Eradication of Introduced Carnivorous Lizards from the Cape Coral Area

Charlotte Harbor National Estuary Program
FY 2003 Research and Restoration Partners Fund

Final Report

Submitted by:

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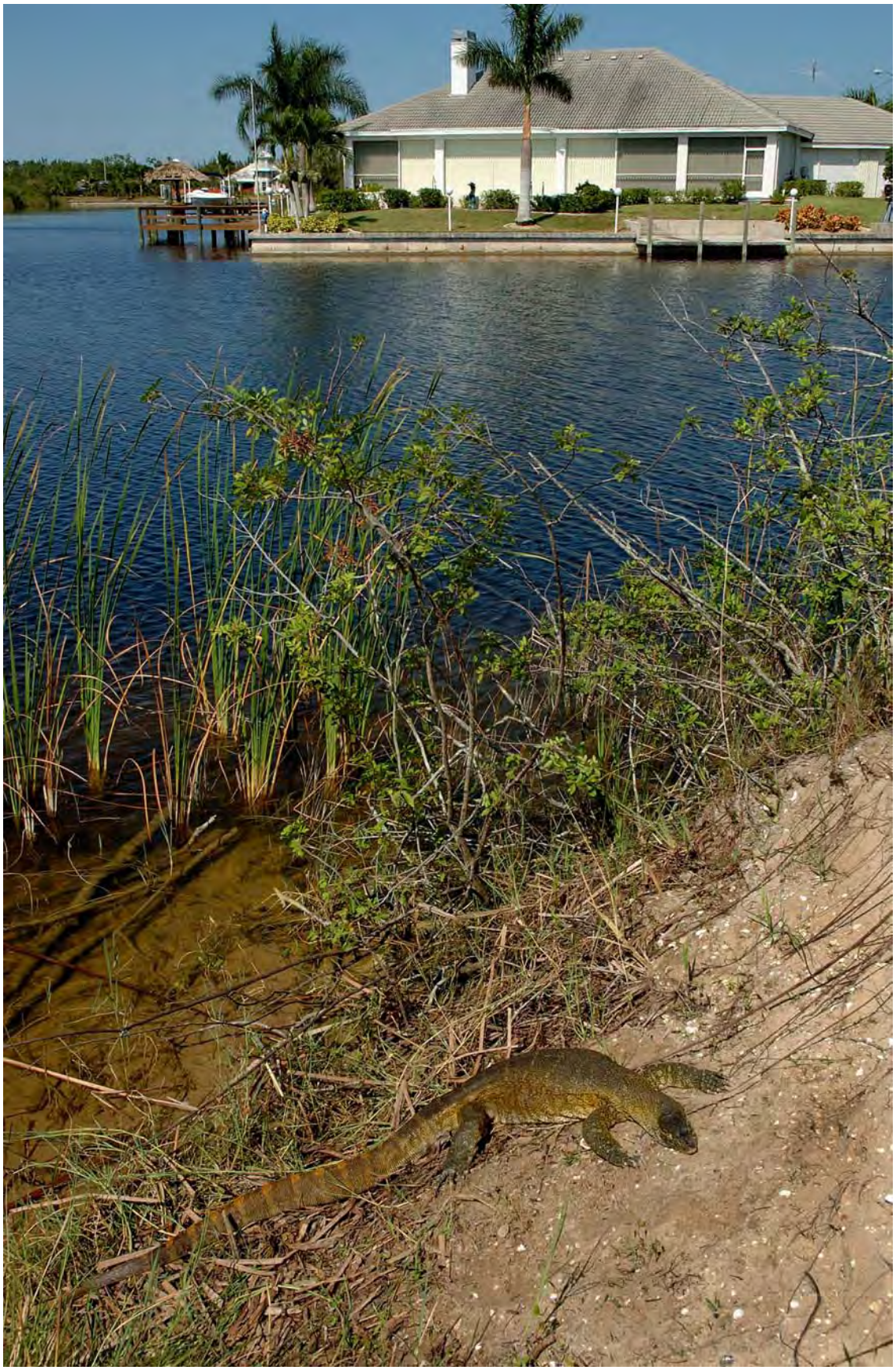
November 8, 2005

The Charlotte Harbor National Estuary Program is a partnership of citizens, elected officials, resource managers and commercial and recreational resource users working to improve the water quality and ecological integrity of the greater Charlotte Harbor watershed. A cooperative decision-making process is used within the program to address diverse resource management concerns in the 4,400 square mile study area. Many of these partners also financially support the Program, which, in turn, affords the Program opportunities to fund projects such as this. The entities that have financially supported the program include the following:

U.S. Environmental Protection Agency
Southwest Florida Water Management District
South Florida Water Management District
Florida Department of Environmental Protection
Florida Coastal Zone Management Program
Peace River/Manasota Regional Water Supply Authority
Polk, Sarasota, Manatee, Lee, Charlotte, DeSoto and Hardee Counties
Cities of Sanibel, Cape Coral, Fort Myers, Punta Gorda, North Port, Venice and Fort Myers Beach
and the Southwest Florida Regional Planning Council.



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This report should be cited as: Campbell, T. S. 2005. Eradication of Introduced Carnivorous Lizards from the Cape Coral Area. Final Report to the Charlotte Harbor National Estuary Program, 1926 Victoria Avenue, Ft. Myers, Florida 33901. 30 pp.

Executive Summary

The Nile monitor (*Varanus niloticus*), an African lizard, is established in Cape Coral, Florida. These large, intelligent, carnivorous lizards pose a significant threat to the myriad native species that many local nature preserves were established to protect. With funding from the Charlotte Harbor National Estuary Program (CHNEP) and the National Fish and Wildlife Foundation (NFWF), I set out to learn as much as possible about this new invader and assess the feasibility of eradicating it from Cape Coral and the surrounding area. A multi-agency team was established, consisting of various university, federal, state, county, and city personnel.

Field surveys for lizards and their burrows, tracks, and sign were conducted to determine their general distribution in the Cape, but were ineffective for locating and capturing lizards. An emergency response program was established, employing local press releases designed to motivate the public to report lizard sightings. Workers set Havahart live traps baited with squid along canal banks in areas which numerous reports indicated a significant lizard problem. Up to 30 traps were set on any given date. The lizards were ethically euthanized and later dissected to reveal their reproductive cycle, diet, and parasite load and to harvest tissues for later demographic, genetic, and ecotoxicological analyses. This report represents a preliminary analysis of these data.

Over 100 Nile monitors were captured and euthanized during this study, ranging in size from hatchlings up to large males nearly 2 meters in length and over 12 kilograms in mass. Captured lizards had surprisingly few external or internal injuries or parasites, and nearly all were in very good condition. In Cape Coral, Nile monitors reproduce between April and September and hatchlings appear mainly between February and April. Stomach content analyses and incidental observations revealed that their diet is extremely broad, including many taxa of aquatic and terrestrial invertebrates and vertebrates, whole clutches of reptile and bird eggs, and one adult Florida burrowing owl.

This study demonstrates that Nile monitors are firmly established and breeding in Cape Coral. It was not possible to quantitatively estimate the size of this population from the trapping and removal data. However, given the large number of lizards collected from this small area, the Cape Coral population was likely in excess of 1000 individuals during this study. This population was thought to be largely confined to the southwest quadrant of Cape Coral, but results of this study indicate they are established on Pine Island, are capable of reaching Sanibel Island, and are moving northward along the west coast of Cape Coral. Sightings in other locations (e.g., Orlando and Miami) indicate they are being released, and could become established, in many other locations.

The emergency response program was effective for finding and capturing lizards and resulted in significant local, national and international media exposure and numerous invited speaking engagements, and instigated a major symposium at a national scientific meeting. In my opinion, eradication of this species from southwest Florida remains possible, but success will likely require funding to support a large team of trappers working for at least two years, a significant public education and volunteer program, and substantial involvement of local stakeholders. As a result of data collected during this project, the Nile monitor is now being considered as a test case species in a newly established rapid response and eradication effort for introduced species in south Florida.

Introduction

Introduced species are second only to habitat alteration in their negative effects on native species, habitats, and even whole ecosystems (Parker et al. 1999). Large, introduced predators such as feral cats and mongoose often obliterate native fauna, especially on islands (Mack et al. 2000). Many non-native species have become established in Florida, often resulting in devastating ecological impacts (Simberloff et al. 1997).

By 1990, a large African lizard, the Nile monitor (*Varanus niloticus*), was established in southwestern Cape Coral, Lee County, Florida (Enge et al. 2005). The source of this population remains unknown, but two scenarios for establishment are possible: 1) individual lizards were released by irresponsible pet owners that became incapable of managing these large, aggressive animals, or 2) a pet trader intentionally released enough individuals to ensure the establishment of this species so they could cull from the local population and thus avoid the costs of purchasing captive-bred individuals and/or avoid the costs and regulatory aspects of importing this species. Since 2000, Kraig Hankins at the City of Cape Coral has been cataloging and mapping Nile monitors and green iguana (*Iguana iguana*) sightings reported by residents and Lee County Animal Control personnel, and over 200 sightings had been reported by 2002.

A large Cape Coral Nile monitor captured by Lee County Animal Control in 2003.

These intelligent, carnivorous lizards often attain total lengths of over two meters and are able to subdue, kill, dismember, and swallow fairly large prey items. Cooperative hunting and nest robbing has been observed in this species (Lenz 2004). In their native lands, they consume a wide range of freshwater, marine, and terrestrial prey, including shellfish, insects, spiders, mollusks and other invertebrates, fish, amphibians, reptiles, birds, bird eggs, and mammals (Lenz 1995, 2004). These semi-aquatic lizards are excellent swimmers, but also make trails, excavate burrows, and reproduce in terrestrial habitats. They excavate their own burrows for cover and reproduction, but will take over and improve burrows of other species. They reach sexual maturity in two years, lay 50-60 eggs per clutch per year, and migrate large distances over land or water. Moreover, this species occurs in high enough densities in its native Africa (40-60 per square km) that it is exploited for food and leather, with over 180,000 skins per year exported from

Mali (de Buffrenil and Hemery 2002). These characteristics, among others, make this species a superior invader and potential pest.

