigida*
Black Swamp Snake *Seminatrix pygaea**
Pigmy Rattlesnake *Sistrurus miliarius*
Brown Snake *Storeria dekayi**
Eastern Ribbon Snake *Thamnophis sauritus*
Common Garter Snake *Thamnophis sirtalis*
Rough Earth Snake *Virginia striatula*

Crocodylians (1)

American Alligator *Alligator mississippiensis*

Total Possible Species: 59

Appendix 2. Herpetofaunal captures in eleven drift fence/funnel trap arrays (see Figure 1) on St. Vincent (Island) National Wildlife Refuge, Franklin County, Florida, from 2–29 April 2001.

Species	Number
Broadhead Skink (<i>Eumeces laticeps</i>)	28
Six-lined Racerunner (<i>Aspidoscelis sexlineata</i>)	18
Eastern Racer (<i>Coluber constrictor</i>)	17
Southern Leopard Frog (<i>Rana sphenoccephala</i>)	10
Southern Toad (<i>Bufo terrestris</i>)	3
Green Treefrog (<i>Hyla cinerea</i>)	3
Green Anole (<i>Anolis carolinensis</i>)	2
Coachwhip (<i>Masticophis flagellum</i>)	2
Eastern Ribbon Snake (<i>Thamnophis sauritus</i>)	2
Oak Toad (<i>Bufo quercicus</i>)	1
American Alligator (<i>Alligator mississippiensis</i>)	1
Common Garter Snake (<i>Thamnophis sirtalis</i>)	1
Eastern Diamondback Rattlesnake (<i>Crotalus adamanteus</i>)	1
Pigmy Rattlesnake (<i>Sistrurus miliarius</i>)	1
Total	
14 species	90 individuals

Appendix 3. Herpetofaunal captures under artificial shelters ($n = 53$) on St. Vincent (Island) National Wildlife Refuge, Franklin County, Florida, from 2–29 April 2001.

Species	Number
Two-toed Amphiuma (<i>Amphiuma means</i>)	4
Six-lined Racerunner (<i>Aspidoscelis sexlineata</i>)	4
Southern Leopard Frog (<i>Rana sphenoccephala</i>)	3
Green Treefrog (<i>Hyla cinerea</i>)	2
Eastern Narrowmouth Toad (<i>Gastrophryne carolinensis</i>)	1
Broadhead Skink (<i>Eumeces laticeps</i>)	1
Ground Skink (<i>Scincella lateralis</i>)	1
Pigmy Rattlesnake (<i>Sistrurus miliarius</i>)	1
Total	
8 species	17 individuals