In their native lands, Nile monitors are abundant in developed areas adjacent to coastline habitats such as marshes and mangroves (Lenz 1995, 2004). Cape Coral is a residential area built around a network of man-made canals and flanked by coastal mangrove and marsh habitats. An increasing number of sightings by Cape Coral residents and local biologists of lizards from all age-classes and active burrows indicate this population is reproducing and expanding its range (Figure 1). Although these lizards are most abundant along canal banks in Cape Coral, local fishing guides and reptile enthusiasts often observe them in the tidal creeks, mangroves, and marshes of the adjacent Charlotte Harbor State Buffer Preserve and Matlacha Pass National Wildlife Refuge (NWR), which have impressive populations of wading birds and other wildlife.

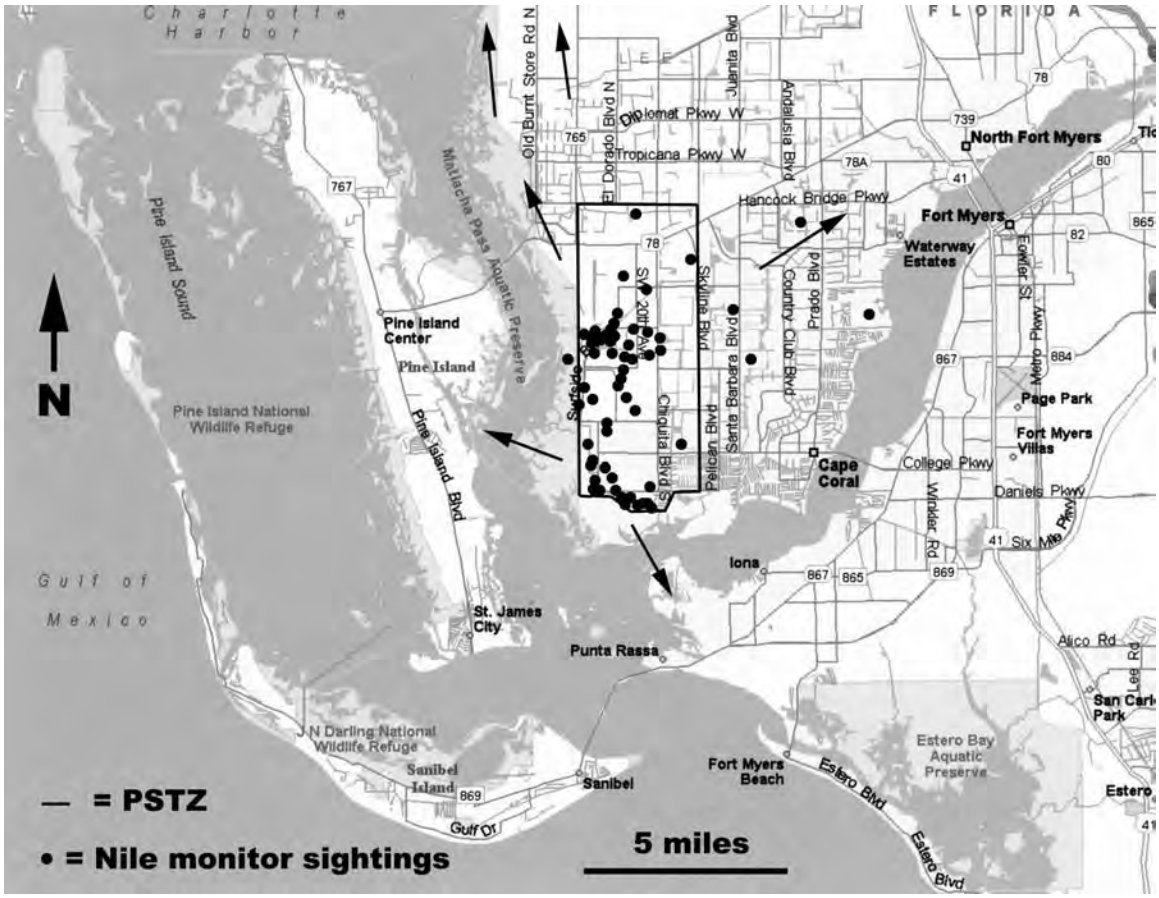

Figure 1. Map of the study area showing Nile monitor sightings as of 2002 (dots) and the boundary of the Primary Survey and Trapping Zone (PSTZ) where survey and trapping efforts were concentrated (source: 2002 CHNEP proposal).

Although it might seem that this species should have spread more widely since being introduced prior to 1990, even the most prolific invasive species tend to "simmer" for many years before entering their exponential phase of expansion (Shigesada and Kawasaki 1997). Moreover, during the winters of 2000-2002, more than 50 of these

lizards were captured and sold by a local pet trader (K. Hankins, pers. comm.), which may have slowed their numerical and geographical expansion somewhat. However, this apparent lag may be an artifact of the paucity of information about this invasion.

Until recently, anecdotal evidence suggested this species was restricted to the residential area of Cape Coral. In fact, during the time between a public request for information in July 2002 (a press release by the City of Cape Coral) and field surveys in August 2002, only one had been sighted north of Pine Island Road (SR 78), few had been recorded in mangroves surrounding Cape Coral, and none had been sighted far from Cape Coral proper (Enge et al. 2004, K. Hankins, pers. comm.). However, during preliminary field surveys and numerous interviews with the public starting in August 2002, Cape Coral residents, recreational boaters, fishing guides, and the Chiquita Lock operator indicated they regularly observed large lizards in the Spreader Canal and adjacent tidal creeks, five more were sighted north of Pine Island Road, and three were sighted on Pine Island itself, confirming the fears that this species would eventually cross wide estuaries and become established on coastal islands. The above facts were the impetus for my attempts at acquiring funding for a preliminary study and eradication attempt (this project).

More often than not, the presence and negative effects of introduced species are not even discovered until the populations become firmly established and the cost and effort required for eradication become prohibitive (Myers et al. 2000). In this project, I attempted to eradicate, or at least find the means to effectively control this population before it is able to spread farther into the Charlotte Harbor Aquatic Preserve system and reaches the Ding Darling NWR, and beyond. The goal of this project was to either eradicate this species from the region or determine whether or not eradication is even feasible, and if not feasible, develop a management plan that will hold its density to acceptable levels with a minimum of cost and effort, and in perpetuity.

While at the Institute for Biological Invasions (IBI) at the University of Tennessee, I assembled a team to perform biological surveys and public interviews to determine the density, geographical extent, reproductive season, diet, ecological impact, and potential for spread of the lizards, initiate a public education campaign, initiate a trapping program to determine the feasibility of eradication, and draft manuscripts for publication in peer-reviewed literature. I was also awarded additional funding for this project from the National Fish and Wildlife Foundation (NFWF). I assembled a partnership between the City of Cape Coral, Florida Department of Environmental Protection (FDEP), Florida Fish and Wildlife Conservation Commission (FWC), U.S. Fish and Wildlife Service (USFWS), Florida Museum of Natural History (FLMNH), and various real estate developers, local businesses, non-governmental organizations, and private residences for this project. Although no cooperative agreement or memorandum of understanding was established, these stakeholders were in general agreement on the need to eradicate this species from Cape Coral in particular, and Florida in general. The City of Cape Coral also agreed to allow project operations to be conducted from, and equipment to be stored at, their Environmental Resources Section Office at the water treatment plant in southwest Cape Coral (hereafter the Cape Coral Field Office).

Materials and Methods

Study Site

This project was conducted entirely within the City of Cape Coral, a residential community constructed in the 1950s by dredging and filling, resulting in over 400 miles of canals. Based on anecdotal data from over 200 sightings of this species from 2000 through 2002 (Enge et al. 2004), the primary area of activity appeared to be restricted to the southwestern quadrant of Cape Coral, largely west of Chiquita Blvd. and south of Pine Island Road, S.R. 78 (Figure 1). A Primary Survey and Trapping Zone (PSTZ) was established to concentrate the trapping effort into a manageable area and thus allow trapping effectiveness and potential for eradication to be assessed (Figure 1).

Lizard Surveys

Surveys for lizards and their burrows, scat, tracks, and other evidence of their presence (sign) were conducted in southwest Cape Coral and surrounding areas to the north and east. Workers conducted surveys on foot, searching along canal banks, in vacant lots, in forested areas, in yards, and around residential and commercial buildings. Nile monitor sign is very distinct from all other species in the Cape, but their burrows are similar to the burrows of gopher tortoises and certain large mammals, so confirmation of an active monitor burrow was only possible when monitor tracks, scat, or other recent, direct evidence was present. During these surveys, workers often queried Cape Coral residents regarding recent and historical sightings of Nile monitors, their general knowledge of the problem (to assess the need for public education), and to recruit volunteers that might be willing to set and check traps.

A Nile monitor burrow in a canal bank (left) and Nile monitor tracks in sand (right).

Emergency Response

Emergency response was the cornerstone of this project, and was instigated by information provided by the general public. Regular press releases in local newspapers were used to educate the public about the lizards and the project in general, but their main function was to disseminate the Cape Coral Field Office telephone number so the public could easily report lizard sightings using a local phone number. Press releases were conducted periodically, the timing of which was largely driven by the willingness of local press outlets to write about this project.

Lizards living large in Cape

Scientists setting traps for thriving giant monitors

By KEVIN LOLLAR

As the midmorning sun pressed down on the mangrove wetlands Thursday, biologist Todd Campbell found himself face to snout with a lizard, a big lizard — a 5-foot-long Nile monitor lizard.

Campbell was not, however, in Africa. He was in southwest Cape Coral.

At about the same time a few miles away, Cape Coral retiree Gordon French had a similar experience.

"Half an hour ago, it just ran into the bushes, 6 feet long. I'd say," French said. "And a few days ago, I was over by the water pump, and one came by, 6 feet, damn near ran me over."

Cape Coral has become a monitor lizard mecca with a possible population in the thousands, said Campbell, a University of Tampa assistant professor of biology.

Working with state and federal grants totalling $50,000, Campbell has started a project to monitor the monitors and, if possible, wipe them out. The official name of the project is "The Eradication of Large Introduced Carnivorous Lizards in Southwest Florida."

"In Africa, they like coastal inland disturbed areas adjacent to waterways and mangroves," Campbell said. "If Africa had a Cape Coral-type area, monitor lizards would be there.

"They've also spread to Pine Island. If they get established there, they'll be free to expand because it's so remote. It's going to be difficult to eradicate them. That's a word we might have to remove from the title of the project."

See LIZARDS / 10A

TERRY ALLEN WILLIAMS/The News-Press

Biologist Todd Campbell baits a trap intended to catch large monitor lizards Thursday morning in a remote area of southwest Cape Coral. Frequent sightings of monitor lizards have created a scientific need to examine their patterns and led to a research project geared toward gathering information.

University of Tampa professor Todd Campbell prepares traps to capture Nile monitors, hoping to control and manage the reptile's population.

A reptilian invasion

The elusive Nile monitor, indigenous to Africa, is scaring up things in Southwest Florida.

By MICHAEL WERNER

Trapping the Nile monitor lizard

Nile monitor lizard

Traps

Two examples of press releases in local newspapers

Project biologists attempted to respond to lizard reports within a few hours (ideally) or at least during the same day, but factors such as workload, time of the call, or location of the sighting sometimes prevented them from responding in a timely manner. Workers recorded the date, time, caller name and contact information, address, and details about each sighting and entered this information into an Excel spreadsheet. For isolated lizard sightings, one or two traps were deployed at the top and bottom of the canal bank at or near the location of the lizard sighting. In cases where numerous lizards had been reported from one or more streets, canals, or neighborhoods, a number of traps were deployed at regular intervals along canals and in forested areas.

Lizard Trapping

Lizards were captured with Havahart model 1078 and 1079 traps that were modified to accommodate large lizards with very long tails. The trigger systems were not modified from their factory settings unless the trigger assembly itself had to be modified due to trap reconstruction. Three basic wire trap designs were tested during this project:

Examples of the trap designs tested in this study, from upper left to lower right: a large, Type I trap (two Havahart 1079s), a Type II trap (one Havahart 1078 with a wire extension), the original Type I trap (two Havahart 1078s), and a Type III trap (two Havahart 1078s with a hardware cloth covering to protect the trigger).

Type I: two traps of the same dimensions (same trap model) were attached end to end after removing the end plate of each, in order to make one double-door trap, with one door of the trap serving as a bait access door and the other set to be tripped by the trigger plate.

Type II: a single-door Havahart trap was modified with a two-foot addition on the rear end to accommodate this species. A similar type of trap, baited with chicken eggs, was utilized for this species in Africa with much success (Lenz 1995). To extend the trap, a two-foot length of 0.25 inch mesh hardware cloth was formed to match the trap dimensions and attached to the rear of the trap with metal "pig" clips. The trigger plate was transferred to the addition and the trigger mechanism was extended with a section of very stout steel wire.

Type III: because the trigger mechanism of these Havahart models lies outside the trap, it is vulnerable to false triggering from lizards and non-target organisms outside the trap. Thus, a few Type I and II traps were modified to protect the trigger mechanism. To protect the trigger mechanism, the entire trap was covered loosely with a single layer of hardware cloth.

Traps were set in obvious lizard trails at the top and bottom of canal banks or along other natural and man-made barriers such as buildings, seawalls, and fences in order to "funnel" lizards into the traps or otherwise increase trapping success and efficiency.

Traps set in exposed or otherwise hot and sunny areas were covered with a thick layer of vegetation obtained locally (usually branches of introduced Brazilian pepper or Australian pine trees).

Traps were baited with animal flesh, including fish, squid (*Loligo*), chicken, and chicken eggs. Only one type of bait was used in any given trap at any given time in order to assess the effectiveness of each kind of bait individually. Traps were baited and set just after first light, and were left open (set) until late afternoon or dusk. Initially, we left the traps open overnight, but this led to an inordinate number of by-catch events, so this practice was ended early in the project. Thus, bait was always removed from the trap and discarded and the trap door was closed at the end of the day.

Trapping efforts were initiated at Charlie's Pond, a ca. 35-acre isolated wetland mitigation site in the center of a residential area on an artificial island in extreme southwest Cape Coral. This was one of the first areas that Nile monitors were observed, and routinely generated numerous sightings by residents. Twelve traps were deployed around the edge of the pond, and were baited and checked weekly for one month.

After working at Charlie's Pond until trapping efforts were not successful, and as emergency response calls started revealing other locations where monitors occurred in high densities, trapping efforts were relocated to an approximately two square mile area bounded by Veterans Parkway to the north, Chiquita Blvd. to the east, Surfside Road to the west, and Gleason Parkway to the south (Figure 2), an area of frequent monitor sightings reported by Cape Coral residents since 2000 (Figure 1). In this area, project biologists deployed between 20 and 30 traps per day, and worked between two and four days per week for over a year. Some Cape Coral residents were willing to bait, set, and check traps and call the Field Office when a lizard was captured.

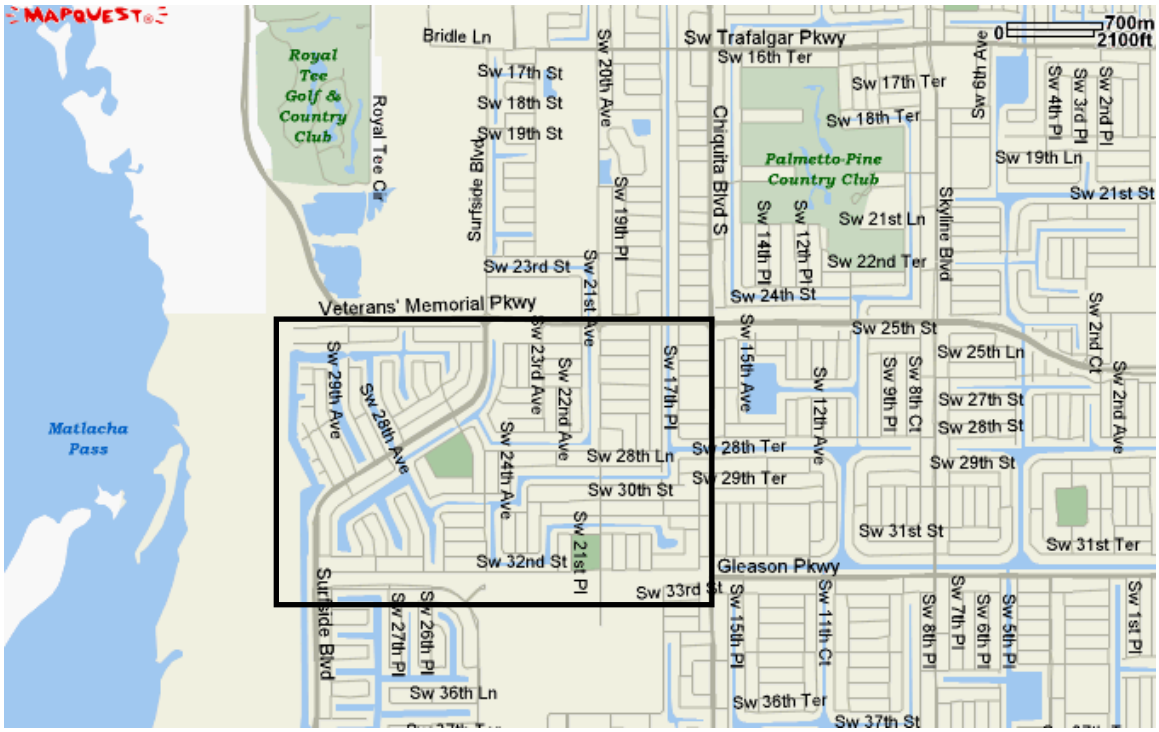

Figure 2. Map of extreme southwest Cape Coral showing the approximately two square mile area where intensive trapping was conducted during this study.

Lizard Processing and Data Collection

Safety was the main consideration in transporting and processing large, potentially dangerous lizards. Project biologists developed the following techniques to avoid direct contact with live lizards. Each captured lizard was immediately transported in its trap to a local veterinarian's office or to the Cape Coral Field Office, where it was directly transferred from the trap to a large graduated cylinder (8 inch diameter by 4 feet long), which served as a euthanization chamber. Transfer was affected by using a 3-foot section of PVC pipe that fit snugly into both the trap and the euthanization chamber. This assembly was tilted until the lizard ran out of the trap and into the chamber.

Isoflurane (or Chloroform) was applied to several cotton swabs and placed in the chamber with the lizard. A plunger slightly smaller than the diameter of the chamber was inserted into the chamber to keep the lizard from escaping and also to minimize the available air space so the lizard would become anaesthetized as soon as possible. The lizard was left in the chamber until breathing had slowed and tonic reflex was not present, then removed from the chamber for processing.

Blood was collected from each lizard while under deep anaesthesis by inserting a needle directly into the heart and drawing up to 4 ml of blood. At least three blood smears were made on glass microscope slides and left to dry. These will later be stained to assess red and white blood cell count and check for any blood parasites (e.g., lizard malaria). The rest of the blood was transferred to a sterile blood vial and frozen for later genetics and ecotoxicological analyses. After drawing blood, the lizard was placed back in the euthanization chamber until no evidence of respiration or tonic reflex was present, and data for all the following parameters were collected post-mortem.

Lizard snout-to-vent length (SVL) and tail length was measured to 1 mm with a folding ruler. Mass was determined using the smallest Pesola spring scale that could accommodate its mass. Head length (anterior edge of ear opening to tip of snout), head width (widest part of head just posterior to the eyes), and head depth (widest part of head posterior to the eyes) were measured using dial calipers. Each lizard was examined for external parasites and at least one dorsal and one ventral picture was taken using a digital camera. These images were archived in a photographic database, and will later be analyzed to document dorsal and ventral coloration and pattern in this lizard population. A museum tag was tied to the rear leg or toe, and the lizard was placed into a freezer in Cape Coral for temporary storage. Lizards were periodically transferred to another freezer in the laboratory at the University of Tampa.

At the University of Tampa, lizards were slowly thawed out and examined for internal parasites, reproductive condition, and stomach contents. All lizards were dissected by making one ventral longitudinal incision from vent to shoulder girdle to expose the body cavity. Both of the bilateral, abdominal fat bodies were removed and each was weighed and placed into a sterile Whirl-Pack plastic baggie, and frozen. Abdominal fat body mass generally exhibits a temporal cycle opposite that of the reproductive cycle in lizards, and can be used to measure temporal trends in reproductive effort, body condition, and other physiological parameters. These fad bodies will be later analyzed for lipid content. The left lobe of the liver was removed and frozen in a Whirl-Pack for later genetic analyses. The body cavity and organ systems were examined carefully for internal injuries, parasites, cysts, and tumors.

The reproductive tract was examined to determine the stage of reproductive development, photographed, and in certain cases, removed and either preserved or frozen. Female reproductive tracts were generally examined for signs of recent activity (e.g., yolked and shelled ovaries, distended or retracted oviduct, and corpora lutea), photographed, and left intact. Male reproductive tracts were examined and photographed, each testis was cut away from the vas deferens, weighed separately, placed in a Whirl-Pac, and frozen.

The digestive tract was examined externally and internally for presence of parasites, tumors, and evidence of food items. The stomach was then removed by cutting the esophagus at the neck level and just below the pyloric valve. Each stomach was cut open and the contents identified to the lowest taxa possible and either preserved in 10% formalin or re-frozen, depending on the contents present (stomachs containing hair, feathers, or eggs were re-frozen to facilitate further identification). Empty stomachs were placed back in the body cavity. Lizard carcasses were either re-frozen for temporary storage or preserved in 10% formalin and later transferred to 70% ethanol for permanent storage. Preserved specimens will eventually be sent to the Florida Museum of Natural History at the University of Florida in Gainesville, Florida.

Clockwise from upper left: A Nile monitor with its abdominal fat bodies removed, numerous yolked but unshelled eggs, an ovary with corpora lutea (bottom) and a stretched out oviduct (top) that is undergoing retraction and exhibiting a "stack of cookies" effect (suggesting this monitor layed eggs approximately three weeks prior to capture), and a disarticulated Cuban brown anole removed from the stomach of a Nile monitor.

Results

Lizard, Burrow, Track, and Sign Surveys

Nile monitors were extremely elusive in Cape Coral, and generally only a few were seen during an entire day of surveys and trapping. Lizards were generally heard or less often observed fleeing into dense vegetation along canal banks or into the water. Lizards were occasionally and briefly observed basking and sleeping in trees, basking on seawalls, basking in yards, walking along canal banks, swimming in canals, entering burrows, or digging up animal nests. However, visual observations of lizards lasting more than one minute were extremely rare, and only a few still photographs and videos of live lizards were obtained during this study.

Project biologists quickly determined that active searching for (and capturing of) Nile monitors in Cape Coral would be a very inefficient way to conduct this project. Workers continued surveying canals for lizards and their sign in order to more accurately define the northward and eastward extent of their current geographic distribution, but sightings by the public followed by emergency response efforts turned out to be the most efficient method of locating and capturing individual lizards.

Multiple foot-surveys along canals north of Pine Island Road and east of Chiquita Blvd. resulted in no sightings of lizards or sign, indicating their range is largely restricted to the southwestern Cape. Surveys around Charlie's Pond (south of Cape Coral Parkway) resulted in a number of lizard sightings very early in the study, but a rapid fall-off in sightings after an intensive trapping effort indicated that the trapping effort had an effect at this site (see below).

Emergency Response

As a result of periodic local press releases in the Ft. Myers News-Press, hundreds of phone calls were received by the public. The number of phone calls peaked in summer months in both years (Figure 3). Call rate declined significantly within days of each press release, but more and more calls were received after each subsequent press release, and the baseline call rate increased over the duration of the project. The City of Cape Coral currently gets approximately four calls per week.

Local press releases were much more effective than national press releases in gathering information about monitors in Cape Coral. However, national press releases resulted in numerous sightings of Nile monitors outside the Cape Coral area. It is possible that follow-up on some of these calls will reveal new populations established elsewhere in Florida (e.g., the Orlando and Miami areas). Press releases also resulted in additional location records for green iguanas, and generated a new distributional record for the curly-tailed lizard in Florida (Campbell and Klowden 2004).

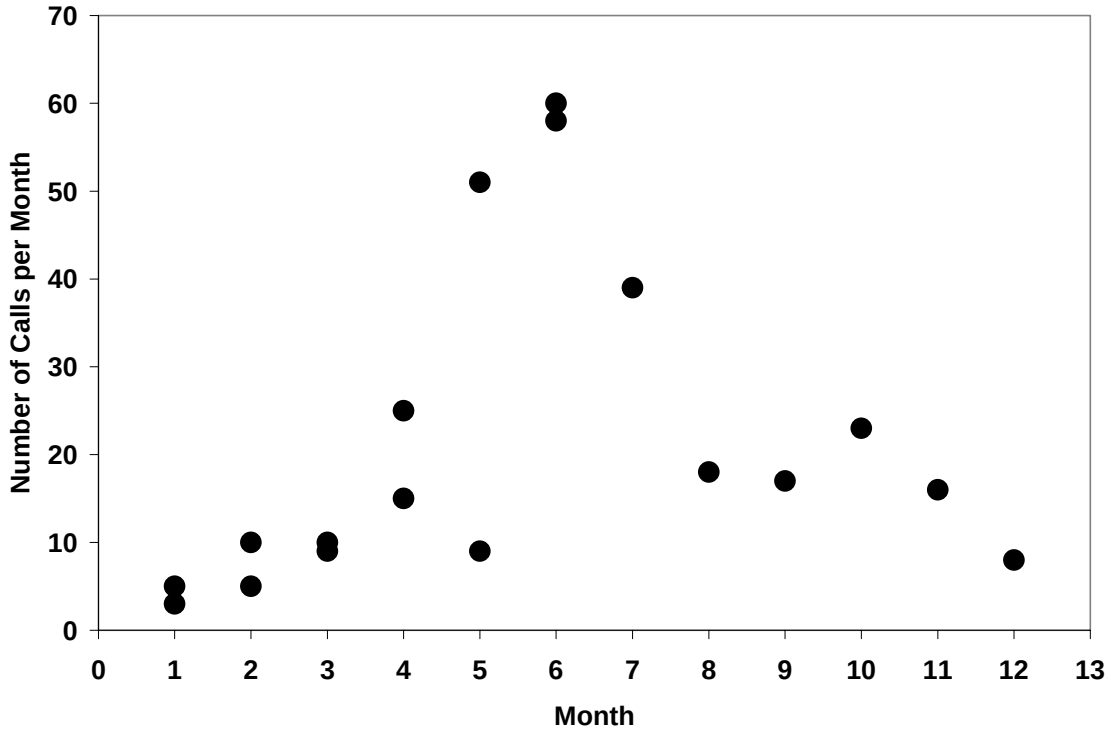

Figure 3. The number of Nile monitor sightings reported by residents of Cape Coral during each month of this study.

Trapping Effort and Success

Trapping effort data from paper data sheets is being verified and entered into an Excel spreadsheet, but this is a complicated data set that will require a significant amount of time to summarize and analyze using statistics. However, some important facts can be gleaned from preliminary analyses of qualitative data and anecdotal evidence.

Between July 7, 2003 and May 31, 2005, over 100 lizards were captured. All but 15 lizards were taken in Havahart traps set by project biologists. Lee County Animal Control brought us a few lizards early in the project, and a few road-killed individuals were reported and retrieved. Citizens turned in a few hatchings and sub-adults which they had shot with pellet guns, trapped in gutter downspouts, removed from toilets, or trapped in their garages with laundry baskets or buckets. A few citizens captured lizards in traps they constructed themselves or in project traps that were lent to them.

The Type I trap was the most efficient to deploy, bait, empty, close, and remove lizards from, and was by far the most economical, given the huge amount of time to took to build and frequently adjust (and fix) the settings on the Type II and III traps. We also attempted to capture lizards in 10-inch diameter PVC pipe traps strapped vertically to tree trunks and capped at the bottom end, but no lizards were captured in three of these traps deployed for over a month (hence, this was not mentioned in the methods). Frozen squid (*Loligo*) was, by far, the most successful bait for capturing Nile monitors in Cape Coral.

Frozen mullet, chicken eggs, and chicken meat were used with little success, but at least one lizard was captured using each of these baits.

During the height of the trapping effort, when at least 20 traps were deployed for at least three days of the week, between one and four lizards were captured each week. Although the most calls were received in summer months, October yielded the highest capture frequency (number of captures per trapping effort), indicating that lizards coming out of the reproductive season were actively searching for prey in order to accumulate fat reserves for the winter (see below). Very few phone calls were received and very few lizards were captured during winter months, indicating these lizards enter a relatively inactive period during the winter. This notion is supported by the fact that a large individual held in a 10x4x4 foot outdoor enclosure in Tampa between July 2003 and July 2004, and another held between July 2004 and July 2005, refused food and confined themselves to their hide box from mid-November to mid-February. Of course, seasonal parameters (temperature and precipitation) are more extreme at this more northern latitude, but these results are largely corroborated by the emergency response and trapping data. Anecdotal evidence and conversations with pet traders indicate that monitors can often be found hiding behind seawalls in winter months in Cape Coral.

Intensive trapping efforts at a relatively small site resulted in evidence of the amount of effort that might be required to eradicate these lizards from the residential areas of Cape Coral. With relatively little trapping effort, consisting of only 12 traps set only a few days per week for less than one month, Nile monitors were apparently eliminated from Charlie's Pond, a ca. 35-acre isolated wetland mitigation site in the center of a residential area on an artificial island in extreme southwest Cape Coral. No monitor burrows, scat, tracks, or other sign were observed during three one-hour surveys conducted around the perimeter of the site at one, three, and six months after the eradication attempt. Of course, a few monitors from the surrounding area have likely re-entered the site by now, but the population reduction resulting from this limited eradication effort was encouraging.

Distribution and Abundance

Lizard surveys, public sightings, and trapping efforts indicate that the main Nile monitor population in Cape Coral had not spread nearly as far as the team had anticipated at the beginning of this study. The vast majority of new lizard sightings (since data presented in Enge et al. 2004) were within the southwestern quadrant of Cape Coral, and most sightings were within the PSTZ established at the beginning of the study (Figure 4, next page). In fact, very few residents living north and east of the PSTZ had ever seen a Nile monitor, and many did not even know about the problem. However, a number of recent sightings have been reported in the neighborhoods east of Chiquita Blvd. and also immediately north of Pine Island Road outside the PSTZ.

During this study, additional sightings from reliable sources on Pine Island indicated that Nile monitors are established and breeding there. In 2005 (subsequent to the end of the study period), a citizen submitted a photograph of a Nile monitor that was taken on Sanibel Island, touching off a flurry of media activity. Most recently, a fisherman contacted me to tell the story of multiple Nile monitors stealing the bait

(which, ironically, was squid) from his cooler while he was fishing along the coast in the Charlotte Harbor State Buffer Preserve west of Durden Parkway West in extreme northern Cape Coral. This indicates that Nile monitors are spreading northward along the coast in the remote natural areas of the State Buffer Preserve.

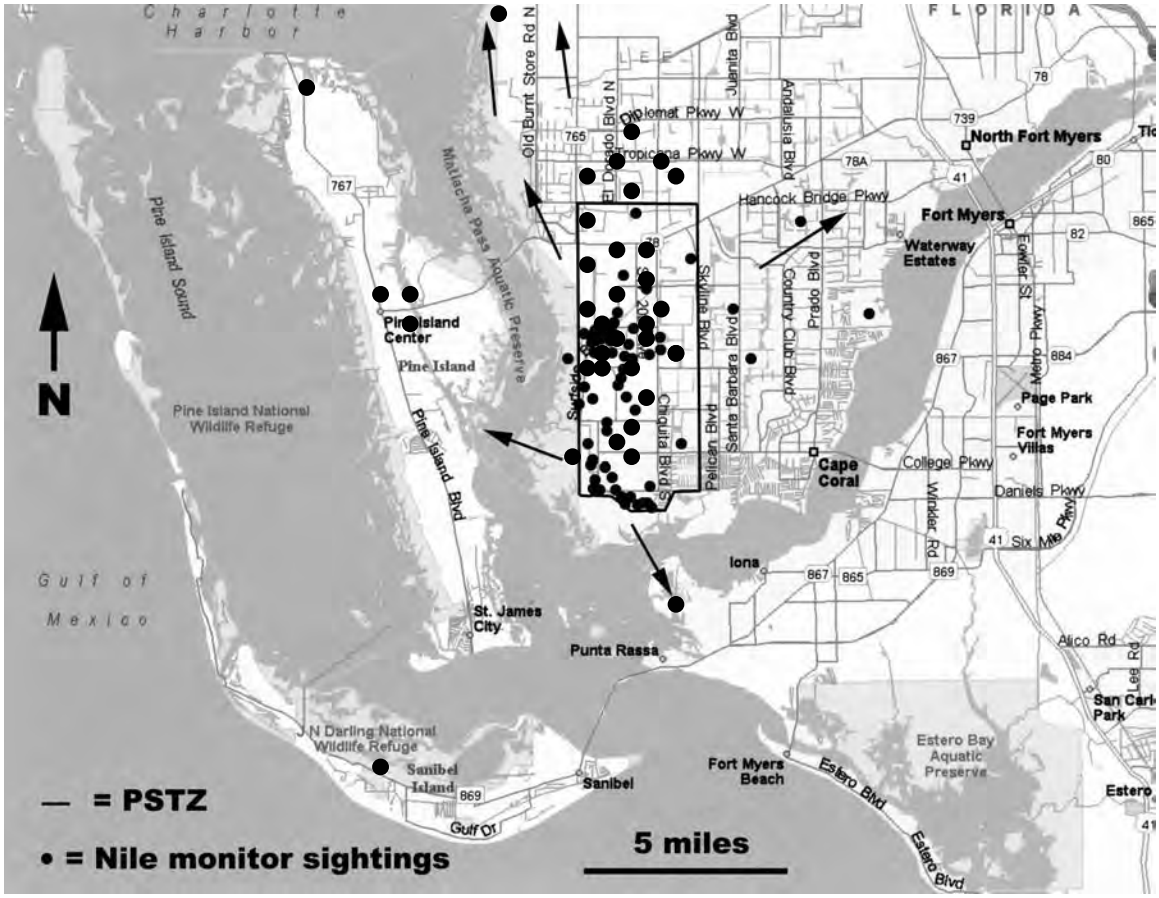

Figure 4. Locations of most of the 80 Nile monitors trapped during this study, indicated by larger dots superimposed on Figure 1.

As a result of the emergency response nature of the trapping effort, and the fact that this was a removal study, not a capture-mark-recapture study, it was not possible to generate accurate, quantitative estimates of the size of the lizard population in Cape Coral. However, based on the consistent high level of trapping success in the two square mile area of Cape Coral (Figure 2), in which over 100 lizards have been captured since the beginning of this study, and given the over 20 square mile area currently inhabited by a fairly dense population of Nile monitors, it is highly likely that the Nile monitor population in Cape Coral proper very likely consists of at least 1000 individuals.

Lizard Size and Morphology

A total of 80 lizards (44 male, 36 female) were processed during this study. Lizards ranged in size from 130mm in snout-to-vent length (335 mm total length) and 31g in mass (hatchlings) up to 805mm SVL (1920 total length) and 12.34kg in mass (Figure 5). Captured lizards had a mean SVL of 430mm, a mean total length of 1077mm, and mean mass of 2002g. Body condition was fairly consistent among the 80 lizards, with the exception of one large individual that was extremely emaciated (Figure 5).

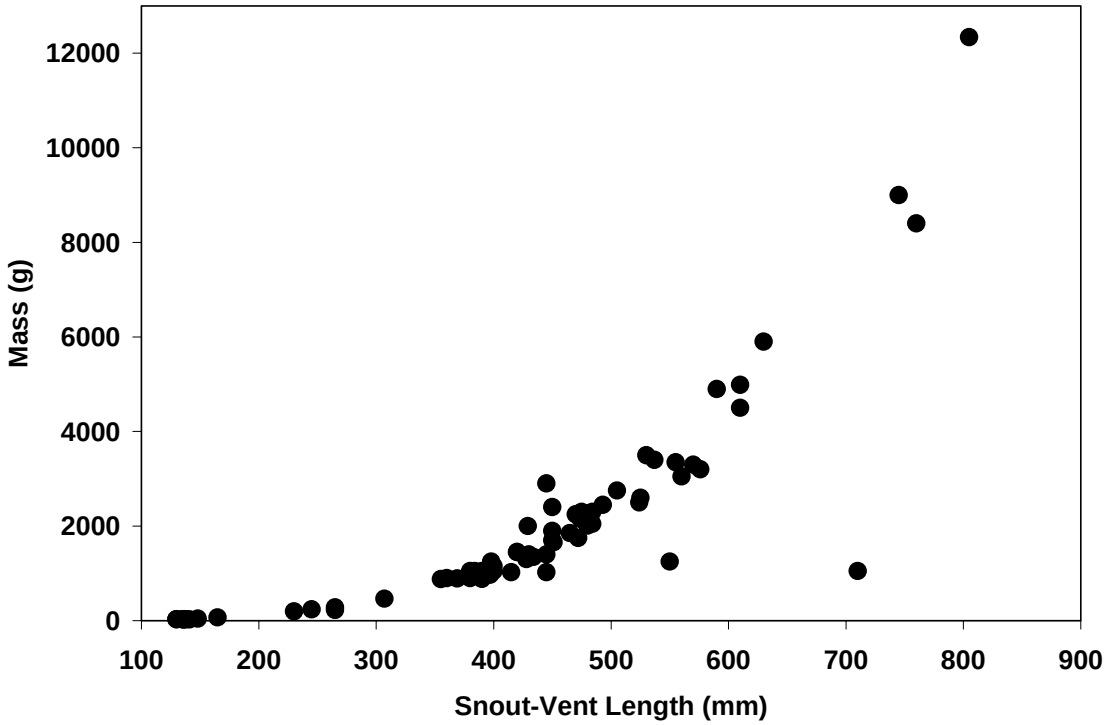

Figure 5. Regression of lizard mass (g) against snout-vent length (mm) for 80 Nile monitors captured in Cape Coral, Florida.

Surprisingly, no external parasites were found on any of the captured lizards. Some of the lizards had minor external injuries including damaged or broken tails, broken legs, and ventral puncture wounds, but no pattern was evident that might indicate a regular exposure to certain natural or human-caused risks. Detailed analyses of the dorsal and ventral photographs have not yet been conducted, but the lizards appear to be very similar in coloration and pattern, suggesting the Cape Coral population was established from only a few highly related individuals.

Reproductive Cycle

Dissections of 80 individuals allowed a fairly accurate determination of the reproductive cycle of this species in Cape Coral. The ratio of abdominal fat body mass to total body mass did not exhibit the expected temporal pattern (Figure 6). However, the data were not partitioned into size classes or by sex for this analysis, and these data do not indicate the quality of the fat in these organs. Once all the lizards captured to date are dissected, a detailed temporal analysis of abdominal fat body mass and lipid content will be conducted (partitioned by sex and size class).

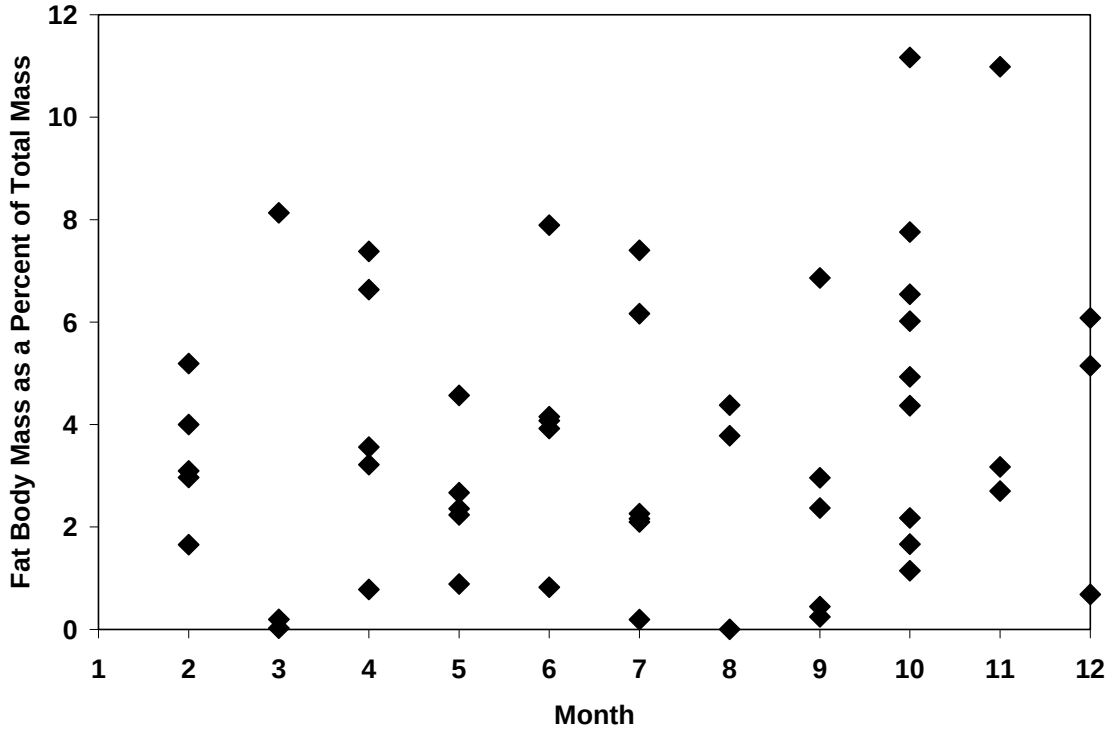

Figure 6. Abdominal fat body mass, reported as a percentage of total body mass, for lizards captured during every month of the year.

Only the female lizards captured between April and September exhibited signs of reproductive activity, including shelled eggs, yolked but unshelled eggs, distended oviducts (indicating very recent oviposition), retracted oviducts (indicating a few weeks since oviposition), and corpora lutea. Male lizards appeared to possess enlarged testes during the same period (Figure 7), but the temporal trend is not strong, possibly because juvenile lizards were included in this analysis.

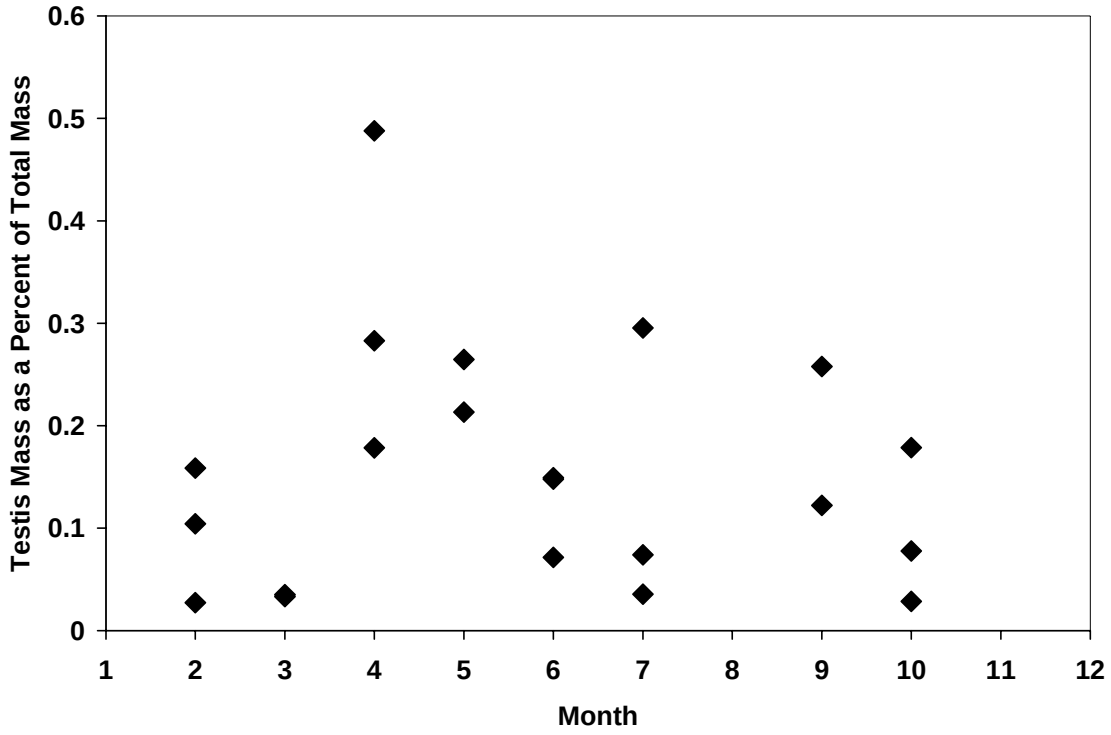

Figure 7. Testis mass, reported as a percentage of total body mass, for male lizards captured during every month of the year.

Hatchlings were captured in the greatest numbers between February and April. We often received phone calls about numerous hatchlings basking on seawalls and hiding in bushes during that period. The above data indicate the incubation period of Cape Coral Nile monitors lasts six to nine months, similar to African populations (Lenz 1995, 2004). Collectively, these data indicate the Cape Coral Nile monitors reproduce in the summer months, and hatchlings emerge in early spring.

Diet Breadth (Stomach Contents)

The stomach contents of 80 dissected individuals indicate Nile monitors have an extremely broad diet in Cape Coral (Figure 8). Fourteen of the 80 stomachs were completely empty. Sixteen stomachs contained cockroaches, 15 contained spiders, 13 contained Cuban brown anoles (or their eggs), 12 contained beetles and their larvae, and nine contained crickets, grasshoppers, and other orthopterans. The mean number of prey items in the 66 stomachs containing at least one prey item was 4.14 (range 1-23 prey items). Nearly 50 of these items were cockroaches, 47 were beetles, 25 were spiders, 24 were frogs, and 17 of them were Cuban brown anoles or their eggs.

Stomachs of these lizards contained marine, freshwater, and terrestrial insects, mollusks, crustaceans, arachnids, fish, amphibians, reptiles, reptile eggs, birds, bird eggs, and mammals. However, they appear to prefer ground-dwelling spiders and insects (mainly cockroaches) and various amphibians and reptiles. Moreover, the prevalence of introduced insects (e.g., cockroaches), introduced frogs (Cuban treefrogs), and introduced lizards (Cuban brown anoles) in the diets of small adults and sub-adults indicates the diets of these lizards are being supplemented by other introduced species, a concept coined "invasional meltdown" (Simberloff and Von Holle 1999).

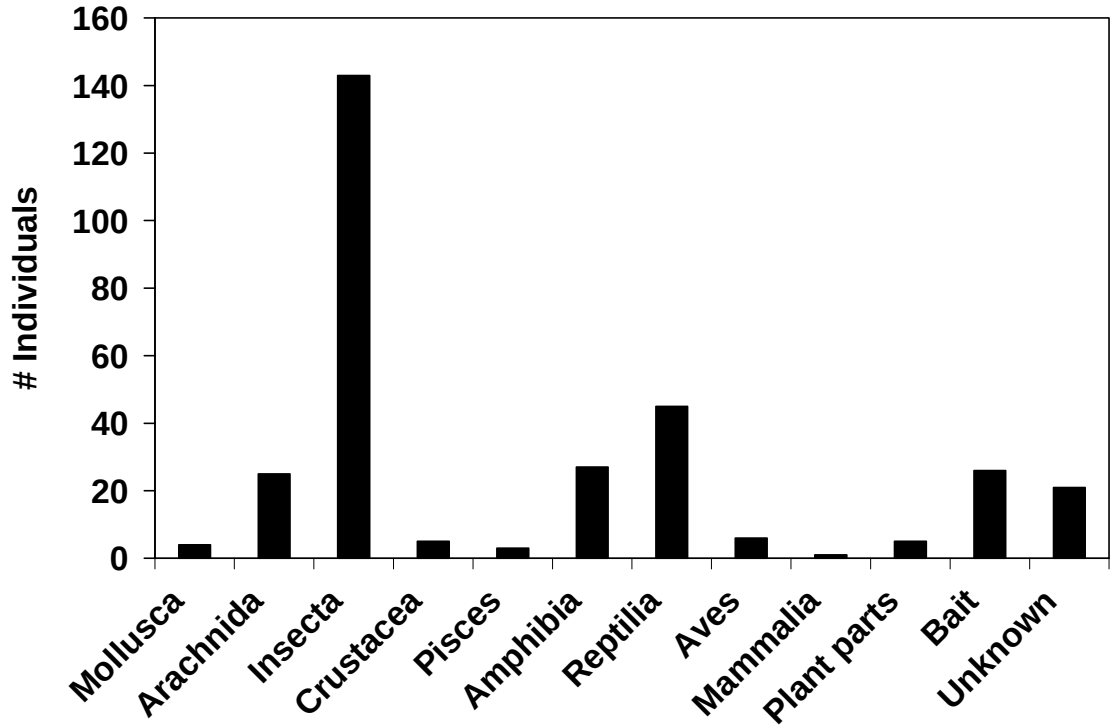

Figure 8. The taxonomic distribution (by number of individuals) of 311 prey items retrieved from the stomachs of 80 Nile monitors collected in Cape Coral, Florida.

Some noteworthy and even bazaar stomach content items included a wasp nest, mangrove tree crabs, an adult pygmy rattlesnake, one stomach containing 16 Cuban treefrogs, and stomachs containing whole clutches of what appear to be snake eggs, turtle eggs, possibly alligator eggs, and bird eggs. The bird feathers, bird egg shell pieces, and

mammal hair will soon be sent to experts at the Cornell Bird Lab and Mammal Lab, and the reptilian egg shells will be sent to the appropriate experts for identification.

A number of anecdotal observations by Cape Coral residents add to the list of native and non-native taxa consumed by Nile monitors. Two residents have observed young Nile monitors eating all of the goldfish in the artificial ponds in their yards. One resident said he watched in horror as a large monitor disarticulated and consumed a marsh rabbit in his back yard. One resident in an area heavily infested with monitors let his two new Dachshund puppies run in his yard and never saw them again, and is convinced a large lizard he had seen patrolling the area ate his puppies. Many residents in the southwest quadrant of Cape Coral have a strong feeling that monitors have helped to minimize the feral cat problem that is usually prevalent in residential areas. Of course, many of these sightings and conjectures cannot be confirmed, but most are plausible.

In May 2005, we received the first confirmation that Nile monitors eat Florida burrowing owls, a state listed species. A resident watched as a large Nile monitor captured one of the resident burrowing owls in her yard. The lizard dropped the owl after the woman threw a flower pot at it, but the eventually owl died, and the carcass was given to a State of Florida biologist studying the owl population in Cape Coral. This was the first verification that Nile monitors could be negatively affecting at least one of the many listed species in this area.

As expected by diet studies in their native lands (Lenz 1995, 2004), but not evident in Figure 8, the diet of Nile monitors changes as these lizards grow in size. Hatchling and subadult individuals eat mostly invertebrates (insects and crustaceans) and small vertebrates (lizards and frogs), while larger individuals consume prey from a wider range of taxa, adding fish, larger reptiles, birds and bird eggs, and mammals to their diet. More detailed analyses of the stomach contents from the 80 lizards already dissected, as well as 40 additional lizards collected since this study ended, are underway.

Other Project Accomplishments

This project has generated professional and popular exposure for the project, for CHNEP and NFWF, and for my colleagues. To date, my colleagues and I have given a total of 16 professional presentations at scientific meetings and public seminars at local organization meetings (Appendix 1). Media coverage has been extensive, including: numerous articles in printed and internet media sources such as National Geographic Magazine (Appendix 2); two radio interviews on National Public Radio; mention of the project on television including the Tonight Show with Jay Leno, the Paul Harvey Show, and numerous local news broadcasts in the Ft. Myers and Tampa Bay areas; personal interviews for television including appearances on the Today Show (NBC), the O'Riley Factor (Fox News), Animal Planet Canada, several local Public Broadcasting Service venues, and an interview for National Geographic Television is scheduled for early 2006.

Discussion and Conclusions

Synopsis of the Problem

Early on, it became evident that little was known about the "natural" history of this species in Cape Coral despite the significant efforts of Kraig Hankins to educate Cape Coral residents, catalog public sightings, and even set up a GIS coverage of monitor and iguana sightings between 2000 and 2002. As a result of this project, we know significantly more about the distribution, abundance, reproductive cycle, movements, diurnal activity, and environmental impacts of this species in the Cape Coral area.

This study provides conclusive evidence that Nile monitors are firmly established and reproducing in Cape Coral and thus they are growing in numbers. This study also suggests that the population is expanding spatially on its own accord, and is capable of reaching barrier islands separated from the mainland by over two miles of open water. Although the trapping methods and study design do not allow an accurate estimation of population size, a simple extrapolation from the capture of over 100 lizards in a two square mile area, combined with a distribution of over 20 square miles, suggests that at least 1000 Nile monitors were present in Cape Coral at the time of this study.

The population is expanding, but not as rapidly as originally expected (or feared). Clearly, they are less abundant to the north, but sightings during this study (and more recently) confirmed some of our worst fears: that they are established on Pine Island, that they are spreading north along the coastline within the very remote Charlotte Harbor State Buffer Preserve, and are capable of island hopping to the extent that one has already been seen on Sanibel Island. This was the most significant of all the potential problems suggested in the proposal for this project, due to the numerous bird rookeries present in Ding Darling NWR. Moreover, given that one was sighted, there are likely more present on Sanibel Island, unless the individual represents an isolated release by a resident.

Nile monitors continue to horrify the residents of Cape Coral by climbing on their houses, attacking their pets, and scaring their children. According to two well-known *Varanus* researchers (Eric Pianka, University of Texas; Sigrid Lenz, Germany), they have the potential to devastate native fish and wildlife populations. Nile monitors are semi-aquatic and consume large numbers of freshwater and estuarine invertebrates (e.g., clams, oysters, and crabs), fish, and amphibians (especially frogs). Hatchling aquatic turtles and gopher tortoises (a listed species) are at risk. In their native lands, Nile monitors and dwarf crocodiles have overlapping diets and also eat each other's hatchlings (Luiselli et al. 1999), thus it is reasonable to anticipate that Nile monitors and American alligators could interact similarly. Nile monitors consume Florida burrowing owls (a listed species), and may also consume other ground-nesting birds (e.g., doves, sandpipers, etc.). Ground-nesting birds and their eggs would obviously be at great risk of predation. Nile monitors, like their larger counterpart, the Komodo dragon, hunt cooperatively, and may lure birds off their nests to get at their eggs (Lenz 2004; E. Pianka, pers. comm.). Many of Florida's wading birds would be an easy target while foraging in mangroves and along tidal creeks and artificial canals, and Nile monitors are excellent tree-climbers, so the nests of wading birds are also at risk, as are small mammals (e.g., beach mice) and even the young of larger species (e.g., raccoons, opossums, and foxes).

Noteworthy was the prevalence of a significant number of introduced insects,

frogs, and lizards in the diets of small adults and sub-adults, indicating their diets are being subsidized by other introduced species, a concept coined "invasional meltdown" (Simberloff and Von Holle 1999). This may bolster their populations by augmenting hatchling and subadult survival rate and thereby interfere with eradication efforts. Given the extensive distribution of the Cuban brown anole in Florida and many other southeastern states (Campbell 2003), and the fact that it is currently the most abundant terrestrial vertebrate in Florida, the situation may be similar to that of the introduced brown treesnake on Guam, which has enjoyed low hatchling and juvenile mortality rates due to the presence of two abundant introduced lizards (Rodda et al. 1999).

Feasibility of Eradication

A major goal of this project was to determine whether or not this species could be eradicated from the Cape Coral area. Clearly, total eradication was not possible during this project given the size and geographic extent of the lizard population, the funding level, the steep learning curve, and time frame of the study. However, much progress was made in determining the level of effort required to eradicate this species from localized areas in Cape Coral and beyond.

I am cautiously optimistic that the Nile monitor population could be extirpated from the Cape Coral area, although I am keenly aware that a successful eradication will require a significant effort. I have not generated a "Nile Monitor Management Plan" because I remain hopeful that funding for a long-term, large-scale eradication program will become available. Efforts in the near future, if significant, should be considered eradication, rather than management, as the term "management" suggests a long-term commitment to controlling a population that has no hope of being eradicated.

Clearly, the top priority for eradication efforts is the large source population in Cape Coral, which should be significantly reduced before it reaches unmanageable levels, both numerically and spatially. The combination of easy access to nearly every tract of land via roads and canals, the presence of a large, educated human population that is willing to report lizard sightings and even volunteer their time trapping them, and a city government that is clearly interested in eliminating the burdens caused by this beast, render an eradication program very feasible in Cape Coral proper. However, it will be extremely difficult to eradicate monitors from the adjacent State Buffer Preserve due to its remoteness, limited access, and predominance of natural habitats. On a positive note, Nile monitors tend to avoid salt water, so they might not reach large numbers in the mangrove areas surrounding Cape Coral (E. Pianka, pers. comm.), but regular lizard surveys should be conducted in the piles of shell and earthen berms along the waterward edge of mangroves, the access road for the power line that penetrates the mangroves west of Cape Coral, and any other upland sites available along the coastline.

Similarly, eradication of this species from Pine Island will be extremely difficult due to the low density of people, ownership of large uninterrupted tracts of land, and remoteness. However, these facts also make eradication in the Buffer Preserve and on Pine Island a very high priority. If efforts are delayed much longer, eradication could be rendered logistically and economically unfeasible.

Conversely, I do not believe that eradication efforts are warranted for Sanibel Island at this time, or at least this would be a low priority, as this species has not been shown to be established there. However, significant public education efforts are warranted, and a set of at least 20 traps and other equipment for emergency response efforts should be on hand in the event that more sightings occur.

Successful eradication will require a large team of biologists and/or professional trappers to work intensively throughout Cape Coral and on Pine Island for at least two years. However, success will require some innovative ideas and methodologies well beyond those pursued in this study. Lately, Cape Coral biologists have been lending more of the project traps and bait to citizens, who set them and call us when they capture a lizard. This is a very efficient use of time, and marks the further development of efforts to establish a volunteer trapping program. I recently met with faculty at Florida Gulf Coast University in order to generate interest in pursuing funding to establish a volunteer eradication program using college students for trapping, educating the public, and helping project biologists and Cape Coral residents trap lizards. I believe that the success of any proposed Nile monitor eradication program absolutely depends on the effective use of college and high school students and Cape Coral residents as volunteers, in addition to a professional trapping team. Beyond this, utilization of active capture techniques is warranted, such as the use of the type of trained scent dogs used in brown treesnake control programs, intensive burrow probing and excavation of burrows, and possibly chemical attractants and poison baits, should all be considered potentially viable tools.

Finally, it is likely that additional populations of Nile monitors are becoming established elsewhere in Florida. Of primary concern are the occasional sightings in two locations around Orlando, and the numerous sightings of many species of monitor lizards in the Miami and Ft. Lauderdale areas. Based on the known latitudinal limits of this species in Africa (over 35 degrees south latitude), this species will likely be able to spread throughout Florida, and possibly the entire southeastern United States; a significant problem indeed. It is imperative that the results of this project be incorporated into a rapid response effort and management plan for this species (see below).

Future Research Needs

In any introduced species management effort, there comes the time to stop studying them and start eradicating them. Hopefully, this study has brought us to that point. However, I have a few suggestions for further studies of the lizards that have already been captured and euthanized, and other suggestions for field studies that could be conducted along with eradication efforts in order to continue learning as much as possible about the aspects of this species' biology that would aid in successful eradication. All studies of this species should clearly focus on parameters that would aid in its eradication.

Unfortunately, because this was a removal study, and because trapping effort was not consistent and trap locations were not established randomly, demographics of the Cape Coral population remain largely unknown. However, skeletochronology performed on long bones or vertebrae of collected individuals are likely to reveal the age structure of the population. These analyses were initiated in Fall 2005 by a student in my laboratory, and this line of inquiry is on-going. A capture-mark-recapture study on this species

would generate additional demographic information, but because of the large number of individuals required to gather suitable data from a CMR study, this clearly would not be in the public interest. In fact, from this point forward, every captured adult individual should probably be euthanized (but see below).

Activity period, diurnal and seasonal movements, body temperature preferences, home range dynamics, and territoriality could not be assessed in this study. However, I was recently given permission to implant radiotransmitters (Holohill model SB-2T with a body temperature sensor and 10 month battery life) on 10 individuals and release them in Cape Coral. Radiotransmitters were implanted in 10 adult lizards and each was located multiple times per week. The transmitters should transmit signals through spring 2006. Preliminary data indicate these lizards are capable of moving incredible distances, as expected from data from African populations. In fact, one individual moved one kilometer in only five hours, and two others recently relocated their home range over seven kilometers from their original capture locations. Further radiotracking studies may not be necessary, and probably should be discouraged, depending on the information obtained from this pilot study. However, unlike a capture-mark-recapture study, a lot of information can be gleaned from a few individuals fitted with radios. For instance, a small radiotracking study of a whole clutch of hatchlings might reveal information that could be used to eradicate entire clutches of hatchlings in a short period of time.

Genetic analyses are needed to determine the source of these lizards so comparisons of their morphology can be made between their native and invaded lands. This might reveal whether or not ecological release has occurred, and if the species is undergoing plastic (non-heritable) or evolutionary (heritable) changes in their new lands. These kinds of studies are needed because introduced species often become "moving targets" (Campbell and Echternacht 2003) where predictions of their ecology made from native populations are ineffective for controlling or eliminating the introduced population. Tissues from previously captured lizards, as well as lizards captured in the future, should be subjected to genetic analyses for these purposes.

Finally, it is widely known that prevention is the best policy for thwarting the introduction of non-native species. During a meeting with various stakeholders in summer 2005, the Nile monitor was placed under consideration as a test case species along with the Gambian Pouch Rat, Burmese python, and spectacled caiman for a new Introduced Species Rapid Response Team in south Florida. Research into the effort needed to initiate and carry out such a program is badly needed. However, the best way to prevent further inoculations of Nile monitors in Cape Coral and other locations may be through restrictions on the sale of this species in this country. I intend to investigate the steps necessary for severely restricting or making illegal the sale of this species in this country. At least two other large varanids are available that actually make decent pets, unlike the Nile monitor, which is nearly untamable and a notoriously bad pet species. Certainly, the pet industry will resist these efforts vigorously, but I see no other way to eliminate the chance that juvenile Nile monitors purchased for 40 dollars (or less) will get released once they become large, aggressive, and potentially dangerous adults.

Acknowledgments

So many people have contributed to the success of this project that it will be impossible for me to remember them all, and impractical to mention them all in one page, but a number of people made this project possible, successful, and meaningful. First and foremost, I thank Catherine Corbett, Lisa Beever, and Maran Hilgendorf at CHNEP for their guidance during the proposal phase, for their assistance during the project, and for their understanding during the final reporting phases. I also thank the proposal reviewers at the CHNEP and NFWF for determining that this idea was worthy of funding.

Special thanks goes to Kenney Krysko for making me aware of the Cape Coral monitor population during a random phone call while I happened to be passing through Ft. Myers in summer 2002. Soon after that trip, Eric Pianka provided me the motivation to do something about this problem (and take on yet another project). Dan Simberloff and Jonathan Losos provided the funds for the trip that resulted in me finding out about this problem. The accounting and administrative staff at the University of Tennessee supported me during the proposal and contracting phases, and University of Tampa staff, particularly Brenda Wendel were very helpful during this challenging project.

Kraig Hankins deserves the vast majority of credit for making this project possible, including initiating the first public education efforts, for setting up the database and GIS coverages of sightings, for lending us equipment, for providing a place for us to hang our hats, store our equipment, and get out of the mid-day sun, and for entertaining us with his unique brand of witty banter. Connie Jarvis is ultimately responsible for the success of the project by allowing Kraig to devote his time to this effort. Kevin Enge provided important background information about Nile monitors and drafted the first manuscript documenting the problem. I also thank Kevin, Kenney, and Kraig for including me as a co-author on a manuscript for which I played such a minor role.

This project would not have gone smoothly without the efforts of the Nile Monitor Eradication Team (Gregg Klowden, Zach Reffner, Brenda Brooks-Solveson, and Lee Quintard). In particular, the field methodology, data sheets, trap design, and many of the logistical aspects of this project were hashed out by Gregg Klowden, my trusty Field Biologist, and it became clear very early on that this project would not have even gotten off the ground, and certainly would not have succeeded, without his raw determination, attention to detail, ability to fashion devices out of duct tape and other household materials, and enthusiasm for interacting with the residents of Cape Coral.

The myriad residents of Cape Coral deserve thanks for listening, for at least attempting to understand a complex problem, for calling us with lizard sightings, and in some cases, for actually helping us trap lizards. Scott Trebatowski brought us one of the first large, live lizards (Thumper). Sue Scott lent us a burrow probe. The staff and doctors at the local animal hospital that helped us with euthanizations deserve special thanks (albeit clandestinely, due to their understandable reluctance to be revealed to animal rights activists; you know who you are!). Numerous reporters and photographers and their editors deserve thanks for their willingness to repeatedly report this important story, and for largely getting the story right. Finally, thanks in advance to all the people who remain interested in trying to tackle this important problem. Without your efforts, the southeastern United States may become a very different place. TSC

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Appendix 1. Complete list of professional presentations and public seminars resulting from this project.

Campbell, T. S. July 2005. Roles of local stakeholders in managing introduced Nile monitors in Florida. Invited speaker, Invasive Snake/Reptile Management and Response Workshop, West Palm Beach, FL.

Campbell, T. S. July 2005. Welcome and introduction. Herpetologists' League Symposium "Introduced amphibian and reptile research: from case studies to solutions" at the 2005 Joint Meeting of the American Elasmobranch Society, American Society of Ichthyologists and Herpetologists, Herpetologists' League, and Society for the study of Amphibians and Reptiles, Tampa, FL.

Campbell, T. S., G. Klowden, and K. Hankins. July 2005. Roles of local stakeholders in managing introduced Nile monitors in Florida. Herpetologists' League Symposium "Introduced amphibian and reptile research: from case studies to solutions" at the 2005 Joint Meeting of the American Elasmobranch Society, American Society of Ichthyologists and Herpetologists, Herpetologists' League, and Society for the study of Amphibians and Reptiles, Tampa, FL.

Campbell, T. S. April 2005. Lizard tales: managing large introduced carnivorous lizards southwest Florida. Invited speaker, lunchtime presentation for the Tampa Bay Chapter of the Sigma Xi Scientific Research Society, Tampa, FL.

Campbell, T. S. March 2005. Big lizards behaving badly: the introduced Nile monitor in Cape Coral, Florida. Invited speaker, 2005 All-Florida Herpetology Conference, Gainesville, FL.

Klowden, G. and T. S. Campbell. March 2005. Big lizards behaving badly. Florida Ornithological Society meeting, Venice, FL.

Campbell, T. S. February 2005. Status of the introduced Nile monitor in Cape Coral, Florida. Charlotte Harbor Watershed Summit, North Ft. Myers, FL.

Klowden, G., J. L. Quintard, and T. S. Campbell. February 2005. The Nile monitor eradication project. Poster and display booth at the Burrowing Owl Festival, Cape Coral, FL.

Klowden, G., J. L. Quintard, and T. S. Campbell. January 2005. The Nile monitor eradication project. Poster and display booth at the Charlotte Harbor Nature Festival in Port Charlotte, FL.

Campbell, T. S. December 2004. Big lizards behaving badly: The status of the Nile monitor lizard in Cape Coral. Invited speaker, 9th Annual Exotic Species Workshop for Southwest Florida, Naples, FL.

Campbell, T. S. October 2004. Big lizards behaving badly: status of the Nile monitor in Cape Coral. Charlotte Harbor National Estuary Program Technical Advisory Committee Meeting, Port Charlotte, FL.

Klowden, G. and T. S. Campbell. July 2004. Big lizards behaving badly: introduced Nile monitors in southwest Florida. Invited speaker, Cape Coral Neighborhood Watch, Cape Coral, FL.

Campbell, T. S. May 2004. Big lizards behaving badly: introduced Nile monitors in southwest Florida. 2004 Joint Meeting of the Society for the Study of Amphibians and Reptiles, American Society of Ichthyologists and Herpetologists, and Herpetologist's League, Norman, OK.

Campbell, T. S. February 2004. Strangers in paradise: introduced Nile monitors in Southwest Florida. Invited speaker, Peace River Audubon Society meeting, Port Charlotte, FL.

Campbell, T. S. February 2004. Strangers in paradise: ecology of novel assemblages of introduced lizards in South Florida. Invited speaker, Department of Biology Seminar, University of South Florida, Tampa, FL.

Campbell, T. S. December 2003. Can introduced Nile monitors be eradicated from Cape Coral? Invited Speaker, 8th Annual Exotic Species Workshop for Southwest Florida, Naples, FL.

Appendix 2. Partial list of exposure in printed media formats resulting from this project.

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Bancroft, C. 2003. Enter the dragons. St. Petersburg Times Floridian Section, September 26, 2003, 1D, 6D. Covers my work on introduced Nile monitors in Cape Coral, with photos.

Werner, M. 2003. A reptilian invasion. Charlotte Herald-Tribune, July 27, 2003, 1B, 2B. Covers my work on introduced Nile monitors in Cape Coral, with photos.

Wilson, D. 2003. Monitor lizards growing out of control. Orlando Sentinel, July 24, 2003, D7. Detailed coverage of my work on introduced Nile monitors in Cape Coral, with photos and graphics.

Lollar, K. 2003. Lizards living large in cape. Ft. Myers News-Press, July 18, 2003, cover and 10A. Covers my work on introduced Nile monitors in Cape Coral, with photos and graphics. This story was picked up by the Associated Press and broadcast worldwide in various newspapers and Internet news sites.